Otway Offshore Gas Victoria Project

Offshore Project Proposal

V-1000-01-MP-0001

Review record (record the last 3 revisions here or the revisions required to achieve current approval version)

Revision	Date	Reason for issue	Reviewer/s	Consolidator	Approver
A	21/08/2023	Draft for internal review	PW	GN	PW
0	11/09/2023	Issued to NOPSEMA	PW	GN	PW
1	21/12/2023	Revised to address NOPSEMA comments	PW	GN	PW
2	15/02/2024	Revised to address NOPSEMA comments	PW	GN	PW

Review due	Review frequency
N/A	N/A

THE THREE WHATS
What can go wrong?
What could cause it to go wrong?
What can I do to prevent it?

Contents

Figures

Tables

Acronyms

Terms/acronym	***Definition/Expansion***
AEMO	Australian Energy Market Operator
AFMA	Australian Fisheries Management Authority
AHO	Australian Hydrographic Office
ALARP	As Low as Reasonably Practicable
AMOSC	Australian Marine Oil Spill Centre
AMP	Australian Marine Park
AMSA	Australian Maritime Safety Authority
ANZECC	Australian and New Zealand Environment and Conservation Council
APPEA	Australian Petroleum Production and Exploration Association
ASAP	As soon as practicable
ASX	Australian Stock Exchange
Bass Strait CZSF	Bass Strait Central Zone Scallop Fishery
bbl	Barrel
Beach	Beach Energy (Operations) Limited
BIA	Biologically Important Area
BOM	Bureau of Meteorology
BOP	Blow-out Preventer
BTEX	Benzene, Toluene, Ethylbenzene and Xylene
CAMBA	China Australia Migratory Bird Agreement
CMMS	Computerised Maintenance Management System
CMT	Crisis Management Team
COLREG	Convention on The International Regulations for Preventing Collisions at Sea
CO	Carbon monoxide
CRA	Corrosion Resistant Alloy
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CUTP	Clean-up to plant
DAFF	Department of Agriculture, Fisheries and Forestry
DAWE	Commonwealth Department of Agriculture, Water and the Environment
DCCEEW	Commonwealth Department of Climate Change, Energy, the Environment and Water formerly DAWE
DEECA	Victorian Department of Energy, Environment and Climate Action (formerly Victorian Department of Jobs, Precincts and Regions)
DEECA: ERR	Victorian Department of Energy, Environment and Climate Action: Earth Resources Regulation
DELWP	Victorian Department of Environment, Land, Water and Planning now DEECA

Terms/acronym	***Definition/Expansion***
DIIS	Department of Industry, Innovation and Science
DISER	Department of Industry, Science, Energy and Resources
DJPR	Victorian Department of Jobs, Precincts and Regions now DEECA
DJPR: ERR	Victorian Department of Jobs, Precincts and Regions: Earth Resources Regulation now DEECA: ERR
DN100	diametre nominal (100 millimetres)
DN500	diametre nominal (500 millimetres)
DNP	Commonwealth Director of National Parks
DO	Dissolved Oxygen
DotEE	Commonwealth Department of the Environment and Energy now DCCEEW
DNRET	Department of Natural Resources and Environment Tasmanian
DP	Dynamic Positioning
DPIPWE	Tasmanian Department of Primary Industries, Parks, Water and Environment (now DNRET)
DSEWPaC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities
EAC	East Australian current
EFL	Electrical Flying Leads
EFL	Electrical Flying Lead
EIS	Environmental Impact Statement
EMBA	Environment That May Be Affected
EMPCA	*Environmental Management and Pollution Control Act 1994*
EMT	Emergency Management Team
ENSO	El Niño – Southern Oscillation
EP	Environment Plan
EPA	Environmental Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EDP/LMRP	Emergency Disconnect and Lower Marine Riser Package
EPO	Environment Performance Outcome
EPS	Environment Performance Standard
ERT	Emergency Response Team
ESD	Ecologically Sustainable Development
ETBF	Eastern Tuna and Billfish Fishery
GHG	Greenhouse gas
H_2S	Hydrogen Sulphide
HDD	Horizontal Directional Drilled
HFC	Hydrofluorocarbons
HISC	Hydrogen Induced Stress Cracking

Terms/acronym	***Definition/Expansion***
HPU	Hydraulic Power Unit
HSE	Health, Safety and Environment
HSEMS	Health, Safety and Environment Management System
HTT	Hot Tap tee
Hz	Hertz
IAPP	International Air Pollution Prevention
IBC	Intermediate Bulk Container
IMO	International Maritime Organisation
IMOS	Integrated Marine Observing System
IMS	Invasive Marine Species
IMT	Incident Management Team
IOGP	International Association of Oil and Gas Producers
IUCN	International Union for Conservation of Nature
JAMBA	Japan Australia Migratory Bird Agreement
JRCC	Joint Rescue Coordination Centre
KEF	Key Ecological Feature
Lattice	Lattice Energy Limited
LOWC	Loss of Well Control
LOC	Loss of Containment
LOR	Limit of Reporting
LPG	Liquefied Petroleum Gas
MARPOL	International Convention for The Prevention of Pollution from Ships
MC	Measurement Criteria
MCRA	Marine and Coastal Regionalisation of Australia
MCS	Master Control Station
MDO	Marine Diesel Oil
MDRT	Measured depth rotary table
MEG	Monoethylene Glycol
MMscf	Million Standard Cubic Feet
MMscfd	Million Standard Cubic Feet per day
MNES	Matters of National Environmental Significance
MNP	Marine National Park
MO	Marine Order
MoC	Management of Change
MODIS	Moderate Resolution Imaging Spectroradiometer
MODU	Mobile Offshore Drilling Unit
MT	Metric Tonne

Terms/acronym	***Definition/Expansion***
N_2O	Nitrous oxide
NatPlan	National Plan for Maritime Environmental Emergencies
NDC	Nationally Determined Contributions
NEBA	Net Environmental Benefit Analysis
NGER	National Greenhouse and Energy Reporting
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NOPTA	National Offshore Petroleum Titles Administrator
NORMs	Naturally Occurring Radioactive Materials
NO_2	Nitrogen dioxide
NPI	National Pollution Inventory
NRE	Department of Natural Resources and Environment (Tas)
NSW	New South Wales
NUI	Normally Unmanned Installation
O_3	Ozone
ODS	Ozone Depleting Substance
OEMS	Operations Excellence Management System
OGP	Otway Gas Plant
OGPP	Otway Gas Production Pipeline
OGUK	Oil and Gas UK
OGV	Offshore Gas Victoria
OPEP	Oil Pollution Emergency Plan
OPGGS Act	Offshore Petroleum and Greenhouse Gas Storage Act 2006
OPGGS Regulations (Vic)	Victorian Offshore Petroleum and Greenhouse Gas Storage Regulations 2011
OPGGS (Environment) Regulations	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023
OPP	Offshore Project Proposal
Origin	Origin Energy Resources Limited
ORP	Oxidation-Reduction Potential
OSCP	Oil Spill Contingency Plan
OSMP	Operational and Scientific Monitoring Plan
OSTM	Oil Spill Trajectory Modelling
OSV	Offshore Support Vessel
OWR	Oiled Wildlife Response
PAH	Polyaromatic hydrocarbons
P&A	Plug and Abandon
Pb	Lead
PCB	Polychlorinated biphenyls

Terms/acronym	***Definition/Expansion***
PCM	Pipeline Corrosion Monitor
PFC	Perfluorocarbons
Platform	Thylacine A Platform
PMST	Protected Matters Search Tool
POB	persons on board
POLREP	Marine Pollution Report
POWBONS Act	Pollution of Waters by Oil and Noxious Substances Act 1986
ppm	Parts Per Million
Project	The Otway Offshore Gas Victoria Project
PSZ	Petroleum Safety Zone
PTS	Permanent Threshold Shift
RFSU	Ready for start-up
ROV	Remotely Operated Vehicle
SBDF	Synthetic Based Drilling Fluids
SBTF	Southern Bluefin Tuna Fishery
SCCP	Source Control Contingency Plan
SCM	Subsea Control Module
SCSSV	Surface Controlled Subsurface Safety Valve
SDU	Subsea Distribution Unit
SEEMP	Ship Energy Efficiency Management Plan
SEL	Sound Exposure Level
SEMR	South-East Marine Region
SESSF	Southern and Eastern Scalefish And Shark Fishery
SETFIA	South East Trawl Fishing Industry Association
SF6	Sulphur hexafluoride
SHX	Subsea Heat Exchanger
SIMAP	Spill Impact Mapping Analysis Program
SIV	Seafood Industry Victoria
SMC	Subsea Manifold Cooler
SMPEP	Shipboard Marine Pollution Emergency Plan
SMS	Short Message Service
SO_2	Sulphur dioxide
SPCU	Subsea Power and Control Unit
SPF	Small Pelagic Fishery
SPL	Sound Pressure Level
SRW	Southern Right Whale
SST	Sea surface temperature

Terms/acronym	***Definition/Expansion***
SVS	Subsea Valve Skid
T-DIS	Thylacine Diverless Interface Skid
TEC	Threatened Ecological Community
TOLC	Top of Line Corrosion
TRH	Total Recoverable Hydrocarbon
TSSC	Threatened Species Scientific Committee
TTS	Temporary Threshold Shift
TUTA	Topside Umbilical Termination Assembly
UTA	Umbilical Termination Assembly
VLSFO	Very Low Sulphur Fuel Oil
VWMS	Victorian Waterway Management Strategy
VSP	Vertical Seismic Profiling
WBDF	Water-Based Drilling Fluid
WECS	Well Engineering and Construction Management System
WOMP	Well Operations Management Plan
Woodside	Woodside Petroleum Ltd
WRSSV	Wireline Retrievable Subsurface Safety Valve

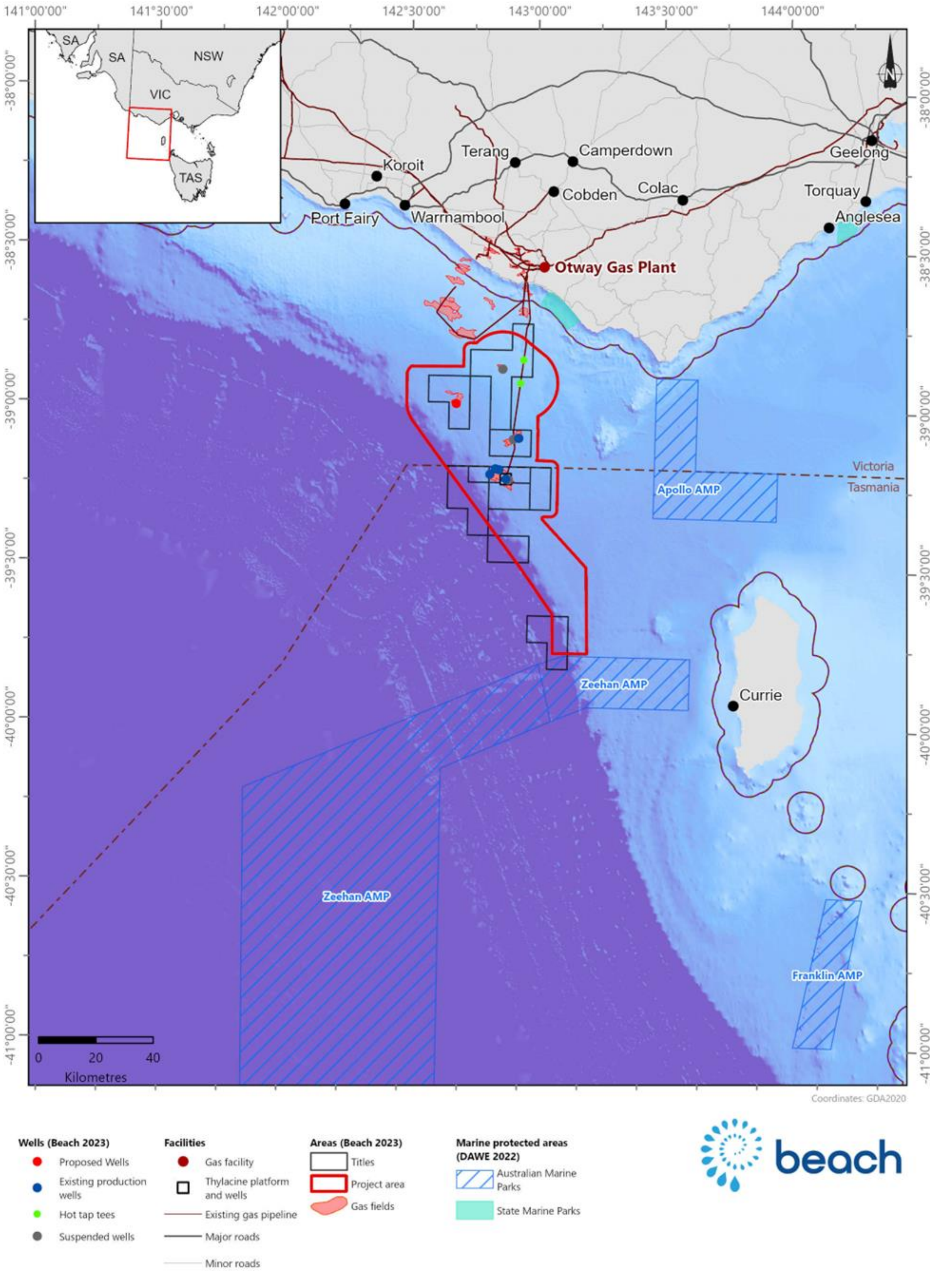
Executive Summary

ES1 Introduction

The Otway Offshore Gas Victoria Project (the Project) is designed to explore and develop new gas discoveries in the offshore Otway Basin. The Project provides an opportunity to develop currently stranded gas reserves and future resources in the offshore Otway Basin through integrated subsea drilling and installation campaigns and by utilising Beach's existing offshore infrastructure.

The development concept for the Project is the subsea development. The stages of the Project will include an initial drilling campaign operated by a semi-submersible MODU. Successful wells will be tied back to existing Otway Gas Production Pipeline (OGPP) and/or Thylacine A platform via installation of new subsea flowlines and facilities. Recovered gas will be transported through the OGPP to the onshore OGP located onshore near Port Campbell, Victoria. The OGP supplies gas to the domestic market in south-east Australia.

The Project focuses on exploration, appraisal and development of existing and future gas discoveries in Beach's exploration permits, VIC/P43, VIC/P73 and T/30P located in the offshore Otway Basin. The Project covers an area that is located approximately 20km south of the Victorian mainland and 40 km west of Tasmania (King Island) at its closest points (**ES Figure 1**). The Project is adjacent to Beach's current production operations at the Geographe and Thylacine gas fields in the offshore Otway Basin.



7/09/2023| OT23-0027G

ES Figure 1: Project Location

The petroleum activities planned for the Project include full lifecycle of petroleum operations summarised in the below ES Table 1.

Project Stage	Key Activities
Seabed surveys	• Geotechnical and geophysical surveys undertaken to assess the suitability of the seabed for drilling and infrastructure placement
Drilling (Exploration, Appraisal & Development)	• Initial exploration & appraisal drilling campaign of up to seven wells • Well testing (contingent) • Drilling operations will be suspended by a combination of the below: ○ Permanent plug and abandon ○ Temporary suspension with cement plug barriers • Suspension with installation of Christmas tree (with or without completion) • Completions (in success case) • Future drilling campaign(s) ○ while not currently planned, there is a possibility that future exploration, appraisal and development drilling of up to ten wells may be required for optimal gas recovery in producing fields over the life of the project
Installation of subsea infrastructure	• Installation of subsea infrastructure to connect gas discoveries Artisan, La Bella and any successful exploration or appraisal wells from the initial drilling campaign to the OGPP including; wellheads, flowlines, umbilicals, manifolds and skids
Commissioning	• Commissioning and testing of new equipment including flowlines, • Unload of drilling and completion fluid from the well is planned through new and existing subsea infrastructure to the onshore Otway Gas Plant (OGP). Well unload and production testing to the MODU is a contingent option.
Operations	• Production from Artisan, La Bella and future prospects is expected to have an operation life of up to 30 years with end of field life estimated as 2055. • However, subject to future investment and developments in surrounding fields, operations and infrastructure life may be extended. • Further well and installation campaigns required to support future developments within the Project Area may be undertaken during the operations stage. • Operations stage may include well intervention and inspection, maintenance and repair of wells and subsea infrastructure as required
Future tie-backs	• Future tie backs of successful exploration or appraisal wells comprising similar subsea infrastructure to the initial development may be undertaken in the Project Area. ○ Geotechnical and Geophysical surveys ○ Installation and commissioning of subsea infrastructure to connect gas discoveries • There is the potential for future tie-ins in the vicinity of the Project Area by other operators comprising similar subsea infrastructure to the initial development. This would be part of the maximum ten additional wells identified for future drilling campaigns.
Decommissioning	• Well abandonment • Decommissioning of subsea infrastructure

ES Table 1: Project Summary

Proponent

Beach Energy (Operations) Limited (Beach) is the proponent for the Project and is the operator and titleholder (60% participating interest) of the Exploration Permits. Beach also owns and operates existing production assets and infrastructure in the Otway Basin at Thylacine and Geographe fields, Thylacine-A platform and Offshore Otway Gas Pipeline.

Offshore Project Proposal Process

This Offshore Project Proposal (OPP) has been prepared in accordance with the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023 (OPGGS (Environment) Regulations) and associated guidelines, which require an OPP to be submitted for all offshore projects. The OPP is an early-stage project assessment which, subject to acceptance by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA), will form the basis for future activity-specific Environment Plans.

For completeness, this OPP includes description of exploration and appraisal drilling activity which is an activity that does not require an accepted OPP as part of the environmental permitting framework.

This OPP also described existing petroleum infrastructure for Thylacine and Geographe which was approved under the *Environment Protection and Biodiversity Conservation Act 1999*.

ES2 Environmental Legislation and Other Requirements

The OGV Project is located entirely in Commonwealth waters. The key legislation and regulations for petroleum activities are:

- *Offshore Petroleum Greenhouse Gas Storage Act 2006* - provides a legal framework for the exploration and recovery of petroleum (and greenhouse gas activities) in Commonwealth waters. The OPGGS Act establishes the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) as the independent regulator for environmental management, health and safety, and well integrity and for all offshore petroleum (and greenhouse gas storage) activities in Commonwealth waters
- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) - provides a legal framework to protect and manage important flora, fauna, ecological communities and heritage places defined in the EPBC Act as matters of national environmental significance. Specifically for petroleum activities in Commonwealth waters:
- In February 2014, a Program was endorsed under the EBPC Act to provide for NOPSEMA to assess and make approval decisions for new offshore petroleum development projects and shorter-term activities. NOPSEMA's environmental assessment processes consider all project and activity specific environmental impacts and risks, including but not limited to those relevant to matters protected under Part 3 of the EPBC Act. Decision-making under the Program ensures that environmental impacts and risks, including to matters protected under Part 3 of the EPBC Act, will be of an acceptable level and reduced to as low as reasonably practicable (ALARP).
- Offshore Petroleum Greenhouse Gas Storage (Environment) Regulations 2023 - provide for the regulation of environmental management of petroleum (and greenhouse gas storage) activities in Commonwealth waters, and aim to ensure that petroleum activities in these areas are carried out

in a manner that is consistent with ecologically sustainable development and consistent with the objective that environmental impacts and risks are of an acceptable level and reduced to ALARP

ES3 Description of the Project

Key Project Characteristics

The Project is a subsea development of new gas fields in the Otway Basin. The key project characteristics are described in ES Table 2.

Project Characteristics	Description
Project Area	The Project Area is defined in ES1
Key Project Stages	Seabed surveys (geotechnical and geophysical) Exploration, appraisal and development drilling Completion of successful wells Subsea infrastructure installation Commissioning Operations and maintenance Future tiebacks Decommissioning
Proposed Wells	In the order of six wells are anticipated to be drilled and completed (in success case) and one re-entered and completed as part of the initial drilling campaign: • Re-entry and completion of Artisan 1 • Drilling and completion of La Bella 2 • In the order of five additional exploration and appraisal wells drilled and completed (in success case) from a portfolio of prospects in the Project Area. Future exploration, appraisal and development drilling campaigns of up to 10 wells may be undertaken in the Project Area. This drilling will use similar techniques as outlined in this OPP and will be detailed in activity specific EPs.
Subsea infrastructure	Installation of subsea infrastructure to connect gas discoveries Artisan 1, La Bella 2 and any successful exploration or appraisal wells from the initial drilling campaign to the OGPP including: • Wellheads, flowlines, umbilicals, manifolds and skids Future tie backs of successful exploration or appraisal wells (up to ten additional wells) comprising similar subsea infrastructure may be undertaken in the Project Area

ES Table 2: Key Project Characteristics

Project Area

The Project will be carried out in the defined Project Area shown in above **ES Figure 1**. The Project Area includes the Artisan and La Bella gas discoveries, future exploration prospects located in VIC/P43, VIC/P73 and T/30P. The Project Area also includes the proposed locations of subsea flowlines and facilities l(with buffer areas) for future subsea tie-back to the OGPP or the Thylacine platform.

Project Stages and Schedule

Beach is planning an initial drilling campaign commencing in 2025, installation of new subsea facilities commencing in 2026 with the earliest achievable date for commissioning and first gas in 2026 subject to corporate, joint venture and regulatory approvals.

Project Stage	Indicative Timing
Execution Decision Gate	Q3 2024
Initial Exploration & Appraisal Drilling Campaign	Q1 2025
Installation of Subsea Infrastructure	Q1 2026
Commissioning & RFSU	Q2 2026
Future drilling and tie-backs	Within operating life of the Project
End of Field Life	2055
Decommissioning	Undertaken at the end of field life

ES Table 3: Indicative Project Schedule

ES4 Description of the Environment

The OPP describes the physical, ecological, and socio-economic environment that may be affected (Planning Area) from planned and unplanned events associated with the Project, including MNES protected under the EPBC Act. This description informs the assessment of environmental impacts and risks.

The outer boundary of the Planning Area is the worst-case and largest spatial extent where unplanned hydrocarbon releases from Project activities could have an environmental consequence. All planned activities will occur within the Project Area (**ES Figure 1**).

Physical Environment

The dominant seabed character is medium to coarse carbonate sands with areas of low relief exposed limestone. There are no known bathymetric features such as reefs, shoals or banks within the Project Area. The continental shelf slope is in close proximity to the Project Area and has been designed to not include the deeper waters off the continental shelf.

Otway is a high-energy environment exposed to frequent storms and significant wave heights. Winds in the area generally exceed 13 knots (23.4km/h) for more than 50% of the time contributing to the moderate to high wave-energy environment.

The region is oceanographically complex, with subtropical influences from the north and subpolar influences from the south. The Leeuwin Current transports warm, subtropical water southward along the

Western Australian coast and then eastward into the Great Australian Bight where it mixes with the cool waters from the Zeehan Current running along the west coast of Tasmania. These currents are stronger in winter than in summer.

Water and sediment quality within the Project Area is high, with little evidence of contamination.

The climate in the Otway is typical of a cool temperate region with cold, wet winters and warm dry summers. In winter, when the subtropical ridge moves northwards over the Australian continent, cold fronts generally create sustained west to south-westerly winds and frequent rainfall in the region. In summer, frontal systems are often shallower and occur between two ridges of high pressure, bringing more variable winds and rainfall.

Ecological Environment

The benthic habitat is similar across the Project Area, consisting of carbonate rich coarse to medium sands with areas of exposed limestone substrate. This type of seabed is highly mobile making it difficult for filter feeders and soft body invertebrates to survive and establish in significant populations. Epifauna is dominated by low density, patchy assemblages of branching bryozoans, gorgonian cnidarians and sponges.

No benthic species or ecological communities listed as threatened under the Environmental Protection and Biodiversity Conservation Act 1999 (the EPBC Act) were identified.

One KEF, West Tasmanian Canyons, was identified within the Project Area. The Project Area overlaps to a minor extent and the KEF is located on the continental slope where Project activities are not planned to occur.

A range of other communities and habitats occur within the Planning Area beyond the Project Area, including:

- benthic habitats such as bare substrate, seagrasses, and macroalgae.
- coastal habitats such as mangroves and saltmarsh.

A number of threatened or migratory species listed under the EPBC Act were listed within the Project Area and Planning Area, including:

- 17 fishes (including sharks) (8 within the Project Area and another 9 within the Planning Area beyond the Project Area)
- 122 birds (32 within the Project Area and another 90 within the Planning Area beyond the Project Area)
- 14 marine mammals (11 within the Project Area and another 3 within the Planning Area beyond the Project Area)
- 3 reptiles (within both the Project Area and Planning Area beyond the Project Area)

Socio-Economic Environment

No protected areas overlap the Project Area, although a number occur within the Planning Area beyond the Project Area, including:

- 8 Commonwealth Australian Marine Parks (AMPs)
- 13 Victorian marine protected areas
- 16 Victorian terrestrial protected areas

- 3 Tasmanian marine protected areas
- 29 Tasmanian terrestrial protected areas
- 7 wetlands of international importance (Ramsar wetlands)

Eight Commonwealth commercial fisheries have jurisdictions to fish within the Planning Area.

There are eight Victorian state-managed commercial fisheries that overlap the Planning Area with catch effort was identified within the Project Area for the Giant Crab Fishery and Rock Lobster Fishery.

There are eight Tasmanian state-managed commercial fisheries that may overlap the Planning Area and the Rock Lobster Fishery occurs within the Project Area.

The Project Area does not overlap any South Australian Fisheries with the Planning Area overlapping five fisheries.

No World, Commonwealth or national heritage properties occur within the Project Area. Several occur within the Planning Area beyond the Project Area, including:

- One World Heritage Property (Tasmanian Wilderness)
- 8 Commonwealth Heritage Places
- 5 National Heritage Places

Within the Planning Area there is a 130km stretch of coastline known as the ‘Shipwreck Coast’ because of the large number of shipwrecks present, with most wrecked during the late nineteenth century. The strong waves, rocky reefs and cliffs of the region contributed to the loss of these ships.

First Nations people groups inhabited the southwest Victorian coast as is evident from the terrestrial sites of Aboriginal archaeological significance throughout the area. During recent ice age periods (the last ending approximately 12,000-14,000 years ago), sea levels were significantly lower, and the coastline was a significant distance seaward of its present location, enabling occupation and travel across land that is now submerged.

The Eastern Maar are Traditional Owners of southwest Victoria, and currently occupy a registered Native Title claim on the land adjacent to the Project Area and Planning Area and 100 m out to sea. Their land extends as far north as Ararat and encompasses Warrnambool, Port Fairy, and other areas along the Great Ocean Road, it also stretches 100 m out to sea from low tide and therefore includes the iconic Twelve Apostles (EMAC 2020). According to EMAC (2020), one of the services provided by the Eastern Maar group is the involvement/consultation and conducting of fieldwork with Cultural Heritage Management Plans in conjunction with a Heritage Advisor, with this collaboration reflecting the notion of “Working on Country together” (EMAC 2020).

Coastal Aboriginal heritage sites include mostly shell middens, some stone artefacts, a few staircases cut into the coastal cliffs, and at least one burial site. The various shell middens within the Port Campbell National Park and Bay of Islands Costal Park are close to coastal access points that are, in some cases, now visitor access points (Parks Victoria 2006b). The Aboriginal Heritage Register (AHR) lists over 13,000 sites; however, there is no searchable database to identify any sites in the Planning Area.

The south-east marine region is one of the busiest shipping regions in Australia and Bass Strait is one of Australia’s busiest shipping routes. Commercial vessels use the route when transiting between ports on the east, south and west coasts of Australia, and there are regular passenger and cargo services between mainland Australia and Tasmania.

Ongoing consultation with Department of Defence has identified that the Project Area is located within restricted airspace, but no other defence areas were identified. The Department of Defence also advised that unexploded ordnance (UXO) may be present on and in the sea floor.

ES5 Environmental Impacts and Risks Assessment Methodology

Beach has undertaken environmental impact and risk assessments for the Project in accordance with the Beach OEMS Risk Management Standard.

The impact or risk for each activity and associated hazards was assessed following the application of controls. For planned events, only the consequence of the impact was assessed. Likelihood was not assessed, as the occurrence of planned events is effectively certain. The consequence for planned events was based on all controls functioning effectively. For unplanned events, the environmental residual risk of the event was determined based on the likelihood and consequence of the events.

The likelihood of an unplanned event occurring was based on all controls functioning effectively. The consequence was based on a worst-case event occurring with all controls having failed. This provides a conservative approach to assessing consequence, as the likelihood of a worst-case event with the failure of all controls is remote.

The resulting consequence (planned events) or residual risk (unplanned events) was then compared to Beach acceptable levels of impact and risk, including receptor-specific acceptable levels of impact. If the impact or residual risk was determined to not be acceptable, additional controls were applied and the impact or risk was assessed again. This process was repeated until each impact or residual risk was reduced to an acceptable level.

In addition to assessing each aspect and its associated hazards independently, Beach has also undertaken a cumulative impact assessment (Section 8). This cumulative impact assessment considered potential synergistic impacts on environmental values and sensitivities from all aspects of the Project and third-party activities. The cumulative impact assessment was only undertaken for planned events. No consideration of cumulative impacts from unplanned events was made, as these events are not expected to occur during the Project activities.

ES6 Environmental Performance Outcomes, Standards and Measurement Criteria

The specific EPOs and control measures of the Project relevant for each impact and risk are provided in Sections 6 and 7. The EPOs for the Project are listed below with the controls for planned activities provided in **ES Table 4** and for unplanned events in **ES Table 5.**

- EPO1 No interference with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted
- EPO2 Commercial marine users are not economically disadvantaged as a result of Project activities
- EPO3 Seabed disturbance is limited to planned well and infrastructure locations within the Project area
- EPO4 No impact to submerged cultural heritage*

- EPO5 No death or injury to marine fauna, including listed threatened or migratory species, from Project activities
- EPO6 Decommissioning of Project facilities in compliance with Section 572 (3) of the Offshore Petroleum and Greenhouse Gas Storage (OPGGS) Act 2006
- EPO7 Biologically important behaviours within or outside a BIA can continue while Project activities are being undertaken
- EOP8 Underwater sound emissions in biologically important areas will be managed such that any whale, including blue and southern right whales, continue to utilise the area without injury, and are not displaced from a foraging area
- EPO9 No substantial reduction of air quality within local airshed caused by atmospheric emissions produced from Project activities
- EPO10 Gas is provided to communities sustainably in a manner which is consistent with the objectives of the Paris Agreement and the global response to the threat of climate change
- EPO11 Monitoring and reporting GHG emissions to the regulator under the NGER Act as required
- EPO12 No impact to water and sediment quality outside of 2km of the discharge location
- EPO13 No impact to water and sediment quality outside of 50m of the discharge location
- EPO14 No impact to water and sediment quality outside of 200m of the discharge location
- EPO15 No impact to water and sediment quality outside of 500m of the discharge location
- EPO16 No introduction of known or potential Invasive Marine Species from Project activities
- EPO17 No unplanned loss of hazardous or non-hazardous materials to marine environment from Project activities
- EPO18 No unplanned discharge of hydrocarbons or chemicals to the marine environment from Project activities
- EPO19 In event of an unplanned release of chemicals or hydrocarbons, spill response control measures will be implemented in accordance with accepted EP, OPEP and OSMP

* In addition to EPO 4, all the other EPOs define the performance of Beach in protecting First Nations Cultural Values and Sensitivities as identified in Section 4.6.3 of this OPP.

Aspect	Residual Impact		Control Measures
Physical Presence - Interaction with Other Users	Minor	CM01 Navigation safety	All vessels operating within the project area will adhere to the navigation safety requirements including: • International Regulations for Preventing Collisions at Sea 1972 • Chapter 5 of International Convention for the Safety of Life at Sea 1974 • International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978 • Navigation Act 2012 and any subsequent Marine Orders that specify standards for crew training and competency, navigation, communication, and safety measures
		CM02 Notifications	The Australian Hydrographic Office will be notified of the Project activities and installed subsea infrastructure prior to commencement to facilitate the issuing of Notice to Mariners and maintain nautical charts. Relevant stakeholders are notified prior to the activity so that third party marine users are aware of vessel location and timing
		CM03: Fair Ocean Access Procedure	Beach's Fair Ocean Access Procedure was developed with input from commercial fishing industry organisations. The procedure details the process whereby a commercial fisher can claim compensation for an economic loss associated with Beach's offshore activities where impacts cannot be avoided
		CM04 Stakeholder consultation	Beach will undertake consultation with relevant persons for all petroleum activities in accordance with the OPGGS (Environment) Regulations and detailed in Section 9 of this OPP
		CM05 Petroleum safety zones	The Project will comply with OPGGS Act 2006 – Section 616(2) petroleum safety zones, which includes establishment and maintenance of petroleum safety zones around wells, offshore structures or equipment which prohibits vessels entering without written consent
		CM06 Temporary exclusion zones	500m temporary exclusion zones will be established and maintained around drilling and installation activities
		CM07 Decommissioning	Decommissioning of Project facilities in compliance with Section 572 of the OPGGS Act.
Presence – Seabed Disturbance	Minor	CM08 Project Execution Plans	Infrastructure will be positioned on the seabed within design footprint to reduce seabed disturbance
		CM09 MODU and vessel anchoring plan	A MODU and vessel anchoring plan will identify suitable areas for anchors to be placed within the Project Area
		CM10 Seabed assessments	Seabed assessments undertaken of each well location and tie-back route prior to final selection to identify seabed composition, benthic habitats and communities and ensure areas of high relief outcrops, reefs, sponge beds, maritime archaeology, submerged cultural heritage and landscapes are avoided where practicable within technical and safety constraints
		CM11 Cultural heritage assessments	Imagery and data from seabed surveys and assessments will be provided to appropriately qualified underwater archaeologists to identify any maritime archaeological and submerged cultural heritage and landscapes and inform protection priorities, management measures and reporting requirements.
		CM7 Decommissioning	Decommissioning of Project facilities in compliance with Section 572 of the OPGGS Act
Light emissions	Minor	CM12 MODU and vessel lighting	MODU and vessel lighting will be limited to the minimum required for navigational and safety requirements, with the exception of emergency events
		CM13 Light Management Procedure	MODU and vessels will implement a Light Management Procedure as per the National Light Pollution Guidelines (Commonwealth of Australia, 2020) for Project activities. The Light Management Procedure will detail mitigations to manage light based on the information in the Seabird Light Mitigation Toolbox and Beach Energy's Vessel Light Management Procedure Guidance (CDN/ID 19012450)
Underwater sound emissions	Moderate	CM14 EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans	Vessels will adhere to EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans in relation to distances to cetaceans. Helicopters will adhere to EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans in relation to distances to cetaceans
		CM15 Geophysical Survey Whale Management Procedure	Development and implementation of a whale management procedure for geophysical surveys using a boomer or SBP that will include the following: • pre-start-up visual observations. Visual observations for the presence of whales carried out at least 30 minutes out to a distance of at least 300m from the source before startup of the boomer or SBP. • If during the prestart visual observation period, a whale is sighted within 300m of the vessel the equipment activation will be delayed until the whale has moved outside of the 300m zone or 30 minutes has lapsed since the last whale sighting within 300m. • SBP equipment will not be started at night if there have been three or more delays to the start-up of the equipment due to whales in the previous 24 hours. • Use of suitably trained personnel and/or Marine Mammal Observers Once the survey has commenced CM14 applies where the vessel is required to maintain a 300m distance to all whales.
		CM16 VSP Whale Management Procedure	Development and implementation of a whale management procedure for VSP activities that complies with 'Standard Management Procedures' set out in EPBC Act Policy Statement 2.1 – Interaction between Offshore Seismic Exploration and Whales: Industry Guidelines (DEWHA 2008c) (or the contemporary requirements at the time of the activity), including: • pre-start-up visual observations. • start-up and normal operating procedures, including a process for delayed start-up/recommencement, should whales be sighted. • night time and low visibility procedures • use of suitably trained personnel and/or Marine Mammal Observers

Aspect	Residual Impact		Control Measures
		CM17 Drilling Whale Management Procedure	Development and implementation of a whale management procedure for drilling activities which details a framework for minimising noise impacts to whales and a procedure to be implemented to ensure impacts and risks are reduced to ALARP. This will include: • pre-start-up visual observations. • start-up and normal operating procedures, including a process for delayed start-up/recommencement, should whales be sighted. • night time and low visibility procedures • use of suitably trained personnel and/or Marine Mammal Observers
		CM18 Vessel Whale Management Procedure	Development and implementation of a whale management procedure for installation, IMR and vessel transit/resupply activities which details a framework for minimising noise impacts to whales and a procedure to be implemented to ensure impacts and risks are reduced to ALARP. This will include: • pre-start-up visual observations. • start-up and normal operating procedures, including a process for delayed start-up/recommencement, should whales be sighted. • night time and low visibility procedures • use of suitably trained personnel and/or Marine Mammal Observers
		CM19 Noise Assessments	Acoustic noise assessments of significant noise generating activities associated with the Project will be detailed in relevant activity specific Environment Plans prior to activities commencing. The EPs will detail the sound levels and distances to noise effect criteria, with the mitigations required to ensure the Environmental Performance Outcomes of this OPP are met and the impact is ALARP and acceptable.
Atmospheric Emissions	Minor	CM20 MARPOL Annex VI (Prevention of Air Pollution from Ships)	Vessels and MODU will comply with MARPOL Annex VI (Prevention of Air Pollution from Ships), the Navigation Act 2012, the Protection of the Sea (Prevention of Pollution from Ships) Act 1983 and Marine Orders – Part 97: Marine Pollution Prevention – Air Pollution (appropriate to vessel class) for emissions from combustion of fuel including: • valid International Air Pollution Prevention (IAPP) certificate and a current international energy efficiency certificate • have a Ship Energy Efficiency Management Plan (SEEMP) as per MARPOL 73/78 Annex VI • engine NOx emission levels will comply with Regulation 13 of MARPOL 73/78 Annex VI • use low sulphur content fuel oil/diesel (≤0.5% m/m S) or an approved measure that achieves an equivalent air quality outcome
		CM21 Emissions Monitoring	Measure, monitor or estimate facility fuel and flare emissions (in accordance with the National Pollutant Inventory) to inform and optimise management practices and minimise environmental impact of emissions
Greenhouse Gas Emissions	Minor	CM22 Beach Sustainability Standard	General requirement within the Standard requires Beach to assess and maintain a register of opportunities to reduce: • emissions • energy consumption • venting and flaring These opportunities will be included in the yearly budget cycle for review, assessment, and approval where reasonably practicable
		CM23 GHG Management Plan	Implementation of Beach GHG Emissions Management Plan that incorporates an adaptive management approach to facilitate a continuous cycle of monitoring, evaluating and implementing improvements to minimise GHG emissions to ALARP and acceptable levels over the life of the Project
		CM24 GHG Emissions Monitoring	Beach is required to annually report their direct GHG emissions (Scope 1 and 2) as per the NGERS regulatory requirements. Beach will use this annual reporting process to internally compare Scope 1 GHG emissions generated by the Project and broader Otway Development against periodic, internal GHG emissions forecasts. Scope 3 emissions derived from use of product will be reviewed against those same forecasts, with this focus reflecting the proportional contribution of final product use to overall Otway asset Scope 3 emissions. Assessment of actual emissions against forecasts will feed into revised assumptions in future emissions forecasts and into the GHG Management Plan review and improvement processes.
		CM25 Fugitive Leak Detection and Repair Program	Beach undertakes periodic leak detection and repair (LDAR) fugitive emissions surveys at the Otway Gas Plant and Thylacine Platform. The scope, methodology, frequency, and repair guidance is detailed in the GHG Management Plan
		CM26 Preventative Maintenance System	Combustion equipment is inspected and maintained in accordance with the preventative maintenance system to ensure efficient operations
		CM27 Logistics Planning	Operations planning is undertaken for supply vessel and helicopter movements, thereby minimising unnecessary travel and minimising fuel combustion
Planned Discharge – Drill Cuttings and Fluids	Minor	CM10 Seabed assessments	Seabed assessments undertaken of each well location and tie-back route prior to final selection to identify seabed composition, benthic habitats and communities and ensure areas of high relief outcrops, reefs, sponge beds, maritime archaeology, submerged cultural heritage and landscapes are avoided where practicable within technical and safety constraints
		CM11 Cultural heritage assessments	Imagery and data from seabed surveys and assessments will be provided to appropriately qualified underwater archaeologists to identify any maritime archaeological and submerged cultural heritage and landscapes and inform protection priorities, management measures and reporting requirements.
		CM28 - Well design	All wells to be drilled with WBDF, with SBDF only to be used where technical requirements preclude the use of WBDF

Aspect	Residual Impact		Control Measures
		CM29 - Chemical selection process	A process for chemical selection will be implemented to ensure chemicals used are environmentally acceptable whilst also meeting technical requirements
		CM30 – Drilling fluid inventory	Drilling fluids inventory will be developed and tracked to reduce discharge of excess powders, brines, and drilling fluids
		CM31 – Solids control equipment	If SBDF is used, drill cuttings will be processed on the MODU to recover and reduce residual SBDF content prior to overboard discharge
		CM32 Minamata convention	Drilling fluids will have concentrations of mercury and cadmium less than 1 mg/kg and 3 mg/kg respectively in stock barite (WBM and SBM)
Planned Discharge – Cement	Minor	CM10 Seabed assessments	Seabed assessments undertaken of each well location and tie-back route prior to final selection to identify seabed composition, benthic habitats and communities and ensure areas of high relief outcrops, reefs, sponge beds, maritime archaeology, submerged cultural heritage and landscapes are avoided where practicable within technical and safety constraints
		CM11 Cultural heritage assessments	Imagery and data from seabed surveys and assessments will be provided to appropriately qualified underwater archaeologists to identify any maritime archaeological and submerged cultural heritage and landscapes and inform protection priorities, management measures and reporting requirements.
		CM33 – Cementing program	Cementing programs shall be developed to minimise the amount of cement discharged to the marine environment, including the minimisation of excess cement discharge upon completion of the drilling program
		CM29- Chemical selection process	A process for chemical selection will be implemented to ensure chemicals used are environmentally acceptable whilst also meeting technical requirements
Planned Discharge – Commissioning and Operational Fluids	Minor	CM10 Seabed assessments	Seabed assessments undertaken of each well location and tie-back route prior to final selection to identify seabed composition, benthic habitats and communities and ensure areas of high relief outcrops, reefs, sponge beds, maritime archaeology, submerged cultural heritage and landscapes are avoided where practicable within technical and safety constraints
		CM11 Cultural heritage assessments	Imagery and data from seabed surveys and assessments will be provided to appropriately qualified underwater archaeologists to identify any maritime archaeological and submerged cultural heritage and landscapes and inform protection priorities, management measures and reporting requirements.
		CM33 Chemical selection process	A process for chemical selection will be implemented to ensure chemicals used are environmentally acceptable whilst also meeting technical requirements
		CM34 Hydrotest assessment	Hydrotest assessments will be detailed in the relevant activity specific EPs developed during the detailed engineering and design studies of the Project. The EPs will detail the hydrotesting requirements including the definition of discharge characteristics (ie chemical additives and concentrations), discharge locations and volumes, methodology and species impact thresholds
Planned Discharge – Routine Operational Wastes from MODU and Vessels	Minor	CM10 Seabed assessments	Seabed assessments undertaken of each well location and tie-back route prior to final selection to identify seabed composition, benthic habitats and communities and ensure areas of high relief outcrops, reefs, sponge beds, maritime archaeology, submerged cultural heritage and landscapes are avoided where practicable within technical and safety constraints
		CM11 Cultural heritage assessments	Imagery and data from seabed surveys and assessments will be provided to appropriately qualified underwater archaeologists to identify any maritime archaeological and submerged cultural heritage and landscapes and inform protection priorities, management measures and reporting requirements.
		CM29 Chemical selection process	A process for chemical selection will be implemented to ensure chemicals used are environmentally acceptable whilst also meeting technical requirements
		CM35 Marine Orders	All wastewater discharges will comply with relevant MARPOL 73/78, Navigation Act 2012, Protection of the Sea (Prevention of Pollution) Act 1983 and subsequent Marine Order requirements (as appropriate for vessel classification): • Marine Order 91 (Marine Pollution Prevention – Oil), which implements Annex I of MARPOL 73/78, including (as required by vessel class): ○ Machinery space bilge/oily water shall have IMO-approved oil filtering equipment (oil/water separator) with an on-line OIW monitoring device ○ OIW content to be less than 15 ppm prior to discharge. ○ A deck drainage system capable of controlling the content of discharges for areas of high risk of fuel/oil/grease or hazardous chemical contamination. ○ Valid International Oil Pollution Prevention Certificate. • Marine Order 95 (Marine Pollution Prevention – Garbage), which implements Annex V of MARPOL 73/78, including: ○ Garbage management plan in place. ○ Garbage record book maintained onboard. • Marine Order 96 (Marine Pollution Prevention – Sewage), which implements Annex IV of MARPOL 73/78, including (as required by vessel class): ○ a valid International Sewage Pollution Prevention Certificate, ○ an IMO-approved sewage treatment plant, ○ a sewage comminuting and disinfecting system, a sewage holding tank sized appropriately to contain all generated waste (sewage and grey water) ○ discharge of sewage will occur at a moderate rate while vessel is proceeding (more than 4 knots)

ES Table 4: Environmental Performance Standards and Measurement Criteria for Planned Activities

Aspect	Residual Risk		Key Control
Invasive Marine Species	Low	CM10 Seabed assessments	Seabed assessments undertaken of each well location and tie-back route prior to final selection to identify seabed composition, benthic habitats and communities and ensure areas of high relief outcrops, reefs, sponge beds, maritime archaeology, submerged cultural heritage and landscapes are avoided where practicable within technical and safety constraints
		CM11 Cultural heritage assessments	Imagery and data from seabed surveys and assessments will be provided to appropriately qualified underwater archaeologists to identify any maritime archaeological and submerged cultural heritage and landscapes and inform protection priorities, management measures and reporting requirements.
		CM36 IMS Management Plan	Implementation of Beach IMS Management Plan which includes the following minimum requirements: • compliance with relevant Australian legislation and current regulatory guidance • outline of when an IMS risk assessment is required and the associated inspection, cleaning and certification requirements • implementation of management measures commensurate with the level of risk based on outcomes if the IMS risk assessment, such as inspections, cleaning and movement restrictions anti-fouling prevention measures, including vessels (of appropriate class) having a valid International Anti Fouling Systems (IAFS) Certificate
		CM37 Australian Ballast Water Management Requirements	The MODU and vessels fulfil the requirements of the Australian Ballast Water Management Requirements (DAWR, 2020, v8). This includes requirements to: • Carry a valid Ballast Water Management Plan (BWMP). • Submit a Ballast Water Report (BWR) through the Maritime Arrivals Reporting System (MARS). • If intending to discharge internationally sourced ballast water, submit BWR through MARS at least 12 hours prior to arrival. • If intending to discharge Australian sourced ballast water, seek a low-risk exemption through MARS. • Hold a Ballast Water Management Certificate (BWMC). • Ensure all ballast water exchange operations are recorded in a Ballast Water Record System (BWRS)
Physical Presence – Interaction with Marine Fauna	Low	CM14 EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans	Vessels will adhere to EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans in relation to distances to cetaceans. Helicopters will adhere to EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans in relation to distances to cetaceans
Accidental Discharge - Hazardous and Non-Hazardous Materials	Low	CM10 Seabed assessments	Seabed assessments undertaken of each well location and tie-back route prior to final selection to identify seabed composition, benthic habitats and communities and ensure areas of high relief outcrops, reefs, sponge beds, maritime archaeology, submerged cultural heritage and landscapes are avoided where practicable within technical and safety constraints
		CM11 Cultural heritage assessments	Imagery and data from seabed surveys and assessments will be provided to appropriately qualified underwater archaeologists to identify any maritime archaeological and submerged cultural heritage and landscapes and inform protection priorities, management measures and reporting requirements.
		CM38 Waste Management Plan	Beach Waste Management Plan implemented that includes details of: • Classification and segregation of wastes • Appropriate storage of wastes Transportation and disposal of wastes to licensed treatment and disposal facilities onshore
		CM35 Marine orders	MODU and vessels will comply with relevant MARPOL Commonwealth requirements and subsequent Marine Orders for waste discharges
		CM39 Lifting	Crane and lifting operations will comply with the following: • Lifting equipment will be inspected and certified • Preventative maintenance will be carried out • Lifting operators will be competent and qualified
Loss of Containment – Hydrocarbons and Chemicals	Medium (MDO) Low (Condensate)	CM40 WOMP	The Well Operations Management Plan (WOMP) is a regulatory requirement under the Offshore Petroleum and Greenhouse Gas Storage Act 2006 and the associated Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011. It is the primary approval document for ensuring a high standard of well integrity and details the risk assessment, critical procedures and safety mechanisms to be implemented throughout the duration of the relevant petroleum activity
		CM41 MODU Safety Case	The Safety Case for the MODU is a regulatory requirement under the OPGGS Act and the associated Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011 The Safety Case identifies hazards and risks specific to drilling wells, describes how the risks are controlled and describes the safety management system in place to ensure the controls are effectively and consistently applied. Prevention of loss of well control and subsequent release of hydrocarbons is a key focus as this is the source of major accident events
		CM42 Well Engineering and Construction Management System (WECS)	Beach Well Engineering and Construction Management System (WECS) that ensures well activities are fit for purpose with operational risks managed to a level that is as low as reasonably practicable. It also ensures that changes are made in a controlled manner, that appropriate standards are adhered to, and that a sufficiently resourced and competent organisation is in place. The Beach Operations Excellence Management System consists of Well Integrity Standard and WECS.
		CM43 Workforce capability	Beach Workforce Capability Requirements Matrix to ensure Operations personnel are qualified, trained and certified as competent to operate and maintain Beach facilities
		CM44 Crisis and Emergency Management	Beach's Crisis and Emergency Management Standard requires Beach to have plans, procedures and resources in place to effectively respond to crisis and emergency situations, including hydrocarbon spills

Aspect	Residual Risk		Key Control
		CM45 Preventative maintenance	Computerised Maintenance Management System to ensure all wells and subsea infrastructure is maintained to schedule
		CM05 Petroleum safety zones	The Project will comply with OPGGS Act – Section 616 (2) petroleum safety zones, which includes establishment and maintenance of petroleum safety zones around wells, offshore structures or equipment which prohibits vessels entering without written consent
		CM06 Temporary exclusion zones	500m temporary exclusion zones will be established and maintained around drilling and installation activities
		CM46: SMPEP or SOPEP (appropriate to class)	In accordance with MARPOL Annex I and AMSA's MO 91 [Marine Pollution Prevention – oil], a SMPEP or SOPEP (according to class) is required to be developed based upon the Guidelines for the Development of Shipboard Oil Pollution Emergency Plans, adopted by IMO as Resolution MEPC.54(32) and approved by AMSA. To prepare for a spill event, the SMPEP/SOPEP details: • response equipment available to control a spill event; • review cycle to ensure that the SMPEP/SOPEP is kept up to date; and • testing requirements, including the frequency and nature of these tests. In the event of a spill, the SMPEP/SOPEP details: • reporting requirements and a list of authorities to be contacted; • activities to be undertaken to control the discharge of hydrocarbon; and • procedures for coordinating with local officials. Specifically, the SMPEP/SOPEP contains procedures to stop or reduce the flow of hydrocarbons to be considered in the event of tank rupture.
		CM47 Bunkering procedure	Bunkering procedures to manage fuel transfers that include: • Weather limits on bunkering operations • Bunkering equipment specifications and inspection • Visual observations during transfers • Emergency shutdowns
		CM48 EP, OPEP and OSMP	Accepted Environment Plans (EP) Oil Pollution Emergency Plans (OPEP) and Operational and Scientific Monitoring Plans (OSMP) in place for all relevant Project activities and oil spills responded to in accordance with the plans
		CM49 Oil spill modelling	Oil spill modelling and environmental risk assessments for the Project EPs and OPEPs will consider the full range of worst-case scenario LOWC consequences
		CM50 Source control	Source Control Emergency Response Plans in place for all drilling activities
		CM02 Notifications	The Australian Hydrographic Office will be notified of the Project activities and installed subsea infrastructure prior to commencement to facilitate the issuing of Notice to Mariners and maintain nautical charts. Relevant stakeholders are notified prior to the activity so that third party marine users are aware of vessel location and timing
		CM03: Fair Ocean Access Procedure	Beach's Fair Ocean Access Procedure was developed with input from commercial fishing industry organisations. The procedure details the process whereby a commercial fishers can claim compensation for an economic loss associated with Beach's offshore activities where impacts cannot be avoided, including in the event of an oil spill.
		CM01 Navigation safety	All vessels operating within the project area will adhere to the navigation safety requirements including: • International Regulations for Preventing Collisions at Sea 1972 • Chapter 5 of International Convention for the Safety of Life at Sea 1974 • International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978 • Navigation Act 2012 and any subsequent Marine Orders that specify standards for crew training and competency, navigation, communication, and safety measures.

ES Table 5: Environmental Performance Standards and Measurement Criteria for Unplanned Events

ES7 Environmental Management Implementation Approach

The Operations Excellence Management System (OEMS) is Beach's framework which provides the basis by which it defines, aligns, standardises and implements company processes to manage risks and ensure successful outcomes in its operations.

The OEMS defines the minimum standards, expectations and behaviours that ensure the company operates successfully in all core business processes including Health & Safety, Environmental Management, Production & Reliability, Financial & Stakeholder Management and Project Delivery). The OEMS applies to all personnel performing work within the company's jurisdiction.

The OEMS defines Beach's key elements and standards and how the proponent will deliver the OGV Project.

ES Figure 2: Operational Excellence Management System

ES8 Stakeholder Consultation

To complement the NOPSEMA assessment process for OPPs and provide stakeholders with sufficient time to consider the project, Beach will adopt a phased consultation approach for this OPP:

- Phase 1: Consultation on the Project prior to OPP public comment period
- Phase 2: Formal consultation via the OPP public comment period
- Phase 3: Ongoing consultation for development activities.

Beach will consider all feedback provided by stakeholders and, where relevant, incorporate information provided by stakeholders into the environmental management of the Project.

1. Introduction

1.1 Project Overview

The Otway Offshore Gas Victoria Project (the Project) is designed to explore and develop new gas discoveries in the offshore Otway Basin. The Project covers an area that is located approximately 20km south of the Victorian mainland and 40km west of Tasmania (King Island) at its closest points.

Beach Energy (Operations) Limited (Beach) is the proponent for the Project and also owns and operates existing production assets and infrastructure in the Otway Basin including the Thylacine-A production platform, Thylacine platform wells and subsea wells, flowlines and facilities, Geographe subsea wells flowlines and facilities, and Otway Gas Production Pipeline (OGPP) which transports gas and liquid hydrocarbons to the onshore Otway Gas Plant (OGP) (**Figure 1**).

The Project focuses on exploration, appraisal and development of existing and future gas discoveries in Beach's exploration permits, VIC/P43, VIC/P73 and T/30P located in the offshore Otway Basin.

The gas discoveries, Artisan and La Bella, are in close proximity to Beach's existing production assets. The development of Artisan and La Bella gas discoveries will involve the drilling and completion of subsea wells, and the tie-back of these wells to the existing OGPP. Recovered gas will be transported through the OGPP to the onshore OGP located onshore near Port Campbell, Victoria. The OGP supplies gas to the domestic market in south-east Australia.

The development of undrilled future prospects will involve the same subsea development concept as Artisan and La Bella and will be tied back to existing infrastructure via the OGPP or Thylacine platform.

The Project provides an opportunity to develop currently stranded gas reserves and future resources in the offshore Otway Basin through integrated subsea drilling and installation campaigns and by utilising Beach's existing offshore infrastructure.

The petroleum activities planned for the Project include exploration, appraisal and development with an initial multi-well drilling campaign commencing in 2025. Beach is part of a rig consortium which has signed an agreement with Transocean to bring a harsh environment semi-submersible rig to the offshore Otway Basin.

Installation of new subsea facilities is anticipated to commence in 2026 with the earliest achievable date for commissioning and first gas in 2026 subject to corporate, joint venture and regulatory approvals.

The subsea installation stage of the Project is the subsea tie-back of Artisan and La Bella gas discoveries, and other gas discoveries identified from the drilling campaign to the existing OGPP. Additional subsea developments from new exploration success in future drilling campaigns may also be carried out and are in the scope of this OPP.

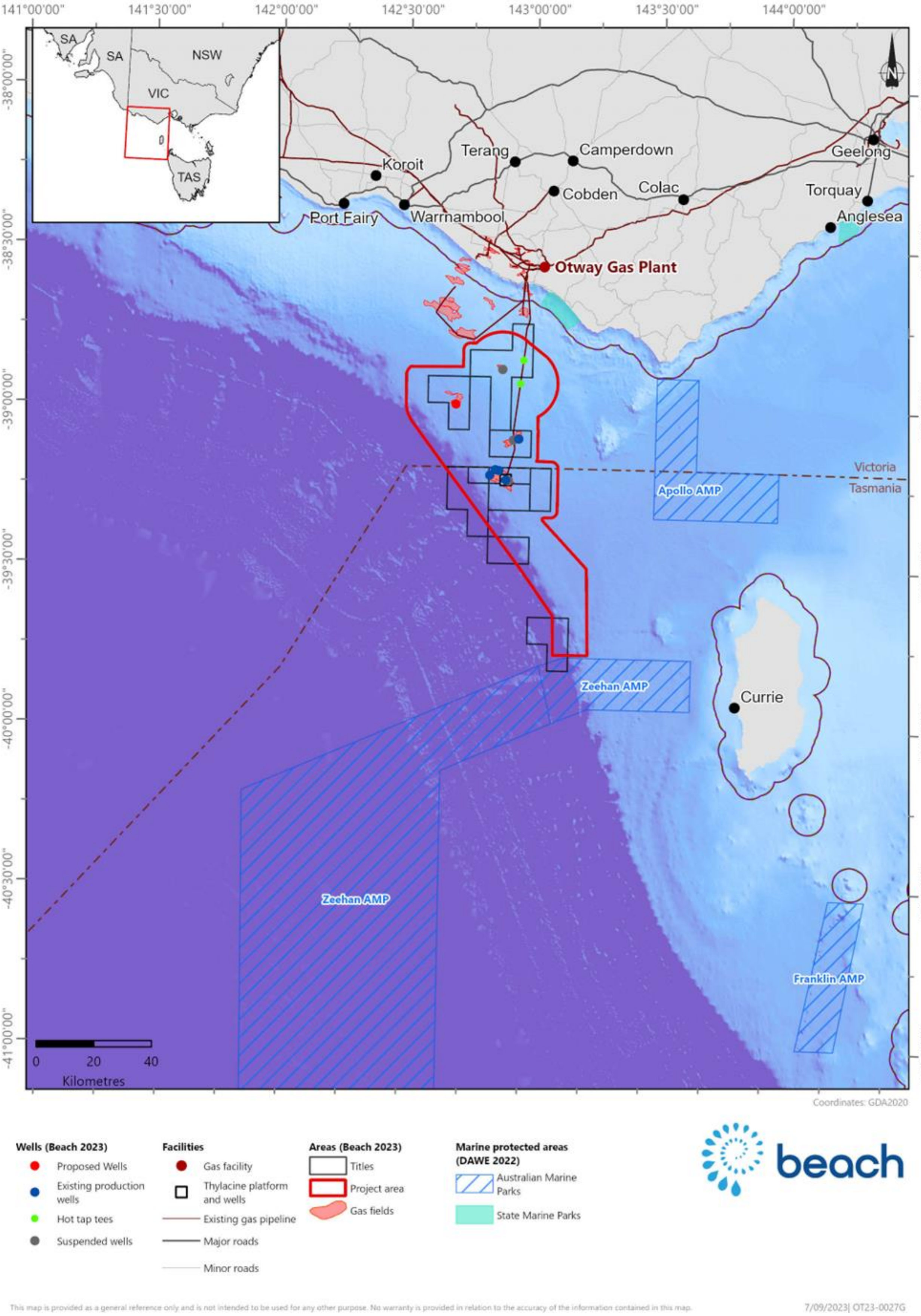


Figure 1: Project location

1.2 Proponent

The Project proponent is Beach Energy (Operations) Limited (Beach) which is a wholly owned subsidiary of Beach Energy Limited.

Beach is the operator of the Otway Joint Venture which includes Thylacine (production licences T/L2, T/L3, T/L4), Geographe (production licence VIC/L23), and exploration permits VIC/P43 and VIC/P73. The participating interests in the Otway Joint Venture are Beach, 60% interest and OGOG (Otway) Pty Ltd, 40% interest.

Beach is the sole permit holder and operator of exploration permit T/30P.

The contact details for Beach are provided in the below **Table 1**.

Details	
Business Address	Level 8 80 Flinders Street Adelaide South Australia 5000
Contact Details	Carrie Trembath Project Director T: (08) 8338 2833 F: (08) 8338 2336 E: info@beachenergy.com.au

Table 1: Proponent details

Beach Energy Limited is an ASX listed, oil and gas exploration and production company headquartered in Adelaide, South Australia. It has operated and non-operated, onshore and offshore, oil and gas production from five producing basins across Australia and New Zealand and is a key supplier to the Australian east coast gas market.

Beach Energy Limited's asset portfolio includes ownership interests in strategic oil and gas infrastructure, as well as a suite of high potential exploration prospects. Beach Energy Limited's gas exploration and production portfolio includes acreage in the Otway, Bass, Cooper/Eromanga and Perth basins in Australia, and the Taranaki Basin in New Zealand.

1.3 Project Scope

The Project provides an opportunity to develop stranded gas reserves and future resources in the Otway Basin through utilisation of the existing offshore infrastructure and creating further efficiencies through consolidated drilling and installation campaigns.

A summary of the key elements and activities for the Project is presented in **Table 2**. The development concept is consistent for all Beach's nearby gas fields in the Otway Basin and involves subsea wells, flowlines and facilities to be tied back to the existing OGPP or Thylacine platform. The scope covers multiple small fields that may be developed in the initial development and future stages.

All activities will be carried out within the Project Area defined in Section 3.5

Project Stage	Key Activities
Seabed surveys	• Geotechnical and geophysical surveys undertaken to assess the suitability of the seabed for drilling and infrastructure placement
Drilling (Exploration, Appraisal & Development)	• Initial exploration & appraisal drilling campaign of up to seven wells • Well testing (contingent) • Drilling operations will be suspended by a combination of the below: ○ Permanent plug and abandon ○ Temporary suspension with cement plug barriers • Suspension with installation of Christmas tree (with or without completion) • Completions (in success case) • Future drilling campaign(s) ○ while not currently planned, there is a possibility that future exploration, appraisal and development drilling of up to ten wells may be required for optimal gas recovery in producing fields over the life of the project.
Installation of subsea infrastructure	• Installation of subsea infrastructure to connect gas discoveries Artisan, La Bella and any successful exploration or appraisal wells from the initial drilling campaign to the OGPP including; wellheads, flowlines, umbilicals, manifolds and skids
Commissioning	• Commissioning and testing of new equipment including flowlines, • Unload of drilling and completion fluid from the well is planned through new and existing subsea infrastructure to the onshore Otway Gas Plant (OGP). Well unload and testing to the drilling rig is a contingent option.
Operations	• Production from Artisan, La Bella and future prospects is expected to have an operational life of up to 30 years with EOFL estimated as 2055. • However, subject to future investment and developments in surrounding fields, operations and infrastructure life may be extended. • Operations stage may include well intervention and inspection, maintenance and repair of wells and subsea infrastructure as required
Future tie-backs	• Future tie backs of successful exploration or appraisal wells (up to ten additional wells) comprising similar subsea infrastructure to the initial development may be undertaken in the Project Area during the life of the Project: ○ Geotechnical and Geophysical surveys ○ Installation and commissioning of subsea infrastructure to connect gas discoveries • There is the potential for future tie-ins in the vicinity of the Project Area by other operators comprising similar subsea infrastructure to the initial development. This would be part of the maximum ten additional wells identified for future drilling campaigns.
Decommissioning	• Well abandonment • Decommissioning of subsea infrastructure

Table 2: Project Summary

1.4 Project Location

The Project is located in the Otway Basin in offshore Commonwealth waters, approximately 20km south of the Victorian mainland and 40km west of Tasmania (King Island) at its closest points in water depths ranging from approximately 65m to 180m. The nearest regional centre of Geelong is located approximately 150km north-east of the Project (at closet point) (**Figure 1**).

The Project Area is described in Section 3.5.

The Project Area does not contain any emergent reefs, submerged shoals or banks, the nearest being Bravenes Rock approximately 20km to the north east and Bell Reef approximately 110km to the south east.

1.5 Project Objectives

The objectives of the proposed Project are:

- Explore, appraise and develop resources from new discoveries and prospects in the Otway Basin
- Provide for a compliant, fit for purpose, standardised approach to develop stranded gas resources in the Otway Basin
- Utilise and extend existing infrastructure in the Otway Basin

Beach has successfully undertaken petroleum activities and operated facilities in the offshore Otway and is confident that the Project can be developed and operated in an environmentally sustainable manner with environmental impacts and risks managed to an acceptable level.

1.6 OPP Purpose and Scope

The Offshore Project Proposal (OPP) has been prepared by Beach, as the proponent of the Otway Project, in accordance with the requirements of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023 (OPGGS (Environment) Regulations), and associated guidelines. the purpose of the OPP process is to allow assessment and decision-making at the whole-of project level. This, together with the assessment of environment plans, are part of the broader environmental management authorisations process for offshore petroleum activities in Commonwealth waters. These processes aim to ensure that activities in the offshore area are carried out in a manner consistent with the principles of ecologically sustainable development (ESD), and that the environmental impacts and risks of the activities will be reduced to as low as reasonably practicable and will be of an acceptable level.

The OPP is an early-stage project assessment which, subject to acceptance by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA), will form the basis for future activity-specific Environment Plans. An OPP must be accepted by NOPSEMA before the proponent can submit EPs for activities that make up the Project. This pre-requisite does not apply to exploration activities such as seismic surveys and exploratory drilling.

More information can be found on the OPP process on NOPSEMA's website.

1.6.1 Exploration and Appraisal Activities

The Project includes exploration and appraisal drilling. To cover the whole lifecycle of the Project, this OPP includes reference to the exploration and appraisal drilling campaign as set out in Section 15 of the OPGGS (Environment) Regulations whereby exploration and appraisal activities may use the arrangements set out for an OPP.

1.6.2 Out of Scope

The Project Area (defined in Section 3.5) also includes the location of existing Otway Development at Thylacine and Geographe which was approved by the Environment Minister under Part 9 of the EPBC Act (EPBC No 2002/621). While the existing Otway infrastructure is fundamental to further Otway development, it is not in scope of this OPP.

1.7 Document Structure

The structure of this OPP is detailed in **Table 3**. This is concordant with the requirements of the OPGGS (Environment) Regulations and NOPSEMA's Offshore Project Proposal Content Requirements Guidance Note (N-04790-GN-1663, 10.8.2020) and Offshore Project Proposal Assessment Policy (N-04790-PL-1650, 11.8.2020) is provided in **Table 4**.

Section		Content
1	Introduction	Development overview, location, proponent details and outlines the purpose and structure of the OPP.
2	Environmental Legislation and Other Requirements	Legislation, other regulatory requirements, relevant standards and guidelines.
3	Description of the Project and Alternatives Analysis	A description of all activities associated with the project and an analysis of alternatives
4	Description of the Environment	A description of the existing environment highlighting significant physical, ecological and socioeconomic values.
5	Environmental Impact and Risk Assessment Methodology	The methodology for identifying and evaluating environmental impacts and risks.
6	Environmental Impact Evaluation - Planned Activities	Results and justification of environmental impact assessments.
7	Environmental Risk Evaluation – Unplanned Events	Results and justification of environmental risk assessments.
8	Cumulative Impact Assessment	Provides an assessment of cumulative impacts for the Project.
9	Implementation Strategy	Details how environmental performance outcomes stated within this OPP will be implemented.
10	Stakeholder Consultation	A summary of Beach's stakeholder consultation methods which includes the process of stakeholder identification and consultation history and future consultation requirements.
11	References	A summary of documents referred to within this OPP.

Table 3: Structure of this document

OPGGS (Environment) Regulations	Requirements	Relevant Section of OPP
Section 7 Contents of Offshore Project Proposal		
7(2) (a)	The proponent's name and contact details.	Section 1
7(2) (b)	A summary of the project, including the following: • a description of each activity that is part of the project • the location or locations of each activity • a proposed timetable for carrying out the project • a description of the facilities that are proposed to be used to undertake each activity • a description of the actions proposed to be taken, following completion of the project, in relation to those facilities.	Section 3
7(2) (c)	A description of the existing environment that may be affected by the project.	Section 4
7(2) (d)	Details of the relevant values and sensitivities (if any) of that environment.	Section 4
7(2) (e)	The environmental performance outcomes for the project.	Section 6 and 7
7(2) (f)	A description of any feasible alternative to the project, or an activity that is part of the project, including: • a comparison of the environmental impacts and risks arising from the project or activity and the alternative. • an explanation, in adequate detail, of why the alternative was not preferred.	Section 3
7(3)	Requirement to address relevant values and sensitivities (as defined in the EPBC Act).	Section 2
7(4)	The proposal must describe: • the requirements, including legislative requirements, that apply to the project and are relevant to the environmental management of the project, and • how those requirements will be met.	Section 2 and 8
7(5)	The proposal must include: • details of the environmental impacts and risks of the activities that are part of the project, and • an evaluation of all the impacts and risks, appropriate to the nature and scale of each impact or risk.	Section 6 and 7

Table 4: Concordance of this document with the OPGGS (Environment) Regulations

2. Environmental Legislation and Other Requirements

The Project is located in Commonwealth waters and is governed by Commonwealth legislation and regulations for petroleum, environment, health and safety and maritime activities which are set out in the below sections.

2.1 Offshore Petroleum and Greenhouse Gas Storage Act 2006 (OPGGS Act)

The *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act) provides a legal framework for the exploration and development of petroleum in Commonwealth waters (beyond the 3 nm), including licensing, health, safety, environment and royalties. Subordinate regulations include:

- Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023 (OPGGS (Environment) Regulations)
- Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009
- Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011

The OPGGS Act establishes the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) as the independent regulator for environmental management, health and safety, and well integrity and for all offshore petroleum (and greenhouse gas storage) activities in Commonwealth waters.

2.2 Offshore Petroleum Greenhouse Gas Storage (Environment) Regulations 2023

The OPGGS (Environment) Regulations provide for the regulation of environmental management of petroleum (and greenhouse gas storage) activities in Commonwealth waters, and aim to ensure that petroleum activities in these areas are:

- Carried out in a manner that is consistent with ecologically sustainable development (ESD) and
- Consistent with the objective that environmental impacts and risks are of an acceptable level and reduced to ALARP

The OPGGS (Environment) Regulations also set out the requirements for an OPP and Environment Plans (EP) as described in the below sections.

2.2.1 Offshore Project Proposal Requirements

The OPGGS (Environment) Regulations defines an offshore project as one or more activities that are undertaken for the purpose of the recovery of petroleum, other than on an appraisal basis, including any conveyance of recovered petroleum by pipeline.

The OPGGS (Environment) Regulations (Section 6(1)) requires that "before commencing an offshore project, a person must submit an offshore project proposal for the project NOPSEMA". However, Section 6(2) states that Subsection 6(1) does not apply if the Environment Minister:

- has made a decision under section 75 of the EPBC Act that an action that is equivalent to or includes the project is not a controlled action; or
- has made a component decision under section 77A of the EPBC Act that a particular provision of Part 3 of that Act is not a controlling provision for an action that is equivalent to or includes the

project, because the Environment Minister believes the action will be taken in a particular manner; or

- has approved, under Part 9 of the EPBC Act, the taking of an action that is equivalent to or includes the project.

Woodside Petroleum Ltd, as the original operator of the Otway Development, submitted an Environmental Impact Statement (EIS) under the EPBC Act for the Otway Development (2002/621) which was approved by the Environment Minister in 2004. In March 2010, Origin Energy Resources Ltd (Origin) commenced operatorship of the development (later changing its name to Lattice Energy Limited (Lattice)). In February 2018, Beach acquired Lattice, which included the Otway Development. The EIS covered development activities at the Geographe and Thylacine fields which make up the existing Otway Development. As these development activities have been approved under Part 9 of the EPBC Act they are not required to be covered by this OPP. As the EIS did not cover development activities at the Artisan and La Bella fields or other fields within the defined Project Area, these constitute this OPP.

2.2.2 Environment Plans

The OPGGS (Environment) Regulations require a titleholder to have an accepted Environment Plan (EP) in place for a petroleum or greenhouse gas activity. EPs for activities that form part of the OPP can only be submitted to NOPSEMA once the OPP has been accepted.

The exploration and appraisal activities, specifically the initial and future drilling campaigns, are included in this OPP under sub-regulation 5F of the OPGGS (Environment) Regulations that allows exploration and appraisal activities to use the OPP process. In including the exploration and appraisal activities in the OPP, the proponent notes that acceptance of an OPP prior to submission of a related EP does not apply to exploration activities. The proponent plans to submit an Environment Plan for the initial drilling campaign in January 2024.

Under the OPGGS (Environment) Regulations, an EP must be appropriate for the nature and scale of the activity and describe the activity, the existing environment, details of environmental impacts and risks and the control measures for the activity. In addition, the EP must include an implementation strategy to demonstrate that the impacts and risks can be managed to as low as reasonably practicable (ALARP) and an acceptable level and to describe how appropriate environmental performance outcomes, standards and measurement criteria detailed in the EP will be met. The EP must also provide a summary of all consultation undertaken with relevant persons. The EPs required in support of the Project will address activities related to:

- drilling and completion of development wells for production
- installation, commissioning and operation of wells and subsea infrastructure
- decommissioning activities at the end of the Project resource life

2.2.3 Other Petroleum Activity Approvals

In addition to environmental approvals, the OPGGS (Safety) Regulations 2009 require that a Safety Case and a Well Operations Management Plan as required by the OPGGS (Resource Management and Administration) Regulations 2011, are assessed and accepted by NOPSEMA for petroleum facilities, along with any relevant licences to support pipelines, infrastructure and production. Beach will prepare and submit the required permit applications, Safety Cases and Well Operations Management Plans to NOPSEMA as the Project is progressed.

2.3 Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The EPBC Act is the Commonwealth Government's primary environmental legislation. This provides a legal framework to protect and manage important flora, fauna, ecological communities and heritage places defined in the EPBC Act as Matters of National Environmental Significance (MNES). Under the EPBC Act, any action that is likely to have a significant impact on the MNES must not be undertaken without the approval of the Minister. Actions with the potential to impact on the MNES trigger the Commonwealth environmental assessment and approval process.

Assessment under the EPBC Act, administered by the Department of Climate Change, Energy, the Environment and Water (DCCEEW)) (formerly the Department of Agriculture, Water and Environment, DAWE) includes an assessment of the impacts of a proposal on MNES listed under Part 3 of the EPBC Act. However, in 2014, NOPSEMA became the sole Commonwealth regulator for environmental management of offshore petroleum activities following streamlining of regulatory processes under the OPGGS Act (Section 2.1) and the EPBC Act. The effect of streamlining is that offshore petroleum activities are no longer required to be subject to separate authorisation processes under the OPGGS Act and the EPBC Act.

These changes took effect following the approval granted on the 27 February 2014 by the Minister for the Environment under section 146B of the EPBC Act, for the taking of actions in accordance with an endorsed "Program" under the EPBC Act.

The 'Program' is described in "Program Report – Strategic Assessment of the environmental management authorisation process for petroleum and greenhouse gas storage activities administered by the National Offshore Petroleum Safety and Environmental Management Authority under the Offshore Petroleum and Greenhouse Gas Storage Act 2016". The Program, which was endorsed by the Minister for the Environment under section 146 of the EPBC Act on 7 February 2014, outlined the environmental management authorisation process for offshore petroleum and greenhouse gas activities administered by NOPSEMA. The objective of this Program Report was to demonstrate how the Program will ensure activities are conducted in a manner consistent with the principles of ecologically sustainable development and will not result in unacceptable impacts to matters protected under Part 3 of the EPBC Act. Specifically, the report outlined the commitments and undertakings of NOPSEMA to ensure adequate protection of Part 3 protected matters.

The endorsement of the Program, and the final approval decision had the effect that certain actions can be undertaken in accordance with the endorsed program without further approval under the EPBC Act. This includes referral of a proposal, or further assessment under the EPBC Act. The class of actions covered by this approval are petroleum and greenhouse gas activities taken in Commonwealth waters and in accordance with the endorsed Program.

The approved class of actions excludes actions which are petroleum and greenhouse gas activities that:

- have, will have or are likely to have a significant impact on the environment on Commonwealth land
- are taken in any area of sea or seabed that is declared to be a part of the Great Barrier Reef Marine park under the Great Barrier Reef Marine Park Act 1975 (Cth)
- have, will have or are likely to have a significant impact on the work heritage values of the Great Barrier Reef National Heritage place
- are taken in the Antarctic
- are injection and/or storage of greenhouse gas

Additionally, actions taken in state or territory waters are also noted to not be covered by the approved class of actions. The scope of this OPP does not include any of the excluded actions.

To allow for streamlining to occur, several changes to the OPGGS (Environment) Regulations administered by NOPSEMA were made. This included introducing the OPP authorisation process to allow for public comment on offshore petroleum developments early in the project lifecycle. The OPP process reflects the level of transparency and opportunity for public comment that is provided for as part of the 'Environmental Impact Statement/Public Environmental Review' assessment process under the EPBC Act.

Unlike the EPBC Act assessment process previously applicable to offshore petroleum activities, the OPP assessment process applies to all offshore petroleum activities regardless of the potential level of impact or risk to the environment that the proposal may present.

2.3.1 Listed Threatened Species Management / Recovery Plans and Conservation Advice

Under Part 13 of the EPBC Act, species can be listed as one, or a combination, of the following protection designations:

- Threatened (further divided into categories; extinct, extinct in the wild, critically endangered, endangered
- vulnerable, conservation dependent)
- Migratory
- Whale and other cetaceans
- Marine

Threatened species are managed through management plans, recovery plans and / or conservation advice. These plans provide advice on relevant impacts and threats and set requirements for management and protection.

Species management plans, recovery plans and conservation advice have been considered during the development of this OPP to identify the appropriate management of the Project activities. These have been considered in the assessment of impacts and risks, the assessment of acceptability, and the development of EPOs. Table 5 outlines the management plans, recovery plans and conservation advice and associated key threats and conservation actions relevant to the Project. Threatened species of state and local significance relevant to the Project are also considered and are included in appropriate State management or recovery plans.

In addition to species specific management plans, recovery plans and conservation advice, the following plans have also been taken into consideration:

- The Action Plan for Australian Cetaceans (Bannister et al., 1996)
- National Recovery Plan for Ten Species of Seabirds (DEH, 2005a)
- King Island Biodiversity Management Plan (DPIPWE, 2012)

Beach is aware that a recovery plan for the Australian Fur Seal is currently being drafted by the Commonwealth Government; although not currently available, this plan will be assessed for relevance when made publicly available.

Relevant Plan/Advice	Description	Applicable Threats and Conservation Actions
Threat abatement plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans (CoA, 2018a)	Threat abatement plan for the impacts of marine debris on vertebrate marine life	*Marine debris* Evaluate risk of marine debris (including risk of entanglement and/or ingestion) and, if required, appropriate mitigation measures are implemented.
The National Strategic Plan for Marine Pest Biosecurity (2018-2023) (DAWR, 2018)	Australia's national strategic plan for marine pest biosecurity.	There are five objectives in the plan: 1. Minimise the risk of marine pest introductions, establishment and spread 2. Strengthen the national marine pest surveillance system 3. Australia's preparedness and response capability for marine pest introductions 4. Support marine pest biosecurity research and development 5. Engage stakeholders to better manage marine pest biosecurity.
National Light Pollution Guideline for Wildlife including Marine Turtles, Seabirds and Migratory Shorebirds (CoA, 2020)	Guideline to raise awareness of the potential impacts of artificial light on wildlife and provide a framework for assessment and managing these impacts around susceptible listed wildlife.	*Light Emissions* Evaluate risk of artificial light on wildlife and, if required, appropriate mitigation measures are implemented.
National Recovery Plan for Albatrosses and Petrels 2022 (CoA, 2022)	The recovery plan is a co-ordinated conservation strategy for albatrosses and giant petrels listed as threatened.	*Marine pollution* Evaluate risk of oil spill impact to nest locations and, if required, appropriate mitigation measures are implemented. *Marine debris* Evaluate risk of marine debris (including risk of entanglement and/or ingestion) and, if required, appropriate mitigation measures are implemented. *Climate change* Appropriate monitoring strategies are implemented to fill information gaps; and Mitigation actions are identified and adopted where feasible and appropriate.
Approved Conservation Advice for *Pterodroma mollis* (soft-plumaged petrel) (TSSC, 2015a)	Conservation advice provides management actions that can be undertaken to ensure the conservation of the soft-plumaged petrel.	None identified.
Approved Conservation Advice for *Sternula nereis* nereis (Australian Fairy Tern) (TSSC, 2011a)	Conservation advice provides management actions that can be undertaken to ensure the conservation of the fairy tern.	*Marine pollution* Ensure appropriate oil-spill contingency plans are in place for the subspecies' breeding sites which are vulnerable to oil spills, such as the breeding colonies in Victoria

Relevant Plan/Advice	**Description**	**Applicable Threats and Conservation Actions**
Draft National Recovery Plan for the Australian Fairy Tern (*Sternula nereis nereis*) (CoA, 2019)	Draft recovery plan for actions so species no longer qualifies for listing as threatened under any of the EPBC Act listing criteria.	*Habitat degradation and loss of breeding habitat / Pollution* No explicit relevant management actions
Conservation Advice for *Numenius madagascariensis* (Eastern Curlew) (DoE, 2015a)	Conservation advice provides management actions that can be undertaken to ensure the conservation of the eastern curlew.	*Habitat degradation/ loss (oil pollution)* No explicit relevant management actions
Conservation Advice *Limosa lapponica menzbieri* (Bartailed Godwit (Northern Siberian)) (TSSC, 2016a)	Conservation advice provides management actions that can be undertaken to ensure the conservation of the bartailed godwit (Northern Siberian).	*Habitat degradation/ loss (oil pollution)* No explicit relevant management actions
Conservation Advice *Limosa lapponica baueri* (Bar-tailed Godwit (Western Alaskan)) (TSSC, 2016b)	Conservation advice provides management actions that can be undertaken to ensure the conservation of the bar-tailed godwit (Western Alaskan).	*Habitat degradation/ loss* No explicit relevant management actions
Approved Conservation Advice for *Pachyptila subantarctica* (Fairy prion (Southern)) (TSSC, 2015b)	Conservation advice provides management actions that can be undertaken to ensure the conservation of the Fairy Prion (Southern).	None identified.
Approved Conservation Advice for *Rostratula australis* (Australian Painted Snipe) (DSEWPaC, 2013a)	Conservation advice provides management actions that can be undertaken to ensure the conservation of the Australian Painted Snipe.	None identified.
Conservation Advice for *Charadrius leschenaultia* (Greater Sand Plover) (TSSC, 2016c)	Conservation advice provides management actions that can be undertaken to ensure the conservation of the Greater Sand Plover.	*Habitat degradation/ loss (oil pollution)* No explicit relevant management actions
Conservation Advice *Calidris ferruginea* (Curlew Sandpiper) (TSSC, 2015c)	Conservation advice provides management actions that can be undertaken to ensure the conservation of the Curlew Sandpiper.	*Habitat degradation/ loss (oil pollution)* No explicit relevant management actions
Approved Conservation Advice for *Calidris canutus* (Red Knot) (TSSC, 2016d)	Conservation advice provides management actions that can be undertaken to ensure the conservation of the Red Knot.	*Habitat degradation/ loss* No explicit relevant management actions; oil pollutions recognised as a threat. *Climate change* No explicit relevant management actions

Relevant Plan/Advice	**Description**	**Applicable Threats and Conservation Actions**
Approved Conservation Advice for *Botaurus poiciloptilus* (Australasian Bittern) (TSSC, 2019)	Conservation advice provides management actions that can be undertaken to ensure the conservation of the Australasian Bittern.	None identified.
National Recovery Plan for Gould's Petrel (*Pterodroma leucoptera leucoptera*) (DEC NSW, 2006)	The recovery plan provides management actions that can be undertaken to ensure the conservation of the Gould's Petrel.	None identified.
National Recovery Plan for the Orange-bellied Parrot (*Neophema chrysogaster*) (DELWP, 2016)	The recovery plan is a co-ordinated conservation strategy for the orange-bellied parrot.	*Barriers to migration and movement* Illuminated boats and structures: Evaluate risk of lighting on vessels and offshore structures. *Climate change* Minimise the impacts of climate change by reducing greenhouse gas concentrations
National Recovery Plan for the Swift parrot (*Lathamus discolor*) (Saunders and Tzaros, 2011)	The recovery plan is a co-ordinated conservation strategy for the Swift parrot.	*Climate change* No explicit relevant management actions
Approved Conservation Advice for the Blue Petrel (*Halobaena caerulea*) (TSSC, 2015d)	Conservation advice provides management actions that can be undertaken to ensure the conservation of the Blue petrel	None identified.
Wildlife Conservation Plan for Migratory Shorebirds – 2015 (CoA, 2015a)	The long-term recovery plan objective for migratory shorebirds is to minimise anthropogenic threats to allow for the conservation status of these bird species.	*Habitat modification (chronic and acute pollution)* No explicit relevant management actions *Anthropogenic disturbance (artificial lighting, aircraft over-flights)* No explicit relevant management actions
National Recovery Plan for the Australian Grayling (*Prototroctes maraena*) (Backhouse et al., 2008)	The recovery plan is a co-ordinated conservation strategy for the Australian grayling.	None identified.
Recovery Plan for the White Shark (*Carcharodon carcharias*) (DSEWPaC, 2013b)	The recovery plan is a co-ordinated conservation strategy for the White shark.	None identified.
Approved Conservation Advice for the Whale Shark (*Rhincodon typus*) (TSSC, 2015e)	Conservation advice provides management actions that can be undertaken to ensure the conservation of the Whale shark	*Vessel disturbance* Minimise offshore developments and transit time of large vessels in areas close to marine features likely to correlate with whale shark aggregations (Ningaloo Reef, Christmas Island and the Coral Sea)
Recovery Plan for Marine Turtles in Australia, 2017-2027 (CoA, 2017)	The long-term recovery plan objective for marine turtles is to minimise anthropogenic threats to allow for the	*Climate change and variability* No specific management actions in relation to climate prescribed in the plan relevant to industry.

Relevant Plan/Advice	Description	Applicable Threats and Conservation Actions
	conservation status of marine turtles	*Marine debris* Support the implementation of the EPBC Act Threat Abatement Plan for the impacts of marine debris on vertebrate marine life *Chemical and terrestrial discharge* Ensure spill risk strategies and response programs adequately include management for marine turtles and their habitats, particularly in reference to 'slow to recover habitats', e.g. nesting habitat, seagrass meadows or coral reefs *Light pollution* Artificial light within or adjacent to habitat critical to the survival of marine turtles will be managed such that marine turtles are not displaced from these habitats; Identify the cumulative impact on turtles from multiple sources of onshore and offshore light pollution. *Habitat modification* No explicit relevant management actions *Vessel disturbance* No explicit relevant management actions *Noise interference* No explicit relevant management actions
Approved Conservation Advice for *Dermochelys coriacea* (Leatherback Turtle) (DEWHA, 2008)	See above for Recovery Plan for Marine Turtles in Australia, 2017-2027.	
Conservation Management Plan for the Blue Whale, 2015-2025 (CoA, 2015b)	The long-term recovery plan objective for blue whales is to minimise anthropogenic threats to allow for their conservation status to improve	*Noise interference* Assess and address anthropogenic noise. Anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilise the area without injury, and is not displaced from a foraging area. *Vessel disturbance* Ensure all vessel strike incidents are reported in the National Ship Strike Database. Ensure the risk of vessel strikes on blue whales is considered when assessing actions that increase vessel traffic in areas where blue whales occur and, if required, appropriate mitigation measures are implemented. *Habitat degradation* (Includes Acute and chronic chemical discharge (Marine pollution)). Maintain and improve existing legal and management protection.

Relevant Plan/Advice	**Description**	**Applicable Threats and Conservation Actions**
		Climate variability and change Continue to meet Australia's international commitments to reduce greenhouse gas emissions and regulate the krill fishery in Antarctica.
Approved Conservation Advice for *Balaenoptera borealis* (Sei Whale) (TSSC, 2015f)	Conservation advice provides threat abatement activities that can be undertaken to ensure the conservation of the sei whale.	*Noise interference* Evaluate risk of noise impacts to cetaceans and, if required, appropriate mitigation measures are implemented. *Vessel disturbance* Minimise vessel collision. Ensure all vessel strike incidents are reported in the National Vessel Strike Database. *Climate variability and change* Continue to meet Australia's international commitments to reduce greenhouse gas emissions and regulate the krill fishery in Antarctica. *Pollution (persistent toxic pollutants)* No explicit relevant management actions; pollution identified as a threat.
Approved Conservation Advice for *Megaptera novaeangliae* (Humpback Whale) (TSSC, 2015g)	Conservation advice provides threat abatement activities that can be undertaken to ensure the conservation of the humpback whale.	*Noise interference* Assess and address anthropogenic noise. *Vessel disturbance* Ensure the risk of vessel strike on humpback whales is considered when assessing actions that increase vessel traffic in areas where humpback whales occur and, if required appropriate mitigation measures are implemented to reduce the risk of vessel strike. Maximise the likelihood that all vessel strike incidents are reported in the National Ship Strike Database. Climate variability and change Continue to meet Australia's international commitments to reduce greenhouse gas emissions and regulate the krill fishery in Antarctica.
Conservation Management Plan for the Southern Right Whale 2011-2021 (DSEWPaC, 2012a) *Draft National Recovery Plan for the Southern Right Whale is proposed to be made under the EPBC Act.	Conservation Management Plan provides threat abatement activities that can be undertaken to ensure the conservation of the Southern right whale.	*Noise interference* Improve the understanding of what impact anthropogenic noise may have on southern right whale populations by: • assessing anthropogenic noise in key calving areas • assessing responses of southern right whales to anthropogenic noise

Relevant Plan/Advice	Description	Applicable Threats and Conservation Actions
		- if necessary, developing further mitigation measures for noise impacts. *Vessel disturbance* Minimise vessel collision *Climate variability and change* Continue to meet Australia's international commitments to reduce greenhouse gas emissions and regulate the krill fishery in Antarctica.
Approved Conservation Advice for *Balaenoptera physalus* (Fin Whale) (TSSC, 2015h)	Conservation advice provides threat abatement activities that can be undertaken to ensure the conservation of the fin whale.	*Noise interference* Evaluate risk of noise impacts to cetaceans and, if required, appropriate mitigation measures are implemented. *Vessel disturbance* Minimise vessel collision. Ensure all vessel strike incidents are reported in the National Vessel Strike Database. *Climate variability and change* Continue to meet Australia's international commitments to reduce greenhouse gas emissions and regulate the krill fishery in Antarctica. *Pollution (persistent toxic pollutants)* No explicit relevant management actions; pollution identified as a threat.
Conservation Listing Advice for the *Neophoca cinerea* (Australian sea lion) (TSSC, 2010)	Conservation advice provides management actions that can be undertaken to ensure the conservation of the Australian sea lion	*Marine debris* No explicit relevant management actions *Disturbance* No explicit relevant management actions *Displacement* No explicit relevant management actions *Habitat degradation* No explicit relevant management actions *Pollution (oil spills, toxins)* No explicit relevant management actions *Climate change* No explicit relevant management actions

Relevant Plan/Advice	Description	Applicable Threats and Conservation Actions
Recovery Plan for the Australian sea-lion (*Neophoca cinerea*) (DSEWPaC, 2013c)	The plan considers the conservation requirements of the species across its range and identifies the actions to be taken to ensure its long-term viability in nature and the parties that will undertake those actions.	*Habitat degradation* No explicit relevant management actions *Vessel strike* Collect data on direct killings and confirmed vessel strikes *Pollution (oil spills, toxins)* implement jurisdictional oil spill response strategies as required *Climate change* No explicit relevant management actions

Table 5: Summary of EPBC Management / Recovery Plans and Conservation Advice relevant to the Project

2.3.2 Biologically Important Areas

Biologically important areas (BIAs) are spatially defined areas where aggregations of individuals of a species are known to display biologically important behaviour such as breeding, foraging, resting or migration. They are a new data construct designed to assist decision-making under the EPBC Act.

BIAs have been identified using expert scientific knowledge about species' distribution, abundance and behaviour in the region. The presence of the observed behaviour is assumed to indicate that the habitat required for the behaviour is also present. The selection of species for which biologically important areas have been identified was informed by the availability of scientific information, the conservation status of listed species and the importance of the region for the species.

The level of certainty attached to a biologically important area has two dimensions:

- the certainty of the species' occurrence
- the certainty of the behaviour occurring

There are two classes of presence: known to occur and likely to occur. The strongest certainty in a BIA would be one where it is known that the species occurs in a particular area, and it is known that the species displays a specific behaviour. A lesser certainty would be one in which the species is likely to occur in the area and is likely to display the behaviour.

Known biologically important area is an area where the species is known to occur and includes areas where there have been confirmed sightings or robust records of the species exhibiting a biologically important behaviour in that area (i.e., sourced from observations or satellite tracking etc).

Likely biologically important area is an area where the species is likely to exhibit a biologically important behaviour in that area. Likely biologically important areas have been identified on the basis of extrapolations made by scientists:

- about suitable habitat that may support a biologically important behaviour
- there is some evidence that the species is likely to be present in the area (e.g. strandings of dead animals on adjacent coastal areas or from fishing records, past observations)

BIAs that overlap the Project Area are listed in Table 6.

Receptor	Type of BIA
Birds	
Antipodean albatross	Foraging
Black-browed albatross	Foraging
Buller's albatross	Foraging
Campbell albatross	Foraging
Common diving petrel	Foraging
Indian yellow-nosed albatross	Foraging
Short-tailed shearwater	Foraging
Shy albatross	Foraging
Wandering albatross	Foraging
Wedge-tailed shearwater	Foraging
Fish	
White shark	Distribution
Cetacean	
Pygmy blue whale	Foraging – likely; annual high use area, known foraging area Distribution
Southern right whale	Migration

Table 6: Biologically important areas overlapping with the Project Area.

2.3.3 Australian Marine Parks Management Principles

Under the EPBC Act, Australian Marine Parks (AMPs) are recognised for the purpose of conserving marine habitats and species that live and rely on these habitats. AMPs which are relevant to the Project are summarised in **Table 7** and described in detail in Section 4.2.2. These AMPs are managed as per the South-East Commonwealth Marine Reserves Network Management Plan 2013 – 2023 (DNP, 2013).

Project activities are not within an AMP.

AMP Name	Approximate Distance from Project Area	IUCN Protected Area Category
Zeehan	1 km	VII - Special Purpose Zone
Apollo	35 km	VI – Multiple Use Zone
Franklin	110 km	VI – Multiple Use Zone
Boags	150 km	VI – Multiple Use Zone
Nelson	160 km	VII - Special Purpose Zone
Beagle	280 km	VI – Multiple Use Zone
Tasman Fracture	350 km	II - Marine National Park Zone; VI - Multiple Use Zone
Huon	370 km	VI – Multiple Use Zone; IV – Habitat Protection Zone

Table 7: Australian Marine Parks that occur near the project area

2.3.4 Other Protected Area Management Plans

The following protected area management plans have been considered during the preparation of this OPP to identify the appropriate management of the activities; in particular these have been considered in the assessment of impacts and risks, the assessment of acceptability, and the development of EPOs:

- South-east Commonwealth Marine Reserves Network Management Plan 2013-2023 (Director of National Parks, 2013)
- Parks Victoria Marine Protected Areas Program Plan 2012-2014 (Parks Victoria, 2012)
- Management Plan for Twelve Apostles Marine National Park and The Arches Marine Sanctuary (Parks Victoria, 2006d)
- Management Plan for Point Addis Marine National Park, Point Danger Marine Sanctuary and Eagle Rock Marine Sanctuary (Parks Victoria, 2005b)
- Barwon Bluff Marine Sanctuary Management Plan (Parks Victoria, 2007b)
- Bunurong Marine National Park Management Plan (Parks Victoria, 2006b)
- Cape Liptrap Coastal Park Management Plan (Parks Victoria, 2003)
- Corner Inlet Ramsar site Ecological Character Description (BMT WBM, 2011 on behalf of DSEWPaC)
- Corner Inlet Ramsar Site Strategic Management Plan (Parks Victoria, 2002a)
- Corner Inlet Marine National Park Management Plan (Parks Victoria, 2005a)
- Corner Inlet Ramsar Site Management Plan (WGCMA, 2014)
- Great Otway National Park and Otway Forest Park Management Plan (Parks Victoria and DSE, 2009)
- Kent Group National Park Management Plan 2005 (Parks and Wildlife Service, 2005)
- Lavinia Ramsar Site Ecological Character Description. Lloyd Environmental (DSEWPaC, 2012b)
- Marengo Reefs Marine Sanctuary Management Plan (Parks Victoria, 2007a)
- Merri Marine Sanctuary Management Plan (Parks Victoria, 2007c)
- Mornington Peninsula National Park and Arthurs Seat State Park Management Plan (Parks Victoria, 2013)
- Mushroom Reef Marine Sanctuary Management Plan (Parks Victoria, 2005c)
- Ngootyoong Gunditj Ngootyoong Mara South West Management Plan (Parks Victoria, 2015)
- Port Phillip Heads Marine National Park Management Plan (Parks Victoria, 2006c)
- Port Campbell National Park and Bay of Islands Coastal Park (Parks Victoria, 1998)
- Port Phillip Bay (Western Shoreline) & Bellarine Peninsula Ramsar Site Strategic Management Plan (DSE, 2003)
- Small Bass Strait Island Reserves Draft Management Plan October 2000 (TPAWS, 2000)

- Tasmanian Marine Protected Areas Strategy (Department of Primary Industries, Water and Environment, 2000).
- Western Port Ramsar Site Management Plan (DELWP, 2017a)
- Western Port Ramsar Wetland Ecological Character Description. (Kellogg et al. 2010 for DSEWPaC)
- Wilsons Promontory National Park Management Plan (Parks Victoria, 2002b)
- Wilsons Promontory Marine National Park and Wilsons Promontory Marine Park Management Plan May 2006 (Parks Victoria, 2006a)

2.4 Other Relevant Commonwealth Legislation

Other Commonwealth legislation that may be applicable to the environmental management of the Project is outlined in Table 8.

2.5 Commonwealth Policies and Guidelines

The Commonwealth Government policies and guidelines and international conventions that are relevant to the Project are summarised in Table 9. Of particular relevance to this proposal, specific consideration is given to the:

- Matters of National Environmental Significance - Significant Impact Guidelines 1.1 published by the DoEE (DoE 2013a). These have been used to inform the definition of acceptability of impacts, and are described in further detail in Section 5.8.5, and carried into the subsequent evaluation of impacts and risks in Section 6 and 7.
- EPBC Act Policy Statement 'Indirect consequences' of an action: Section 527E of the EPBC Act (Department of Sustainability, Environment, Water, Population and Communities ((DSEWPaC) 2013a). This has been consideration in the specific context of indirect consequences of a proposal with regard to GHG emissions.

2.6 State Legislation

Although offshore petroleum activities within the scope of this OPP are located entirely in Commonwealth waters, Victorian and Tasmanian legislation relevant to offshore petroleum activities are described in Table 10 and Table 11 on the basis that modelling indicates a worst-case credible oil spill (Section 7.4) has the potential to intersect Victorian or Tasmanian waters.

2.7 International Agreements

Relevant international agreements and conventions that Australia is signatory to are summarised in Table 12. These are typically implemented by Commonwealth legislation.

Legislation/Regulation	Scope	Related International Conventions	Administering Authority
Air Navigation Act 1920 Air Navigation Regulations 1947 Air Navigation (Aerodrome Flight Corridors) Regulations 1994 Air Navigation (Aircraft Engine Emissions) Regulations 1995 Air Navigation (Aircraft Noise) Regulations 1984 Air Navigation (Fuel Spillage) Regulations 1999	This Act and associated regulations relate to the management of air navigation. **Relevance to Project**: Applies to helicopter activities undertaken during all stages. The requirements under this Act are related to safety, and therefore not relevant to the environmental management of the Project.	Chicago Convention 1947	Department of Infrastructure, Transport, Regional Development, Communications and the Arts
Australian Maritime Safety Authority Act 1990	This Act facilitates international cooperation and mutual assistance in preparing and responding to a major oil spill incident and encourages countries to develop and maintain an adequate capability to deal with oil pollution emergencies. Requirements are affected through Australian Maritime Safety Authority (AMSA) who administers the National Plan for Maritime Environmental Emergencies (NatPlan). **Relevance to Project** AMSA is the designated Control Agency for oil spills from vessels in Commonwealth waters. These arrangements will be detailed in the OPEP associated with the relevant EPs for petroleum activities.	International Convention on Oil Pollution Preparedness, Response and Cooperation 1990 Protocol on Preparedness, Response and Co-operation to Pollution Incidents by Hazardous and Noxious Substances, 2000 International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties 1969 Articles 198 and 221 of the United Nations Convention on the Law of the Sea 1982	AMSA
Biosecurity Act 2015 Biosecurity Regulations 2016 Biosecurity Amendment (Biofouling Management) Regulations 2021	This Act and associated regulations replaced the Quarantine Act 1908 in 2015 and is the primary legislation for the management of the risk of diseases and pests that may cause harm to human, animal or plant health, the environment and the economy. The objects of this Act are to provide for: (a) managing biosecurity risks; human disease; risks related to ballast water; biosecurity emergencies and human biosecurity emergencies	International Convention for the Control and Management of Ships' Ballast Water and Sediments (adopted in principle in 2004 and in force on 8 September 2017)	Department of Agriculture, Fisheries and Forestry (DAFF)

Legislation/Regulation	Scope	Related International Conventions	Administering Authority
	(b) to give effect to Australia's international rights and obligations, including under the International Health Regulations, the Sanitary and Phytosanitary Agreement and the Biodiversity Convention **Relevance to Project**: The Biosecurity Act and regulations apply to 'Australian territory' which is the airspace over and the coastal seas out to 12nm from the coastline. The Act regulates vessels entering Australian territory regarding ballast water and hull fouling. Biosecurity risks associated with the activity are detailed in Section 6.2.1.		
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	This Act applies to actions that have, will have or are likely to have a significant impact on matters of national environmental or cultural significance. The Act protects matters of national environmental significance (MNES) and provides for a Commonwealth environmental assessment and approval process for actions. There are eight MNES, these being: • World heritage properties • Ramsar wetlands • Listed threatened species and communities • Listed migratory species • Protection of the environment from nuclear actions • Marine environment (Commonwealth) • Great Barrier Reef Marine Park • Protection of water resources from coal seam gas developments and large coal mining developments **Relevance to Project**: Petroleum activities are excluded from within the boundaries of a World Heritage Area (Sub regulation 10A(f)). The project is not within a World Heritage Area. The OPP must describe matters protected under Part 3 of the EPBC Act and assess any impacts and risks to these.	1992 Convention on Biological Diversity and 1992 Agenda 21 Convention on International Trade in Endangered Species of Wild Fauna and Flora 1973 Agreement between the Government and Australia and the Government of Japan for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment 1974 Agreement between the Government and Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment 1986 Agreement between the Government of Australia and the Government of the Republic of Korea on The Protection of Migratory Birds 2006 Convention on Wetlands of International Importance especially as Waterfowl Habitat 1971 (Ramsar)	DCCEEW

Legislation/Regulation	Scope	Related International Conventions	Administering Authority
	The OPP must assess any actual or potential impacts or risks to MNES from the activity. Section 6 provides an assessment of the impacts and risks from the activity to matters protected under Part 3 of the EPBC Act.	International Convention for the Regulation of Whaling 1946 Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) 1979	
Environment Protection (Sea Dumping) Act 1981 Environment Protection (Sea Dumping) Regulations 1983	This Act and associated regulations provide for the protection of the environment by regulating dumping matter into the sea, incineration of waste at sea and placement of artificial reefs. **Relevance to Project**: Sea dumping permits will be in place where required. Sea dumping activities will be undertaken in accordance with the Act and under permit as required.	London Protocol	DCCEEW
National Environment Protection Measures (Implementation) Act 1998 National Environment Protection Measures (Implementation) Regulations 1999	This Act and associated regulations provide for the implementation of National Environment Protection Measures (NEPMs) to protect, restore and enhance the quality of the environment in Australia and ensure that the community has access to relevant and meaningful information about pollution. The National Environment Protection Council has made NEPMs relating to ambient air quality, the movement of controlled waste between states and territories, the national pollutant inventory, and used packaging materials. **Relevance to Project**: Activities associated with the project will meet any relevant requirements of the Act including energy and greenhouse gas reporting.	-	DCCEEW
National Greenhouse and Energy Reporting Act 2007 (NGER Act)	The Act provides for the reporting and dissemination of information related to greenhouse gas emissions (GHG), greenhouse gas projects, energy production and energy consumption, and for other purposes. **Relevance to Project**: GHG emissions and energy use from offshore facilities, vessels and MODU will be reported in accordance with the requirements of the NGER Act. Applicable requirements are specified as controls to relevant impacts and risks.	-	Clean Energy Regulator

Legislation/Regulation	Scope	Related International Conventions	Administering Authority
Navigation Act 2012	This Act regulates ship-related activities and invokes certain requirements of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) relating to equipment and construction of ships. Several Marine Orders (MO) are enacted under this Act relating to offshore petroleum activities, including: • MO 27: Safety of navigation and radio equipment • MO 30: Prevention of collisions • MO 31: Safety of Life at Sea (SOLAS) and non-SOLAS certification **Relevance to Project**: Vessels (according to class) will adhere to the relevant Marine Orders with regard to navigation and preventing collisions in Commonwealth waters.	Certain sections of MARPOL International Convention for the SOLAS 1974 COLREG 1972	AMSA
Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 Ozone Protection and Synthetic Greenhouse Gas Management Regulations 1995	This Act and associated regulations provide for measures to protect ozone in the atmosphere by controlling and ultimately reducing the manufacture, import and export of ozone depleting substances (ODS) and synthetic greenhouse gases, and replacing them with suitable alternatives. **Relevance to Project**: The Act will only apply to Beach if it manufactures, imports or exports ODS. Activities undertaken as a part of this project will adhere to the requirements of this Act including restrictions on import and use of ODS (in refrigeration and air conditioning equipment) through control measures in procurement. Applicable requirements are specified as controls to relevant impacts and risks .	Vienna Convention for the Protection of the Ozone Layer, the Montreal Protocol on Substances that Deplete the Ozone Layer, and the United Nations Framework Convention on Climate Change and its Kyoto Protocol	DCCEEW
Protection of the Sea (Harmful Antifouling Systems) Act 2006	Under this Act, it is an offence for a person to engage in negligent conduct that results in a harmful anti-fouling compound being applied to or present on a ship. The Act also provides that Australian ships must hold 'anti-fouling certificates', provided they meet certain criteria. **Relevance to Project**: Vessels will comply with anti-fouling system requirements in accordance with this Act.	International Convention on the Control of Harmful Anti-fouling Systems on Ships 2001	AMSA

Legislation/Regulation	Scope	Related International Conventions	Administering Authority
	MO 98: Marine Pollution Prevention – Anti-fouling Systems is enacted under this Act.		
Protection of the Sea (Prevention of Pollution from Ships) Act 1983 Protection of the Sea (Prevention of Pollution from Ships) (Orders) Regulations 1994	This Act and associated regulations regulate Australian regulated vessels with respect to ship-related operational activities and invokes certain requirements of the MARPOL Convention relating to discharge of noxious liquid substances, sewage, garbage, air pollution etc. **Relevance to Project**: Vessels are required to abide to the requirements under this Act. Several MOs are enacted under this Act relating to the Project activities, including: • MO 91: Marine Pollution Prevention – Oil • MO 93: Marine Pollution Prevention – Noxious Liquid Substances • MO 94: Marine Pollution Prevention – Packaged Harmful Substances • MO 95: Marine Pollution Prevention – Garbage • MO 96: Marine Pollution Prevention – Sewage • MO 97: Marine Pollution Prevention – Air Pollution	Various parts of MARPOL	AMSA
Underwater Cultural Heritage Act 2018	This Act protects the heritage values of shipwrecks, sunken aircraft and relics (older than 75 years) in Australian Territorial waters from the low water mark to the outer edge of the continental shelf (excluding the State's internal waterways). The Act allows for protection through the designation of protection zones. Activities / conduct prohibited within each zone will be specified. **Relevance to Project**: In the event of removal, damage or interference to shipwrecks, sunken aircraft or relics declared to be historic under the legislation, activity is proposed with declared protection zones, or there is the discovery of shipwrecks or relics. Section 4 identifies no known shipwrecks or sunken aircrafts in Planning Area	Agreement between the Netherlands and Australia concerning old Dutch Shipwrecks 1972	DCCEEW

Table 8: Other relevant Commonwealth Legislation

Policy / Guideline / Convention	Purpose	Relevance to the Project
Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000	Aims to achieve the sustainable use of water resources by protecting and enhancing their quality while maintaining economic and social development.	Provide guideline values on ambient water quality and monitoring assessment.
Australian Ballast Water Management Requirements Version 8	Provides guidance on how vessel operators should manage ballast water when operating within Australian seas in order to comply with the *Biosecurity Act 2015*. They also align to the International Convention for the Control and Management of Ships’ Ballast Water and Sediments 2004 (the Ballast Water Management Convention).	All vessels and installations are required to manage their ballast water and sediments in accordance with the Convention and *Biosecurity Act 2015*.
Australian Offshore Petroleum Development Policy	Encourages ongoing investment in, and development of, Australia’s offshore petroleum (oil and gas) resources.	Beach has an obligation to undertake exploration and development of petroleum reserves within the held title.
EPBC Act environmental offsets policy for residual impacts on MNES	Provides guidance on the use of offsets under the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)*	Guidance for consideration of environmental offsets for residual impacts on MNES.
EPBC Act Policy Statement - 'Indirect consequences' of an action: Section 527E of the EPBC Act	Provides guidance on determining whether an event or circumstance is an 'indirect consequence' of an action for the purposes of the EPBC Act. An indirect consequence is frequently referred to as an 'indirect impact'.	Provides guidance for assessing direction and indirect impacts from proposed activities on MNES.
EPBC Act Policy Statement 3.21—Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species	To assist proponents in avoiding, assessing and mitigating significant impacts on migratory shorebirds listed under the EPBC Act. This policy statement is a key action under the Wildlife Conservation Plan for Migratory Shorebirds.	Provides a framework for minimising impacts to EPBC listed migratory shorebird species.
EPBC Act Policy Statements: Significant Impact Guidelines 1.1 - Matters of National Environmental Significance	Provide overarching guidance on determining whether an action is likely to have a significant impact on a matter protected under national environment law — the *Environment Protection and Biodiversity Conservation Act 1999.*	Provides a framework for development of environmental performance outcomes and acceptability levels to assess significance of impacts to MNES.
International Maritime Organisation (IMO) Guidelines for the Control and Management of Ships' Biofouling to	Guidelines for the control and management of ships' biofouling to minimize the transfer of invasive aquatic species	Specific requirements that vessels have a biofouling management plan and biofouling record book.

Policy / Guideline / Convention	Purpose	Relevance to the Project
Minimize the Transfer of Invasive Aquatic Species (Biofouling Guidelines) 2011		
Marine Bioregional Plans	Designed to improve decisions made under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), particularly in relation to the protection of marine biodiversity and the sustainable use of our oceans and their resources by our marine-based industries. Plans have been developed for four of Australia's marine regions - South-west, North-west, North and Temperate East.	The plans provide information on the Australian Government's marine environment protection and biodiversity conservation responsibilities, objectives and priorities in the four marine regions for which plans have been developed. There is currently no marine bioregional plan for the South-east Marine Region. Unlike marine bioregional plans, the South-east Marine Region Profile (CoA, 2015c) has not been made under s176 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). As such, it has no legal status in decision-making. However, it provides a useful source of information about the South-east Marine Region that could inform decisions made under the EPBC Act
National Biofouling Management Guidelines for the Petroleum Production and Exploration Industry 2018	Voluntary biofouling management guidance documents for risk of marine pest translocation and introduction via biofouling.	All vessels and installations to implement effective biofouling controls as best practice.
National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna 2017	Provides guidance on understanding and reducing the risk of vessel collisions and the impacts they may have on marine megafauna.	Applying the recommendations and implementing effective controls can reduce the risk of the vessel collisions with megafauna.

Table 9: Relevant Commonwealth Policies and Guidelines

Legislation/ Regulation	Scope	Application to Activity	Administering Authority
Environment Protection Act 2017 (& Environmental Protection Regulations 2021)	This is the key Victorian legislation which controls discharges and emissions (air, water) to the environment within Victoria (including state and territorial waters). It gives the Environment Protection Authority (EPA) powers to licence premises discharges to the marine environment, control marine discharges and to undertake prosecutions. Provides for the maintenance and, where necessary, restoration of appropriate environmental quality.	Oil pollution management in Victorian State waters	Environment Protection Authority (EPA)
	The State Environment Protection Policy (Waters of Victoria) designates: Spill response responsibilities by Victorian Authorities to be undertaken in the event of spills (DJPR) with EPA enforcement consistent with the Environment Protection Act 2017 and the Pollution of Waters by Oil & Noxious Substances Act 1986. Requires vessels not to discharge to surface waters sewage, oil, garbage, sediment, litter or other wastes which pose an environmental risk to surface water beneficial uses. To protect Victorian State waters from marine pests introduced via domestic ballast water, ballast water management arrangements applying to all ships in State and territorial waters must be observed as per the Environment Protection (Ships' Ballast Water) Regulations 2006, Waste Management Policy (Ships' Ballast Water) and the Protocol for Environmental Management. High risk domestic ballast water (ballast water which leachates from an Australian port or within the territorial sea of Australia (to 12 nm)), regardless of the source, must not be discharged into Victorian State waters. Ship masters must undertake a ballast water risk assessment on a voyage by voyage basis to assess risk level, provide accurate and comprehensive information to the EPA on the status and risk of ballast water contained on their ships (i.e. domestic/international), and to manage domestic ballast water discharges with EPA written approval.	Discharge of domestic ballast water from emergency response vessels into Victorian State waters must comply with these requirements.	
Emergency Management Act 2013	Provides for the establishment of governance arrangements for emergency management in Victoria, including the Office of the	Emergency response structure for managing emergency incidents within Victorian State waters.	Department of Justice and Community Safety

Legislation/ Regulation	Scope	Application to Activity	Administering Authority
	Emergency Management Commissioner and an Inspector-General for Emergency Management. Provides for integrated and comprehensive prevention, response and recovery planning, involving preparedness, operational co-ordination and community participation, in relation to all hazards. These arrangements are outlined in the Emergency Management Manual Victoria.	Emergency management structure will be triggered in the event of a spill impacting or potentially impacting State waters.	(Inspector General for Emergency Management)
Flora and Fauna Guarantee Act 1988 (FFG Act) (& Regulations 2020)	The purpose of this Act is to protect rare and threatened species; and enable and promote the conservation of Victoria's native flora and fauna and to provide for a choice of procedures that can be used for the conservation, management or control of flora and fauna and the management of potentially threatening processes. Where a species has been listed as threatened an Action statement is prepared setting out the actions that have or need to be taken to conserve and manage the species and community.	Action Statement controls for threatened species present in the zone of potential impact as adopted (as relevant) within this OPP. Triggered if an incident results in the injury or death of an FFG Act listed species (e.g. collision with a whale).	Victoria Department of Energy, Environment and Climate Action (DEECA)
Heritage Act 2017	The purpose of the Act is to provide for the protection and conservation of historic places, objects, shipwrecks and archaeological sites in state areas and waters (complementary legislation to Commonwealth legislation). Part 4 Underwater cultural heritage of the Act is focused on historic shipwrecks, which are defined as the remains of all ships that have been situated in Victorian State waters for 75 years or more. The Act addresses, among other things, the registration of wrecks, establishment of protected zones, and the prohibition of certain activities in relation to historic shipwrecks.	May be triggered in the event of impacts to a known or previously un-located shipwreck in Victorian State waters whilst undertaking emergency response activities.	Heritage Victoria Department of Transport and Planning)
Marine Safety Act 2010 (& Regulations 2012)	Act provides for safe marine operations in Victoria, including imposing safety duties on owners, managers and designers of vessels, marine infrastructure and marine safety equipment; marine safety workers, masters and passengers on vessels; regulation and management of vessel use and navigation in Victorian State waters; and enforcement provisions of Police Officers and the Victorian Director of Transport Safety. This Act reflects the requirements of international conventions - Convention on the International Regulations for Preventing Collisions at Sea & International Convention for the Safety of Life at Sea.	Applies to vessel masters, owners, crew operating vessels in Victorian State waters.	Maritime Safety Victoria

Legislation/ Regulation	Scope	Application to Activity	Administering Authority
	The Act also defines marine incidents and the reporting of such incidents to the Victorian Director of Transport Safety.		
National Parks Act 1975	Established a number of different types of reserve areas onshore and offshore, including Marine National Parks and Marine Sanctuaries. A lease, licence or permit under the OPGGS Act 2010 that is either wholly or partly over land in a marine national park or marine sanctuary is subject to the National Parks Act 1975 and activities within these areas require Ministerial consent before activities are carried out.	Applies where there are activities within marine reserve areas.	DEECA
Pollution of Waters by Oil and Noxious Substances Act 1986 (POWBONS) (& Regulations 2022)	The purpose of the Pollution of Waters by Oils and Noxious Substances Act 1986 (POWBONS) is to protect the sea and other waters from pollution by oil and noxious substances. This Act also implements the MARPOL Convention (the International Convention for the Prevention of Pollution from Ships 1973) in Victorian State waters. Requires mandatory Reporting of marine pollution incidents. Act restricts within Victorian State waters the discharge of treated oily bilge water according to vessel classification (>400 tonnes); discharge of cargo substances or mixtures; prohibition of garbage disposal and packaged harmful substances; restrictions on the discharge of sewage; regulator reporting requirements for incidents; ship construction certificates and survey requirements. Restriction on discharges within Victorian State waters incorporated into EP.	Triggered in the event of a spill impacting or potentially impacting State waters.	Jointly administered by DECCA and EPA
Wildlife Act 1975 (& Regulations 2013)	The purpose of this Act is to promote the protection and conservation of wildlife. Prevents wildlife from becoming extinct and prohibits and regulates persons authorised to engage in activities relating to wildlife (including incidents). The Wildlife (Marine Mammal) Regulations 2019 prescribe minimum distances to whales and seals/seal colonies, restrictions on feeding/touching and restriction of noise within a caution zone of a marine mammal (dolphins (150m), whales (300m) and seals (50m).	Applies where vessels are within State waters responding to a spill event. Prescribed minimum proximity distances to whales, dolphins and seals will be maintained. Triggered if an incident results in the injury or death of whales, dolphins or seals.	DECCA

Table 10: Relevant Victorian Legislation

Legislation/ Regulation	Scope	Application to Activity	Administering Authority
Environmental Management and Pollution Control Act 1994 (EMPCA) (& Regulations)	EMPCA is the primary environment protection and pollution control legislation in Tasmania. It is a performance-based style of legislation, with the fundamental basis being the prevention, reduction and remediation of environmental harm. The clear focus of the Act is on preventing environmental harm from pollution and waste. Relevant regulations under the EMPCA include: • Environmental Management and Pollution Control (General) Regulations 2017 • Environmental Management and Pollution Control (Waste Management) Regulations 2010 The EPA Division Compliance Policy provides the Director of the Environment Protection Authority (EPA) powers of compliance.	Defines the EPA's jurisdiction during a spill event. Prescribes the fee structure to waste events and environmental protection notices. Regulates the management and control of controlled wastes.	EPA Tasmania - Department of Natural Resources and Environment (NRE)
Marine-related Incidents (MARPOL Implementation) Act 2020	Pollution of the sea in Tasmanian State waters may be regulated by general pollution laws such as the EMPCA (see above), but the deals specifically with discharges of oil and other pollutants from ships. . It gives effect in Tasmania to the MARPOL international convention on marine pollution	Gives effect to MARPOL in Tasmanian waters.	NRE (Tasmania)
Threatened Species Protection Act 1995	Provide for the protection and management of threatened native flora and fauna and to enable and promote the conservation of native flora and fauna.	Identification of species that are also protected under Tasmanian legislation.	NRE (Tasmania)

Table 11: Relevant Tasmanian Legislation

Agreement / Convention	Summary	Relevance to the Project
Convention on the Conservation of Migratory Species of Wild Animals 1979 (the Bonn Convention)	This convention aims to conserve migratory fauna species throughout their ranges, particularly where their range crosses international jurisdictional boundaries. It is implemented in Commonwealth law by the EPBC Act, which makes provision for species listed under the Bonn Convention to be listed as migratory under the EPBC Act. Species listed as migratory under the EPBC Act are MNES.	Several species listed as migratory under the EPBC Act were identified as potentially being impacted by the petroleum activities considered in this OPP. Refer to Section 7.3.5.
The Agreement on the Conservation of Albatrosses and Petrels (ACAP)	ACAP through its 13 Parties strives to conserve albatrosses and petrels by coordinating international activities to mitigate threats to their populations.	Several albatross and petrel species were identified as potentially being impacted by the petroleum activities considered in this OPP. Section Refer to Section 7.3.5.
Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment 1974 (JAMBA)	This agreement aims to conserve migratory bird species that travel between Japan and Australia. This includes many species of shorebirds that use the East Asian - Australasian Flyway. It is implemented in Commonwealth law by the EPBC Act, which makes provision for species listed under JAMBA to be listed as migratory under the EPBC Act. Species listed as migratory under the EPBC Act are MNES.	Several birds listed as migratory under the EPBC Act were identified as potentially being impacted by the petroleum activities considered in this OPP. Section Refer to Section 7.3.5.
Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment 1986 (CAMBA)	This agreement aims to conserve migratory bird species that travel between China and Australia. This includes many species of shorebirds that use the East Asian - Australasian Flyway. It is implemented in Commonwealth law by the EPBC Act, which makes provision for species listed under CAMBA to be listed as migratory under the EPBC Act. Species listed as migratory under the EPBC Act are MNES.	Several birds listed as migratory under the EPBC Act were identified as potentially being impacted by the petroleum activities considered in this OPP. Refer to Section 7.3.5.
Agreement between the Government of Australia and the Government of the Republic for Korea for the Protection of Migratory Birds and their Environment 2007 (ROKAMBA)	This agreement aims to conserve migratory bird species that travel between the Republic of Korea and Australia. This includes many species of shorebirds that use the East Asian - Australasian Flyway. It is implemented in Commonwealth law by the EPBC Act, which makes provision for species listed under ROKAMBA to be listed as migratory under the EPBC Act. Species listed as migratory under the EPBC Act are MNES.	Several birds listed as migratory under the EPBC Act were identified as potentially being impacted by the petroleum activities considered in this OPP. Refer to Section Refer to Section 7.3.5.
International Convention on Wetlands of International Importance 1975 (Ramsar)	This convention aims to conserve and promote the sustainable human use of wetlands. Many wetlands have been identified as important habitat for migratory bird species, and Ramsar wetlands are	The Ashmore Reef Ramsar wetland was identified as potentially being impacted in the event of an unplanned

Agreement / Convention	Summary	Relevance to the Project
	of importance in conserving many species of migratory shorebirds and waders. Ramsar wetlands are protected under the EPBC Act and are MNES.	release of large volumes of hydrocarbons (e.g. loss of well control). Refer to Section 7.3.4.
London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (London Convention)	This convention is an agreement to control pollution of the sea by intentional disposal at sea of potentially harmful materials. It is implemented under Commonwealth law by the *Environment Protection (Sea Dumping) Act 1981*.	Chemical inventories onboard vessels and MODUs may potentially breach this convention if unpermitted via this OPP and deliberately discharged to the sea.
Minamata Convention on Mercury 2017	This convention is an agreement to protect human and environmental health from the effects of releases of mercury and mercury-containing compounds to the environment. The convention is not yet ratified by Australia, and hence is not currently implemented in Commonwealth law. Australia has signed the convention and is currently undertaking an assessment process prior to ratification.	Drilling activities may result in mercury compounds being produced from wells as a by-product. Mercury may pose a risk to the environment if not managed appropriately.
International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 (commonly known as MARPOL 73/78)	This convention is an agreement to minimise the pollution of the marine environment by ships. The convention provides a standardised approach to the environmental management of international and domestic shipping. The convention is implemented in Commonwealth law by the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* and a series of Marine Orders made under this Act.	All marine support vessels are required to comply with MARPOL.
International Convention on Standards of Training, Certification and Watch keeping for Seafarers 1978 (STCW)	This convention provides a standardised approach to the qualifications and competencies of masters, officers and watch personnel. It is implemented in Commonwealth law by the *Navigation Act 2012* and a series of Marine Orders made under this Act.	All project vessels and crew are required to comply with STCW.
International Convention for the Safety of Life at Sea 1974 (SOLAS)	This convention provides internationally agreed minimum standards for the construction, equipment and operation of vessels. It is implemented in Commonwealth law by the *Navigation Act 2012* and a series of Marine Orders made under this Act.	All project vessels are required to comply with SOLAS.
International Regulations for Preventing Collisions at Sea 1972 (COLREGS)	These regulations provide internationally agreed rules for the navigation of vessels, which are intended to reduce the likelihood of vessel collisions. COLREGS are implemented in Commonwealth law by the *Navigation Act 2012* and a series of Marine Orders made under this Act.	All project vessels are required to comply with COLREGS.
Paris Agreement on Climate Change (2015)	The Paris Agreement is an instrument made under the UNFCCC, with the central aim of strengthening the global response to the threat of	The Paris Agreement provides the international framework and context around Australia's NDC, which is important to

Agreement / Convention	Summary	Relevance to the Project
	climate change by keeping the global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius in order to prevent dangerous human caused interference with the climate system. It deals with GHG emissions mitigation, adaptation, and finance. The agreement's language was negotiated by representatives of 196 state parties, including Australia, and adopted by consensus on 12 December 2015, before entering in to force in late 2016. Australia has since ratified the Paris Agreement. The Paris Agreement requires each party to: volunteer its own Nationally Determined Contributions (NDCs), to report against them annually, and improve them if it is determined that the collective commitment to NDCs is considered ineffective or insufficient to keep global temperature increases to less than 2°C below pre-industrial levels. This allows for variation in emissions reduction performance according to the development status of the country; and determine, plan, and regularly report on the contribution that it undertakes to mitigate global warming. No mechanism forces a country to set a specific emissions target by a specific date, but each target should go beyond previously set targets. The Intergovernmental Panel on Climate Change (IPCC) released a report in October 2018 on the 1.5 degrees Celsius target; it concluded that global emissions need to reach net zero around mid-century to give a reasonable chance of limiting warming to 1.5 degrees Celsius.	establishing the defined acceptable level of GHG emissions from the Otway project.

Table 12: Relevant international agreements and conventions

3. Description of the Project and Alternatives Analysis

3.1 Overview

The purpose of this section is to provide a description of the key project stages and activities for the development of new gas discoveries in the Otway Basin. The Project is the development of new discoveries at Artisan and La Bella and development of future discoveries in surrounding exploration permits identified by initial and future drilling campaigns. Development of both known discoveries and potential future fields are considered in this OPP.

3.2 Project Concept and Design

A key feature of the Project is the use of existing production assets to develop surrounding gas discoveries. The development of the Thylacine and Geographe gas fields was approved under Part 9 of the Environment Protection and Biodiversity Act (EPBC Decision No. 2002/621). Development of the gas fields commenced in 2004 by Woodside Petroleum Ltd under a joint venture arrangement, with first production in mid-2007. Since this date, additional wells have been drilled at the Geographe location (VIC/L23) and the Thylacine location (T/L2) to maintain supply. A further exploration well was drilled in 2021 at the Artisan location (VIC/P43).

Natural gas is produced from Thylacine gas fields via a combination of subsea wells and Thylacine offshore production platform, while Geographe field is produced via subsea wells and infrastructure. Gas from Geographe and Thylacine fields is transport by the OGPP to the OGP. urrently, production from these fields is in natural decline with end of field life expected by 2038.

The current project provides an opportunity for Artisan, La Bella and surrounding fields to be developed through existing infrastructure. The concept therefore relies on existing pipeline and production operations at Thylacine platform with the following concepts:

- Initial development of Artisan and La Bella gas discoveries, and any additional gas discoveries identified from the initial drilling campaign:
    - Suspending successful wells with two verified barriers and installation of completions and Christmas Tree
    - Subsea tie-back of wells to existing OGPP via hot tap tee assembly, Geographe tee or via the connection point at the base of the Thylacine platform
    - Control of all new wells via extension of the existing electro-hydraulic (EH) control system linked to the Thylacine Platform and the OGP.

Beach is undertaking concept engineering to support the subsea developments. The subsea development will be optimised for recovery of gas from potentially multiple fields via new subsea installation and tie-back to existing OGPP (via hot tap tee assemblies and Geographe tee) or Thylacine-A platform. The development concepts may require some brownfield modifications to existing production infrastructure at the hot tap tee assembly, Geographe tee, Thylacine platform and the OGP.

The project is designed to accommodate future tie back opportunities identified via future drilling campaigns, with the infrastructure to support any future development is likely to be similar to that required for the initial development. Any future development will be undertaken in accordance with the environmental legislative requirements in force at that time.

The key characteristics of the Project are summarised in **Table 13**.

Project Characteristics	Description
Project Area	The Project Area is defined in Section 3.5
Key Project Stages	Seabed surveys (geotechnical and geophysical) Exploration, appraisal and development drilling Completion of successful wells Subsea infrastructure installation Commissioning Operations and maintenance Future tiebacks Decommissioning
Proposed Wells	Up to six wells are anticipated to be drilled and completed (in success case) and one re-entered and completed as part of the initial drilling campaign: • Re-entry and completion of Artisan 1 • Drilling and completion of La Bella 2 • Up to five additional exploration and appraisal wells drilled and completed (in success case) from a portfolio of prospects in the Project Area consisting of: ○ Up to 5 wells located north of the Thylacine platform in the area of permits VIC/P43 and VIC/P73 and expected to be within approximately 10km of Artisan, La Bella or HTT locations ○ Up to 2 wells located within the T/30P permit in the southern section of Project Area Future exploration, appraisal and development drilling campaigns may be undertaken in the Project Area. This drilling will use similar techniques as outlined in this OPP and detailed in activity specific EPs. • Up to an additional 10 exploration and appraisal wells may be drilled and completed (in success case) in the future consisting of: ○ Up to 6 wells located north of the Thylacine platform in the area of permits VIC/P43 and VIC/P73 and expected to be within approximately 10km of Artisan, La Bella or HTT locations ○ Up to 4 wells located within the T/30P permit in the southern section of the Project Area
Subsea infrastructure	Installation of subsea infrastructure to connect gas discoveries Artisan 1, La Bella 2 and any successful exploration or appraisal wells from the initial drilling campaign (up to five wells) or future campaigns (up to 10 additional wells) to the OGPP including: • Wellheads, flowlines, umbilicals, manifolds and skids

Table 13: Key Project Characteristics

3.3 Project Schedule

Table 14 provides an indicative and earliest project schedule which is subject to corporate, joint venture and regulatory approvals.

Project Stage	Indicative Timing
Execution Decision Gate	Q3 2024
Initial Exploration & Appraisal Drilling Campaign	Q1 2025
Installation of Subsea Infrastructure	Q1 2026
Commissioning & RFSU	Q2 2026
Future drilling and tie-backs	Within operating life of the Project
End of Field Life	2055
Decommissioning	Undertaken at end of field life

Table 14: Project Schedule Summary

3.4 Project Location

The Project is located in the Otway Basin in offshore Commonwealth waters, approximately 20km south of the Victorian mainland and 40km west of Tasmania (King island) at its closest points in water depths ranging from 65m to 190m. The nearest regional centre of Geelong is approximately 150km to the north east.

The Project Area is described in Section 3.5.

The Project Area does not contain any emergent reefs, submerged shoals or banks, the nearest being Bravenes Rock at approximately 20km to the north east and Bell Reef at approximately 110km to the south east.

The locations of key existing and proposed initial development infrastructure are presented in Figure 1 and **Figure 2**: Project Area.

3.5 Project Area Definition

The Project Area is shown in Figure 2: Project Area and defines the geographic extent of the area that is applicable for planned activities, which are considered and risk assessed in this OPP.

The Project Area is defined as a single combined area extending north and south of the existing Thylacine platform.

The Project Area located north of the Thylacine platform includes the locations of gas discoveries (Artisan and La Bella) and exploration prospects within approximately 10km of these discoveries and pipeline tie in points with the likely corridors (with buffer) for subsea connections.

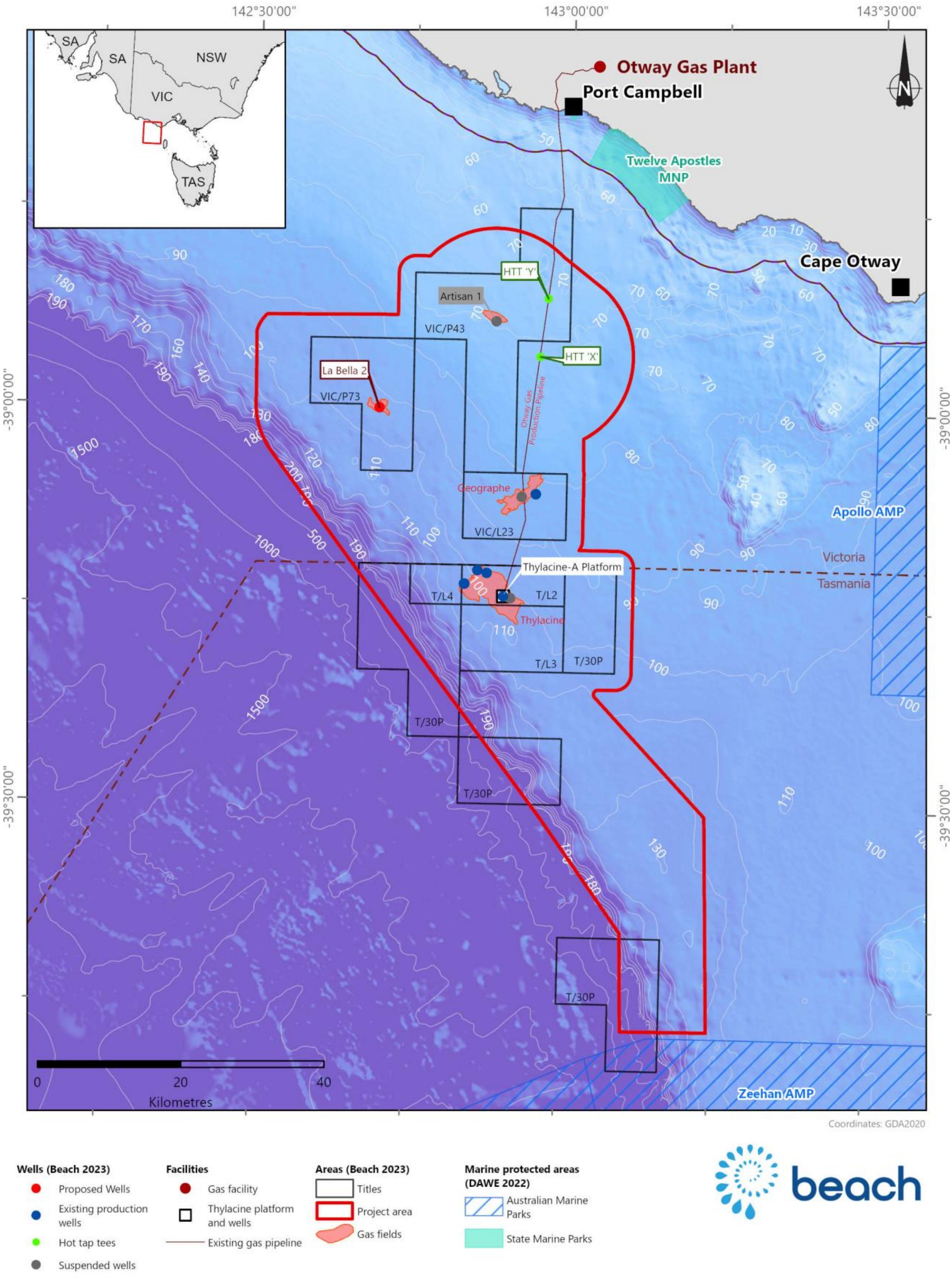
The Project Area also incorporates exploration prospects located south of the Thylacine platform within Exploration Permit T/30P and corridors (with buffer) for future subsea tie-back.

Expected to be significantly smaller than the area shown in Figure 2: Project Area, Beach has taken a conservative approach and defined a larger Project Area with buffer extents applied to inform the basis of the impact and risk assessment and provide flexibility to account for the early design phase and potential future developments.

The Project Area is 3,248km^2 and the estimated footprint of subsea disturbance of the initial development is up to 0.07km^2 (less than 0.003% of the Project Area) and a total of 0.06km^2 for future tiebacks (less than 0.003% of the Project Area). The Project Area has been designed to not include the deeper waters off the continental shelf and to avoid potential overlap with the Zeehan Marine Park with a minimum 1km buffer applied.

The Project Area will accommodate the MODU for drilling and well activities and movement of all vessels around the offshore facilities during installation and commissioning and operation. Transit of vessels to and from the offshore locations is excluded from this OPP as this is outside the scope of the OPGGS Act and is regulated by maritime legislation, including the Commonwealth *Navigation Act 2012*.

Onshore support facilities required during construction, commissioning and operation will be located in existing ports. It is expected that the project will utilise the onshore supply base facilities (Geelong and Portland) that are used to service Beach's Otway Basin operations.



This map is provided as a general reference only and is not intended to be used for any other purpose. No warranty is provided in relation to the accuracy of the information contained in this map.

7/09/2023| OT23-0027D

Figure 2: Project Area

3.6 Hydrocarbon Characteristics

The reservoir targets are gas within the Turonian Waarre Formation. Liquid condensate will form within the gas stream as temperature and pressure decrease when the gas is brought to the surface. The initial condensate gas ratio is expected to be up to 20 barrels per million standard cubic feet of gas.

Compositions for Thylacine, Artisan and La Bella gas are provided in Table 15: Gas composition and Figure 3. Thylacine and La Bella are similar composition, with Artisan having lower CO_2, higher methane and fewer heavy ends (lower condensate yield). These gas compositions are considered suitable analogues for all potential new fields within the Project Area

Composition (mol%)	Thylacine	Artisan	La Bella
H_2S	0.00	0.00	0.00
CO_2	9.29	1.63	13.30
N_2	1.38	1.63	2.90
C1	81.13	94.79	75.43
C2	4.88	1.25	4.91
C3	1.61	0.36	1.81
iC4	0.29	0.07	0.32
nC4	0.39	0.08	0.35
iC5	0.15	0.02	0.13
nC5	0.11	0.01	0.10
C6	0.14	0.03	0.23
C7	0.23	0.03	0.29
C8	0.21	0.01	0.10
C9	0.06	0.01	0.07
C10	0.03	0.00	0.04
C11	0.02	0.01	0.02
C12+	0.08	0.07	0.00
Total	100.00	100.00	100.00

Table 15: Gas composition

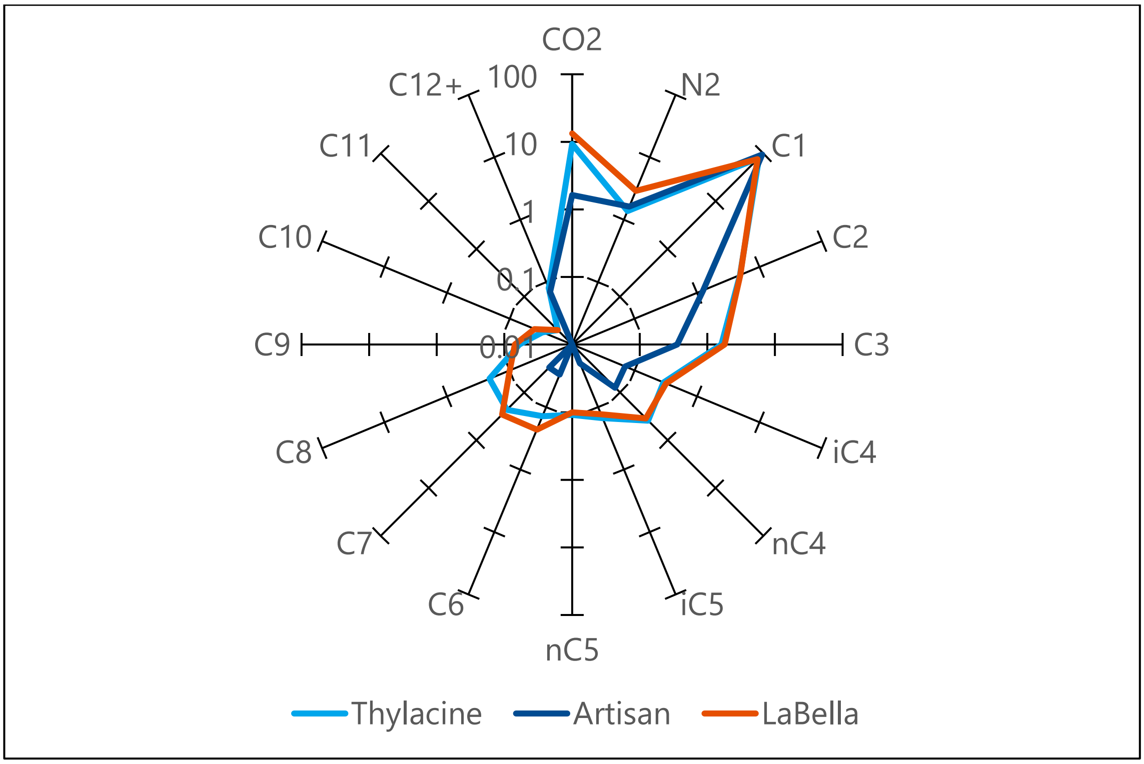


Figure 3: Gas composition

3.7 Project Infrastructure

3.7.1 Existing Infrastructure

A key feature of the Project is the use of existing infrastructure to develop surrounding gas discoveries with a schematic of the key existing development infrastructure is shown in Figure 4 and described below:

- Thylacine-A Platform - a normally unmanned installation (NUI) wellhead platform with four production wells
- Four subsea Thylacine wells, flowlines and infrastructure tied back to Thylacine-A platform
- Geographe subsea facilities –subsea wells connected by flexible flowline directly into the OGPP with control and services provided via an umbilical from Thylacine-A Platform and MEG supplied directly from the MEG Service Line via an in-field umbilical.
- OGPP system:
  - Offshore section of DN500 raw gas pipeline from Thylacine-A Platform (Platform) to the onshore Otway Gas Plant and a DN100 MEG Service Line supplying MEG (Monoethylene glycol) and chemicals from the OGP for injection into the OGPP and Thylacine subsea flowlines.
  - The OGPP design for the Thylacine Otway development included two pre-installed hot tap tee assemblies (HTT 'X' and HTT 'Y') located in the vicinity of the VIC/P43 exploration permit to allow for future development of additional fields in the Otway Basin. There is also the potential to extend the Geographe infrastructure, which has additional capacity in relation to tie-in to the Subsea Valve Structure (SVS) and Tee, which sits adjacent to the OGPP.

Figure 4: Schematic diagram of existing Otway infrastructure

3.7.2 Planned Infrastructure

The key infrastructure components of the Project are subsea and include wells, flowlines, umbilicals, manifolds and skid structures.

3.7.2.1 Wells

Up to six wells are anticipated to be drilled and completed (in success case) and one re-entered and completed as part of the initial drilling campaign:

- Re-entry and completion of Artisan 1
- Drilling and completion of La Bella 2
- Up to five additional exploration and appraisal wells drilled and completed (in success case) from a portfolio of prospects in the Project Area

Up to five of these wells may be located north of the Thylacine platform in the area of permits VIC/P43 and VIC/P73 and expected to be within approximately 10km of Artisan, La Bella or HTT locations. Up to two wells may be drilled within the T/30P permit in the southern section of Project Area.

Future exploration, appraisal and development drilling campaigns may be undertaken in the Project Area with up to an additional 10 wells drilled and completed (in success case).

Up to 6 wells may be located north of the Thylacine platform in the area of permits VIC/P43 and VIC/P73 and expected to be within approximately 10km of Artisan, La Bella or HTT locations. Up to 4 wells may be located within the T/30P permit in the southern section of the Project Area.

Each well will have a wellhead, which provides means for hanging the production well casing and installing the Christmas tree and well control facilities. The Christmas tree enables reservoir fluids to flow from the well to the flowlines. It is also used to manage chemical injection and control production. Hydraulically controlled valves are used to control flow rates and provide well shut-off mechanism.

The subsea Christmas Tree (or ‘tree’) consists of a series of hydraulically operated valves, spools and instrumentation that are used to control and manage the production flow from a well. The tree includes a subsea control module (SCM). The SCM receives hydraulic and electrical signals from the topside facility and communicates this to a specific tree function. The hydraulic system operates with low pressure (LP), high pressure (HP) and chemical injection capabilities.

Trees are typically designed with open loop hydraulic systems with actuation fluid which will vent to sea via the SCM. Included in the system are accumulators which are mounted on the tree frame which are used to supply and open actuators fitted to each hydraulic valve (fail safe closed type). The hydraulic fluid used to fill the actuator open side (to compress a spring) will be vented to sea when it is closed.

The tree valves and functions are typically tested prior to installation and therefore this is not repeated at the time of installation, only the connection between the tree and the wellhead. During well construction including completion and well testing operations (if required) the tree valves and some functions will be required to be functioned. The volume which is vented to sea is variable depending on the tree type and size however is in the order of 40 litres. This fluid is water-soluble and readily disperses in the receiving waters after discharge.

3.7.2.2 Subsea System

The Artisan and La Bella gas discoveries and any successful exploration or appraisal wells from the initial and future drilling campaigns will be connected to the OGPP by flowlines, umbilicals, manifolds and skid structures.

Beach is undertaking concept engineering to support the subsea developments and a base case and alternatives have been identified. Several options to tie-back new gas fields to the existing Thylacine and Geographe infrastructure exist including HTT X and Y on the OGPP, Geographe Tee and at the base of the Thylacine-A platform.

A schematic of the base case for the subsea infrastructure of the Artisan tie-back is shown in Figure 5 and is representative of the La Bella and potential future tie-backs north of the Thylacine platform in the area of permits VIC/P43 and VIC/P73. The base case for the Artisan and La Bella flowline and umbilical routes are shown in Figure 6.

Additional gas discoveries in T/30P permit south of Thylacine platform will constitute the longest potential flowline and umbilical routes. The base case flowline and umbilical routes for the two currently identified potential well locations in T/30P are shown in Figure 7 and for the most southerly potential well the route is approximately 65km in length.

Flowlines will transport production fluids (gas and condensate) from the wellheads and manifolds to the pipeline or platform. This includes flowline end terminations (FLETs) to connect the flowline to other infrastructure.

Umbilicals will transfer power, electric and communication signals, hydraulic fluids and chemicals (such as MEG) to the wellheads. The umbilicals will connect to other infrastructure via umbilical termination assemblies (UTAs).

Flowlines or umbilicals will not be trenched and may either be rigid or flexible. Localised placement of stabilisation material may be required to assure stability, primarily adjacent to well and structure tie-in locations.

Additional in-field subsea structures such as manifolds, skids, and distribution units will connect flowlines and umbilicals together and to the pipeline or platform tie-in points.

The total extent of seabed footprint required for the installation of seabed infrastructure for the initial development is estimated at approximately 68,750m^2 (0.07km^2). This includes stabilisation support at tie in points if required. This total area is subject to refinement during the design process and drilling campaign outcomes however it represents a conservative approach of each potential exploration and appraisal well being tied back.

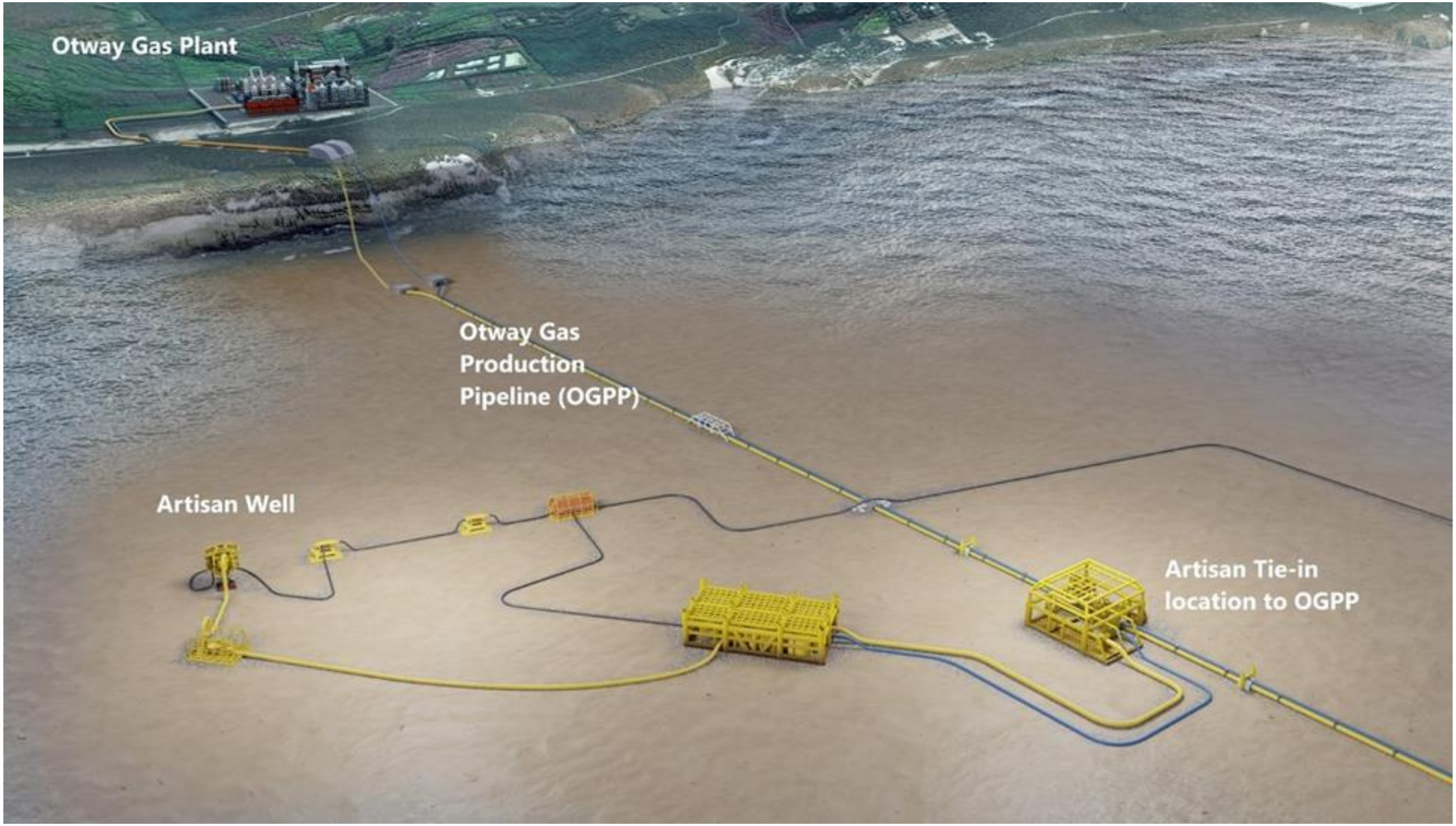
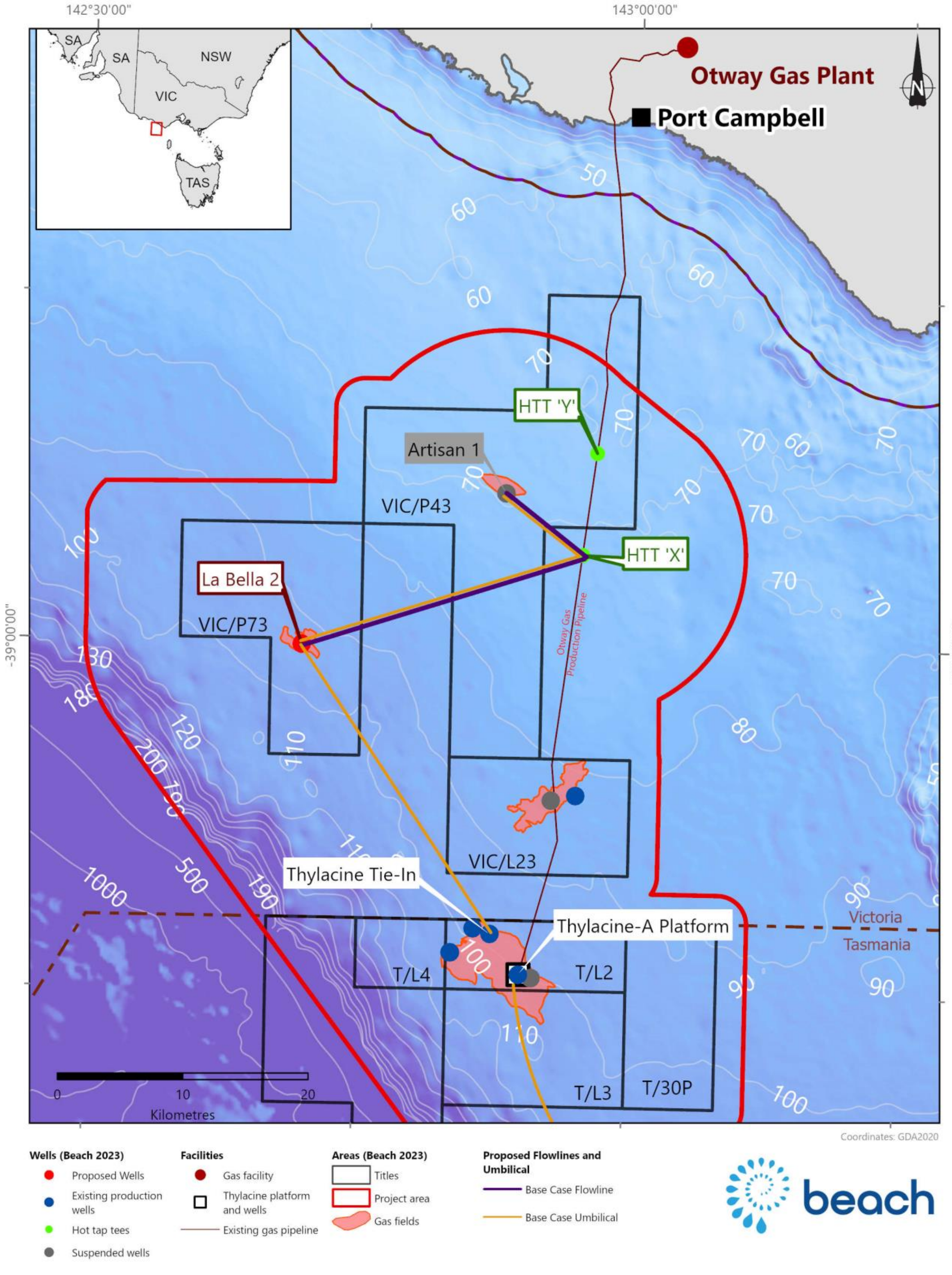


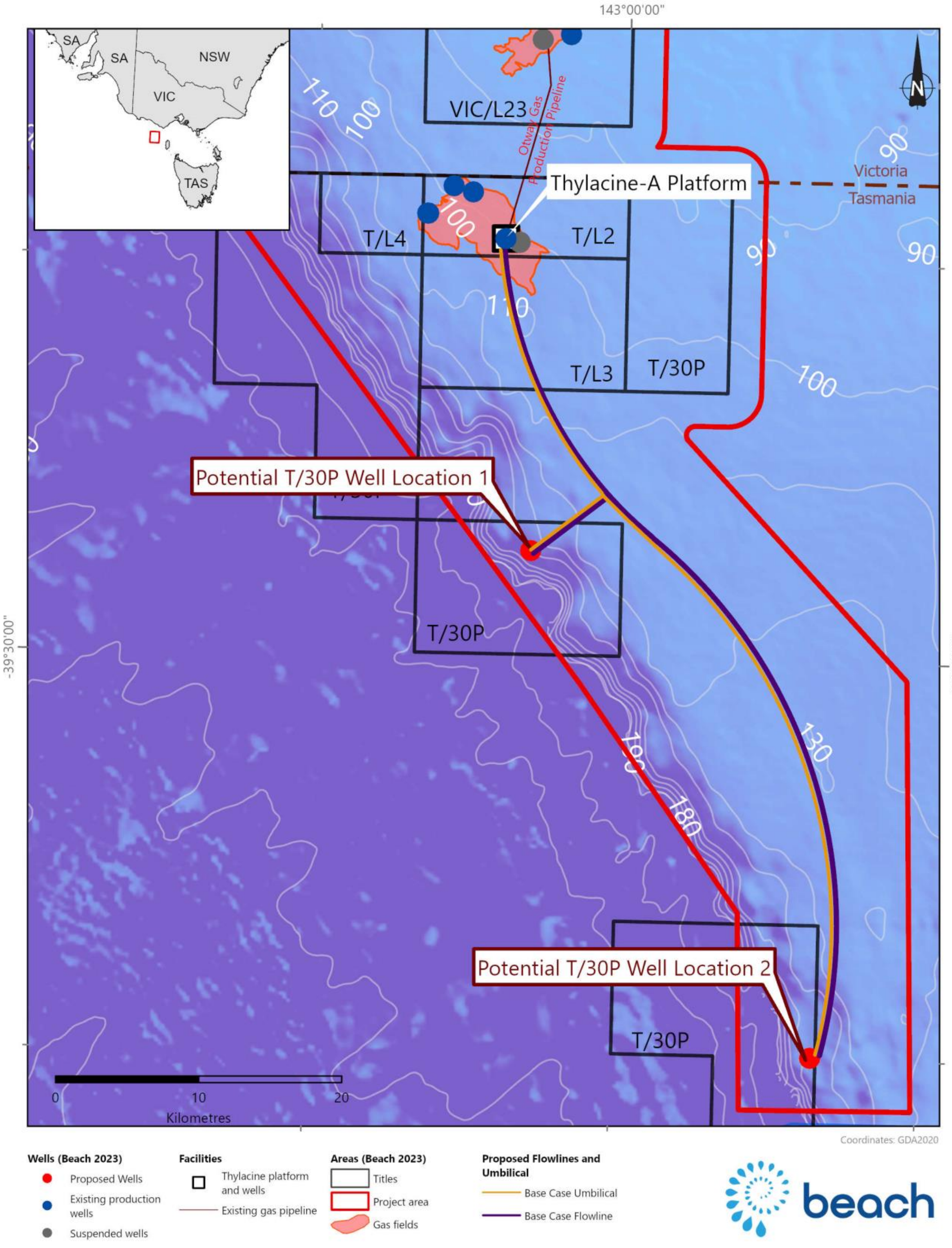
Figure 5: Schematic diagram of proposed Artisan tie-back



This map is provided as a general reference only and is not intended to be used for any other purpose. No warranty is provided in relation to the accuracy of the information contained in this map.

7/09/2023| OT23-0027E

Figure 6: Proposed Artisan and La Bella flowline tie-back routes



This map is provided as a general reference only and is not intended to be used for any other purpose. No warranty is provided in relation to the accuracy of the information contained in this map.

7/09/2023| OT23-0027F

Figure 7: Proposed T/30P tie-back routes

3.8 Description of Activities

Project activities associated with the Project are summarised in the sections below.

3.8.1 Seabed Surveys (Geotechnical and Geophysical)

Geotechnical and geophysical surveys may be required to be undertaken to assess the suitability of the seabed for drilling, infrastructure or surveys may be needed along the length of proposed flowlines routes. These geotechnical surveys may include techniques that involve using high-frequency sonar to provide high-resolution bathymetry and geophysical data, such as side-scan sonar, sub bottom profiler or multibeam echo sounder. Sonar generates high-frequency acoustic emissions that attenuate rapidly in the underwater environment. These geophysical surveys would be expected to take up to in the order of forty days to complete, depending on the length of the flowline routes.

Geotechnical surveys typically involve in-situ testing and piston/push sampling and coring. Following sampling, all equipment is withdrawn from the seabed. A small hole ($<1m^2$) will remain, which will eventually collapse and infill with the movement of surface sediments in ocean current.

Specific noise modelling from geophysical survey equipment was carried out to inform the risk assessment. The acoustic emissions will decrease rapidly due to the relatively high frequency of the acoustic emissions, with received sound levels estimated to be reduced to 160dB re 1µPa within 150m.

Depending on the scope and flowline route, seabed surveys could be in the order of approximately 10-20 days duration per tie-back.

3.8.2 Drilling and Completions

3.8.2.1 Drilling Method

The initial drilling campaign will be undertaken via a semi-submersible MODU with future drilling being undertaken by either a semi-submersible or jack-up MODU (Figure 8).

The initial drilling campaign wells are planned to be drilled vertically. The wells will be drilled to depths of approximately between 2,000m and 3,500m beneath sea level to intersect the reservoirs. Drilling is expected to be in the order of approximately 30 to 40 days duration for each well.

While not currently planned, where there is high inclination wells or wells with extended reach requirements in the future, these wells may require directional drilling to depths of up to approximately 4,500m beneath sea level. Drilling of these wells is expected to be in the order of approximately 30 to 40 days duration for each well.

The drilling process will use standard offshore drilling methods with the wells drilled in sections which decrease in diameter at increasing depths until the target reservoir is reached. Protective steel casing is inserted into the wells and cemented into place to isolate each section from subsequent sections and provide structural support and stability to the well.

In the process of drilling, drilling fluids (also known as drilling muds) will be used to lubricate and cool the drill bit, maintain well bore stability, and remove drill cuttings (rock fragments) from the well sections as they are drilled.

It is envisaged that water-based drilling fluid (WBDF) will be appropriate to drill and complete the wells associated with the Project, and that up to approximately 4,000m^3 of WBDFs per well will be discharged to the marine environment.

Synthetic based drilling fluids (SBDF) may be required in the future for high inclination wells or wells with extended reach requirements. In the unlikely scenario that SBDF is required, the potential discharge volumes will be minimised and be up to approximately 100m^3. There will be no bulk discharge, with all SBDF remaining at the end of the well either being reused on the next well, passed onto the next operator or returned to the vendor for reprocessing or appropriate disposal. This will be detailed in the relevant activity specific Environment Plans.

Table 16 presents the types of drilling fluids and their typical components proposed to be used for the different sections of each well.

Drilling fluids and cuttings will be discharged at the seabed during drilling of the upper well sections as is standard industry practice due to the wellhead not yet being installed. The drilling fluids and cuttings from the lower sections will be circulated to the MODU, with fluids separated for recycling and cuttings discharged overboard. It is expected that up to approximately 600m^3 of drill cuttings per well will be discharged.

Cementing of the casings may result in the release of small amounts of cement (up to approximately 50m^3 per well) when the cement mixture is circulated to the seabed during grouting or when surplus fluids require disposal after cementing operations.

Well Section Diameter (inches)	Drilling Fluid Type and Typical Main Components
36	WBDF - seawater and prehydrated gel sweeps (i.e. seawater to which high viscosity prehydrated bentonite has been added).
26	
17.5	WBFD - drilling fluids in which seawater is the major component of the liquid phase and to which bentonite clay, barite, brine and/or gellants (such as guar gum or xanthum gum) have been added
12.25	
8.5	
Future wells depending on well profile (intermediate and/or production hole sections)	SBDF - drilling fluids in which synthetic oil is the base fluid with bentonite clay, barite, fluid-loss control agents, lime, aqueous chloride, bridging agents and emulsifiers added

Table 16: Drilling fluid types and typical components

3.8.2.2 Blow-out preventer installation and function testing

After completion of the top-hole sections, a BOP is installed onto the wellhead. The BOP consists of a series of hydraulically operated valves and sealing mechanisms (annular preventers, ram preventers and blind shear rams) that are used to close in the well should a loss of well control situation arise. The annular preventers and ram preventers are used to shut in around various tubulars and regaining hydrostatic overbalance using the MODU's high pressure circulating system. The blind shear rams are designed to shear the pipe and seal the well.

Once the BOP is installed, function and pressure tests are undertaken in accordance with industry standards and the drilling contractor's maintenance system. Function testing involves activating the hydraulic control system aboard the MODU and is generally undertaken every seven days. Pressure testing is undertaken to verify seals on the BOP stack and is undertaken every 21-days. The tests discharges approximately 2 m^3 of control fluid to the ocean. This fluid is water-soluble and readily disperses in the receiving waters after discharge from the BOP.

3.8.2.3 Formation Evaluation

During drilling, the formation may be evaluated to determine the presence and quantity of hydrocarbon within the target reservoir. This information is gathered real-time from 'logging while drilling' techniques or by running wireline tools into the well. Vertical seismic profiling is not planned.

'Logging while drilling' and wireline logging involve the use of downhole instruments such as sonic and resistivity sensors, low-level radioactive sources, magnetic resonance imaging, coring, and formation pressure/sampling tools.

There are no planned emissions or discharges during formation evaluation. All instruments are deployed directly down hole with no exposure to the marine environment.

3.8.2.4 Vertical Seismic Profiling

While vertical seismic profiling (VSP) is not expected to be required for the initial drilling campaign, VSP may be performed at some stage in the Project, such as during future drilling campaigns within the in-field development area. VSP may also be performed on a targeted basis during operations. The use of VSP in these instances will be through deployment of a single small sound source from the drilling rig or vessel in the water column while receivers are positioned at specific depths downhole within the well.

VSP provides a seismic image of the geology in the immediate vicinity of the well, with the survey taking approximately eight to 24 hours per well

VSP noise is not continuous. Each discharge of the seismic source generates a short, discrete, low frequency sound impulse. Seismic impulses during VSP are typically much lower than those generated during typical marine seismic surveys.

3.8.2.5 Well Completion, Unload and Test

Well completion is the process of preparing a drilled well for production. It involves installing production and flow control equipment, and completing the final construction of the well, including:

- Installation of the sand face completion, typically a production liner or sand screen across the producing reservoir interval
- Wellbore cleanup where the drilling fluid is displaced from the well and replaced with a filtered completion fluid, typically brine
- Evaluation of the cement bond for barrier and/or zonal isolation confirmation
- Perforating cemented production casing or liner with explosive charges to create communication from the reservoir into the wellbore
- Installation of the upper completion consisting of the production tubing, tubing hanger, surface-controlled subsurface safety valve and production packer. The completion may also include downhole monitoring capability and flow control equipment

- Installation of a production Christmas tree (an assembly of valves, spools, and fittings used to regulate hydrocarbon flow within a well). Trees will be located on the seabed

Completion operations may be performed immediately following the drilling of a new well or re-entry into an existing suspended well. In the case of a new well the completion would be performed immediately after drilling operations have concluded. A well re-entry operation would require the mobilisation of MODU to the existing well and removal of downhole barriers prior to commencing completion operations.

A re-entry operation may also entail a drilling element to either deepen or sidetrack the well to access undamaged or alternative reservoir targets or increase the reservoir interval available to production.

Discharge of completion fluids may occur as part of wellbore clean-up during completions. During the clean-up process, the completion fluids (consisting of completion brine and any formation water or condensate present in the wellbore) are circulated back to the MODU for treatment prior to discharge. Discharge may also include any excess completion brine remaining in the MODU tank system discharged to sea as per standard operating procedures.

If there is the potential for oil to be present, the completion fluids will be tested and discharged only if the oil in water content is below 30ppm. Fluid not meeting this criterion will be stored in tanks onboard the MODU for later onshore disposal.

Well completion is expected to be in the order of approximately 30 to 40 days duration for each well.

A well unload and test operation is performed after the well has been completed and is the process of removing well construction fluid from the well and bringing reservoir fluid (oil, condensate and/or gas) to surface. The objective of this activity is to remove well construction fluid so this is not received by the onshore Otway Gas Plant, and if necessary, undertake production testing to evaluate the reservoir potential and understand reservoir fluid properties. Unloading and testing the well to the rig for the Project is not intended however is provided for in this OPP as a contingency in the event it is required for technical and feasibility reasons..

The well construction fluid is typically a mixture of completion fluid (completion brine and any formation water or condensate present in the wellbore) and underbalance/low density fluid (base oil, diesel or nitrogen), remnants of drilling mud and loss control materials. Depending on the formation and well construction process there could also be solids such as formation and perforating debris. As the well construction fluid exits the well, reservoir fluid becomes more prominent in the flow stream consisting of gas and/or oil and native groundwater present in the formation.

In the case of a rig-based unloading operation undertaken on the MODU, the various flow stream mediums are separated (gas, oil, water) and either burnt off via a flare boom or stored in tanks for treatment prior to disposal overboard or onshore. Well testing may be undertaken for up to 48 hours depending on the well geometry, the objectives of the clean-up and the test operation.

Unloading a well of well construction fluid to the rig would be performed at up to approximately 65MMscf of gas per day being flared for between one and two days per well. Gas is flowed to flare via a dedicated gas line whilst high efficiency burners will be used that minimise the risk of fallout to ocean and enhance smokeless combustion of liquids.

The majority of fluids returned from the wellbore and formation are flammable and will be sent to the flare and burnt off. Non-flammable fluids, including any produced formation water or completion brine initially present in the wellbore, will be discharged to the marine environment via the well test water filtration treatment package.

Undertaking a well unloading operation direct to the OGP is the base case and eliminates the requirement to return well construction fluids and hydrocarbon to the MODU and subsequent flaring and offshore discharge. Once subsea facilities were installed and commissioned well fluid would flow to the OGP via the existing flowline.

In some operations, there may be applications it is necessary to bleed off formation fluids (gas) direct to atmosphere. This can be performed by the rig degasser (mud gas separator) or in some situations a dedicated “bleed off package” may be required. In such instances, gas is cold vented rather than flared. This may be required during abandonment and intervention operations when gas which is present in the wellbore needs to be removed, such as when performing a leak off test on a downhole device (barrier) or when displacing gas to fluid to perform a well re-entry, intervention or abandonment operation. Cold venting is considered an appropriate method of reservoir gas emission in instances when the gas volume and the rate of emission is typically significantly lower than which would be burnt at flare during a well unload and test.

Total discharge volume of completion fluids from well completion, unloading and testing will be up to approximately 300m3. Approximately 100 bbls (16 m3) of produced water may be generated and discharged per well a spart of this total volume, which will be treated to reduce the oil in water content to below 30ppm oil in water content prior to overboard discharge. Fluid not meeting this criterion will be stored in tanks for later onshore disposal. This low volume of 16m3 is due to the low formation water content in formation gas.

3.8.3 Installation and Commissioning

3.8.3.1 Installation

Subsea infrastructure will be transported to site and installed by Installation Support Vessels (ISVs) equipped with remotely operated vehicles (ROVs). A dedicated pipelay vessel or multipurpose service vessel may be required for long flowlines or umbilicals.

Diving operations may be required for limited activities such as tie-in to the existing OGPP hot tap tee assemblies, which are equipped with diver connections only. Such activities will be undertaken from a dive support vessel using saturation diving.

Flowlines and umbilicals will be laid directly onto the seabed within defined corridors, with no trenching required, and will be designed to be inherently stable. Localised placement of stabilisation mattresses, gravity weights, or small rock anchor structures may be required to assure stability adjacent to well and structure tie-in locations. Generally, stabilisation mattress are used for the flowlines, while gravity weights or anchor piles are used for OGPP and the hot tap tee locations to mitigate the lateral movement of these structures.

Stabilisation mattresses and gravity weights are lowered over the flowline from a vessel and typically cover an area of 18m^2. Rock anchor structures are generally installed by divers using a small installation frame. Once installed, the rock anchor sits above the flowline and has minimal impact on the seafloor.

Depending on the scope and length of flowlines, the installation of could be in the order of approximately between 10 to 20 days duration per well tieback.

3.8.3.2 Commissioning

It is anticipated that the majority of the commissioning activities will take place onshore, with only limited commissioning activities occurring within the Project Area.

Once installation is complete, subsea infrastructure will be integrity tested by hydrotesting from the ISV to verify system leak integrity before the ISV leaves the field. Flowlines are filled with fluid test medium and subjected to test pressures that will meet design code requirements, typically significantly above any pressures seen during operation.

The hydrotest fluid will comprise filtered seawater with corrosion inhibitor, oxygen scavenger and biocide additives. These chemicals are required to avoid metal corrosion, prevent bacterial growth and the accumulation of scale on internal surfaces. The hydrotest fluid volume is typically 120% of the flowline volume. The longest flowline for the Artisan and La Bella tie back base case is up to approximately 23km and longest single potential flowline from the southern T/30P permit to Thylacine field is up to approximately 65km in length. Based on a conservative flowline diameter (12 inches) this would result in a discharge of approximately 5,700m^3 of hydrotest fluid.

3.8.4 Operations

Activities associated with production operations include:

- hydrocarbon extraction and export;
- inspection, maintenance and repair; and
- well intervention.

3.8.4.1 Hydrocarbon Extraction and Export

Reservoir fluids will flow via the subsea infrastructure to the existing OGPP for export to the Otway Gas Plant. Control of the subsea system is via the umbilical(s) which transport electrical power, hydraulic fluids and chemicals to the required subsea locations.

The hydraulic fluid is glycol based and used to actuate subsea valves. The system is open so there will be a small volume released each time the valve is actuated. Based on the existing Otway Development, we estimate about 4 m^3 per year will be discharged to the marine environment.

Chemicals transported for injection into the wells including hydrate inhibitor (likely MEG or methanol) and scale inhibitor. These fluids operate in a closed loop system, with no planned discharges to the marine environment.

3.8.4.2 Inspection Maintenance and Repair (IMR)

Inspection, maintenance and repair activities are ongoing activities to ensure the reliability and performance of equipment. An as-built survey will be undertaken on completion of infrastructure installation with further inspections on a risk based frequency. Depending on the scope, each campaign could take in the order of approximately 30 days.

Inspections are undertaken by a ROV from a vessel and may include but are not limited to:

- Christmas Tree valve and equipment assessments
- cathodic protection surveys and anode replacement

- fluid leak detection
- general visual inspections for damage and missing items, fishing and anchoring interactions
- marine growth and fouling
- seabed scouring and flowline/structure freespans
- wall thickness measurements

Maintenance and repair activities are typically part of regular inspections but may also be required in response to inspection results. These activities are undertaken by ROV or divers from an appropriate vessel. Typical maintenance and repairs undertaken which may have an environmental impact include:

- Christmas Tree Control Module and/or choke replacement
- Wet Gas Flowmeter Replacement
- Acoustic Sand Detector Replacement
- anode replacement
- cathodic protection system maintenance
- flowline and umbilical repairs
- flowline and umbilical stabilisation
- general subsea infrastructure servicing including leak testing
- marine growth removal
- removal of fishing nets or other marine debris

3.8.4.3 Well Intervention and Workovers

Well interventions will be conducted from either a MODU or a light well intervention vessel. It may be required to:

- evaluate well condition or performance
- undertake well servicing operations such as to function or remediate downhole valves, remove obstructions, stimulate the well and shut-off or access producing zones
- restore well integrity
- suspend or prepare the well for abandonment

Intervention operations include activities such as:

- slickline / wireline / coil-tubing operations
- well testing and flowback
- well stimulation (acidizing, hydraulic fracturing)
- subsea Christmas Tree replacement

The most likely requirement for Otway well intervention would be slickline and/or wireline.

Subsea well intervention and servicing occurs by accessing the wellbore via the Christmas Tree. This would be managed either by utilising the MODU BOP and marine riser, an EDP/LMRP system, or a light well intervention system.

An intervention takes place within the upper completion and can often also involve access to the sand face completion. Specific types of tools that can be deployed down the well, conveyed by slickline, wireline or coil tubing to achieve the operation objectives.

A workover typically refers to the replacement of the well upper completion. This may be required due to the following

- restore well integrity not possible via intervention
- restore production and/or flow control functionality not possible by intervention
- isolate and/or access alternative reservoir targets not possible via intervention
- replace a horizontal Subsea Christmas Tree

Workovers are not anticipated as would result from an unplanned event. The frequency of well intervention and workover activities depends on well performance, objective criticality, MODU/vessel availability and regulatory requirements with an anticipated frequency for the Project of up to one well being worked over every seven years. The duration for workovers is up to 30 days.

Note there may be a potential requirement to cold vent formation gas during intervention and workover operations (refer to Section 3.8.2.5).

3.8.5 Decommissioning

3.8.5.1 Removal of subsea infrastructure

Decommissioning of wells and infrastructure installed as part of this Project will occur at the end of field life. Once production has ceased, wells will be shut-in and monitored as part of the Inspection Maintenance and Repair program. P&A of wells and removal of subsea infrastructure described within this OPP will occur as either a standalone campaign or as part of a wider decommissioning campaign. Decommissioning of subsea infrastructure is expected to take up to approximately 30 days per tie-back, with P&A of wells estimated at up to approximately 30 days per well.

Activities associated with decommissioning include:

- removal of subsea infrastructure, including flowlines, umbilicals and subsea structures
- plug and abandonment of wells

The OPGGS Act (Section 572(3)) states that a titleholder must remove from the title area all structures that are, and all equipment and other property that is, neither used nor to be used in connection with the operations. This obligation is subject to other provisions of the Act and allows titleholders to identify and seek approval for alternative arrangements.

The base case for decommissioning will involve the complete removal of all infrastructure.

In general, decommissioning includes:

- Displacement of hydrocarbons in manifolds, flowlines and umbilicals with a displacement fluid such as treated seawater to the existing infrastructure or a support vessel, followed by depressurisation. This fluid will be treated to remove hydrocarbons and discharged to the ocean, with volumes in the order of those estimated for commissioning and detailed in activity specific EPs

- Disconnection and removal of production manifolds and subsea structures
- Disconnection and removal of umbilicals
- Disconnection and removal of flowlines
- Retrieval of any flowline stabilisation equipment such as mattresses where possible
- Cutting of rock anchors or piles level with seabed
- Plugging and abandonment of wells

3.8.5.2 Well plugging and abandonment (P&A)

Well plugging and abandonment (P&A) procedures are designed to isolate the well and prevent the release of well fluids to the marine environment. During abandonment, cement and/or mechanical plugs may be set within the well to install a permanent reservoir and surface barrier. P&A includes activities such as:

- installation of a temporary isolation plug in wellbore
- removal of Christmas Tree
- installation of BOP
- isolation of all reservoir and production zones with cement plugs
- setting of permanent cement plug just below the mudline
- removal of BOP stack
- cutting of conductor below the mudline and recovery to MODU

Discharges to the marine environment will be limited to cement dust, cement contaminated water, excess dry cement (due to cement job for P&A operations) and annulus fluid released during conductor cutting, and those associated with MODU and vessel operations (Section 3.8.6.2). There may be a potential requirement to cold vent formation gas during P&A operations.(refer to Section 3.8.2.5).

3.8.6 Support Operations

Support operations associated with the project will include the use of MODUs, vessels, helicopters and ROVs with requirements varying depending on the project stage (Table 17).

Support Activity type	Drilling	Installation and commissioning	Operations	Decommissioning
MODU	✓		✓	✓
Helicopter	✓	✓	✓	✓
ROV	✓	✓	✓	✓
Anchor handler	✓		✓	✓

Support Activity type	Drilling	Installation and commissioning	Operations	Decommissioning
Supply	✓	✓	✓	✓
Pipelay/Multipurpose service		✓		✓
Installation support		✓		✓
Inspection, maintenance, repair			✓	
Saturation Dive support		✓	✓	✓

Table 17: Support Operations for each project stage

3.8.6.1 MODU Operations

The MODU selected for the initial drilling campaign, well intervention and workover, and plug and abandonment operations is a semi-submersible. The drill rig is expected to accommodate approximately 170 workers and will be equipped with marine–standard catering and ablution facilities. Capacity for fuel oil is expected to be up to approximately 3500m^3 and it will use approximately 15m^3 of diesel per day.

Environmental aspects include:

- bunkering / bulk transfer of fuel, chemicals, and supplies
- transfer of waste to supply vessels
- bilge water discharge
- sewage, greywater and food waste discharge
- cooling water, bilge and reverse osmosis (RO) brine discharge

The drilling unit will likely be mobilised from the previous operator's location to offshore Victoria using one or two vessels with a third vessel providing support. Essential personnel will remain on the MODU during mobilisation, with the remainder to transit to the vessel by helicopter once moored on location.

The semi-submersible drilling unit will run eight or twelve anchors to secure it on location. Each anchor ranges from 15 to 30MT with a footprint between 30 and 60m^2. Anchors are attached to the MODU by a chain or chain / wire system. The anchors will be positioned at approximately 1,300 m to 2,000m from the well location. Transponders using clump weights may be required to inform anchor position. A surface buoy with a navigation light and a device tracking and control (DTAC) transmitter enclosed inside the buoy will be attached to each anchor. Temporary wet storage of mooring equipment on the seabed may be required.

A jack-up rig may be utilised for future drilling, well intervention and workover campaigns.

If a jack-up is selected, it will be fixed in position by three rig feet, each with an approximate footprint of approximately 315m^2 each, giving a conservative total footprint of 1,500m^2 per well location.

While on location, a temporary exclusion zone will be gazetted in accordance with the OPGGS Act (500m radius around the drill rig). The purpose of the exclusion zone is to maintain a safe distance between the drilling campaign areas and fishing boats and other vessels that may operate in the area.

Representative semi-submersible and jack-up MODUs are shown in **Figure 8**.

Figure 8: Representative semi-submersible (left) and jack-up (right) MODUs

3.8.6.2 Vessel Operations

Table 18 summarises the expected vessel types, numbers and specifications for each stage of the Project. Examples of vessel types are shown in **Figure 9** to **Figure 13**. Vessels will use dynamic positioning (DP) to maintain position while undertaken activities. No vessel anchoring will take place unless in an emergency situation.

Typically, three vessels would operate in the project area at any one time, however, this could increase to five if, for example, pipelay and diving/tie-ins are undertaken at the same time as MODU positioning. Simultaneous operations will be kept to a minimum and are unlikely to occur for more than two days.

Vessel Type	**Duration**	**Purpose**	**Typical POB per vessel**
Anchor Handling Tug Support Vessel (**Figure 9**)	1-2 days per well location	Up to three vessels could be used to tow the MODU into position.	60
Supply/Support vessel (**Figure 10**)	As required for all stages of the project	Throughout all stages, support vessels will transport fuel, stores, waste and specialist supplies such as cement and drilling fluids to the MODU / vessels operating in the project area. Whilst drilling one support vessel will always be with the MODU.	30
Pipelay and multipurpose service vessel (**Figure 11**)	Approximately 10-20 days per tie-in for Installation and Commissioning stages and the same for Decommissioning	Installation and decommissioning of the flowlines and umbilicals	120-160

Vessel Type	Duration	Purpose	Typical POB per vessel
Installation Support Vessel and/or Dive Support Vessel (**Figure 12**)	Approximately 10-20 days per tie-in for Installation and Commissioning stages and the same for Decommissioning	Installation and commissioning of subsea infrastructure and decommissioning activities	120
Inspection Maintenance and Repair vessel (**Figure 13**)	Approximately 1 month	Inspections, maintenance and repair campaigns are expected to be conducted annually for the life of the field.	30

Table 18: Summary of Typical Support Vessel Requirements

Figure 9: Example of an Anchor Handling Tug

Figure 10: Example of a Supply Vessel

Figure 11: Example of a Pipelay/Multipurpose Service Vessel

Figure 12: Example of an Installation Support Vessel/Dive Support Vessel

Figure 13: Example of an Inspection, Maintenance, Repair Vessel

3.8.6.3 Helicopters

Helicopters are the primary form of transport for personnel to be transported to and from the MODU and may be used for installation and construction vessel transfers. It is also the quickest and preferred method to evacuate personnel in an emergency.

During drilling it is expected that there will be 5-8 round trips per week from the mainland to the MODU for crew changes and urgent supply needs. Helicopters will not be required during the operations stage.

Refuelling of helicopters does not usually take place offshore.

3.8.6.4 Remotely Operated Vehicles (ROV) and Autonomous Underwater Vehicles (AUV)

ROV and AUV operations may be conducted throughout all Project stages. ROVs and AUVs may also be used in an unplanned event such as a loss of well control.

ROVs and AUVs are not likely to be required to park or moor on the seabed during planned / routine activities.

3.8.6.5 Diving

Saturation and Air Diving operations may be conducted as part of installation activities, for commissioning and operational support (inspections, maintenance and repair), and decommissioning. Diving may also be used in an unplanned event such as a loss of containment from a flowline.

There are no emissions or discharges expected from diving activities other than those generated by the vessel.

3.9 Assessment of Alternatives

3.9.1 Overview

The OPGGS (Environment) Regulations require that the OPP describe any feasible alternatives to the Project or to an activity that is part of the Project, including:

- a comparison of the environmental impacts and risks arising from the project or activity and the alternative; and
- an explanation as to why the alternative was not preferred.

This section of the OPP presents the alternatives considered for the Project concept and design and an overview of the advantages and disadvantages of each alternative with an emphasis on environmental impacts and risks. It also provides a justification for the selection of the preferred option.

3.9.2 Alternative project concepts

Previous work was undertaken in assessing the facility type and functionality of the nearby proposed Trefoil Project in Bass Strait with minimum facility and full processing platforms eliminated as a requirement due primarily to the presence of existing infrastructure, and the wellhead platform and subsea development options being assessed in more detail. The mitigation of risks and complexity associated with platform installation as well as rig-based workovers was an important consideration.

The learnings on technically and commercially feasible options were applied to the screening of development options for this Project in addition to factors specific to the Otway development, particularly the presence of existing subsea infrastructure and the relatively small number of additional potential wells.

The two main alternative development options for the Project were subsea development or wellhead platforms.

The first concept is completely subsea, with subsea wellheads connected to existing infrastructure with the shortest suitable routes between fields and tie-ins., controls via umbilical and intelligent completions.

The second concept involves the installation of wellhead platforms (most likely unmanned) over the fields with dry trees (surface wellheads) and tying back export flowlines to the existing OGPP, as per the first concept.

Table 19 provides more detail on the environmental risks and impacts of both of these concepts.

For the purpose of this OPP, the assessment of alternatives is carried out by undertaking a comparative assessment of the alternatives against environmental criteria to identify the options with the least environmental impact.

The qualitative assessment of each concept shows that Concept 1 – Subsea tie-backs to the existing infrastructure has the lowest environmental footprint when considered over the life of the development. Furthermore, it is the most economical, safe and feasible option and as such is the preferred choice.

The proposed subsea concept is the simplest possible, utilising existing infrastructure and subsea wellheads, with the shortest suitable routes between fields and tie-ins. The alternative of installation of a wellhead platform adds complexity and cost in addition to increased environmental impact, compared to the subsea development proposed.

The preferred subsea concept offers the smallest environmental footprint and lowest environmental impact. In simple terms, the current development is considered a brownfield development and extension of the current Otway Development (Thylacine and Geographe).

The no further activity option is described in Section 3.9.2.1.

Criteria	Comparison of Concept 1 (Subsea tie-back to existing facilities) and Concept 2 (WHP with dry trees)
Environmental	
Seabed disturbance	Concept 1 has the lower seabed disturbance based on the following: • Concept 1 footprint is limited to subsea infrastructure whereas Concept 2 footprint includes WHP and associated infrastructure. • Concept 2 has additional seabed disturbance due to positioning of MODU on seabed for well interventions. Subsea completions of Concept 1 enable the use of a light intervention vessel instead of a MODU and reduced intervention frequency.
Interaction with marine fauna (MODU and vessels)	Concept 1 has the lower risk of interaction with marine fauna based on the following: • Concept 2 has additional risk of interactions due to a MODU and associated support vessels being required for well interventions. Subsea completions of Concept 1 enable the use of a light intervention vessel instead of a MODU and reduced intervention frequency. • The WHP and dry trees of Concept 2 require increased IMR activities and associated vessels than the intelligent completion of Concept 1 and so an increased risk of adverse interaction with marine fauna. • The WHP of Concept 2 require increased decommissioning activities and associated vessels to remove than the subsea development of Concept 1 and so an increased risk of adverse interaction with marine fauna.
Displacement of other users	Concept 1 has the lower risk of displacement of other users based on the following: • Concept 1 avoids the navigation hazard of the WHP of Concept 2- there is significant surface vessel traffic through this area and hence subsea facilities offer least risk of collision or vessel traffic disturbance (reduced PSZ area). • Concept 2 has additional risk of interactions due to a MODU and associated support vessels being required for well interventions. Subsea completions of Concept 1 enable the use of a light intervention vessel instead of a MODU and reduced intervention frequency. • The WHP and dry trees of Concept 2 require increased IMR activities and associated vessels than the intelligent completion of Concept 1 and so an increased risk of adverse interaction with stakeholders. • The WHP of Concept 2 require increased decommissioning activities and associated vessels to remove than the subsea development of Concept 1 and so an increased risk of adverse interaction with stakeholders.
Underwater noise	Concept 1 has the lowest underwater noise emissions due to the following: • Concept 2 includes a WHP which will produce continuous long-term underwater noise, although minimal, during operations • Concept 2 has additional noise from a MODU which is required for well interventions. Subsea completions of Concept 1 enable the use of a light intervention vessel instead of a MODU and reduced intervention frequency. • The WHP and dry trees of Concept 2 require increased IMR activities and associated vessels than the intelligent completion of Concept 1 and so increased underwater noise emissions. • The WHP of Concept 2 require increased installation and decommissioning activities and associated vessels than the subsea development of Concept 1 and so increased underwater noise emissions
Atmospheric emissions	Concept 1 has the lowest atmospheric emissions due to the following: • Concept 2 includes a WHP which will result in continuous long-term atmospheric emissions from power generation. • Concept 2 has additional emissions from a MODU which is required for well interventions. Subsea completions of Concept 1 enable the use of a light intervention vessel instead of a MODU and reduced intervention frequency. • The WHP and dry trees of Concept 2 require increased IMR activities and associated vessels than the intelligent completion of Concept 1 and so increased atmospheric emissions • The WHP of Concept 2 require increased installation and decommissioning activities and associated vessels than the subsea development of Concept 1 and so increased atmospheric emissions
Light emissions	Concept 1 has the lowest underwater noise emissions due to the following: • Concept 2 includes a WHP which will produce continuous, although minimal, light emissions during operations • Concept 2 has additional noise from a MODU which is required for well interventions. Subsea completions of Concept 1 enable the use of a light intervention vessel instead of a MODU and reduced intervention frequency. • The WHP and dry trees of Concept 2 require increased IMR activities and associated vessels than the intelligent completion of Concept 1 and so increased light emissions. • The WHP of Concept 2 require increased installation and decommissioning activities and associated vessels than the subsea development of Concept 1 and so increased light emissions
Introduction of IMS	Concept 1 has the lower risk of IMS introductions based on the following: • Concept 2 has additional risk due to a MODU and associated support vessels being required for well interventions. Subsea completions of Concept 1 enable the use of a light intervention vessel instead of a MODU and reduced intervention frequency. • The WHP and dry trees of Concept 2 require increased IMR activities and associated vessels than the intelligent completion of Concept 1 and so an increased risk of IMS introduction
Planned liquid, solid discharges and waste	Concept 1 has the lowest planned discharges due to the following: • Concept 2 has additional planned discharges from a MODU which is required for well interventions. Subsea completions of Concept 1 enable the use of a light intervention vessel instead of a MODU and reduced intervention frequency. • The WHP and dry trees of Concept 2 require increased IMR activities and associated vessels than the intelligent completion of Concept 1 and so increased planned discharges

Criteria	Comparison of Concept 1 (Subsea tie-back to existing facilities) and Concept 2 (WHP with dry trees)
	• The WHP of Concept 2 require increased installation and decommissioning activities and associated vessels than the subsea development of Concept 1 and so increased planned discharges
Unplanned discharges and releases	Concept 1 has the lowest risk of unplanned discharges and releases based on the following: • •Concept 2 has additional planned unplanned release risk from MODU well interventions. Subsea completions of Concept 1 enable the use of a light intervention vessel instead of a MODU and reduced intervention frequency. • The WHP and dry trees of Concept 2 require increased IMR activities and associated vessels than the intelligent completion of Concept 1 and so increased risk of unplanned releases. • The WHP of Concept 2 require increased installation and decommissioning activities and associated vessels than the subsea development of Concept 1 and so increased risk of unplanned releases
Safety	Concept 1 has the lowest safety risks based on the following: • The installation of a WHP for Concept 2 requires major offshore construction • Concept 2 has additional risk due to a MODU and associated support vessels being required for well interventions. Subsea completions of Concept 1 enable the use of a light intervention vessel instead of a MODU and reduced intervention frequency. • The WHP and dry trees of Concept 2 require increased IMR activities and so personnel visits via helicopter to the WHP and so an increased risk. There is no accommodation so crews will need to flyin/out on daily basis. • The WHP and dry trees of Concept 2 require increased IMR activities and associated vessels than the intelligent completion of Concept 1 and so an increased risk. • The WHP of Concept 2 require increased installation and decommissioning activities and associated vessels than the subsea development of Concept 1 and so increased safety risks. • Concept 1 avoids the navigation hazard of the WHP of Concept 2- there is significant surface vessel traffic through this area and hence subsea facilities offer least risk of collision
Economics	Both Concepts have similar CAPEX, whereas Concept 1 has lower OPEX.

Table 19: Alternate Analysis of development concepts

3.9.2.1 No further activity

Not undertaking the Project was an alternative considered by Beach. If the project does not go-ahead, then gas production from Beach's Otway assets will decline and the gas pools will become stranded.

The Project is being undertaken to replace existing production in the Otway Basin and ultimately to deliver natural gas into three million Victorian homes and businesses. Importantly, this gas will help arrest a predicted gas shortfall in Victoria and is therefore critical to ensure Victoria's energy security.

In March 2023 the Australian Energy Market Operator (AEMO) published the 2023 Victorian Gas Planning Report which found that Victorian production continues to decline, with large forecast reductions in 2024 and 2027. This will impact negatively on the reliability of the gas supply system and ability to meet daily peak supplies.

The Victorian economy is heavily reliant on gas. It is utilised for electricity generation, and for manufacturing, construction, agricultural and chemical industries. Victorian households have the highest natural gas usage in Australia. The state accounts for approximately 50% of gas demand in south-eastern Australia. It is vitally important to the viability of Victorian industries and residents that gas supplies are adequate and price volatility is suppressed. The additional supply from offshore will contribute not only to individual and community well-being but will support businesses and industry to maintain a competitive economy.

Demand is expected to continue in Victoria and the south-eastern states particularly because of the decline in coal consumption with the closure of coal-fired power stations. Peak gas demand records are being broken and will likely increase due to coal to gas switching competing for gas for heat use.

Existing southern gas reserves are in decline, and more development is required in the southern states from 2024 to ensure that all demand is met. AEMO has forecast that if Victoria wishes to accelerate the closure of its coal-fired power stations, more peaking gas-powered generation (gas needed during periods of high demand) will be needed to ensure the reliability of supply. As Australia transitions to a low emissions economy underpinned by renewable energy, natural gas will play a critical role by efficiently supporting the intermittency of solar and wind energy and future renewable technologies whilst assisting in the continued development of an internationally competitive economy. The role of gas is illustrated in **Figure 14**.

Figure 1 **Forecast NEM capacity to 2050, *Step Change* scenario**

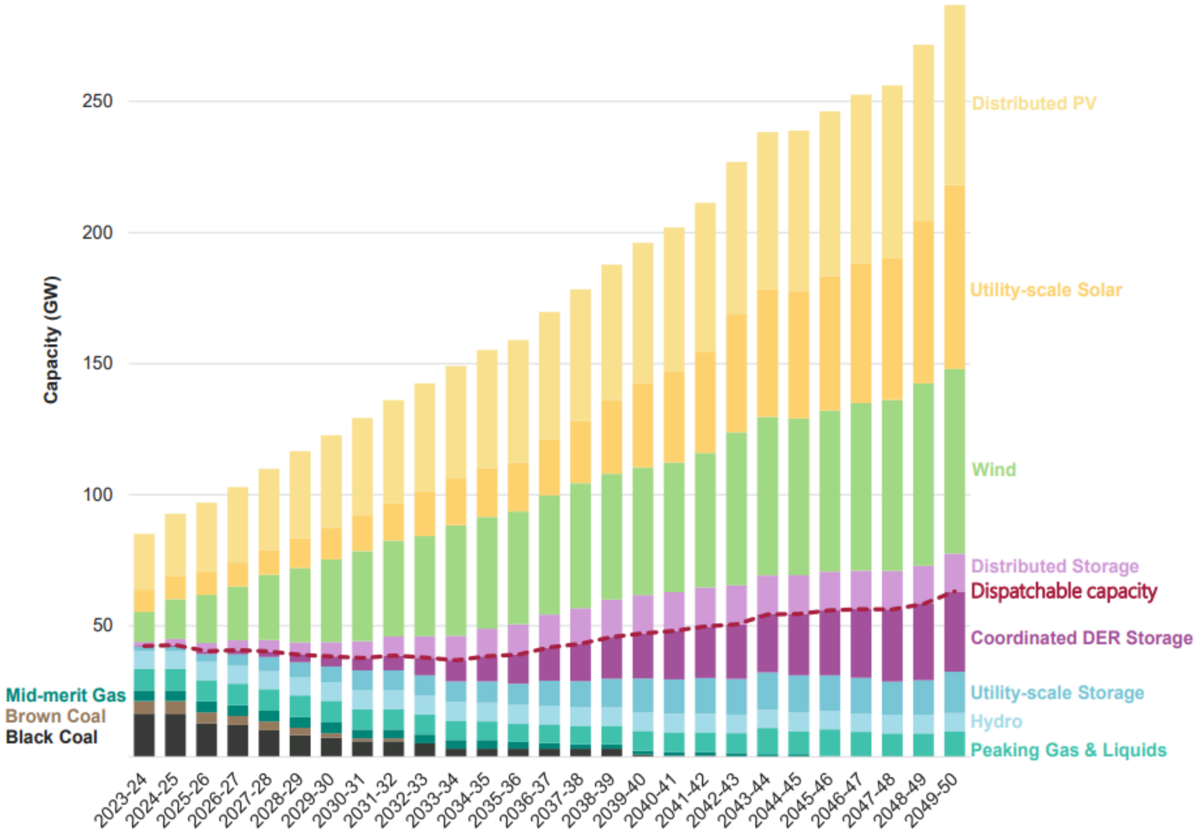


Figure 14: Forecast National Energy Market capacity to 2050, Step Change scenario (AEMO 2022 Integrated System Plan)

The *Victorian Climate Change Act 2017* establishes a long-term emissions reduction target for Victoria of Net Zero by 2050. The legislation requires 5-year interim targets to track the state's progress. From 2021, Adaptation Action Plans are required for key Victorian systems that may be vulnerable to climate change impacts. The legislation also requires periodic reporting to ensure transparency and accountability to the community.

The role of new gas investments within this geopolitical context is part of the transition toward lower emissions technologies and energy sources. Otway gas will play a role in reducing Victoria and Australia's emissions footprint. The development of more natural gas supplies is seen as critical in reducing Australia's emissions footprint. The Integrated System Plan (ISP), which models electricity generation over the next 20 years in the National Electricity Market (NEM), was updated in June 2022 by AEMO. In the ISP most aggressive 'Step Change' scenario, it forecasts 10 GW of gas-fired generation will be required for peak loads and firming. The ISP states that "Gas-fired generation will play a crucial role as coal-fired generation retires. It will complement battery and pumped hydro generation in periods of peak demand, particularly during long 'dark and still' weather periods. It will help cover for planned maintenance of existing generation and transmission and provide essential power system services to maintain grid security and stability, particularly following unexpected outages or earlier than expected generation withdrawal. "(AEMO, *Integrated System Plan June 2022*).

3.9.3 Subsea development design/activity alternatives

The Project a brownfield extension of the existing production infrastructure and operations. The design of the Thylacine and Geographe production operations planned for future subsea development of surrounding fields with the installation of hot tap tees on the OGPP and connections at the base of the Thylacine platform.

The preferred development concept for the project is installation of new subsea wells, flowlines and facilities utilising existing production and transport infrastructure. While other development concepts were not considered in detail for the Project, concept studies did assess alternate facility design.

Table 20 summarises the base case, alternative design options considered and environmental assessments identified from workshops, scoping studies and risk assessments undertaken to date to optimise the subsea development with environmental impacts a key consideration.

Further consideration of controls will be provided in activity specific Environment Plans.

Base case	Alternatives considered	Environmental assessment
Drilling design for exploration wells that allow conversion to production well in success case	P&A exploration wells and drill additional wells in a success case	The base case reduces the number of wells being drilled and associated reduction in drilling environmental impacts and risks
Subsea architecture optimisation – hub and spoke arrangement for initial development with well tiebacks direct to pipeline tie in points.	Subsea architecture – daisy chain arrangement for initial development with well tie backs to either pipeline tie in points or tied back into other wells.	The base case enables each well tieback production system to be isolated If there was a leak, reducing the potential volume of hydrocarbon lost to sea. In addition the hub and spoke arrangement results in less installation time, reducing the associated environmental impacts and risks.
DP assist MODU	Anchored floating MODU or Jack up MODU	The base case involves the use of thrusters that generate underwater noise emissions. This capability could assist in reducing fatigue on the mooring system and assist the MODU during transit. A review of operational data indicates thrusters are typically not active (>96% of the time) and utilisation is limited to low loads across a few thrusters for short periods, (typically hours) in response to metocean conditions The base case MODU reduces the seabed disturbance due to reduced anchor usage.
Unloading of well construction fluids by flow of fluids directly to the OGP	Unloading of completion fluids to the MODU	The base case eliminates flaring and completion fluid discharge offshore and associated environmental impacts. Unloading to the MODU is a contingency option if required for technical reasons and so is assessed in the OPP.
Water Based Drilling Fluids (WBDF)	Synthetic Based Drilling Fluids (SBDF)	WBDF is a low to no toxicity whereas SBDF can have higher toxicity dependent on composition and technical requirement. Beach uses WBDF where there is no technical detriment and is the base case. The use of SBDF is a contingency option if required for technical reasons and so is assessed in the OPP.
Overboard disposal of well construction, reservoir and completion fluids from MODU	Onshore disposal	Onshore disposal is not considered practicable due to the large volumes involved and the number of vessel movements required to store and transport the fluid and cutting. The vessels required will increase the associated environmental impacts and risks, including emissions, interactions with marine users and marine fauna, as well as HSE risks. The fluids are typically low toxicity and are selected in accordance with chemical assessment protocols to ensure that the chemicals selected are the least toxic and environmentally harmful chemicals able to meet technical requirements.
Overboard disposal of drill cuttings and fluids from MODU		
Overboard disposal of MODU planned discharges – sewage, grey water, food, drainage, bilge, cooling water		
Hydrotest fluid discharge to sea		

Table 20: Subsea development design options environmental assessment

4. Description of the Environment

The physical, biological, and socio-economic environment that may be affected by the project is described in this section, together with the details of the particular relevant values and sensitivities of that environment.

The existing environment that may be affected by the project is defined as the area where a change to ambient environmental conditions may potentially occur as a result of planned activities or unplanned events. It is noted that a change does not always imply that an adverse impact will occur; for example, a change may be required over a particular exposure value or over a consistent period of time for an adverse impact to occur.

Table 21 and Figure 15 detail the areas associated with the project that are used to describe the environmental that may be affected. In addition to those zones, aspect-specific EMBAs are defined in the environmental impact evaluation, including light EMBAs and noise EMBAs. Where relevant, these EMBAs are shown spatially within this chapter.

Zones	Description
Project Area	The Project Area is within Commonwealth waters and is where all infrastructure and activities associated with the project will be undertaken as detailed in Section 3.5. The EPBC Protected Matters Search Tool (PMST) Report for the Project Area is provided in Appendix A.
Planning Area	The Planning Area is within Commonwealth, Victorian and Tasmanian waters and reaches Victorian and Tasmanian shorelines (**Figure 15**). The Planning Area is based on a combination of the MDO (Diesel) Planning Area and Condensate Planning Area based on the spill modelling to the low thresholds as detailed in Section 7.4 for two separate release locations for conservatism. The PMST Report for the Planning Area is in Appendix B.

Table 21: Description of the Areas Used to Define the Existing Environment

4.1 Regional Context

The Project Area and Planning Area are within the South-east Marine Region, with the Project Area within the Western Bass Strait Shelf Transition and West Tasmania Transition Provincial bioregions (Figure 15). The bioregions are based on the Integrated Marine and Coastal Regionalisation of Australia (IMCRA v4.0) which is a spatial framework for classifying Australia’s marine environment into bioregions that make sense ecologically and are at a scale useful for regional planning (CoA 2005).

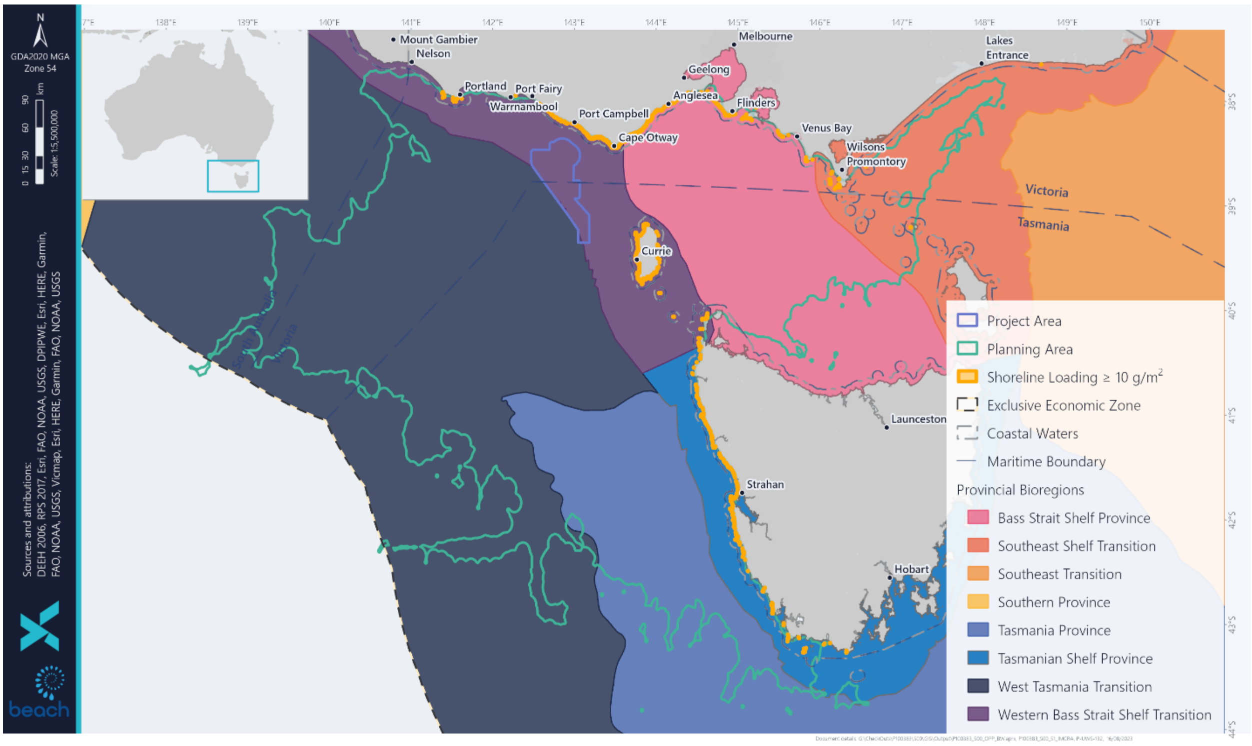


Figure 15: Provincial Bioregions within the Project Area and Planning Area

4.2 Conservation Values and Sensitivities

The following section details the conservation values and sensitivities identified within the Project Area and Planning Area identified from PMST Reports, referenced material and relevant person consultation.

4.2.1 World Heritage Properties

No World Heritage Properties were identified within the Project Area. The PMST Report (Appendix B) identified one World Heritage Property, Tasmanian Wilderness, within the Planning Area (**Figure 16**).

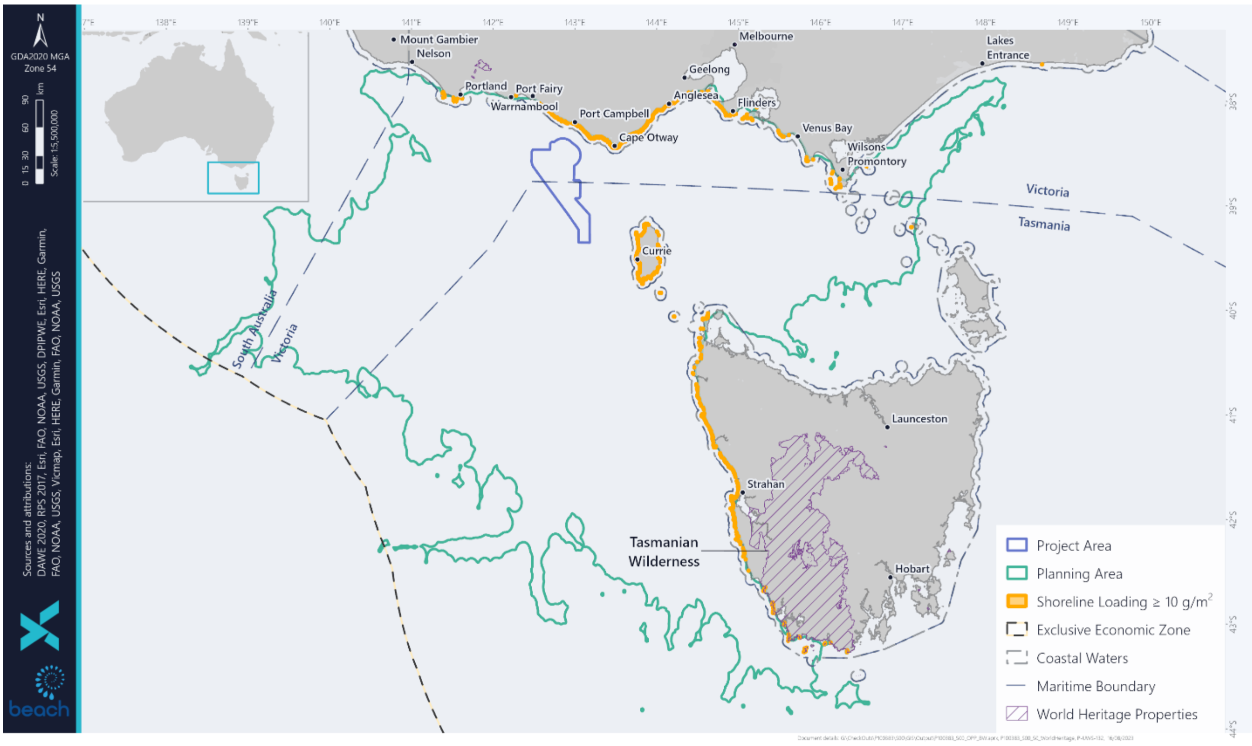


Figure 16: World Heritage Properties within the Planning Area

4.2.1.1 Tasmanian Wilderness

The Tasmanian Wilderness is one the world’s largest temperate wilderness areas. Listed in 1982, it is a precious cultural landscape for Tasmanian Aboriginal people, who lived there for at least 35,000 years (DPIPWE 2016). The Tasmanian Wilderness is an outstanding example representing major stages of the earth's evolutionary history. The Tasmanian Wilderness has outstanding examples representing significant ongoing geological processes and ongoing ecological and biological processes in the evolution and development of terrestrial, fresh water and coastal ecosystems and communities.

The landscape of the Tasmanian Wilderness has exceptional natural beauty and aesthetic importance and contains superlative natural phenomena including rare fauna and flora. The ecosystems of the Tasmanian Wilderness contain important and significant natural habitats where threatened species of animals and plants of outstanding universal value from the point of view of science and conservation still survive including habitats important for endemic plant and animal taxa and taxa of conservation significance (DPIPWE 2016).

The Tasmanian Wilderness bears a unique and exceptional testimony to an ancient, ice age society, represented by Pleistocene archaeological sites that are unique, of great antiquity and exceptional in nature, demonstrating the sequence of human occupation at high southern latitudes during the last ice age (DPIPWE 2016).

The Tasmanian Wilderness provides outstanding examples of a type of landscape which illustrates a significant stage in human history. The world heritage values include archaeological sites which provide important examples of the hunting and gathering way of life, showing how people practised this way of life over long time periods, during often extreme climatic conditions and in contexts where it came under the impact of irreversible socio-cultural and economic change.

4.2.2 Australian Marine Parks

One Australian Marine Park (AMP), Zeehan Multiple Use Zone (IUCN VI) was identified within the Project Area according to the PMST Report, however this is due to the size of the grids used in the PMST and does not actually intersect the Project Area.

Eight AMPs were identified within the Planning Area from the PMST Report (Appendix B) (**Figure 17**):

- Apollo (Multiple Use Zone IUCN VI)
- Beagle (Multiple Use Zone IUCN VI)
- Boags (Multiple Use Zone IUCN VI)
- Franklin (Multiple Use Zone IUCN VI)
- Nelson (Special Purpose Zone IUCN VII)
- Tasman Fracture (Marine National Park Zone IUCN II; Multiple Use Zone IUCN VI)
- Zeehan (Special Purpose Zone IUCN VI)
- Huon (Multiple Use Zone IUCN VI)

The majority of AMPs within the Planning Area are classified as International Union for Conservation of Nature (IUCN) VI – Multiple Use Zone, in which a wide range of sustainable activities are allowed if they do not significantly impact on benthic (seafloor) habitats or have an unacceptable impact on the values of the area. Allowable activities include commercial fishing, general use, recreational fishing, defence, and emergency response. Some forms of commercial fishing, excluding demersal trawl, Danish seine, gill netting (below 183m) and scallop dredging, are allowed, provided that the operator has approval from the Director of National Parks and abides by the conditions of that approval.

The Nelson AMP and a section of Zeehan AMP within the Planning Area are classified as IUCN VI - Special Purpose Zone, which allows for limited mining and low-level extraction of natural resources. Permitted activities are similar to Multiple Use Zones; however, commercial fishing is not permitted.

The north-east section of the Tasman Fracture AMP within the Planning Area is classified as IUCN II – Marine National Park Zone, which does not allow recreational or commercial fishing. Research and monitoring as well as structures and works are permitted with required authorisation.

The South-east Marine Reserves are managed under the South-east Marine Reserves Management Plan (DNP 2013).

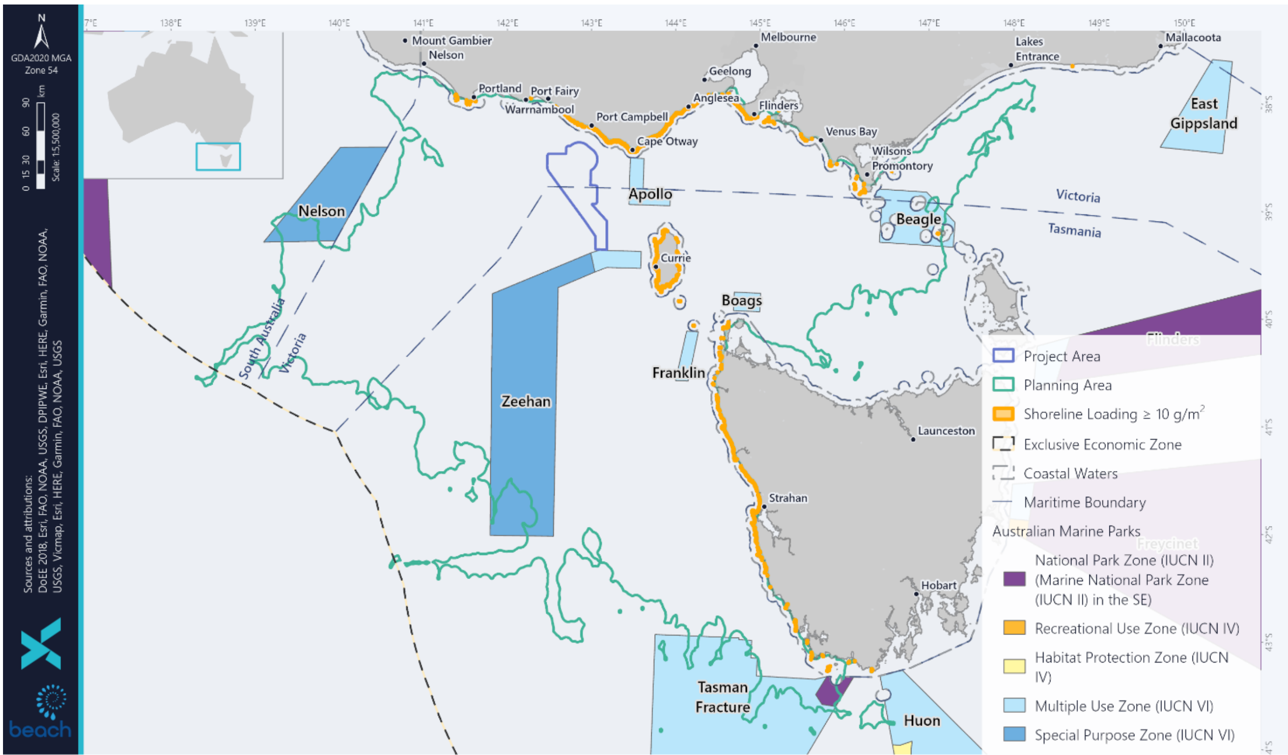


Figure 17: Australian Marine Parks within the Planning Area

4.2.2.1 Apollo AMP

The Apollo AMP is located off Apollo Bay on Victoria's west coast in waters 80m to 120m deep on the continental shelf. The reserve covers 1,18km^2 of Commonwealth ocean territory (DNP 2013). The AMP encompasses the continental shelf ecosystem of the major biological zone that extends from South Australia to the west of Tasmania. The area includes the Otway Depression, an undersea valley that joins the Bass Basin to the open ocean. Apollo AMP is a relatively shallow reserve with big waves and strong tidal flows; the rough seas provide habitats for Fur Seals and School Sharks (DNP 2013).

The major conservation values of the Apollo AMP (DNP 2013) are:

- ecosystems, habitats, and communities associated with the Western Bass Strait Shelf Transition and the Bass Strait Shelf Province and associated with the seafloor features: deep/hole/valley and shelf.
- important migration area for Blue, Fin, Sei and Humpback Whales.
- important foraging area for Black-browed and Shy Albatross, Australasian Gannet, Short-tailed Shearwater and Crested Tern.
- cultural and heritage site - wreck of the MV City of Rayville.

4.2.2.2 Beagle AMP

The Beagle AMP is an area in shallow continental shelf depths of about 50m to 70m, which extends around south-eastern Australia to Tasmania covering an area of 2,928km^2 (DNP 2013). The reserve includes the fauna of central Bass Strait; an area known for its high biodiversity. The deeper water habitats are likely to include rocky reefs supporting beds of encrusting, erect and branching sponges, and sediment composed of shell grit with patches of large sponges and sparse sponge habitats.

The reserve includes islands that are important breeding colonies for seabirds and the Australian Fur-seal, and waters that are important foraging areas for these species. The species-rich waters also attract top predators such as Killer Whales and White Sharks.

The major conservation values of the Beagle AMP (DNP 2013) are:

- ecosystems, habitats, and communities associated with the Southeast Shelf Transition and associated with the seafloor features: basin, plateau, shelf, and sill.
- important migration and resting areas for Southern Right Whales.
- provides important foraging habitat for the Australian Fur-seal, Killer Whale, White Shark, Shy Albatross, Australasian Gannet, Short-tailed Shearwater, Pacific and Silver Gulls, Crested Tern, Common Diving Petrel, Fairy Prion, Black-faced Cormorant, and Little Penguin.
- cultural and heritage sites including the wreck of the steamship SS Cambridge and the wreck of the ketch Eliza Davies.

4.2.2.3 Boags AMP

The Boags AMP is located off the northwest tip of Tasmania, just north of Three Hummock Island. It has a depth range of 40-80 m, covering an area of 537km^2 (DNP 2013). The park encompasses diverse soft sediment communities dominated by crustaceans, polychaete worms and molluscs.

The major conservation values for the Boags AMP (DNP 2013) are:

- shallow waters of central Bass Straight are habitat to rich arrays of animals that live on the seafloor and in the sediment.
- provides important foraging grounds for nearby breeding colonies of seabirds and
- habitat for Southern Right and Pygmy Blue Whales.

4.2.2.4 Franklin AMP

The Franklin AMP covers an area of 671km^2 west of the north-western corner of Tasmania and south-east of King Island (DNP, 2013). At its northern end, the waters are only 40m deep, and in much of the reserve the sea floor slopes gently and is covered by fine and coarse sediments. At the southern end of the reserve there is a valley where the water is up to 150m deep.

The major conservation values for the Franklin AMP (DNP 2013) are:

- examples of ecosystems, habitats and communities associated with the Tasmanian Shelf Province and the Western Bass Strait Shelf Transition and associated with sea-floor features: shelf, deep/hole/valley, escarpment, and plateau.
- important foraging area for Shy Albatross, Short-Tailed shearwater, Australasian Gannet, Fairy Prion, Little Penguin, Common Diving Petrel, Black-Faced Cormorant and Silver Gull.

Black Pyramid Rock, 6km north of the AMP supports the largest breeding colony of the Australasian Gannet in Tasmania, and one of only eight breeding sites for this species in Australia. White shark also forage in the AMP.

4.2.2.5 Nelson AMP

The Nelson AMP covers an area of 6,123km^2 off the coast of South Australia, along the shared maritime border with Victoria (DNP 2013). Due to being beyond the continental shelf, water depths within the park exceed 3,000m and contains geological features including plateaus, knolls, canyons and the abyssal plain.

The major conservation values of the Nelson AMP (DNP 2013) are:

- examples of ecosystems, habitats and communities associated with the West Tasmanian Transition and associated with sea-floor features: abyssal plain/deep ocean floor, canyon, knoll/abyssal hill, plateau and slope.
- important migration area for:
  - Humpback Whale
  - Blue, Fin and Sei Whales (likely migration)

4.2.2.6 Tasman Fracture AMP

The Tasman Fracture AMP covers an area of 42,501km^2 in the south-west of Tasmania. (DNP 2013). The AMP extends beyond continental shelf, covering the continental slope and deepwater ecosystems as well as several geological features. Waters surrounding Mewstone, which hosts the largest colony of Shy Albatrosses, are also protected by the AMP. Water depths vary significantly throughout the AMP, ranging from 60m to 5,559m. The Planning Area overlaps the Multiple Use Zone (IUCN VI) and National Park Zone (IUCN II). There is an additional Special Purpose Zone to the south of the Planning Area.

The major conservation values for the Tasman Fracture AMP (DNP 2013) are:

- examples of ecosystems, habitats and communities with the Tasman Province, the Tasmanian Shelf Province and West Tasmania Transition and associated with sea-floor features: abyssal plain/deep ocean floor, basin, canyon, knoll/abyssal hill, pinnacle, plateau, ridge, saddle, shelf, slope, terrace, and trench/trough.
- important whale migration for:
  - Humpback Whale
- important foraging areas for:
  - New Zealand Fur-seal
  - Wandering, Black-browed and Shy Albatrosses; White-chinned Petrel; Common Diving-petrel; Short-tailed Shearwater; and Fairy Prion
  - White Shark

4.2.2.7 Zeehan AMP

The Zeehan AMP covers an area of 19,897 km^2 to the west and south-west of King Island in Commonwealth waters surrounding north-western Tasmania (DNP 2013). It covers a broad depth range from the shallow continental shelf depth of 50 m to the abyssal plain which is over 3,000 m deep. The AMP spans the continental shelf, continental slope and deeper water ecosystems of the major biological zone that extends from South Australia to the west of Tasmania. Four submarine canyons incise the continental slope, extending from the shelf edge to the abyssal plains. A rich community made up of large sponges and other permanently attached or fixed invertebrates is present on the continental shelf, including Giant Crab (*Pseudocarcinus gigas*). Concentrations of larval Blue Wahoo (*Seriolella brama*) and Ocean Perch (*Helicolenus* spp.) demonstrate the role of the area as a nursery ground.

Rocky limestone banks provide important seabed habitats for a variety of commercial fish and crustacean species including the Giant Crab. The area is also a foraging area for a variety of seabirds such as Fairy Prion, Shy Albatross, Silver Gull, and Short Tail Shearwater (DNP 2013).

The major conservation values for the Zeehan AMP (DNP 2013) are:

- examples of ecosystems, habitats and communities associated with the Tasmania Province, the West Tasmania Transition and the Western Bass Strait Shelf Transition and associated with the seafloor features: abyssal plain/deep ocean floor, canyon, deep/hole/valley, knoll/abyssal hill, shelf, and slope.
- important migration area for Blue and Humpback Whales.
- important foraging habitat for Black-Browed, Wandering and Shy Albatrosses, and Great-Winged and Cape Petrels.

4.2.2.8 Huon AMP

- The Huon AMP is located 19km south-east of Tasmania and comprises a total area of 9,991 km2 with water depths ranging from 70m to 3,000m (DNP 2013). The reserve contains the largest cluster of seamounts in Australian waters which provide a range of depths for a diversity of species. Seamounts are areas of high productivity and play an important role in the transoceanic dispersal of larvae for bottom-dwelling species. The undulating slopes of the seamounts accelerates water currents which expose rocky substrate for many species including corals and sponges and provide a rich food source for filter feeders (DNP 2013). The reserve is also an important foraging area for seabirds including black-browed, Buller's and shy albatrosses, great-winged petrel, short-tailed shearwater and fairy prion. Commercially important fish species such as the blue warehou and ocean perch are known use the reserve as a spawning and nursery area. White sharks and Australian fur seals are also known to utilise the reserve.

- The major conservation values of the Huon AMP (DNP 2013) are:
- Ecosystems, habitats and communities associated with the Tasmanian Shelf Province, Tasmania Province and associated with seafloor features: canyon, seamount, pinnacle, saddle, shelf, and terrace.
- Features with high biodiversity and productivity: seamounts south and east of Tasmania
- Important foraging area for black-browed, Buller's and shy albatrosses, great-winged petrel, short-tailed shearwater and fairy prion, Australian fur seal and killer whale
- Important migration area for humpback whale

4.2.3 National Heritage Places

No National Heritage Places were identified within the Project Area (Appendix A). Five National Heritage places were identified within the Planning Area (PMST Report Appendix B) (**Figure 18**):

- Great Ocean Road and Scenic Environs
- Point Nepean Defence Sites and Quarantine Station Area
- Quarantine Station and Surrounds (within Point Nepean Site)

- Tasmanian Wilderness
- Western Tasmania Aboriginal Cultural Landscape

Two nominated places, Point Lonsdale Lighthouse Reserve and Environs and Summerland Peninsula, overlap the Planning Area but are not yet listed (**Figure 18**). Information on the National Heritage Places is sourced from the Australian Heritage Database.

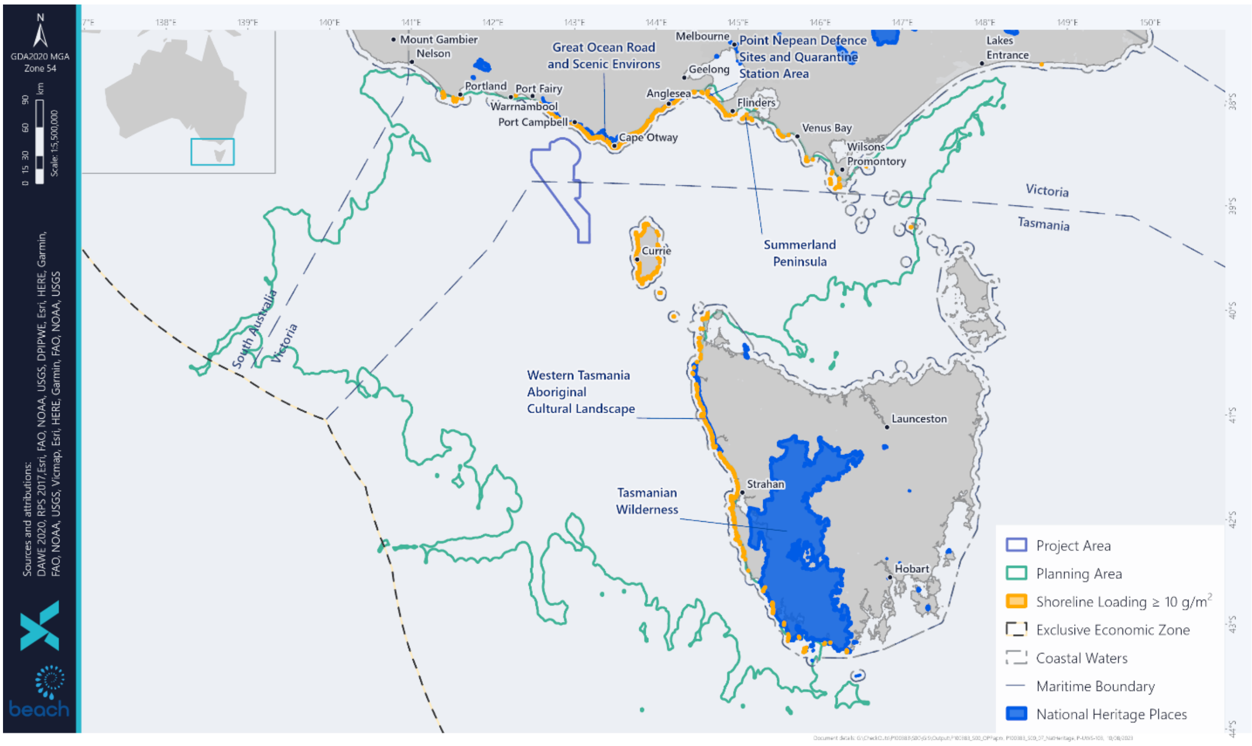


Figure 18: National Heritage Places within the Planning Area

4.2.3.1 Great Ocean Road and Scenic Environs

The Australian Heritage Council found the Great Ocean Road and its scenic environs road from Torquay to Allansford, a journey of 242km, as a place of outstanding national heritage significance. Constructed by workers, including more than 3000 returned servicemen, as a memorial to First World War servicemen, the Great Ocean Road is a significant reminder of the participation of Australian servicemen in the First World War, the Australian community's appreciation of their service, and the support provided for the welfare of servicemen and women upon returning to Australia.

The scenic environs include all views from the Great Ocean Road and Great Ocean Walk, including the Twelve Apostles, the Bay of Islands and Bay of Martyrs. The coastline from Lorne to Kennett River is among the world's most dramatic cliff and ocean scenery able to be viewed from a vehicle.

Along the length of the Great Ocean Road, the pullover points, and lookouts beside or nearby the road provide travellers with spectacular views of the coastline, hinterland, and Bass Strait seascape, framed only by cliffs, lighthouses and unencumbered by intrusive built structures. The place is also listed for its; outstanding rocky coastline, dinosaur fossil sites, geomorphological monitoring sites, its association with the pioneering landscape architect Edna Walling, and for the significance of Bells Beach to surfing.

4.2.3.2 Point Nepean Defence Sites and Quarantine Station Area including Quarantine Station and Surrounds

Point Nepean comprises approximately 520 ha at the western end of the Mornington Peninsula, along the southern coast of Port Phillip Bay. The coastline at Point Nepean is rocky with cliffs as well as Pleistocene and Holocene dunes. Ninety species of birds have been recorded at the site.

Point Nepean demonstrates the primary importance of coastal defence as well as Victorian and national quarantine processes. It contains the oldest surviving quarantine accommodation buildings in Australia which was established in 1852 after the discovery of gold which saw 100,000 migrants arriving to the region by sea.

4.2.3.3 Tasmanian Wilderness

The Tasmanian Wilderness Heritage Area comprises approximately 1,383,640 ha (nearly 20% of the land area of Tasmania), which includes 21 parks and reserves as well as privately owned land. It is considered significant for both natural and cultural values. It is one of only three temperate wilderness areas remaining in the southern hemisphere and contains rich flora and fauna biodiversity, much of which is endemic to the region. For further details see section 4.2.1.1.

4.2.3.4 Western Tasmania Aboriginal Cultural Landscape

The Western Tasmania Aboriginal Cultural Landscape represents the best evidence of an Aboriginal economic adaptation which included the Project of a semi-sedentary way of life with people moving seasonally up and down the north west coast of Tasmania. This way of life began approximately 1,900 years ago and lasted until the 1830s.

Dotted along the wind-swept coastline of the Western Tasmania Cultural Landscape are the remains of numerous hut depressions found in Aboriginal shell middens. These huts and middens are the remnants of an unusual, specialised and more sedentary Aboriginal way of life which was based on the hunting of seals and land mammals, and the gathering of shellfish.

The Western Tasmania Cultural Landscape covers approximately 21,000 ha. Much of the area is remote and uninhabited with its remoteness being a significant factor in the area's relatively low level of resource use since European settlement.

4.2.4 Commonwealth Heritage Places

No Commonwealth Heritage Places were identified within the Project Area (Appendix A). Eight Commonwealth Heritage Places were identified within the Planning Area (PMST Report Appendix B) (**Figure 19**):

- Cape Sorell Lighthouse (Historic, Listed place)
- Cape Wickham Lighthouse (Historic, Listed place)
- Fort Queenscliff (Historic, Listed place)
- HMAS Cerberus Marine and Coastal Area (Natural, Listed place)
- Sorrento Post Office (Historic, Listed place)
- Swan Island and Naval Waters (Natural, Listed place)
- Swan Island Defence Precinct (Historic, Listed place)

- Wilsons Promontory Lighthouse (Historic, Listed place)

The listed historic Commonwealth Heritage Places are located inland of the coastal area that may be affected by a spill and therefore the associated heritage values are not affected (**Figure 18**). Natural Commonwealth Heritage Places which may be affected by a spill (HMAS Cerberus Marine and Coastal Area and Swan Island and Naval Waters) are described in the following sections.

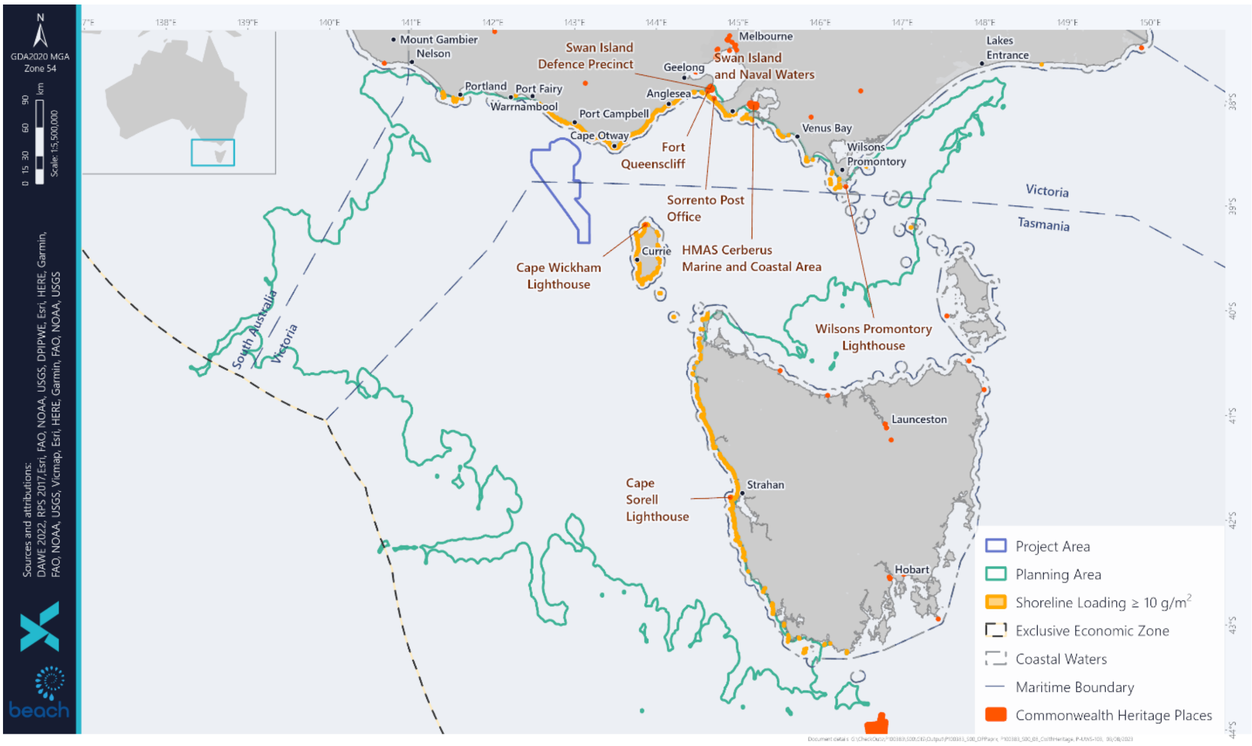


Figure 19: Commonwealth Heritage Places within the Planning Area

4.2.4.1 HMAS Cerberus Marine and Coastal Area

The HMAS Cerberus Marine and Coastal Area comprises 2,400ha at Sandy Point, one of the largest spit systems on the Victorian coast and thus one of the most dynamic shorelines. It is located along the western shore of the Western Port Ramsar site and shares its significance in providing habitat for migratory and resident waders and shorebirds, primarily on the intertidal mudflats. The site also hosts a large diversity of invertebrates in its wide range of habitats including tidal channels, tidal currents, tidal mudflats, mangroves, saltmarshes, and sand beaches. The intertidal flats are covered by seagrass *Zostera muelleri* which supports a wide range of crustaceans including amphipods, crabs, shrimps, polychaetes and many bivalves. The mangroves are known to support crabs, polychaetes, bivalves, pulmonated gastropods, amphipods and isopods. Marine mammals, including the Australian Fur-seal and Bottlenose Dolphin, are also known to occur in the area. There is likely to be cultural values associated with the site which have not yet been identified or documented.

4.2.4.2 Swan Island and Naval Waters

The Swan Island and Naval Waters heritage site comprises approximately 1,000ha including the whole of Swan Island as well as its surrounding waters. Swan Island is the largest emergent sand accumulation feature in Port Phillip Bay. The heritage site is regarded as an integral part of Swan Bay, an internationally important wetland which supports at least 46 water bird species. Swan Bay also contains extensive sheltered seagrass meadows which serve as a breeding and nursery area for a diverse array of fish species. Swan Bay is one of four major wintering sites for the Orange-bellied Parrot, providing abundant food sources in the saltmarshes surrounding Swan Island. There is likely to be cultural values associated with the site which have not yet been identified or documented.

4.2.5 Maritime Archaeological Heritage

Shipwrecks over 75 years old are protected within Commonwealth waters under the *Underwater Cultural Heritage Act 2018* (Cth), in Victorian State waters under the *Victorian Heritage Act 1995* (Vic) and in Tasmanian waters under the *Historic Cultural Heritage Act 1995*. Some historic shipwrecks lie within protected zones of up to 800m radius, typically when the shipwreck is considered fragile or at particular risk of interference. In Tasmania, the Historic Heritage Section of the Parks and Wildlife Service is the government authority responsible for the management of the State's historic shipwrecks and other maritime heritage sites.

Within the Planning Area there is a 130km stretch of coastline known as the ‘Shipwreck Coast’ because of the large number of shipwrecks present, with most wrecked during the late nineteenth century. The strong waves, rocky reefs and cliffs of the region contributed to the loss of these ships. More than 180 shipwrecks are believed to lie along the Shipwreck Coast (DELWP 2016a) and well-known wrecks include Loch Ard (1878), Thistle (1837), Children (1839), John Scott (1858) and Schomberg (1855).

The wrecks represent significant archaeological, educational, and recreational (i.e. diving) opportunities for locals, students and tourists (Flagstaff Hill 2015). There are over 480 historic wrecks in the Planning Area, two of which (S.S. Alert and S.S. Glenelg) have a protection zone (**Figure 20**). The S.S. Selje a Norwegian cargo ship wrecked in 1929 is on the edge of the Project Area.

Beach commissioned a seabed site assessment for the Otway Basin Environmental Survey (Ramboll, 2020. Appendix C). As part of the seabed site assessment a sub-bottom profiler was used to identify any buried objects. The penetration of the sub-bottom profiler was limited to a maximum of approximately 100 cm, with the average thickness of the sand patches being approximately 20-30 cm precluding burial of a shipwreck.

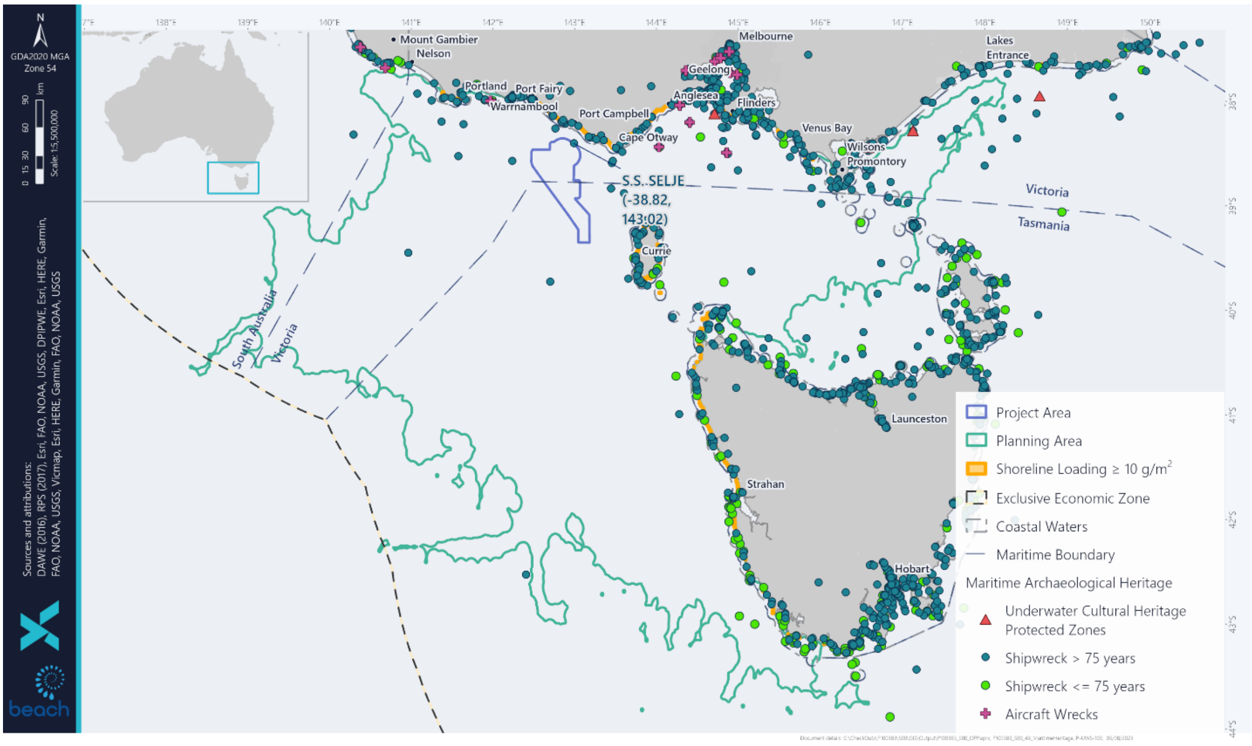


Figure 20: Maritime Archaeological Heritage within the Project and Planning Areas

4.2.6 Wetlands of International Importance

No Wetlands of International Importance were identified within the Project Area (Appendix A) (**Figure 21**).

Seven Wetland of International Importance (Ramsar-listed wetlands) were identified within the Planning Area (PMST Report Appendix B):

- Corner Inlet
- Gippsland Lakes
- Glenelg Estuary and Discovery Bay Wetlands
- Lavinia
- Piccaninnie Ponds
- Port Phillip Bay (Western Shoreline) and Bellarine Peninsula
- Western Port

However, only Glenelg Estuary, Lavinia, Port Phillip Bay, and Western Port actually overlap the Planning Area. The remaining intersections in the PMST Report are due to the size of the grids used in the PMST.

As defined in Regulations 21(3)(c) of the OPGGS (Environment) Regulations, particular relevant values and sensitivities include: the ecological character of a declared Ramsar wetland within the meaning of that Act.

The ecological character and values of the overlapping Ramsar sites are described in the following sections.

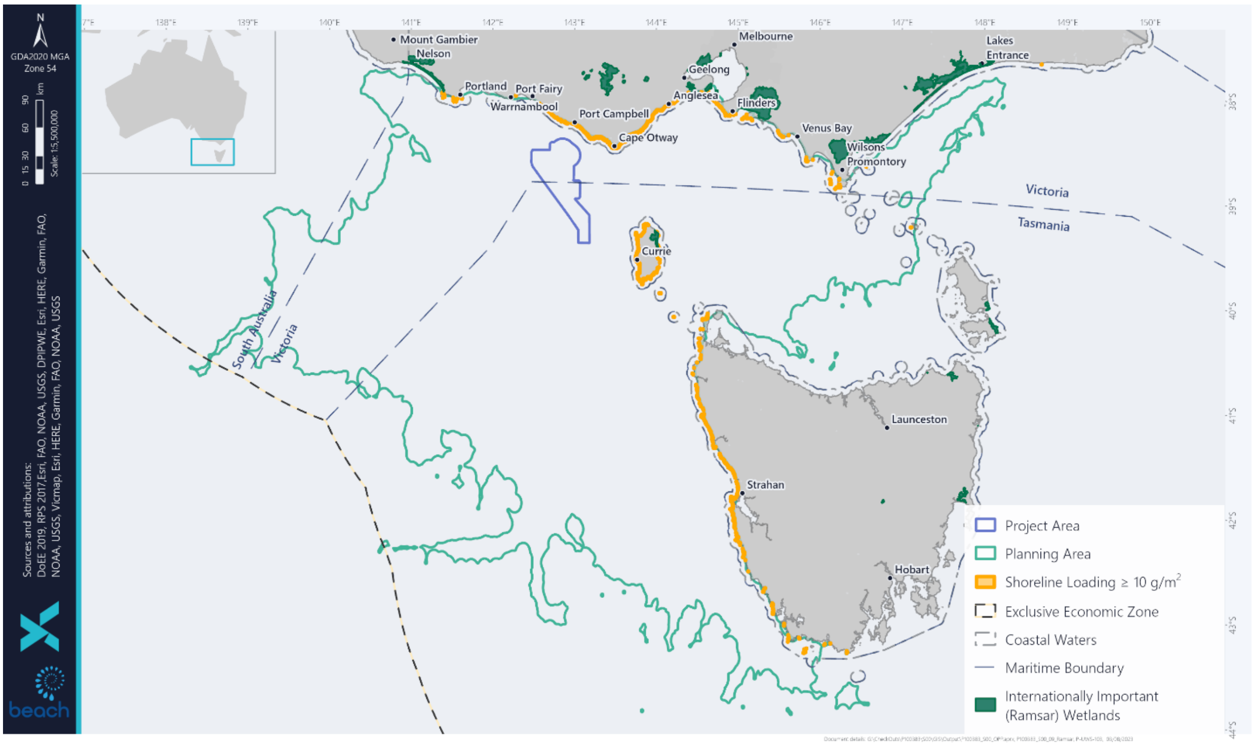


Figure 21: Wetlands of International Importance (Ramsar) within the Planning Area

4.2.6.1 Glenelg Estuary and Discovery Bay Wetlands

The Glenelg Estuary and Discovery Bay Wetlands Ramsar site is located in western Victoria, approximately 340km west of Melbourne along the South Australian border. It is subject to the Glenelg Estuary and Discovery Bay Wetlands Management Plan (DELWP 2017a).

The site comprises approximately 22,289ha which contain three broad systems of wetlands: freshwater wetlands, the Glenelg Estuary and beach and dune system. The site also contains regionally and internationally rare wetland types, including intact fen peatlands and a humid dune slack system. Several threatened flora and fauna species are supported by the site, including 95 waterbird species and 14 diadromous fish species.

There are 10 critical components, process and services which define the area. Components include hydrology, vegetation type and extent, as well as fish and waterbird diversity and abundance. The stratification process is considered significant in the area. Services include special features (dune slacks), supporting a diversity of wetland types, supporting threatened species, providing physical habitat for waterbirds and ecological connectivity.

The site is of great significance to the Gunditjmara people as part of their Koonang (sea) and Bocara Woorrowarook (river forest) country. Recreational and tourism activities are popular in the area including recreational fishing, camping, walking, and sightseeing.

4.2.6.2 Lavinia

The Lavinia Ramsar site is located on the north-east coast of King Island, Tasmania. The boundary of the site forms the Lavinia State Reserve, with major wetlands in the reserve including the Sea Elephant River estuary area, Lake Martha Lavinia, Penny's Lagoon, and the Nook Swamps. It is subject to the Lavinia Nature Reserve Management Plan (2000) (in draft).

The shifting sands of the Sea Elephant River's mouth have caused a large back-up of brackish water in the Ramsar site, creating the saltmarsh which extends up to 5km inland. The present landscape is the result of several distinct periods of dune formation. The extensive Nook Swamps, which run roughly parallel to the coast, occupy a flat depression between the newer parallel dunes to the east of the site and the older dunes further inland. Water flows into the wetlands from the catchment through surface channels and groundwater and leaves mainly from the bar at the mouth of the Sea Elephant River and seepage through the young dune systems emerging as beach springs.

The Lavinia State Reserve is one of the few largely unaltered areas of the island and contains much of the remaining native vegetation on King Island. The vegetation communities include Succulent Saline Herbland, Coastal Grass and Herbfield, Coastal Scrub and King Island Eucalyptus globulus Woodland. The freshwater areas of the Nook Swamps are dominated by swamp forest. Nook Swamps and the surrounding wetlands contain extensive peatlands.

The site is an important refuge for a collection of regional and nationally threatened species, including the nationally endangered, Orange-bellied Parrot. This parrot is heavily dependent upon the samphire plant, which occurs in the saltmarsh, for food during migration. They also roost at night in the trees and scrub surrounding the Sea Elephant River estuary.

Several species of birds which use the reserve are rarely observed on the Tasmanian mainland, including the Dusky Moorhen, Nankeen Kestrel, Rufous Night Heron and the Golden-headed Cisticola.

The site is currently used for conservation and recreation, including boating, fishing, camping and off-road driving. There are artefacts of Indigenous Australian occupation on King Island that date back to the last ice age when the island was connected to Tasmania and mainland Australia via the Bassian Plain.

There are ten critical components and processes identified in the Ramsar site: wetland vegetation communities, regional and national rare plant species, regionally rare bird species, Kind Island scrubtit, Orange-bellied Parrot, water and sea birds, migratory birds, striped marsh frog and the green and gold frog. Elements essential to the site are the marine west coast climate, mild temperatures along with wind direction and speed. Sandy deposits dominant the site, inland sand sheets cover majority of the western area of the site (PWS 2000). Between these sand sheets and the eastern coast there is an important geoconservation feature, several sand dunes. The dunes impede drainage from inland causing extensive swamps, lakes and river reflections. Terrestrial vegetation communities are important in providing the overall structure by buffering and supporting habitat (PWS 2000). Wetland vegetation in the Ramsar site include swamp forest and forested peatlands are rare and vulnerable in the region. Along with other types the vegetation, the wetland provides support and provides habitat for rare flora and fauna highlighting the significance of the wetlands. Six wetland associated species have been recorded within the site. Rare bird and frog species are dependent on the wetland habitat along with ten migratory birds and other water and sea birds. Benefits provided by the Lavinia Ramsar site include aquaculture (oyster farming), tourism, education, and scientific value.

There has been considerable damage caused to the saltmarsh community by vehicle disturbance in the Sea Elephant Estuary and the coastal strip (PWS 2000). Vegetation clearance in parts of the catchment upstream as contributed to altered water balance due to less evapotranspiration of rainfall and build-up of the groundwater. There are threats to flora and fauna by invasive weeds and fungus. Although aquaculture plays a role in the Lavinia benefits risk from inputs of nutrients from feeding and occasional opening of the barred estuary for tidal flushing although with farm vehicles disturbance can impact the site.

4.2.6.3 Port Phillip Bay (Western Shoreline) and Bellarine Peninsula

The Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site is located on the western shore of Port Phillip Bay between Melbourne and Geelong and along the Bellarine Peninsula. It is subject to the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site Management Plan (DELWP 2018).

The site comprises 22,897 ha and 6 distinct areas including Point Cooke/Cheetham, Werribee/Avalon, Point Wilson/Limeburner's Bay, Swan Bay, Mud Islands, and the Lake Connewarre complex. These areas contain freshwater wetlands, estuaries, intertidal shorelines, sub-tidal beds, inland saline wetlands as well as a wastewater treatment facility. Coastal saltmarsh and seagrass meadows are dominant within the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site. Smaller areas of freshwater vegetation occur within the Lake Connewarre complex and mangroves at Limeburner's Bay and Barwon Estuary.

The site provides important habitat for many threatened species and is the most important area in Victoria for migratory wading birds. The Orange-bellied Parrot is known to winter in Port Phillip Bay following their breeding season in Tasmania. Important fish breeding habitat is also present in Swan Bay and Limeburner's Lagoon.

The site also boasts many social and cultural values, including to at least two indigenous language groups. Mud Island is part of Boonwurrung country. The remainder of the site is part of Wathaurong country. Important indigenous sites include burial sites, middens, and artefacts, some of which are at least 5,000 years old.

4.2.6.4 Western Port

The Western Port Ramsar Site is located approximately 60km to the south-east of Melbourne, occupying a large proportion of the Western Port embayment. It is subject to the Western Port Ramsar Site Management Plan (DELWP 2017b).

Western Port comprises approximately 60,000 ha of many habitats including large shallow intertidal mudflats, seagrass meadows, fringing saltmarsh and mangroves which support a large diversity of birds, fish and invertebrates. The site contains four wetland types including marine subtidal aquatic beds (underwater vegetation), intertidal mud, sand or salt flats, intertidal marshes and intertidal forested wetlands (Hale 2016). Over 20,000 waterbirds utilise the site most years.

The site is located within the traditional lands of the Boonwurrung people, who maintain a strong connection the waters and the land. Commercial fishing has been banned within the site and is now considered a 'Recreational Fishing Haven.' The Port of Hastings is also within the site which services approximately 200 ships per year.

4.2.7 Nationally Important Wetlands

No Nationally Important Wetlands were identified within the Project Area (Appendix A) (Figure 22).

The Planning Area PMST Report (Appendix B) identified 21 Nationally Important Wetlands (Figure 22):

- Aire River (Vic)
- Anderson Inlet (Vic)
- Bungaree Lagoon (Tas)
- Corner Inlet (Vic)

- Jack Smith Lake State Game Reserve (Vic)
- Lake Ashwood (Tas)
- Lake Bantick (Tas)
- Lake Connewarre State Wildlife Reserve (Vic)
- Lake Flannigan (Tas)
- Lake Garcia (Tas)
- Lavinia Nature Reserve (Tas)
- Lower Aire River Wetlands (Vic)
- Lower Merri River Wetlands (Vic)
- Mud Islands (Vic)
- Pearshape Lagoon 1,2,3,4 (Tas)
- Powlett River Mouth (Vic)
- Princetown Wetlands (Vic)
- Swan Bay & Swan Island (Vic)
- Tower Hill (Vic)
- Western Port (Vic)
- Yambuk Wetlands (Vic)

Of these, Corner Inlet, Jack Smith Lake, Lake Ashwood, Lake Bantick, Lake Garcia, Lower Merri River Wetlands, Tower Hill and Yambuk Wetlands do not overlap the Planning Area and have been identified due to the size of the grids used in the PMST.

Additionally, Bungaree Lagoon, Lake Flannigan and Pearshape Lagoon have no connection to the ocean so would not be impacted by a spill or any other aspects associated with the Project activities and are not further described.

Information provided on the wetlands is from the DCCEEW Directory of Important Wetlands in Australia.

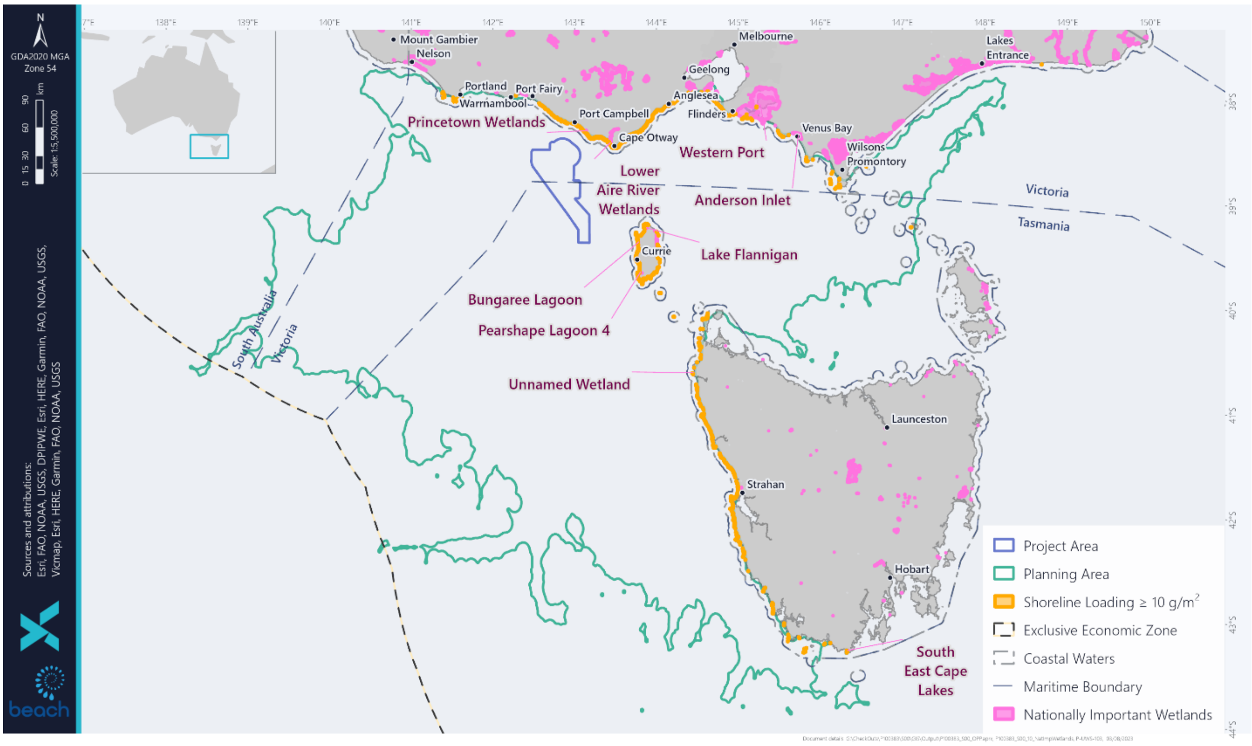


Figure 22: Nationally Important Wetlands within the Planning Area

4.2.7.1 Aire River/Lower Aire River Wetlands

These Victorian wetlands consist of three shallow freshwater lakes, brackish to saline marshes and an estuary on the Aire River floodplain. This floodplain occurs at the confluence of the Ford and Calder Rivers with the Aire River. It is surrounded by the Otway Ranges and dune-capped barrier along the ocean shoreline.

The Lower Aire River Wetlands have extensive beds of Common Reed and groves of Woolly Tea-tree which can support large numbers of waterbirds. These wetlands act as a drought refuge for wildlife.

Lake Hordern is considered to be of State significance for its geomorphology.

4.2.7.2 Anderson Inlet

Anderson Inlet is located in the South Gippsland Basin on the south-east coast and is one of the largest estuaries in Victoria. Twenty-three species of waterbirds have been recorded at Anderson Inlet including internationally significant numbers of Eastern Curlew, Double-banded Plover, Sharp-tailed Sandpiper, and Red-necked Stint as well as nationally significant numbers of Pacific Golden Plover and Greenshank (SGCS 2003).

Camping in the area is considered a major pressure due to resulting degradation of vegetation and soil compaction. Weeds also pose a threat to the ecological integrity of the reserve as approximately 66% of the 280 flora species recorded are introduced.

4.2.7.3 Lake Connewarre State Wildlife Reserve

Lake Connewarre State Wildlife Reserve is within the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site (see Section 4.2.6.3).

4.2.7.4 Lavinia Nature Reserve

Lavinia Nature Reserve is within the Lavinia Ramsar wetland (see Section 4.2.6.2).

4.2.7.5 Mud Islands

Mud Islands wetland is within the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site (see Section 4.2.6.3).

4.2.7.6 Powlett River Mouth

Powlett River Mouth is located in the South Gippsland Basin approximately 130km to the south-east of Melbourne and supports saltmarsh vegetation. Orange-bellied Parrots have been recorded feeding within the site (Parks 1995). Twenty-two fish species have been recorded in the Powlett River, including the Australian Grayling (WGCMA 2015). Thirty-one significant bird species have been recorded within the estuary, wetlands, and coastal zone. The dunes near the river mouth have records of Aboriginal cultural heritage significance, containing several shell middens (WGCMA 2015).

4.2.7.7 Princetown Wetlands

The Princetown Wetlands consist of swamps of varying salinity on the floodplains of the Gellibrand River and its tributary, the Serpentine (Latrobe) Creek. Wetland types present are a deep freshwater marsh, semi- permanent saline marshes and a shallow freshwater marsh.

The wetlands have extensive beds of Common Reed (*Phragmites australis*) and meadows dominated by Beaded Glasswort (*Sarcocornia australis*) which can support large numbers of waterbirds. Significant numbers of the Swamp Greenhood (*Pterostylis tenuissima* (Nv)) occur in the Princetown Wetlands; this species is found under dense Woolly Tea-tree groves.

The wetlands are used for camping, fishing, boating, duck hunting with parts of the wetlands in the Otway National Park and the Serpentine Creek State Wildlife Reserve.

4.2.7.8 Swan Bay & Swan Island

Swan Bay & Swan Island is within the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site (see Section 4.2.6.3) as well as the Swan Island and Naval Waters Commonwealth heritage site (see Section 4.2.4.2).

4.2.7.9 Western Port

Western Port is a large bay with extensive intertidal flats, mangroves, saltmarsh, seagrass beds, several small islands and two large islands.

Western Port is a high value wetland for its ecological, recreational, tourist, scientific, educational, cultural, and scenic features. It is a very good example of a saltmarsh-mangrove-seagrass wetland system.

Western Port is of high value for its avifauna and flora. The bays seagrass flats are nursery grounds for King George Whiting and other species of fish and many birds depend on these areas. Many sites in Western Port are of special significance as breeding, roosting, or feeding sites for waterbirds, including migratory waders.

4.2.8 Victorian Protected Areas – Marine

Victoria has a representative system of 13 Marine National Parks and 11 Marine Sanctuaries established under the National Parks Act 1975 (Vic).

No Victorian marine protected areas were identified within the Project Area (Appendix A) (**Figure 23**).

Thirteen Victorian marine protected areas were identified within the Planning Area (PMST Report Appendix B) (**Figure 23**).

- Barwon Bluff Marine Sanctuary
- Bunurong Marine National Park
- Discovery Bay Marine National Park
- Eagle Rock Marine Sanctuary
- Marengo Reefs Marine Sanctuary
- Merri Marine Sanctuary
- Mushroom Reef Marine Sanctuary
- Point Addis Marine National Park
- Point Danger Marine Sanctuary
- Port Phillip Heads Marine National Park
- The Arches Marine Sanctuary
- Twelve Apostles Marine National Park
- Wilsons Promontory Marine National Park

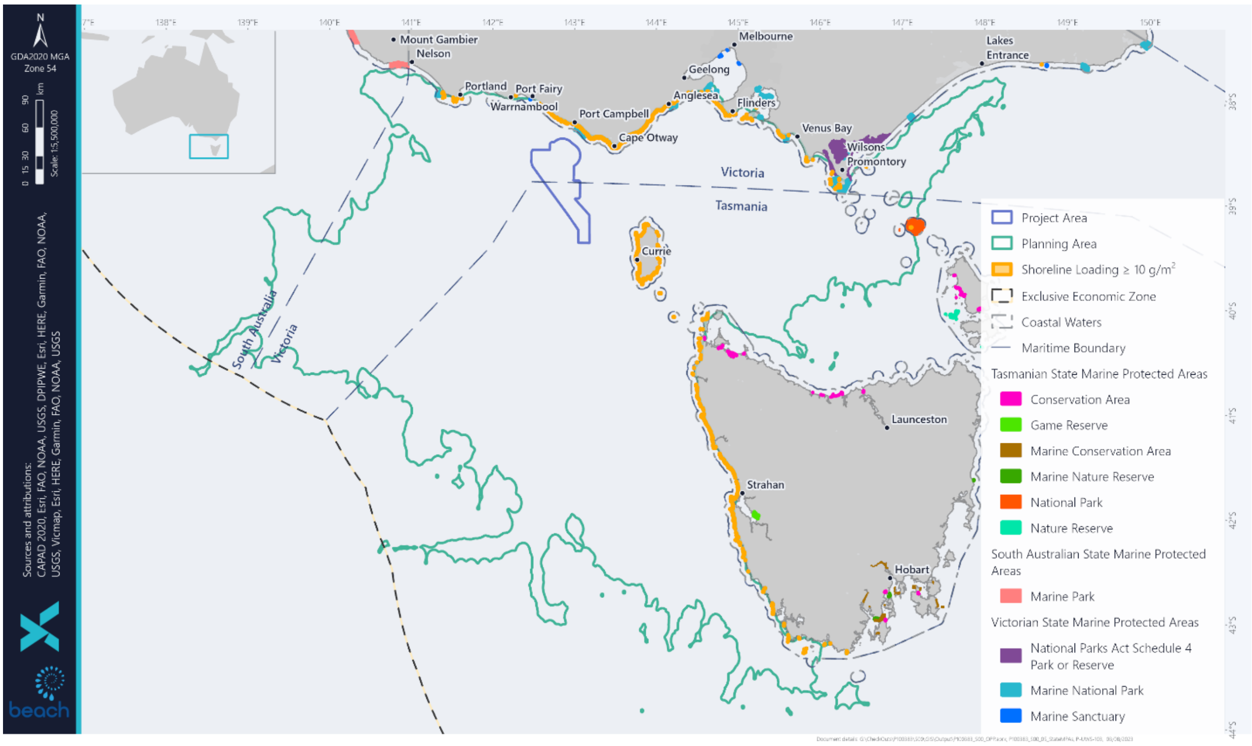


Figure 23: State Marine Protected Areas within the Planning Area

4.2.8.1 Barwon Bluff Marine Sanctuary

Barwon Bluff Marine Sanctuary is managed through the Barwon Bluff Marine Sanctuary Management Plan (Parks Victoria 2007b). The marine sanctuary protects 17ha of reef and marine environment near the mouth of the Barwon River. The management plan identifies the key values of the sanctuary as:

- intertidal reef platforms with a high diversity of invertebrate fauna and flora.
- subtidal reefs that support diverse and abundant flora, including kelps, other brown algae, and green and red algae.
- calcarenite and basalt reefs extending from The Bluff that are of regional geological significance.
- intertidal habitats that support resident and migratory shorebirds, including threatened species.
- subtidal habitats that support sedentary fish and are also used by migratory fish and marine mammals.
- marine habitats and species that are of scientific interest and valuable for marine education.
- an important landmark and area for gathering fish and shellfish for the Wathaurong people.
- a strong historic and ongoing connection with marine education.
- remnants from the Earl of Charlemont, a heritage-listed shipwreck.

4.2.8.2 Bunurong Marine National Park

The Bunurong Marine National Park and Bunurong Marine Park are managed through the Bunurong Marine National Park Management Plan (Parks Victoria 2006a). The Plan identifies the key values of the Parks as:

- extensive intertidal rock platforms and subtidal rocky reefs with a geology and form that is uncommon along the Victorian coast.
- abundant and diverse marine flora and fauna including over 22 species of marine flora and fauna recorded, or presumed to be, at their eastern or western distributional limits (Plummer et al. 2003).
- highest diversity of intertidal and shallow subtidal invertebrate fauna recorded in Victoria on sandstone (ECC 2000).
- a high proportion of the common invertebrates occurring along the Victorian coast.
- high diversity of vegetation communities, many of which are considered rare, depleted or endangered within the region (WGCMA 2003; Carr 2003).
- important coastal habitat for several threatened species.
- spectacular coastal scenery, featuring rugged sandstone cliffs, rocky headlands, intertidal rock platforms and sandy cove.
- Eagles Nest, a prominent rock stack, recognised as a site of national geological and geomorphological significance (Buckley 1993).
- one of the richest Mesozoic fossil areas in Victoria.
- landscape and seascape of cultural significance to Indigenous people.
- numerous places and objects of significance to Indigenous people.
- a European history rich in diversity, including sites associated with shipping, coal mining, holidaying and living on the coast.
- two historical shipwrecks listed on the Victorian Heritage Register (Heritage Victoria 2004).
- opportunities for cultural values investigation in an area protected from human disturbance.
- extensive subtidal reefs with magnificent underwater seascapes, offering numerous opportunities for diving and snorkelling.
- highly accessible intertidal rock platforms offering opportunities for rock-pooling, marine education, and interpretation.
- spectacular coastal drive, with numerous lookouts and panoramic views of the coast and surrounding waters.
- coastline offering opportunities for swimming, surfing, boating, fishing, and rock-pooling in a natural setting.
- the Bunurong Marine National Park is classified as IUCN II (National Parks) and the Bunurong Marine Park as IUCN IV (Habitat/species management area).

4.2.8.3 Discovery Bay Marine National Park

Discovery Bay Marine National Park protects 2,770ha within the Southern Ocean and experiences some of the highest wave energy environments in Victoria. The Bonney Coast Upwelling provides a nutrient-rich environment for fish, whales, seals, penguins, and invertebrates. Important values for Discovery Bay Marine National Park include (Parks 2007c):

- a range of marine habitats representative of the Otway bioregion.
- indigenous culture based on spiritual connection to sea country and a history of marine resource use.
- the wrecks of two wooden sailing barques, the Jane and the Ann, are thought to be in the vicinity of the park.
- opportunities to view marine life and spectacular scenery from nearby lookouts and from within the park.

4.2.8.4 Eagle Rock Marine Sanctuary

The Eagle Rock Marine Sanctuary covers 17.9ha and is located along the Victorian Surf Coast in the township of Aireys Inlet, approximately 100 km south-west of Melbourne. The sanctuary extends from the intertidal zone to 300 m offshore and protects many habitats including intertidal and subtidal soft sediment as well as intertidal and subtidal reefs.

It is managed under the Management Plan for Point Addis Marine National Park, Point Danger Marine Sanctuary and Eagle Rock Marine Sanctuary (Parks Victoria 2005) and is classified as IUCN III. The plan identifies the following environmental, cultural, and social values for the sanctuary:

- sandy beaches, subtidal soft sediments, subtidal rocky reefs, rhodolith beds and intertidal reefs.
- Eagle Rock, a rock stack of geological significance.
- high diversity of algal, invertebrate and fish species.
- evidence of a long history of Indigenous use, including many Indigenous places and objects adjacent to the park and sanctuaries near dunes, headlands, estuaries, and creeks.
- surf breaks, including those at Bells Beach, which are culturally important to many people associated with surfing.
- coastal seascapes of significance for many who live in the area or visit.
- recreational and tourism values.
- spectacular underwater scenery for snorkelling and scuba diving.
- intertidal areas for exploring rock pools.
- opportunities for a range of recreational activities.

4.2.8.5 Marengo Reefs Marine Sanctuary

The Marengo Reefs Marine Sanctuary (12ha) is in Victorian State waters near Marengo and Apollo Bay, which are on the Great Ocean Road, approximately 220km south-west of Melbourne. The sanctuary protects two small reefs and a wide variety of microhabitats. Protected conditions on the leeward side of the reefs are unusual on this high wave energy coastline and allow for dense growths of bull kelps and other seaweed. There is an abundance of soft corals, sponges, and other marine invertebrates, and over 56 species of fish have been recorded in and around the sanctuary. Seals rest on the outer island of the reef and there are two shipwrecks (the Grange and Woolamai) in the sanctuary (Parks Victoria 2007a).

The Marengo Reefs Marine Sanctuary Management Plan (Parks Victoria 2007a) identifies the environmental, cultural, and social values as:

- subtidal soft sediments, subtidal rocky reefs, and intertidal reefs.
- high diversity of algal, invertebrate and fish species.
- Australian Fur-seal haul out area.
- evidence of a long history of Indigenous use, including many Indigenous places and objects nearby.
- wrecks of coastal and international trade vessels in the vicinity of the sanctuary.
- spectacular underwater scenery for snorkelling and scuba diving.
- intertidal areas for exploring rock pools.
- opportunities for a range of aquatic recreational activities including seal watching.

4.2.8.6 Merri Marine Sanctuary

Merri Marine Sanctuary covers 29ha within the city of Warrnambool in south-western Victoria and protects many habitats including intertidal reef, sand, shallow reef, and rocky overhang. These habitats support many species of algae, invertebrates, fish, and shorebirds. Islands adjacent to the sanctuary provide nesting and roosting areas for many species including Little Penguins, Little Pied Cormorants, Short-tailed Shearwaters, and Pacific Gulls. It is managed under the Merri Marine Sanctuary Management Plan (Parks Victoria 2007b) and is classified as IUCN III.

4.2.8.7 Mushroom Reef Marine Sanctuary

Mushroom Reef Marine Sanctuary covers 80ha along the southern Mornington Peninsula and protects a system of ancient basalt platforms and reefs. The sanctuary is adjacent to Mornington Peninsula National Park, extending from the high water mark to approximately 1km offshore. The Mushroom Reef Marine Sanctuary Management Plan (Parks Victoria 2007d) identifies the following important natural values:

- among the most diverse intertidal and rocky reef communities in Victoria.
- numerous subtidal pools and boulders in the intertidal area that provide a high complexity of intertidal basalt substrates and a rich variety of microhabitats.
- subtidal reefs that support diverse and abundant flora including kelps, other brown algae, and green and red algae.
- sandy bottom habitats that support large beds of *Amphibolis* seagrass and patches of green algae.
- diverse habitats that support sedentary and migratory fish species.
- a range of reef habitats that support invertebrates including gorgonian fans, seastars, anemones, ascidians, barnacles and soft corals.

- a distinctive basalt causeway that provides habitat for numerous crab, seastar and gastropod species.
- intertidal habitat that support resident and migratory shorebird species including threatened species.

4.2.8.8 Point Addis Marine National Park

Point Addis Marine National Park lies east of Anglesea and covers 4,600ha. This park protects representative samples of subtidal soft sediments, subtidal rocky reef, rhodolith beds and intertidal rocky reef habitats. The park also provides habitat for a range of invertebrates, fish, algae, birds and wildlife. The world-famous surfing destination of Bells Beach is within Point Addis Marine National Park.

It is managed under the Management Plan for Point Addis Marine National Park, Point Danger Marine Sanctuary and Eagle Rock Marine Sanctuary (Parks Victoria 2005a) and is classified as IUCN II. The plan identifies the following environmental, cultural, and social values for the parks and sanctuaries:

- sandy beaches, subtidal soft sediments, subtidal rocky reefs, rhodolith beds and intertidal reefs.
- a high diversity of algal, invertebrate and fish species.
- a high diversity of sea slugs (opisthobranchs) and other invertebrate communities within Point Danger Marine Sanctuary.
- evidence of a long history of Indigenous use, including many Indigenous places and objects adjacent to the park and sanctuaries near dunes, headlands, estuaries, and creeks.
- surf breaks, including those at Bells Beach, which are culturally important to many people associated with surfing.
- coastal seascapes of significance for many who live in the area or visit.
- recreational and tourism values.
- spectacular underwater scenery for snorkelling and scuba diving.
- intertidal areas for exploring rock pools.
- opportunities for a range of recreational activities.
- a spectacular seascape complementing well-known visitor experiences on the Great Ocean Road.

4.2.8.9 Point Danger Marine Sanctuary

Point Danger Marine Sanctuary covers 21.7ha between the townships of Torquay and Jan Juc along Victorian Surf Coast, approximately 100km south-west of Melbourne. It extends 600m offshore and encompasses an offshore rock platform, protecting many habitats including intertidal and subtidal soft sediment as well as intertidal and subtidal reefs which are home to a large diversity of marine plants and invertebrates.

It is managed under the Management Plan for Point Addis Marine National Park, Point Danger Marine Sanctuary and Eagle Rock Marine Sanctuary (Parks Victoria 2005) and is classified as IUCN III. The plan identifies the following environmental, cultural, and social values for the sanctuary:

- sandy beaches, subtidal soft sediments, subtidal rocky reefs, rhodolith beds and intertidal reefs.
- Eagle Rock, a rock stack of geological significance.

- high diversity of algal, invertebrate and fish species.
- high diversity of sea slug and other invertebrate communities
- evidence of a long history of Indigenous use, including many Indigenous places and objects adjacent to the park and sanctuaries near dunes, headlands, estuaries, and creeks.
- surf breaks, including those at Bells Beach, which are culturally important to many people associated with surfing.
- coastal seascapes of significance for many who live in the area or visit.
- recreational and tourism values.
- spectacular underwater scenery for snorkelling and scuba diving.
- intertidal areas for exploring rock pools.
- opportunities for a range of recreational activities.

4.2.8.10 Port Phillip Heads Marine National Park

Port Phillip Heads Marine National Park protects 3850ha across 6 sections including Swan Bay, Mud Islands, Point Lonsdale, Point Nepean, Popes Eye and Portsea Hole.

4.2.8.11 The Arches Marine Sanctuary

The Arches Marine Sanctuary protects 45ha of ocean directly south of Port Campbell. It has a spectacular dive site of limestone formations, rocky arches, and canyons. The sanctuary is also ecologically significant, supporting habitats such as kelp forests and a diverse range of sessile invertebrates on the arches and canyons. These habitats support schools of reef fish, seals, and a range of invertebrates such as lobster, abalone, and sea urchins. The Arches Marine Sanctuary is managed in conjunction with the Twelve Apostles Marine Park under the Management Plan for Twelve Apostles Marine National Park and The Arches Marine Sanctuary.

4.2.8.12 Twelve Apostles Marine National Park

The Twelve Apostles Marine National Park (75km^2) is located 7km east of Port Campbell and covers 16km of coastline from east of Broken Head to Pebble Point and extends offshore to 5.5km (Plummer et al. 2003).

The area is representative of the Otway Bioregion and is characterised by a submarine network of towering canyons, caves, arches, and walls with a large variety of seaweed and sponge gardens plus resident schools of reef fish. The park contains areas of calcarenite reef supporting the highest diversity of intertidal and sub-tidal invertebrates found on that rock type in Victoria (DSE 2012).

The park includes large sandy sub-tidal areas consisting of predominantly fine sand with some medium to coarse sand and shell fragment (Plummer et al. 2003). Benthic sampling undertaken within the park in soft sediment habitats at 10m, 20m and 40m water depths identified 31, 29 and 32 species respectively based upon a sample area of 0.1m^2. These species were predominantly polychaetes, crustaceans, and nematodes with the mean number of individuals decreasing with water depth (Heisler and Parry 2007). No visible macroalgae species were present within these soft sediment areas (Plummer et al. 2003; Holmes et al. 2007). These sandy expanses support high abundances of smaller animals such as worms, small molluscs, and crustaceans; larger animals are less common.

The Twelve Apostles Marine Park is managed in conjunction with the Arches Marine Sanctuary under the Management Plan for Twelve Apostles Marine National Park and The Arches Marine Sanctuary (Parks Victoria 2006b) and is classified as IUCN II. The Plan describes the key environmental, cultural, and social values as:

- unique limestone rock formations, including the Twelve Apostles.
- a range of marine habitats representative of the Otway marine bioregion.
- indigenous culture based on spiritual connection to sea country and a history of marine resource use.
- the wreck of the Loch Ard (shipwreck).
- underwater limestone formations of arches and canyons.
- a diverse range of encrusting invertebrates.
- a spectacular dive site (Parks Victoria 2006b).

4.2.8.13 Wilsons Promontory Marine National Park

Wilsons Promontory National Park is in South Gippsland, about 200km south-east of Melbourne and at 15,550ha is Victoria’s largest Marine Protected Area. It extends along 17km of mainland coastline around the southern tip of Wilsons Promontory and is managed through the Wilsons Promontory Marine National Park and Wilsons Promontory Marine Park Management Plan May 2006 (Parks Victoria 2006a) and is classified as IUCN II (National Parks). The Plan describes the key environmental, cultural and social values as:

- granite habitats, which are unusual in Victorian marine waters, including extensive heavy reefs with smooth surfaces, boulders and rubble and low-profile reefs.
- biological communities with distinct biogeographic patterns, including shallow subtidal reefs, deep subtidal reefs.
- intertidal rocky shores, sandy beaches, seagrass and subtidal soft substrates.
- abundant and diverse marine flora and fauna, including hundreds of fish species and invertebrates such as sponges, ascidians, sea whips and bryozoans.
- 68 species of marine flora and fauna recorded, or presumed to be, at their eastern or western distributional limits.
- important breeding sites for a significant colony of Australian Fur-seals.
- important habitat for several threatened shorebird species, including species listed under international migratory bird agreements.
- outstanding landscapes, seascapes, and spectacular underwater scenery.
- seascape, cultural places, and objects of high traditional and cultural significance to Indigenous people.
- Indigenous cultural lore and interest maintained by the Gunai / Kurnai and Boonwurrung people.
- important maritime and other history.

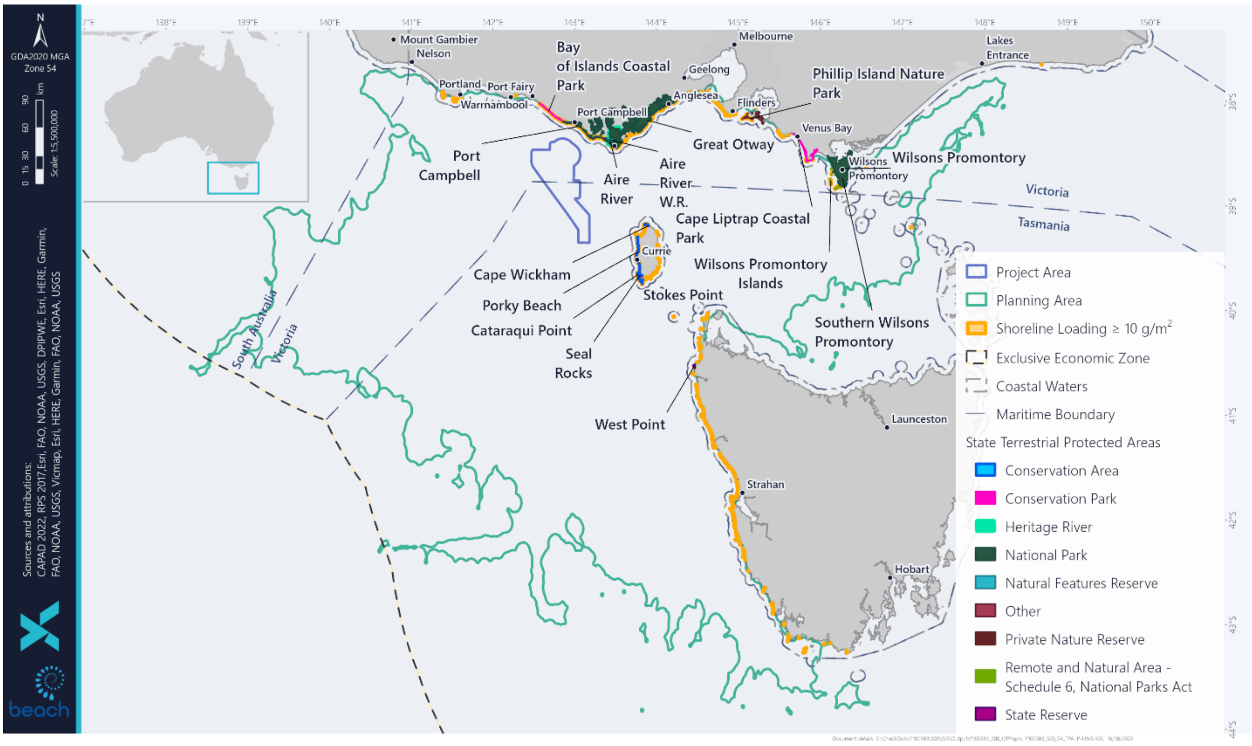
- historic shipwrecks, many of which are listed on the Victorian Heritage Register (Parks Victoria 2006a).

4.2.9 Victorian Protected Areas – Terrestrial

No Victorian terrestrial protected areas were identified within the Project Area (PMST Report Appendix A) (Figure 24).

Numerous Victorian terrestrial protected areas were identified within the Planning Area (PMST Report Appendix B). However, only the following terrestrial protected areas are within the area where shoreline oil may reach the Victorian coastline (Figure 24):

- Aire River Natural Features Reserve, Heritage River
- Anser Island Reference Area
- Bay of Islands Coastal Park
- Cape Conram Coastal Park
- Cape Liptrap Coastal Park
- Cape Nelson State Park
- Discovery Bay Coastal Park
- French Island National Park
- Great Otway National Park
- Lake Connewarre Wilderness Reserve
- Mornington Peninsula National Park
- Phillip Island Nature Park
- Point Nepean National Park
- Port Campbell National Park
- Seal Islands Wilderness Reserve
- Southern Wilsons Promontory, Wilsons Promontory and Wilson Promontory Islands National Parks



Sources and attributions: CAPAD 2022, RPS 2017,Esri, FAO, NOAA, USGS, DPIPWE, Esri, HERE, Garmin, FAO, NOAA, USGS, Vicmap, Esri, HERE, Garmin, FAO, NOAA, USGS

Figure 24: State Terrestrial Protected Areas within the Planning Area

4.2.9.1 Aire River Heritage River

The Aire River is a perennial river of the Corangamite catchment, located in the Otway region. The river generally flows west by south then south through the Great Otway National Park, joined by three minor tributaries, before reaching its mouth and emptying into Bass Strait west of Cape Otway. It is a popular fishing and camping area.

4.2.9.2 Anser Island Reference Area

Anser Island is the largest island of the Anser Group, spanning 80 ha and located 1.5km south-west of Wilsons Promontory. Anser Island is within the Wilsons Promontory National Park (see Section 4.2.8.13) and managed under its management plan. The general management aim of reference areas is to protect viable samples of one or more land types that are relatively undisturbed for comparative study with similar land types elsewhere, by keeping all human interference to the essential minimum and ensuring as far as practicable that the only long-term change results from natural processes (Parks Victoria 2002).

4.2.9.3 Bay of Islands Conservation Park

This coastal park has outstanding ocean views and geological features and covers an extensive area of the coastline (~32km in length and 950ha), stretching east from Warrnambool to Peterborough. Sheer cliffs and rock stacks dominate the bays, and the heathlands contain wildflowers. Beaches are accessible at some points (Parks Victoria 1998).

This park protects the terrestrial environment above the low water mark of this coastline. This Coastal Park is protected under the Port Campbell National Park and Bay of Islands Coastal Park Management Plan (Parks Victoria 1998).

4.2.9.4 Cape Conran Coastal Park

Cape Conran Coastal Park is located to the east of Marlo along Victoria's Wilderness Coast. The park is very popular for camping, containing several campsites within the park for visitors to observe the seasonal whale migrations.

4.2.9.5 Cape Liptrap Conservation Park

Cape Liptrap Coastal Park is located in South Gippsland, 180km south-east of Melbourne. It is protected under the Cape Liptrap Coastal Park Management Plan (Parks Victoria 2003). The Management Plan identifies the following significant values which may be within the Planning Area:

- thirty threatened fauna species, including ten species listed as threatened under the Flora and Fauna Guarantee Act 1988 (Vic.), 17 migratory bird species and ten threatened flora species.
- spectacular coastal landforms at Cape Liptrap, Arch Rock and at Walkerville.
- numerous middens and other significant Aboriginal sites.
- Cape Liptrap lighthouse.
- spectacular and diverse coastal scenery.
- opportunities for fishing, nature observation, camping, and walking in natural settings.

This park protects the terrestrial environment above the low water mark of this coastline.

4.2.9.6 Cape Nelson State Park

Cape Nelson State Park comprises 210ha and is located near Portland, 377km south-west of Melbourne. The park is a popular destination for hikers as it is positioned along the Great South West Walk as well as several other popular day walks. The park is managed under the Ngootyoong Gunditj Ngootyoong Mara South West Management Plan (DELWP 2015). Cape Nelson contains rocky platforms which provide habitat for the Australian Fur-seal and New Zealand Fur-seal.

4.2.9.7 Discovery Bay Coastal Park

Discovery Bay Coastal Park comprises 10,460ha and extends along the coast of Discovery Bay from Cape Nelson north-westwards for 50 kilometres to the border with South Australia. The park is managed under the Ngootyoong Gunditj Ngootyoong Mara South West Management Plan (DELWP 2015). The Cape Bridgewater fur seal colony is located within the park.

4.2.9.8 French Island National Park

French Island National Park protects 11,100ha of wetlands of international significance and is the only national park in Victoria totally contained on an island. It is the largest island along the Victorian coastline, located off the Mornington Peninsula in Western Port (see Section 4.2.7.9) and characterised by a range of coastal habitats including rocky shorelines, sandy beaches, mangroves, saltmarshes and wetlands. More than 230 bird species have been recorded on French Island, including the Orange-bellied Parrot, White-bellied Sea Eagle and 33 species of waders.

The park is protected under the French Island National Park Management Plan (Parks Victoria 1998). The Management Plan identifies the following significant values which may be within the Planning Area:

- the only substantial representation of the land systems of the coastal sand plains and clayey-sand plains of Western Port within the State's nature conservation reserve system.
- extensive mangrove and saltmarsh areas along the north coast which are of State geomorphological importance.
- part of the Western Port site listed under the Convention on Wetlands of International Importance especially as Waterfowl Habitat (the Ramsar Convention).
- habitat for a vast number of migratory birds which are listed under the JAMBA and CAMBA.
- the sand spit along the west coast is an important research site for sediment movement and coastal dynamics.
- a rich flora with more than 580 species, including about 100 orchids and 12 threatened species.
- vegetation of at least State botanical significance, with high quality representative samples of sand heathland, shrubby foothill forest, coastal heathland, coastal saltmarsh and swamp sedgeland and grassland.
- fauna of international and national significance, including more than 260 species, whose conservation is enhanced by the island's isolation from the mainland preventing colonisation by foxes and limiting the degree of habitat disturbance.

4.2.9.9 Great Otway National Park

The Great Otway National Park (103,185ha) is located near Cape Otway and stretches from the low water mark inland on an intermittent basis from Princetown to Apollo Bay (approximately 100km).

Landscapes within the park are characterised by tall forests and hilly terrain extending to the sea with cliffs, steep and rocky coasts, coastal terraces, landslips, dunes and bluffs, beaches, and river mouths. There is a concentration of archaeological sites along the coast, coastal rivers, and reefs. The park contains many sites of international and national geological and geomorphological significance including Dinosaur Cove (internationally significant dinosaur fossil site), Lion Headland and Moonlight Head to Milanesia Beach (internationally significant coastal geology and fossils).

The park provides habitats for the conservation of the Rufous Bristlebird, Hooded Plover, White-Bellied Sea Eagle, Fairy Tern, Caspian Tern and Lewin's Rail and native fish such as the Australian Grayling.

The park contains significant Aboriginal cultural sites adjacent to rivers, streams and the coastline including over 100 registered archaeological sites, particularly shell middens along the coast, as well as non-physical aspects such as massacre sites, song lines, family links and stories. The park also contains four sites listed on the Victorian Heritage Register including the Cape Otway Light Station and several shipwreck features along the coast (i.e. anchors) (Parks Victoria and DSE 2009).

This park protects the terrestrial environment above the low water mark of this coastline. The Park is protected under the Great Otway National Park and Otway Forest Park Management Plan (Parks Victoria and DSE 2009) and relevant values are:

- a large area of essentially unmodified coastline, linking the land to marine ecosystems and marine national parks.
- a diverse range of lifestyle and recreation opportunities for communities adjacent to the parks – for local permanent residents and holiday homeowners Regionally, nationally, and internationally.

- significant tourist attractions, close to access routes and accommodation, such as spectacular coastal scenery along the Great Ocean Road, access to beautiful beaches, clifftop lookouts, picnic areas, historic sites, waterfalls and walking tracks such as the Great Ocean Walk.
- the basis for continued growth of nature-based tourism associated with the parks and the region, providing economic opportunities for accommodation providers, food and services providers, and recreation, tourism, and education operators.

4.2.9.10 Lake Connewarre Wilderness Reserve

Lake Connewarre Wilderness Reserve is within the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site (see Section 4.2.6.3).

4.2.9.11 Mornington Peninsula National Park

Mornington Peninsula National Park protects 2,686ha of land along the coast approximately 70km south of Melbourne, often described as ‘Melbourne’s Playground’ due to its popularity for recreation. Mornington Peninsula National Park is the most visited park in Victoria.

The park is managed under the Mornington Peninsula National Park and Arthurs Seat State Park Management Plan (Parks Victoria 1998) which identifies the following natural values:

- largest and most significant remaining areas of native vegetation on the Mornington Peninsula.
- numerous sites and features of geomorphic significance, particularly along the coast (cliffed calcarenite coast, sandy forelands and basalt shore platforms).
- only representation in the Victorian conservation reserve system of four particular land systems formed within the Southern Victorian Coastal Plains and the Southern Victorian Uplands.
- many significant native plants and vegetation communities.
- highly scenic landscape values along the ocean coast and at Port Phillip heads and prominent feature of Arthurs Seat.
- many significant fauna species, including populations of the nationally significant Hooded Plover, over 30 species of State significance and many species of regional significance.
- high quality marine and intertidal habitats, with some pristine areas within Point Nepean.

4.2.9.12 Phillip Island Nature Park

Phillip Island is east of Melbourne and forms a natural breakwater for the shallow waters of Western Port. Phillip Island is Biologically Important Area (BIA) for the Little Penguin, with breeding and foraging sites present. There is no management plan for Phillip Island Nature Park.

4.2.9.13 Point Nepean National Park

Point Nepean National Park protects 560ha of land at the tip of Mornington Peninsula, surrounded by Port Phillip Heads Marine National Park (see Section 4.2.8.10). The park is of great cultural significance as a sacred place to Traditional Owners for over 35,000 years, a landmark and natural resource to European settlers, as well as a line of defence for Victoria and Australia (Parks Victoria 2017). Restricted access has allowed the park to maintain the largest and most intact area of remnant coastal vegetation on the Port Phillip coast and Victoria’s largest remnant area of coastal alkaline scrub. Intertidal rock platforms support a diverse marine ecosystem while dune habitats provide roosting and feeding opportunities for resident and migratory seabirds.

4.2.9.14 Port Campbell National Park

Port Campbell National Park is slightly west of Twelve Apostles Marine National Park and 10km east of Warrnambool. The park is 1,750ha that presents an extraordinary collection of wave-sculptured rock formations. Port Campbell National Park is home to various fauna such as the Little Penguin, Short-tailed Shearwater and various whale species (Parks Victoria 2019b).

4.2.9.15 Seal Islands Wildlife Reserve

Seal Islands Wildlife Reserve is located on the Seal Islands group approximately 15km east of Wilsons Promontory. The islands are part of the Wilsons Promontory Islands Important Bird Area recognised by BirdLife Australia (BirdLife International 2017). The Seal Islands provide important breeding habitat for many significant waterbirds including the Little Penguin, Fairy Prion, Short-tailed Shearwater and Common Diving-petrel (Harris and Deerson 1980). No hunting is permitted within the reserve.

4.2.9.16 Wilsons Promontory National Park including South Wilsons Promontory and Wilsons Promontory Islands

The Wilsons Promontory National Park is in South Gippsland, about 200km southeast of Melbourne and includes the Wilsons Promontory Wilderness Zone, Southern Wilsons Promontory Remote and Natural Area and Wilsons Promontory Islands. It is managed under the Wilsons Promontory National Park Management Plan. The Plan identifies the key environmental, social, and cultural values as (Parks Victoria 2002):

- entire promontory of national, geological, and geomorphological significance containing a number of sites of State and regional significance.
- diverse vegetation communities, including warm temperate and cool temperate rainforest, tall open forests, woodlands, heathlands, and swamp and coastal communities.
- unmodified rivers and streams with no introduced fish species.
- half of Victoria’s bird species.
- intertidal mudflats, which are an internationally important habitat for migratory wading birds.
- the largest coastal wilderness area in Victoria.
- numerous middens and other significant Aboriginal sites.
- remains of sites of several small European settlements and past uses including timber milling, mining, and grazing.
- a number of shipwrecks in the waters around Wilsons Promontory.
- the heritage buildings of Wilsons Promontory Light Station.
- outstanding natural landscapes including spectacular and diverse coastal scenery.

This park protects the terrestrial environment above the low water mark of this coastline.

4.2.10 Tasmanian Protected Areas - Marine

No Tasmanian marine protected areas were identified within the Project Area (PMST Report Appendix A) (Figure 23).

Three Tasmanian marine protected area was identified within the Planning Area (PMST Report Appendix B) (Figure 23).

- Kent Group National Park
- Murkay Islets Conservation Area
- Shell Islets Conservation Area

4.2.10.1 Kent Group National Park

Kent Group National Park is made up of islands and islets, situated halfway between Wilsons Promontory in Victoria and Flinders Island off Tasmania's north-eastern tip. Kent Group National Park is in the middle of Bass Strait where it is subject to a constant barrage of wild seas and currents that with it brings richness in nutrients that supports a unique diversity of marine life. The islands are an important refuge for seabirds along with providing a sanctuary for the Australian Fur-seals who make their home on the rocky outcrops (DPIPWE 2020).

4.2.10.2 Murkay Islets Conservation Area

The Murkay Islets are part of the Trefoil Island Group near Cape Grim off the north-western coast of Tasmania, comprising a combined area of approximately 0.5ha. They are also included in the Hunter Island Group Important Bird Area, recognised by BirdLife Australia for providing important breeding habitat for significant bird species including the Short-tailed Shearwater, Black-faced Cormorant, Pacific Gull and Orange-bellied Parrot (BirdLife International 2023a).

4.2.10.3 Shell Islets Conservation Area

The Shell Islets are a group of small islands within the Trefoil Island Group near Cape Grim off the north-western coast of Tasmania, comprising a combined area of approximately 0.08ha (Brothers et al. 2001). The islets provide important breeding and foraging habitat for several seabird, shorebird and wader species including the Caspian Tern, Red-necked Stints and Sanderlings.

4.2.11 Tasmanian Protected Areas – Terrestrial

No Tasmanian terrestrial protected areas were identified within the Project Area (PMST Report Appendix A) (Figure 24).

Numerous Tasmanian terrestrial protected areas were identified within the Planning Area PMST Report (Appendix B). However, only the following terrestrial protected areas are within the area where shoreline oil may reach the Tasmanian coastline (Figure 24):

- Arthur-Pieman Conservation Area
- Badger Box Creek Nature Reserve
- Black Pyramid Rock Nature Reserve
- Calm Bay State Reserve

- Cape Sorell Historic Site
- Cape Wickham Conservation Area
- Cataraqui Point Conservation Area
- Christmas Island Nature Reserve
- City of Melbourne Bay Conservation Area
- Colliers Swamp Conservation Area
- Councillor Island Nature Reserve
- Four Mile Beach Regional Reserve
- Hunter Island Conservation Area
- Lavinia State Reserve
- Mount Heemskirk Regional Reserve
- Nares Rocks Conservation Area
- New Year Island Game Reserve
- Ocean Beach Conservation Area
- Porky Beach Conservation Area
- Red Hut Point Conservation Area
- Reid Rocks Nature Reserve
- Sea Elephant Conservation Area
- Seal Rocks State Reserve
- Southwest National Park
- Stokes Point Conservation Area
- Sundown Point State Reserve
- The Doughboys Nature Reserve
- Trial Harbour State Reserve
- West Point State Reserve

4.2.11.1 Arthur-Pieman Conservation Area

The Arthur-Pieman Conservation Area covers 102,982ha along the north-west coast of Tasmania at the mouth of the Arthur River, containing extensive peatlands and large dune fields. The area provides important habitat for many bird species including the Orange-bellied Parrot, Hooded Plovers, White-bellied Sea Eagles, Fairy Terns and Pacific Gulls. There is no management plan for the Arthur-Pieman Conservation Area.

4.2.11.2 Badger Box Creek Nature Reserve

Badger Box Creek Nature Reserve covers an area of 23.51ha on King Island. It is designated as IUCN Category V which is a protected landscape/seascape. There is no management plan for the Badger Box Creek Nature Reserve.

4.2.11.3 Black Pyramid Rock Nature Reserve

Black Pyramid Rock Nature Reserve covers 14.47ha on the basaltic rock island. The island is part of the Hunter Island Group between King Island and north-west Tasmania. The reserve is also part of the Albatross Island and Black Pyramid Rock Important Bird Area recognised by BirdLife Australia (BirdLife International 2023b). The Important Bird Area provides habitat for many species including Little Penguins, Short-tailed Shearwaters, Pacific and Silver Gulls. Black Pyramid Rock Nature Reserve is the only documented breeding site for the Australasian Gannet in the Bass Strait and one of only eight breeding sites within Australia (PWS 2000).

4.2.11.4 Calm Bay State Reserve

Calm Bay State Reserve covers 321.19ha within Circular Head at the north-west of Tasmania. There is no management plan for the Calm Bay State Reserve.

4.2.11.5 Cape Sorell Historic Site

Cape Sorell Historic Site covers 69.63ha of headland along the West Coast of Tasmania. The heritage-listed Cape Sorell Lighthouse is located within the site. No Management Plan is available for the Cape Sorell Historic Site.

4.2.11.6 Cape Wickham Conservation Area

The Cape Wickham Conservation Area on the northern tip of King Island and contains Cape Wickham lighthouse and the gravesites of the crew of Loch Leven, a ship that was wrecked nearby. It is designated as IUCN Category V which is a protected landscape/seascape. There is no management plan for the Cape Wickham Conservation Area.

4.2.11.7 Cataraqui Point Conservation Area

Cataraqui Point Conservation Area is located on the west coast of King Island covering an area of 3.05km^2 and extending from the coast to 100-200m inland. The conservation area is designated as IUCN Category V and there is no management plan in place.

4.2.11.8 Christmas Island Nature Reserve

Christmas Island Nature Reserve covers 84.24ha surrounding the granite island to the north-west of King Island. The reserve is part of the King Island Important Bird Area recognised by BirdLife Australia for providing important habitat for the Orange-bellied Parrot during its migration as well as significant numbers of Short-tailed Shearwater, Black-faced Cormorant, Fairy Tern, Hooded Plover and Pacific Gull (BirdLife Australia 2023c).

4.2.11.9 City of Melbourne Bay Conservation Area

City of Melbourne Bay Conservation Area covers 201.03ha on King Island. The conservation area is designated as IUCN Category V and there is no management plan in place.

4.2.11.10 Colliers Swamp Conservation Area

Colliers Swamp Conservation Area covers 1,089.8ha on King Island. The conservation area is designated as IUCN Category VI and there is no management plan in place.

4.2.11.11 Councillor Island Nature Reserve

Councillor Island Nature Reserve covers 17.58ha of the granite island within the New Year Group. The reserve is part of the King Island Important Bird Area recognised by BirdLife Australia for providing important habitat for the Orange-bellied Parrot during its migration as well as significant numbers of Short-tailed Shearwater, Black-faced Cormorant, Fairy Tern, Hooded Plover and Pacific Gull (BirdLife Australia 2023d). The conservation area is designated as IUCN Category Ia and there is no management plan in place.

4.2.11.12 Four Mile Beach Regional Reserve

Four Mile Beach Regional Reserve covers 3,280.45ha along the west coast of Tasmania. The reserve is designated as IUCN Category VI and there is no management plan in place.

4.2.11.13 Hunter Island Conservation Area

Hunter Island Conservation Area covers 7,330.41ha between King Island and north-west Tasmania. Hunter Island is the main island of the Hunter Island Group which is also an Important Bird Area recognised by BirdLife Australia as supporting the Orange-bellied Parrot, Short-tailed Shearwater, Black-faced Cormorant and Pacific Gull (BirdLife International 2023e).

4.2.11.14 Lavinia State Reserve

Lavinia State Reserve covers 7,860.4 ha on King Island at the Lavinia Ramsar Site. See Section 4.2.6.2.

4.2.11.15 Mount Heemskirk Regional Reserve

Mount Heemskirk Regional Reserve covers 16,737.11ha along the west coast of Tasmania. The reserve is designated as IUCN Category VI and there is no management plan in place.

4.2.11.16 Nares Rocks Conservation Area

Nares Rocks Conservation Area covers 3.06ha in the Hunter Island Group between King Island and north-west Tasmania. Breeding activity has been recorded in the area for significant species including the Common Diving-petrel, Pacific Gull, Silver Gull and Black-faced Cormorant (Brothers et al. 2001).

4.2.11.17 New Year Island Game Reserve

New Year Island Game Reserve covers 118.22ha to the north-west of King Island. The reserve is part of the King Island Important Bird Area recognised by BirdLife Australia for providing important habitat for the Orange-bellied Parrot during its migration as well as significant numbers of Short-tailed Shearwater, Black-faced Cormorant, Fairy Tern, Hooded Plover and Pacific Gull (BirdLife Australia 2023f).

4.2.11.18 Ocean Beach Conservation Area

Ocean Beach Conservation Area covers 6,192.8ha along the west coast of Tasmania. The conservation area is an IUCN category V and there is no management plan in place.

4.2.11.19 Porky Beach Conservation Area

Porky Beach Conservation Area is located on the west coast of King Island covering an area of 4.55km^2 and extending from the coast to 100-200m inland. The conservation area is designated as IUCN Category V and there is no management plan in place.

4.2.11.20 Red Hut Point Conservation Area

Red Hut Point Conservation Area covers an area of 159.84ha on King Island. The conservation area is designated as IUCN Category V and there is no management plan in place.

4.2.11.21 Reid Rocks Nature Reserve

Reid Rocks Nature Reserve covers 6.62ha in the New Year Island Group. It is the only breeding site in Tasmania for Australian Fur-seals (PWS 2000).

4.2.11.22 Sea Elephant Conservation Area

Sea Elephant Conservation Area covers 722.06ha on King Island, approximately 25km north-east of Currie. The conservation area is designated as IUCN Category VI and there is no management plan in place.

4.2.11.23 Seal Rocks State Reserve

Seal Rocks State Reserve is a 5.84km^2 area on the south-western coast of King Island. The state reserve is an IUCN category III and there is no management plan in place. Images produced by google maps and google earth, show the coastal sections of the reserve consist primarily of large rocks and rocky cliffs.

4.2.11.24 Southwest National Park

Southwest National Park is Tasmania’s largest National Park, covering 641,313ha and is part of the Tasmanian Wilderness World Heritage Area (See Section 4.2.1.1).

4.2.11.25 Stokes Point Conservation Area

Stokes Conservation Area is a 2.44 km^2 area on the south-western coast of King Island. The state reserve is an IUCN category V and there is no management plan in place.

4.2.11.26 Sundown Point State Reserve

Sundown Point State Reserve covers 149.4ha and is within the Arthur-Pieman Conservation Area (see Section 4.2.11.1).

4.2.11.27 The Doughboys Nature Reserve

The Doughboys Nature Reserve covers 19.98ha at the Doughboy Islands (Koindrim) as part of the Trefoil Island Group off the north-west of Tasmania. The Doughboys are part of the Hunter Island Group Important Bird Area, recognised by BirdLife Australia as supporting the Orange-bellied Parrot, Short-tailed Shearwater, Black-faced Cormorant and Pacific Gull (BirdLife International 2023g).

4.2.11.28 Trial Harbour State Reserve

Trial Harbour State Reserve covers 0.71ha along the west coast of Tasmania. The state reserve is an IUCN category III, aimed to protect a natural monument or feature.

4.2.11.29 West Point State Reserve

West Point State Reserve is a 5.56km^2 area on the northwest coast of Tasmania. The state reserve is an IUCN category V and there is no management plan in place.

4.2.12 South Australian Protected Areas – Marine

The PMST identified Lower South East Marine Park within the Planning Area, however this is due to the size of grids used in the PMST and does not actually overlap the project.

4.2.13 Key Ecological Features

Key Ecological Features (KEFs) are elements of the marine environment, based on current scientific understanding, and are considered to be of regional importance for either the region's biodiversity or ecosystem function and integrity of a Commonwealth Marine Area.

One KEF, West Tasmanian Canyons, was identified within the Project Area (Appendix A). The Project Area overlaps to a minor extent and the KEF is located on the continental slope where Project activities are not planned to occur.

Four KEFs were identified within the Planning Area (Appendix B) (Figure 25):

- Bonney Coast Upwelling
- Seamounts South and East of Tasmania
- Upwelling East of Eden
- West Tasmanian Canyons
-

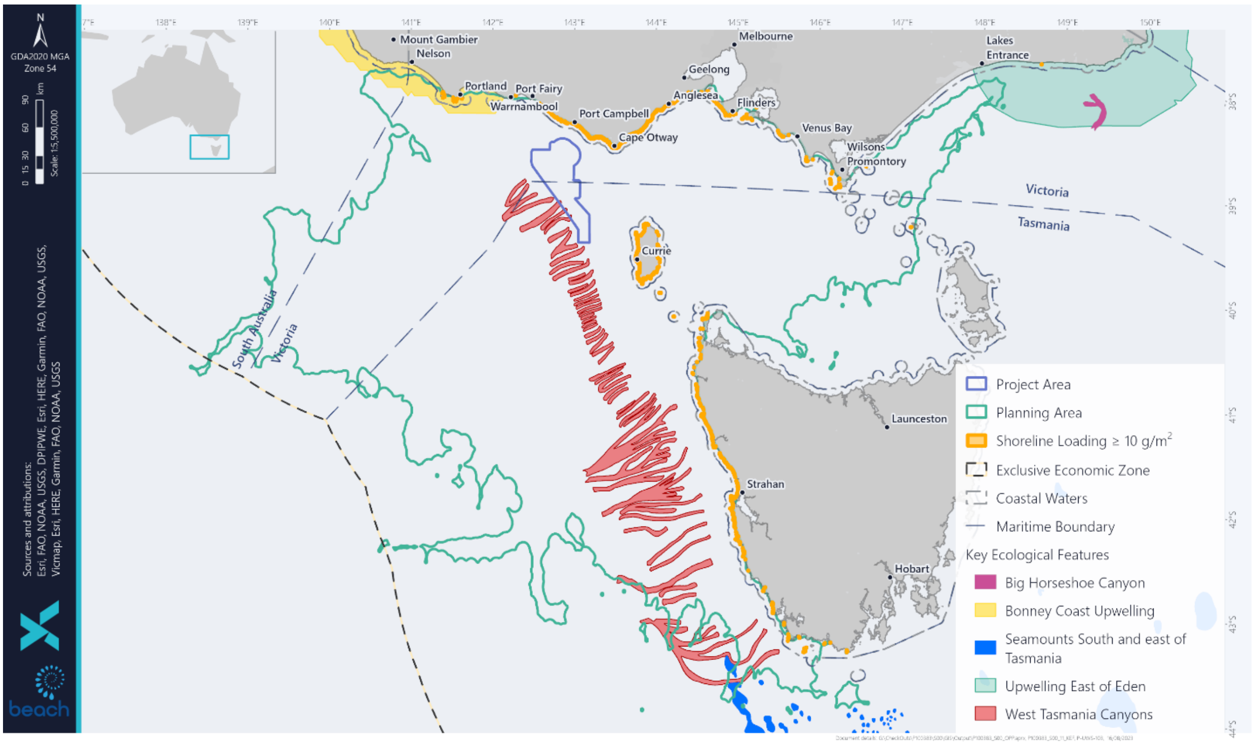


Figure 25: Key Ecological Features within the Project and Planning Areas

4.2.13.1 Bonney Coast Upwelling

The Bonney Coast upwelling is a predictable, seasonal upwelling bringing cold nutrient rich water to the sea surface and supporting regionally high productivity and high species diversity in an area where such sites are relatively rare and mostly of smaller scale (CoA 2015c). The Bonney Coast upwelling is defined as a key ecological feature as it is an area of enhanced pelagic productivity and has high aggregations of marine life (DCCEEW 2023a). In addition to whales, many endangered and listed species frequent the area, possibly also relying on the abundance of krill that provide a food source to many seabirds and fish. The high productivity of the Bonney coast upwelling is also capitalised on by other higher predator species such as little penguins and Australian Fur-seals feeding on baitfish (CoA 2015c).

The Bonney Coast Upwelling KEF lies on the continental shelf situated approximately 120km northwest of Cape Jaffa, South Australia to Portland, Victoria (Figure 25). The location of the Bonney Coast Upwelling KEF was originally derived through a review of enhanced chlorophyll occurrence for summer seasonal data between the years of 1998 and 2010 (Research Data Australia 2013).

4.2.13.2 Seamounts South and East of Tasmania

The Seamounts South and East of Tasmania are a cluster of seamounts east of Flinders Island to the south-east of Tasmania which rise from abyssal plain, continental rise or plateau at least 200km from shore. The seamounts provide substrate and habitat for invertebrates which attracts aggregations of marine life (CoA 2015).

4.2.13.3 Upwelling East of Eden

The Upwelling East of Eden is an area of high primary productivity, supporting fisheries and biodiversity including top order predators, marine mammals, and seabirds. Episodic productivity events are caused by dynamic eddies of the East Australian Current as they interact with the continental shelf and headlands. The nutrient mixing and enrichment drives phytoplankton blooms which provide a basis for the food chain including zooplankton, copepods, krill, and small pelagic fish. The location of the KEF varies seasonally and annually but has been spatially derived based on chlorophyll occurrence during winters from 1998 to 2010 (CoA 2015).

4.2.13.4 West Tasmanian Canyons

The West Tasmanian Canyons are located on the relatively narrow and steep continental slope west of Tasmania. This location has the greatest density of canyons within Australian waters where 72 submarine canyons have incised a 500 km-long section of slope (Heap and Harris 2008). The canyons in the Zeehan AMP are relatively small on a regional basis, each less than 2.5km wide and with an average area of 34km^2 shallower than 1,500m (Williams et al. 2009). The Zeehan canyons are typically gently sloping and mud-filled with less exposed rocky bottoms compared with other canyons in the south-east marine region (e.g. Big Horseshoe Canyon).

Submarine canyons modify local circulation patterns by interrupting, accelerating, or redirecting current flows that are generally parallel with depth contours. Their size, complexity and configuration of features determine the degree to which the currents are modified and therefore their influences on local nutrients, prey, dispersal of eggs, larvae and juveniles and benthic diversity with subsequent effects which extend up the food chain.

Eight submarine canyons surveyed in Tasmania, Australia, by Williams et al. (2009) displayed depth-related patterns with regard to benthic fauna, in which the percentage occurrence of faunal coverage visible in underwater video peaked at 200-300m water depth, with averages of over 40% faunal coverage. Coverage was reduced to less than 10% below 40 m depth. Species present consisted of low-relief bryozoan thicket and diverse sponge communities containing rare but small species in 150 to 300m water depth.

Sponges are concentrated near the canyon heads, with the greatest diversity between 200m and 350m depth. Sponges are associated with abundance of fishes and the canyons support a diversity of sponges comparable to that of seamounts. Based upon this enhanced productivity, the West Tasmanian canyon system includes fish nurseries (Blue Wahoo and Ocean Perch), foraging seabirds (albatross and petrels), White Shark and foraging Blue and Humpback Whales (TSSC 2015a).

4.3 Physical Environment

4.3.1 Climate

The climate in the Otway is typical of a cool temperate region with cold, wet winters and warm dry summers. It is located on the northern edge of the westerly wind belt known as the Roaring Forties. In winter, when the subtropical ridge moves northwards over the Australian continent, cold fronts generally create sustained west to south-westerly winds and frequent rainfall in the region (McInnes and Hubbert 2003). In summer, frontal systems are often shallower and occur between two ridges of high pressure, bringing more variable winds and rainfall.

4.3.2 Oceanography

4.3.2.1 Winds

Otway is a high-energy environment exposed to frequent storms and significant wave heights. Winds in the area generally exceed 13 knots (23.4km/h) for more than 50% of the time contributing to the moderate to high wave-energy environment. Strongest winds are associated with eastward-moving low pressure and frontal systems that cross the site every 4 to 6 days in winter. Directions are predominantly south-westerly veering north-westerly. September is the windiest month, with average wind speeds of 29 km/h.

4.3.2.2 Waves

The Otway coast has a predominantly south-westerly aspect and is highly exposed to swell from the Southern Ocean. Wave heights generally range from 1.5m to 2m. Waves up to 10m can occur during winter storm events.

4.3.2.3 Tides

Tides are semi-diurnal with a diurnal inequality (Jones and Padman 1983). The maximum tidal range in western Bass Strait is 1.2m. Currents are directed along a north-east/south-west axis, with maximum speeds of 0.3m/s (Fandry 1983).

4.3.2.4 Ocean Currents

The South-east Marine Region is oceanographically complex, with subtropical influences from the north and subpolar influences from the south. The Leeuwin Current transports warm, subtropical water southward along the Western Australian coast and then eastward into the Great Australian Bight where it mixes with the cool waters from the Zeehan Current running along the west coast of Tasmania. These currents are stronger in winter than in summer (**Figure 26**).

The eastern parts of the Region are strongly influenced by the East Australian Current (EAC) that flows southward adjacent to the east coast of New South Wales, Victoria, and Tasmania, carrying warm equatorial waters. The EAC is up to 500m deep and 100 km wide and is strongest in summer when it can flow at up to 5 knots. In winter it flows at 2–3 knots as the oceanographic and climatic drivers in the Coral Sea diminish.

The EAC tends to form ocean eddies that rotate around warm, central cores that can be up to 200km across and may persist for months. The eddies can cross the continental shelf, and when mixing with shelf break waters, create upwellings that form isolated areas of enhanced productivity 200–300km in diameter. Eddies form more frequently off the south coast of New South Wales than other areas but are also common along the east coast of Tasmania. The EAC affects sea surface temperatures on the eastern Tasmanian shelf, which can vary substantially among years depending on the relative influence of subtropical waters.

During winter, the South Australian current moves dense, salty warmer water eastward from the Great Australian Bight into the western margin of the Bass Straight. In winter and spring, waters within the straight are well mixed with no obvious stratification, while during summer the central regions of the straight become stratified.

4.3.2.5 Sea Temperature

Surface seawater temperatures range from 14°C in winter to 21°C in summer. However, upwelling of cooler nutrient-rich water occur along the seafloor during mid to late summer. This upwelling is an extension of the regional Bonney coast upwelling system, which affects southern Australia because of south-east winds forcing surface water offshore thus triggering a compensatory subduction along the bottom. If the wind is strong enough the water sometimes shoals against the coast. The water originates from a subsurface water flow called the Flinders current and has the characteristics of reheated Antarctic Intermediate Water (Levings and Gill 2011).

During winter and spring onshore winds cycling from the southwest to northwest mound the surface layer against the land and cause a south-easterly flow along the coast that fills the shelf from the shore outwards to a depth of 500m deep. Shelf water temperatures at these times range from between 18°C to 14°C with seafloor temperatures warmer in winter than in summer.

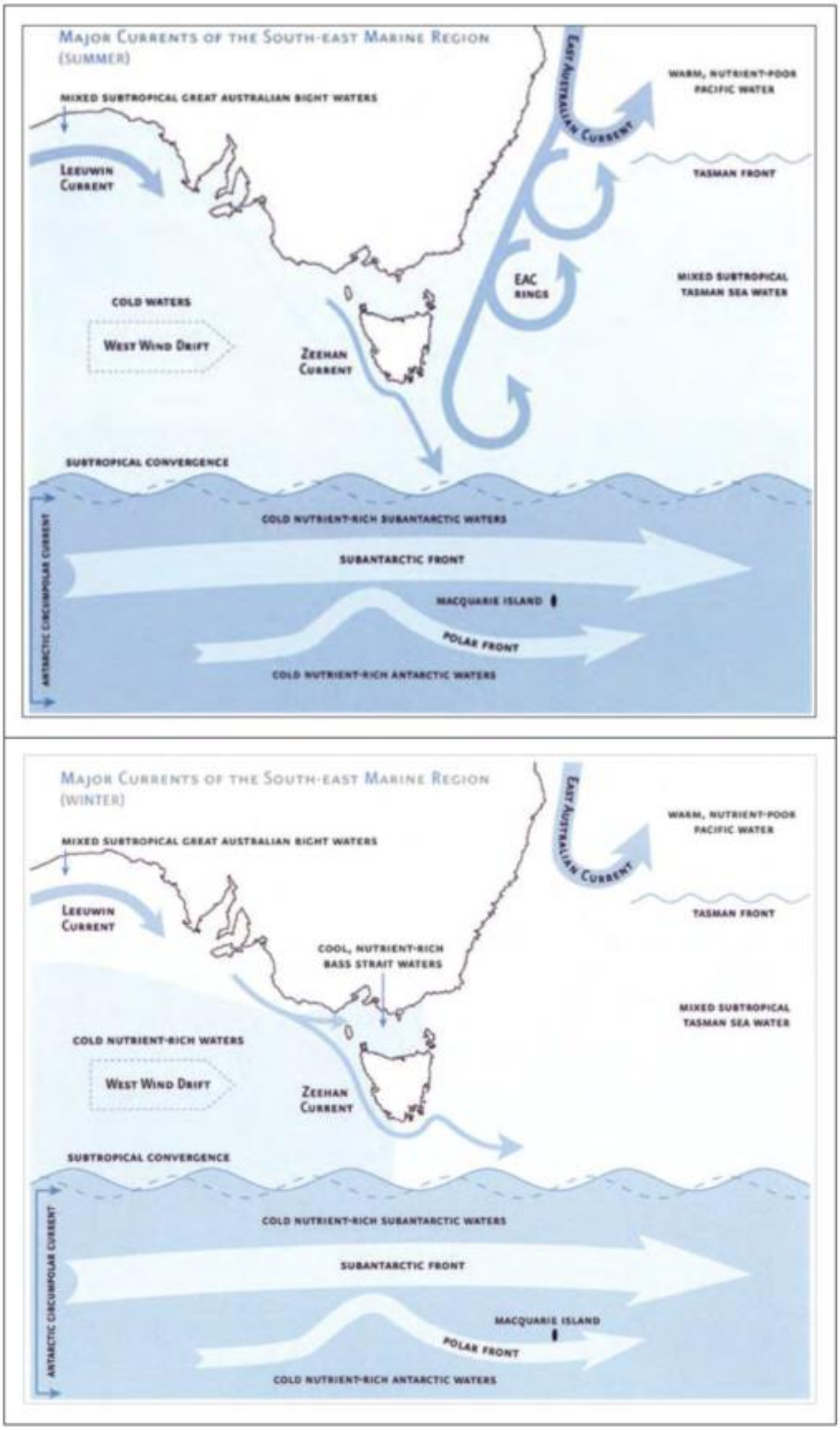


Figure 26: Ocean Currents in South-eastern Australian Waters during Summer (top) and Winter (bottom) (Source: DoE 2015b).

4.3.3 Geomorphology

The south-eastern section of Australia's continental margin comprises the Otway Shelf and the Bonney Coast, Bass Strait, and the western shelf of Tasmania. The 400 km long Otway Shelf lies between 37° and 43.5°S and 139.5°E (Cape Jaffa) and 143.5°E (Cape Otway). The narrowest point is off Portland, where the shelf is less than 20 km wide. It broadens progressively westward, to 60 km of Robe, SA, and eastward to 80 km of Warrnambool. The Otway shelf is comprised of Miocene limestone below a thin veneer of younger sediments.

Boreen et al. (1993) examined 259 sediment samples collected over the Otway Basin and the Sorell Basin of the west Tasmanian margin. Based on assessment of the sampled sediments the authors concluded the Otway continental margin is a swell-dominated, open, cool-water, carbonate platform. A conceptual model was developed which divided the Otway continental margin into five depth-related zones – shallow shelf, middle shelf, deep shelf, shelf edge and upper slope (Figure 27).

In the shallow shelf are exhumed limestone substrates that host dense encrusting mollusc, sponge, bryozoan, and red algae assemblages. The middle shelf is a zone of swell-wave shoaling and production of mega-rippled bryozoan sands. The deep shelf is described as having accumulations of intensely bioturbated, fine, bioclastic sands. At the shelf edge and top of slope, nutrient-rich upwelling currents support extensive, aphotic bryozoan/sponge/coral communities. The upper slope sediments are a bioturbated mixture of periplatform bioclastic debris and pelleted foraminiferal/nano-fossil mud. The lower slope is described as crosscut by gullies with low accumulation rates, and finally, at the base of the slope the sediments consist of shelf-derived, coarse-grain turbidites and pelagic ooze.

The Project Area is primarily located within the shallow, middle and deep shelf zones with the southwestern portions extending beyond the shelf edge to the upper slope.

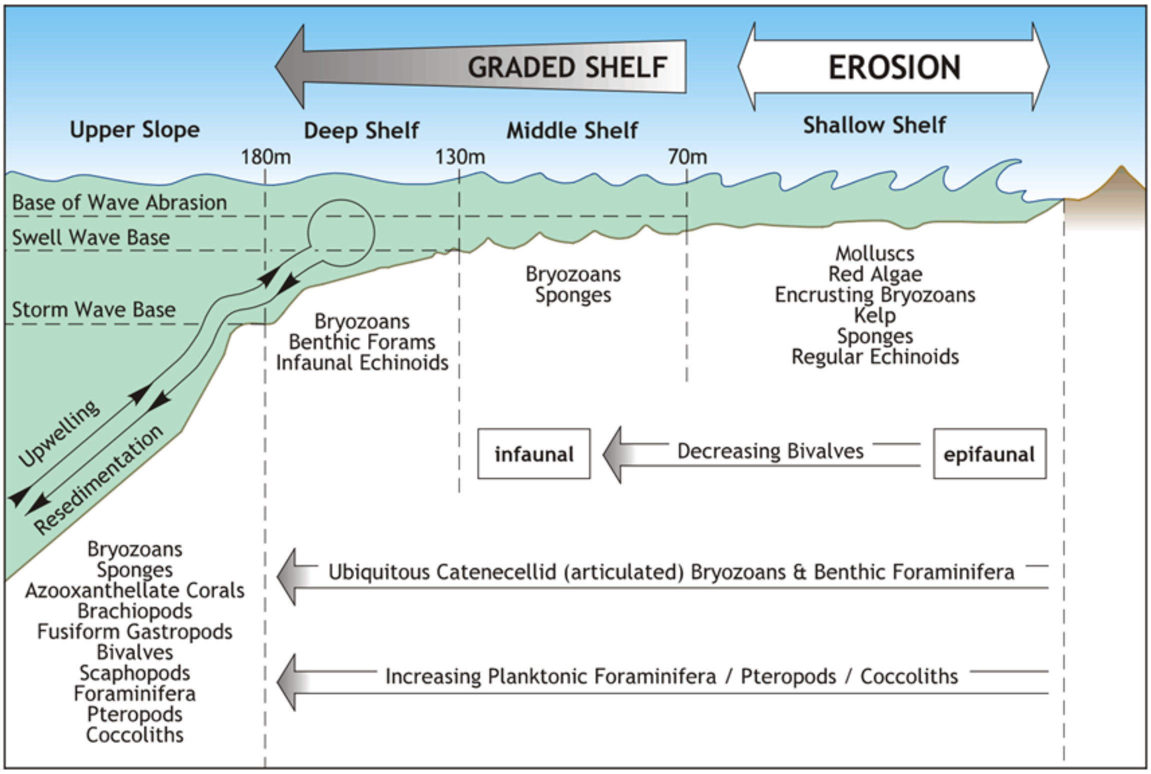


Figure 27: Model of the Geomorphology of the Otway Shelf (Boreen et al. 1993)

Previous surveys of the shallow shelf and middle shelf zones where existing Beach infrastructure is located are provided in detail in Section 4.4.1. A video survey of the seabed at selected sites along proposed offshore pipeline routes for the Otway Gas Development (BBG 2003) found that the substrate in water depths between 82 and 66m were predominantly low profile limestone with an incomplete sand veneer that supported a low to medium density, sponge dominated filter feeding community. Fish and other motile organisms were uncommon.

In shallower depths of between 63 and 30m, the video surveys showed a rippled, sand or sand/pebble substrate with minor sponge dominated benthic communities. The epibenthic organisms were generally attached to outcropping or sub-outcropping limestone pavements. Only in waters shallower than approximately 20 m, was an area of significant, high profile reef and associated high density macroalgae dominated epibenthos encountered.

Prior to activities in the deep shelf and upper slope, further studies will be undertaken to understand the geomorphology of areas where infrastructure will be installed. Section 4.4.1 provides further detail on studies to be undertaken.

4.3.4 Sediment Quality

Sediments were sampled during the Otway Basin Environmental Survey (Ramboll, 2020. Appendix C). Sediment samples were collected at two of the gas fields, Artisan and Thylacine. For sample locations see **Figure 30**. The Artisan field would be representative of the sediments closer to shore, while the Thylacine field which is further offshore would be representative of the sediments in the deeper waters of the Project Area. Further studies are planned to understand the sediment quality of the deepest portion of the Project Area, located on the upper slope (refer to Section 4.4.1).

The sediment within all samples was predominantly sand with a range of 95-97% as a proportion of each sample. There was very little silt and a maximum of 4.7% for the clay fraction. There were no discernible trends based on the location of sample collection.

The oxidation reduction potential (ORP) of sediments within the samples was measured and the anoxic layer with low ORP was not detected in any of the sediments analysed and the range of measurements indicated that these sediments maintain a well oxygenated, unmodified environment.

There was a notable degree of variability in the nutrient samples collected in the Thylacine field, however the small number of samples means that a trend or pattern was not discernible. Nitrate-nitrite was not detected in any samples. Total organic content and detectable nitrogen concentrations were slightly higher in the Artisan samples compared to the Thylacine samples. Generally, the concentrations of nutrients in the marine sediments were to be expected for this environment and type of sediment.

Of the inorganic compounds tested, Cd, Cu, Pb, Hg, Ni and Sn were below the limit of reporting in all sediment samples. The concentration of Cr in sediments was low, and well below the Interim Sediment Quality Guidelines low trigger value from the recommended sediment quality guidelines set out in ANZECC (2000). The concentration of Cr was slightly higher in the samples from Artisan than those from Thylacine. Zn was detected in two of the six samples (one sample from each field) and was well below the Interim Sediment Quality Guidelines low trigger value.

BTEXs, PAHs, PCBs and TRHs were either below the LOR or at levels of no concern.

In summary, sediments had a high ORP and low or undetectable levels of toxicants indicating an unmodified seabed environment. It is expected that sediment quality within the Project Area and Planning Area will be typical of the offshore marine environment of the Otway Basin.

4.3.5 Water Quality

Water quality was sampled during the Otway Basin Environmental Survey (Ramboll, 2020. Appendix C). For sample locations see **Figure 30**. Water samples were collected at two of the gas fields, Artisan and Thylacine. The Artisan field would be representative of the water quality closer to shore, while the Thylacine field which is further offshore would be representative of the water quality in the deeper waters of the Project Area.

In situ measurements were taken for dissolved oxygen (DO), pH and oxidation-reduction potential (ORP) and DO and pH were assessed against the default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems set out in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000). Trigger values are used to assess risk of adverse effects due to nutrients, biodegradable organic matter, and pH in various ecosystem types.

DO was between the lower and upper limits of 90 and 110% saturation for marine waters in all samples. Likewise, pH was between the lower and upper limits of 8.0 and 8.4 for all samples. The range of ORP measurements indicated a well oxygenated, ecologically healthy environment.

Laboratory analyses for a suite of analytes were undertaken and compared to the ANZECC (2000) default trigger values for physical and chemical stressors for nutrient analytes and the trigger values for toxicants at alternative levels of protection for all other analytes.

The concentration of ammonia, nitrite and reactive phosphorus was at or below the level of reporting (LOR) for all samples. Only one sample contained a concentration of nitrate-nitrite, NO-3, Total Kjeldahl Nitrogen and Total Nitrogen above the LOR, however, none of the measurements exceeded ANZECC trigger values. Concentrations of Total Phosphorus were recorded in all samples, but all measurements were well below ANZECC trigger values. Total Suspended Solids was typically within the range expected for unmodified marine waters.

The concentrations of Cd, Cr, Co, Pb, Hg, and Ni were at or below LOR in all samples. The concentration of Cu was below, at or very close to the LOR for all samples. The concentration of Zn against ANZECC protection level (or trigger values) were below the 90% protection level but concentrations variously exceeded 95 or 99% protection levels. This result is consistent with a slightly disturbed marine system which is described in (ANZECC 2000) as an ecosystem in which biodiversity may have been affected to small degree by human activity.

BTEXs and PAHs were below the detection limit in all water samples. Very low traces of Total Recoverable Hydrocarbon (TRHs) were detected in a Thylacine water sample but were at levels of no concern. TRHs were below detection limits in all other samples. The level of chlorophyll a in filtered samples was below the detection level.

In summary, the water quality at the Thylacine and Artisan survey areas indicated an undisturbed mid-depth environment.

It is expected that water quality within the Project Area and Planning Area will be typical of the offshore marine environment of the Otway Basin, which is characterised by high water quality with low background concentrations of trace metals and organic chemicals.

4.3.6 Light

Ambient light is predominantly from solar/lunar luminescence. There are minor anthropogenic sources from townships and nearby shipping lanes.

4.3.7 Ambient Sound

McCauley and Duncan (2001) undertook a desktop review of natural and man-made sea sound sources likely to be encountered in the Otway Basin. They concluded that natural sea sound sources are dominated by wind noise, but also include rain noise, biological noise and the sporadic noise of earthquakes. Man-made underwater sound sources in the region comprise shipping and small vessel traffic, petroleum production and exploration drilling activities and sporadic petroleum seismic surveys.

Between 2009 and 2016 the Integrated Marine Observing System (IMOS) recorded underwater sound south of Portland, Victoria (38°32.5' S, 115°0.1'E). Prominent sound sources identified in recordings include Blue and Fin Whales at frequencies below 100 Hz, ship noise at 20 to 200Hz and fish at 1 to 2kHz (Erbe et al. 2016). In the broader region, primary contributors to background sound levels were wind, rain and currents-and waves associated sound at low frequencies under 2kHz (Przeslawski et al. 2016). Biological sound sources including dolphin vocalisations were also recorded (Przeslawski et al. 2016).

During April-May 2001 two underwater noise loggers were placed (5.1 km and 2.9 km south-west of an exploration petroleum drilling vessel at the Thylacine site) to measure underwater noise before, during and after drilling activity. A further logger was placed in the shipping lane approximately 60 km due south of Port Fairy to measure ambient noise produced by physical, manmade and biological sources between late November 2001 and early March 2002 (Woodside 2003). Baseline broadband underwater noise for the period was in the order of 93 to 97 dB re 1 µPa with shipping raising the averaged noise level above 105 dB re 1 µPa for 6% of the deployment time.

An acoustic monitoring program was also undertaken during exploratory drilling of the Casino-3 well. A sound logger located 28.03 km from the drill site did not detect drilling noise and recorded ambient noise that ranged between 90 and 110 dB re 1 µPa (McCauley 2004). Passive acoustic monitoring commissioned by Origin from April 2012 to January 2013, 5 km offshore from the coastline east of Warrnambool, identified that ambient underwater noise in coastal areas is generally higher than further offshore, with a mean of 110 dB re 1 µPa and maximum of 161 dB re 1 µPa (Duncan et al. 2013).

More recently, JASCO Applied Sciences (Australia), JASCO, completed a monitoring study for Beach in relation to exploration drilling activities at the Artisan-1 well with the aim of completing an acoustic characterisation of the drilling and associated vessel activity within the Otway Basin. McPherson et al. (2021) details the monitoring program and results. Four recorders were deployed in February and retrieved in early April 2021 with Stations 1 through 4 deployed at distances of 0.336, 1.13, 5.11, and 25 km from the Ocean Onyx drill rig. The results for Station 4, the furthest from the drill rig, were a median broadband ambient noise of 104.5 dB re 1 µPa, a mean of 118.3 dB re 1 µPa, a minimum of 86.6 dB re 1 µPa, and a maximum of 153.6 dB re 1 µPa. This is both quieter and louder than those for Casino 3. The mean levels at Station 4 are 8.3 dB higher than those recorded 5 km offshore of Warrnambool, while the maximum recorded at Station 4 is lower by 7.4 dB. For Station 4 contributors to the soundscape were weather, shipping, and marine mammals. Local variations in ambient noise and received levels can depend upon water depth and the proximity to contributors. In this case, the shipping lanes and the frequency and proximity of vessel passes are strong drivers of the ambient noise at Station 4. The quieter levels reported at Thylacine in Lattice Energy (2017) are likely due to the placement of the monitoring station at a distance from the shipping lanes, which limited their contributions to the data set and thus resulted in a lower reported range of received sound levels.

4.3.8 Bonney Coast Upwelling

The Bonney coast upwelling is mainly driven by the frequent south-easterly winds during the austral summer (Lewis 1981, Middleton and Bye 2007, Nieblas et al. 2009, Schahinger 1987). The frequent south-easterly winds are the result of southern migration of the subtropical ridge (Nieblas et al. 2009, Schahinger 1987). The upwelling occurs via Ekman dynamics, where the ocean surface experiences a steady wind stress which results in a net transport of water at right angles to the left of the wind direction which brings cold, nutrient rich water to the sea surface.

Huang and Wang (2019) developed an image processing technique to map upwelling areas along the south-eastern coast of Australia. This study used monthly Moderate Resolution Imaging Spectroradiometer (MODIS) sea surface temperature (SST) composites between July 2002 and December 2016, which were generated from daily SST images with a spatial resolution of ~1 km. As upwelling in winter is unlikely to occur images during this period were not analysed. Upwelling reaching the surface often displays a colder SST signature than the adjacent area (e.g., Dabuleviciene et al. 2018, Gill et al. 2011, Kampf et al. 2004, McClatchie et al. 2006, Oke and Griffin 2011, Oke and Middleton 2001, Roughan and Middleton 2004, Willis and Hobday 2007). This negative SST anomaly is the foundation of upwelling mapping using SST data (Huang and Wang 2019).

The spatial patterns of the mapped Bonney coast upwelling have been shown to follow a clear temporal pattern. When the upwelling season starts during late spring and early summer (November and December), the influence of the Bonney coast upwelling was found to be often restricted to the coast. During the mid-summer and early autumn (January to March) when the upwelling is the strongest, the upwelling influence often extended to the shelf break before retreating in April (Huang and Wang 2019).

Gill et al (2011) states that the Bonney coast upwelling generally starts in the eastern part of the Great Australian Bight and spreads eastwards to the Otway Basin. At the height of the Bonney coast upwelling during February and March, the upwelling's area of influence often exceeds 12,000 km^2, its SST anomaly often exceeds 1°C, and its chlorophyll-a concentrations are often > 1.5 times of its adjacent areas (Huang and Wang 2019).

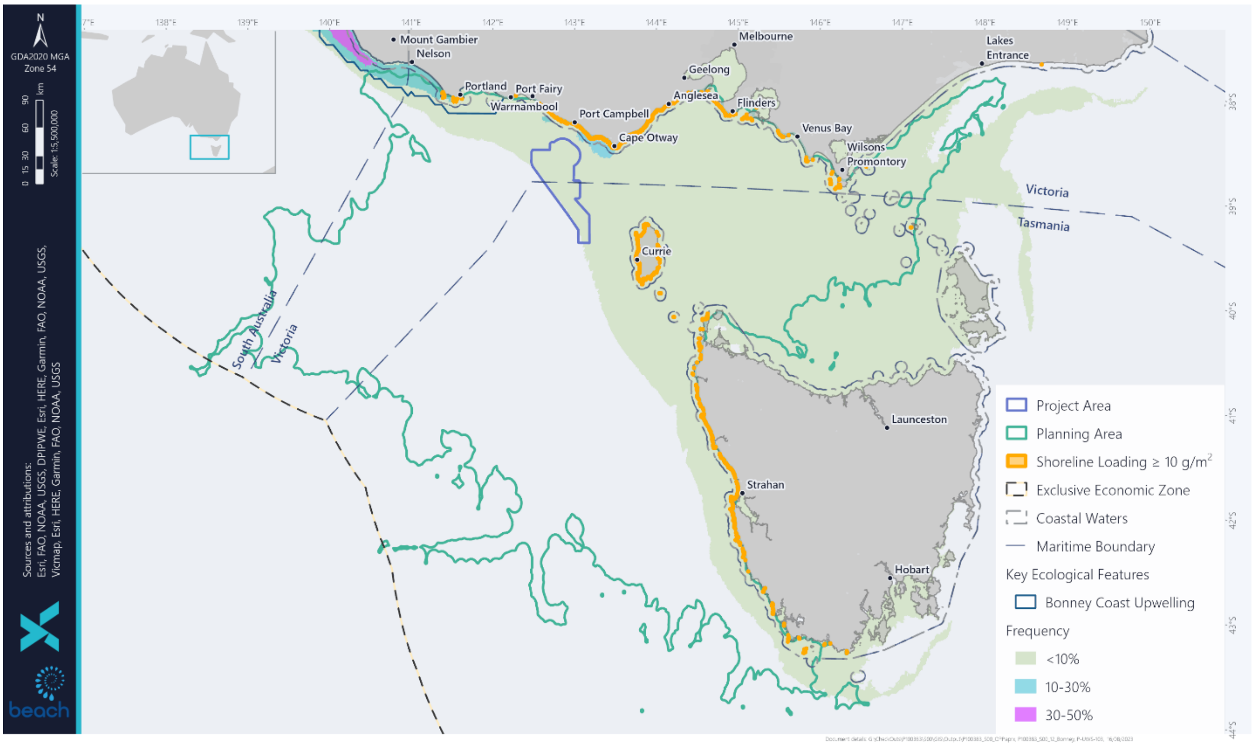


Figure 28: Bonney Coast Upwelling Frequency within the Project and Planning Areas (Source: Huang and Wang 2019, Geoscience Australia 2020)

4.3.8.1.1 Variability

While the general characteristics of the Bonney coast upwelling are broadly understood virtually nothing is known of the longer-term variability of the phenomenon. Alongshore wind is the predominant mechanism in the upwelling, which is, therefore, directly impacted by any changes to the strength or frequency of these winds. However, not all favourable upwelling winds lead to an upwelling event. Huang and Wang (2019) state that each year for the period of 14 years (Sept 2002 to May 2016) of their study there was large variability in the distribution of the upwelling influence areas, month to month, season to season and year to year.

The El Niño – Southern Oscillation (ENSO) has been identified by some authors as a potential driver of upwelling strength along the south Australian coast. The ENSO is the dominant global mode of inter-annual climate variability, is a major contributor to Australia's climate and influences Australia's marine waters to varying degrees around the coast. The two phases of ENSO, El Niño and La Niña, produce distinct and different changes to the climate.

Middleton et al. (2007) examined meteorological and oceanographic data and output from a global ocean model. The authors concluded that El Niño events lead to enhanced upwelling along Australia's southern shelves. However, it has been found that relationships between ENSO events and upwelling and production indices off southern Australia are weak due to the high interannual and inter-seasonal variability in these indices.

Huang and Wang (2019) results indicate that the ENSO events are likely to have a low-to-moderate impact on the upwelling intensity although the El Nino events tend to strengthen upwelling intensity along the south-east coast of Australia with La Nina events tending to weaken upwelling intensity. Previous studies (Middleton and Bye 2007; Middleton et al. 2007) indicated that the El Nino events would raise the thermocline (along the Australian margin) which effectively forms a colder and nutrient-rich pool at shallower depths. This is likely to enhance upwelling intensity, with higher SST and chlorophyll-a anomalies and a larger area of influence.

4.3.8.1.2 Ecological Importance

The primary ecological importance of the Bonney coast upwelling is as a feeding area for the Blue Whale (*Balaenoptera musculus*). The upwelled nutrient-rich re-heated Antarctic intermediate water promotes blooms of coastal krill, *Nyctiphanes australis*, which in turn attracts Blue Whales to the region to feed.

The Bonney coast upwelling is one of only two identified seasonal feeding areas for Blue Whales in Australian coastal waters and is one of 12 known Blue Whale feeding aggregation areas globally. Sightings of the sei whale in the upwelling indicate this is potentially an important feeding ground for the species (Gill et al. 2015). There have also been sightings of the fin whale, which indicate this could potentially be an important feeding ground (Morrice et al. 2004)

The high productivity of the Bonney coast upwelling also leads to other attributes such as algal diversity and its productivity as a fishery. This productivity is also capitalised on by other higher predator species such as Little Penguins and Fur-seals feeding on baitfish. Robinson et al. (2008) postulated that upwelling waters may bring fish prey of Australian Fur-seals to surface waters, which are then flushed into Bass Strait within foraging range of seals.

4.3.8.1.3 Linkages between Climate, Upwelling Strength, and Blue Whale Abundance

The complex interaction between climatic conditions, upwelling strength and seasonal Blue Whale distribution and abundance within the Bonney coast upwelling is currently poorly understood other than at a general level. Factors to be resolved to enable a more detailed understanding include observations that not all strong upwelling-favourable winds necessarily lead to strong upwelling events (Griffin et al. 1997) and that increased upwelling does not necessarily equate to increased productivity as conditions may be less optimal for plankton growth. Huang and Wang (2019) found a generally weak and unclear correlation between chlorophyll-a and SST. This weak correlation may be due to chlorophyll-a concentrations (a remote measure of plankton population) are also influenced by other complex oceanographic and biological mechanisms such as grazing, seasonality and transportation.

Further an increase in plankton biomass does not necessarily coincide with the presence of the Blue Whales. Review of pygmy Blue Whale aerial observation data from Gill et al. (2011) from the 2001-02 to 2006-07 seasons, and additional surveys in the Otway Basin commissioned by Origin during February 2011 and November -December 2012 did not find a significant positive correlation between El Niño conditions and pygmy Blue Whale abundance. Such a positive correlation could be expected if El Niño conditions caused stronger upwelling, stronger upwelling led to increased planktonic productivity and Blue Whales were more likely to be present when productivity is higher.

Two of the six seasons subject to aerial surveys in the eastern section of the Otway Basin (Gill et al. 2011) were determined by the Bureau of Meteorology to demonstrate weak to moderate El Nino conditions. The remainder of the years were assessed to be neutral. The two El Nino seasons (2002-03 and 2006-07) corresponded with the lowest observation frequencies (sightings/1,000 km) for pygmy Blue Whales of all the yearly surveys.

Aerial surveys commissioned by Origin undertaken during February 2011 and November-December 2012 were undertaken during La Nina events classified by the Bureau of Meteorology as very strong and strong respectively. Although observation frequencies are not available, the absolute numbers of pygmy Blue Whales observed was substantially higher than during the 2001-01 to 2006-07 surveys. Also, of note is that pygmy Blue Whales observed during February 2011 were congregated along the seaward edge of a plume of terrestrial runoff, potentially suggesting use of this plume as a feeding resource, which has no relationship to upwelling.

As such, the interactions between climate and ecology for this upwelling system are complex and no definitive linkages between climatic events, upwelling strength and Blue Whale abundance have yet been described.

4.3.8.1.4 Operational Setting

Mapping of the Bonney coast upwelling frequency by Huang and Wang (2019) identified that the occurrence of an upwelling event between 2002 and 2016 (measured by remote sensing of a combination of SST anomaly and chlorophyll-a) within the Project Area was unlikely with an upwelling frequency for this area of <10%. The closest areas of increased frequency of upwelling events to the Project Area (10-30% occasional/semi-seasonal) were small, isolated areas situated in coastal areas to the north and north-east (**Figure 28**). Areas of further increased frequencies of Bonney coast upwellings (30-50% seasonal) were found over 198 km to the west of the Project Area.

4.4 Ecological Environment

To characterise the ecological environment, a literature search and online resources and databases were reviewed to identify and assess species that may be present or potentially present in the Project and Planning Areas. The following information sources were used:

- Online government databases, publications, and interactive mapping tools, such as the SPRAT database and National Conservation Values Atlas.
- Protected Matters Search Tool (PMST) for Matters of National Environmental Significance (MNES) protected under the EPBC Act.
- Species conservation advice and recovery plans.
- In field survey data for the Otway area.
- Published observations, data, and statistics on marine mammals.
- Reports from scientific experts and institutions, marine biologist and experts in Blue Whale and Southern Right Whale populations in the Otway area.
- Relevant listings under the Victorian FFG Act 1988
- Relevant listings under the Tasmanian Threatened Species Conservation Act (1995)
- Relevant environmental guidelines and publicly available scientific literature on individual species.

4.4.1 Benthic Habitats and Communities

As discussed in Section 4.3.3, a number of studies (Boreen et al. 1993, BBG 2003, CEE Consultants Pty Ltd 2003 and Ramboll 2020) have been undertaken within the Project Area within the shallow and middle shelf zones. These studies have identified the seabed is similar across these areas, consisting of carbonate rich coarse to medium sands with areas of exposed limestone substrate. This type of seabed is highly mobile making it difficult for filter feeders and soft body invertebrates to survive and establish in significant populations. Epifauna is dominated by low density, patchy assemblages of branching bryozoans, gorgonian cnidarians and sponges. A summary of these studies is provided below.

The existing studies focus on the shallow and middle shelf zones of up to approximately 130m water depth (refer to Section 4.3.3). Further seabed assessments will be undertaken of the deep shelf and upper slope zones (from approximately 130m to 200m water depth) located predominantly in the southern and western portions of the Project Area. These assessments will enable the seabed composition, benthic habitats and communities to be identified for locations where seabed disturbance activities such as drilling and infrastructure installation may take place and will include:

- geophysical surveys consisting of multibeam bathymetry, side scan sonar, magnetometer, and sub-bottom profiling
- geotechnical sampling consisting of cone penetration tests and coring
- biological sampling consisting of sediment and water samples, and use of seabed imagery to identify benthic habitats at representative locations

In 2002, 2003 and 2004, Fugro undertook a number of bathymetric surveys of the two proposed pipeline rights of way: one constructed for the Thylacine Geographe pipeline and one extending from the completed Geographe A well to Flaxman's Hill.

A review of the available geotechnical data was carried out in March 2011 for the Geographe location (Advanced Geomechanics 2011). Overall, the seabed in the Otway area surveyed slopes to the south at a gentle average gradient of less than 1. However, the local topography is predominantly irregular in nature, varying from gently undulating and locally smooth in areas of increased sediment deposition, to areas of outcropping cemented calcrete features that are from smooth to jagged relief. These areas are covered in marine growth. ROV video survey confirmed the presence of a shallow hard underlying substrate at a depth of 50 mm below the sediment in areas of marine growth (JP Kenny 2012).

The Flaxman's Hill alignment traverses the Thistle drilling area and the Thylacine Geographe pipeline runs parallel and north east of this area. During 2003, bathymetric data was collected, and the right of way was assessed and recorded using an underwater video camera (CEE Consultants Pty Ltd 2003). The Flaxman's Hill pipeline route travels approximately 68 km from the Geographe gas field to the shoreline. Visual assessment of the sea floor was undertaken from a water depth of 99 m to 16 m terminating at Flaxman's Hill.

A summary of the seabed morphology and benthic assemblages is provided in Tables 22 to 26.

Zone	Depth (m)	Width (m/km)	Gradient	Features
Shallow Shelf	30 - 70	4 - 28	1.5 - 10	Drops rapidly from strandline to depths of 30 m, characterised by rugged but subdued topography
Middle Shelf	70 - 130	7 - 65	1 - 8.5	Generally smooth topography with occasional rock out crops

Table 22: Otway margin geomorphology (Boreen et al. 1993)

Depth (m)	Seabed morphology	Benthic assemblage
92	High profile reef stone with deep sand gutters.	Diverse, high density sessile: sponge, coral dominated crinoids common and mobile species
88	Low profile with areas of high profile limestone ridges; incomplete sand veneer.	Diverse, high density sessile: sponge, dominated and mobile species

Table 23: Thylacine to Geographe seabed morphology and benthic assemblages (CEE Consultants Pty Ltd 2003)

Depth (m)	Seabed morphology	Benthic assemblage
82	Low profile with areas of high profile limestone ridges; incomplete sand veneer	Medium density sessile: sponge, dominated low density mobile species. (small shark)
82	Equal % of exposed low profile limestone and sand. Two reef outcrops. Low profile with areas of high profile limestone ridges; incomplete sand veneer.	Medium density, sessile: sponge, dominated
78	Low profile with areas of high profile limestone ridges; incomplete sand veneer	Medium density, sessile: sponge, dominated Motile: sea urchins dominated
76		Medium density, sessile: sponge, dominated
76		Low - Medium density, sessile: sponge, dominated
70		Diverse, med density sessile, sponge dominated
68		Medium density, sessile: sponge, dominated
65		Diverse, med density sessile, sponge dominated
60		Medium density, sessile: sponge, dominated

Table 24: Geographe to Flaxman's Hill seabed morphology and benthic assemblages (CEE Consultants Pty Ltd 2003)

Depth (m)	Seabed morphology	Benthic assemblage
82	Low profile with areas of high profile limestone ridges; incomplete sand veneer	Very low density sessile; large sponge.
79		Diverse, low – high density sessile
75	Low profile with areas of high profile limestone ridges; incomplete sand veneer	Medium density, sessile: sponge, dominated. Motile: sea urchins dominated
74		Medium density, sessile: sponge, dominated
70		Low - Medium density, sessile: sponge, dominated
67		Diverse, med density sessile, sponge dominated
66	Low profile limestone with sand gutters	Medium density, sessile: sponge, dominated

Depth (m)	Seabed morphology	Benthic assemblage
66	Low profile with areas of high profile limestone ridges; incomplete sand veneer	Diverse, med density sessile, sponge dominated
70	(Pock marks) Data not documented.	Medium density, sessile: sponge, dominated
63	Corse gravel to fine sand	High density sessile: micro algae dominated

Table 25: Geographe to Rifle Range seabed morphology and benthic assemblages (CEE Consultants Pty Ltd 2003)

Depth (m)	Seabed morphology	Benthic assemblage
53	Sand	None observed
45		Only sea pens noted
16-30	Very high profile l/stone reef to sand	High density, sessile: sponge, macroalgae (Bull Kelp common)

Table 26: Nearshore seabed morphology and benthic assemblages (CEE Consultants Pty Ltd 2003)

A video survey of the seabed at selected sites along proposed offshore pipeline routes for the Otway Gas Development was undertaken by BBG during 2003 (Figure 29). BBG (2003) found that the substrate in water depths between 82 and 66 m were predominantly low profile limestone with an incomplete sand veneer that supported a low to medium density, sponge dominated filter feeding community. Fish and other motile organisms were uncommon.

In shallower depths of between 63 and 30 m, the video surveys showed a rippled, sand or sand/pebble substrate with minor sponge dominated benthic communities. The epibenthic organisms were generally attached to outcropping or sub-outcropping limestone pavements. Only in waters shallower than approximately 20 m, was an area of significant, high profile reef and associated high density macroalgae dominated epibenthos encountered. Details of the seabed and benthic epifaunal assemblage are provided in Table 27.

Site No.	Depth (m)	Seabed type	Benthic Assemblage
3097	99	Bare rippled sand; minor limestone outcrops	Low density sessile; small sponge dominated
3118	99	Low profile limestone reef with sand veneer. isolated areas of raised l/stone	Low density sessile; sponge dominated
3084	99	Low profile limestone reef with incomplete sand veneer	Low density sessile; sponge dominated
3072	99	Low profile limestone reef with incomplete sand veneer	Low density sessile; sponge dominated
3054	98	Mix of low and high profile l/stone; shallow and deep sand	Low density sessile on low l/stone; high density sessile on high l/stone plus fish; sponge dominated

Site No.	Depth (m)	Seabed type	Benthic Assemblage
3185	95	Low profile limestone reef with incomplete sand veneer	Low density sessile; sponge dominated
3196	94	Low profile limestone reef with incomplete sand veneer	Low density sessile; sponge dominated
3232	92	High profile reef stone with deep sand gutters.	Diverse, high density sessile: sponge, coral dominated crinoids common and mobile species
3267	88	Low profile with areas of high profile limestone ridges; incomplete sand veneer.	Diverse, high density sessile: sponge, dominated and mobile species
2801	82	Low profile with areas of high profile limestone ridges; incomplete sand veneer	Very low density sessile; large sponge.
2720	79		Diverse, low – high density sessile
2590	75	Low profile with areas of high profile limestone ridges; incomplete sand veneer	Medium density, sessile: sponge, dominated. Motile: sea urchins dominated
2490	74		Medium density, sessile: sponge, dominated
2339	70		Low - Medium density, sessile: sponge, dominated
2291	67		Diverse, med density sessile, sponge dominated
2191	66	Low profile limestone with sand gutters	Medium density, sessile: sponge, dominated
2181	66	Low profile with areas of high profile limestone ridges; incomplete sand veneer	Diverse, med density sessile, sponge dominated
1191	63	Coarse gravel to find sand	High density sessile: micro algae dominated
1668	53	Sand	None observed

Table 27: Seabed characteristics and epifaunal assemblage at video survey sites (BBG 2003)

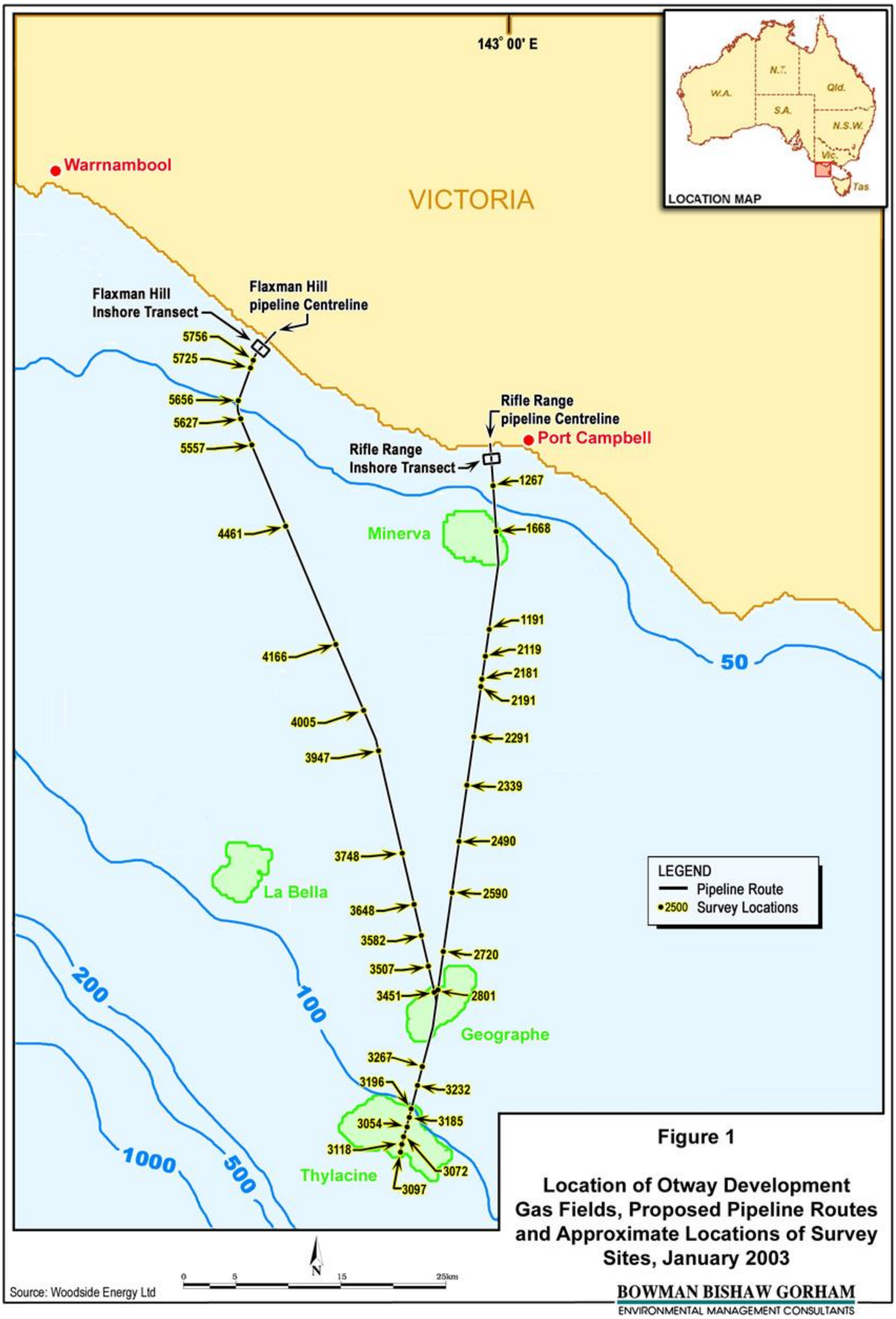


Figure 29: Seabed Sites Assessed by Video Survey During 2003 (BBG 2003)

Beach commissioned a seabed site assessment of the preferred infrastructure routes for the Otway Gas Development which was undertaken during the Otway Basin Environmental Survey from November 2019 to January 2020 and ranged in water depths from 70 to 104 m (Ramboll, 2020. Appendix C). Figure 30 details the survey area and sample locations.

The objective of the seabed site assessment was to determine suitable locations for anchoring and MODU placement for drilling operations and the installation of infrastructure to connect new production wells to the existing platform or pipeline. Several different investigation techniques were used to examine and describe the seabed and benthic habitats, as well as identify possible hazards from manmade, natural, and geological features including benthic habitats

The survey comprised of multibeam bathymetry, side scan sonar, magnetometer, and sub-bottom profiling, cone penetration tests and seabed samples. In addition, sediment samples for infauna were collected and the composition and percent coverage of epifauna was assessed from photographs of the seafloor taken with a drop camera. Drop camera images at various locations are shown in Figure 31 to Figure 38 and survey results are summarised in Table 28.

Sediment samples for infauna were collected at two of the gas fields, Artisan and Thylacine. It was considered that the Artisan field would be representative of the infauna closer to shore (such as along the pipeline route), while the Thylacine field which is further offshore would represent the Geographe field.

The benthic infauna identified and counted from samples collected at the Thylacine and Artisan sites were relatively depauperate in both abundance and diversity. A total of 22 morpho-species were identified, from a total of 45 organisms collected from the grab samples, most of which were polychaete worms or crustaceans. These results are reflective of the sedimentary environment at the Thylacine and Artisan fields. All sites were dominated by sand, which typically have a lower abundance and diversity of infauna given that this abrasive type of substrate tends to be more easily subjected to laminar flows that move the sediment more dynamically than muddy substrates. The consequence of this is a physical environment that is not favourable for filter feeding and burrowing infauna species to inhabit. The types of species that were present in the samples were all those which can be expected to tolerate this somewhat dynamic environment. There were no discernible spatial trends in the distribution of sediment particle size. Likewise, there were no clear trends in the abundance, diversity, or composition of benthic infauna.

The composition and percent coverage of epifauna was assessed from photographs of the seafloor taken with a drop camera system. Percent cover ranged from 0 to 80% of the sample photograph for all samples but on average the percent cover was typically no more than 37%. The seabed at Hot Tap X had the greatest average coverage of epibiota (Figure 36) while the lowest coverage of epibiota was recorded along the route between Artisan and Hot Tap Y (Figure 38). Of the gas field sites, Artisan and Hercules had a slighted greater coverage of epifauna, while the routes between gas fields and Hot Tap Y have the least coverage of epifauna. Of the individual epibenthic organisms, Gastropoda sp. 2 (a cone shell) and crionids (featherstars) were the most abundant.

Further analysis of epifauna from a grab samples at Artisan showed that much of the epifauna is comprised of branching bryozoans, feather-like gorgonian cnidarians and sponges. This complex of encrusting/branching fauna provides refuge for macrofauna such as amphipods, isopods, polychaete worms and molluscs.

Based on the assessment of epifauna using seabed photographs, the general impression of the seafloor is of a unmodified marine environment that supports a patchy complex of branching epibiota (i.e., bryozoans, gorgonian cnidarians, and sponges). This complex was highly patchy, covering 0.25 m^2 on average but could be found in patches of at least 0.4 m^2. A microscopic examination of a qualitative sample of this epibiota indicated that this complex of fauna provide microhabitat for a range of macrofauna such as amphipods, isopods, polychaete worms and molluscs. Such epifaunal habitats are known to provide refuge and other resources for benthic species (Jones 2006). By comparison, there was a low abundance and diversity of infauna living within the sediment which reflects the coarse nature of the substrate. This type of substrate is highly mobile making it difficult for filter feeders and soft bodies invertebrates to survive and establish significant populations.

Ramboll (2020) summarise that the epibiota on the seabed in the vicinity of the Thylacine and Artisan gas fields is representative of what is expected at depths around 70-100 m. The infauna was of relatively low abundance and diversity as expected for coarse sand substrates. No benthic species or ecological communities listed as threatened under the Environmental Protection and *Biodiversity Conservation Act 1999* (the EPBC Act) were identified.

The findings from Ramboll (2020) align with findings from the Otway Gas Development studies (CEE Consultants Pty Ltd 2003; BBG 2003) and Boreen et al. (1993) concerning the subsea features and biological communities likely to dominate the middle shelf zones of the Project Area. In summary the seabed of the Project Area can be characterised as a carbonate mid shelf and deeper sections (60 – 70 m) of the shallow shelf with surficial sediments of carbonate rich coarse to medium sands with areas of exposed limestone substrate. The epifauna is dominated by low density, sessile sponge assemblages.

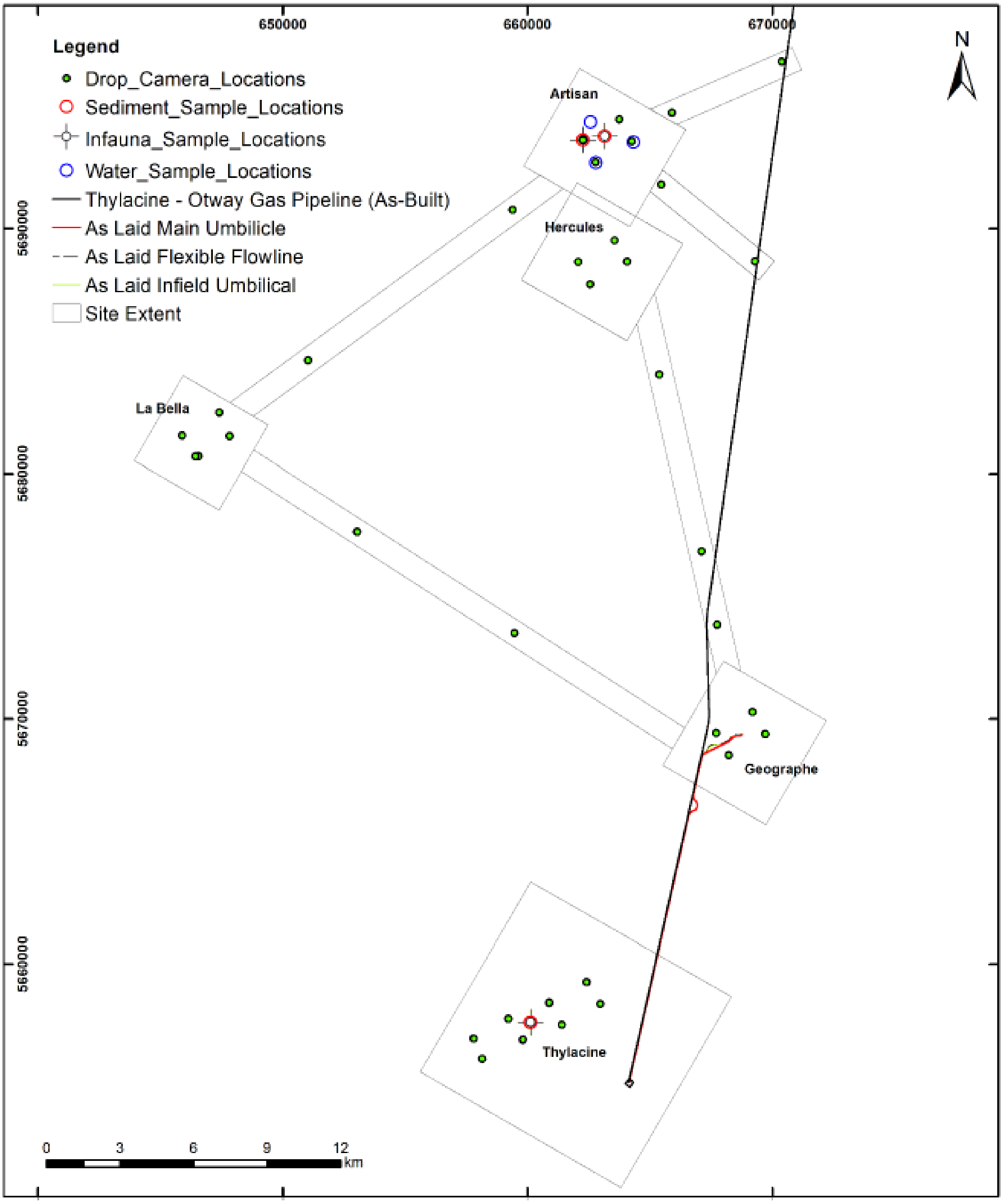
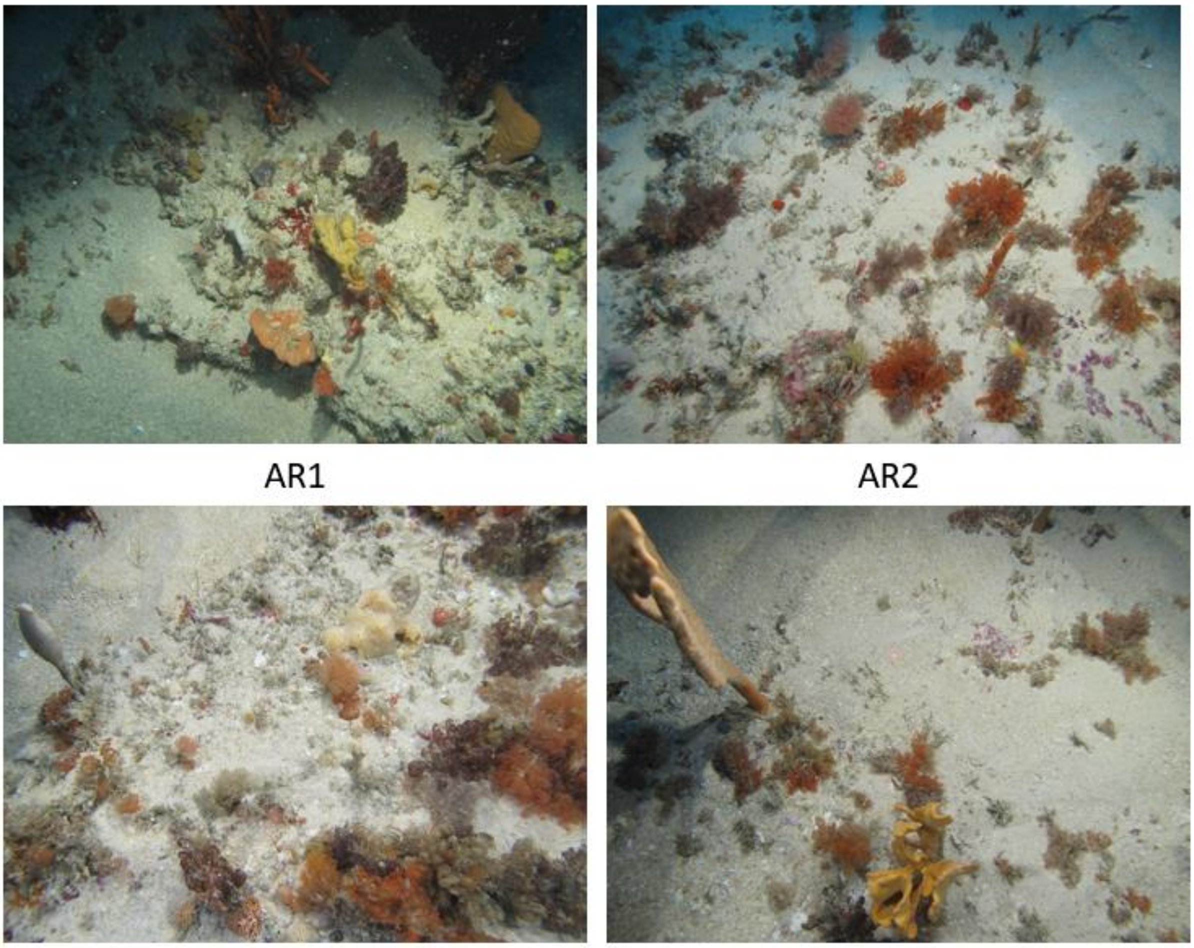


Figure 30: Location of the Otway Gas Development Phase 4 Seabed Site Assessment

Table 28: Results of the Otway Gas Development Phase 4 Seabed Survey (Fugro, 2019; Ramboll, 2020)

Survey Location	Results
Artisan (**Figure 31**)	Very little bathymetric variation across the survey area with water depths ranging from 68 to 74m. Seabed topography dominated by exposed rock on the seabed. Small patches of very thin transgressive coarse sand are present across the survey area. Megaripples were seen in some areas, with a wavelength of 1.5 to 2m and a height of 0.3 to 0.5m. Survey area characterised by low to moderate reflectivity characteristic of rock outcrop. A series of elevated mounds were noted in the north-west of the Artisan survey area 0.5 -1.0m above ambient seabed. Seabed showed a scattered sessile biota on a sandy seafloor.
Thylacine (**Figure 32**)	Seabed depths vary ranging from 92 to 115m, with an overall southwestern slope. Seabed topography compromises of rocky outcrops of the regionally dipping Port Campbell limestones. Sands are coarse (siliceous) calcareous medium sand. A local relief of up to 3m is identified on the rocky scarp surfaces, which are separated by shallow depressions often with a transgressive sandy infill. Percentage epifauna cover from the eight drop camera sites ranged from zero to 65% with an average percentage cover of 14%. Predominantly hard seabed with coarse sand substrates that supports a patchy complex of branching epibiota (i.e., bryozoans, gorgonian cnidarians and sponges). Epibiota on the seabed in the vicinity of the Thylacine gas fields is representative of what is expected at depths around 70 – 100m. Infauna was of relatively low abundance and diversity as expected for coarse sand substrates.
Geographe (**Figure 33**)	Very little bathymetric variation across the survey area with water depths ranging from 80 to 91m. Rocky outcrops of the Port Campbell Limestone show some variable relief up to 2m. Sand is clean washed and well sorted and comprising predominantly of angular broken shells and bryozoans. Percentage cover from the four drop camera sites ranged from zero to 55% with an average percentage cover of 13%. Predominantly hard seabed with coarse sand substrates that supports a patchy complex of branching epibiota (i.e., bryozoans, gorgonian cnidarians, and sponges).
La Bella (**Figure 34**)	Water depth varies from 89 to 104m, with an overall southwestern slope. Seabed characterised by rocky outcrops interspersed with low-lying areas of shallow uncemented sediment. Seabed topography is typical of an eroded platform, with inferred calcarenite lithology. Side scan sonar results also provide flat seabed and megarippled sands and rock outcrop features. At rock exposures, seabed photographs appear to show biogenic growth.
Hercules (**Figure 35**)	Very little bathymetric variation across the survey area with water depths ranging from 71 to 77m. Seabed characterised by rocky outcrops interspersed with low-lying areas of shallow uncemented sediment. Port Campbell limestone cap rock is covered in places by mobile sediments of 1m thickness.

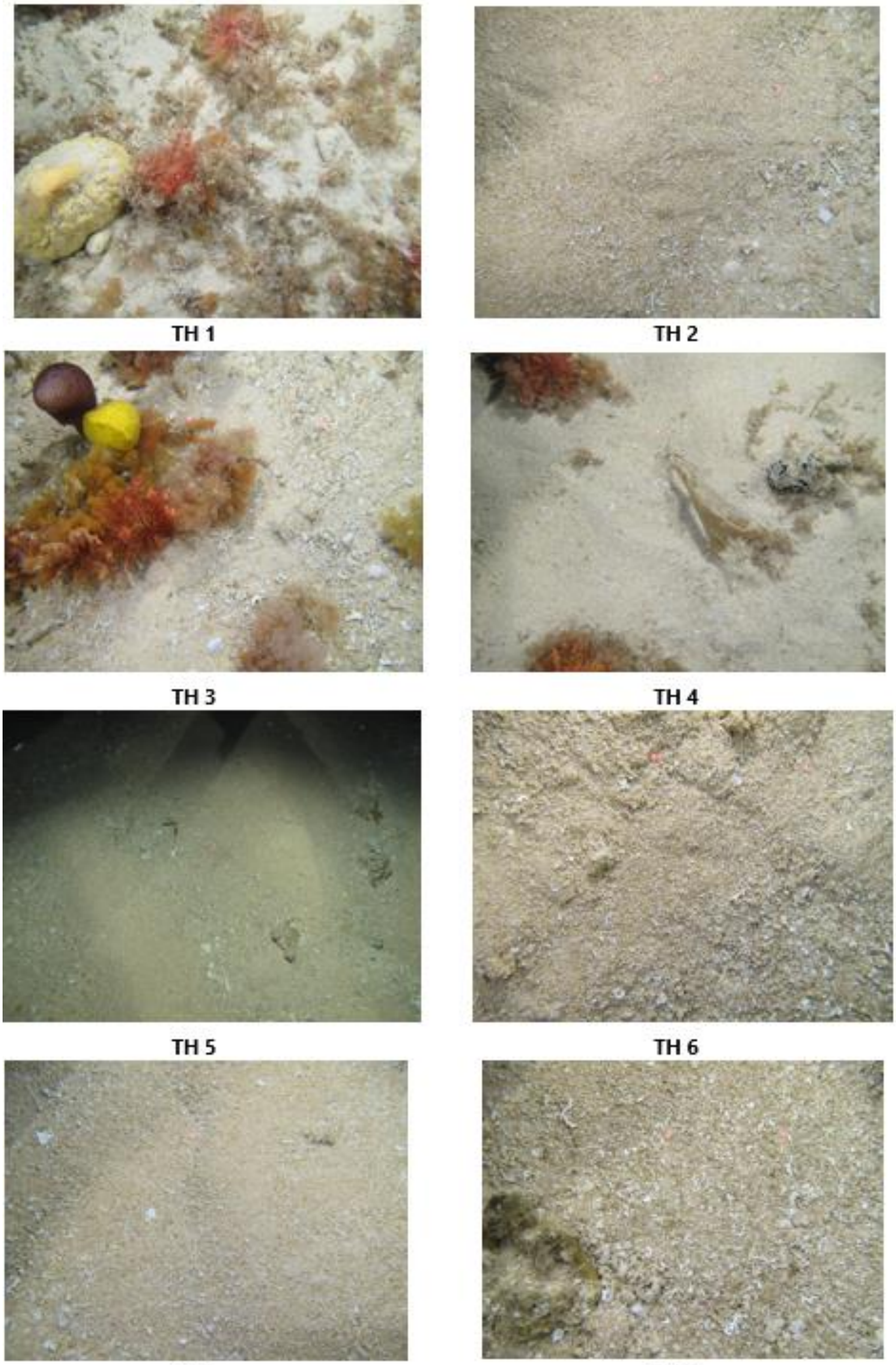
Survey Location	Results
	Hercules site is a southern extension of the Artisan site, and therefore the seabed features bear strong similarities to those seen at Artisan site. Seabed features are typical of an eroded platform, including parallel asymmetric ridges with intermittent depressions.
OGPP and Umbilical Routes (**Figure 36** **Figure 37** **Figure 38**)	Seabed terrain is largely comprised of outcropping calcarenites, incised with erosional features and interspersed with (relatively) low-lying areas where shallow uncemented sands occur. Sands are generally less than 1m thick. Side scan sonar results also provide flat seabed and megarippled sands and rock outcrop features. At rock exposures, seabed photographs appear to show biogenic growth.



AR1 AR2

AR3 AR4

Figure 31: Drop Camera Images at Artisan



TH 1

TH 2

TH 3

TH 4

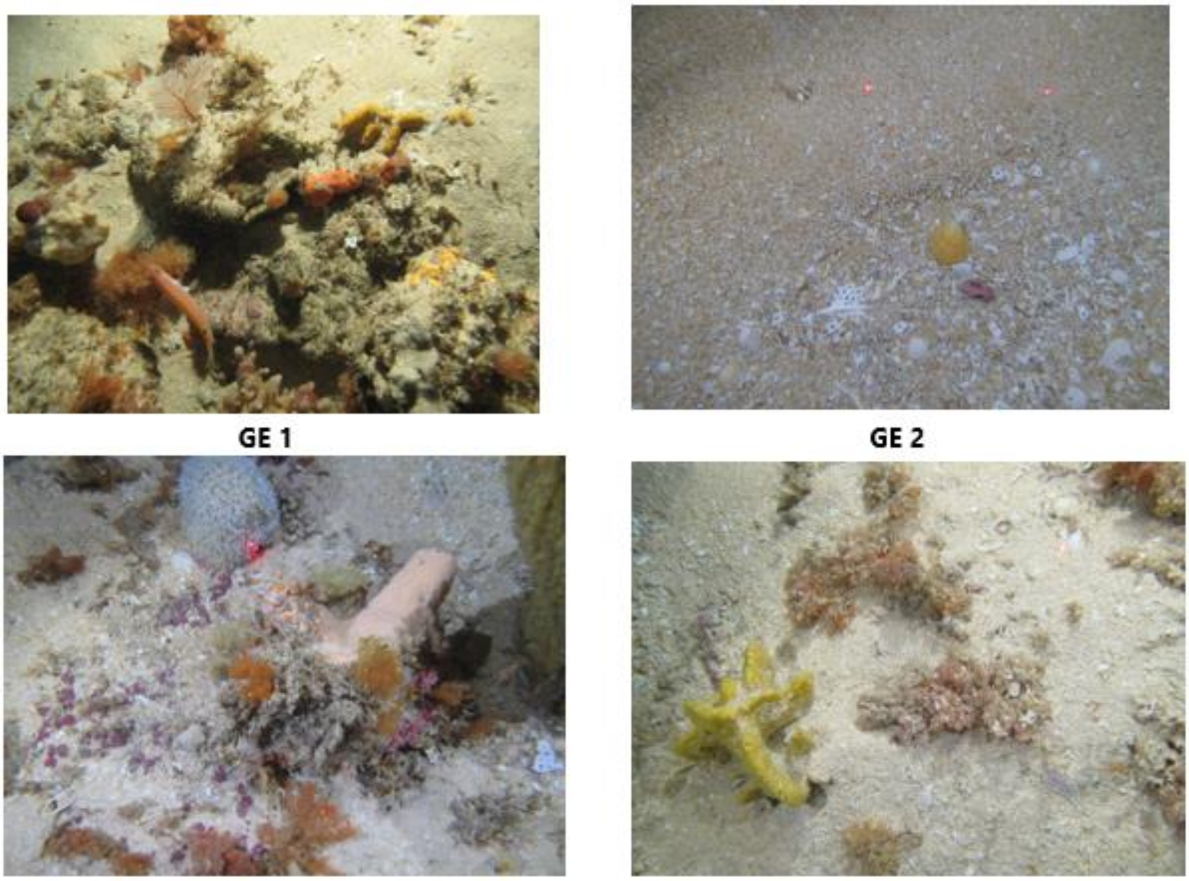
TH 5

TH 6

TH 7

TH 8

Figure 32: Drop Camera Images at Thylacine



GE 1

GE 2

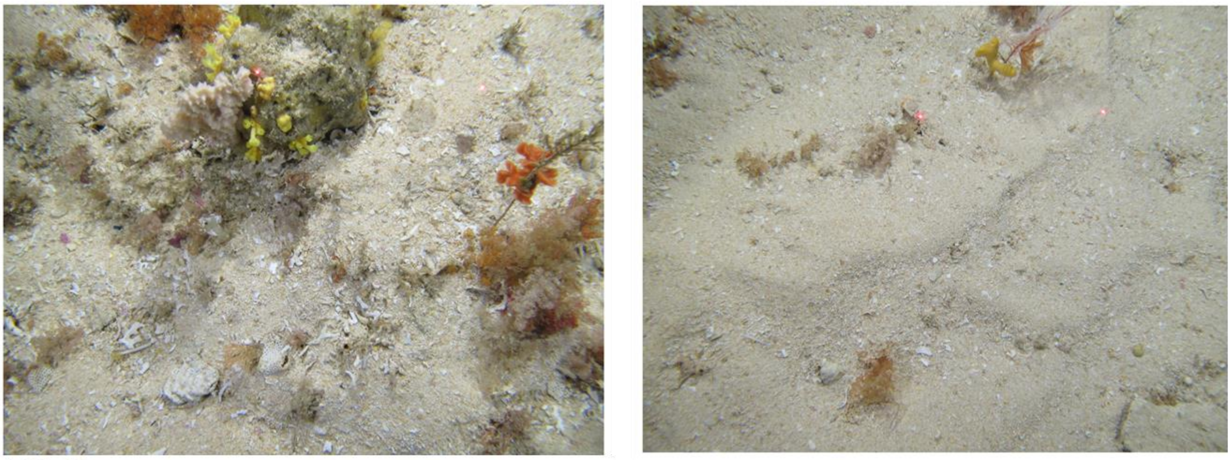
GE 3

GE 4

Figure 33: Drop Camera Images at Geographe

La Bella, LB1

La Bella, LB2



La Bella, LB3

La Bella, LB4

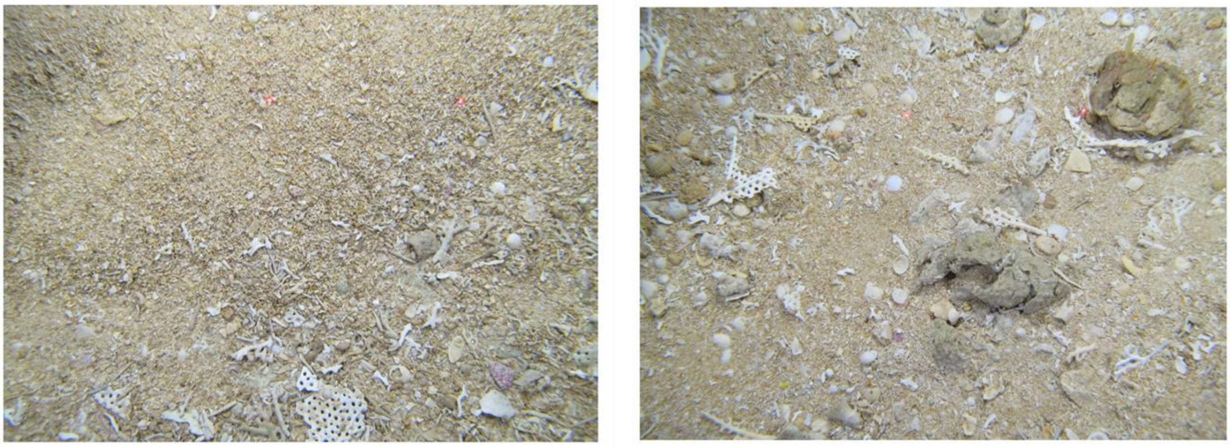


Figure 34: Drop Camera Images at La Bella

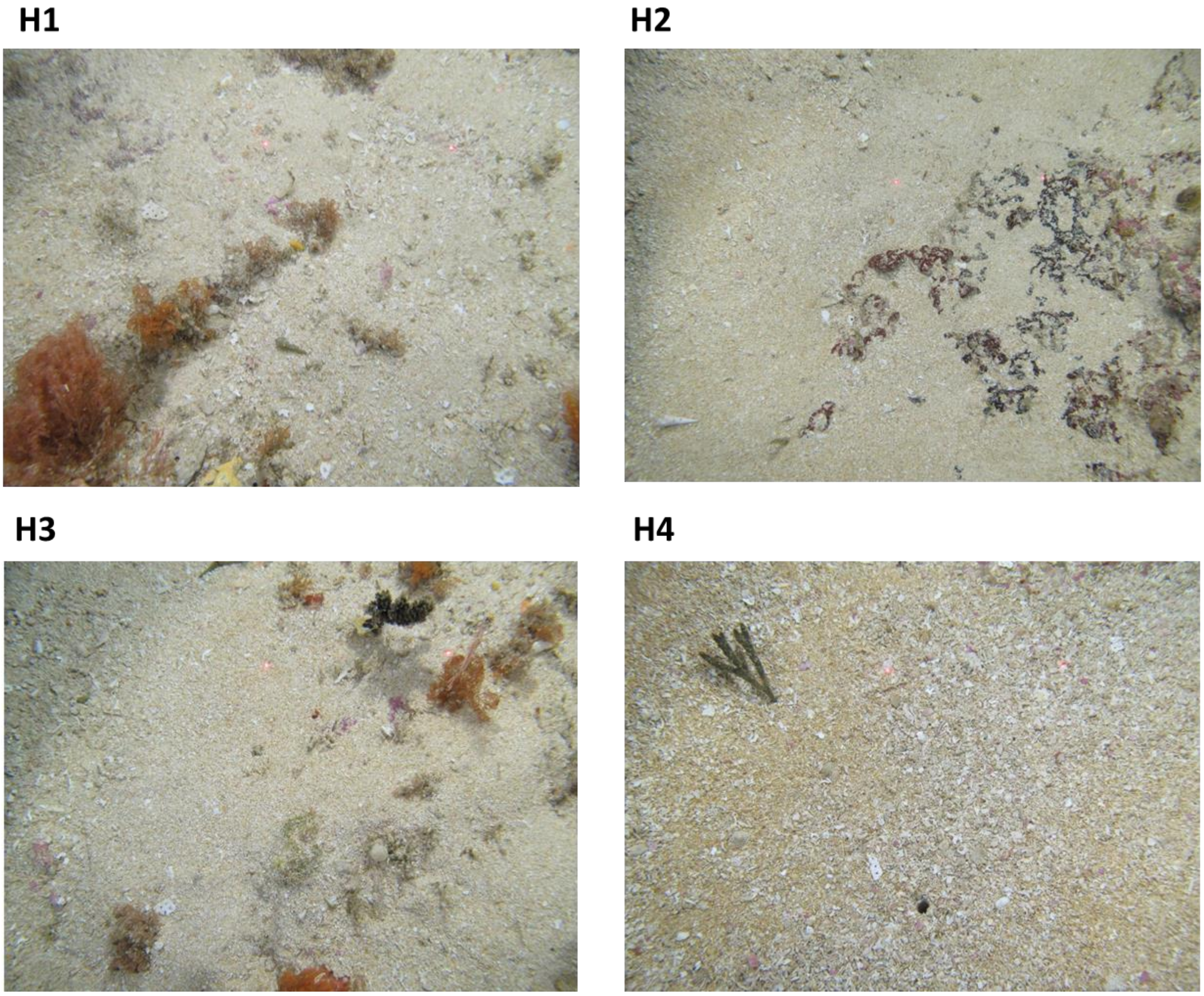
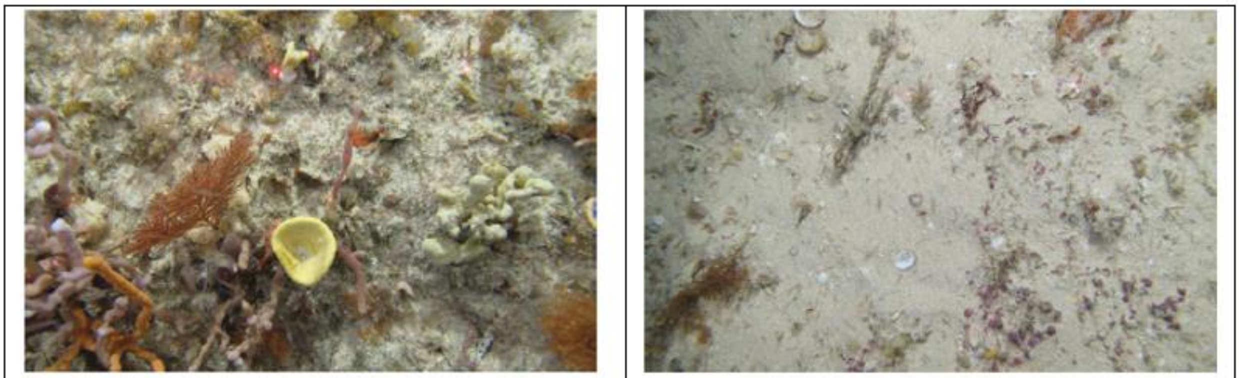
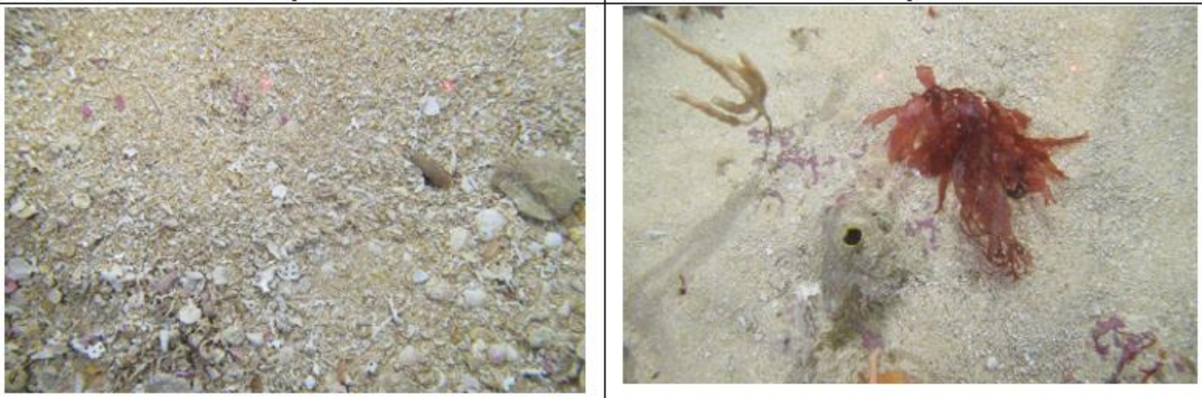


Figure 35: Drop Camera Images at Hercules



Hot Tap Tee X

Hot Tap Tee X



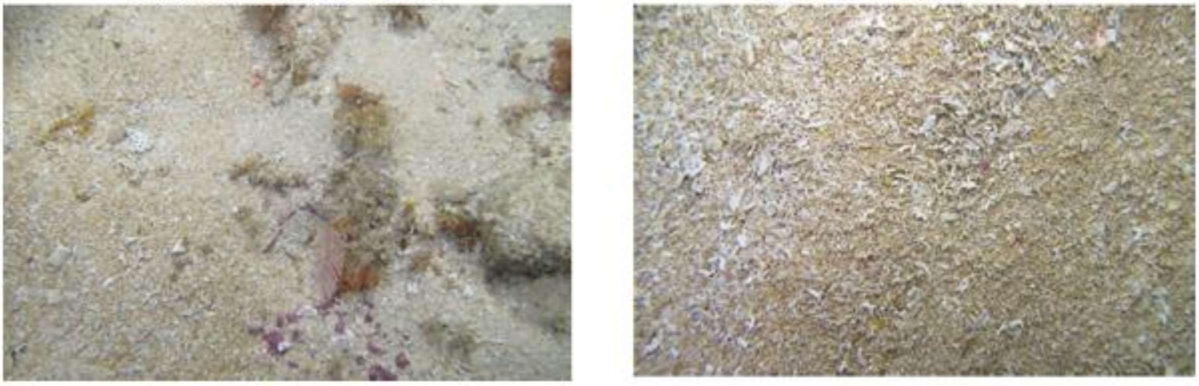
Hot Tap Tee Y

Hot Tap Tee Y

Figure 36: Drop Camera Images at the Hot Tap Tee locations

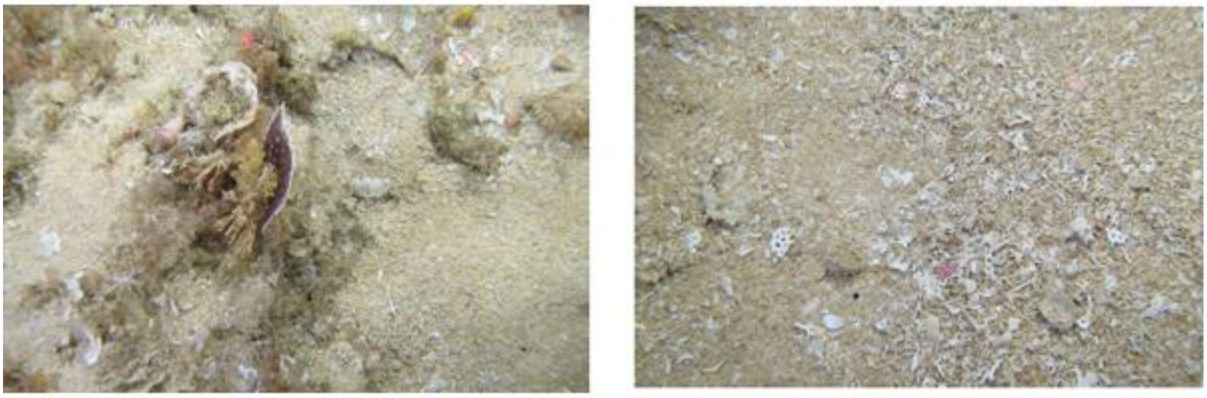
Artisan to Geographe Route

Artisan to Geographe Route



Artisan to La Bella Route

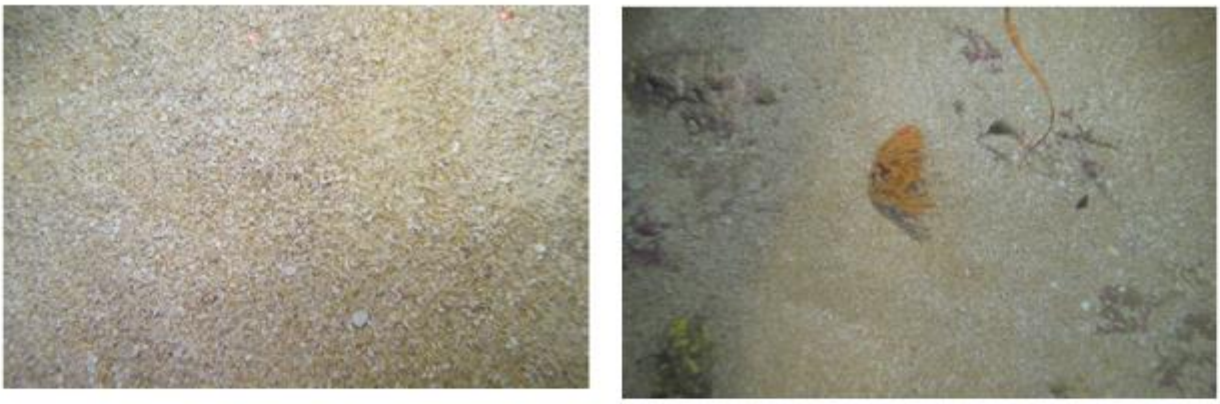
Artisan to La Bella Route



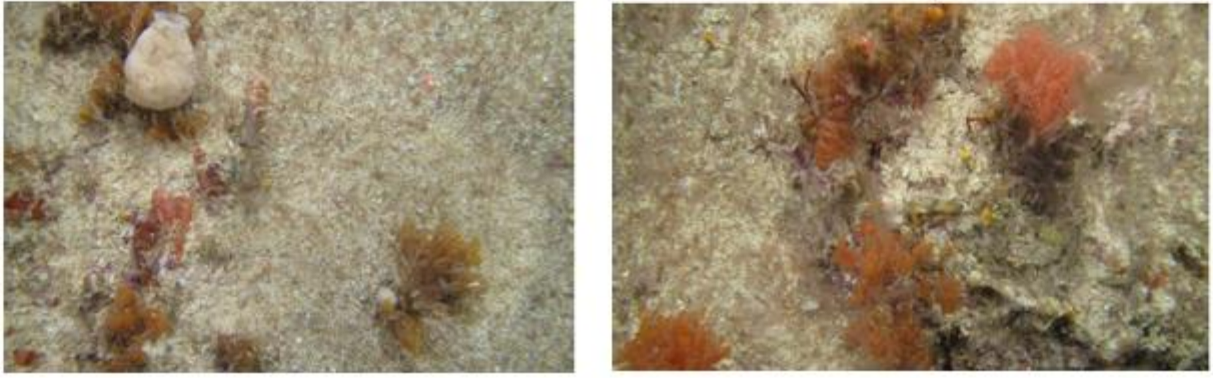
La Bella to Geographe Route

La Bella to Geographe Route

Figure 37: Drop Camera Images along Flowline and Umbilical Routes



Artisan to Hot Tap Tee Y Route **Artisan to Hot Tap Tee Y Route**



Artisan to Hot Tap Tee X Route **Artisan to Hot Tap Tee X Route**

Figure 38: Drop Camera Images along Flowline Routes

4.4.2 Seagrass

Seagrasses are marine flowering plants, with around 30 species found in Australian waters (Huisman 2000). While seagrass meadows are present throughout southern and eastern Australia, the proportion of seagrass habitat within the south-eastern sector is not high compared to the rest of Australia (in particular with parts of South Australia and Western Australia) (Kirkham 1997).

Seagrass generally grows in soft sediments within intertidal and shallow subtidal waters where there is sufficient light and are common in sheltered coastal areas such as bays, lees of islands and fringing coastal reefs (McClatchie et al. 2006, McLeay et al. 2003). Seagrass meadows are important in stabilising seabed sediments, and providing nursery grounds for fish and crustaceans, and a protective habitat for the juvenile fish and invertebrates species (Huisman 2000, Kirkham 1997).

Known seagrass meadows within the Planning Area are present along the Victorian coastline (**Figure 39**). No seagrass meadows were identified within the Project Area.

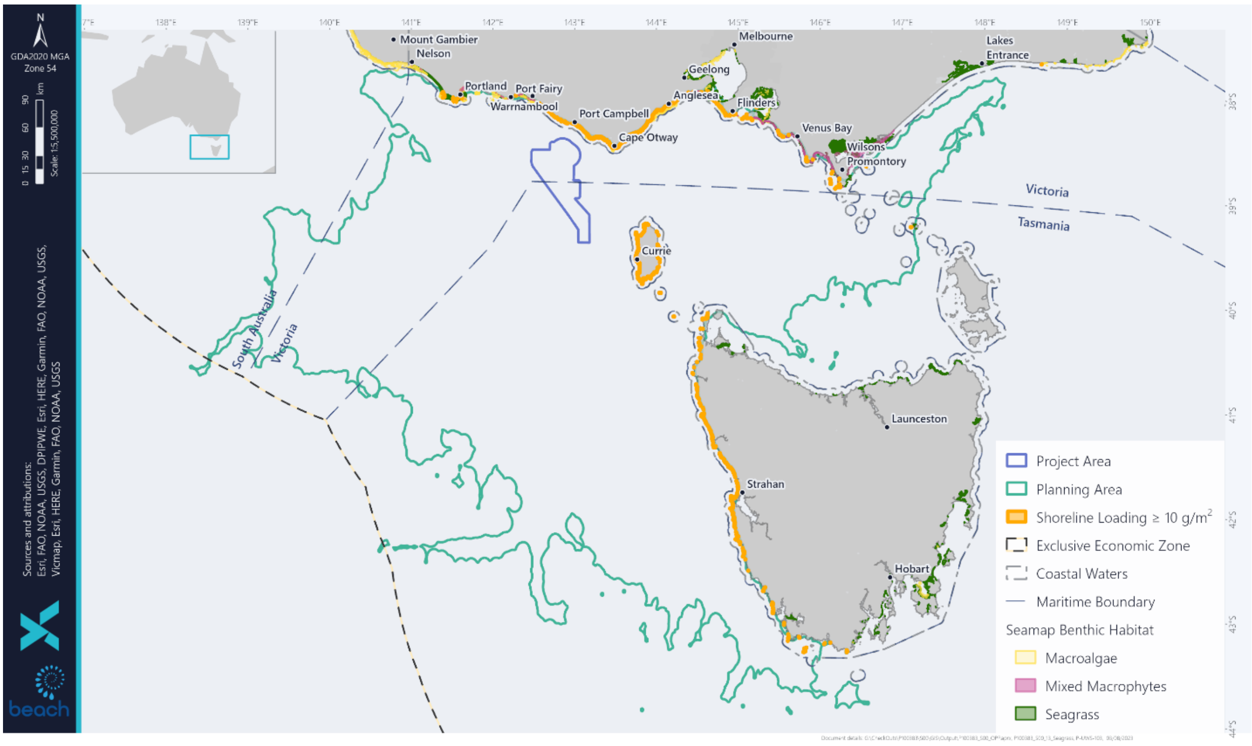


Figure 39: Presence of Seagrass (and mixed macrophyte) Habitat within the Planning Area

4.4.3 Algae

Benthic microalgae are present in areas where sunlight reaches the sediment surface. Benthic microalgae are important in assisting with the exchange of nutrients across the sediment-water interface; and in sediment stabilisation due to the secretion of extracellular polymetric substances (Ansell et al. 1999). Benthic microalgae can also provide a food source to grazers such as gastropods and amphipods (Ansell et al. 1999).

Macroalgae communities occur throughout the Australian coast and are generally found on intertidal and shallow subtidal rocky substrates. Macroalgal systems are an important source of food and shelter for many ocean species; including in their unattached drift or wrack forms (McClatchie et al. 2006). Macroalgae are divided into three groups: Phaeophyceae (Brown Algae), Rhodophyta (Red Algae), and Chlorophyta (Green Algae). Brown Algae are typically the most visually dominant and form canopy layers (McClatchie et al. 2006). The presence and growth of macroalgae are affected by the principal physical factors of temperature, nutrients, water motion, light, salinity, substratum, sedimentation, and pollution (Sanderson 1997). Macroalgae assemblages vary, but *Ecklonia radiata* and *Sargassum* sp. are typically common in deeper areas.

Within the Planning Area, macroalgae are present along the Victorian coastline (Figure 39). No macroalgae have been mapped within Project Area.

Kelp are a special group of large brown algae that attach themselves to solid structures to form forests. They extend their leaf-like fronds into the waters above them reaching towards the sunlight. These larger algae in turn create a habitat for smaller algae, invertebrates, and fish (VFA 2023). On Victoria's coast kelp forests grow on most rocky reefs in waters to a depth of around 30 m, although most are found in shallower waters (VFA 2023).

Bull Kelp or Southern Bull Kelp (*Durvillaea potatorum*) is a fast-growing brown macroalgae (seaweed) with large dark brown and leathery strap-like blades. It consists of a body, called the thallus, with a stipe connecting the blades to the holdfast (a structure adhering the Bull Kelp to the seafloor.

Offshore Victoria and Tasmania there are two main species of *Durvillaea*, these are *D. potatorum* and *D. amatheiae*. The approximate distribution of the species is shown in Figure 40.

Durvillaea spp. are a significant habitat. The holdfast can be inhabited by a diverse array of epifauna and infauna invertebrates. These burrow into the holdfast creating holes that can be used by a wide variety of animals. In addition, *Durvillaea* spp. grow in large groups or forests that can become important nursery areas and sanctuary areas for fish, crustaceans, and other fauna.

Thurstan et al. (2018) gathered historical data on the use of Bull Kelp by First Nations. Bull Kelp has a long history of use by First Nations in Australia, New Zealand, and Chile. In Australia this reportedly dates back 65,000 years (Thurstan et al. 2018). First Nation people in Tasmania used dried bull kelp to transport water and food. The species name came from this use: potatorum means 'to drink' in Latin (Govt of SA 2023).

Thurstan et al. (2018) details a number of First Nations historical references for Bull Kelp including:

- Cultural activities and cultural history –mythology and sacred songs.
- Ceremonial activities –being burned or being used during smoking ceremonies.
- Medicinal use –bandages and medicinal poultice.
- Clothing – cloaks and shoes.
- Diet – raw, jelly, dried and roasted (preserving for several months).
- Fishing – ropes and fishing nets / traps, traps for short-finned eels, also used to assist during diving for crayfish.
- Shelter – waterproofing, wind proofing and carpeting.

Bulk Kelp is also collected by the seaweed industry as described in Section 4.5.13.

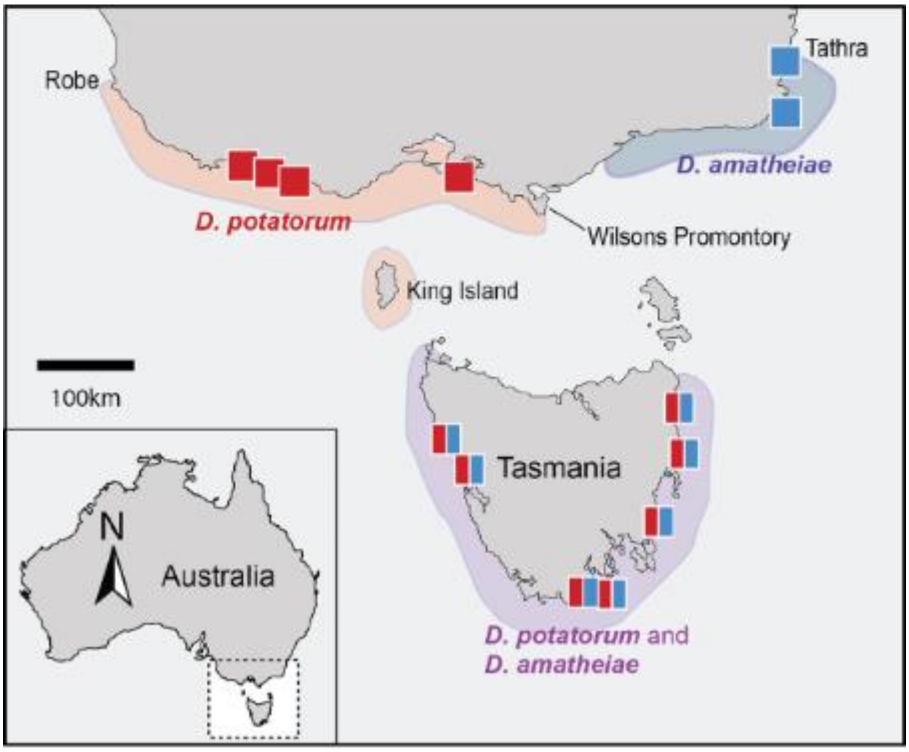


Figure 40: Distribution of Bull Kelp off Victoria and Tasmania (Velasquez et al. 2029)

4.4.4 Mangroves

Mangroves grow in intertidal mud and sand, with specially adapted aerial roots (pneumatophores) that provide for gas exchange during low tide (McClatchie et al. 2006). Mangrove forests are important in helping stabilise coastal sediments, providing a nursery ground for many species of fish and crustacean, and providing shelter or nesting areas for seabirds (McClatchie et al. 2006).

The mangroves in Victoria are the most southerly extent of mangroves found in the world and are located mostly along sheltered sections of the coast within inlets or bays (MESA 2015). There is only one species of mangrove found in Victoria, the white or grey mangrove (*Avicennia marina*), which is known to occur at Western Port and Corner Inlet. Small patches of mangroves have been mapped within the Planning Area at the Cumberland and Erskine Rivers (Figure 41).

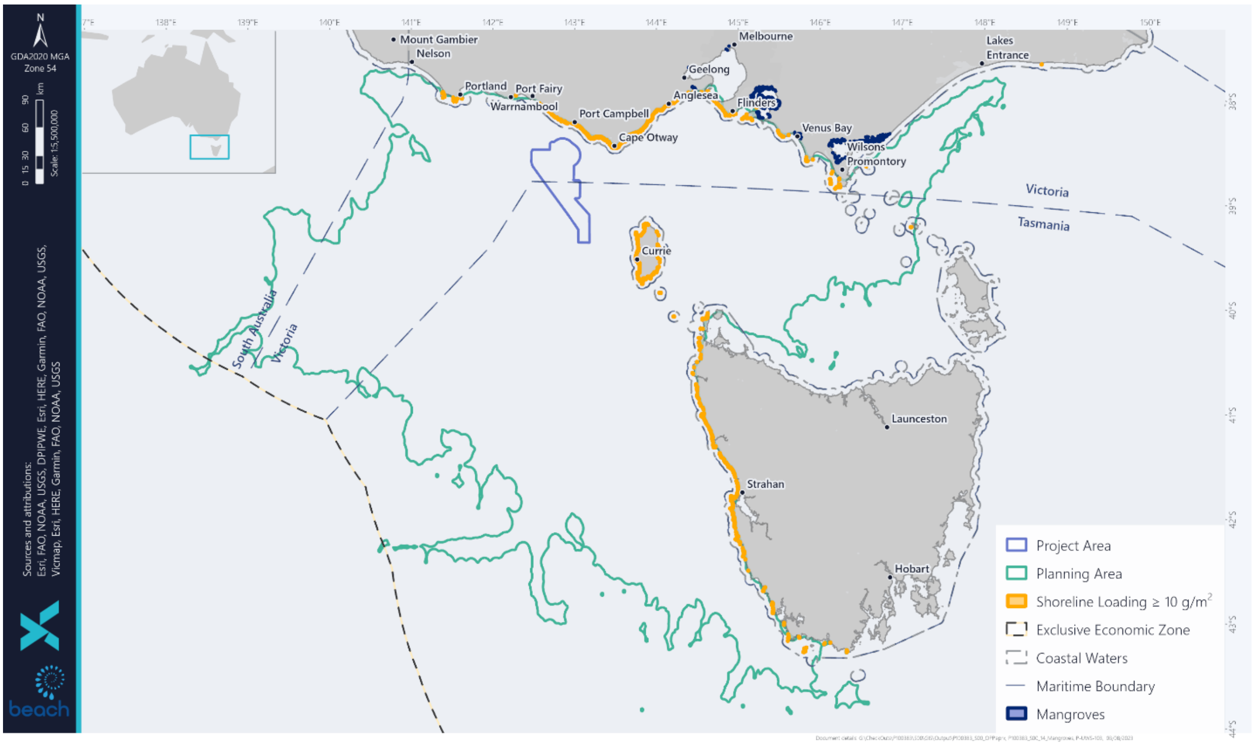


Figure 41: Presence of Mangrove Habitat within the Planning Area

4.4.5 Saltmarsh

Saltmarshes are terrestrial halophytic (salt-adapted) ecosystems that mostly occur in the upper-intertidal zone and are widespread along the coast. Saltmarshes are typically dominated by dense stands of halophytic plants such as herbs, grasses, and low shrubs. In contrast to mangroves, the diversity of saltmarsh plant species increases with increasing latitude. The vegetation in these environments is essential to the stability of the saltmarsh, as they trap and bind sediments. The sediments are generally sandy silts and clays and can often have high organic material content. Saltmarshes provide a habitat for a wide range of both marine and terrestrial fauna, including infauna and epifaunal invertebrates, fish, and birds.

Saltmarsh is found along many parts of the Victorian coast, although is most extensive in western Port Phillip Bay, northern Western Port, within the Corner Inlet-Nooramunga complex, and behind the sand dunes of Ninety Mile Beach in Gippsland (Boon et al. 2011). Within the Planning Area, saltmarsh habitat has been mapped along the Victorian coastline including at Twelve Apostles, Curdies Inlet and Thompson Creek (Figure 42).

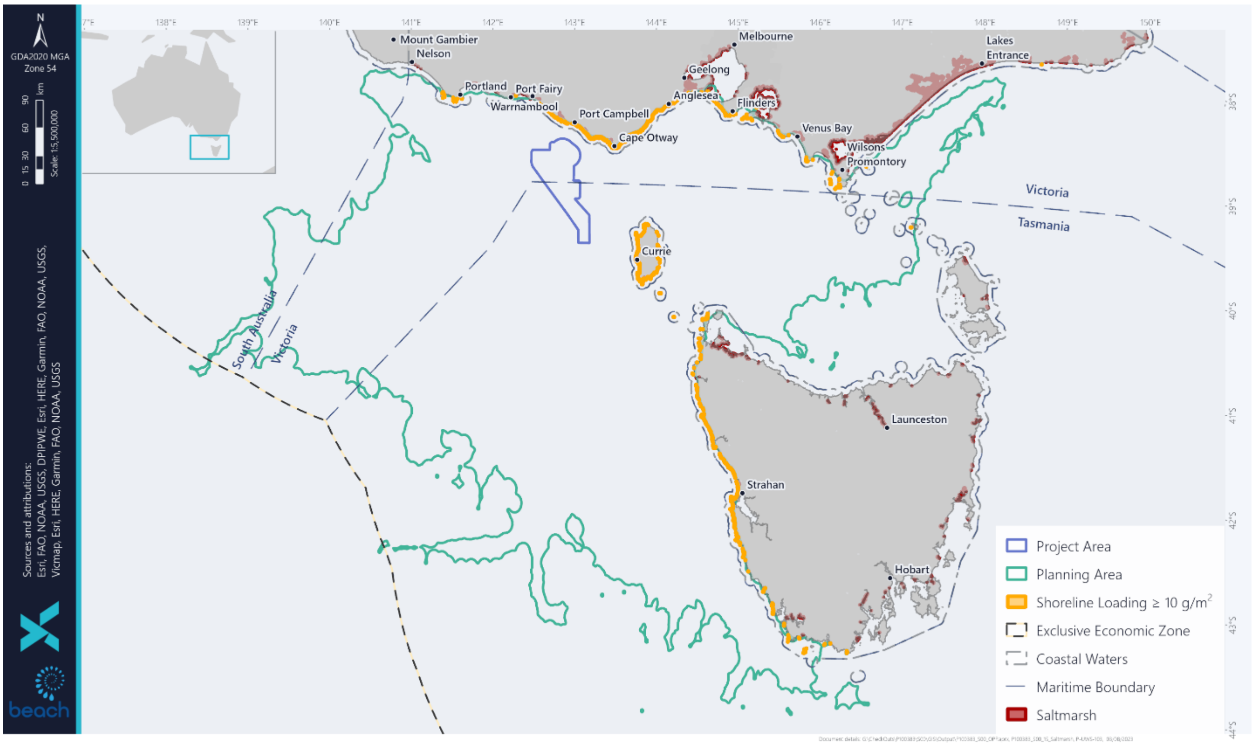


Figure 42: Presence of Saltmarsh Habitat within the Planning Area

4.4.6 Plankton

Plankton are small animals and plants that float or drift on the surface or within the water column. Some forms have limited swimming ability but are still dispersed mainly by water currents. Plankton are a very important part of the ecosystem for several reasons:

- Primary production of the phytoplankton is considerable.
- Much of the plankton consists of eggs and juvenile stages of organisms which are not planktonic as adults. It is thus an important contributor to the maintenance of population and diversity in other habitats.
- Plankton is an important food resource for many larger organisms, including fish.

Plankton are abundant and widely distributed in the South East Marine Region. In the Otway Basin, they have patchy distributions linked to localised and seasonal productivity that produces sporadic bursts in populations (CoA 2015c). Distribution in the Project Area is expected to be highly variable both spatially and temporally and are likely to comprise characteristics of tropical, Southern Australian, central Bass Strait and Tasman Sea distributions.

Plankton are not protected under the EPBC Act.

4.4.7 Invertebrates

There is a very large number of marine invertebrates in deep waters around Australia. Knowledge of the species in different habitats is extremely patchy; the number of deep-water benthic fauna is large but almost unknown. Throughout the region, a variety of seabed habitats support a range of animal communities such as sparse sponges to extensive 'thickets" of lace corals and sponges, polychaete worms and filter feeders (DNP 2013).

Characteristics of large species of crustacea, such as lobster, prawn and crab, which are significant commercial species in southern Australia, are well known. Mollusc species, such as oysters, scallops and abalone are also commercially fished, and their biology and abundance are well known. Major fisheries for the Blacklip and to a lesser extent, Greenlip Abalone and scallops have been founded. The cooler waters of southern Australia also support the Maori Octopus commercial fishery, which is one of the largest octopuses in Australia (with arm spans longer than 3 m and weighing more than 10 kg). Other molluscs are abundant in southern Australia and Tasmania such as the sea-slug with more than 500 species. Volutes and cowries represent a relic fauna in southern Australia, with several species being very rare and can be highly sought after by collectors.

Echinoderms, such as sea stars, sea urchins and sea cucumbers are also an important fauna species of the southern Australian and Tasmanian waters, with several species at risk of extinction (DPIPWE 2016).

Studies by the Museum of Victoria found that invertebrate diversity was high in southern Australian waters although the distribution of species was patchy, with little evidence of any distinct biogeographic regions (Wilson and Poore 1987). Results of sampling in shallower inshore sediments reported high diversity and patchy distribution (Parry et al. 1990). In these areas, crustaceans, polychaetes, and molluscs were dominant.

4.4.8 Threatened Ecological Communities

Threatened Ecological Communities (TECs) provide wildlife corridors or refugia for many plant and animal species, and listing a TEC provides a form of landscape or systems-level conservation (including threatened species).

No TECs were identified within the Project Area.

The Planning Area PMST Report (Appendix B) (Figure 43) identified the following TECs:

- Alpine Sphagnum Bogs and Associated Fens
- Assemblages of species associated with open-coast salt-wedge estuaries of western and central Victoria ecological community
- Giant Kelp Marine Forests of South East Australia
- Grassy Eucalypt Woodland of the Victorian Volcanic Plain
- Karst springs and associated alkaline fens of the Naracoorte Coastal Plain Bioregion
- Lowland Native Grasslands of Tasmania
- Natural Damp Grassland of the Victorian Coastal Plains
- Natural Temperate Grassland of the Victorian Volcanic Plain
- Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains
- Subtropical and Temperate Coastal Saltmarsh
- Tasmanian Forests and Woodlands dominated by black gum or Brookers gum (*Eucalyptus ovata / E. brookeriana*)
- Tasmanian White Gum (*Eucalyptus viminalis*) wet forest
- White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland

Of the TECs listed above, only the Assemblages of species associated with open-coast salt-wedge estuaries of western and central Victoria ecological community, the Giant kelp marine forests of South East Australia, and the Subtropical and temperate coastal saltmarsh are marine/coastal features; the rest are terrestrial or inland listings (Figure 43).

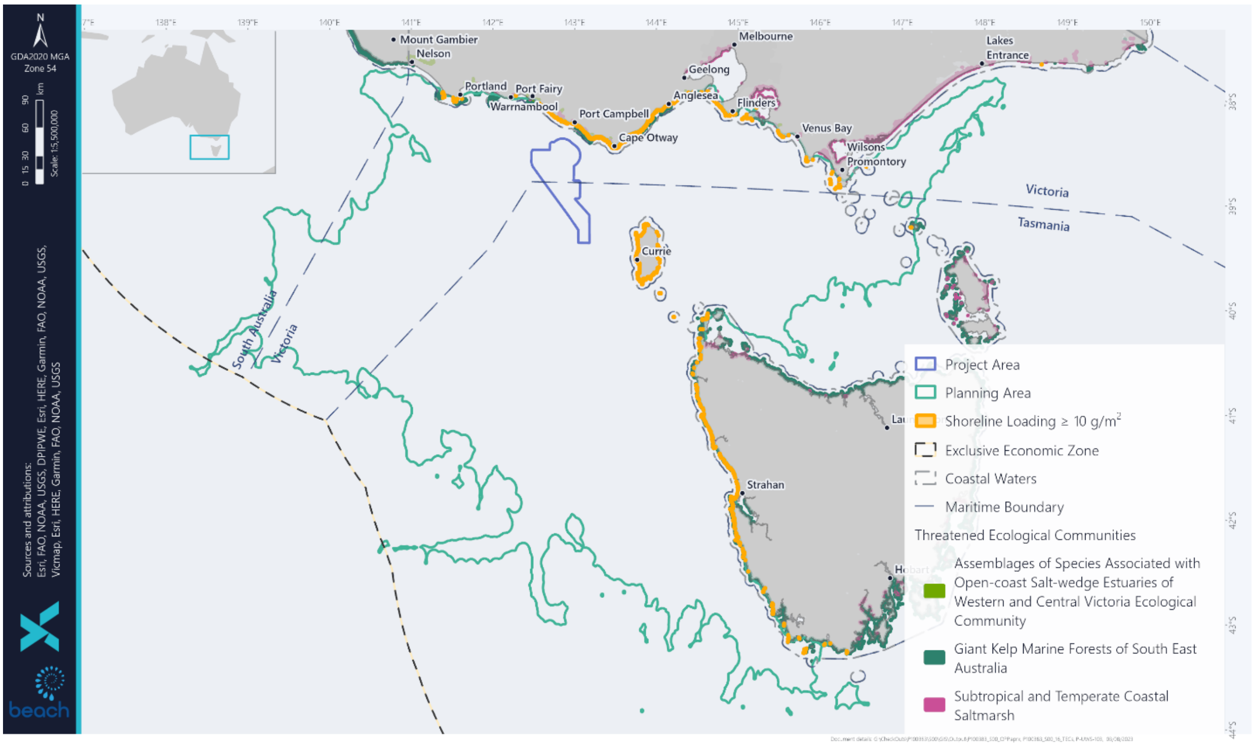


Figure 43: Threatened Ecological Communities within the Planning Area

4.4.8.1 Assemblages of Species associated with Open-coast Salt-wedge Estuaries of Western and Central Victoria Ecological Community

This ecological community is the assemblage of native plants, animals and micro-organisms associated with the dynamic salt-wedge estuary systems that occur within the temperate climate, microtidal regime (< 2 m), high wave energy coastline of western and central Victoria. The ecological community currently encompasses 25 estuaries in the region defined by the border between South Australia and Victoria and the most southerly point of Wilsons Promontory (TSSC 2018).

Salt-wedge estuaries are usually highly stratified, with saline bottom waters forming a 'salt-wedge' below the inflowing freshwater layer of riverine waters. The dynamic nature of salt-wedge estuaries has important implications for their inherent physical and chemical parameters, and ultimately for their biological structure and ecological functioning. Some assemblages of biota are dependent on the dynamics of these salt-wedge estuaries for their existence, refuge, increased productivity, and reproductive success. The ecological community is characterised by a core component of obligate estuarine taxa, with associated components of coastal, estuarine, brackish, and freshwater taxa that may reside in the estuary for periods of time and/or utilise the estuary for specific purposes such as reproduction, feeding, refuge, migration (TSSC 2018).

4.4.8.2 Giant Kelp Marine Forests of South East Australia

Giant Kelp (*Macrocystis pyrifera*) is a large brown algae that grows on rocky reefs in cold temperate waters off south east Australia. The kelp grows up from the sea floor 8 m below the sea surface and deeper, vertically toward the water surface. It is the foundation species of this TEC in shallow coastal marine ecological communities. The kelp species itself is not protected, rather, it is communities of closed or semi-closed Giant Kelp canopy at or below the sea surface that are protected (DSEWPaC 2012b).

Giant Kelp is the largest and fastest growing marine plant. Their presence on a rocky reef adds vertical structure to the marine environment that creates significant habitat for marine fauna, increasing local marine biodiversity. Species known to shelter within the kelp forests include Weedy Sea Dragons (*Phyllopteryx taeniolatus*), Six-Spined Leather Jacket (*Mesuchenia freycineti*), brittle stars (ophiuroids), sea urchins, sponges, Blacklip Abalone (*Tosia* spp.) and Southern Rock Lobsters (*Jasus edwardsii*). The large biomass and productivity of the giant kelp plants also provides a range of ecosystem services to the coastal environment.

Giant Kelp requires clear, shallow water no deeper than approximately 35 m deep (Edyvane 2003; Shepherd and Edgar 2012; cited in TSSC 2012). They are photo-autotrophic organisms that depend on photosynthetic capacity to supply the necessary organic materials and energy for growth. O'Hara (in Andrew 1999) reported that giant kelp communities in Tasmanian coastal waters occur at depths of 5-25m.

Figure 43 shows that the largest extent of Giant Kelp marine forests are along the SA coastline with patches around the Victorian coastline.

James et al (2013) undertook extensive surveys of macroalgal communities along the Otway Shelf from Warrnambool to Portland in south-west Victoria. Sites were adjacent to shore or on offshore rocky reefs covering a depth range of 0 to 36 meters water depth. These surveys did not locate Giant Kelp at any site but identified that other brown algae species (*Durvillaea, Ecklonia, Phyllospora, Cystophora,* and *Sargassum*) are prolific to around 20 m water depth. Brown algae tend to be replaced by red algae in deeper waters.

Surveys of the Arches Marine Sanctuary (Edmunds et al. 2010) and Twelve Apostles Marine National Park (Holmes et al. 2007 cited in Barton et al. 2012) have not located giant kelp. The species has been recorded in Discovery Bay National Park forming part of a mixed brown algae community (Ball and Blake 2007) (not part of the TEC), on basalt rocky reefs. An assemblage dominated by the species has been recorded from Merri Marine Sanctuary occupying a very small area (0.2ha) of rocky reef (Barton et al. 2012).

4.4.8.3 Subtropical and Temperate Coastal Saltmarsh

The Subtropical and Temperate Coastal Saltmarsh TEC occurs in a relatively narrow strip along the Australian coast, within the boundary along 23°37′ latitude along the east coast and south from Shark Bay on the west coast (DSEWPaC 2013). The community is found in coastal areas which have an intermittent or regular tidal influence. Figure 43 shows that from Corner Inlet to Marlo there is a substantial amount of subtropical and temperate coastal saltmarsh along the Victorian coastline.

The coastal saltmarsh community consists mainly of salt-tolerant vegetation including grasses, herbs, sedges, rushes, and shrubs. Succulent herbs, shrubs and grasses generally dominate, and vegetation is generally less than 0.5 m in height (Adam 1990). In Australia, the vascular saltmarsh flora may include many species, but is dominated by relatively few families, with a high level of endism at the species level.

The saltmarsh community is inhabited by a wide range of infaunal and epifaunal invertebrates and low and high tide visitors such as fish, birds, and prawns (Adam 1990). It is often important nursery habitat for fish and prawn species. Insects are also abundance and an important food source for other fauna. The dominant marine residents are benthic invertebrates, including molluscs and crabs (Ross et al. 2009).

The coastal saltmarsh community provides extensive ecosystem services such as the filtering of surface water, coastal productivity and the provision of food and nutrients for a wide range of adjacent marine and estuarine communities and stabilising the coastline and providing a buffer from waves and storms. Most importantly, the saltmarshes are one of the most efficient ecosystems globally in sequestering carbon, due to the biogeochemical conditions in the tidal wetlands being conducive to long-term carbon retention. A concern with the loss of saltmarsh habitat is that it could release the huge pool of stored carbon to the atmosphere.

4.4.9 Threatened and Migratory Species

PMST Reports were generated for the Project Area and Planning Area to identify the listed Threatened and Migratory species that may be present (Appendix A and B). The Planning Area encompasses the smaller Project Area.

4.4.9.1 Marine Fauna of Conservation Significance

Under Part 13 of the EPBC Act, species can be listed as one, or a combination, of the following protection designations:

- Threatened (further divided into categories; extinct, extinct in the wild, critically endangered, endangered, vulnerable, conservation-dependent)
- Migratory
- Whale or other cetaceans
- Marine

Details of listed fauna and their likely presence in the Project or Planning Areas are provided in the following sections.

For the purpose of the OPP, species listed as threatened or migratory under the EPBC Act and are known or likely to occur in the Project or Planning Areas and/or have an intercepting BIA with the Project or Planning Areas are discussed in more detail. Known and likely occurrence was determined from the PMST report or through designation of important habitat (e.g. BIA).

4.4.9.2 Biologically Important Areas and Habitat Critical to the Survival of the Species

DCCEEW (2023) detail that biologically important areas (BIAs) are spatially defined areas where aggregations of individuals of a species are known to display biologically important behaviour such as breeding, foraging, resting or migration. Their designation is based on expert scientific knowledge about species' distribution, abundance, and behaviour. The presence of the observed behaviour is assumed to indicate that the habitat required for the behaviour is also present.

CoA (2013) details that habitat critical to the survival of a species or ecological community' refers to areas that are necessary:

- for activities such as foraging, breeding, roosting, or dispersal.

- for the long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators)
- to maintain genetic diversity and long-term evolutionary development, or
- for the reintroduction of populations or recovery of the species or ecological community.

Such habitat may be but is not limited to: habitat identified in a recovery plan for the species or ecological community as habitat critical for that species or ecological community; and/or habitat listed on the Register of Critical Habitat maintained by the minister under the EPBC Act.

BIAs and habitat critical to the survival of a species within the Project Area and Planning Area are detailed in Table 29 with further details in the relevant species sections. Seasonality of important behaviours within BIAs is summarised in Table 30. No habitat critical to the survival of species was identified within the Project Area.

Receptor	Project Area	Planning Area	Type of BIA	Habitat Critical to the Survival of a Species
Birds				
Antipodean Albatross	Overlap	Overlap	Foraging	-
Australasian Gannet	56 km	Overlap	Foraging	-
	90 km	Overlap	Aggregation	-
Black-browed Albatross	Overlap	Overlap	Foraging	-
Black-faced Cormorant	50 km	Overlap	Breeding	-
	40 km	Overlap	Foraging	-
Buller's Albatross	Overlap	Overlap	Foraging	-
Campbell Albatross	Overlap	Overlap	Foraging	-
Common Diving-petrel	Overlap	Overlap	Foraging	-
	67 km	Overlap	Breeding	-
Indian Yellow-nosed Albatross	Overlap	Overlap	Foraging	-
Little Penguin	42 km	Overlap	Foraging	-
	50 km	Overlap	Breeding	-
Short-tailed Shearwater	Overlap	Overlap	Foraging	-
	50 km	Overlap	Breeding	-
Shy Albatross	Overlap	Overlap	Foraging likely	-
	136 km	Overlap	Breeding	-
	136 km	Overlap	-	Breeding
Soft-plumaged Petrel	221 km	Overlap	Foraging	-
Wandering Albatross	Overlap	Overlap	Foraging	-
Wedge-tailed Shearwater	Overlap	Overlap	Foraging	-

Receptor	Project Area	Planning Area	Type of BIA	Habitat Critical to the Survival of a Species
	18 km	Overlap	Breeding	-
White-faced Storm Petrel	39 km	Overlap	Foraging	-
	160 km	Overlap	Breeding	-
Fish				
White Shark	Overlap	Overlap	Distribution	-
	280 km	Overlap	Breeding	-
	38 km	Overlap	Foraging	-
Cetaceans				
Pygmy Blue Whale	Overlap	Overlap	Foraging likely	-
	Overlap	Overlap	Foraging (annual high use area)	-
	Overlap	Overlap	Known Foraging Area	-
	Overlap	Overlap	Distribution	-
Southern Right Whale	Overlap	Overlap	Migration	-
	10km	Overlap	Reproduction	-

Table 29: BIAs and Habitat Critical to the Survival of a Species identified within the Project and Planning Area

Species	Biologically Important Behaviour	J	F	M	A	M	J	J	A	S	O	N	D
Birds													
Antipodean Albatross	Foraging	P	P	P	P	P	P	P	P	P	P	P	P
Australasian Gannet	Foraging	L	L	L	L	L	P	P	P	P	L	L	L
	Aggregation	L	L	L	L	L	P	P	P	P	L	L	L
Black-browed Albatross	Foraging						L	L	L				
Black-faced Cormorant	Breeding						P	L	P	P			
	Foraging	L	L	L	L	L	L	L	L	L	L	L	L
Buller's Albatross	Foraging	P	P	P	P	P	P	P	P	P	P	P	P
Campbell Albatross	Foraging					P	P	P					
Common Diving-petrel	Foraging	L	P	P	P	P	P	L	L	L	L	L	L
	Breeding	L						L	L	L	L	L	L
Indian Yellow-nosed Albatross	Foraging						P	P	P				
Little Penguin	Foraging	L	L	P	P	P	P	P	P	L	L	L	L
	Breeding	L	L							L	L	L	L
Short-tailed Shearwater	Foraging	L	L	L	L	L				P	L	L	L
	Breeding	L	L	L	L	L					L	L	L
Shy Albatross	Foraging likely	P	P	P	P	P	P	P	P	P	P	P	P
	Breeding	P	P	P	P				P	P	P	P	P
Soft-plumaged Petrel	Foraging	P	P	P	P	P				P	P	P	P
Wandering Albatross	Foraging	P	P	P	P	P	P	P	P	P	P	P	P
Wedge-tailed Shearwater	Foraging	L	L	L	L	L			L	L	L	L	L
	Breeding	L	L	L	L	L			L	L	L	L	L
White-faced Storm Petrel	Foraging	P	P	P						P	P	P	P
	Breeding	P	P	P						P	P	P	P
Fish													
White Shark	Distribution	L	L	L	L	L	L	L	L	L	L	L	L

Species	**Biologically Important Behaviour**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
	Breeding	P	P	P	P	P	P	P	P	P	P	P	P
	Foraging	L	L	L	L	L	L	L	L	L	L	L	L
Whales													
Pygmy Blue Whale	Foraging (annual high use)	P	L	L	P	P	P					P	P
Southern Right Whale	Migration				P	P	P	L	L	P	P		
	Reproduction					P	P	P	P	P			

Table 30: Seasonality of Biologically Important Behaviours relevant to the Project

4.4.9.3 Fish

Fish species present in the Project or Planning Areas are either pelagic (living in the water column), or demersal (benthic). Fish species inhabiting the region are largely cool temperate species, common within the South-east Marine Region. Table **31** details the listed fish species identified in the Project and Planning Areas PMST Reports (Appendix A and B).

Two fish species identified in the PMST Reports are freshwater species, Dwarf Galaxias and Yarra Pygmy Perch as they will be outside of the area potentially affected by the Project they are not discussed further.

Threatened or migratory species that are likely or known to occur in the area or have an intercepting BIA with the Project or Planning Areas are discussed in more detail.

Six species of fish are listed as Conservation Dependent which do not receive special protection, as they are not considered MNES under the EPBC Act. These species are targeted by commercial fisheries as detailed in Sections 4.5.9 to 4.5.11.

Information on eels is also provided as Beach's consultation with the Eastern Maar Aboriginal Corporation for the previous Otway Project activities identified that they have interests regarding eels, and they are possibly present within the Planning Area during migration and spawning seasons.

4.4.9.3.1 Australian Grayling

The Australian Grayling (*Prototroctes maraena*) is a dark brown to olive-green fish attaining 19cm in length. The species typically inhabits the coastal streams of New South Wales, Victoria, and Tasmania, migrating between streams and the ocean. Spawning occurs in freshwater, with timing dependant on many variables including latitude and temperature regimes (Backhouse et al. 2008). Most of its life is spent in fresh water, with parts of the larval or juvenile stages spent in coastal marine waters (Backhouse et al. 2008), though its precise marine habitat requirements remain unknown (Backhouse et al. 2008). They are a short-lived species, usually dying after their second year soon after spawning (a small proportion may reach four or five years) (DSE 2008).

Australian Grayling has been recorded from the Gellibrand River (DSE 2008) making it likely that it occurs in coastal waters. As marine waters are not part of the species' spawning grounds, the Planning Area is not likely to represent critical habitat for the species.

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Area (BIAs)	Presence in Planning Area	Presence in Project Area
Fish								
Australian Grayling	*Prototroctes maraena*	Vulnerable					Species or species habitat known to occur within area	Species or species habitat may occur within area
		National Recovery Plan for the *Prototroctes maraena* (Australian Grayling) (Backhouse et al. 2008). No threats relevant to the project identified.						
Blue Warehou	*Seriolella brama*	Conservation Dependent					Species or species habitat known to occur within area	Species or species habitat known to occur within area
Eastern Dwarf Galaxias, Dwarf Galaxias	Galaxiella pusilla	Vulnerable					Species or species habitat known to occur within area	_
Eastern Gemfish	*Rexea solandri (eastern Australian population)*	Conservation Dependent					Species or species habitat likely to occur within area	_
Orange Roughy, Deep-sea Perch, Red Roughy	*Hoplostethus atlanticus*	Conservation Dependent					Species or species habitat likely to occur within area	Species or species habitat likely to occur within area
Red Handfish	*Thymichthys politus*	Critically Endangered					Species or species habitat may to occur within area	_
		Approved Conservation Advice for *Thymichthys politus* (Red Handfish) (DSEWPAC 2012e). Recovery Plan for Three Handfish Species (DETG 2016). Threats relevant to the project include habitat degradation as a result of environmental pollutants.						
Yarra Pygmy Perch	*Nannoperca obscura*	Vulnerable					Species or species habitat known to occur within area	_
Ziebell's Handfish, Waterfall Bay Handfish	*Brachiopsilus ziebelli*	Vulnerable					Species or species habitat likely occur within area	_

Common Name	**Scientific Name**	**Threatened Category**	**Migratory Status**	**Migratory Category**	**Marine Status**	**Biologically Important Area (BIAs)**	**Presence in Planning Area**	**Presence in Project Area**
		Recovery Plan for Three Handfish Species (DETG 2016).						
Sharks								
Harrisson's Dogfish, Endeavour Dogfish, Dumb Gulper Shark, Harrison's Deepsea Dogfish	*Centrophorus harrissoni*	Conservation Dependent					Species or species habitat likely to occur within area	_
Little Gulper Shark	*Centrophorus uyato*	Conservation Dependent (listed as *Centrophorus zeehaani)*					Species or species habitat likely to occur within area	Species or species habitat likely to occur within area
Maugean Skate, Port Davey Skate	*Zearaja maugeana*	Endangered					Species or species habitat known to occur within area	_
Oceanic Whitetip Shark	*Carcharhinus longimanus*		Migratory	Migratory Marine Species			Species or species habitat may occur within area	_
Porbeagle, Mackerel Shark	*Lamna nasus*		Migratory	Migratory Marine Species			Species or species habitat likely to occur within area	Species or species habitat likely to occur within area
School Shark, Eastern School Shark, Snapper Shark, Tope, Soupfin Shark	*Galeorhinus galeus*	Conservation Dependent					Species or species habitat likely to occur within area	Species or species habitat may occur within area
Shortfin Mako, Mako Shark	*Isurus oxyrinchus*		Migratory	Migratory Marine Species			Species or species habitat likely to occur within area	Species or species habitat likely to occur within area
Whale Shark	*Rhincodon typus*	Vulnerable	Migratory	Migratory Marine Species			Species or species habitat may occur within area	_

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Area (BIAs)	Presence in Planning Area	Presence in Project Area
White Shark, Great White Shark	*Carcharodon carcharias*	Vulnerable	Migratory	Migratory Marine Species		Breeding (Nursery area), distribution, foraging	Species or species habitat known to occur within area	Species or species habitat known to occur within area
		Recovery Plan for the *Carcharodon carcharias* (White Shark) (DSEWPaC 2013a). No threats relevant to the activity identified.						
Syngnathids								
Australian Smooth Pipefish, Smooth Pipefish	*Lissocampus caudalis*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Big-belly Seahorse, Eastern Potbelly Seahorse, New Zealand Potbelly Seahorse	*Hippocampus abdominalis*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Brushtail Pipefish	*Leptoichthys fistularius*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Bullneck Seahorse	*Hippocampus minotaur*				Listed		Species or species habitat may occur within area	_
Common Seadragon, Weedy Seadragon	*Phyllopteryx taeniolatus*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Crested Pipefish, Briggs' Crested Pipefish, Briggs' Pipefish	*Histiogamphelus briggsii*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Deepbody Pipefish, Deep-bodied Pipefish	*Kaupus costatus*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Area (BIAs)	Presence in Planning Area	Presence in Project Area
Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish	*Syngnathoides biaculeatus*				Listed		Species or species habitat may occur within area	_
Hairy Pipefish	*Urocampus carinirostris*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Halfbanded Pipefish	*Mitotichthys semistriatus*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Javelin Pipefish	*Lissocampus runa*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Knifesnout Pipefish, Knife-snouted Pipefish	*Hypselognathus rostratus*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Leafy Seadragon	*Phycodurus eques*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Longsnout Pipefish, Australian Long-snout Pipefish, Long-snouted Pipefish	*Vanacampus poecilolaemus*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Mollison's Pipefish	*Mitotichthys mollisoni*				Listed		Species or species habitat may occur within area	_
Mother-of-pearl Pipefish	*Vanacampus margaritifer*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Port Phillip Pipefish	*Vanacampus phillipi*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Area (BIAs)	Presence in Planning Area	Presence in Project Area
Pugnose Pipefish, Pug-nosed Pipefish	*Pugnaso curtirostris*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Red Pipefish	*Notiocampus ruber*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Rhino Pipefish, Macleay's Crested Pipefish, Ring-back Pipefish	*Histiogamphelus cristatus*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Ringback Pipefish, Ring-backed Pipefish	*Stipecampus cristatus*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Robust Pipehorse, Robust Spiny Pipehorse	*Solegnathus robustus*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Sawtooth Pipefish	*Maroubra perserrata*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Short-head Seahorse, Short-snouted Seahorse	*Hippocampus breviceps*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Spiny Pipehorse, Australian Spiny Pipehorse	*Solegnathus spinosissimus*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Spotted Pipefish, Gulf Pipefish, Peacock Pipefish	*Stigmatopora argus*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Trawl Pipefish, Bass Strait Pipefish	*Kimblaeus bassensis*				Listed		Species or species habitat may occur within area	_

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Area (BIAs)	Presence in Planning Area	Presence in Project Area
Tucker's Pipefish	*Mitotichthys tuckeri*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Upside-down Pipefish, Eastern Upside-down Pipefish, Eastern Upside-down Pipefish	*Heraldia nocturna*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish	*Stigmatopora nigra*				Listed		Species or species habitat may occur within area	Species or species habitat may occur within area

Table 31: Listed Fish Species or Species Habitat identified in the Project and/or Planning Areas

4.4.9.3.2 Eels

Ecology & Biology

The Shortfin Eel (*Anguilla australis australis*) and the Longfin Eel (*A. reinhardtii*) both occur naturally within Victoria and are the target species of the Victorian Eel Fishery. The eels have differing but overlapping distributions east and south of the Great Dividing Range in estuarine and freshwater catchments (VFA 2022b) (Figure 44).

The Shortfin Eel is widespread across the southern parts of the Victoria and occurring occasionally in northern streams draining into the Murray River, while the Longfin Eel is found within south-east parts of Victoria only (VFA 2022a). Both species spend the majority of their life cycle in fresh water or estuaries before travelling to the ocean to spawn once before dying (VFA 2022a). Shortfin Eels are listed as 'near threatened' on the IUCN red list, with barriers to riverine movement and freshwater habitat loss being key threats. Additionally, changes in ocean currents, primary production, and thermal regimes may also affect eel migration, spawning success, and recruitment (Koster et al. 2021). The Longfin Eel is listed as 'least concern' by the IUCN. Neither species are listed as threatened under the EPBC Act.

Both species of eel are primarily carnivorous, however, they will both opportunistically eat plant material (VFA 2022a; 2022c). The Shortfin Eel is known to eat various types of fish, worms, insects, small crustaceans, molluscs, and water plants and can grow up to 1.1 m long and weigh up to 6.8 kg (VFA 2022a). The Longfin Eel consumes primarily fish and insects. The Longfin Eel is larger in size compared to the Shortfin Eel, reported to grow up to 2 m and weigh up to 16 kg, however, they are usually much smaller and often reach 1 m in length (VFA 2022c). Both species are believed to follow a seasonal feeding pattern, with the most intense feeding window being at night during summer and spring (VFA 2022a; 2022c). Both species sexes are determined by influences such as salinity, temperature, diet, and population density (more females as the population density decreases) (VFA 2017).

Migration & Spawning

Both species of eel have a remarkable lifecycle that is not entirely understood, remaining a natural phenomenon. They spend most of their life cycle in freshwater or estuaries before undergoing a mass migration into the ocean, travelling in excess of 3,000km to spawn once (VFA 2022b). Spawning location is believed to be in the Coral Sea near New Caledonia although no precise spawning location for either species has been identified (VFA 2022a). Both species migrate to the ocean once matured; male Shortfin Eels generally mature at 8 to 12 years of age, whilst females mature at 10 to 20 years and long-finned eels can take double this time to mature. Migration occurs during late summer to autumn, and after a period of insatiable feeding and significant growth, the eels undergo a series of physical changes to prepare for their migration (VFA 2022a).

Once the eels are prepared for spawning, they move out of their freshwater environments into the ocean in total darkness and swim north against the current to reach the Coral Sea. By the time they arrive, they have used up all their energy resources then they spawn and die, and their young commence the cycle over again. Their life begins at unknown spawning sites at a depth of 200 m as larvae. The pelagic larvae are then carried southwards by the ocean currents that parallel the east coast of Australia such as the EAC and swing east past Tasmania and then north to New Zealand. Along the way, they feed on microscopic organisms and develop into transparent, leaf-shaped larvae and eventually metamorphose into 'glass eels' which are eel-shaped, but extremely small and still transparent. At this stage, they move closer to land and commence migrating towards estuaries. Most glass Shortfin Eels migrate in the winter and spring, while glass Longfin Eels migrate during summer and autumn (VFA 2022a), although glass eels of both species may continue to arrive anytime throughout the year (VFA 2017).

Koster et al. (2021) tracked the Shortfin eel spawning migration for the first time in Australia. Sixteen eels were collected and tagged from the Hopkins and Fitzroy River estuaries as they migrated from the river mouths outwards to the Southern Ocean over a sandbar in 2019. They were then released at either Warrnambool Harbour, Hopkins's mouth beach or Killarney beach. Twelve of the 16 tags returned data. The results showed that the Shortfin Eels exhibit diel vertical migration, meaning they travel in the top layers of water during the night and travel further down in the water column during the day (Koster et al. 2021). Of the small number of eels that made the entire journey to the spawning location their last movements were recorded in the Coral Sea. Many of the eels (about 30%) migrations were cut short due to predation, suspected by sharks, tuna, or other marine mammals. The conclusion of the study talks about the need for further research to determine the eel's exact spawning locations and timing and how the information can be used to support conservation management, particularly when looking at anthropogenic impacts on the species. Koster et al. (2021) listed construction and operation of energy developments as having potential to interact with eel migration.

Victorian Eel Fishery

Both the Longfin and Shortfin Eel are the target species for the Victorian eel fishery. The first commercial catches of eel were recorded in 1914, and up until 1950 eel was primarily fished for bait. Export of frozen Shortfin Eel to Europe began in the 1960s (VFA 2022a). Eel are harvested in Victorian coastal river basins south of the Great Dividing Range using fyke nets, with a maximum of 18 licences allowed in Victoria. Certain waterways are closed to fishing to allow for eels to escape and spawn (VFA 2022a). Shortfin Eels are the most abundant and the most keenly targeted eel species in Victoria, productivity from the fishery is highly susceptible to short and long term and seasonal environmental variations, particularly drought (VFA 2017).

The eel fishery comprises both a wild catch sector and a culture (stock enhanced) sector. The culture sector has developed strategies for growth consistent with the species life cycle by translocating juvenile eels from other parts of Victoria into lakes and impoundments (culture waters) in western inland Victoria where they continue to grow (VFA 2017). Fishing for glass eels has been of limited success due to the highly variable abundance in Victoria. Most of Victoria's eel catch is taken by commercial fishers and is comprised of adult eels during different stages of their migration.

First Nations Connection to Eels

Eels were, and continue to be, an important resource for certain First Nation communities. Their use for communal gatherings and for barter and trade was extensive in pre-colonial times. Today, eel remains a popular food for community events (VFA 2017). Shortfin Eels in particular hold a cultural significance to First Nations people. For example, the Gunditjmara people of south-western Victoria built and used sophisticated aquaculture systems throughout the Budj Bim cultural landscape to exploit eel migrations at least 7,000 years ago. These systems and their eel catches have since provided a lasting and sustainable economic and social base for the Gunditjmara society (Koster et al. 2021). The Budj Bim cultural landscape is outside of the Planning Area.

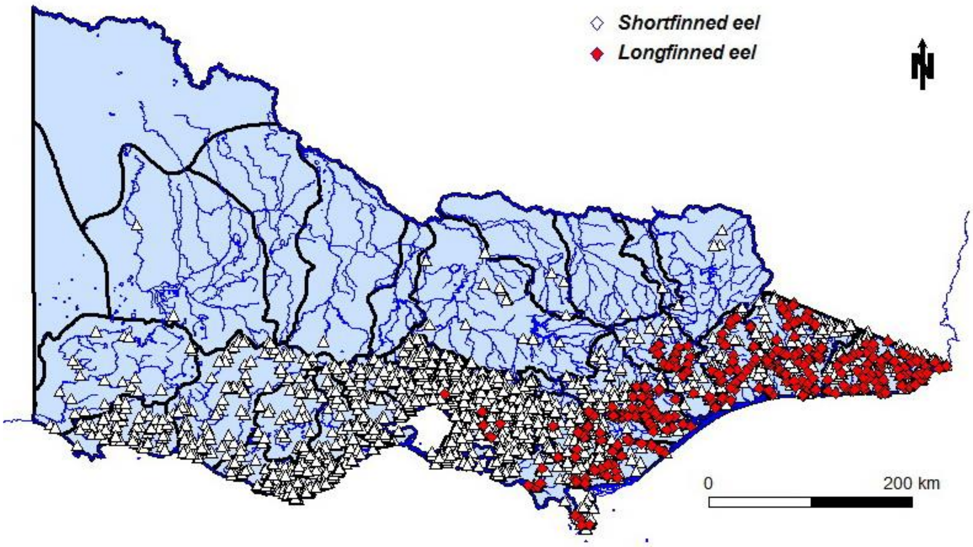


Figure 44: Distribution of Longfinned and Shortfinned Eels in Victoria (VFA 2017)

4.4.9.3.3 Maugean Skate, Port Davey Skate

The Maugean Skate (*Zearaja maugeana*) is a medium-sized skate growing to 84cm in females. It is dark brown above and dark with dark-edged pores beneath (Last and Stevens 1994, 2009). The species inhabits two small estuarine systems, in Bathurst Harbour and Macquarie Harbour in Southwest Tasmania, which abut the Planning Area. The total range of the species is thought to be no more than 100km^2 with an estimated population of 1,000 individuals (TSSC 2004). The Maugean Skate is restricted to brackish, estuarine, low nutrient water, 5–7m deep in shallow upper regions of the estuaries (IUCN 2007) and their distribution is not known to overlap with any EPBC Act-listed threatened ecological communities. Given their restricted distribution, the Maugean Skate is unlikely to be present in large numbers within the Planning Area.

4.4.9.3.4 Oceanic Whitetip Shark

The Oceanic Whitetip Shark (*Carcharhinus longimanus*) is a widely distributed tropical and subtropical pelagic species. They are found in water from Cape Leeuwin (Western Australia) through parts of the Northern Territory, down the east coast of Queensland and New South Wales to Sydney (Last and Stevens 2009). They are generally found offshore in the open ocean, on the outer continental shelf, or around oceanic islands in deep water areas. Although they can make deep dives and have been recorded up to 1,082 m deep, they typically live in the upper part of the water column, from the surface to at least 200 m (NOAA 2021a). No known habitat occurs within Victorian or Tasmanian waters (DoE 2023b). The Oceanic Whitetip Shark has the potential to be present within the Planning Area.

4.4.9.3.5 Porbeagle Shark

The Porbeagle Shark (*Lamna nasus*) is widely distributed in the southern waters of Australia including Victorian and Tasmanian waters. The species preys on bony fishes and cephalopods and is an opportunistic hunter that regularly moves up and down in the water column, catching prey in mid-water as well as at the seafloor. It is most commonly found over food-rich banks on the outer continental shelf, but does make occasional forays close to shore or into the open ocean, down to depths of approximately 1,300 m. It also conducts long-distance seasonal migrations, generally shifting between shallower and deeper water (Pade et al. 2009). The porbeagle shark is likely to be present in the Project Area in low numbers.

4.4.9.3.6 Red Handfish

The Red Handfish (*Thymichthys politus*) is a small and slow-moving benthic fish. It is eligible for its critically endangered status under the EPBC Act due to its restricted geographic distribution. Only a small population is known and is found along the southern coast of Tasmania. The Red Handfish appears to require green algae to use as a spawning substrate. Increased numbers of the native sea urchin has resulted in increased grazing of algae and therefore depletion of Red Handfish habitat (DSEWPAC 2012). The Red Handfish is unlikely to be present within the Planning Area due to its current distribution being recorded only in Frederick Henry Bay.

4.4.9.3.7 Shortfin Mako Shark

The Shortfin Mako Shark (*Isurus oxyrinchus*) is a pelagic species with a circum-global oceanic distribution in tropical and temperate seas (Mollet et al. 2000). It is widespread in Australian waters, commonly found in water with temperatures greater than 16°C. Populations of the Shortfin Mako Shark are considered to have undergone a substantial decline globally. These sharks are a common by-catch species of commercial fisheries (Mollet et al. 2000).

The use of dorsal satellite tags on 10 juvenile Shortfin Mako Sharks captured in the Great Australian Bight between 2008 and 2011 investigated habitat and migration patterns. It revealed GAB and south east of Kangaroo Island near the norther extent of the Bonney Upwelling Region, to be areas of highest fidelity and indicating critical habitats for juvenile Shortfin Mako Sharks (Rogers 2011). The tagged sharks also showed migration to south west Western Australia, Victoria, Bass Strait and south-west of Tasmania. Stomachs of Shortfin Mako Shark were also analysed from specimens collected by game fishing competitors in Port MacDonnell, South Australia and Portland, Victoria from 2008 and 2010 which found they specialise in larger prey including pelagic teleosts and cephalopods (Rogers 2011). Due to their widespread distribution in Australian waters, Shortfin Mako Sharks are likely to be present in the Project Area and Planning Area in low numbers.

4.4.9.3.8 Syngnathids

Syngnathids identified in the EPBC PMST Reports include seahorses and their relatives (sea dragon, pipehorse and pipefish). The majority of these fish species are associated with seagrass meadows, macroalgal seabed habitats, rocky reefs and sponge gardens located in shallow, inshore waters (e.g. protected coastal bays, harbours, and jetties) less than 50 m deep (Fishes of Australia 2015). They are sometimes recorded in deeper offshore waters, where they depend on the protection of sponges and rafts of floating seaweed such as *Sargassum*.

Of the 33 species of Syngnathids identified in the EPBC PMST Report, only one (*Hippocampus abdominalis*, big-belly seahorse) has a documented species profile and threats profile, indicating how little published information exists in general regarding Syngnathids.

The PMST report species profile and threats profiles indicate that the Syngnathids species identified in the Project Area and Planning Area are widely distributed throughout southern, southeastern and southwestern Australian waters. It is unlikely that these species will be present within the Project Area as water depths are greater than 50 m, however they may be present within the Planning Area.

4.4.9.3.9 Whale Shark

The Whale Shark (*Rhincodon typus*) is most commonly seen in waters off Western Australia, Northern Territory and Queensland however is occasionally seen off Victoria and South Australia (DoE 2023c). It is generally found in areas where the surface temperature is 21 to 25°C, preferably with cold water of 17°C or less upwelling into it. It is generally observed singularly at the surface but can occasionally be in schools or aggregations of up to hundreds of sharks (Compagno 1984). The Whale Shark is a suction filter feeder and feeds on a variety of planktonic and nektonic prey, including small crustaceans, small schooling fishes and, to a lesser extent, on small tuna and squid. The Whale Shark is listed as Vulnerable and Migratory under the EPBC Act (TSSC 2015b) and is not likely to occur in the Project Area but may be present in the Planning Area in low numbers.

4.4.9.3.10 White Shark

The White Shark (*Carcharodon carcharias*) is widely distributed and located throughout temperate and sub-tropical waters with their known range in Australian waters from the Northwest Cape, Western Australia, through southern waters to the central coast of Queensland (Last and Stevens 2009; DoE 2023d). Studies of White Sharks indicate that they are largely transient, with several discrete populations (Pardini et al. 2000; Gubili et al. 2012). In the Australasian region, White Sharks differ genetically from other populations and data suggest there is an eastern and a western population in southern Australia, divided by the Bass Strait (Blower et al. 2012). A recent long-term electronic tagging study of juvenile White Sharks off eastern Australia, indicated complex movement patterns over thousands of kilometres, including annual fidelity to spatially restricted nursery areas, directed seasonal coastal movements, intermittent areas of temporary nearshore residency and offshore movement into the Tasman Sea (Bruce et al. 2019). This study also supported the two-population model for the species in Australian waters with restricted east to west movements through Bass Strait. Bruce et al. (2019) observed seasonal movements of juvenile White Sharks being in the northern region during winter and spring (June through November) and southern region during summer and autumn (December through May).

Observations of adult sharks are more frequent around fur seal and sea lion colonies, including Wilsons Promontory and the Skerries. Juveniles are known to congregate in certain key areas including the Ninety Mile Beach area (including Corner Inlet and Lakes Entrance) in eastern Victoria and the Portland area of western Victoria).

The distribution BIA for the White Shark intersects the Project Area. The foraging BIA is 38 km, and the breeding BIA is 280 km from the Project Area (**Figure 45**). The known distribution is on the coastal shelf/upper slope waters out to 1000 m and the broader area where they are likely to occur extends from Barrow Island in WA to Yeppoon in NSW. They are more likely to be found between the 60 to 120 m depth contours than in the deeper waters. There is a known nursery area at Corner Inlet, and they are known to forage in waters off pinniped colonies throughout the SEMR. It is likely that White Sharks will be present in the Project and Planning Areas.

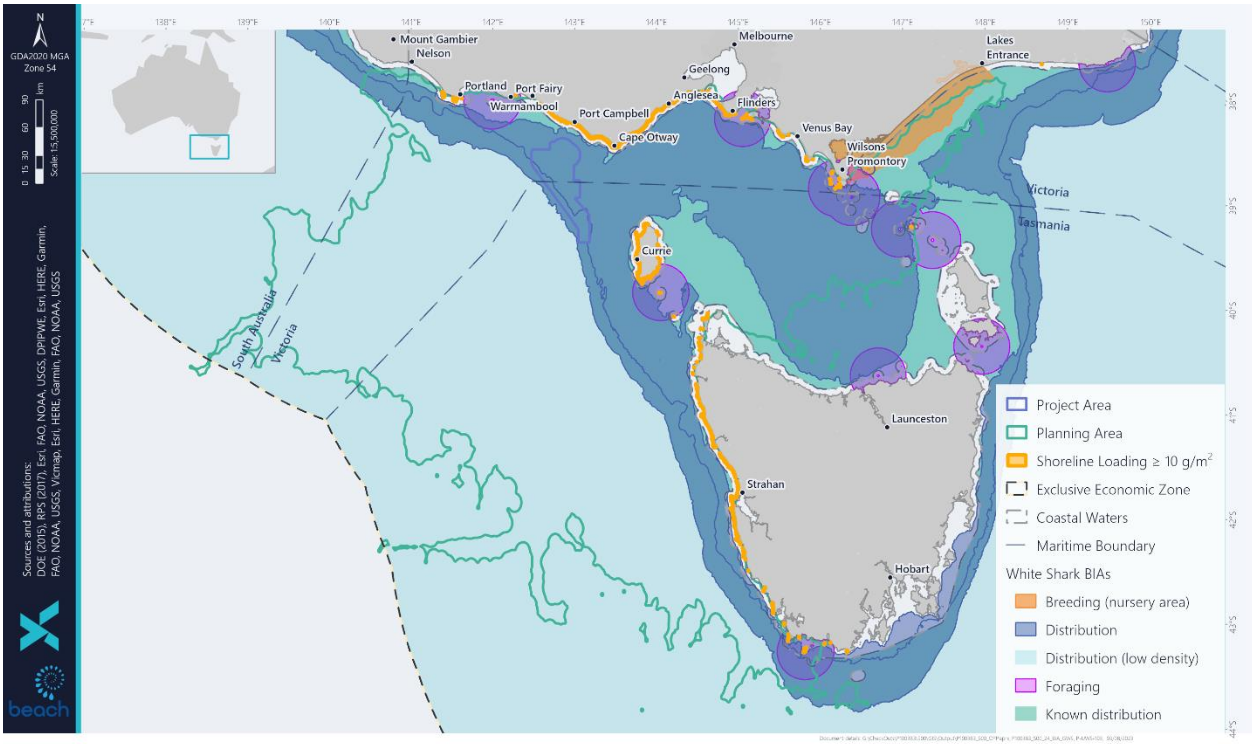


Figure 45: White Shark BIAs within the Project and Planning Areas

4.4.9.3.11 Ziebell's Handfish

Ziebell's Handfish are the largest species of handfish and use their hands to crawl across the seafloor while feeding on invertebrates. They prefer soft-bottomed habitat with patches of rock to support sponge and algae communities. Ziebell's Handfish has not been observed or systematically surveyed for several years, therefore the current distribution and abundance of the species is unknown (DoE 2023e). As a result, it is not expected to be present within the Planning Area.

4.4.9.4 Seabirds and Shorebirds

A diverse array of seabirds and shorebirds birds utilise the Otway region and potentially forage within or fly over the Project Area. **Figure 46**, **Figure 47** and **Figure 48** show the seabird BIAs that overlap the Project and Planning Areas. No shorebird BIAs were identified within the Project and Planning Areas.

Table 32 details the listed bird species identified in the Project and Planning Areas PMST Reports (Appendix A and B).

Threatened or migratory species that are likely or known to occur or have an intercepting BIA with the Project or Planning Areas are discussed in more detail.

No habitats critical to the survival of a birds were identified in the Project Area. The Planning Area overlaps listed critical habitat for one species, the Shy Albatross.

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Area	Present in Planning Area	Present in Project Area
Albatrosses and Petrels								
Antipodean Albatross	*Diomedea antipodensis*	Vulnerable	Migratory	Migratory Marine Birds	Listed	Foraging	Foraging, feeding or related behaviour likely to occur within area	Foraging, feeding or related behaviour likely to occur within area
Black-browed Albatross	*Thalassarche melanophris*	Vulnerable	Migratory	Migratory Marine Birds	Listed	Foraging	Foraging, feeding or related behaviour likely to occur within area	Foraging, feeding or related behaviour likely to occur within area
Blue Petrel	*Halobaena caerulea*	Vulnerable			Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
		Approved Conservation Advice for the *Halobaena caerulea* (Blue Petrel) (TSSC 2015a). No threats relevant to the activity were identified.						
Buller's Albatross, Pacific Albatross	*Thalassarche bulleri*	Vulnerable	Migratory	Migratory Marine Birds	Listed	Foraging	Foraging, feeding or related behaviour likely to occur within area	Foraging, feeding or related behaviour likely to occur within area
Campbell Albatross, Campbell Black-browed Albatross	*Thalassarche impavida*	Vulnerable	Migratory	Migratory Marine Birds	Listed	Foraging	Foraging, feeding or related behaviour likely to occur within area	Foraging, feeding or related behaviour likely to occur within area
Chatham Albatross	*Thalassarche eremita*	Endangered	Migratory	Migratory Marine Birds	Listed		Foraging, feeding or related behaviour may occur within area	_
Common Diving-petrel	*Pelecanoides urinatrix*				Listed	Breeding, Foraging	Breeding known to occur within area	_
Gibson's Albatross	*Diomedea antipodensis gibsoni*	Vulnerable			Listed (as *Diomedea gibsoni*)		Foraging, feeding or related behaviour likely to occur within area	_
Gould's Petrel, Australian Gould's Petrel	*Pterodroma leucoptera leucoptera*	Endangered					Species or species habitat may occur within area	Species or species habitat may occur within area
		National Recovery Plan for *Pterodroma leucoptera leucoptera* (Gould's Petrel) (DEC NSW 2006). No threats relevant to the activity were identified.						

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Area	Present in Planning Area	Present in Project Area
Grey-headed Albatross	*Thalassarche chrysostoma*	Endangered	Migratory	Migratory Marine Birds	Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Indian Yellow-nosed Albatross	*Thalassarche carteri*	Vulnerable	Migratory	Migratory Marine Birds	Listed	Foraging	Species or species habitat likely to occur within area	Species or species habitat likely to occur within area
Northern Buller's Albatross, Pacific Albatross	*Thalassarche bulleri platei*	Vulnerable			Listed (as *Thalassarche* sp. nov.)		Foraging, feeding or related behaviour likely to occur within area	Foraging, feeding or related behaviour likely to occur within area
Northern Giant Petrel	*Macronectes halli*	Vulnerable	Migratory	Migratory Marine Birds	Listed		Foraging, feeding or related behaviour likely to occur within area	–
Northern Royal Albatross	*Diomedea sanfordi*	Endangered	Migratory	Migratory Marine Birds	Listed		Foraging, feeding or related behaviour likely to occur within area	Foraging, feeding or related behaviour likely to occur within area
Salvin's Albatross	*Thalassarche salvini*	Vulnerable	Migratory	Migratory Marine Birds	Listed		Foraging, feeding or related behaviour likely to occur within area	Foraging, feeding or related behaviour likely to occur within area
Shy Albatross	*Thalassarche cauta*	Endangered	Migratory	Migratory Marine Birds	Listed	Breeding, Foraging Critical Habitat: Breeding	Breeding known to occur within area	Foraging, feeding or related behaviour likely to occur within area
Soft-plumaged Petrel	*Pterodroma mollis*	Vulnerable			Listed	Breading, Foraging	Breeding known to occur within area	Species or species habitat may occur within area
		Approved Conservation Advice for *Pterodroma mollis* (Soft-plumaged Petrel) (TSSC 2015a). No threats relevant to the activity were identified.						
Sooty Albatross	*Phoebetria fusca*	Vulnerable	Migratory	Migratory Marine Birds	Listed		Species or species habitat likely to occur within area	Species or species habitat likely to occur within area
Southern Giant-Petrel, Southern Giant Petrel	*Macronectes giganteus*	Endangered	Migratory	Migratory Marine Birds	Listed		Foraging, feeding or related behaviour likely to occur within area	Foraging, feeding or related behaviour likely to occur within area

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Area	Present in Planning Area	Present in Project Area
Southern Royal Albatross	*Diomedea epomophora*	Vulnerable	Migratory	Migratory Marine Birds	Listed		Foraging, feeding or related behaviour likely to occur within area	Foraging, feeding or related behaviour likely to occur within area
Wandering Albatross	*Diomedea exulans*	Vulnerable	Migratory	Migratory Marine Birds	Listed	Foraging	Foraging, feeding or related behaviour likely to occur within area	Foraging, feeding or related behaviour likely to occur within area
White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian)	*Fregetta grallaria grallaria*	Vulnerable					Species or species habitat likely to occur within area	–
White-capped Albatross	*Thalassarche steadi*	Vulnerable	Migratory	Migratory Marine Birds	Listed		Foraging, feeding or related behaviour known to occur within area	Foraging, feeding or related behaviour known to occur within area
White-faced Storm-Petrel	*Pelagodroma marina*				Listed	Breeding, Foraging	Breeding known to occur within area	–
Terns and Shearwaters								
Australian Fairy Tern	*Sternula nereis nereis*	Vulnerable					Species or species habitat known to occur within area	Foraging, feeding or related behaviour likely to occur within area
		Approved Conservation Advice for *Sternula nereis nereis* (Australian fairy Tern) (DSEWPC 2011). Threats identified relevant to the activity: • Marine pollution - Evaluate risk of oil spill impact to nest locations and, if required, appropriate mitigation measures are implemented. • National Recovery Plan for the Australian Fairy Tern (Sternula nereis nereis) (CoA 2020). Threats identified relevant to the activity: • Habitat degradation • Climate variability • Pollution No actions specific to the activity were identified.						
Caspian Tern	*Hydroprogne caspia*		Migratory	Migratory Marine Birds	Listed (as *Sterna caspia*)		Breeding known to occur within area	–

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Area	Present in Planning Area	Present in Project Area
Fairy Tern	*Sternula nereis*				Listed (as *Sterna nereis*)		Breeding known to occur within area	_
Flesh-footed Shearwater, Fleshy-footed Shearwater	*Ardenna carneipes*		Migratory	Migratory Marine Birds	Listed (as *Puffinus carneipes*)		Species or species habitat known to occur within area	Foraging, feeding or related behaviour likely to occur within area
Greater Crested Tern	*Thalasseus bergii*		Migratory	Migratory Wetlands Species	Listed (as *Sterna bergii*)		Breeding known to occur within area	_
Little Tern	*Sternula albifrons*		Migratory	Migratory Marine Birds	Listed (as *Sterna albifrons*)		Breeding known to occur within area	_
Short-tailed Shearwater	*Ardenna tenuirostris*		Migratory	Migratory Marine Birds	Listed (as *Puffinus tenuirostris*)	Breeding, Foraging	Breeding known to occur within area	-
Sooty Shearwater	*Ardenna grisea*		Migratory	Migratory Marine Birds	Listed (as *Puffinus griseus*)	Breeding, Foraging	Breeding known to occur within area	Species or species habitat may occur within area
Sooty Tern	*Onychoprion fuscatus*				Listed (as *Sterna fuscata*)		Breeding known to occur within area	_
White-fronted Tern	*Sterna striata*				Listed		Foraging, feeding or related behaviour likely to occur within area	Foraging, feeding or related behaviour likely to occur within area
Other								
Australasian Bittern	*Botaurus poiciloptilus*	Endangered					Species or species habitat known to occur within area	_
		Approved Conservation Advice for *Botaurus poiciloptilus* (Australasian Bittern) (TSSC 2019). No threats relevant to the activity were identified.						

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Area	Present in Planning Area	Present in Project Area
Australasian Gannet	*Morus serrator*				Listed	Aggregation, Foraging	Breeding known to occur within area	_
Australian Painted Snipe	*Rostratula australis*	Endangered			Listed - overfly marine area (as *Rostratula benghalensis* (sensu lato))		Species or species habitat known to occur within area	_
		Approved Conservation Advice for *Rostratula australis* (Australian Painted Snipe) (DSEWPaC 2013a). No threats relevant to the activity were identified. National Recovery Plan for the Australian Painted Snipe (CoA 2022a). Threats identified relevant to the activity: • Deterioration of water quality, human disturbance.						
Bar-tailed Godwit	*Limosa lapponica*		Migratory	Migratory Wetlands Species	Listed		Species or species habitat known to occur within area	_
		Conservation Advice for *Limosa lapponica baueri* (Bar-tailed Godwit (western Alaskan)) (TSSC 2016a). Threats identified relevant to the activity: • Habitat degradation/ loss.						
Black Currawong (King Island)	*Strepera fuliginosa colei*	Vulnerable					Breeding likely to occur within area	_
Black-eared Cuckoo	*Chalcites osculans*				Listed - overfly marine area (as *Chrysococcyx osculans*)		Species or species habitat known to occur within area	_
Black-faced Cormorant	*Phalacrocorax fuscescens*				Listed	Breeding, Foraging	Breeding known to occur within area	_
Black-faced Monarch	*Monarcha melanopsis*		Migratory	Migratory Terrestrial Species	Listed - overfly marine area		Species or species habitat known to occur within area	_

Common Name	**Scientific Name**	**Threatened Category**	**Migratory Status**	**Migratory Category**	**Marine Status**	**Biologically Important Area**	**Present in Planning Area**	**Present in Project Area**
Black-tailed Godwit	*Limosa limosa*		Migratory	Migratory Wetlands Species	Listed - overfly marine area		Roosting known to occur within area	_
Blue-winged Parrot	*Neophema chrysostoma*	Vulnerable			Listed - overfly marine area		Species or species habitat known to occur within area	_
Broad-billed Sandpiper	*Limicola falcinellus*		Migratory	Migratory Wetlands Species	Listed - overfly marine area		Roosting known to occur within area	-
Brown Skua	*Stercorarius antarcticus*				Listed (as *Catharacta skua*)		Species or species habitat may occur within area	Species or species habitat may occur within area
Brown Treecreeper (south-eastern)	*Climacteris picumnus victoriae*	Vulnerable					Species or species habitat may occur within area	_
Cape Gannet	*Morus capensis*				Listed		Breeding known to occur within area	_
Cattle Egret	*Bubulcus ibis*				Listed - overfly marine area (as *Ardea ibis*)		Species or species habitat may occur within area	_
Common Greenshank, Greenshank	*Tringa nebularia*		Migratory	Migratory Wetlands Species	Listed - overfly marine area		Species or species habitat known to occur within area	_
Common Noddy	*Anous stolidus*		Migratory	Migratory Marine Birds	Listed		Species or species habitat likely to occur within area	_
Common Sandpiper	*Actitis hypoleucos*		Migratory	Migratory Wetlands Species	Listed		Species or species habitat known to occur within area	Species or species habitat may occur within area

Common Name	**Scientific Name**	**Threatened Category**	**Migratory Status**	**Migratory Category**	**Marine Status**	**Biologically Important Area**	**Present in Planning Area**	**Present in Project Area**
Curlew Sandpiper	*Calidris ferruginea*	Critically Endangered	Migratory	Migratory Wetlands Species	Listed - overfly marine area		Species or species habitat known to occur within area	Species or species habitat may occur within area
		Conservation Advice for *Calidris ferruginea* (Curlew Sandpiper) (DoE 2015f). Threats identified relevant to the activity: • Habitat degradation/ loss (oil pollution)						
Diamond Firetail	*Stagonopleura guttata*	Vulnerable					Species or species habitat known to occur within area	–
Double-banded Plover	*Charadrius bicinctus*		Migratory	Migratory Wetlands Species	Listed - overfly marine area		Roosting known to occur within area	–
Eastern Curlew, Far Eastern Curlew	*Numenius madagascariensis*	Critically Endangered	Migratory	Migratory Wetlands Species	Listed		Species or species habitat known to occur within area	Species or species habitat may occur within area
Eastern Hooded Plover, Eastern Hooded Plover	*Thinornis cucullatus cucullatus*	Vulnerable			Listed - overfly marine area (as *Thinornis rubricollis rubricollis*)		Species or species habitat known to occur within area	–
Fairy Prion	*Pachyptila turtur*				Listed		Species or species habitat known to occur within area	Species or species habitat may occur within area
Fairy Prion (southern)	*Pachyptila turtur subantarctica*	Vulnerable					Species or species habitat known to occur within area	Species or species habitat may occur within area
		Approved Conservation Advice for *Pachyptila subantarctica* (Fairy Prion (southern)) (TSSC 2015b). No threats relevant to the activity were identified.						
Fork-tailed Swift	*Apus pacificus*		Migratory	Migratory Marine Birds	Listed - overfly marine area		Species or species habitat likely to occur within area	–

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Area	Present in Planning Area	Present in Project Area
Gang-gang Cockatoo	*Callocephalon fimbriatum*	Endangered					Species or species habitat known to occur within area	–
Great Knot	*Calidris tenuirostris*	Critically Endangered	Migratory	Migratory Wetlands Species	Listed - overfly marine area		Roosting known to occur within area	–
Greater Sand Plover, Large Sand Plover	*Charadrius leschenaultii*	Vulnerable	Migratory	Migratory Wetlands Species	Listed		Species or species habitat known to occur within area	–
		Conservation Advice for *Charadrius leschenaultia* (Greater sand Plover) (TSSC 2016b). Threats identified relevant to the activity: • Habitat degradation/ loss (oil pollution)						
Green Rosella (King Island)	*Platycercus caledonicus brownii*	Vulnerable					Species or species habitat known to occur within area	–
Grey Falcon	*Falco hypoleucos*	Vulnerable					Species or species habitat likely to occur within area	–
Grey Plover	*Pluvialis squatarola*		Migratory	Migratory Wetlands Species	Listed - overfly marine area		Roosting known to occur within area	–
Grey-tailed Tattler	*Tringa brevipes*		Migratory	Migratory Wetlands Species	Listed (as Heteroscelus brevipes)		Roosting known to occur within area	–
Hooded Plover, Hooded Dotterel	*Thinornis cucullatus*				Listed - overfly marine area (as *Thinornis rubricollis*)		Species or species habitat known to occur within area	–
Kelp Gull	*Larus dominicanus*				Listed		Breeding known to occur within area	–

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Area	Present in Planning Area	Present in Project Area
King Island Brown Thornbill, Brown Thornbill (King Island)	*Acanthiza pusilla magnirostris*	Endangered (listed as *Acanthiza pusilla archibaldi*)					Species or species habitat known to occur within area	_
King Island Scrubtit, Scrubtit (King Island)	*Acanthornis magna greeniana*	Critically Endangered					Species or species habitat known to occur within area	_
Latham's Snipe, Japanese Snipe	*Gallinago hardwickii*		Migratory	Migratory Wetlands Species	Listed - overfly marine area		Species or species habitat known to occur within area	_
Lesser Sand Plover, Mongolian Plover	*Charadrius mongolus*	Endangered	Migratory	Migratory Wetlands Species	Listed		Roosting known to occur within area	_
Little Curlew, Little Whimbrel	*Numenius minutus*		Migratory	Migratory Wetlands Species	Listed - overfly marine area		Roosting known to occur within area	_
Little Penguin	*Eudyptula minor*				Listed	Breeding, Foraging	Breeding known to occur within area	_
Magpie Goose	*Anseranas semipalmata*				Listed - overfly marine area		Species or species habitat may occur within area	_
Marsh Sandpiper, Little Greenshank	*Tringa stagnatilis*		Migratory	Migratory Wetlands Species	Listed - overfly marine area		Roosting known to occur within area	_
Masked Owl (Tasmanian)	*Tyto novaehollandiae castanops* (Tasmanian population)	Vulnerable					Breeding known to occur within area	_

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Area	Present in Planning Area	Present in Project Area
Nunivak Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit	*Limosa lapponica baueri*	Vulnerable					Species or species habitat known to occur within area	–
Orange-bellied Parrot	*Neophema chrysogaster*	Critically Endangered			Listed - overfly marine area		Breeding known to occur within area	Migration route likely to occur within area
		National Recovery Plan for the *Neophema chrysogaster* (Orange-bellied Parrot) (DELWP 2016). Threats identified relevant to the activity: • Illuminated boats and structures: evaluate risk of lighting on vessels and offshore structures.						
Oriental Plover, Oriental Dotterel	*Charadrius veredus*		Migratory	Migratory Wetlands Species	Listed - overfly marine area		Species or species habitat known to occur within area	–
Osprey	*Pandion haliaetus*		Migratory	Migratory Wetlands Species	Listed		Species or species habitat known to occur within area	–
Pacific Golden Plover	*Pluvialis fulva*		Migratory	Migratory Wetlands Species	Listed		Roosting known to occur within area	–
Pacific Gull	*Larus pacificus*				Listed		Breeding known to occur within area	–
Painted Honeyeater	*Grantiella picta*	Vulnerable					Species or species habitat known to occur within area	–
Pectoral Sandpiper	*Calidris melanotos*		Migratory	Migratory Wetlands Species	Listed - overfly marine area		Species or species habitat known to occur within area	Species or species habitat may occur within area
Pied Stilt, Black-winged Stilt	*Himantopus himantopus*				Listed - overfly marine area		Roosting known to occur within area	–

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Area	Present in Planning Area	Present in Project Area
Pilotbird	*Pycnoptilus floccosus*	Vulnerable					Species or species habitat known to occur within area	_
Pin-tailed Snipe	*Gallinago stenura*		Migratory	Migratory Wetlands Species	Listed - overfly marine area		Species or species habitat known to occur within area	_
Plains-wanderer	*Pedionomus torquatus*	Critically Endangered					Species or species habitat likely to occur within area	_
Rainbow Bee-eater	*Merops ornatus*				Listed - overfly marine area		Species or species habitat may occur within area	_
Red Knot, Knot	*Calidris canutus*	Endangered	Migratory	Migratory Wetlands Species	Listed - overfly marine area		Species or species habitat known to occur within area	Species or species habitat may occur within area
		Approved Conservation Advice for *Calidris canutus* (Red Knot) (TSSC 2016c). Threats identified relevant to the activity: • Marine pollution - Evaluate risk of oil spill impact to nest locations and, if required, appropriate mitigation measures are implemented.						
Red-capped Plover	*Charadrius ruficapillus*				Listed - overfly marine area		Roosting known to occur within area	_
Red-necked Avocet	*Recurvirostra novaehollandiae*				Listed - overfly marine area		Roosting known to occur within area	_
Red-necked Phalarope	*Phalaropus lobatus*		Migratory	Migratory Wetlands Species	Listed		Roosting known to occur within area	_
Red-necked Stint	*Calidris ruficollis*		Migratory	Migratory Wetlands Species	Listed - overfly marine area		Roosting known to occur within area	_

Common Name	**Scientific Name**	**Threatened Category**	**Migratory Status**	**Migratory Category**	**Marine Status**	**Biologically Important Area**	**Present in Planning Area**	**Present in Project Area**
Regent Honeyeater	*Anthochaera phrygia*	Critically Endangered					Foraging, feeding or related behaviour likely to occur within area	_
Ruddy Turnstone	*Arenaria interpres*		Migratory	Migratory Wetlands Species	Listed		Roosting known to occur within area	_
Ruddy Turnstone	*Arenaria interpres*		Migratory	Migratory Wetlands Species	Listed		Roosting known to occur within area	_
Ruff (Reeve)	*Philomachus pugnax*		Migratory	Migratory Wetlands Species	Listed - overfly marine area		Roosting known to occur within area	_
Ruff (Reeve)	*Philomachus pugnax*		Migratory	Migratory Wetlands Species	Listed - overfly marine area		Roosting known to occur within area	_
Rufous Fantail	*Rhipidura rufifrons*		Migratory	Migratory Terrestrial Species	Listed - overfly marine area		Species or species habitat known to occur within area	_
Sanderling	*Calidris alba*		Migratory	Migratory Wetlands Species	Listed		Roosting known to occur within area	_
Satin Flycatcher	*Myiagra cyanoleuca*		Migratory	Migratory Terrestrial Species	Listed - overfly marine area		Breeding known to occur within area	_
Sharp-tailed Sandpiper	*Calidris acuminata*		Migratory	Migratory Wetlands Species	Listed		Roosting known to occur within area	Species or species habitat may occur within area
Silver Gull	*Chroicocephalus novaehollandiae*				Listed (as *Larus novaehollandiae*)		Breeding known to occur within area	_

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Area	Present in Planning Area	Present in Project Area
South-eastern Glossy Black-Cockatoo	*Calyptorhynchus lathami lathami*	Vulnerable					Species or species habitat may occur within area	–
South-eastern Hooded Robin, Hooded Robin (south-eastern)	*Melanodryas cucullata cucullata*	Endangered					Species or species habitat may occur within area	–
South-eastern Red-tailed Black-Cockatoo	*Calyptorhynchus banksii graptogyne*	Endangered					Species or species habitat may occur within area	–
Southern Whiteface	*Aphelocephala leucopsis*	Vulnerable					Species or species habitat known to occur within area	–
Swift Parrot	*Lathamus discolor*	Critically Endangered			Listed - overfly marine area		Species or species habitat known to occur within area	–
		National Recovery Plan for the Swift Parrot *Lathamus discolour* (Saunders and Tzaros 2011). Draft National Recovery Plan for the Swift Parrot (*Lathamus discolor*) (CoA 2019). No threats relevant to the activity were identified.						
Swinhoe's Snipe	*Gallinago megala*		Migratory	Migratory Wetlands Species	Listed - overfly marine area		Roosting likely to occur within area	–
Swinhoe's Snipe	*Gallinago megala*		Migratory	Migratory Wetlands Species	Listed - overfly marine area		Roosting likely to occur within area	–
Tasmanian Azure Kingfisher	*Ceyx azureus diemenensis*	Endangered					Breeding known to occur within area	–
Tasmanian Wedge-tailed Eagle, Wedge-tailed Eagle (Tasmanian)	*Aquila audax fleayi*	Endangered					Breeding likely to occur within area	–

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Area	Present in Planning Area	Present in Project Area
Terek Sandpiper	*Xenus cinereus*		Migratory	Migratory Wetlands Species	Listed - overfly marine area		Roosting known to occur within area	_
Wandering Tattler	*Tringa incana*		Migratory	Migratory Wetlands Species	Listed (as *Heteroscelus incanus*)		Roosting known to occur within area	_
Whimbrel	*Numenius phaeopus*		Migratory	Migratory Wetlands Species	Listed		Roosting known to occur within area	_
White-bellied Sea-Eagle	*Haliaeetus leucogaster*				Listed		Breeding known to occur within area	_
White-throated Needletail	*Hirundapus caudacutus*	Vulnerable	Migratory	Migratory Terrestrial Species	Listed - overfly marine area		Species or species habitat known to occur within area	_
Wood Sandpiper	*Tringa glareola*		Migratory	Migratory Wetlands Species	Listed - overfly marine area		Roosting known to occur within area	_
Yellow Wagtail	*Motacilla flava*		Migratory	Migratory Terrestrial Species	Listed - overfly marine area		Species or species habitat known to occur within area	_

Table 32: EPBC Listed Seabird and Shorebird Species Identified in the Project and/or Planning Areas

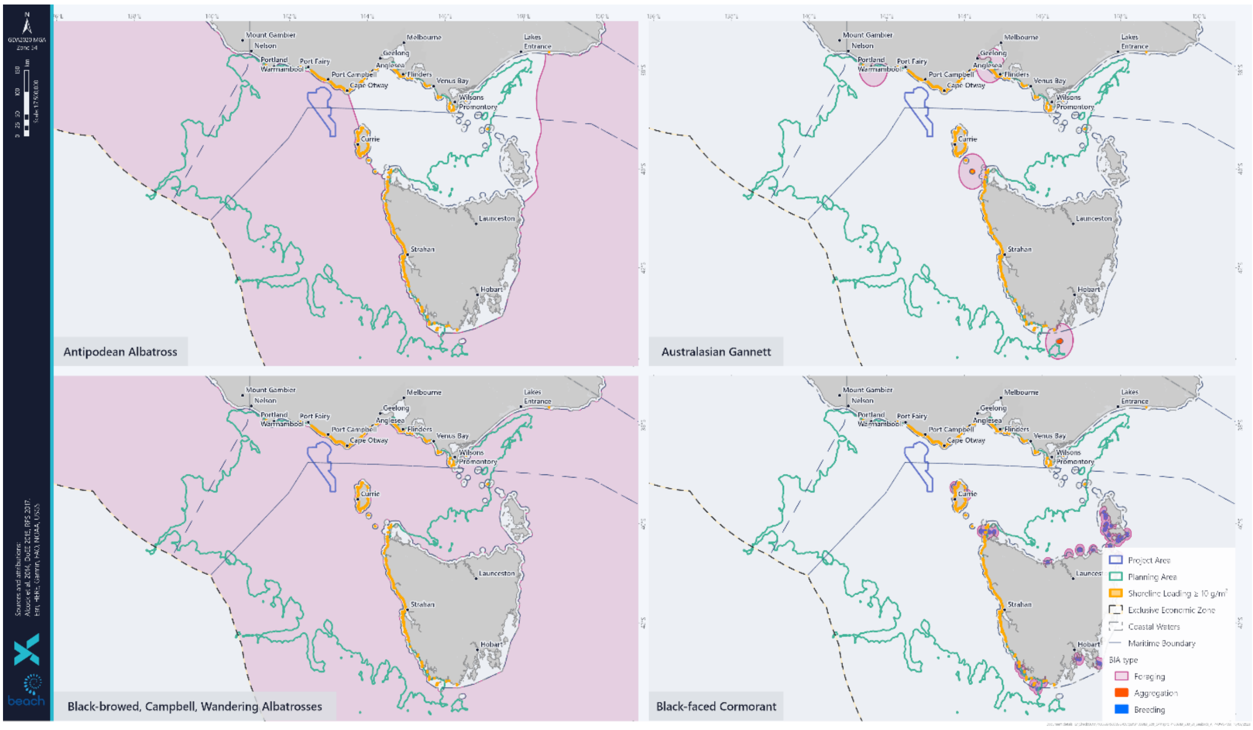


Figure 46: BIAs for Birds in the Project and Planning Areas

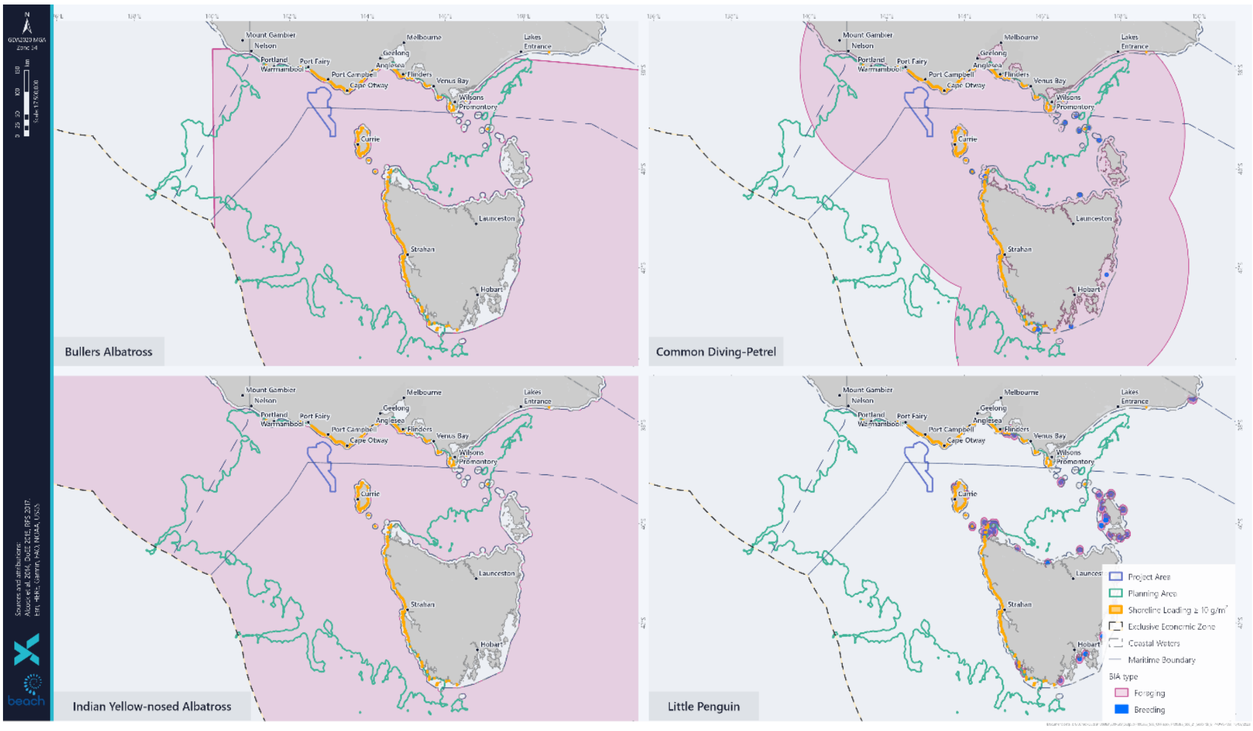


Figure 47: BIAs for Birds in the Project and Planning Areas

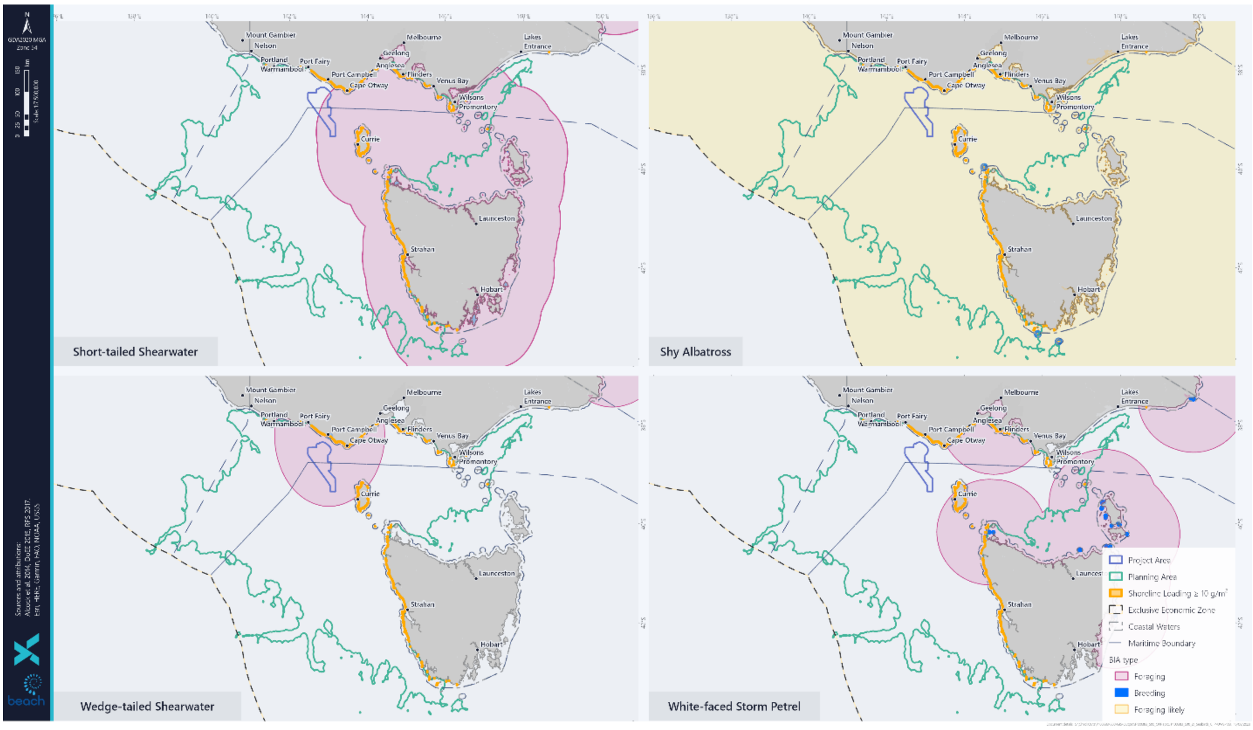


Figure 48: BIAs for Birds in the Project and Planning Areas

4.4.9.4.1 *Albatross and Petrels*

Albatross and Giant-petrels are among the most dispersive and oceanic of all birds, spending more than 95% of their time foraging at sea in search of prey and usually only returning to land (remote islands) to breed (CoA 2022). Only seven species of Albatross and the Southern and Northern Giant Petrel are known to breed within Australia, which are protected under The National Recovery Plan for Albatross and Petrels (CoA 2022). Breeding within Australian territory occurs on the isolated islands of Antarctica (Giganteus Island, Hawker Island and Frazier islands) and the Southern Ocean (Heard Island, McDonald Island, Macquarie Island, Bishop and Clerk Islands), as well as islands off the south coast of Tasmania and Albatross Island off the north-west coast of Tasmania in Bass Strait (CoA 2022). There are no islands with colonies of threatened marine seabirds within the Project Area. Albatross Island, supporting a breeding population of approximately 5,000 Shy Albatross (*Thallassarche cauta*), is the closest breeding colony of threatened seabirds to the Project Area (136 km).

Albatross and Giant Petrel species exhibit a broad range of diets and foraging behaviours; hence their at-sea distributions are diverse. Combined with their ability to cover vast oceanic distances, all waters within Australian jurisdiction can be considered foraging habitat, however the most critical foraging habitat is those waters south of 25° where most species spend most of their foraging time (CoA 2022).

The Antipodean Albatross, Black-browed Albatross, Campbell Albatross, Wandering Albatross Figure 46), Buller's Albatross, Indian yellow-nosed Albatross (Figure 47) and Shy Albatross (Figure 47) have BIAs for foraging that overlap the Project Area and Planning Area. The Shy Albatross also has critical habitat within the Planning Area at Albatross Island and Mewstone Island (CoA 2022) (Figure 48).

Both the Common Diving-petrel and the White-faced Storm Petrel are not listed as threatened species under the EPBC Act, and have large populations within Australia, accounting for 5% and 25% respectively of the global population (CoA 2015c). The Common Diving-petrel breeds on islands off south-east

Australia and Tasmania; there are 30 sites with significant breeding colonies (defined as more than 1,000 breeding pairs) known in Tasmania, and 12 sites in Victoria (including Seal Island, Wilson's Promontory and Lady Julia Percy Island) (DCCEEW 2023). There are 15 sites with significant breeding colonies for the White-faced Storm Petrel in Tasmania and 3 sites within Victoria (CoA 2015c). The Project Area overlaps a foraging BIA for the Common Diving-petrel.

Southern Royal Albatross forage from 36° to 63°. They range over the waters off southern Australia at all times of the year but especially from July to October (CoA 2022). The Northern Royal Albatross is regularly recorded throughout the year around Tasmania and South Australia at the continental shelf edge and feeds frequently in these waters. Despite breeding colonies in New Zealand, the White Capped and the Chatham Albatross are common off the coast of south-east Australia throughout the year (CoA 2022). During the non-breeding season, the Salvin's Albatross occur over continental shelves around continents with a small number of non-breeding adults flying regularly across the Tasman Sea to south-east Australian waters (CoA 2022). Sooty Albatrosses although rare are likely regular migrants to Australian waters mostly in the autumn to winter months and have been observed foraging in southern Australia (Thiele 1977; Pizzey and Knight 1999). The Pacific Albatross (equivalent to the Northern Buller's Albatross) is a non-breeding visitor to Australian waters mostly limited to the Tasman Sea and Pacific Ocean, occurring over inshore, offshore, and pelagic waters and off the east-coast of Tasmania (CoA 2022). Gibson's Albatross has breeding colonies in New Zealand but has been known to forage in the Tasman Sea and South Pacific Ocean with individuals occurring offshore from Coffs harbour in the north to Wilson's Promontory in the south (CoA 2022; Marchant and Higgins 1990). Therefore, it is likely that these along with the Tasmanian Shy Albatross will be present and forage in the Project Area.

The White-bellied Storm Petrel breed on small offshore islets and rocks in Lord Howe Island and has been recorded over near-shore waters off Tasmania (Baker et al. 2002). The Great-winged Petrel breeds in the Southern Hemisphere between 30° and 50° south, outside of the breeding season they are widely dispersed (Birdlife International 2019)

4.4.9.4.2 Terns and Shearwaters

Flesh-footed Shearwater is a trans-equatorial migrant widely distributed across the south-western Pacific during breeding season (early September to early May) and is a common visitor to the waters of the continental shelf/slope and occasionally inshore waters (DoE 2023b). The species breeds in burrows on sloping ground in coastal forest, scrubland, or grassland. Thirty-nine of the 41 islands on which the species breeds lie off the coast of southern Western Australia, with the remaining two islands being Smith Island (SA) and Lord Howe Island (DoE 2023b). The Flesh-footed Shearwater feeds on small fish, cephalopod molluscs (squid, cuttlefish, nautilus and argonauts), crustaceans (barnacles and shrimp), other soft-bodied invertebrates (such as *Velella*) and offal (DoE 2023b). The species forages almost entirely at sea and very rarely on land. It obtains most of its food by surface plunging or pursuit plunging. It also regularly forages by settling on the surface of the ocean and snatching prey from the surface ('surface seizing'), momentarily submerging onto prey beneath the surface ('surface diving') or diving and pursuing prey beneath the surface by swimming ('pursuit diving'). Birds have also been observed flying low over the ocean and pattering the water with their feet while picking food items from the surface (termed 'pattering') (DoE 2023b). This species is likely to visit the Project and Planning Areas foraging for food.

The Short-tailed Shearwater has a foraging BIA within the Project Area. The Short-tailed Shearwater is migratory, and breeding is restricted to southern Australia being most abundant in Victoria and Tasmania (Skira et al. 1996). Huge numbers arrive along the south and south-east coast of Australia from wintering grounds in the North Pacific and are observed in large numbers foraging the surrounding coastal and offshore waters (Marchant and Higgins 1990). Short-tailed shearwaters have been identified as a conservation value in the temperate east and south-west marine areas and are likely to be present in the Project Area.

The Sooty Shearwater has a foraging and breeding BIA within the Project Area. The Sooty shearwater is migratory and breeds in summer around southern Australia in New South Wales and Tasmania. The species forages mainly in subtropical (open ocean), sub-Antarctic and Antarctic waters. It has been recorded in areas with sea surface temperature of 8.7-22.0 ^{0}C (Reid et al. 2002). The species takes most food by pursuit-plunging and other methods and feeding concentrations are often observed over thermal fronts at edges of upwellings at boundaries of cool and warm water-masses.

The Wedge-tailed Shearwater has a foraging and breeding BIA within the Project Area. A review of the DCCEEW Species Profile and Threats Database (SPRAT), Atlas of Living Australia and South-east Marine Region Profile did not provide any information on the Victorian Muttonbird Island Wedge-tailed Shearwater colony. The DCCEEW SPRAT profile does not show any locations for the Wedge-tailed Shearwater in Victoria and Beaver (2018) details Montague Island in NSW was the southernmost known colony, however, in 2017 breeding individuals of Wedge-tail Shearwaters were discovered a couple of hundred kilometres further south on Gabo Island Lighthouse Reserve, Victoria near the NSW border.

The Australian Fairy Tern occurs along the coastline of Victoria, South Australia, Western Australia and Tasmania. Breeding habitat for the Caspian, Little Tern and Australian Fairy Tern vary from terrestrial wetlands, rocky islets or banks, low islands, beaches, cays and spits. Nests are present in the open sparse vegetation such as tussocks and other sand binding plants to sometimes near bushes and driftwood. Their diet also consists primarily of fish along with aquatic invertebrates, insects, and eggs and the young of other birds (Higgins and Davis 1996; Taylor and Roe 2004; Van de Kam et al. 2004).

The Caspian Tern is the largest tern in Australia, they inhabit both coastal and inland regions and breeding occurs widespread throughout Australia. In Victoria breeding sites are mostly along coastal regions with three significant regular breeding colonies, Corner Inlet, Mud Island and Mallacoota (Minton and Deleyev 2001). Breeding occurs between September to December are resident and occur throughout the year at breeding sites (Minton and Deleyev 2001).

The Little Tern species is also widespread in Australia with three major sub populations, the northern population that breeds from Broome to Northern Territory. The eastern subpopulation breeds on the eastern and southeastern coast extending as far as western Victoria and the south-eastern parts of South Australia, to the northern and eastern coast of Tasmania. The third population migrate from breeding grounds in Asia to spend the spring and summer in Australia. The Little Tern has a naturally high rate of breeding failure due to the ground nets being exposed to adverse weather conditions, and native predators.

The Sooty Tern has a much larger foraging range, encompassing open shelf waters, shelf edge and deep water (DSEWPaC 2012d). Main breeding colonies occur off Australia’s west and east coast. Like the Crested Tern where distribution is widespread in Australia, but breeding occurs off islands in large colonies off Queensland and NSW (Higgins and Davis 1996). Foraging diet consists of pelagic fish, cephalopods, crustaceans and insects. Sooty Terns were observed amongst mixed flocks of seabirds (such as Albatross and Shearwaters) during drilling activities within the Project Area in April 2021.

4.4.9.4.3 Osprey and white bellied sea eagle

No BIAs were identified for Osprey or White Bellied Sea Eagles within the Project Area. The White-bellied Sea Eagle is a large raptor generally seen singly or in pairs, distributed along the coastline of mainland Australia and Tasmania (Department of the Environment 2020). Breeding records are patchily distributed mainly along the coastline especially the eastern coast extending from Victoria and Tasmania to Queensland. There are recorded breeding sites as far inland as the Murray, Murrumbidgee and Lachlan River in norther Victoria (Marchant and Higgins 1993). There is no quantitative data available on area of occupancy, but it is believed that there could be a decline due to increased development of coastal areas. Estimations of 500 or more pairs in Australia account for 10-20% of the global population (Marchant and Higgins 1993). Recorded decline in numbers have been recorded across Australia, with a decline in Victoria's Gippsland Lakes, Phillip Island and the Sunraysia district (Bilney and Emison 1983; Quinn 1969). White-bellied Sea Eagle feed on a variety of fish, birds, reptiles, mammals and crustaceans. They hunt from a perch and while in flight (circling slowly). Described as a breeding resident throughout much of its range in Australia, breeding is generally sedentary, and the home range can be up to 100km^2 (Marchant and Higgins 1993). White-bellied Sea Eagle are sensitive to disturbance particularly in the early stages of nesting, human activity may cause nests and young to be abandoned (Debus et al. 2014). Breeding is known to occur within the Planning Area, so they are likely to be common visitor.

The Osprey is a medium sized raptor extending around the northern coast of Australia from Albany, Western Australia to Lake Macquarie in NSW with an isolated breeding population on the coast of South Australia. Listed as migratory under the EPBC Act they are resident around breeding territories. They are found along coastal habitats and terrestrial wetlands and require open fresh or saltwater for foraging (Marchant and Higgins 1993). Osprey feed mainly on fish, occasionally molluscs, crustaceans, mammals, birds, reptiles, and insects. Generally, they search or prey by soaring, circling, and quartering above water and dive directly into the water at their target prey (Clancy 2005). This species is likely to be an uncommon visitor to the Project and Planning Areas.

4.4.9.4.4 Orange-bellied Parrot

The Orange-bellied Parrot (*Neophema chrysogaster*) (listed as critically endangered under the EPBC Act) breeds in south-west Tasmania during summer (November to March), migrates north across Bass Strait in autumn and spends winters (April to October) on the coast of south-east mainland Australia (DELWP 2016). The migration route includes the west coast of Tasmania and King Island (**Figure 49**). Birds depart the mainland for Tasmania from September to November (Green 1969). The southward migration is rapid (Stephenson 1991), so there are few migration records. The northward migration across western Bass Strait is more prolonged (Higgins and Davies 1996); but typically occurs late-February to early-April (Australian Museum 2020). The Orange-bellied Parrot is protected under the National Recovery Plan for the Orange-bellied Parrot (DELWP 2016). The parrot's breeding habitat is restricted to south-west Tasmania, where breeding occurs from November to mid-January mainly within 30 km of the coast. Breeding activities are known to occur within the Planning Area based on the PMST Report (Appendix B).

The species forage on the ground or in low vegetation (Loyn et al. 1986). During winter, on mainland Australia, Orange-bellied Parrots are found mostly within 3 km of the coast. In Victoria, they mostly occur in sheltered coastal habitats, such as bays, lagoons and estuaries. They are also found in low samphire herbland dominated by beaded glasswort (*Sarcocornia quinqueflora*), Sea Heath (*Frankenia pauciflora*) or Sea-Blite (*Suaeda australis*), and in taller shrubland dominated by Shrubby Glasswort (*Sclerostegia arbuscula*). There are also non-breeding Orange-bellied Parrots on mainland Australia, between Goolwa in

Australia and Corner Inlet in Victoria. The west coast of King Island and coastal Victoria has been identified as resting and feeding areas, however, parrots rarely land or forage out at sea.

The Orange bellied Parrot may overfly the Project Area, which overlaps a small portion of the probable migration route and where the species is likely to occur. The Planning Area overlaps the migration route in the Bass Strait as well as habitat along the west coast of Tasmania (**Figure 49**).

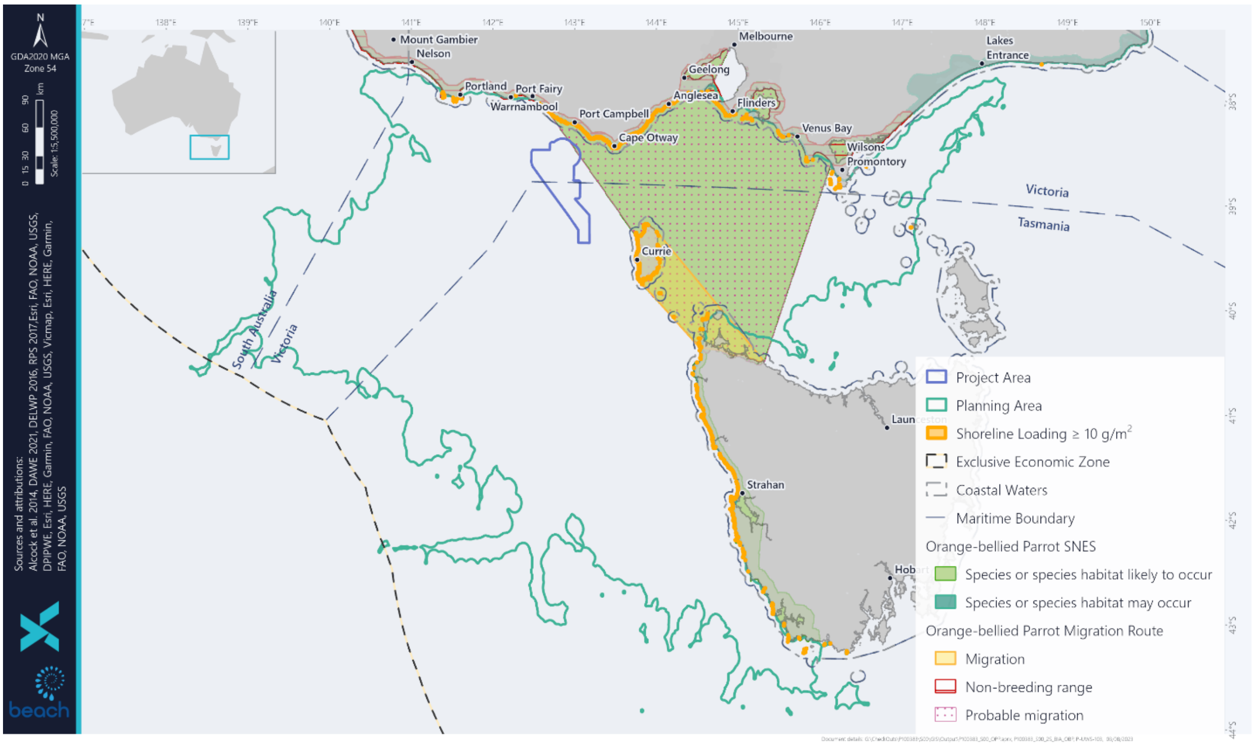


Figure 49: Distribution of the Orange-bellied Parrot within the Project and Planning Areas

4.4.9.4.5 Other Shorebirds

A number of species listed in **Table 32** use coastal shoreline habitats such as, Australasian Bittern, Australasian Gannet, Fairy Prion, Red knot, Pectoral Sandpiper, Fork-tailed Swift, Sharp-tailed Sandpiper, Curlew Sandpiper, Eastern Curlew, Little Curlew, Yellow Wagtail, and species of plover. These species are commonly found on coastal shores including beaches and rocky shores and either feed at low tide on worms, crustaceans and molluscs or fish species or feed on aquatic biota (Parks Victoria 2016). These species are unlikely to be present in the Project Area due to the distance offshore but are likely to be present in the Planning Area.

Many sandpipers including the Broad-billed, Common, Marsh, Terek, and Wood are widespread through Australia's coastline inhabiting saltwater and freshwater ecosystems. They migrate from the Northern Hemisphere in non-breeding months, favouring estuaries, saltmarshes, intertidal mudflats, swamps, and lagoons and foraging on worms, molluscs, crustaceans, insects, seeds and occasionally rootlets and other vegetation (Marchant and Higgins 1993; Higgins and Davies 1996).

The Australian Painted Snipe is a stocky wading bird most commonly in eastern Australian wetlands. Feeding on vegetation, insects, worms, molluscs, crustaceans, and other invertebrates. Latham's, Swinhoe's and Pin-tailed Snipe is a non-breeding visitor to Australia occurring at the edges of wetlands, shallow swamps, ponds, and lakes (Marchant and Higgins 1993). The Wandering Tattler and Grey-tailed Tattler migrate from the Northern hemisphere and inhabit rocky coasts with reefs and platforms, offshore islands, and intertidal mudflats. Foraging on polychaete worms, molluscs and crustaceans and roosting on branches of mangroves and rocks and boulders close to water. The Bar-tailed Godwit and Black-tailed Godwit are large waders, migrating from the Northern hemisphere in the noon-breeding months to coastal habitat in Australia. The large waders are commonly found in sheltered bays, estuaries, intertidal mudflats, and occasionally on rocky coasts (Higgins and Davies 1996).

Hooded and Eastern Hooded Plovers are small beach nesting birds. They predominantly occur on wide beaches and are easily disturbed by human activity. The Lesser Sand and Greater Sand Plover are migratory and inhabits intertidal sand and mudflats, forage on invertebrates and breed in areas characterised by high elevation. Breeding occurs outside Australia, but roosting occurs near foraging areas on beaches, banks, spits and banks (Pegler 1983). The Pacific Golden and Grey Plover are widespread in coastal regions foraging on sandy beaches, spits, rocky points, exposed reef and occasional low saltmarsh and mangroves. Roosting usually occurs near foraging areas while breeding occurs in dry tundra areas away from the coast (Bransbury 1985; Pegler 1983; Marchant and Higgins 1993). The Double-banded Plover is found in both coastal and inland areas with greatest numbers in Tasmania and Victoria. It breeds only in New Zealand and migrates to Australia.

Other waders including Common Noddy, Ruddy Turnstone, Sanderling, Red-necked Stint, Whimbrel, Common Greenshank, Pied Stilt, White-throated Needletail, Red-necked Phalarope, Ruff, Red-necked Avocet, Rufous Fantail and Black-faced Cormorant are common along Australia's coastline. Many are migratory travelling from the Northern Hemisphere in non-breeding months. Most inhabit intertidal mudflats, rocky islets, sand beaches, mangroves, rocky coastline, and coral reefs. Roosting occurs in similar habitats and species are found feeding on fish, crustaceans, aquatic insects, as well as plants and seeds (Higgins and Davies 1996). These species are unlikely to be present in the Project Area due to the distance offshore. The Plains Wanderer is a unique bird that lives predominantly in grasslands in Victoria, South Australia, New South Wales, and Queensland. The Swift Parrot is a small parrot breeding in colonies in Tasmania. The entire population migrates to the mainland during winter. The Great Knot is critically endangered migratory arriving in large numbers in Australia occurring in sheltered coastal habitats with large intertidal mudflats. Typically, they roost in large open areas at the water's edge to in shallow water close to foraging grounds (Higgins and Davies 1996). These species are critically endangered and may occur within the Planning Area.

4.4.9.5 Marine Reptiles

The PMST reports identified three marine turtle species with potential to occur in the Project Area and/or Planning Area (**Table 33**). All three species of marine turtles are protected by the Recovery Plan for Marine Turtles in Australia (CoA 2017a). Foraging, feeding or related behaviours are known to occur within the Planning Area for two of the identified marine turtle species. No BIAs or habitat critical to the survival of marine turtles overlap the Project Area or Planning Area.

4.4.9.5.1 Green turtle

Green Turtles (*Chelonia mydas*) nest, forage and migrate across tropical northern Australia. They usually occur between the 20°C isotherms, although individuals can stray into temperate waters as vagrant visitors. Green turtles spend their first 5 to 10 years drifting on ocean currents. During this pelagic (ocean-going) phase, they are often found in association with drift lines and floating rafts of Sargassum. Green Turtles are predominantly found in Australian waters off the Northern Territory, Queensland, and Western Australian coastlines, with limited numbers in New South Wales, Victoria, and South Australia. There are no known nesting or foraging grounds for Green Turtles offshore Victoria; they occur only rarely in these waters (DoE 2023m) therefore it is expected they would only be occasional visitors in the Project Area and Planning Area.

4.4.9.5.2 Leatherback turtle

The Leatherback Turtle (*Dermochelys coriacea*) is a pelagic feeder found in tropical, sub-tropical and temperate waters throughout the world. Unlike other marine turtles, the leatherback turtle utilises cold water foraging areas, with the species most commonly reported foraging in coastal waters between southern Queensland and central NSW, southeast Australia (Tasmania, Victoria, and eastern SA), and southern WA (CoA 2017a). This species is an occasional visitor to the Otway shelf and has been sighted on a number of occasions during aerial surveys undertaken by the Blue Whale Study Group, particularly to the southwest of Cape Otway. It is mostly a pelagic species, and away from its feeding grounds is rarely found inshore (CoA 2017a). Adults feed mainly on soft-bodied organisms such as jellyfish, which occur in concentrations at the surface in areas of convergence and upwelling (Bone 1998; Cogger 1992). Bass Strait is one of three of the largest concentrations of feeding Leatherback Turtles (DoE 2023n).

No major nesting has been recorded in Australia, with isolated nesting recorded in Queensland and the Northern Territory. The Leatherback turtle is expected to be only an occasional visitor in the Project Area and Planning Area.

4.4.9.5.3 Loggerhead turtle

The Loggerhead Turtle (*Caretta caretta)* is globally distributed in tropical, sub-tropical waters and temperate waters. The loggerhead is a carnivorous turtle, feeding primarily on benthic invertebrates in habitat ranging from nearshore to 55 m depth (Plotkin et al. 1993).

The main Australian breeding areas for Loggerhead Turtle are generally confined to southern Queensland and Western Australia (Cogger et al. 1993). Loggerhead Turtle will migrate over distances in excess of 1,000 km but show a strong fidelity to their feeding and breeding areas (Limpus 2008). Loggerhead Turtle forage in all coastal states and the Northern Territory, but are uncommon in South Australia, Victoria, and Tasmania (CoA 2017a). Due to water depths it is unlikely Loggerhead Turtle would be present in the Project Area but may be occasional visitors to the Planning Area.

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Areas	Present in Planning Area	Present in Project Area
Green Turtle	*Chelonia mydas*	Vulnerable	Migratory	Migratory Marine Species	Listed		Species or species habitat may occur within area	Species or species habitat may occur within area
Leatherback Turtle, Leathery Turtle	*Dermochelys coriacea*	Endangered	Migratory	Migratory Marine Species	Listed		Foraging, feeding or related behaviour known to occur within area	Species or species habitat likely to occur within area
		Approved Conservation Advice for *Dermochelys coriacea* (leatherback turtle) (DEWHA 2008). Threats identified relevant to the activity are as per the recovery plan.						
Loggerhead Turtle	*Caretta caretta*	Endangered	Migratory	Migratory Marine Species	Listed		Foraging, feeding or related behaviour known to occur within area	Species or species habitat likely to occur within area

Table 33: Listed Turtle Species or Species Habitat identified in the Project and/or Planning Areas

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Areas	Presence in Planning Area	Presence in Project Area
Australian Fur-seal, Australo-African Fur-seal	*Arctocephalus pusillus*				Listed		Breeding known to occur within area	Species or species habitat may occur within area
Australian Sea-lion, Australian Sea Lion	*Neophoca cinerea*	Endangered			Listed		Species or species habitat may occur within area	_
		Conservation listing advice for the Neophoca cinerea (Australian sea lion) (TSSC 2010). Threats relevant to the activity are: • Entanglement in marine debris, disturbance, harassment, displacement, habitat degradation, oil spills, pollution, toxins and climate change. • Recovery Plan for the Neophoca cinerea (Australian sea lion) (DSEWPaC 2013b). Threats relevant to the activity are: • Habitat degradation - No explicit relevant management actions • Vessel strike - Collect data on direct killings and confirmed vessel strikes • Pollution (oil spills, toxins) - implement jurisdictional oil spill response strategies as required • Climate change - No explicit relevant management actions						
Long-nosed Fur-seal, New Zealand Fur-seal	*Arctocephalus forsteri*				Listed		Breeding known to occur within area	Species or species habitat may occur within area
Southern Elephant Seal	*Mirounga leonina*	Vulnerable			Listed		Breeding may occur within area	_
		Conservation listing advice for the Mirounga leonine (Southern Elephant Seal) (TSSC 2001). Threats relevant to the activity may include: Entanglement in oceanic debris, oil spills, pollution, habitat degradation and climate change.						

Table 34: Listed Pinniped Species or Species Habitat identified in the Project and/or Planning Areas

4.4.9.6 Marine Mammals - Pinnipeds

The PMST Report identified four pinnipeds with potential to occur in the Planning Area (**Table 34**). Two of these were also identified within the Project Area. The Project and Planning Areas do not overlap any BIAs for pinnipeds.

4.4.9.6.1 Australian Fur-seal

Australian Fur-seals (*A. pusillus*) breed on islands of the Bass Strait but range throughout waters off the coasts of South Australia, Tasmania, Victoria, and NSW. Numbers of this species are believed to be increasing as the population recovers from historic hunting (Hofmeyr et al. 2008). The species is endemic to south-eastern Australian waters.

Australian Fur-seals are present in the region all year, with breeding taking place during November and December. In Victorian State waters they breed on offshore islands, including Lady Julia Percy Island, Seal Rocks in Westernport Bay, Kanowna, and Rag Islands off the coast of Wilson’s Promontory and The Skerries off Wingan Inlet in Gippsland. Within the Planning Area, there are breeding colonies at Cape Bridgewater, Cape Volney, Judgement Rocks, Kanowna Island, Lady Julia Percy Island, Rag Island, Reid Rocks, Seal Rocks and West Moncoeur Island (Figure 50). There are important breeding sites on Lady Julia Percy Island and Seal Rocks, with 25% of the population occurring at each of these islands. Their preferred breeding habitat is a rocky island with boulder or pebble beaches and gradually sloping rocky ledges.

Haul-out sites with occasional pup births are located at Cape Bridgewater, at Moonlight Head, on various small islands off Wilsons Promontory and Marengo Reef near Apollo Bay. Within the Planning Area, haul-out sites include Maatsuyker Island and Walker Island (Figure 50).

Research being undertaken at Lady Julia Percy Island indicates that adult females feed extensively in the waters between Portland and Cape Otway, out to the 200 m bathymetric contour. Seal numbers on the island reach a maximum during the breeding season in late October to late December. By early December, large numbers of lactating females are leaving for short feeding trips at sea and in late December there is an exodus of adult males. Thereafter, lactating females continue to alternate between feeding trips at sea and periods ashore to suckle their pups. Even after pups begin to venture to sea, the island remains a focus, and at any time during the year groups may be seen ashore resting (Robinson et al. 2008; Hume et al. 2004; Arnould and Kirkwood 2007).

During the summer months, Australian Fur-seals travel between northern Bass Strait islands and southern Tasmania waters following the Tasmanian east coast, however, lactating female fur-seals and some territorial males are restricted to foraging ranges within Bass Strait waters. Lactating female Australian Fur-seals forage primarily within the shallow continental shelf of Bass Strait and Otway on the benthos at depths of between 60 to 80 m and generally within 100 to 200 km of the breeding colony for up to five days at a time.

Male Australian Fur-seals are bound to colonies during the breeding season from late October to late December, and outside of this they time forage further afield (up to several hundred kilometres) and are away for long periods, even up to 9 days (Kirkwood et al. 2009; Hume et al. 2004).

As there are breeding and haul out sites within the Planning Area it is expected that Australian Fur-seals would be present in the Planning Area. During Beach's Otway drilling campaign in 2021, 394 Australian Fur-seal detections were made, spread across the year.

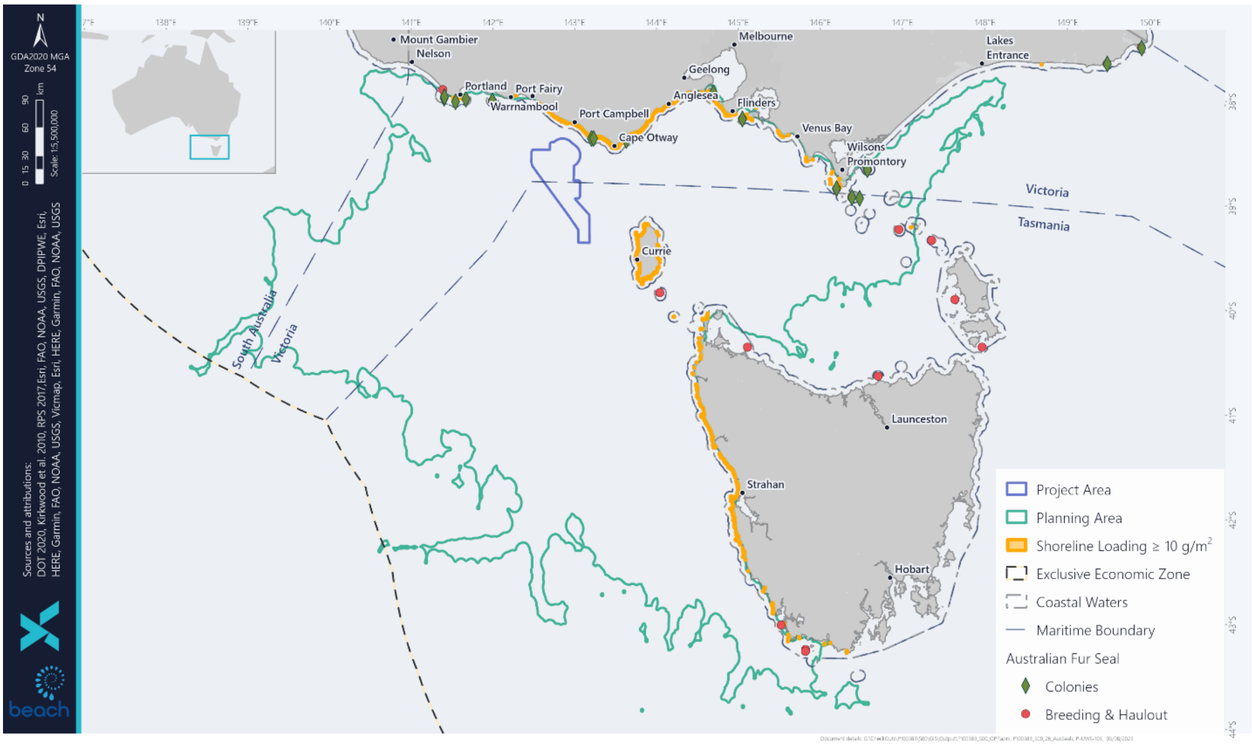


Figure 50: Australian Fur-seal Breeding and Haul-out Sites within the Planning Area (Kirkwood et al. 2010)

4.4.9.6.2 *Australian Sea Lion*

The Australian Sea Lion is the only endemic, and least abundant, pinniped that breeds in Australia (DoE 2013b). All current breeding populations are outside of the Planning Area and are located from the Abrolhos Islands (Western Australia) to the Pages Islands (South Australia). The Australian Sea Lion uses a variety of shoreline types but prefer the more sheltered side of islands and typically avoid rocky exposed coasts (Shaughnessy 1999). The nearest BIA is for male foraging off the South Australian coast, 60 km to the west of the Planning Area and over 250 km west of the Project Area.

The Australian Sea Lion is a specialised benthic forager, i.e. it feeds primarily on the sea floor (DSEWPaC 2013b). The Australian Sea Lion feeds on the continental shelf, most commonly in depths of 20–100 m, with adult males foraging further and into deeper waters (DSEWPaC 2013). They typically feed on a range of prey including fish, cephalopods (squid, cuttlefish and octopus), sharks, rays, rock lobster and penguins (DSEWPaC 2013) They typically forage up to 60 km from their colony but can travel up to 190 km when over shelf waters (Shaughnessy 1999).

4.4.9.6.3 *New Zealand Fur-seal*

New Zealand Fur-seal (*Arctocephalus forsteri*) are found in the coastal waters and offshore islands of South and Western Australia, Victoria, NSW and New Zealand. Population studies for New Zealand Fur-seal in Australia carried out in 1990 estimated an increasing population of about 35,000. The species breeds in southern Australia at the Pages Islands and Kangaroo Island, which produces about 75% of the total pups in Australia. Small populations are established in Victorian coastal waters including at Cape Bridgewater near Portland, Lady Julia Percy Island near Port Fairy, Kanowna Island (near Wilsons Promontory) and The Skerries in eastern Victoria.

Figure 51 shows the current and historic distribution of New Zealand Fur-seal colonies (Kirkwood et al. 2009). These colonies are typically found in rocky habitat with jumbled boulders. Colonies are typically occupied year-round, with greater activity during breeding seasons. Pups are born from mid-November to January, with most pups born in December (Goldsworthy 2008). Known sites for New Zealand Fur-seal breeding colonies within the Planning Area include Judgement Rocks (Kent Group Islands), Kanowna Island, Lady Julia Percy Island, Maatsuyker Island and Seal Rocks (off King Island) (Figure 51).

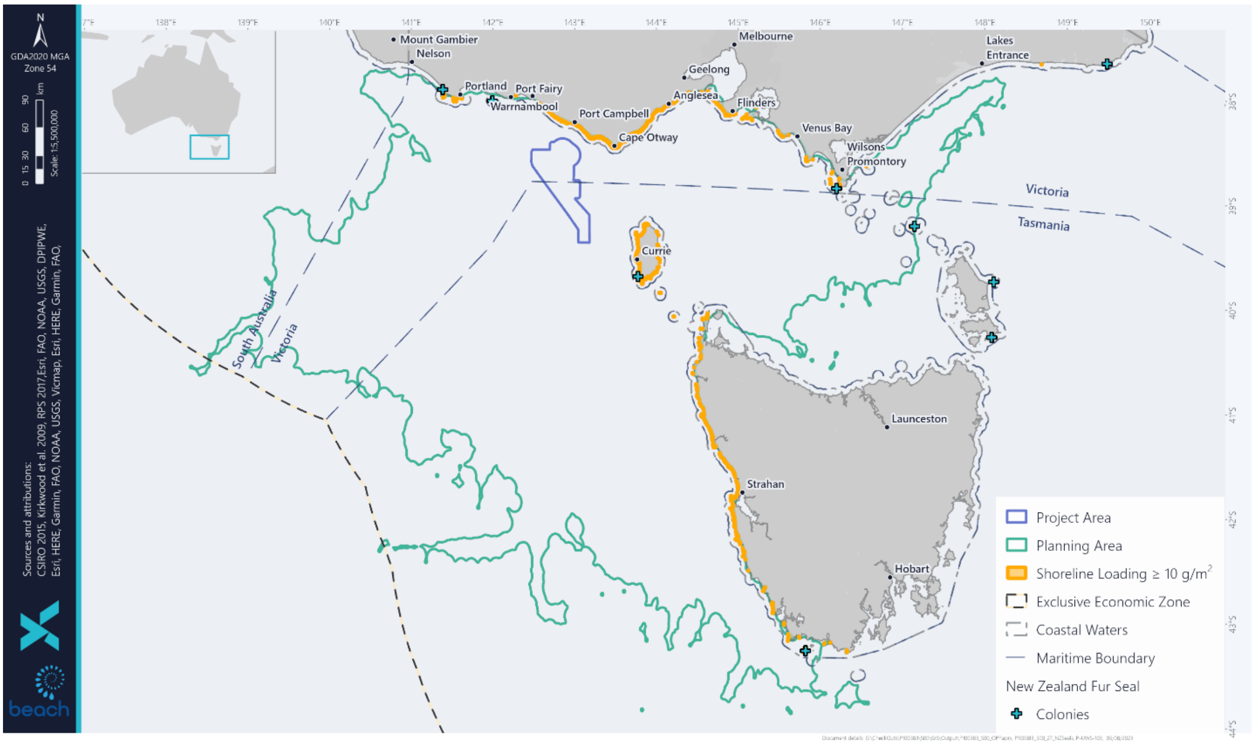


Figure 51: New Zealand Fur-seal colonies within the Planning Area

4.4.9.6.4 Southern Elephant Seal

The Southern Elephant Seal (*Mirounga leonina*) is the largest species of pinniped and has a nearly circumpolar distribution throughout the southern hemisphere. Most breeding colonies and haul-out areas have been recorded on subantarctic islands. The global population was estimated to be approximately 650,000 individuals in the mid-1990s and comprised of three sectors, the Atlantic, Indian and Pacific sectors. In the Australian sector, breeding and haul-out occurs primarily on Macquarie Island and Heard Island, approximately 1,500 km to the south-east of Australia and 4,000 km to the south-west of Australia, respectively. Occasional pupping has been recorded in southern Tasmania on Maatsuyker Island (TSSC 2016). Southern Elephant Seals may be present within the Planning Area but only around Maatsuyker Island at the southern-most reaches of the Planning Area.

4.4.9.7 Marine Mammals - Cetaceans

The PMST Reports identified several cetaceans with potential to occur in the Project and Planning Areas (Table 35). Threatened or migratory species that are likely or known to occur or have a BIA that overlaps the Project and/or Planning Areas are discussed in more detail in the following sections.

The Bass Strait and the Otway Basin are considered an important migratory path for Humpback, Blue, Southern Right, and to some extent the Fin and Sei Whales. The whales use the Otway region to migrate to and from the north-eastern Australian coast and the sub-Antarctic. Of environmental importance in the Otway is the Bonney coast upwelling, the eastward flow of cool nutrient rich water across the continental shelf of the southern coast of Australia that promotes blooms of krill and attracts baleen whales during the summer months.

4.4.9.7.1 Cultural significance

First nation's people around Australia have long had a strong connection to whales, which has significance as totemic ancestors to some groups. The arrival of whales along Australia's coastline marked the arrival of the "elders of the sea", which follows a songline or ancient memory code, that traces the journeys of ancestral spirits as they created the land, animals, and lore.

Indigenous Australians have a long tradition of utilising beached (or stranded) whales as a food source and whale stranding's were occasions for feasting (Clarke 2001). For example, Ngarrindjeri had gathered to harvest the bodies of stranded whales well before Kringkari (pink-skinned men) arrived in their lands. Runners were sent inland telling others of the arrival of Kondoli, which was a time for ceremony and trade (Paterson and Wilson 2019).

4.4.9.7.2 Otway Whale Surveys

Gill et al. (2015) summarised cetacean sightings from 123 systematic aerial surveys undertaken over western Bass Strait and the eastern Great Australian Bight between 2002 and 2013. This paper does not include sighting data for Blue Whales, which has previously been reported in Gill et al. (2011).

These surveys recorded 133 sightings of 15 identified cetacean species consisting of seven mysticetes (baleen) whale species, eight odontocete (toothed) species and 384 sightings of dolphins (Table 36 and Table 37). Survey effort was biased toward coverage of upwelling seasons, corresponding with Pygmy Blue Whales' seasonal occurrence (November to April; 103 of 123 surveys), and relatively little survey effort occurred during 2008–2011. Cetacean species sighted within the region are described in the following sections.

Gill et al. (2015) encountered Southern Right and Humpback Whales most often from May to September, despite low survey effort in those months. Southern Right Whales were not recorded between October and May. Fin, Sei, and Pilot whales were sighted only from November to May (upwelling season), although this may be an artefact of their relative scarcity overall and low survey effort at other times of year. Dolphins were sighted most consistently across years. The authors caution that few conclusions about temporal occurrence can be drawn because of unequal effort distribution across seasons and the rarity of most species.

Species of cetacean sighted in the period 31 October to 19 December 2010 during the Speculate 3D Transitions Zone Seismic Survey (3DTZSS) undertaken by Origin Energy, recorded species of Common Dolphin (*Delphinus* spp.), Bottlenose Dolphin (*Tursiops* spp.), unidentified small cetaceans and fur-seals.

Origin Energy conducted a survey for cetaceans focused on Origin operations and permit in the Otway basin from June 2012 through to March of 2013. Table 38 lists the species present in the area Origin surveyed.

As part of Beach's Otway drilling campaign, marine fauna observations occurred through most of 2021 (2 February to 31 December 2021) from the drill rig and support vessels at the Artisan-1, Geographe-4, Geographe-5 and Thylacine North-1 drilling locations. Table 39 provides this cetacean sighting data. For whales, the highest number of detections was for Blue Whales (198), while for dolphins, it was the Common Dolphin (519).

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Areas	Presence in Planning Area	Presence in Project Area
Andrew's Beaked Whale	*Mesoplodon bowdoini*						Species or species habitat may occur within area	Species or species habitat may occur within area
Antarctic Minke Whale, Dark-shoulder Minke Whale	*Balaenoptera bonaerensis*		Migratory	Migratory Marine Species			Species or species habitat likely to occur within area	Species or species habitat likely to occur within area
Arnoux's Beaked Whale	*Berardius arnuxii*						Species or species habitat may occur within area	Species or species habitat may occur within area
Blainville's Beaked Whale, Dense-beaked Whale	*Mesoplodon densirostris*						Species or species habitat may occur within area	Species or species habitat may occur within area
Blue Whale	*Balaenoptera musculus* .	Endangered	Migratory	Migratory Marine Species		Foraging, Distribution,	Foraging, feeding or related behaviour known to occur within area	Foraging, feeding or related behaviour known to occur within area
	Conservation Management Plan for the Blue Whale (CoA 2015b). The long-term recovery plan objective for Blue Whales is to minimise anthropogenic threats to allow for their conservation status to improve. Threats relevant to the activity are: • Noise interference -Evaluate risk of noise impacts and, if required, appropriate mitigation measures are implemented • Vessel disturbance - Evaluate risk of vessel strikes and, if required, appropriate mitigation measures are implemented.							
Bottlenose Dolphin	*Tursiops truncatus s. str.*						Species or species habitat may occur within area	Species or species habitat may occur within area
Bryde's Whale	*Balaenoptera edeni*		Migratory	Migratory Marine Species			Species or species habitat may occur within area	_
Common Dolphin, Short-beaked Common Dolphin	*Delphinus delphis*						Species or species habitat may occur within area	Species or species habitat may occur within area

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Areas	Presence in Planning Area	Presence in Project Area
Cuvier's Beaked Whale, Goose-beaked Whale	*Ziphius cavirostris*						Species or species habitat may occur within area	Species or species habitat may occur within area
Dusky Dolphin	*Lagenorhynchus obscurus*		Migratory	Migratory Marine Species			Species or species habitat likely to occur within area	Species or species habitat likely to occur within area
Dwarf Sperm Whale	*Kogia sima*						Species or species habitat may occur within area	Species or species habitat may occur within area
False Killer Whale	*Pseudorca crassidens*						Species or species habitat likely occur within area	Species or species habitat likely to occur within area
Fin Whale	*Balaenoptera physalus*	Vulnerable	Migratory	Migratory Marine Species			Foraging, feeding or related behaviour known to occur within area	Foraging, feeding or related behaviour likely to occur within area
		Approved Conservation Advice for Balaenoptera physalus (Fin Whale) (TSSC 2015f). Threats relevant to the activity are: • Noise interference - Evaluate risk of noise impacts to cetaceans and, if required, appropriate mitigation measures are implemented. • Vessel disturbance - Evaluate risk of vessel strikes and, if required, appropriate mitigation measures are implemented.						
Gray's Beaked Whale, Scamperdown Whale	*Mesoplodon grayi*						Species or species habitat may occur within area	_
Hector's Beaked Whale	*Mesoplodon hectori*						Species or species habitat may occur within area	Species or species habitat may occur within area
Humpback Whale	*Megaptera novaeangliae*		Migratory	Migratory Marine Species			Species or species habitat known to occur within area	Species or species habitat likely to occur within area
		Approved Listing Advice for Megaptera novaeangliae (Humpback Whale) (TSSC 2022). Listing advice details that the humpback is no longer listed as vulnerable and has been removed from the threatened species list. It will remain a matter of national environmental significance under the EPBC Act as a listed Migratory Species. • Threats identified relevant to the activity: • Marine debris						

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Areas	Presence in Planning Area	Presence in Project Area
		• Noise interference • Pollution • Vessel disturbance and strike No explicit relevant management actions.						
Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin	*Tursiops aduncus*						Species or species habitat likely to occur within area	–
Killer Whale, Orca	*Orcinus orca*		Migratory	Migratory Marine Species			Species or species habitat likely to occur within area	Species or species habitat likely to occur within area
Long-finned Pilot Whale	*Globicephala melas*						Species or species habitat may occur within area	Species or species habitat may occur within area
Long-nosed Fur-seal, New Zealand Fur-seal	*Arctocephalus forsteri*				Listed		Breeding known to occur within area	Species or species habitat may occur within area
Minke Whale	*Balaenoptera acutorostrata*						Species or species habitat may occur within area	Species or species habitat may occur within area
Pygmy Right Whale	*Caperea marginata*		Migratory	Migratory Marine Species			Foraging, feeding or related behaviour likely to occur within area	Foraging, feeding or related behaviour may occur within area
Pygmy Sperm Whale	*Kogia breviceps*						Species or species habitat may occur within area	Species or species habitat may occur within area
Risso's Dolphin, Grampus	*Grampus griseus*						Species or species habitat may occur within area	Species or species habitat may occur within area
Sei Whale	*Balaenoptera borealis*	Vulnerable	Migratory	Migratory Marine Species			Foraging, feeding or related behaviour known to occur within area	Foraging, feeding or related behaviour likely to occur within area

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Areas	Presence in Planning Area	Presence in Project Area
		Approved Conservation Advice for Balaenoptera borealis (Sei Whale) (TSSC 2015g). Threats identified relevant to the activity: • Noise interference -Evaluate risk of noise impacts to cetaceans and, if required, appropriate mitigation measures are implemented. • Vessel disturbance -Evaluate risk of vessel strikes and, if required, appropriate mitigation measures are implemented.						
Shepherd's Beaked Whale, Tasman Beaked Whale	*Tasmacetus shepherdi*						Species or species habitat may occur within area	_
Short-finned Pilot Whale	*Globicephala macrorhynchus*						Species or species habitat may occur within area	Species or species habitat may occur within area
Southern Bottlenose Whale	*Hyperoodon planifrons*						Species or species habitat may occur within area	_
Southern Right Whale	*Eubalaena australis*	Endangered	Migratory (as Balaena glacialis australis)	Migratory Marine Species		Migration Reproduction	Breeding known to occur within area	Species or species habitat known to occur within area
		Conservation Management Plan for the Southern Right Whale 2011-2021 (DSEWPaC 2012a); Draft National Recovery Plan for the Southern Right Whale (DCCEEW 2022a). Threats identified relevant to the activity: • Noise interference - Evaluate risk of noise impacts to cetaceans and, if required, appropriate mitigation measures are implemented. • Vessel disturbance - Evaluate risk of vessel strikes and, if required, appropriate mitigation measures are implemented.						
Southern Right Whale Dolphin	*Lissodelphis peronii*						Species or species habitat may occur within area	Species or species habitat may occur within area
Sperm Whale	*Physeter macrocephalus*		Migratory	Migratory Marine Species			Species or species habitat may occur within area	Species or species habitat may occur within area
Strap-toothed Beaked Whale, Strap-toothed Whale, Layard's Beaked Whale	*Mesoplodon layardii*						Species or species habitat may occur within area	Species or species habitat may occur within area

Common Name	Scientific Name	Threatened Category	Migratory Status	Migratory Category	Marine Status	Biologically Important Areas	Presence in Planning Area	Presence in Project Area
True's Beaked Whale	*Mesoplodon mirus*						Species or species habitat may occur within area	Species or species habitat may occur within area

Table 35: Listed Cetacean Species or Species Habitat identified in the Project and/or Planning Area

Taxon	Common name	Species group*	Sightings	Individual	Mean group size (+/- SD)
Baleen whales					
Eubalaena australis	Southern Right Whale	SRW	12	52	4.2 +/- 4.2
Caperea marginata	Pygmy Right Whale		1	100	100
Balaenoptera physalus	Fin and like Fin Whale	ROR	7	8	1.1 +/- 0.4
B. borealis	Sei and like Sei Whale	ROR	12	14	1.3 +/- 0.5
B. acutorostrata	Dwarf Minke Whale	ROR	1	1	1
B. bonaerensis	like Antarctic Minke Whale	ROR	1	1	1
Megaptera novaeangliae	Humpback Whale	ROR	10	18	1.8 +/- 1.0
Toothed whales					
Physeter macrocephalus	Sperm Whale	ODO	34	66	1.9 +/- 2.2
Mesoplodon spp.	Unidentified beaked whales	ODO	1	20	20
Orcinus orca	Killer whale	ODO	6	21	3.5 +/- 2.8
Globicephala melas	Long-finned Pilot Whale	ODO	40	1853	46.3 +/- 46.7
Grampus griseus	Risso's Dolphin	ODO	1	40	40
Lissodelphis peronii	Southern Right Whale dolphin	ODO	1	120	120
Tursiops spp.	Bottlenose Dolphin	DOL	4	363	90.8 +/- 140.1
	Dolphins	DOL	384	22169	58 +/- 129.6
Unidentified large whales			3	3	1
Unidentified small whales			2	2	1

Table 36: Cetacean Species Recorded during Aerial Surveys 2002–2013 in Southern AustraliaSRW = Southern Right Whales; ROR = rorquals; ODO = other odontocetes; DOL = dolphins

.

Species	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Southern Right Whale	0	0	0	0	0	0	0	0	0.8	3.1	6.8	8.8
Pygmy Right Whale*	0	0	0	0	0	0	0	0	19.8	0	0	0
Fin Whale	0	0.10	0.14	0.07	0.08	0	0	0	0	0	0	0
Sei Whale	0	0.25	0.07	0.04	0.08	0.19	0	0.21	0	0	0	0
Minke Whale*	0	0	0.02	0	0	0	0.12	0	0	0	0	0
Humpback Whale	0	0.05	0.07	0	0	0	0	0.11	0.99	1.0	0	0.35
Sperm Whale	1.7	1.2	0.23	0.53	0.08	0.13	0.75	0.85	0	0	0	0
Unidentified beaked whale*	0	0	0.47	0	0	0	0	0	0	0	0	0
Killer Whale	0	0	0.19	0	0	5.0	0	6.0	0	0.68	0	0
Pilot Whale	0	59.6	7.0	19.3	4.0	39.5	0	26.3	0	0	0	0
Southern Right Whale dolphin*	0	59.6	0	0	0	0	0	0	0	0	0	0
Risso's Dolphin*	0	0	0	0	1.7	0	0	0	0	0	0	0
Bottlenose Dolphin	0	1.5	7.7	0	0	0	0	0	0	0	0	1.1
Dolphins	545.1	120.3	105.0	151.8	105.6	233.4	26.9	257.6	155.8	2.7	0	0

Table 37: Temporal Occurrence across Months of Cetaceans Sighted during Aerial Surveys from November 2002 to March 2013 in Southern Australia

*Species sighted 2 or fewer times.

Species	Jun	Jul	Aug	Sep *	Oct	Nov	Dec	Jan	Feb	Mar	Total
Blue Whale	0	0	0	0	0	23	70	17	8	2	120
Southern Right Whale	2	0	12	13	0	0	0	0	0	0	39*
Humpback Whale	3	2	0	1	0	1	0	0	0	0	7
Sperm Whale	2	0	0	0	4	0	0	3	1	0	10
Pilot Whale	0	0	0	0	0	70	0	0	55	0	125
Dolphins	13	298	0	33	54	620	80	672	1526	21	3317
Southern Right Whale	0	0	0	0	0	120	0	0	0	0	120

Table 38: Observed Cetaceans in the Otway Basin.

*September values averaged over two surveys on 1 and 11 September 2012. Totals include individuals from both September surveys

Species	Feb	Mar	Apr	May	Jun	July	Aug	Sep *	Oct	Nov	Dec	Total
Whales												
Blue	0	101	66	16	2	0	0	1	0	7	5	198
SRW	0	0	0	0	1	1	1	0	0	0	0	3
Humpback	0	0	7	9	25	4	2	11	14	18	5	95
Minke	0	0	0	3	0	0	0	0	0	0	0	3
Pilot	0	0	0	0	1	0	0	0	0	0	0	1
No ID	0	0	0	3	0	0	0	0	1	2	1	7
Dolphins												
Common	40	103	44	28	16	37	8	21	37	85	100	519
Bottlenose	12	4	1	2	1	3	2	4	3	1	7	40
No ID	32	27	30	10	15	11	11	5	2	2	5	150

Table 39: Marine Fauna Observations at Project Locations during the Otway Drilling Project in 2021

4.4.9.7.3 Antarctic Minke Whale

The Antarctic Minke Whale (*Balaenoptera bonaerensis*) has been found in all Australian states except the Northern Territory and occupies cold temperate to Antarctic offshore and pelagic habitats between 21°S and 65°S (Bannister et al. 1996). In summer the species is found in pelagic waters from 55°S to the Antarctic ice edge. During winter the species retreat to breeding grounds between 10-30°S, occupying oceanic waters exceeding 600 m depth and beyond the continental shelf break (DoE 2023f). They have been observed as far north as 21°S along the east coast of Australia and are presumed to follow the same migration pattern on Australia’s west coast (Bannister et al. 1996). Mating occurs from June through December, with a peak in August and September and calving occurs during late May and early June in warmer waters north of the Antarctic Convergence (DoE 2023f). The species primarily feeds in the Antarctic during summer on Antarctic krill and does not appear to feed much while in the breeding grounds of lower latitudes (DoE 2023f).

The Antarctic Minke Whale has been observed within the region, however, there are no BIAs in the Project Area or Planning Area.

4.4.9.7.4 Blue Whale

The Pygmy Blue Whale has a foraging (annual high use area) BIA within the Project and Planning Areas (Figure 52).

Data, as detailed in this section, suggests that Blue Whales are most likely to first appear during December/January and reach peak number during February/March. The likelihood and extent of the interaction is dependent on broad scale environmental factors affecting the abundance and distribution of Blue Whale feeding resources.

Status

The Blue Whale (*Balaenoptera musculus*) is listed as an endangered species under the EPBC Act (1999) and the IUCN Red List. There are two subspecies of Blue Whales that use Australian waters (including Australian Antarctic waters), the Pygmy Blue Whale (*B. m. brevicauda*) and the Antarctic Blue Whale (*B. m. intermedia*). Reference to Blue Whale unless otherwise specified is generally synonymous to both species. The Conservation Management Plan for the Blue Whale (CoA 2015b) identifies threats and establishes actions for assisting the recovery of Blue Whale populations using Australian waters (CoA 2015b).

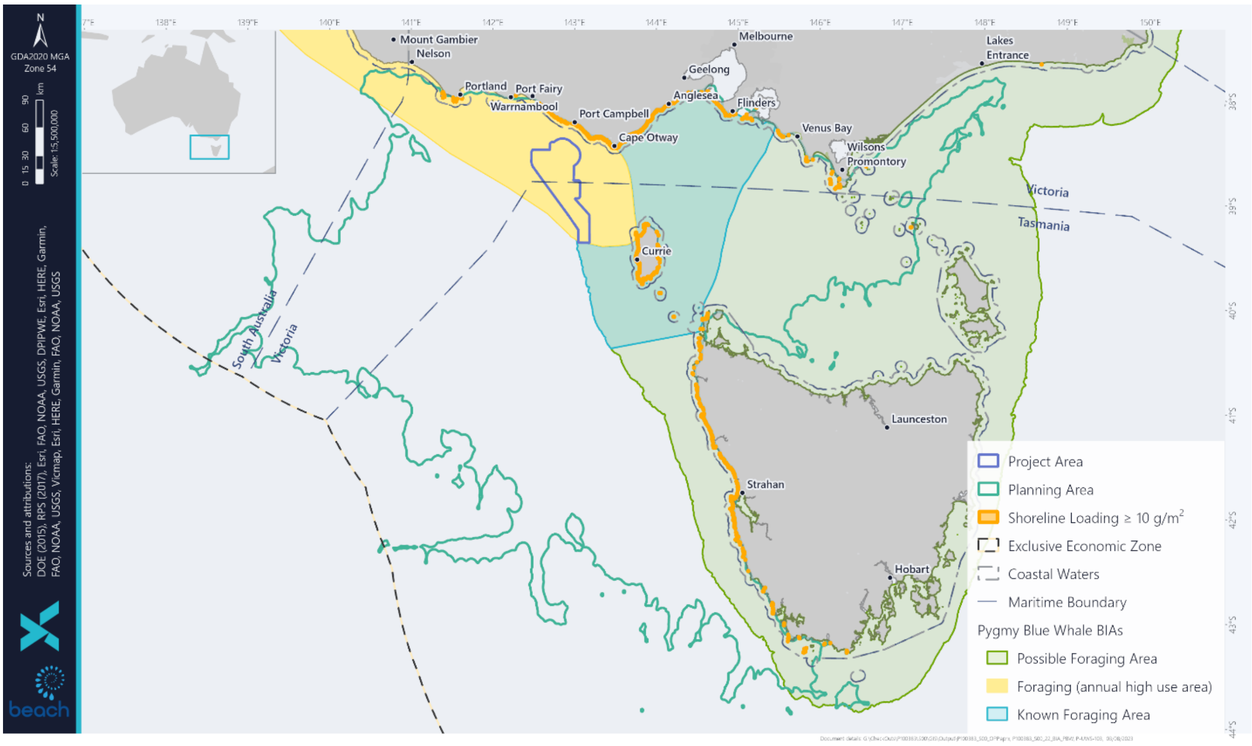


Figure 52: Pygmy Blue Whale BIAs within the Project and Planning Areas

Population

The Antarctic Blue Whale was extremely abundant until the early 20th century when they were hunted to near extinction. Approximately 341,830 Blue Whale takes were recorded by commercial whaling in the Antarctic and sub-Antarctic in the 20th century, of which 12,618 were identified as Pygmy Blue Whales (Branch et al. 2004). The current global population of Blue Whales is uncertain but is plausibly in the range of 10,000 to 25,000, corresponding to about 3-11% of the 1911 estimated population size (Reilly et al. 2008). The Antarctic Blue Whale subspecies remains severely depleted from historic whaling and its numbers are recovering slowly. The Antarctic Blue Whale population is growing at an estimated rate of 7.3% per year, but it was hunted to such a low level that it remains at a tiny fraction of pre-whaling numbers (Branch et al. 2004). Recent studies suggest an updated rate of increase in population growth of 12.6 %, consistent with growth rates in waters off the south of Australia (McCauley et al. 2018). The updated abundance estimate uses acoustic chorus squared pressure levels to estimate growth rate off Portland (McCauley et al. 2018). This growth rate considers the number of whales calling assuming the range distribution of whales, source levels, sound propagation and calling behaviour were all similar between years.

Genetic analysis has shown that Pygmy Blue Whales which feed off the Perth Canyon, WA and the Bonney Upwelling, SA and Victoria constitute the same population (Attard et al. 2010, in Commonwealth of Australia 2015b). Photo identification and genomic studies suggest population exchange between the two feeding grounds of the Bonney coast upwelling and the Perth Canyon (Attard et al. 2018). A Pygmy Blue Whale was tagged in 2014 north of the Perth Canyon and travelled a total distance of 506.3 km in 7.6 days, indicating the vast distances that the large marine mammals can travel in a short amount of time (Owen et al. 2016). While migrating the whale made dives at depths just below the surface which likely reduces energy expenditure but also increases the risk of ship strike greatly for longer periods than previously thought.

Global Pygmy Blue Whale abundance estimates range from 2,000 to 5,000 individuals (Reilly et al. 2018). Abundance estimates based on photo-identification mark-recapture from 1999/2000 to 2004/2005 for Blue Whales in the Perth Canyon were between 532 and 1,754 individuals, which generally agree with acoustic abundance estimates of 662 to 1,559 calling Blue Whales migrating south in 2004 past Exmouth in Western Australia and a 1992/1993 season cruise which estimated 671 (95% interval 289–1,557) individuals offshore of southern Western Australia (35–45^0 South, 115–125^0 East) (Commonwealth of Australia 2015b).

Distribution

The Blue Whale is a cosmopolitan species, found in all oceans except the Arctic, but absent from some regional seas such as the Mediterranean, Okhotsk and Bering seas. Little is known about mating behaviour or breeding grounds. The Pygmy Blue Whale is mostly found north of 55°S, while Antarctic Blue Whales are mainly sighted south of 60°S in Antarctic waters. The presence of Antarctic Blue Whales in the area is considered rare (Gavrilov 2012), however acoustic detection of Antarctic Blue Whales indicates that they occur along the entire southern coastline of Australia (McCauley et al. 2018).

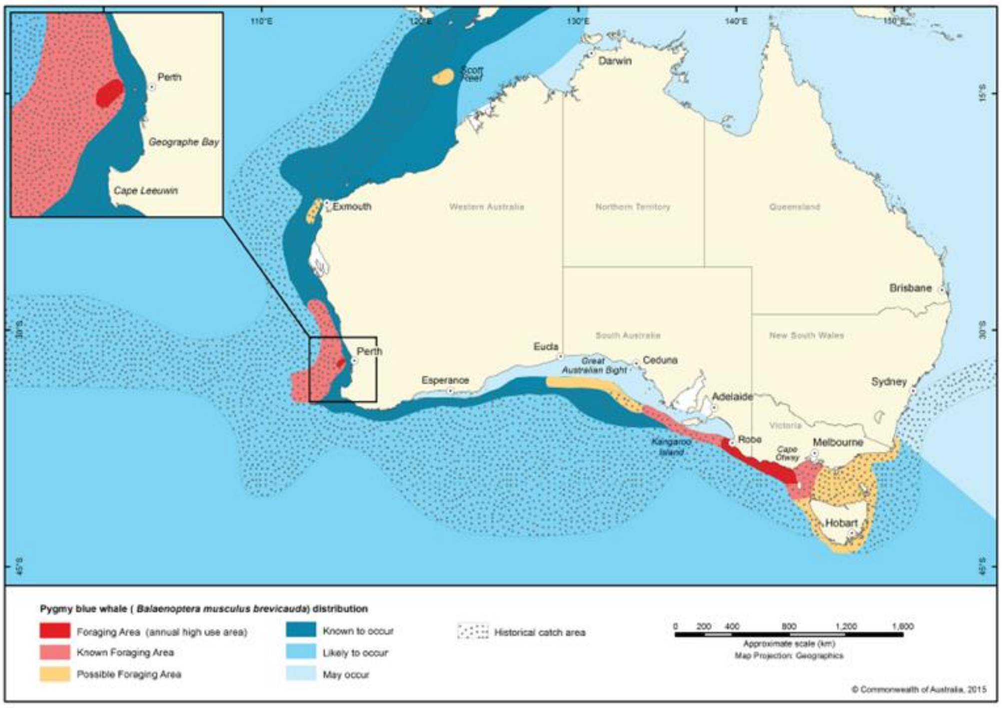
Pygmy Blue Whales are most abundant in the southern Indian Ocean on the Madagascar plateau, and off South Australia and Western Australia, where they form part of a more or less continuous distribution from Tasmania to Indonesia.

Blue Whales are rapid long-distance travellers, and pygmy Blue Whales spend the winter breeding in Indonesian waters, returning to cool temperate waters around November each year, interchanging between these waters and remoter waters of the Southern Ocean during the upwelling 'season' (Gill 2020). Pygmy Blue Whales have three migratory stages around Australia; the "southbound migration stage" is predominantly between October to December (sometimes into January) where whales travel from Indonesian waters down to the WA coast. The "southern Australian stage" between January and June is where whales spread across the southern Australian waters. The "northbound migration stage" is where whales travel back up to Indonesia between April and August. The "southern stage" involves animals searching for feeding sites, feeding and then marking their way north towards June (McCauley et al. 2018).

The distribution of Blue Whales in the Australian region is shown in Figure 53. There are two known seasonal feeding aggregations areas in Australia, the Bonney Coast Upwelling KEF and adjacent waters off South Australia and Victoria and the Perth Canyon KEF and adjacent waters in Western Australia. The Otway Offshore Project is located within a Blue Whale BIA – Foraging Area (annual high use area).

McCauley et al. (2018) suggests that acoustic detection of Pygmy Blue Whales indicate they predominantly occur west of Bass Strait. Acoustic detections of Pygmy Blue Whales off Portland Victoria correlated with upwelling indicators in the Bonney coast upwelling in late summer to autumn (February to April) (McCauley et al. 2018). The two Pygmy Blue Whale call types and the Antarctic Blue Whale call have been detected in central Bass Strait. On one occasion all three types were detected between April and June with more commonly two calls present over this period during other years.

The Otway Shelf is squarely within the productive, and to a certain extent predictable, Great Southern Australian Upwelling System. It has been shown to be an important, consistently used Blue Whale foraging area over many years (Gill et al. 2011)



Foraging Area (Annual high use area)	Blue whales are regularly observed feeding on a seasonal basis
Known Foraging Area	Known foraging occurs in these areas but is highly variable both between and within seasons
Possible Foraging Area	Evidence for feeding is based on limited direct observations or through indirect evidence, such as occurrence of krill in close proximity of whales, or satellite tagged whales showing circling tracks. Blue whales travel through on a seasonal basis, possibly as part of their migratory route

Known to occur	Blue whales are known to occur based on direct observations, satellite tagged whales or based on acoustic detections
Likely to occur	Blue whales are likely to occur based on occasional observations in the area and nearby areas
May occur	Evidence for the presence of blue whales through strandings or rare observations
Historical catch area	Blue whales were caught during the whaling period based on whaling data

Figure 53: Pygmy Blue Whale Distribution Areas around Australia (CoA 2015b)

Foraging Ecology

Krill are the key to understanding the ecology and behaviour of Blue Whales. Krill is sensitive to temperature and migrates vertically and horizontally to maintain optimal positioning with respect to nutrients, often being found along thermal fronts and thermoclines. Krill abundance in a given season may be linked to oceanographic conditions of the previous year. Unlike most krill species, *Nyctiphanes australis* frequently swarm at or near the surface, making it easily available to foraging Blue Whales. However, it is often found at depth, when Blue Whales must dive to search for and consume it. Foraging is energetically expensive for these giant mammals, which must regularly find sufficient food to balance their enormous energy requirements (Gill 2020). Blue Whales typically feed during daylight hours when krill is visible to them (Gill 2020).

Between the months of November and April, south-east winds drive upwelling of nutrient-rich water drawn from the continental slope, onto the continental shelf. An upwelling regime known as the Great Southern Australian Upwelling System extends along the shelf from the eastern Great Australian Bight to western Tasmania. Prominent surface upwelling commonly occurs west of Portland where the shelf is narrow (the Bonney Upwelling); whereas on the broader shelf between Portland and King Island, upwelling is usually subsurface, with cooler upwelled water beneath a warmer surface layer (Gill 2020).

Important foraging grounds for Blue Whales include the Great Australian Bight, South Australia and off Portland Victoria where Blue Whales visit between December and June to forage on the inshore shelf break (Figure 53). The time and location of the appearance of Blue Whales in the east generally coincides with the upwelling of cold water in summer and autumn along this coast (the Bonney Upwelling) and the associated aggregations of krill that they feed on (Gill and Morrice 2003). The Bonney Upwelling generally starts in the eastern part of the Great Australian Bight in November or December and spreads eastwards to the Otway Basin around February as southward migration of the subtropical high-pressure cell creates upwelling favourable winds. Sighting data indicates that Blue Whales are seasonally distributed (Gill et al. 2011; McCauley et al. 2018).

Diving behaviour of Blue Whales associated with feeding at depth was observed by Gill and Morris (2003) in the Otway region, who note that Blue Whales dived steeply, submerging for 1 to 4 minutes, then returned to the surface. Tagging of a Pygmy Blue Whale at the Perth Canyon identified 1,677 dives over the tag duration (7.6 days) (Owen et al. 2016). The duration of dives was:

- Feeding - mean of 7.6 minutes, maximum of 17.5 minutes;
- Migratory – mean of 5.2 minutes, maximum of 26.7 minutes; and
- Exploratory – mean of 8.6 minutes, maximum of 22.05 minutes.
- Tagging of 13 Pygmy Blue Whales (five of which had tags that monitored dive depth and duration) in the Bonney Upwelling identified (Möller et al. 2015):
- Whales predominantly carried out area-restricted search (presumably foraging) with generally shallow and short dives. However, dives were generally deeper at night compared to during the day.
- Whales performed mostly square shaped dives that were shallow in depth and short in duration.
- Dives recorded to a maximum of 492 m (mean = 59.5 m ± 94.3), and for a maximum duration of 112 minutes (mean = 6.1 minutes ± 5.2).

The seasonal distribution and abundance of Blue Whales are variable across years and influenced by climate variables. The time and location of the appearance of Blue Whales in the Otway region generally coincides with the upwelling of cold water between November and April along the Bonney coast and the associated aggregations of krill that they feed on (Gill and Morrice 2003). The Bonney Upwelling generally starts in the eastern part of the Great Australian Bight in November or December and spreads eastwards to the Otway Basin around February as southward migration of the subtropical high-pressure cell creates upwelling favourable winds. Sighting data indicates that Blue Whales are seasonally distributed (Gill et al. 2011; McCauley et al. 2018).

Foraging of Pygmy Blue Whales is known to occur in Bass Strait and the west coast of Tasmania where they have been recorded diving at depth presumably feeding (DoE 2023). Blue Whales are known as ‘constant foragers’; their ecology in feeding grounds consists of constantly searching for patchily distributed krill resources, preferably those that reward the effort involved in consuming them (Torres et al. 2020). They are physically well-adapted for rapid movement between widely separated foraging areas (Woodward et al. 2006), but when they enter areas where krill may occur, they carry out zigzagging 'area-restricted searches' (ARS) patterns until either they find prey, or exhaust local possibilities, and move on to another possible foraging ground based on past experience (Abrahms et al. 2019). Based on this it is assumed that once the blues have finished feeding, they will move from the feeding area to commence searching for another area.

The Otway Region

Aerial Surveys (2001-02 to 2006-07)

Seasonal (November to April) aerial surveys between Cape Jaffa and Cape Otway over six seasons found that the general pattern of seasonal movement of Blue Whales is from west to east, with whales foraging between the Great Australian Bight and Cape Nelson in November and spreading further east into the Otway Shelf between Portland and Cape Otway around December. Whales were typically widely distributed throughout Otway shelf waters from January through to April (Gill et al. 2011) (Figure 54 and Figure 55.

The sighting and effort data presented in Figure 54 and Figure 55 was used to calculate an 'encounter rate' (NB: key in upper right corner of the November, January and April figures). Dots represent Blue Whale sightings while squares are aerial survey effort (10 km by 10 km squares) represented as minutes flown per grid square. The data was pooled for all seasons. Thick solid lines represent 50% and 95% probability contours for Blue Whale distribution from density kernel analysis. Dashed lines are central and eastern boundaries (Gill et al. 2011). During 2002-11, Blue Whales were twice more likely to be found west of Portland than to its east (Gill et al. 2011).

The Project Area is on the outer edge of the eastern distribution.

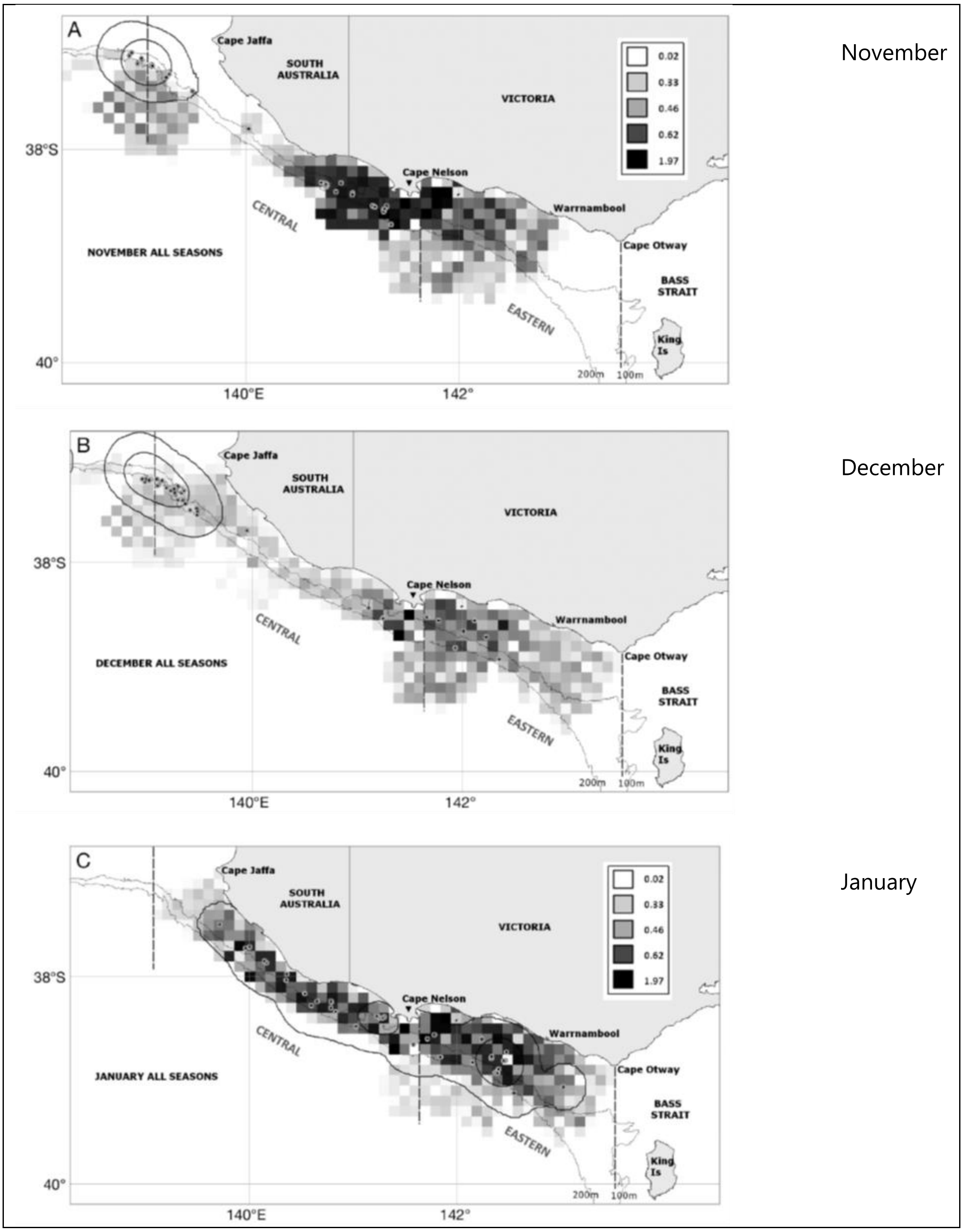


Figure 54: Blue Whale Sightings in the Otway Basin (Nov, Dec, Jan) (Gill et al. 2011)

Note: Dots represent Blue Whale sightings while squares are aerial survey effort (10 km by 10 km squares) represented as minutes flown per grid square (key, upper right corner of the November and January figures).

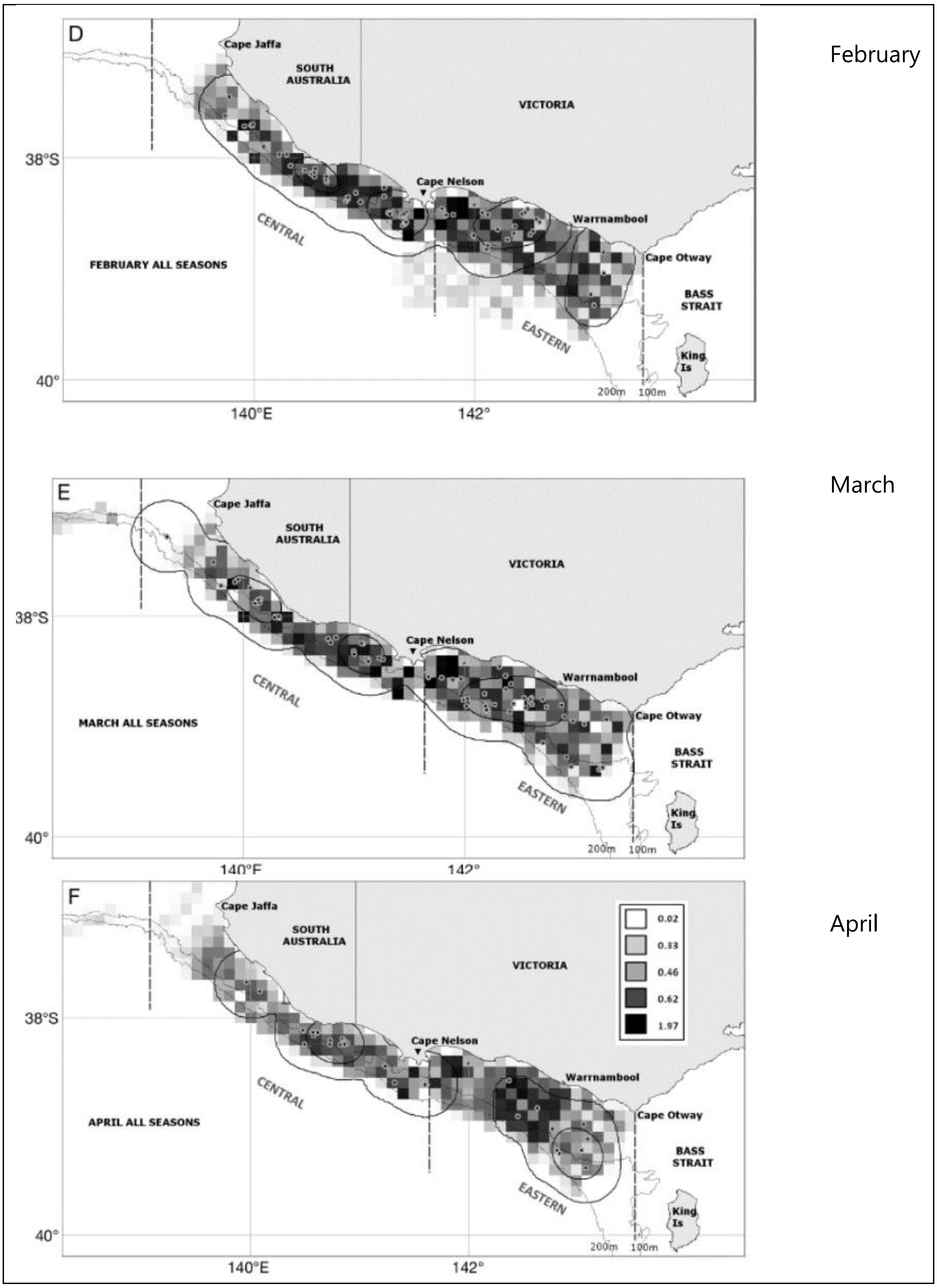


Figure 55: Blue Whale sightings in the Otway Basin (Feb, Mar, Apr) (Gill et al. 2011)

Note: Dots represent Blue Whale sightings while squares are aerial survey effort (10 km by 10 km squares) represented as minutes flown per grid square (key, upper right corner of the April figure).

Monthly Blue Whale encounter rates between 2001 and 2007 in the central and eastern study area (Cape Nelson to Cape Otway) are shown in Figure 56: Blue Whale Encounter Rates in the Central and Eastern Study (Cape Nelson to Cape Otway) Area by Month (Gill et al. 2011)

The encounter rates increased from 1.6 whales per 1,000 km in December, to 9.8 whales per 1,000 km in February, decreased slightly to 8.8 whales per 1,000 km in March, then declined sharply to a single sighting for May (0.4 whales per 1,000 km) (Gill et al. 2011). A mean Blue Whale group size of 1.3±0.6 was observed per sighting with cow-calf pairs observed in 2.5% of the sightings. Gill et al. (2011) also identified that 80% of Blue Whale sightings are encountered in water depths between 50 and 150 m; 93% of sightings occurred in water depths <200 m and 10% of sightings occurred within 5 km of the 200 m isobath in the eastern and central zones (Gill et al. 2011).

Gill et al. (2011) found that across the eastern zone (Cape Nelson to Cape Otway), there were no Blue Whale sightings in November (2001-2007) despite significant effort (Figure 56).

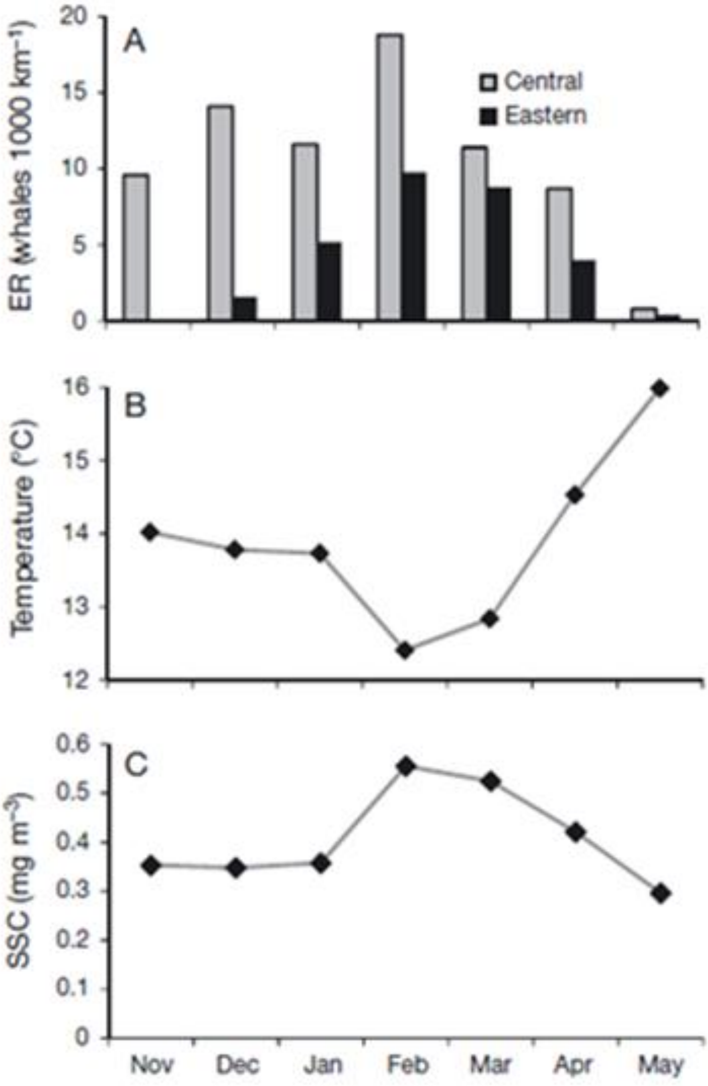


Figure 56: Blue Whale Encounter Rates in the Central and Eastern Study (Cape Nelson to Cape Otway) Area by Month (Gill et al. 2011)

- Blue Whales are typically widely distributed throughout central and eastern areas shelf waters from January through to April.
- Blue Whale numbers are significantly lower in November, December and January in the eastern area compared to the central area.
- No Blue Whales were sighted in the eastern area (Cape Nelson to Cape Otway) during November for any season despite significant effort.
- Encounter rates in central and eastern zones peaked in February, coinciding with peak upwelling intensity and primary productivity.

Origin Energy Surveys (2010-2014)

There were no confirmed sightings of Blue Whales during Origin's Speculant 3D Transition Zone marine seismic survey in November and December 2010, the Astrolabe 3D seismic survey undertaken in early November 2013 (RPS 2014) or during the Enterprise 3D seismic survey undertaken in late October and early November 2014 (RPS 2014).

From February to October 2011 Origin located an array of marine loggers east of the Thylacine platform to document nearby ambient marine noise, detect cetaceans and measure acoustics associated with the Origin 3D Bellerive Marine Seismic Survey. Pygmy and Antarctic Blue Whales were acoustically detected in the monitored area (east of the Thylacine-A wellhead platform). Pygmy Blue Whales were observed from early February to early June being abundant from March to mid-May. Rare calls from Antarctic Blue Whales were observed in June.

Aerial surveys were commissioned by Origin and undertaken during 2011 and 2012 by the Blue Whale Study. During five aerial surveys between 8 and 25 February 2011, 56 Blue Whales were sighted. Most of the sightings were at inshore areas between Moonlight Head to Port Fairy with whales apparently aggregating along and offshore of the boundary between the runoff plume from major flooding prevalent at the time and adjacent seawater. Figure 57 shows sightings from 14 February 2011 (Gill 2020).

The 2012 aerial surveys found that Blue Whales were common in the eastern upwelling zone during November and December 2012 (Figure 57 and Figure 58). In November, an estimated 21 individual Blue Whales were sighted, with most sightings near the 100 m isobath or deeper. December 2012 surveys identified 70 Blue Whales foraging along the edge of the continental shelf west of King Island. This was the largest recorded aggregation of Blue Whales during any aerial surveys of the Bonney coast upwelling since 1999 (Gill 2020).

The large numbers of whales found in this area during November and December indicated high productivity, although the krill was too deep to be seen from the air. Subsequent surveys in the same area for Origin Energy in early 2013 resulted in 17 Blue Whales sighted in January, eight in February, and two (a cow and calf) in March 2013, despite the extremely warm surface conditions. The high productivity of this area seen in November to December 2012 evidently tailed off during the next few months (Gill 2020).

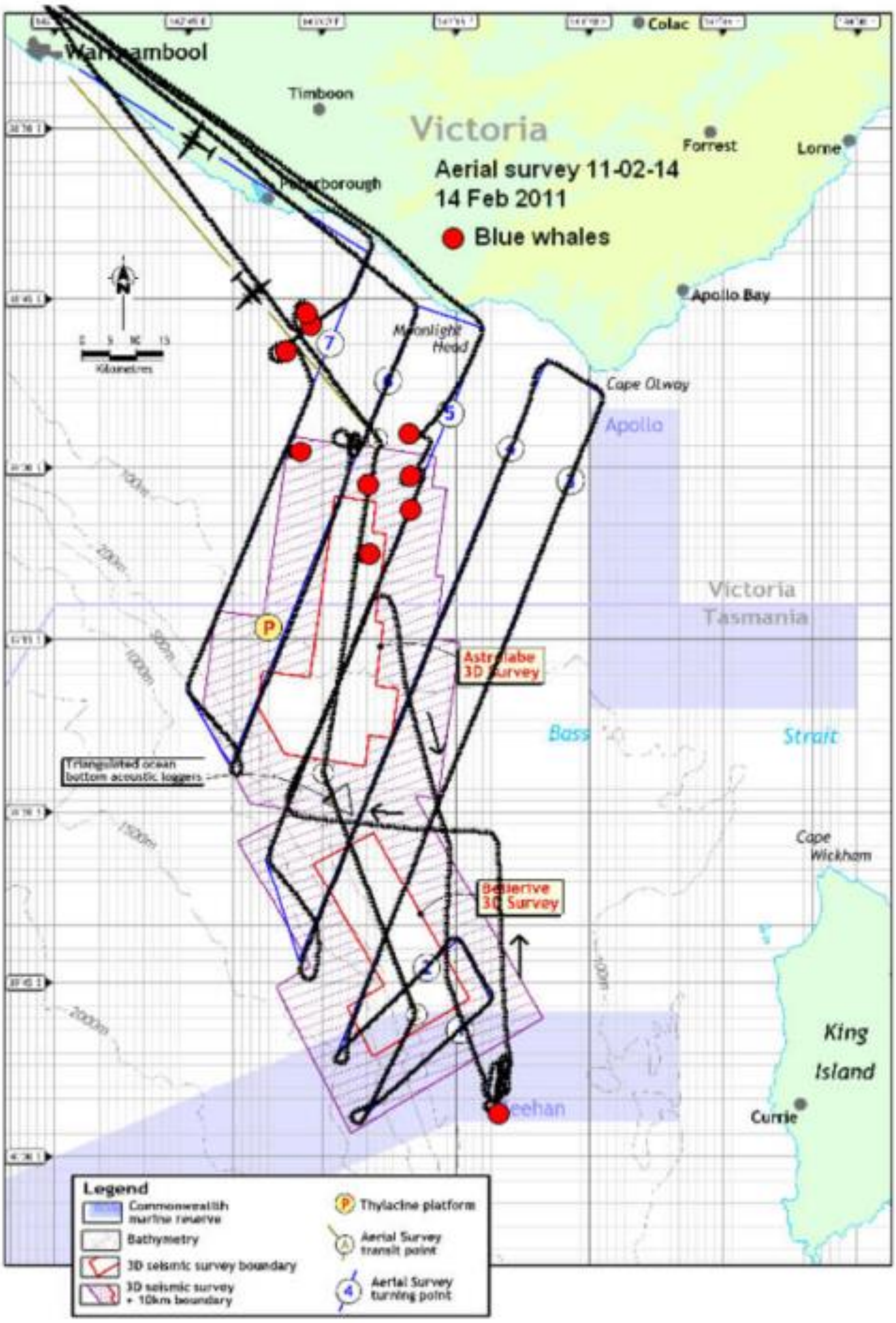


Figure 57: Blue Whale sightings during an aerial survey for Origin Energy in February 2011 (Gill 2020).

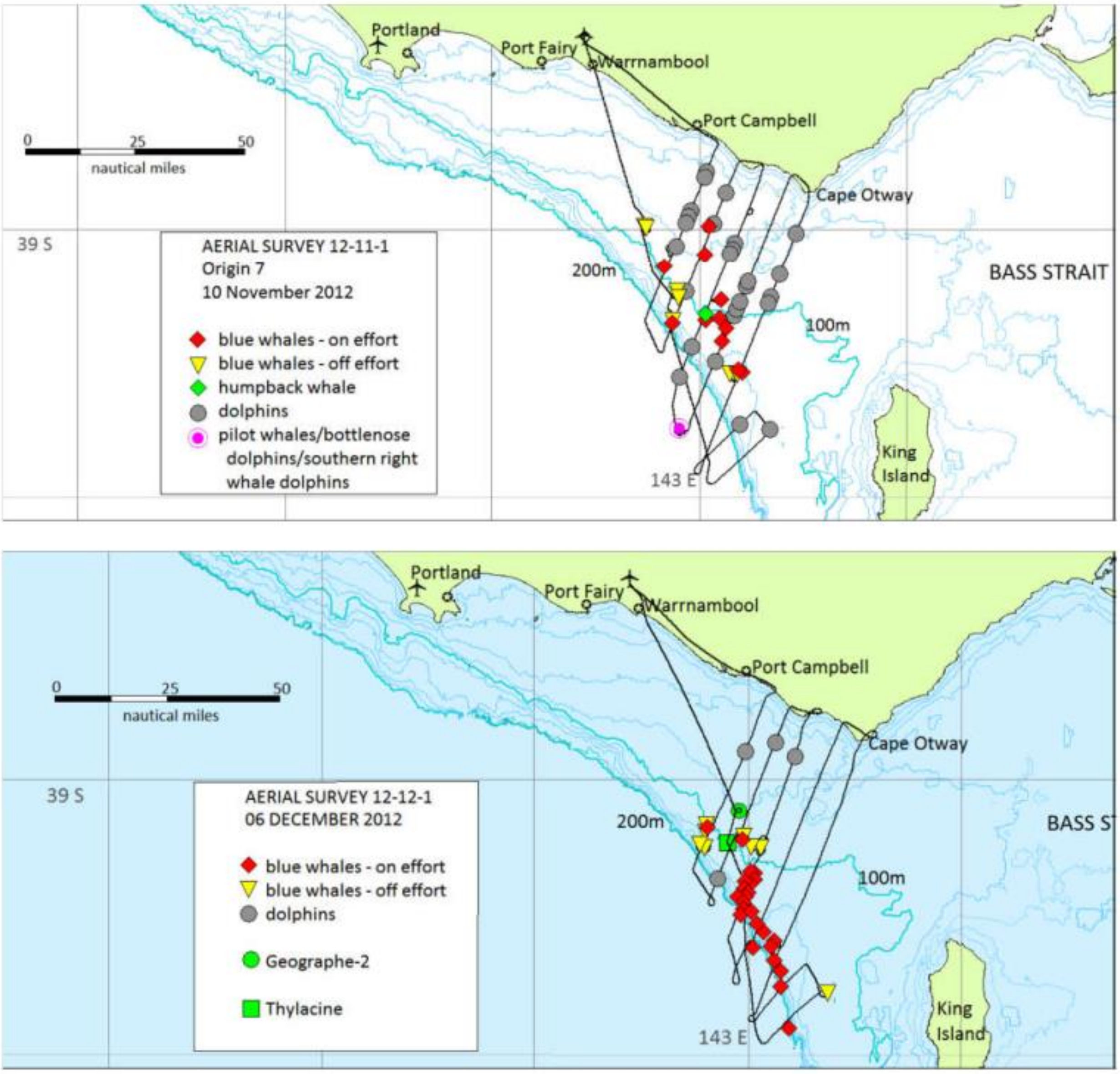


Figure 58: Blue Whale sightings during an aerial survey for Origin Energy in November and December 2012 (Gill 2020).

Tagging Study (2015-2016)

Möller et al. (2020) analysed data from 13 Pygmy Blue Whales tagged in the Bonney Upwelling region in January 2015 with tags transmitting up to March 2016 (**Figure 59**). In summary:

- the whales' movements in the Great Southern Australian Coastal Upwelling System (GSACUS) ranged mostly from eastern South Australia, over the continental shelf south of Kangaroo Island, to between mainland Australia and Tasmania), with a few whales performing some movements to the continental slope and the deep-sea.
- in the GSACUS, most tagged whales remained over the continental shelf, utilising this region from at least January to July. This was the area of highest occupancy by the whales, with one whale returning to the Bonney Upwelling in January the year after and remaining there for at least three

months. This timing coincides with the upwelling season, which generally occurs from November to March each year.

- a low probability of area restricted search (ARS) behaviour (i.e. high probability of transiting behaviour) was mainly observed between April and June, and then between November and December, suggesting that the Pygmy Blue Whales were mainly migrating during those times.
- seascape correlates of ARS behaviour for these whales suggested the importance of sea surface temperature, sea surface height anomaly, wind speed and chlorophyll a concentration as proxies of upwelling productivity and presence of krill patches.

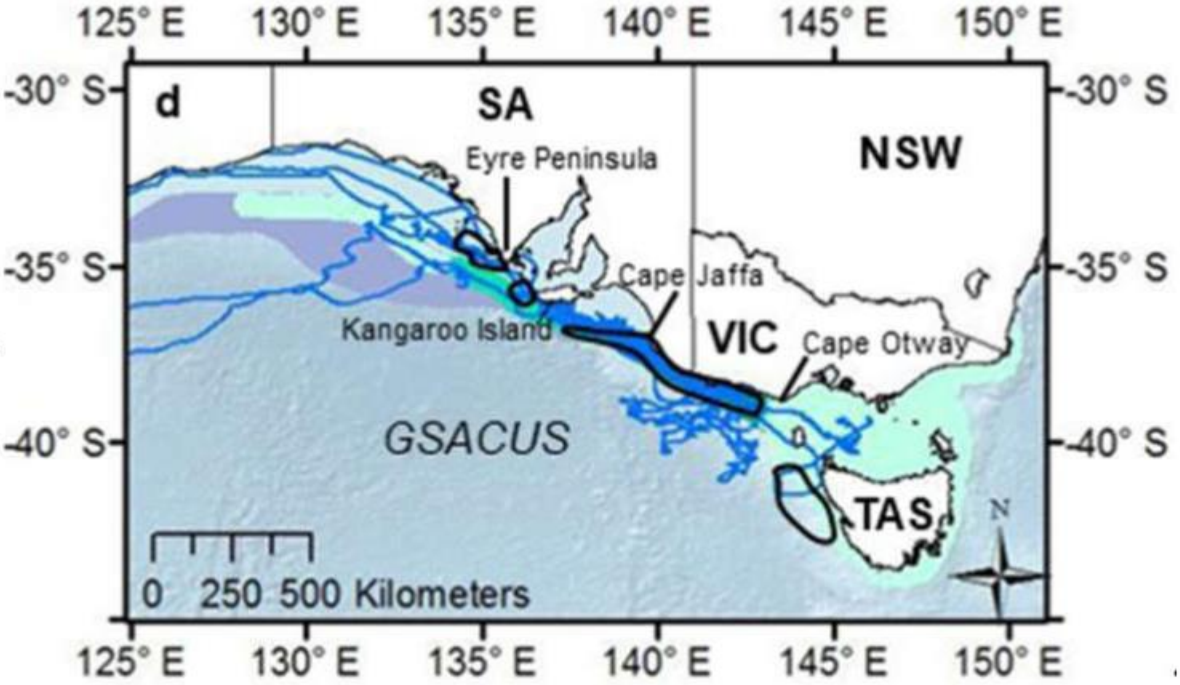


Figure 59: Tracks of 13 Pygmy Blue Whales in the GSACUS (Möller et al. 2020)

Passive Acoustic Recorders (2009-2017)

Between 2009 and 2016 the Integrated Marine Observing System (IMOS) has been recording underwater sound south of Portland, Victoria. McCauley et al. (2018) analysed the data from to look at Blue Whale presence, distribution, and population parameters.

Antarctic Blue Whale calls were received via deep sound channel propagation south of Portland and the maximum chorus levels occurred from late February to late June with yearly increases in chorus levels (McCauley et al. 2018).

In 2009 and 2011, Pygmy Blue Whales arrived in November or December whereas in other years, calls were not detected until January or February (**Figure 60**). There was substantial variation in presence within a season, with some whales remaining in the Portland detection area until mid-June each year with no consistent trend other than a peak in presence somewhere over February to June.

McCauley et al. (2018) noted it is difficult to predict numbers within a season but when correlated across seasons, the strength and persistence of the Bonney Coast Upwelling, given by time integrated water temperature, significantly correlates with time integrated number of individual whales calling from the same site (**Figure 60**). The upwelling index explains 83% of the variability in Blue Whale calling presence across seasons when using seasonal whale counts (not corrected for population growth). When a growth rate of 4.3% is applied a correlation of 90% of the variance in seasonal occurrence is predicted by the upwelling index. McCauley et al. (2018) also noted that the number of Pygmy Blue Whale calling in Portland could be expected in increase yearly with whale population growth.

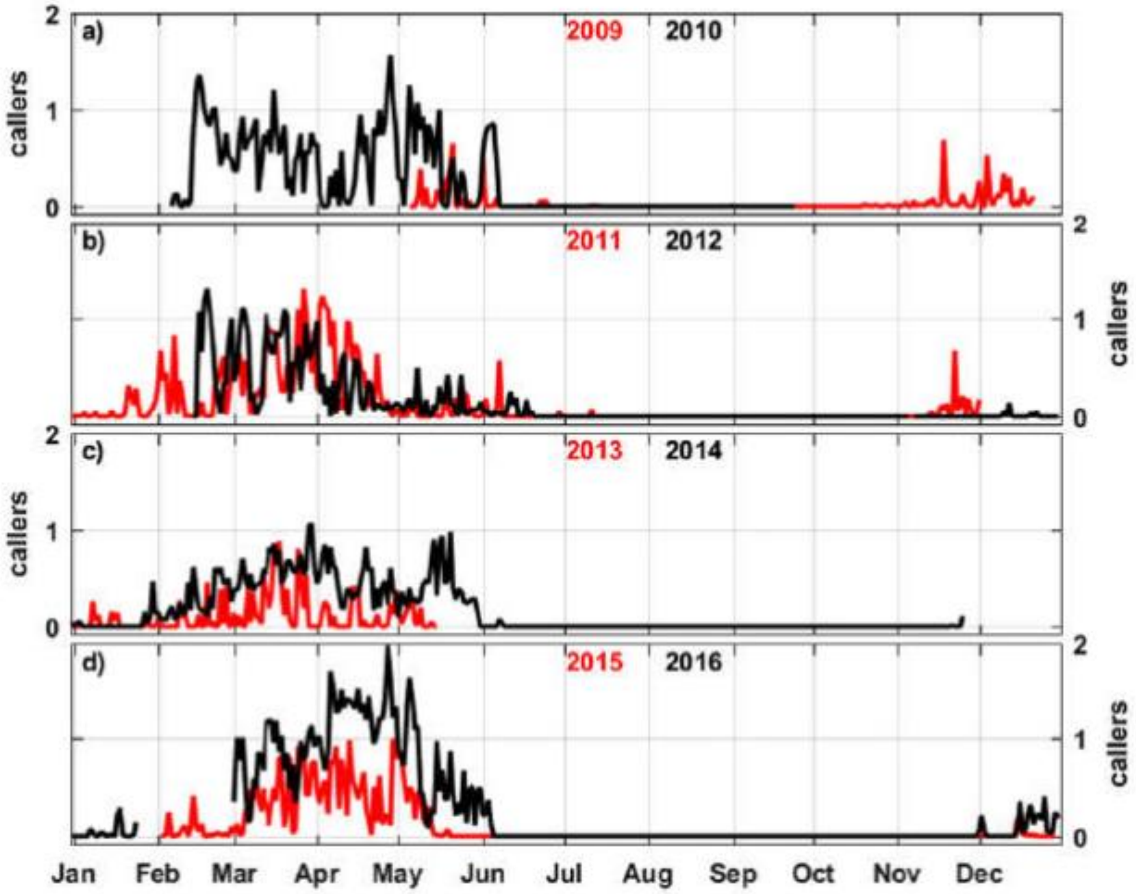


Figure 60: Mean Number of Individual Pygmy Blue Whales Calling (McCauley et al. 2018)

Beach Surveys (2019-2022)

During the Beach Otway Development Seabed Survey there were 4 sightings of Blue Whales within 3.5 km of the Thylacine Platform in November 2019 and one sighting in January 2020 about 1 km from the Artisan well location. The whales were identified as swimming.

JASCO completed a monitoring study for Beach in relation to exploration drilling activities at the Artisan-1 well from the 1 Feb to 6 April 2021 (McPherson et al. 2021). Songs of Pygmy Blue Whales were detected sporadically through February and the first half of March. By the end of March, the signals were present in almost every hour of recording. This pattern of occurrence was reflected across all recording stations. The data were too sparse to confirm anything about animal movements.

Beach commenced its Otway drilling program in February 2021 in the Otway Project Area, including:

- Exploration drilling at the Artisan-1 location (2 February 2021 – 27 March 2021)

- Development drilling, well abandonment, subsea installation, and commissioning activities in the Geographe field (27 March 2021 – 13 November 2021)
- Development drilling of the Thylacine North-1 well (16 November 2021 – 11 January 2022)
- Development drilling of the Thylacine West wells (23 January 2022 – 30 April 2022)

Drilling was undertaken by a mobile offshore drilling unit (MODU), the Ocean Onyx. The Blue Whale Study was engaged to undertaken aerial surveys from February to May 2021 to identify Blue Whale and krill surface swarms within the Otway Project Area and outside of this area. A preliminary data summary provided to Beach detailed:

- Nine aerial surveys were undertaken from 25 February to 21 May 2021
- There were 34 Blue Whale sightings consisting of 43 individuals
- The highest number of Blue Whale sightings was on 7 April 2021, with 19 Blue Whales sighted
- The first Blue Whale was sighted 25 February 2021and the final Blue Whale was sighted 7 April 2021
- Blue Whales and krill surface swarms were distributed throughout the area surveyed

Throughout the drilling campaign, Marine Fauna Observers (MFOs) were used to implement controls and monitor for whale activity. The data collected includes the numbers of Blue Whales observed at varying distances from the MODU, based on the management zones, during different MODU activities, along with information on whether the whale was observed to be approaching the MODU or moving away from it. They also collect additional data whilst in transit, or at distances outside of the zones. Observations are based on distances of:

- 0 – 500 m
- 501 – 1,500 m
- 1,501 – 2,000 m
- 2,001 – 3,000 m
- 3,000 m

The total number of Blue Whales sighted by the aerial surveys and by MFOs was 324 individuals (**Figure 61**, with a peak of 102 whales in March 2021 (note that the period February – May 2021 includes aerial survey data). Over this period, whales were observed in most months apart from July, August, and October 2021.

Figure 62 shows all whale sightings by MFOs between 2 February 2021 and 31 March 2022 across all well locations. **Figure 63** shows Blue Whale sightings within the Thylacine field between 16 November 2021 and 31 March 2022. Note that many observations were made whilst in transit.

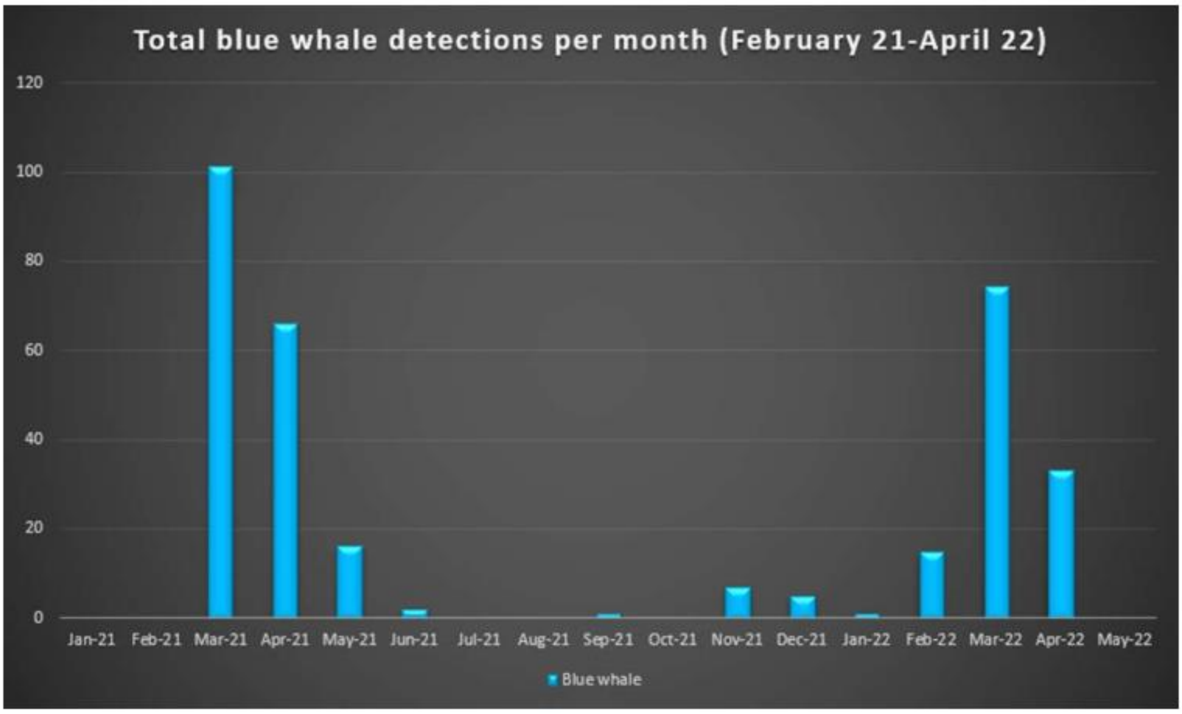


Figure 61: Blue Whale Observations during the Otway Offshore Drilling Campaign

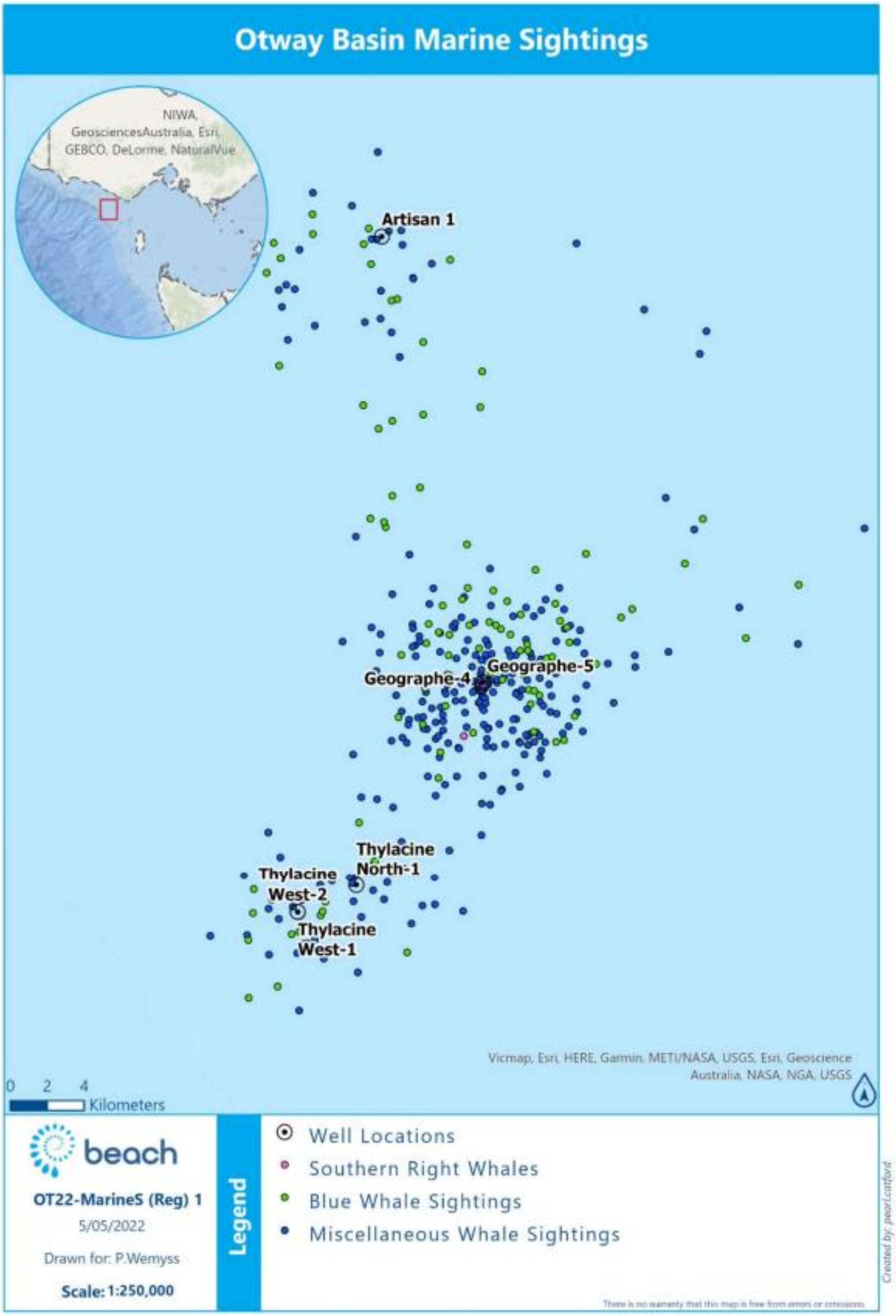


Figure 62: Whale Sightings between 2 February 21 – 31 March 22.

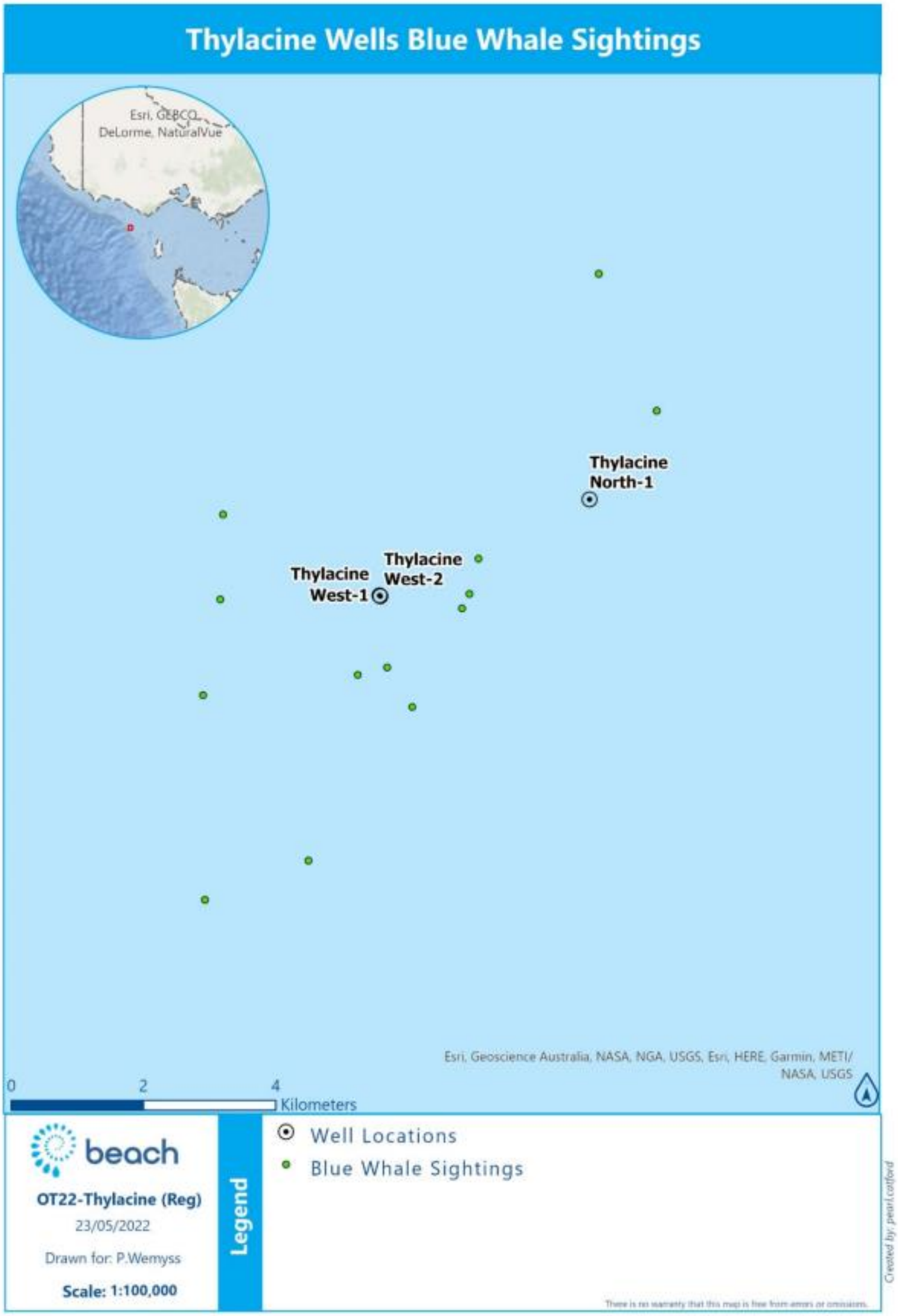


Figure 63: Blue Whale Sightings in the Thylacine field TN-1 (16 Nov 21 – 11 Jan 22); TW (23 Jan 22 – 31 Mar 22)

4.4.9.7.5 Bryde's Whale

Bryde's Whales are the second smallest species of baleen whale and occur in temperate to tropical waters between 40°N and 40°S. They have been recorded in all Australian states except the Northern Territory (Bannister et al. 1996). Minimal information is available regarding the population size of Bryde's Whales partially due to it being difficult to positively identify them compared to the Sei Whale.

4.4.9.7.6 Fin whale

Fin Whales are considered a cosmopolitan species and occur from polar to tropical waters and are rarely in inshore waters. They show well defined migratory movements between polar, temperate, and tropical waters. Migratory movements are essentially north–south with little longitudinal dispersion. Fin Whales regularly enter polar waters. Unlike Blue Whales and minke whales, Fin Whales are rarely seen close to ice, although recent sightings have occurred near the ice edge of Antarctica.

There are stranding records of this species from most Australian states, but they are considered rare in Australian waters (Bannister et al. 1996). The fin whale has been infrequently recorded between November and Feb during aerial surveys in the region (Gill et al. 2015). Fin Whales have been sighted inshore in the proximity of the Bonney Upwelling, Victoria, along the continental shelf in summer and autumn months (Gill 2002). Fin Whales in the Bonney Upwelling are sometimes seen in the vicinity of Blue Whales and Sei Whales.

Fin Whales were sighted, and feeding was observed between November-May (upwelling season) during aerial surveys conducted between 2002 and 2013 in South Australia (Gill et al. 2015). This is one of the first documented records these whales feeding in Australian waters, suggesting that the region may be used for opportunistic baleen whale feeding (Gill et al. 2015). Fin Whales have also been acoustically detected south of Portland, Victoria (Erbe et al. 2016). Aulich et al. (2019) recorded infrequent presence of Fin Whales in Portland between 2009 to 2016. This suggests that the area may not be a define migratory route however, calls recorded in July may be from whales migrating northward towards the east coast of NSW. Calls detected in late August and September may be indication of the presence of whales on their migration route back to Antarctica waters.

The sighting of a cow and calf in the Bonney Upwelling in April 2000 and the stranding of two Fin Whale calves in South Australia suggest that this area may be important to the species' reproduction, perhaps as a provisioning area for cows with calves (Morrice et al. 2004). However, there are no defined mating or calving areas in Australia waters.

4.4.9.7.7 Humpback Whale

Humpback Whales (*Megaptera novaeangliae*) are listed as Vulnerable and Migratory under the EPBC Act and are present around the Australian coast in winter and spring. Humpbacks undertake an annual migration between the summer feeding grounds in Antarctica to their winter breeding and calving grounds in northern tropical waters (DoE 2023i). Along the southeast coast of Australia, the northern migration starts in April and May while the southern migration peaks around November and December (DoE 2023i). A discrete population of humpback whales have been observed to migrate along the west coast of Tasmania and through Bass Strait, and these animals may pass through the Project Area and Planning Area. The exact timing of the migration period varies between years in accordance with variations in water temperature, extent of sea ice, abundance of prey, and location of feeding grounds (DoE 2023i). Feeding occurs where there is a high krill density, and during the migration this primarily occurs in Southern Ocean waters south of 55°S (DoE 2023i).

Humpback Whale satellite-tagged off Australia's east coast were tracked during three austral summers in 2008/2009, 2009/2010 and 2010/2011 (Andrews-Goff et al. 2018). Of the 30 tagged Humpbacks, 21 migrated south along the coastline across into Bass Strait during October. In November the whales then migrated along the east coast (12 whales) and west coast (1 whale) of Tasmania to Antarctic feeding grounds. The state space model used shows both search and transit behaviour revealing new temperate feeding grounds in Bass Strait, the east coast of Tasmania and in the eastern Tasman Sea.

There is no known feeding, resting or calving grounds for Humpback Whales in the Project Area or Planning Area, although feeding may occur opportunistically where sufficient krill density is present DoE 2023i). The nearest BIA which is important habitat for migrating humpback whales is Twofold Bay, a resting area off the NSW coast (CoA 2015d).

During Origin's Enterprise 3D seismic survey undertaken during early November 2014, 16 Humpback Whales were sighted (RPS 2014).

The recovery of Humpback Whale populations following whaling has been rapid. The Australian east coast Humpback Whale population, which was hunted to near-extinction in the 1950s and early 1960s, had increased to 7,090±660 (95% CI) whales by 2004 with an annual rate of increase of 10.6±0.5% (95% CI) between 1987–2004 (Noad et al. 2011). The available estimates for the global population total more than 60,000 animals, and global population is categorised on the IUCN Red List as Least Concern.

4.4.9.7.8 Killer Whale

Killer Whales (*Orcinus orca*) are thought to be the most cosmopolitan of all cetaceans and appear to be more common in cold, deep waters; however, they have often been observed along the continental slope and shelf particularly near seal colonies (Bannister et al. 1996). The killer whale is widely distributed from polar to equatorial regions and has been recorded in all Australian waters with concentrations around Tasmania. The only recognised key locality in Australia is Macquarie Island and Heard Island in the Southern Ocean (Bannister et al. 1996). The habitat of Killer Whales includes oceanic, pelagic and neritic (relatively shallow waters over the continental shelf) regions, in both warm and cold waters (DoE 2023l).

Killer Whales are top-level carnivores. Their diet varies seasonally and regionally. The specific diet of Australian Killer Whales is not known, but there are reports of attacks on dolphins, young Humpback Whales, Blue Whales, Sperm Whales, dugongs and Australian sea-lions (Bannister et al. 1996). In Victoria, sightings peak in June/July, where they have been observed feeding on sharks, sunfish, and Australian Fur-seals (Morrice et al. 2004; Mustoe 2008).

The breeding season is variable, and the species moves seasonally to areas of food supply (Bannister et al. 1996; Morrice et al. 2004). Killer Whales are frequently present in Victorian waters with sightings recorded along most of Victoria's coastline. Mustoe (2008) describes between 2002 and 2008 web-based casual sightings had an average of 13 Killer Whales sighted per year in Victoria and NSW, more than half in Victorian waters. This combined with the Atlas of Victorian Wildlife indicates a peak in killer whale sightings in June to July and September to November (Mustoe 2008).

The Killer Whale has been observed within the region however there are no BIAs in the Project Area and Planning Area.

4.4.9.7.9 Pygmy Right Whale

The Pygmy Right Whale (*Caperea marginata*) is a little-studied baleen whale species that is found in temperate and sub-Antarctic waters in oceanic and inshore locations. The species, which has never been hunted commercially, is thought to have a circumpolar distribution in the Southern Hemisphere between about 30°S and 55°S. Distribution appears limited by the surface water temperature as they are almost always found in waters with temperatures ranging from 5° to 20°C (Baker 1985) and staying north of the Antarctic Convergence. There are few confirmed sightings of Pygmy Right Whales at sea (Reilly et al. 2008). The largest reported group was sighted (100+) just south-west of Portland in June 2007 (Gill et al. 2008).

Species distribution in Australia is found close to coastal upwellings and further offshore it appears that the Subtropical Convergence may be important for regulating distribution (Bannister et al. 1996). Key locations include south-east Tasmania, Kangaroo Island (SA) and southern Eyre Peninsula (SA) close to upwelling habitats rich in marine life and zooplankton upon which it feeds (Bannister et al. 1996).

The Pygmy Right Whale has been observed in surveys in the region, however, Origin Energy did not observe it during the 2010 Speculant MSS and 2014 Enterprise MSS. There are no BIAs identified in the Project Area or Planning Area.

4.4.9.7.10 Sei Whale

Sei Whales (*Balaenoptera borealis*) are listed as Vulnerable and migratory under the EPBC Act, and are considered a cosmopolitan species, ranging from polar to tropical waters, but tend to be found more offshore than other species of large whales. They show well defined migratory movements between polar, temperate, and tropical waters. Migratory movements are essentially north-south with little longitudinal dispersion. Sei Whales do not penetrate the polar waters as far as the Blue, Fin, Humpback and Minke Whales (Horwood 1987), although they have been observed very close to the Antarctic continent.

Sei Whales move between Australian waters and Antarctic feeding areas; sub-Antarctic feeding areas (e.g. Subtropical Front); and tropical and subtropical breeding areas. The proportion of the global population in Australian waters is unknown as there are no estimates for Sei Whales in Australian waters.

Sei Whales feed intensively between the Antarctic and subtropical convergences and mature animals may also feed in higher latitudes. Sei Whales feed on planktonic crustaceans, in particular copepods and amphipods. Below the Antarctic convergence Sei Whales feed exclusively upon Antarctic krill (*Euphausia superba*).

In the Australian region, Sei Whales occur within Australian Antarctic Territory waters and Commonwealth waters, and have been infrequently recorded off Tasmania, NSW, Queensland, the Great Australian Bight, Northern Territory and Western Australia (Parker 1978; Bannister et al. 1996; Chatto and Warneke 2000; Bannister 2008).

Sightings of Sei Whales within Australian waters includes areas such as the Bonney Coast Upwelling off South Australia (Miller et al. 2012), where opportunistic feeding has been observed between November and May (Gill et al. 2015).

There are no known mating or calving areas in Australian waters.

4.4.9.7.11 Southern Right Whale

The southern right whale (Eubalaena australis) is listed as endangered under the EPBC Act in Australia and as endangered on the Victorian Threatened Species Advisory List.

The Draft National Recovery Plan for the Southern Right Whale (DCCEEW 2022a) provides an update to BIAs and emerging aggregation areas. The proposed changes are:

- Reproductive areas - Areas where mating, calving, nursing and/or presence of neonates are known, or likely, to occur. For Victoria this is the nearshore area between Portland and Port Campbell (Figure 64).
- Migration areas - Areas southern right whales are known, or likely, to use for movement between regions that support biologically important behaviour (e.g., coastal movement between reproductive areas) (Figure 64).

In addition, no 'Critical Habitat' as defined under section 207A of the EPBC Act have been identified, or included, in the Register of Critical Habitat.

The Project Area overlaps the southern right whale migration BIA and the Planning Areas overlap the southern right whale reproduction and migration BIAs (Figure 64).

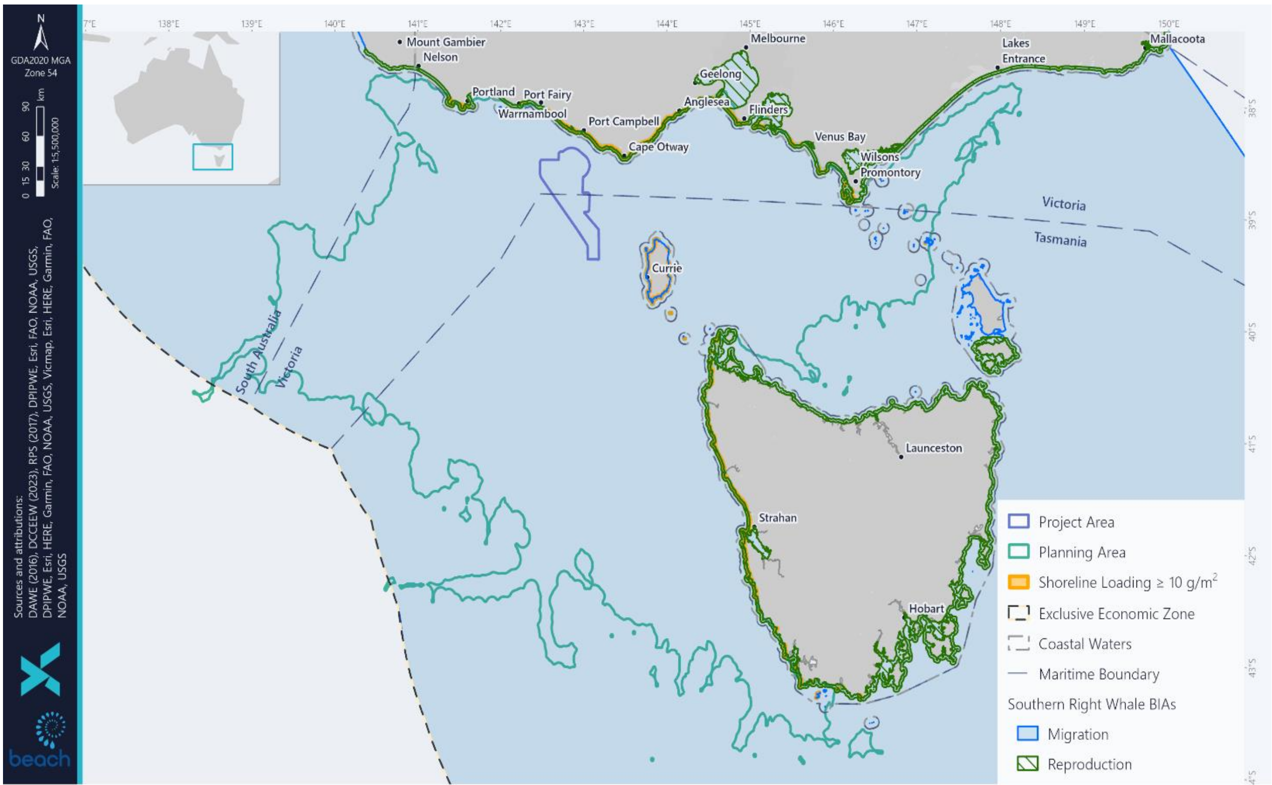


Figure 64: Project and Planning Areas and Southern Right Whale BIAs

Population

Southern right whales were depleted to less than 300 individuals globally due to commercial whaling in the 19th and 20th centuries (Tormosov et al. 1998). They were protected from whaling in 1935 however, due to illegal whaling in the 1970s and because southern right whales have a slow rate of increase compared to other marine mammals, their numbers remain low (IWC 2013). Global abundance estimates are 13,000 for the species, across key wintering grounds in South Africa, Argentina, Australia, and New Zealand.

The Australian population of southern right whales is divided into two sub-populations due to genetic diversity (Carroll et al. 2011; Baker et al. 1999) and different rates of increase (DSEWPaC 2012a). The western sub-population occurs predominantly between Cape Leeuwin, Western Australia (WA) and Ceduna, South Australia (SA) This sub-population comprises most of the Australian population and is estimated at 3,200 individuals increasing at an annual rate of approximately 6% p.a. (Smith et al. 2019). The eastern sub-population can be found along the south-eastern coast, including the region from Tasmania to Sydney, with key aggregation areas in Portland and Warrnambool in Victoria. The eastern sub-population is estimated at less than 300 individuals and is showing no signs of increase (Bannister, 2017). A rate of around 7% p.a. is considered the maximum biological rate of increase for southern right whales (IWC 2013). Connectivity between the two populations is unknown however, some limited movement between the two areas has been recorded (Burnell 2001, Charlton 2017, Pirzl et al. 2009).

Distribution

Southern right whales are distributed in the Southern Hemisphere with a circumpolar distribution between latitudes of 16°S and at least 65°S. They migrate from southern feeding grounds in sub-Antarctic waters to Australia in between May and November to calve, mate and rest (Bannister et al. 1996; DCCEEW 2022a). They are distributed across thirteen primary aggregation areas along the southern coast of Australia (Figure 6 58) (DSEWPaC 2012a). In Australian coastal waters, they occur along the southern coastline of the mainland and Tasmania and generally extend as far north as Sydney on the east coast and Perth on the west coast (DSEWPaC 2012a). There are occasional sightings further north, with the extremities of their range recorded at Hervey Bay and Exmouth (DSEWPaC 2012a).

The largest established calving areas in Australia include Head of Bight in SA, and Doubtful Island Bay and Israelite Bay in WA. Smaller but established aggregation areas regularly occupied by southern right whales include Yokinup Bay in WA, Fowlers Bay in SA and the Warrnambool and Portland in Victoria. Emerging aggregation areas include Flinders Bay, Hassell Beach, Cheyne/Wray Bays, and Twilight Cove in WA, and sporadically occupied areas include Encounter Bay in SA (DSEWPaC 2012a) Southern right whales generally occupy shallow sheltered bays within 2 km of shore and within water depths of less than 20 m (Charlton et al. 2019). A number of additional areas for southern right whales are emerging that might be of importance, particularly to the south-eastern population. In these areas, small but growing numbers of non-calving whales regularly aggregate for short periods of time. These areas include coastal waters off Peterborough, Port Campbell, Port Fairy, and Portland in Victoria (DSEWPaC 2012a) (Figure 65).

There is variation in annual abundance on the coast of Australia due to the 3-year calving cycles (Charlton 2017). Female and calf pairs generally stay within the calving ground for 2–3 months (Burnell 2001). Peak periods for mating in Australian coastal waters are from mid-July through August (DSEWPaC 2012a). Pregnant females generally arrive during late May/early June and calving/nursery grounds are generally occupied until October (occasionally as early as April and as late as December) (Charlton et al. 2019). A study conducted by Stamation et al. (2020) shows that despite an increase in breeding females sighted in south-eastern Australian between 1985 and 2017, there is no evidence of an increase in annual numbers of mother-calf pairs.

As a highly mobile migratory species, southern right whales travel thousands of kilometres between habitats used for essential life functions. Movements along the Australian coast are reasonably well understood, but little is known of migration travel, non-coastal movements and offshore habitat use. Exactly where southern right whales approach and leave the Australian coast from, and to, offshore areas remain unknown (DSEWPaC 2012a). The Victorian and Tasmania coastal waters are known to include migrating habitat and SRW are known to arrive at the south eastern Australian coastline and travel west to established aggregation areas in South Australia such as the Head of the Great Australian Bight (Watson et al. 2021). There is one established calving ground for female and calf pairs in south-eastern Australian at Logans Beach, Warrnambool, Victoria (Watson et al. 2021). A predominance of westward movements amongst long-range photo-identification re-sightings may indicate a seasonal westward movement in coastal habitat (Burnell 2001). Direct approaches and departures to the coast have also been recorded through satellite telemetry studies (Mackay et al. 2015).

Aerial surveys of western Bass Strait and eastern Great Australian Bight undertaken by Gill et al. (2015) detected southern right whales between May and September. A survey in early November 2010 did not observe any whales in the Warrnambool area and it was assumed that cows and calves had already left the calving and aggregation areas (M. Watson pers. comm. 2010). No southern right whales were encountered during Origin's Enterprise 3D seismic survey undertaken during November 2014 (RPS 2014), or during spotter flights of the coastline undertaken prior to the survey in late October 2014. Aerial surveys between Ceduna, SA and Sydney NSW (and included Tasmania) were undertaken in August of 2013 and 2014 and recorded a total of 34 southern right whale individuals (17 breeding females) in 2013 and 39 (11 breeding females) in 2014, respectively (Watson et al. 2015).

Marine mammal observer data from January 2021 to April 2022 for the drilling program in the Otway Development Area identified three southern right whales consisting of a single individual in June and August., and two in July (Figure 66).

The Conservation Management Plan for the Southern Right Whale (DSEWPaC 2012a) reports that known and potential threats that may have individual or population level impacts to southern right whales include entanglement in fishing gear, vessel disturbance, climate variability and change, noise interference, habitat modification and overharvesting of prey.

Cultural significance

The Draft National Recovery Plan for the Southern Right Whale (DCCEEW 2022a) provides information on the cultural significance of southern right whales to Indigenous Australians. The plan details:

- At the Great Australian Bight in South Australia, the Mirning people are whale people, and the white whale Jeedara is their totem and part of the Dreaming, which tells how the Mirning and Southern Right Whales are connected (Burgoyne 2000). Mirning Country is the sacred place of the Mirning People, and the Yinyila Nation of Mirning clans forms a huge yerrambai, or rainbow arch, spanning the length of the coastal area of the Great Australian Bight from Point Culver in Western Australia to near Streaky Bay in South Australia (Burgoyne 2000). The Far West Coast Aboriginal Corporation (FWCAC) manages the Far West Coast land, which belongs to the Far West Coast Aboriginal Peoples. FWCAC represents six distinct cultural groups of Aboriginal people: Mirning Peoples, The descendants of Edward Roberts, Wirangu Peoples, Yalata Peoples, Kokatha Peoples and Maralinga Tjaratja (Oak Valley) Peoples.
- In Victoria, Koontapool (southern right whales) occur along the coastlines of south-west Victoria in Gunditjmara Sea Country to feed and birth. These Koontapool Woorrkngan Yakeen (Whale Birthing Dreaming Sites), are in coastal bay areas from Port Campbell to Portland, including Warrnambool. These places on Gunditjmara Country are known resting and feeding sites for mothers and calves and are directly related to Gunditjmara Neeyn (midwives), explaining why Gunditjmara is a Matrilineal Nation.

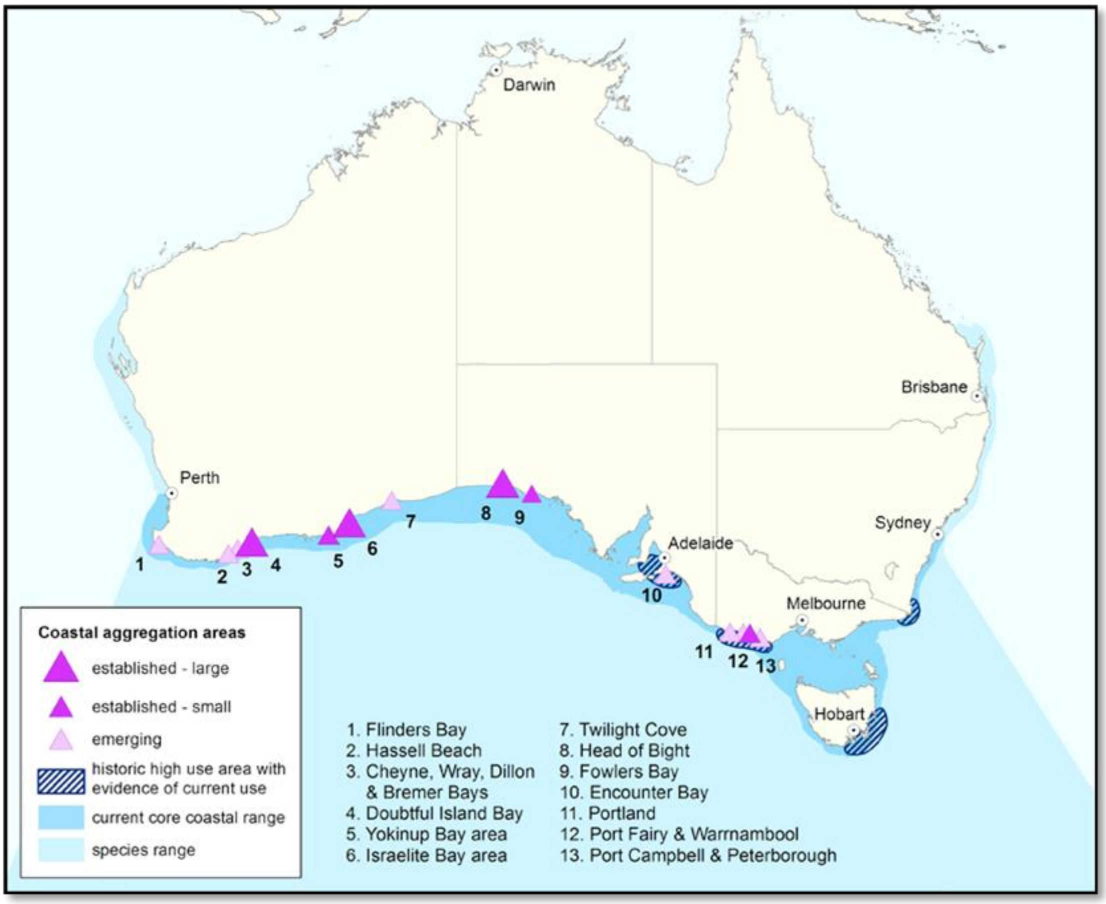


Figure 65: Aggregation Areas for Southern Right Whales (DSEWPaC 2012a)

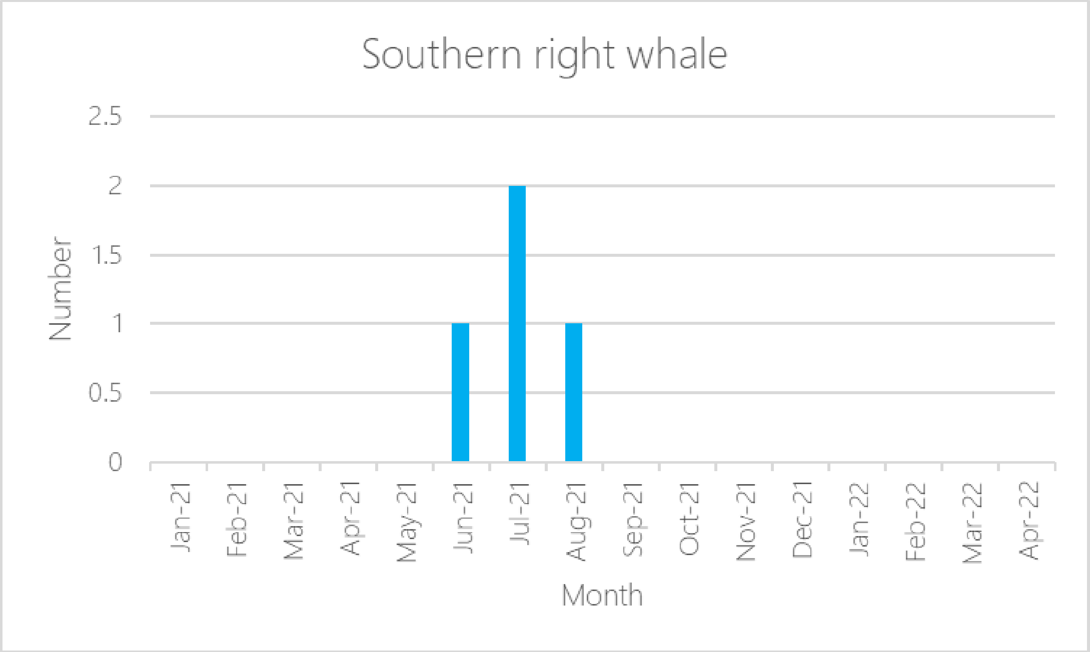


Figure 66: Southern Right Whale Sightings for the Otway Drilling Campaign

4.4.9.7.12 Sperm Whale

The Sperm Whale (*Physeter macrocephalus*) has a worldwide distribution and has been recorded in all Australian states. Sperm Whales tend to inhabit offshore areas with a water depth of 600 m or greater and are uncommon in waters less than 300 m deep (DoEE 2019j). Key locations for the species include the area between Cape Leeuwin to Esperance (WA); southwest of Kangaroo Island (SA), deep waters of the Tasmanian west and south coasts, areas off southern NSW (e.g., Wollongong) and Stradbroke Island (Qld) (DoEE 2019j). Concentrations of Sperm Whales are generally found where seabed rise steeply from a great depth (i.e., submarine canyons at the edge of the continental shelf) associated with concentrations of food such as cephalopods (DoEE 2019j).

Females and young males are restricted to warmer waters (i.e., north of 45°S) and are likely to be resident in tropical and sub-tropical waters year-round (DoE 2023i). Adult males are found in colder waters and to the edge of the Antarctic pack ice. In southern Western Australian waters Sperm Whales move westward during the year. For species in oceanic waters, there is a more generalised movement of Sperm Whales' southwards in summer and northwards in winter (DoEE 2019j).

Sperm Whales are prolonged and deep divers often diving for over 60 minutes (Bannister et al. 1996) however studies have observed Sperm Whales do rest at, or just below, surface for extended periods (>1 hr) (Gannier et al. 2002). In addition, female and juvenile Sperm Whales in temperate waters have been observed to spend several hours a day at surface resting or socialising (Hastie et al. 2003).

The Sperm Whale has been observed in the region, however the closest recognised BIA for foraging is further west near Kangaroo Island in South Australia (CoA 2015d). Therefore, it is likely they would be uncommon visitors in the Project Area and Planning Area.

4.4.9.7.13 Dusky Dolphin

The Dusky Dolphin (*Lagenorhynchus obscurus)* is rare in Australian waters and has been primarily reported across southern Australia from Western Australia to Tasmania with a handful of confirmed sightings near Kangaroo Island and off Tasmania (DoE 2023k). Only 13 reports of the Dusky Dolphin have been made in Australia since 1828, and key locations are yet to be identified (Bannister et al. 1996). Therefore, it is likely that they would be uncommon visitors in the Project Area and Planning Area. The species is primarily found from approximately 55°S to 26°S, though sometimes further north associated with cold currents. They are considered to be primarily an inshore species but can also be oceanic when cold currents are present (DoE 2023k). No Dusky Dolphins were detected during Beach's Otway drilling campaign.

4.5 Socio-Economic Values

Potential socio-economic receptors occurring within the Project Area and Planning Area are detailed in the following sections.

4.5.1 Coastal Settlements

There are no coastal settlements or Local Government Areas (LGAs) within the Project Area. The nearest settlement to the Project Area is Port Campbell. The Planning Area is within the following LGAs (**Figure 67**):

- Bass Coast Shire
- Circular Head Council

- Colac Otway Shire
- Corangamite Shire
- East Gippsland Shire
- Flinders Council
- French-Elizabeth-Sandstone Islands
- Glenelg Shire
- Greater Geelong City
- Huon Valley Council
- King Island Council
- Mornington Peninsula Shire
- Moyne Shire
- Queenscliffe Borough
- South Gippsland Shire
- Surf Coast Shire
- Warrnambool City
- West Coast Council

The larger Victorian coastal settlements within the Planning Area are described below based on ABS (2021) census data:

- Anglesea has a population of 3,208 people and a median age of 54. Of those in the labour force, 54.9% work full-time and 39.9% work part-time. Professionals and managers are the most popular occupations, comprising 48.5% of the workforce.
- Apollo Bay has a population of 1,790 people and a median age of 52. Of those in the labour force, 40.05% work full-time and 44.2% work part-time. Labourers and managers are the highest occupation making up 33.9% of the workforce. Accommodation and supermarket and grocery stores are the biggest industries, making up 21.1% of employment.
- Warrnambool has a population of 35,406 and a median age of 42. Of those in the labour force, 53.3% work full-time and 36.6% work part-time. Hospitals employ 6.6% of the workforce followed by cheese and other dairy product manufacturing, aged care residential services, other social assistance services and supermarket and grocery stores. Professionals, technicians and trade workers and labourers comprise 47.7% of occupations.

The largest Tasmanian coastal settlements within the Planning Area is described below based on ABS (2021) census data:

- Currie (King Island) has a population of 659 and a median age of 49. Of those in the labour force, 63.0% work fulltime and 33.3% work part-time. Dairy and beef cattle farming comprise 34.6% of occupations.

- Strahan has a population of 697 and a median age of 40. Of those in the labour force, 48.7% work full-time and 38% work part-time with labourers and managers being the most popular occupations (18.8% and 18.5%, respectively). Accommodation is the major industry, employing 17.1% of employees in the workforce.

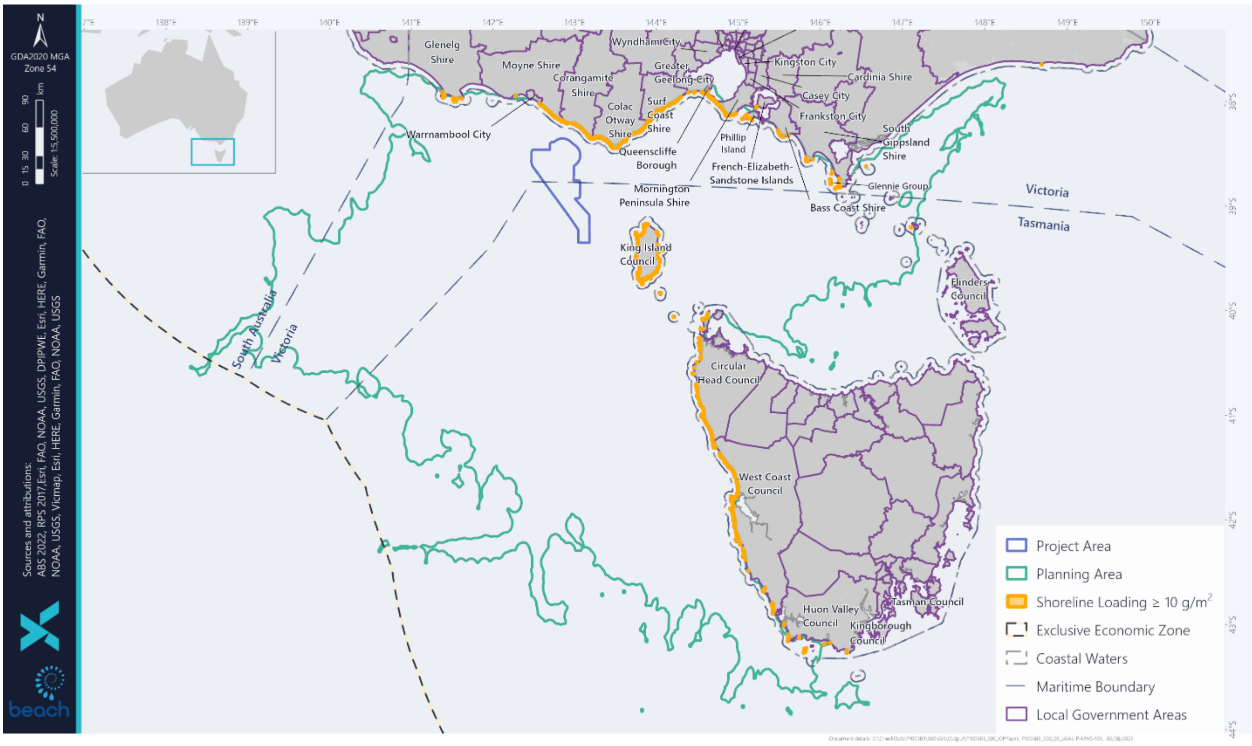


Figure 67: Local Government Areas within the Planning Area

4.5.2 Offshore Petroleum Industry

Petroleum exploration has been undertaken within the Otway Basin since the early 1960s. Gas reserves of approximately 2 trillion cubic feet (tcf) have been discovered in the offshore Otway Basin since 1995, with production from five gas fields using 700 km of offshore and onshore pipeline. Up to 2015, the DEDJTR reports that 23 PJ of liquid hydrocarbons (primarily condensate) has been produced from its onshore and offshore basins, with 65 PJ remaining, while 85 PJ of gas has been produced (Victoria and South Australia), with 1,292 PJ remaining.

There is no non-Beach oil and gas infrastructure within the Project Area. The Cooper Energy Casino and Henry gas fields and Casino-Henry pipeline and the Minerva gas field and pipeline are within the Planning Area to the north of the Project Area. The Planning Area also overlaps a portion of the Esso oil and gas production facilities in the Bass Strait.

4.5.3 Other Infrastructure

The Victorian Desalination Plant is located at Wonthaggi within the Planning Area. Operation of the plant commenced in December 2012. The seawater intake and outlet structures are connected to the onshore plant via a 1.2 km and 1.5 km underground tunnel, respectively. The two intake structures are 8 m high, 13 m in diameter, situated 50 m apart and located in a water depth of 20 m. They draw in water at very low speeds (the suction effect is not strong enough to draw fish in).

The Indigo Central telecommunications cable, which connects Perth and Sydney through southern Australia, intersects the Project Area. There are two Telstra telecommunications cables located in central Bass Strait, Bass Strait-1, and Bass Strait-2, which intersect the Planning Area. The Basslink submarine also traverses the Planning Area (**Figure 68**).

Three new cables are planned to be installed in the next 5 years that are within the Planning Area:

- East Coast Cable System between Melbourne, Sydney and Brisbane is being developed by Vocus.
- Hawaiki Nui – Hawaiki Submarine Cable between Melbourne and Sydney.
- Marinus Link undersea electricity and data cable that will connect Tasmania and Victoria. Construction is likely to commence in early 2025.

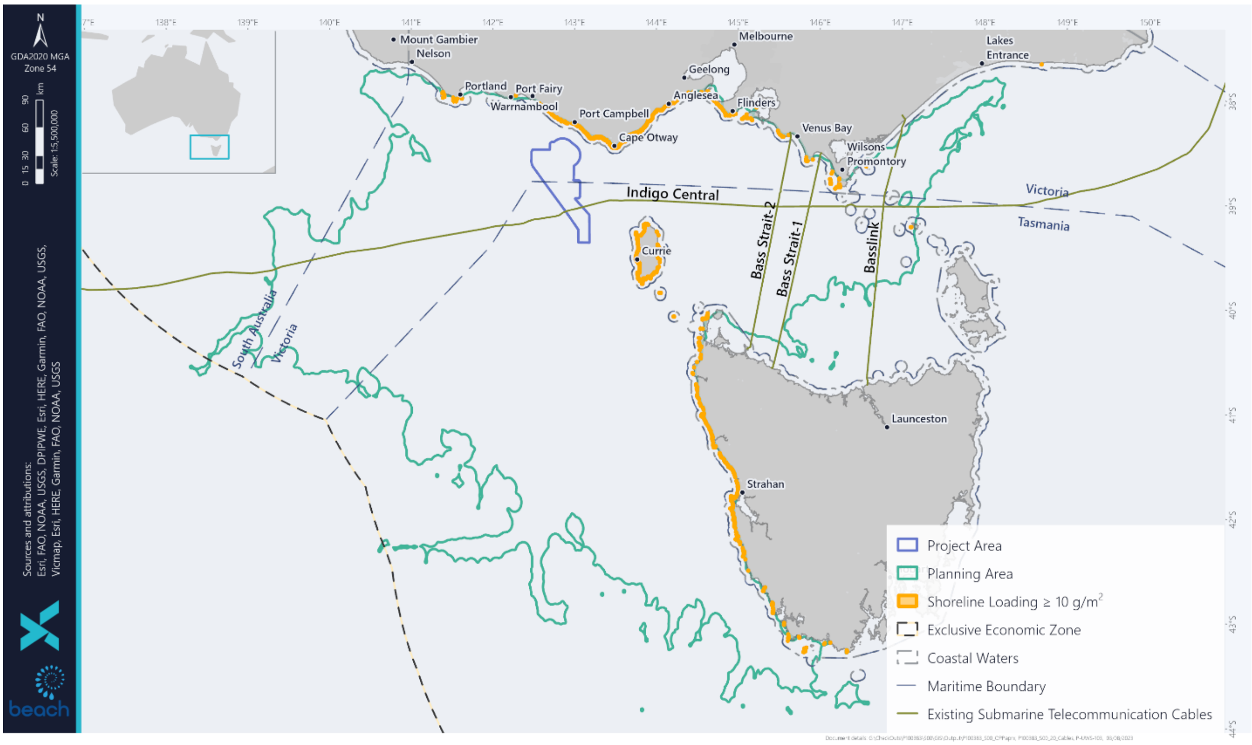


Figure 68: Existing Submarine Telecommunication Cables within the Project and Planning Areas

4.5.4 Defence Activities

Ongoing consultation with Department of Defence has identified that the Project Area is located within restricted airspace, but no other defence areas were identified. The Department of Defence also advised that unexploded ordnance (UXO) may be present on and in the sea floor.

UXO is a by-product of past training activities undertaken by the Australian Defence Force or foreign defence forces.

The interactive Department of Defence database (DoD 2023) indicates that the Project Area is located within a UXO Zone 1052 King Island (**Figure 69**), which is within the 'slight potential' category', meaning there is confirmed history of military activities that may have resulted in numerous residual hazardous munitions, components, or constituents, but where confirmed UXO affected areas cannot be defined (DoD 2022). The site was used during 1954 as an Air-to-Air Firing Range (DoD 2022).

Beach will undertake site surveys ahead of any seabed disturbing activities to confirm the absence of UXO within the Project Area.

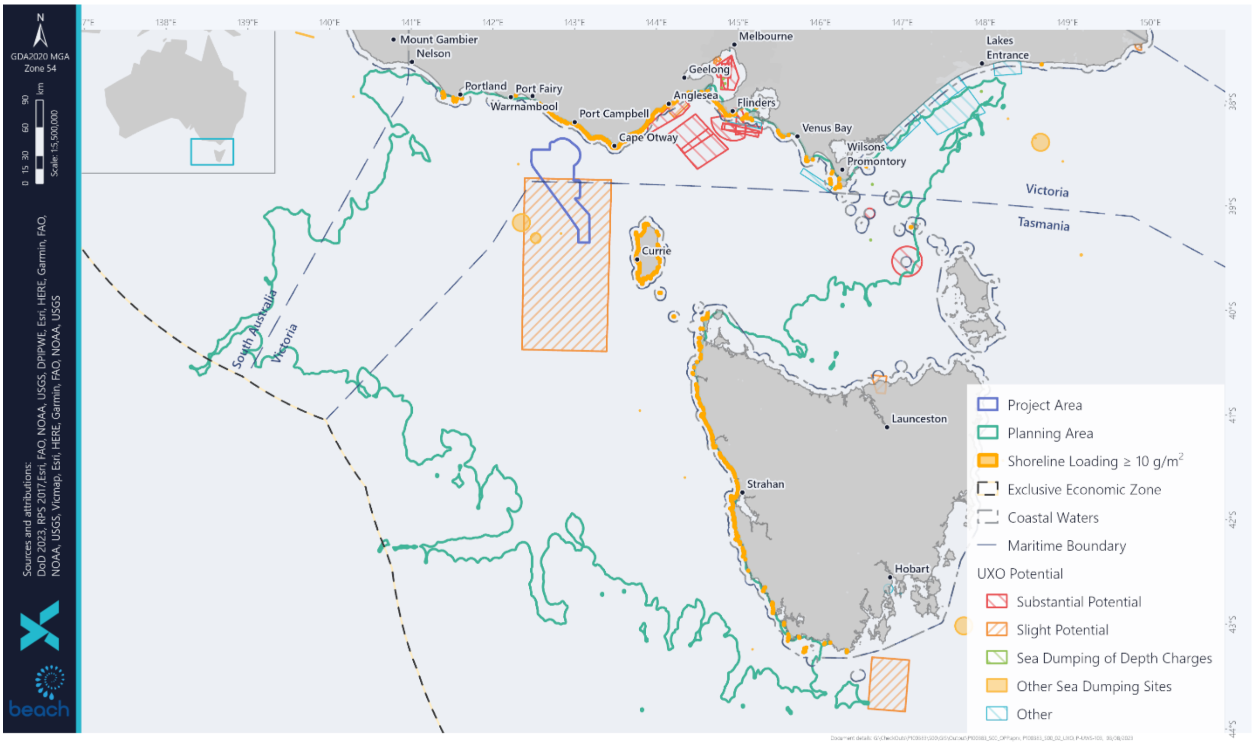


Figure 69: UXO within Project and Planning Areas

4.5.5 Shipping

The south-east marine region is one of the busiest shipping regions in Australia and Bass Strait is one of Australia's busiest shipping routes (**Figure 70**). Commercial vessels use the route when transiting between ports on the east, south and west coasts of Australia, and there are regular passenger and cargo services between mainland Australia and Tasmania.

Ports Australia (2022) provide statistics for port operations throughout Australia's main commercial ports. Based on the latest information (2021) the majority of commercial shipping traffic transiting to and from Victorian ports were container (3,682), general cargo (2,663, bulk liquid carriers (2,019), dry bulk (1,715), car carrier (1,342), bulk gas (220), other cargo (47) and livestock (9).

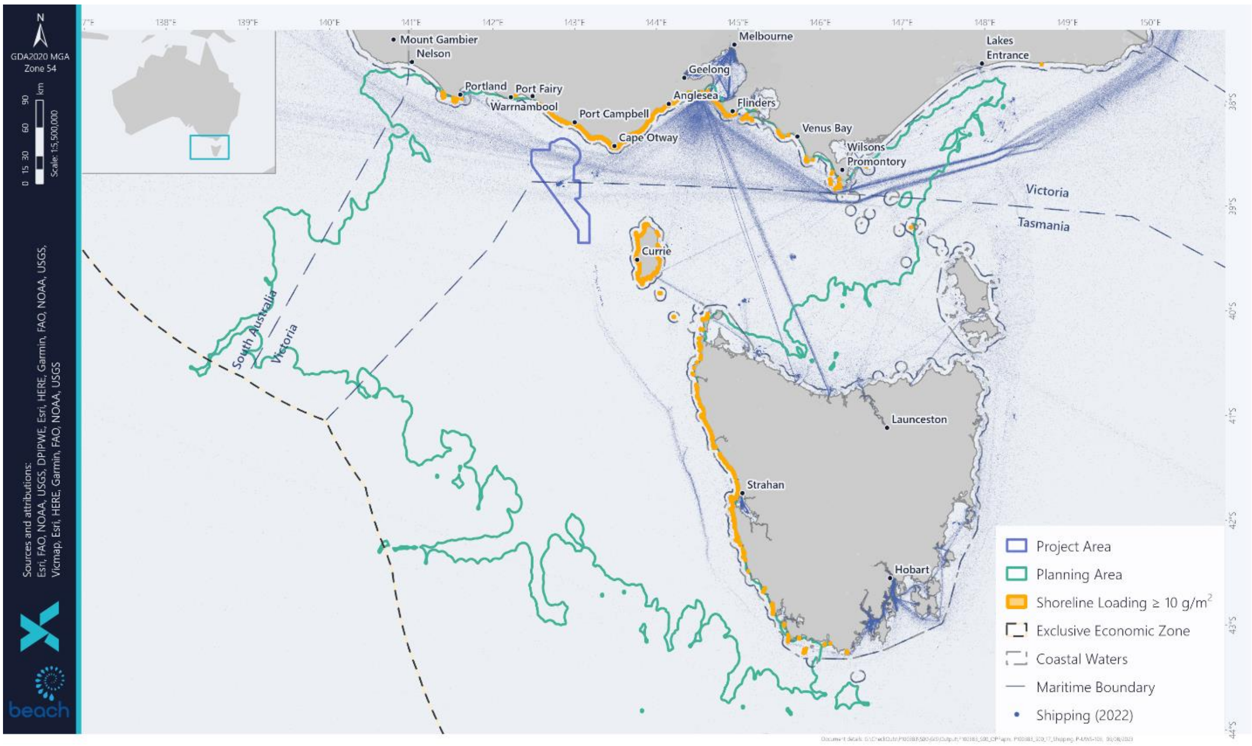


Figure 70: Shipping traffic within the Project and Planning Areas

4.5.6 Tourism

Consultation has identified that the key areas of tourism in the region include land-based sightseeing from the Great Ocean Road and lookouts along that road, helicopter sightseeing, private and chartered vessels touring into the Twelve Apostles Marine Park, diving and fishing. Land-based tourism in the region peaks over holiday periods and in 2011, Tourism Victoria reported a total of approximately 8 million visitors to the Great Ocean Road region.

Local vessels accessing the area generally launch from Boat Bay in the Bay of Islands or from Port Campbell. Given the available boat launching facilities in the area (Peterborough and Port Campbell), and the prevailing sea-state of the area, vessel-based tourism is limited.

4.5.7 Recreational Diving

Recreational diving occurs along the Victorian coastline. Popular diving sites near Peterborough include a number of shipwrecks such as the Newfield, which lies in 6 m of water and the Schomberg in 8 m of water. Peterborough provides a number of good shore dives at Wild Dog Cove, Massacre Bay, Crofts Bay and the Bay of Islands. In addition, there is the wreck of the Falls of Halladale (4 to 11 m of water) which can be accessed from shore or via boat.

Consultation with local vessel charterers and providers of SCUBA tank fills has confirmed that diving activity is generally concentrated around The Arches Marine Sanctuary and the wreck sites of the Loch Ard and sometimes at the Newfield and Schomberg shipwrecks. Diving activity peaks during the Rock Lobster season with the bulk of recreational boats accessing the area launching from Boat Bay at the Bay of Islands or Port Campbell.

4.5.8 Recreational Fishing

Recreational fishing is popular in Victoria and is largely centred within Port Phillip Bay and Western Port, although beach and boat-based fishing occurs along much of the Victorian coastline.

Recreational fishing also occurs in Tasmania in coastal and offshore waters, primarily within 3 nm of the shore. Diving occurs in nearshore waters, though is not common due to the cold water temperatures. Diving is popular around Bicheno and Maria Island, and the kelp forests off the Tasman Peninsula.

Due to the distance offshore (approximately 20 km) and the lack of emergent features, recreational fishing and tourism in the Project Area is unlikely.

4.5.9 Commonwealth Managed Fisheries

Commonwealth fisheries are managed by the Australian Fisheries Management Authority (AFMA) under the *Fisheries Management Act* 1991 (Cth). AFMA jurisdiction covers the area of ocean from 3 nm from the coast out to the 200 nm limit (the Australian Fishing Zone (AFZ)). Commonwealth commercial fisheries with jurisdictions to fish within the Planning Areas are:

- Bass Strait Central Zone Scallop Fishery (Bass Strait CZSF)
- Eastern Tuna and Billfish Fishery (ETBF)
- Skipjack Tuna Fishery
- Small Pelagic Fishery (SPF)
- Southern Bluefin Tuna Fishery (SBTF)
- Southern and Eastern Scalefish and Shark Fishery (SESSF)
- Southern Squid Jig Fishery
- Western Tuna and Billfish Fishery (WBTF).

Of these fisheries, the Bass Strait CZSF, ETBF, SBTF, SESSF, Southern Squid Jig Fishery and WBTF have catch effort within the Planning Area and the Bass Strait CZSF, ETBF, SESSF and Southern Squid Jig Fishery have catch effort within the Project Area based on ABARES reports 2022 (Patterson et al. 2022) (**Table 40**). The Skipjack Fishery is not currently active and management arrangements for the fishery are under review.

Information relating to the target species, fishing locations, landed catch, value and other relevant aspects of each fishery from the Commonwealth Fishery Status Report 2022 (Patterson et al. 2022), unless indicated, is summarised in **Table 40**.

Maps of fishing intensity for 2016–2020 (latest data available from AFMA) are provided where there is an overlap with fishing intensity and the Project Area and/or Planning Area. The maps show the maximum area fished and the fishing intensity. Fishing intensity is mapped to show high, medium, and low relative intensity. The fishing intensity data has been filtered to exclude catch from areas where fewer than 5 boats operated during a given year. The maximum area fished shows the area fished by all fishers aggregated by 1-degree (111 km x 111 km) grid cells.

A report commissioned by Beach and developed by South East Trawl Fishing Industry Association (SETFIA) on Trawl and Gillnet fishing activity (October 2019)

Beach commissioned South East Trawl Fishing Industry Association to provide a report on trawl and gillnet fishing activity in Otway Gas Development Phase 4 Project area (October 2019). The report concluded the following:

- Trawl fishing in the SESSF CTS board trawl sub-sector does not occur in the Otway Gas Development Phase 4 Project area proposed footprint. It does occur to the south-east of the Project Area. The grounds around the Otway Gas Development Phase 4 Project area appear too rough for trawl fishing in its current form.
- For unknown reasons gillnet fishing in the SeSSF GHaT gillnet sub-sector does not seem to occur within the Otway Gas Development Phase 4 Project area. However, there is some activity from this sub-sector nearby to the east.
- Gillnet fishing cannot occur deeper than 183 m (100 fathoms).
- There is no SESSF CTS Danish seine sub-sector fishing in the Otway Gas Development Phase 4 Project area.

Fishery	Target species	Description	Fishing Effort Project Area	Fishing Effort Planning Area
Bass Strait Central Zone Scallop Fishery	Scallop	Fishery operates in the Bass Strait between Victorian and Tasmanian and starts at 20 nm from their respective coastlines. In 2021, fishing was permitted throughout the management area, except in 4 scallop beds that were closed to fishing under the harvest strategy. Fishing in 2021 was concentrated on beds east of King Island and north of Flinders Island. With 10 active boats using towed dredges. Fishing season is 1 April to 31 December. Actual catch in 2021 was 2,344 tonnes. The major landing ports in Victoria are Apollo Bay and Queenscliff. Total fishery value in 2020-2021 was A$4.7 million. Fishing mortality: Not subject to overfishing. Biomass: Not overfished. The Project Area overlaps the maximum area fished which contains confidential fishing intensity due to less than 5 vessels operating (**Figure 71**). There has been fishing effort in the Planning Area (**Figure 71**). The highest fishing intensity within the Planning Area is concentrated to the east of King Island.	Yes	Yes
Eastern Tuna and Billfish Fishery	Albacore Tuna Bigeye Tuna Yellowfin Tuna Swordfish Striped Marlin	The Eastern Tuna Billfish Fishery is a longline and minor-line fishery that operates in water depths >200 m from Cape York to Victoria. Fishing effort is typically concentrated along the NSW coast and southern Queensland coast. No Victorian ports are used. In 2021 there was some fishing effort in Victoria at low levels. The number of active vessels has decreased within the fishery from around 150 in 2002 to 41 in 2021. Actual catch in the 2021 season was 5,148 tonnes. Total fishery value in 2021 was A$35.6 million. Fishing mortality: Striped Marlin subject to overfishing. Biomass: Striped marlin, south-west Pacific stock overfished, all other species not overfished. The Project Area and Planning Area overlap the maximum area fished which contains confidential fishing intensity due to less than 5 vessels operating (Figure 72: Commonwealth Eastern Tuna and Billfish Fishery Fishing Intensity (effort, net length, m/km2) and Maximum Area Fished	Yes	Yes

Fishery	Target species	Description	Fishing Effort Project Area	Fishing Effort Planning Area
Skipjack Tuna Fishery (Eastern and Western)	Skipjack Tuna	The Skipjack Tuna Fishery is not currently active and the management arrangements for this fishery are under review. There has been no catch effort in this fishery since the 2008 -2009 season.	No	No
Small Pelagic Fishery (Western sub-area)	Australian Sardine Blue Mackerel Jack Mackerel Redbait	The Small Pelagic Fishery extends from the southern Queensland to southern Western Australia. Fishers use midwater trawls and purse seine nets. Geelong is a major landing port. Total retained catch of the four target species was 18,878 tonnes in the 2021-2022 season. Fishery effort is generally concentrated near-shore in South Australia and along the east coast. Six vessels were active during the 2021-2022 season. Fishing mortality: Not subject to overfishing. Biomass: Not overfished. There has been no fishing effort in the Project Area (**Figure 73**). The Planning Area overlaps the maximum area fished which contains confidential fishing intensity due to less than 5 vessels operating (**Figure 73**).	No	Yes
Southern and Eastern Scalefish and Shark Fishery (SESSF) Commonwealth Trawl Sector (CTS) Danish-seine	Blue-eye trevalla Blue grenadier Eastern school whiting Orange roughy Pink ling Ribaldo Tiger flathead	The Commonwealth Trawl Sector (CTS) is part of the SESSF and extends from Barrenjoey Point in northern New South Wales to Kangaroo Island in South Australia. Management of the CTS is separated into demersal otter-board trawl and Danish-seine fishing methods. Fishing in the CTS is generally concentrated along the 200 m bathymetric contour. Total retained catch of the fishery (combined with otter-board trawl and scalefish hook subsectors) was 19,501 tonnes in the 2021-22 season. In 2020-2021, the fishery value was A$64 million. No value is provided for 2021-22 season. Thirty-two otter-board trawl vessels were active during the 2021-2022 fishing season. Fishing mortality: some species subject to overfishing. Biomass: some species over fished. The Project Area overlaps the maximum area fished which contains confidential fishing intensity due to less than 5 vessels operating. There has been fishing effort in the Planning Area with the highest fishing intensity concentrated near Lakes Entrance (**Figure 74**).	Yes	Yes

Fishery	Target species	Description	Fishing Effort Project Area	Fishing Effort Planning Area
Southern and Eastern Scalefish and Shark Fishery (SESSF) Commonwealth Trawl Sector (CTS): Otter-board trawl	Blue-eye trevalla Blue grenadier Eastern school whiting Orange roughy Pink ling Ribaldo Tiger flathead	The Commonwealth Trawl Sector (CTS) is part of the SESSF and extends from Barrenjoey Point in northern New South Wales to Kangaroo Island in South Australia. Management of the CTS is separated into demersal otter-board trawl and Danish-seine fishing methods. Fishing in the CTS is generally concentrated along the 200 m bathymetric contour. Total retained catch of the fishery (combined with Danish-seine and scalefish hook subsectors) was 19,501 tonnes in the 2021-22 season. In 2020-2021, the fishery value was A$64 million. No value is provided for 2021-22 season. Thirty-two trawl vessels were active during the 2021-2022 fishing season. Fishing mortality: some species subject to overfishing. Biomass: some species over fished. There has been fishing effort in the Project Area and Planning Area (**Figure 75**). The north-west corner of the Project Area overlaps an area of low relative fishing intensity. The entire Project Area overlaps the maximum area fished which contains confidential fishing intensity due to less than 5 vessels operating. The highest fishing intensity within the Planning Area is concentrated along the west coast of Tasmania as well as along the coast of Victoria between Nelson and Portland.	Yes	Yes
Southern and Eastern Scalefish and Shark Fishery (SESSF) Gillnet, Hook and Trap Sector (GHTS) Scalefish Hook Sector (SHS)	Blue-eye trevalla Blue grenadier Eastern school whiting Orange roughy Pink ling Ribaldo Tiger flathead	The Scalefish Hook Sector (SHS) is primarily in the southeast of Australia with most fishing intensity occurring off the coast of Tasmania. The SHS is managed under the Gillnet, Hook and Trap Sector (GHTS) of the SESSF. The broader SESSF stretches south from Fraser Island in southern Queensland, around Tasmania, to Cape Leeuwin in southern Western Australia. The SHS shares target species with the CTS. Fishing is generally concentrated along the 200 m bathymetric contour. Total retained catch of the fishery (combined with CTS) was 19,501 tonnes in the 2021-22 season. In 2020-2021, the fishery value was A$64 million. No value is provided for 2021-22 season. Twenty-one scalefish hook vessels were active during the 2021-2022 fishing season. Fishing mortality: some species subject to overfishing. Biomass: some species over fished.	Yes	Yes

Fishery	Target species	Description	Fishing Effort Project Area	Fishing Effort Planning Area
		The Project Area and Planning Area overlap the maximum area fished which contains confidential fishing intensity due to less than 5 vessels operating (**Figure 76**). The Planning Area overlaps a small area of high fishing intensity off the south coast of Tasmania.		
Southern and Eastern Scalefish and Shark Fishery (SESSF) Gillnet, Hook and Trap Sector (GHTS) Shark Gillnet and Shark Hook Sectors (SGSHS) Shark Gillnet subsector	Elephantfish Gummy Shark Sawsharks School Shark	The shark gillnet and shark hook sectors (SGSHS) are part of the Gillnet, Hook and Trap Sector (GHTS) of the Southern and Eastern Scalefish and Shark Fishery (SESSF). Most fishing in the SGSHS using nets occurs in the Bass Strait while most fishing using hooks occurs off South Australia. Fishing is generally concentrated east of King Island. During the 2021-22 season, 27 shark gillnet vessels were active which hauled a total of 27,820 km of net. Total retained catch of the target species was 2,150 tonnes in the 2021-22 season. In 2020-21, the fishery value was A$28.84 million. No value is provided for 2021-22 season. Fishing mortality: School Shark is uncertain. Biomass: School Shark is overfished. There has been fishing effort in the Project Area and Planning Area (**Figure 77**). The northern-most portion of the Project Area overlaps an area of low to medium relative fishing intensity. The entire Project Area overlaps the maximum area fished which contains confidential fishing intensity due to less than 5 vessels operating. Areas of high fishing intensity occur within the Planning Area throughout the Bass Strait.	Yes	Yes

Fishery	Target species	Description	Fishing Effort Project Area	Fishing Effort Planning Area
Southern and Eastern Scalefish and Shark Fishery (SESSF) Gillnet, Hook and Trap Sector (GHTS) Shark Gillnet and Shark Hook Sectors (SGSHS) Shark Hook subsector	Elephantfish Gummy Shark Sawsharks School Shark	The shark gillnet and shark hook sectors (SGSHS) are part of the Gillnet, Hook and Trap Sector (GHTS) of the Southern and Eastern Scalefish and Shark Fishery (SESSF). Most fishing in the SGSHS using nets occurs in the Bass Strait while most fishing using hooks occurs off South Australia. Fishing is generally concentrated off the South Australian coast, but fishing activity also occurs in the waters around Flinders Island, particularly between Flinders Island and Tasmania. During the 2021-22 season, 40 shark hook vessels were active and set a total of 2,493,920 hooks. Total retained catch of the target species was 2,150 tonnes in the 2021-22 season. No value is provided for 2021-22 season. In 2020-21, the fishery value was A$28.84 million. Fishing mortality: School Shark is uncertain. Biomass: School Shark is overfished. The Project Area and majority of the Planning Area overlap the maximum area fished which contains confidential fishing intensity due to less than 5 vessels operating (**Figure 78**). The Planning Area also overlaps small areas of low to medium relative fishing intensity off the coast of Nelson in Victoria and between King Island and Tasmania.	Yes	Yes
Southern Bluefin Tuna Fishery	Southern Bluefin Tuna	The Southern Bluefin Tuna Fishery covers the entire sea area around Australia, out to 200 nm from the coast. The majority of catch since 1992 has been taken in the Great Australian Bight via purse seine. Longline fishing effort is more common along the east coast. The pelagic longline and purse seine fisheries were worth a combined A$43.39 million in the 2020-21 fishing season (actual catch was 5,656 tonnes). Fishing mortality: Not subject to overfishing. Biomass: Not overfished. There has been no fishing effort in the Project Area (**Figure 79**). The Planning Area overlaps the maximum area fished at the southern coast of Tasmania, which contains confidential fishing intensity due to less than 5 vessels operating (**Figure 79**).	No	Yes

Fishery	Target species	Description	Fishing Effort Project Area	Fishing Effort Planning Area
Southern Squid Jig Fishery	Gould's Squid (Arrow Squid)	The Southern Squid Jig Fishery is a single species fishery that operates year-round. Portland and Queenscliff are the major Victorian landing ports. Jigging typically occurs midwater at depths between 50 and 100 m at night using large lights that illuminate the waters around a boat. In 2021, the actual catch of 939 tonnes was worth A$3.30 million. In 2021 there were eight active vessels in the fishery with the landing ports being Triabunna (Tasmania); Queenscliff and Apollo Bay (Victoria). Fishing mortality: Not subject to overfishing. Biomass: Not overfished. There has been fishing effort in the Project Area and Planning Area (**Figure 80**). The Project Area and Planning Area overlap the maximum area fished which contains confidential fishing intensity due to less than 5 vessels operating. One area of low to high relative fishing intensity overlaps the Project Area and Planning Area off the coast of Warrnambool.	Yes	Yes
Western Tuna and Billfish Fishery	Bigeye Tuna Yellowfin Tuna Broadbill Swordfish Striped Marlin	The Western Tuna and Billfish Fishery primarily uses pelagic longline gear with low levels of minor-line fishing. The management area extends west from the eastern border of South Australia to Cape York, including Cocos Keeling Islands and Christmas Island. Fishing effort in recent years has been mostly concentrated in south-west Western Australia with occasional activity off South Australia. The value of the fishery is confidential but the total annual catch of the fishery in 2021 was 252 tonnes. Less than 5 vessels have been active in the fishery every year since 2005. Fishing mortality: Striped Marlin, Albacore, Bigeye Tuna and Yellowfin Tuna subject to overfishing. Biomass: Striped Marlin overfished. The Planning Area overlaps the maximum area fished which contains confidential fishing intensity due to less than 5 vessels operating (**Figure 81**). There has been no fishing effort in the Project Area.	No	Yes

Table 40: Commonwealth Managed Fisheries within the Project Area and Planning Area

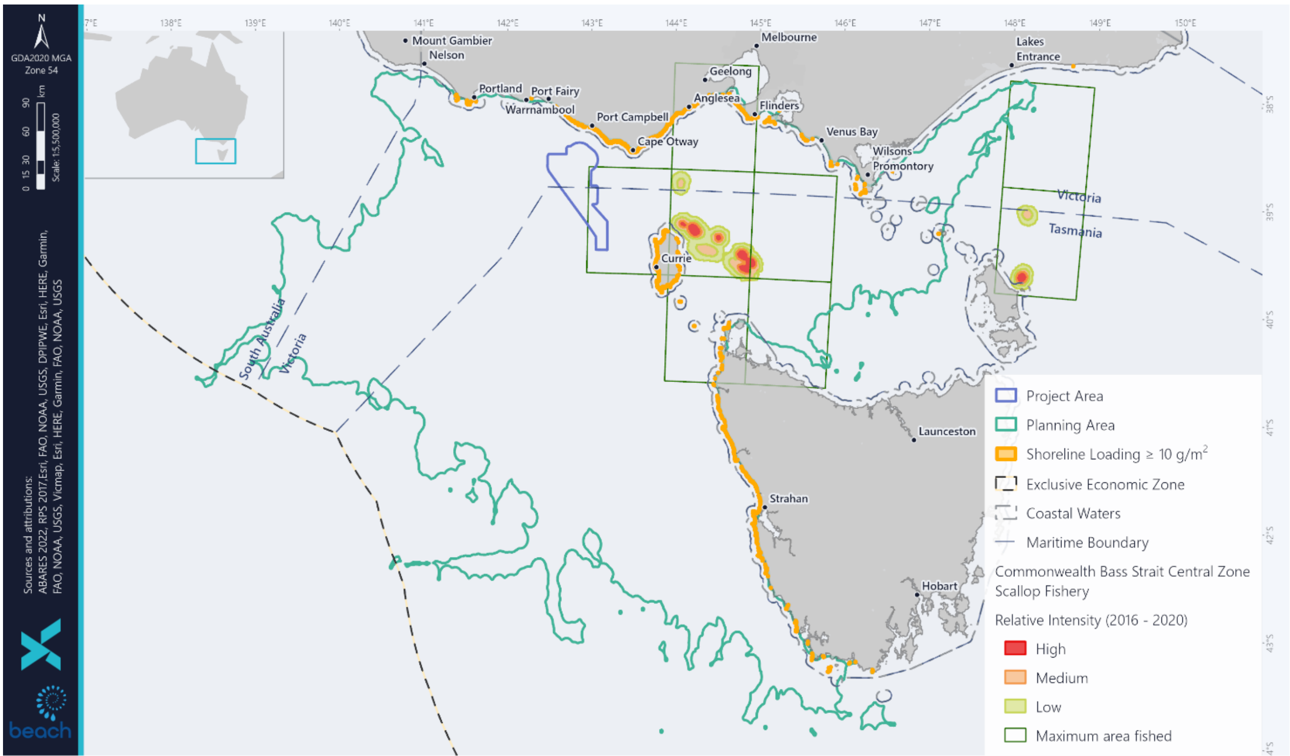


Figure 71: Commonwealth Bass Strait Central Zone Scallop Fishery Fishing Intensity (effort, net length, m/km2) and Maximum Area Fished

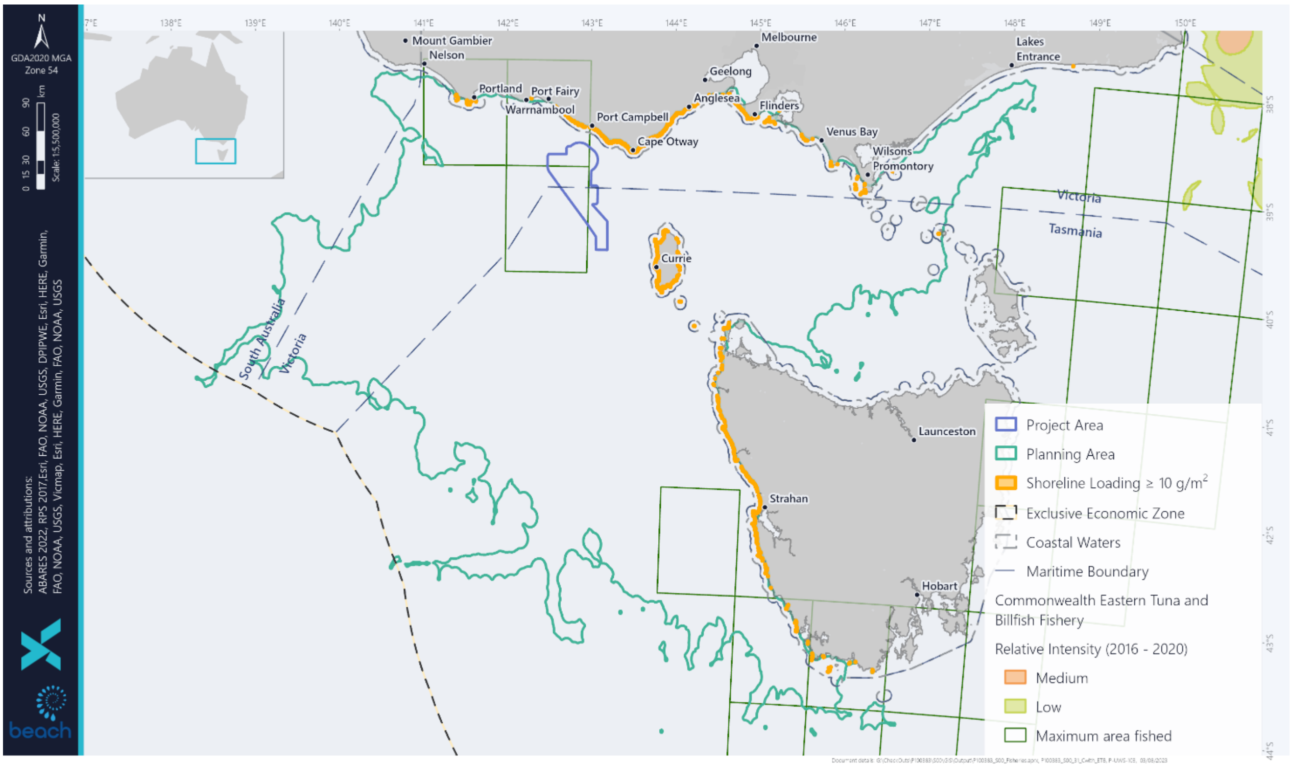


Figure 72: Commonwealth Eastern Tuna and Billfish Fishery Fishing Intensity (effort, net length, m/km2) and Maximum Area Fished

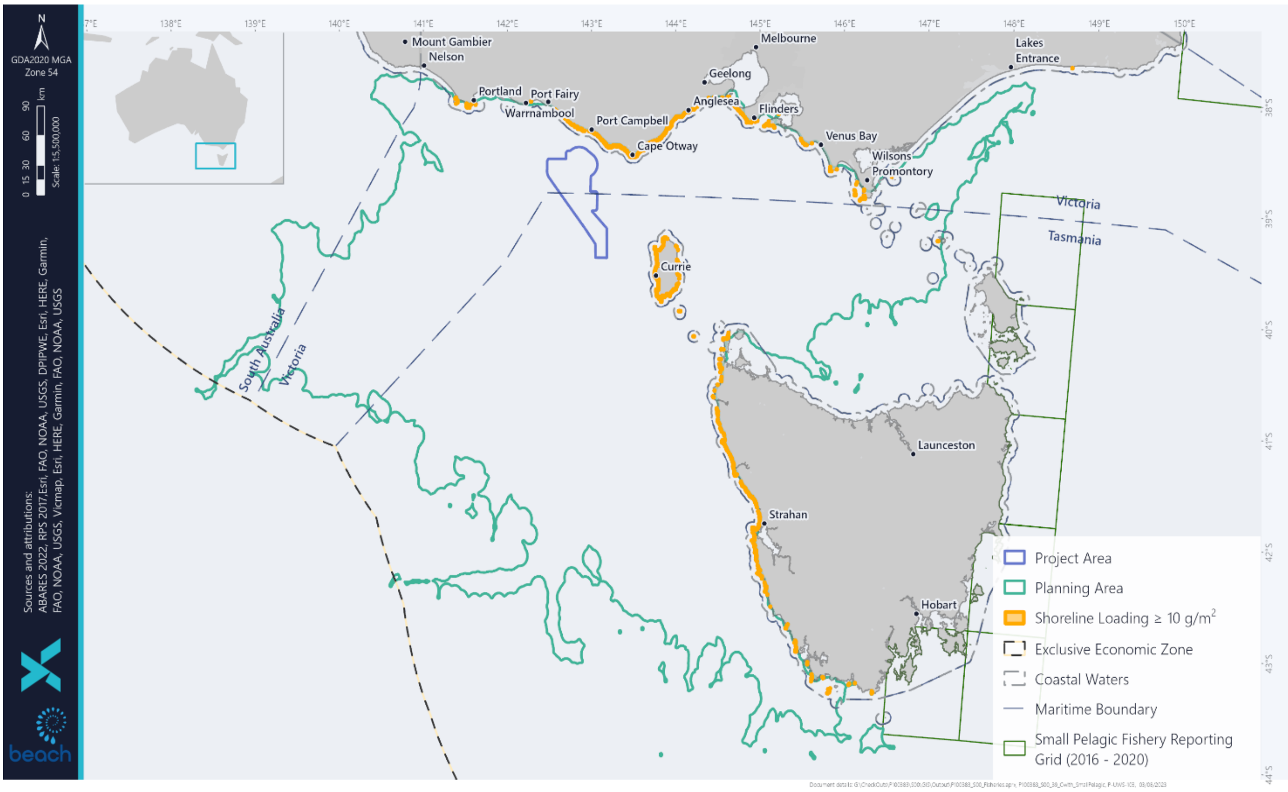


Figure 73: Commonwealth Small Pelagic Fishery Fishing Intensity (effort, net length, m/km2) and Maximum Area Fished

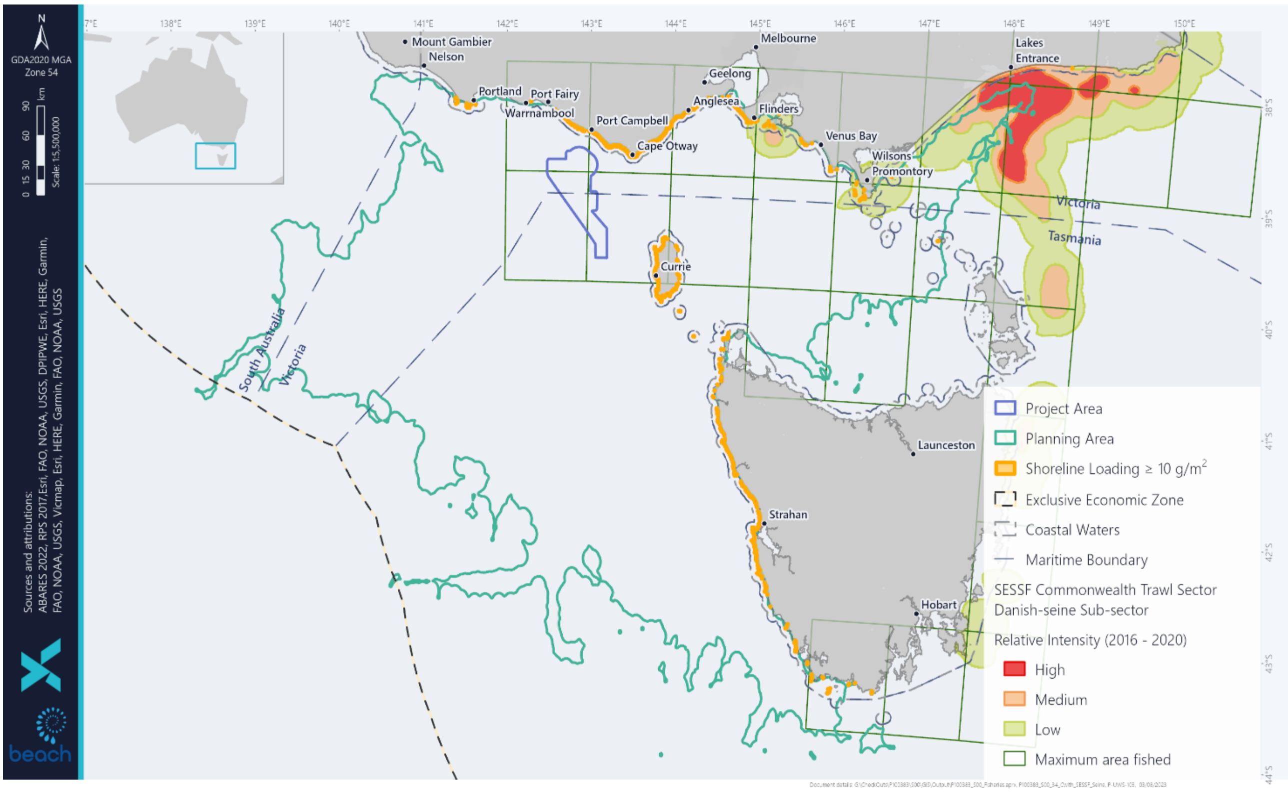


Figure 74: Southern and Eastern Scalefish and Shark Fishery (Commonwealth Trawl Sector) Danish-seine Fishing Intensity (effort, net length, m/km2) and Maximum Area Fished

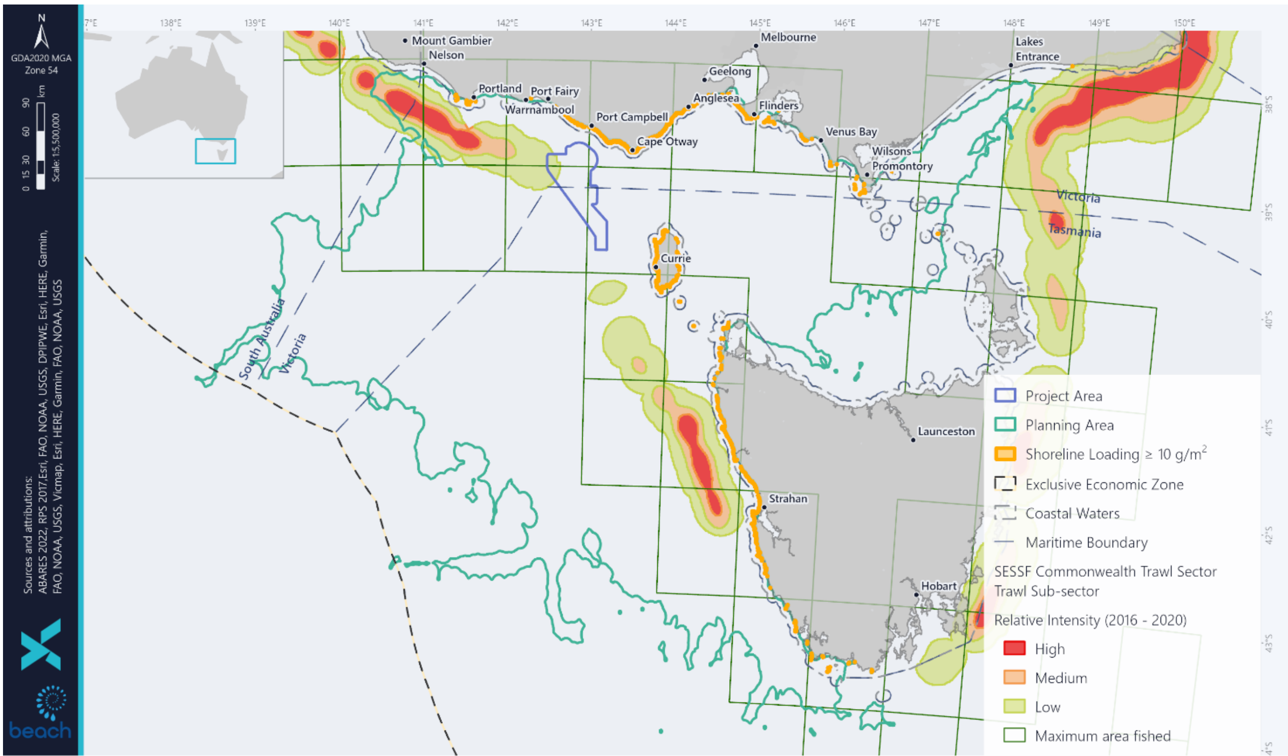


Figure 75: Southern and Eastern Scalefish and Shark Fishery (Commonwealth Trawl Sector) Otter Board Trawl Fishing Intensity (effort, net length, m/km2) and Maximum Area Fished

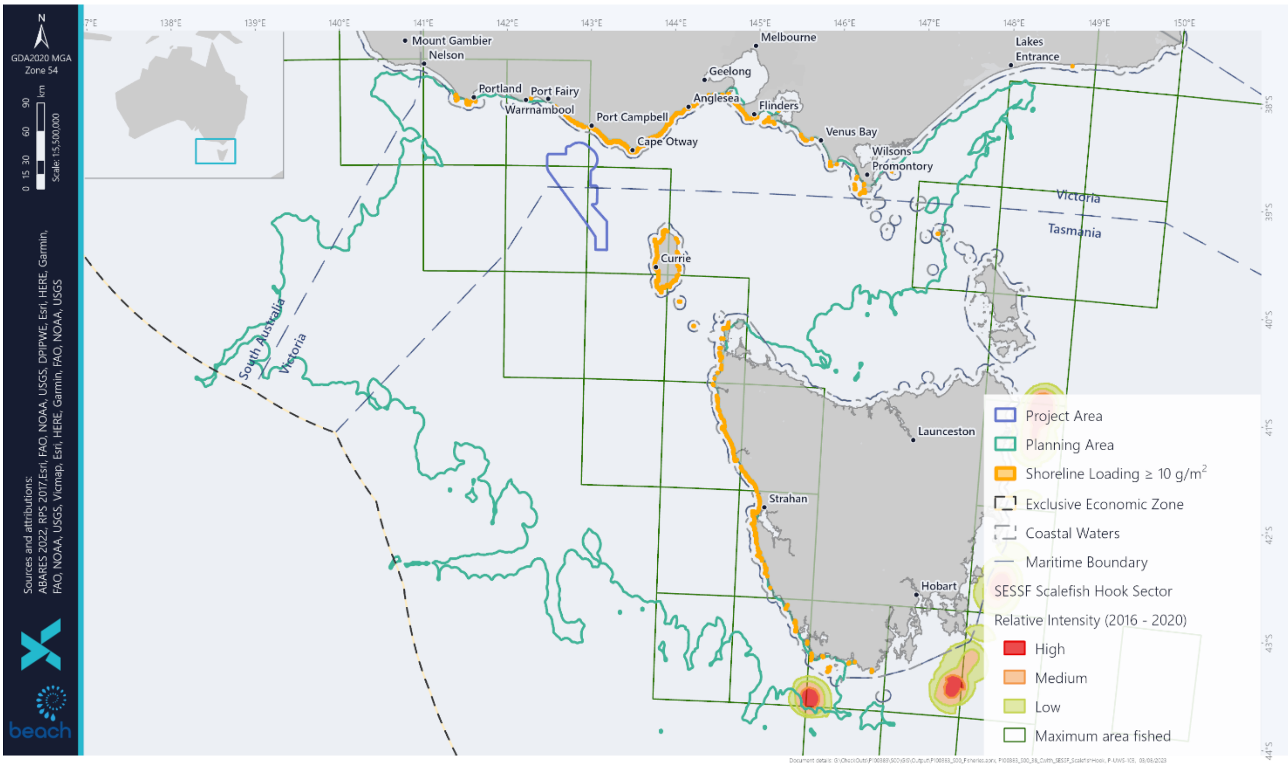


Figure 76: Southern and Eastern Scalefish and Shark Fishery (Scalefish Hook Sector) Fishing Intensity (effort, net length, m/km2) and Maximum Area Fished

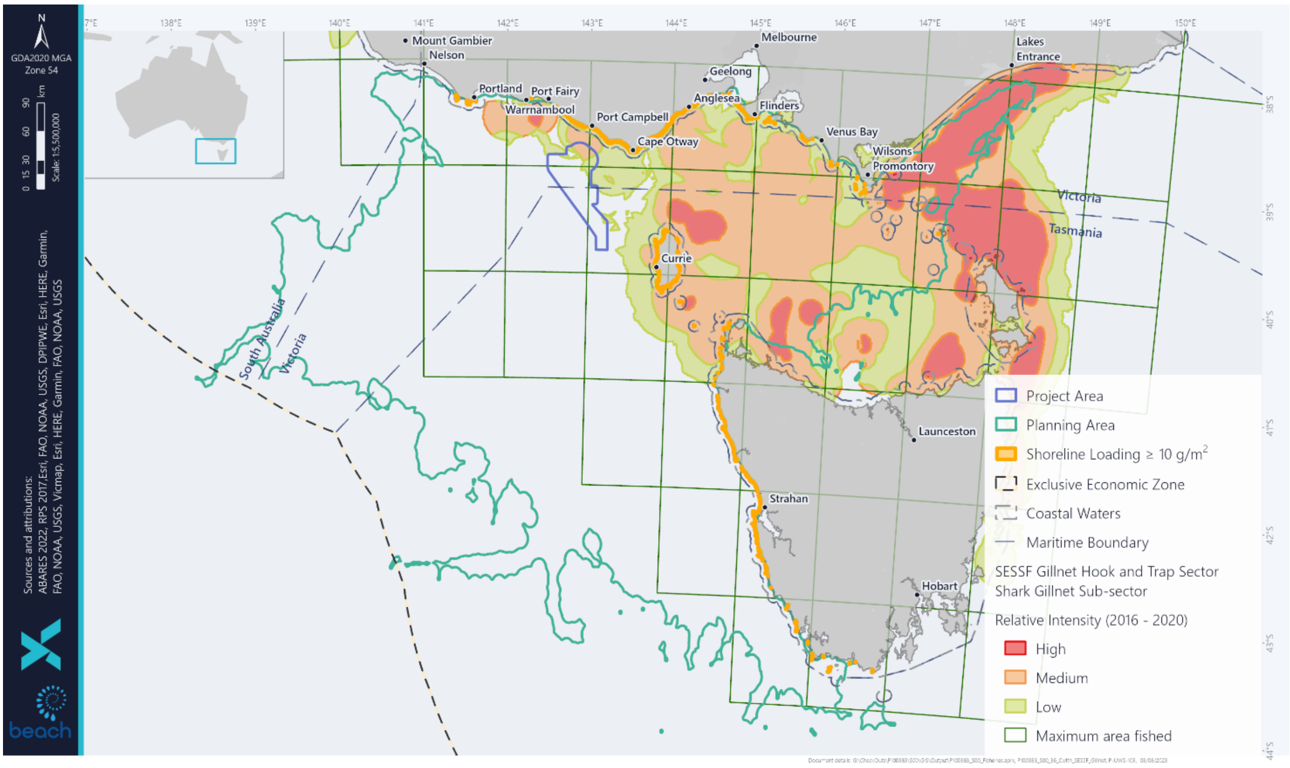


Figure 77: Southern and Eastern Scalefish and Shark Fishery (Commonwealth Trawl Sector) Danish-seine Fishing Intensity (effort, net length, m/km2) and Maximum Area Fished

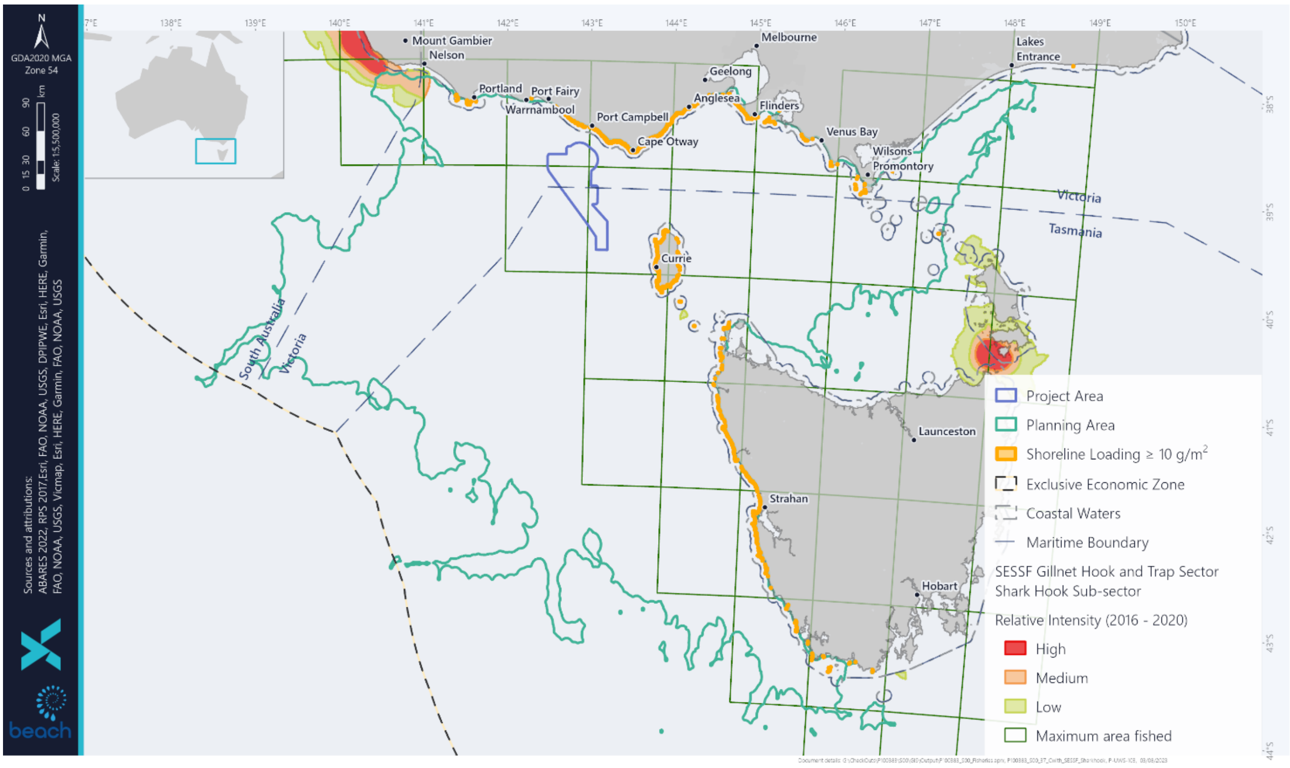


Figure 78: Southern and Eastern Scalefish and Shark Fishery (Gillnet Hook and Trap Sector) Shark Hook Fishing Intensity (effort, net length, m/km2) and Maximum Area Fished

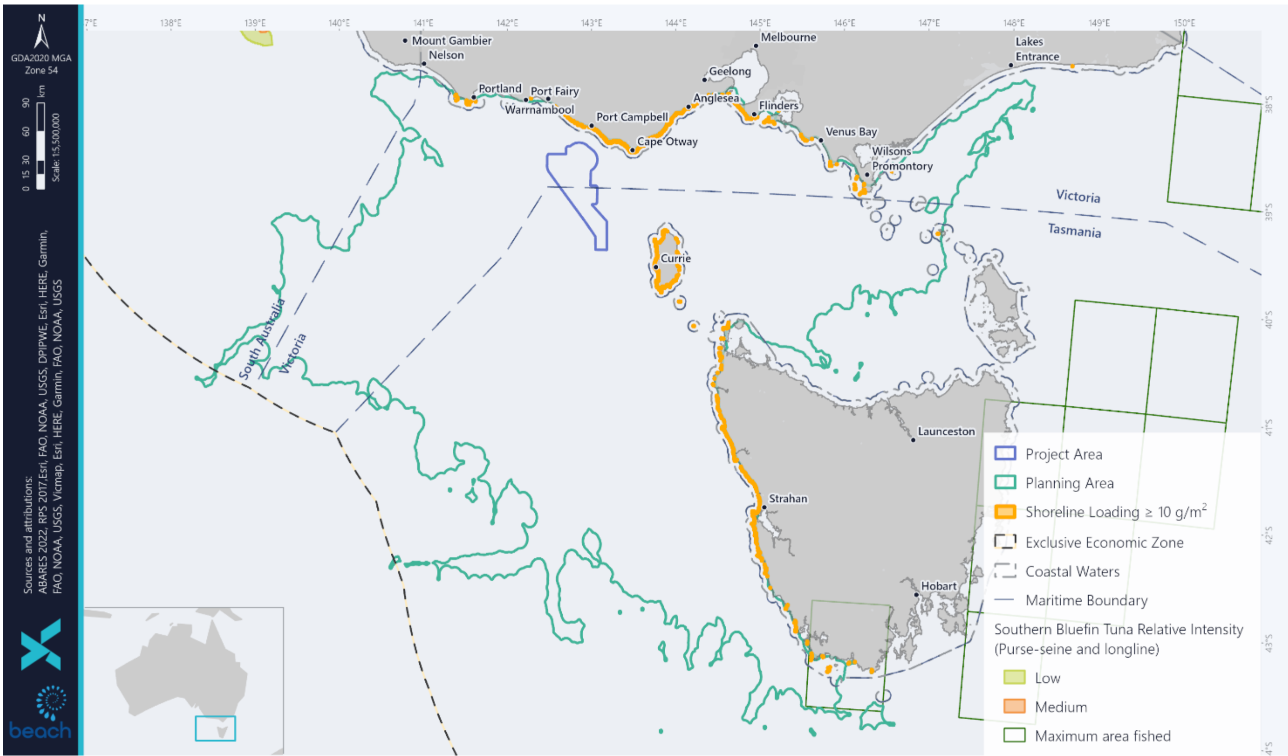


Figure 79: Commonwealth Southern Blue Fin Tuna Fishing Intensity (effort, net length, m/km2) and Maximum Area Fished

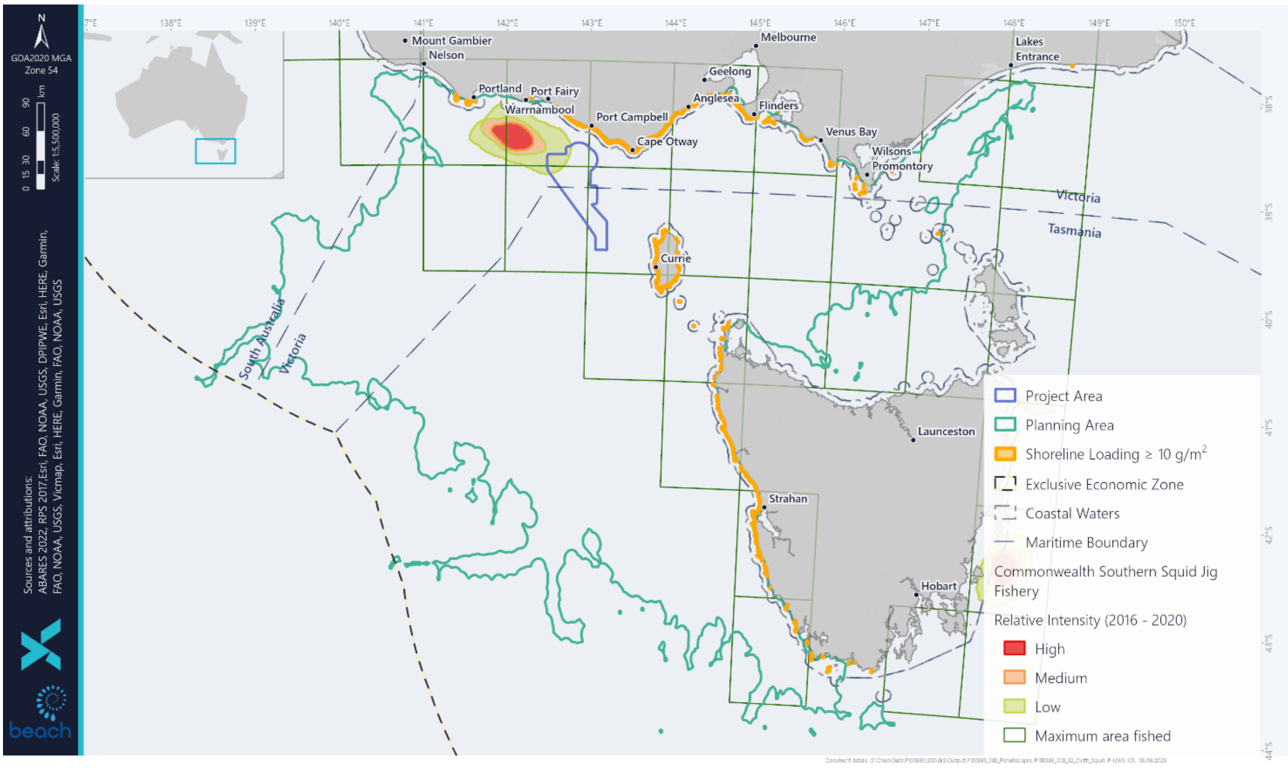


Figure 80: Commonwealth Southern Squid Jig Fishery Fishing Intensity (effort, net length, m/km2) and Maximum Area Fished

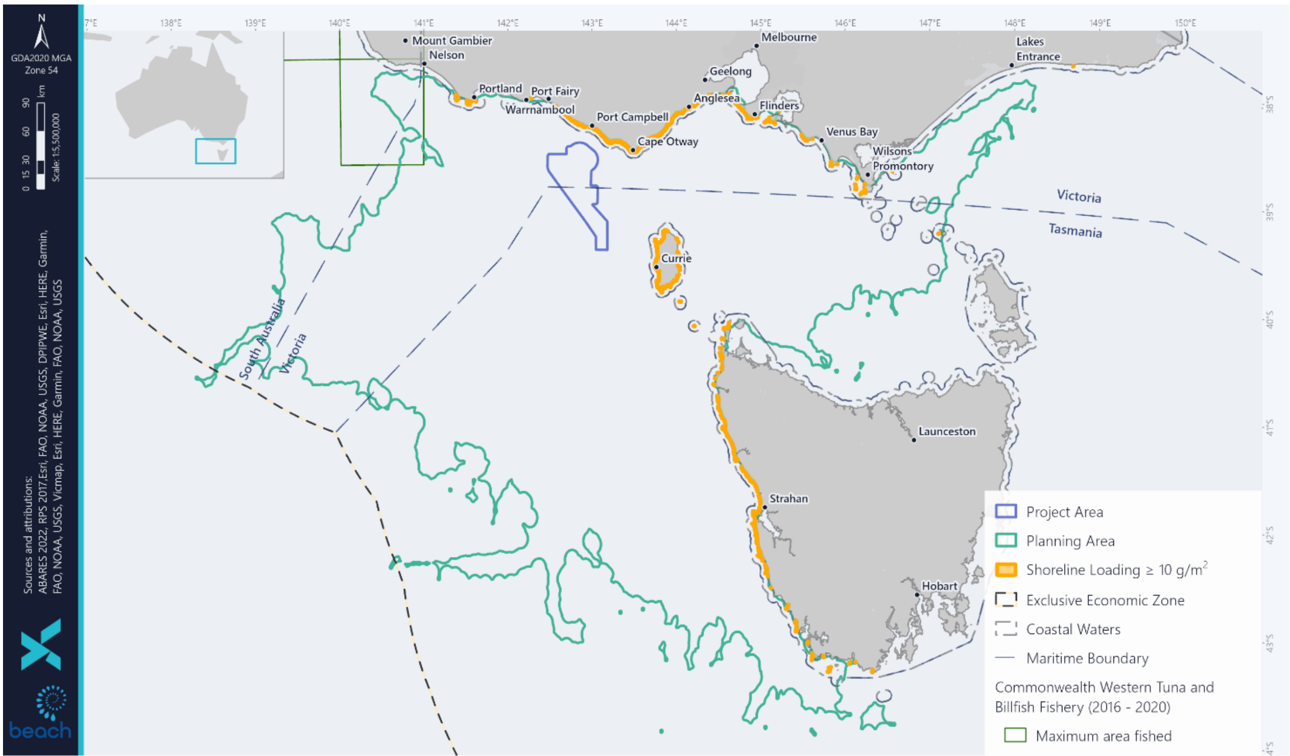


Figure 81: Commonwealth Western Tuna and Billfish Fishery Fishing Intensity (effort, net length, m/km2) and Maximum Area Fished

4.5.10 Victorian Managed Fisheries

There are eight Victorian state-managed commercial fisheries that overlap the Planning Area:

- Abalone Fishery
- Giant Crab Fishery
- Multispecies Ocean Fisheries (Inshore Trawl and Ocean General)
- Octopus Fishery
- Pipi Fishery
- Rock Lobster Fishery
- Scallop (Ocean) Fishery
- Wrasse (Ocean) Fishery

Of these, catch effort was identified within the Project Area for the Giant Crab Fishery and Rock Lobster Fishery.

Information relating to the target species, fishing locations, landed catch, value and other relevant aspects of each fishery is provided in **Table 41**. Maps are also provided displaying the number of vessels reported in a VFA grid between 2011–2021 in relation to the Project and/or Planning Areas. Fishing effort data is confidential if a grid has less than 5 active vessels. No data on the Abalone Fishery locations was available from VFA due to the confidential nature of the data.

Data sources are from the Victorian Fisheries Authority Commercial Fish Production Information Bulletin July 2020 to June 2021 (VFA 2021) and VFA website (VFA 2023) unless indicated.

Fishery	Target species	Description	Fishing Effort Project Area	Fishing Effort Planning Area
Abalone Fishery (central, eastern and western zones)	Blacklip Abalone Greenlip Abalone	The Victorian Abalone Fishery is a highly valuable fishery (A$16.8 million in 2020-21) that operates along most of the Victorian shoreline, generally to 30 m depth. Abalone are harvested by divers. Total allowable commercial catch (TACC) limits of Blacklip Abalone for the western zone are considerably less than the central and eastern zone (for 2019-20 season, 73.2 tonnes compared with 262.5 and 345.5 tonnes, respectively). There are 14 licences in the western zone, 23 in the eastern zone and 34 in the central zone. No fishing effort is expected within the Project Area due to depth. The water depths where abalone are fished are close to shore within the Planning Area.	No	Yes
Giant Crab Fishery	Giant Crab	The Giant Crab Fishery is a small fishery operating in western Victoria and closely linked with the Rock Lobster Fishery. Most vessels are used primarily for Rock Lobster fishing with Giant Crab taken as by-product. Fishing effort is concentrated on the continental shelf edge (~200 m deep). Giant Crabs inhabit the continental slope at approximately 200 m depth and are most abundant along the narrow band of the shelf edge. Closed seasons operate for male (15 Sept to 15 Nov) and female (1 June to 15 Nov) Giant Crabs. Total landed catch in 2015-16 was 10 tonnes. Data for 2020/21 is not available due to insufficient data to report because there are less than five licence holders (policy requirement to protect commercial confidentiality of data). **Figure 82** shows overlap of Giant Crab fished areas with the Project Area and Planning Area, which both contain areas with up to 15 active vessels. Catch effort data is considered confidential if there are less than 5 vessels active.	Yes	Yes
Multispecies Ocean Fisheries – Inshore Trawl	Eastern King Prawn School Prawn Shovelnose Lobster/Balmain Bug Minor bycatch of School Whiting	The fishery operates along the entire Victorian coastline, excluding marine reserves, bays and inlets. Most operators are based at Lakes Entrance. Otter-board trawls with no more than a maximum head- line length of 33 m, or single mesh nets are used. As of June 2019, there were 54 fishery access licences, with only about 15 active to various degrees. **Figure 83** shows the Planning Area overlaps areas with up to 19 active vessels. No fishing effort was identified within the Project Area. Catch effort data is considered confidential if there are less than 5 vessels active.	No	Yes

Fishery	Target species	Description	Fishing Effort Project Area	Fishing Effort Planning Area
Multispecies Ocean Fisheries – Ocean General Fishery	Gummy Shark School Shark Australian Salmon Snapper Small Flathead bycatch	The Wrasse, Inshore Trawl, Southern Rock Lobster and Giant Crab Fisheries are able to catch Gummy Shark and School Sharks as part of their fishery. Snapper are caught using lines, nets and haul seine. Over 90% of the catch is from Port Phillip Bay, and around 5% from coastal waters. In 2020-21, 45 tonnes were landed but a values could not be provided as there is insufficient data to report because there are less than five licence holders (policy requirement to protect commercial confidentiality of data). **Figure 84** shows the Planning Area overlaps areas with up to 88 active vessels. No fishing effort was identified within the Project Area. Catch effort data is considered confidential if there are less than 5 vessels active.	No	Yes
Octopus Fishery	Pale Octopus Maori Octopus Gloomy Octopus	The Octopus Fishery (Eastern Zone) is a new fishery harvesting mainly Pale Octopus (Octopus pallidus) in East Gippsland. The fishery may also catch Maori Octopus (Macroctopus maorum) and Gloomy Octopus (Octopus tetricus). Octopus are caught using purpose-built unbaited traps. The fishery commenced on 1st August 2020. Three fishery locations have been established for this new fishery; Eastern, Central and Western octopus zones. The Eastern zone is where the majority of commercial octopus takes place with the Central and Western zones are less established but are being managed by VFA through exploratory, temporary permits. **Figure 85** shows the Planning Area overlaps areas with up to 10 active vessels. No fishing effort was identified within the Project Area. Catch effort data is considered confidential if there are less than 5 vessels active.	No	Yes
Pipi Fishery	Pipi	The Pipi Fishery is a newly managed fishery with its first management plan declared in 2018. The fishery is now utilising an ongoing quota management regime with access licences issued for Discovery Bay and Venus Bay management zones, each with their own TACC. Commercial gear is restricted to dip nets but may allow new equipment based on trials and assessment. Mechanical harvesting will not be permitted. Pipi harvested commercially are sold for bait or for human consumption. **Figure 86** shows the Planning Area overlaps areas with less than 5 active vessels. No fishing effort was identified within the Project Area.	No	Yes

Fishery	Target species	Description	Fishing Effort Project Area	Fishing Effort Planning Area
Rock Lobster Fishery (western zone)	Southern Rock Lobster	The Rock Lobster Fishery is Victoria's second most valuable fishery with a production value of A$13.6 million in 2020/21. Since 2009-10, annual quotas have been set at between 230 and 260 tonnes and have been fully caught each year. In the western zone, most catch is landed through Portland, Port Fairy, Warrnambool, Port Campbell and Apollo Bay. Closed seasons operate for male (15 Sept to 15 Nov) and female (1 June to 15 Nov) lobsters. Southern Rock Lobsters are found to depths of 150 m, with most of the catch coming from inshore waters less than 100 m deep. **Figure 88** shows the Project Area and Planning Area overlap the Southern Rock Lobster fished areas. The Project Area overlaps areas with up to 34 active vessels while the Planning Area overlaps areas with as many as 117 active vessels. Catch effort data is considered confidential if there are less than 5 vessels active.	Yes	Yes
Scallop (Ocean) Fishery	Commercial Scallop	The Scallop Fishery extends the length of the Victorian coastline from high tide mark to 20 nm offshore. Fishers use a scallop dredge. Doughboy Scallops are taken as by-product but are not harvested in commercial quantities. Temporary closures occur when stocks are low to allow scallop beds to recover. TACC for 2015-16 was set at 135 tonnes, with results from the 2017/18 abundance survey indicating that TACC should remain at the same level. Scallops are mostly fished from Lakes Entrance and Welshpool. **Figure 87** shows the Planning Area overlaps a small area with up to 14 active vessels between Wilsons Promontory and Lakes Entrance. No fishing effort was identified within the Project Area. Catch effort data is considered confidential if there are less than 5 vessels active.	No	Yes
Wrasse (Ocean) Fishery	Bluethroat Wrasse Purple Wrasse Small catches of Rosy Wrasse, Senator Wrasse and Southern Maori Wrasse	The Victorian Wrasse (Ocean) Fishery extends the length of the Victorian coastline from high tide mark to 20 nm offshore. Fishers mostly use hook and line. There is limited entry to the fishery with 22 current licences. Total annual catches in 2014-15 and 2015-16 were approximately 30 tonnes. **Figure 89** shows the Planning Area overlaps areas along the coast with up to 14 active vessels. No fishing effort was identified within the Project Area. Catch effort data is considered confidential if there are less than 5 vessels active.	No	Yes

Table 41: Victorian Managed Fisheries within the Project Area and Planning Area

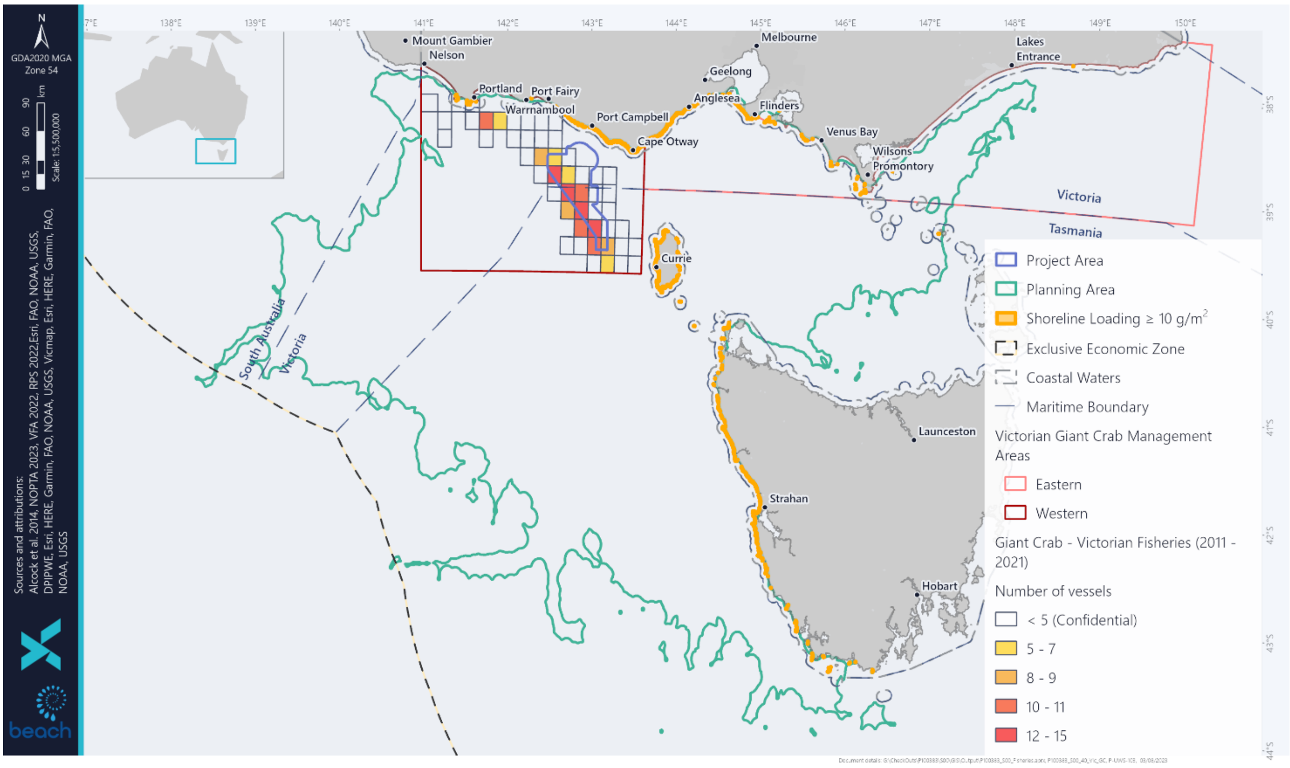


Figure 82: Giant Crab Fishery Number of Vessels from 2021-2021. Data obtained from VFA 2022

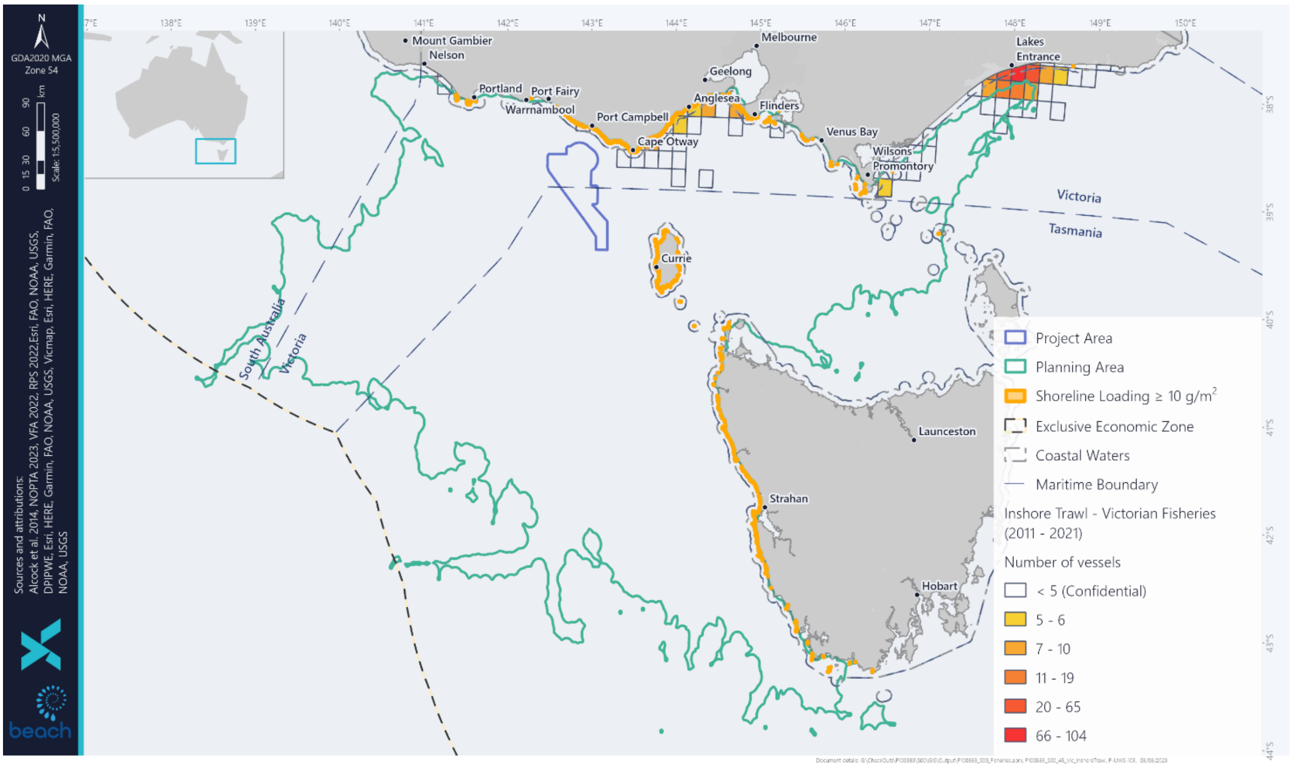


Figure 83: Multispecies Ocean Fisheries – Inshore Trawl Fishery Number of Vessels from 2011-2021. Data obtained from VFA 2022.

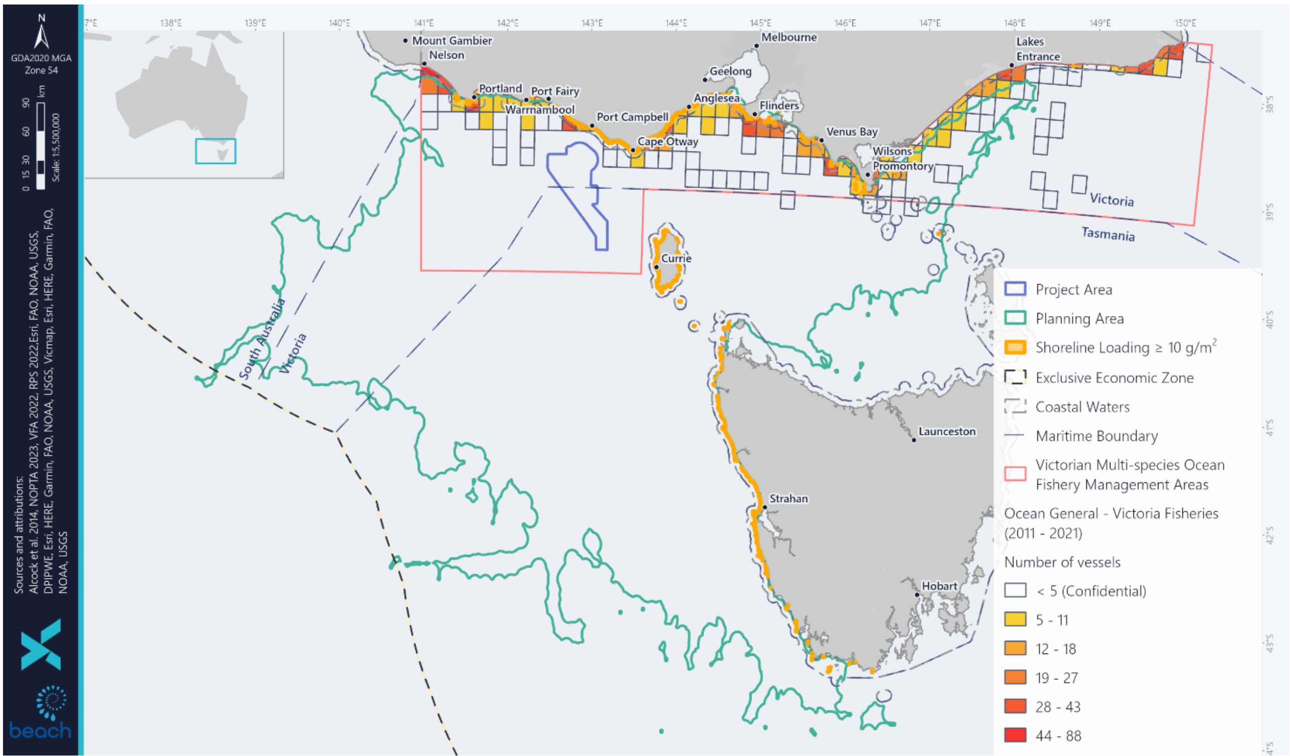


Figure 84: Multispecies Ocean Fisheries – Ocean General Fishery Number of Vessels from 2011-2021. Data obtained from VFA 2022

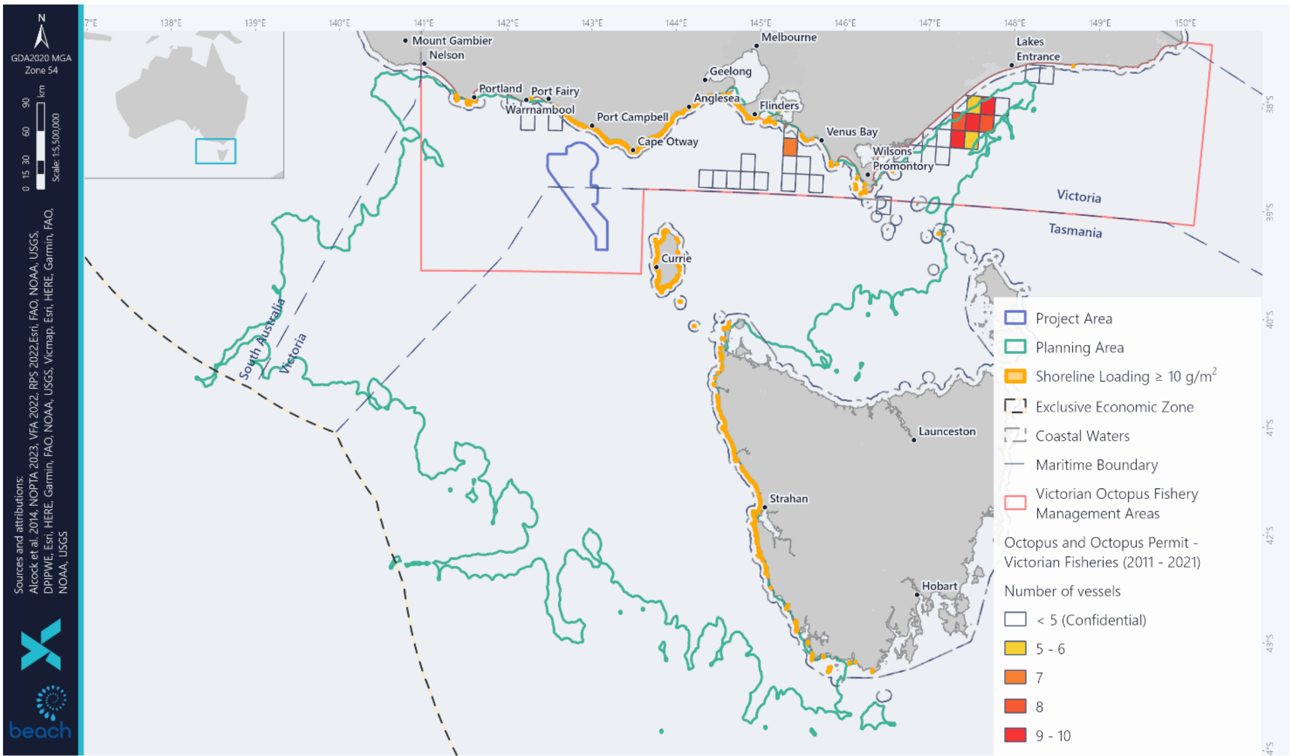


Figure 85: Octopus and Octopus Permit Fishery Number of Vessels from 2011-2021. Data obtained from VFA 2022

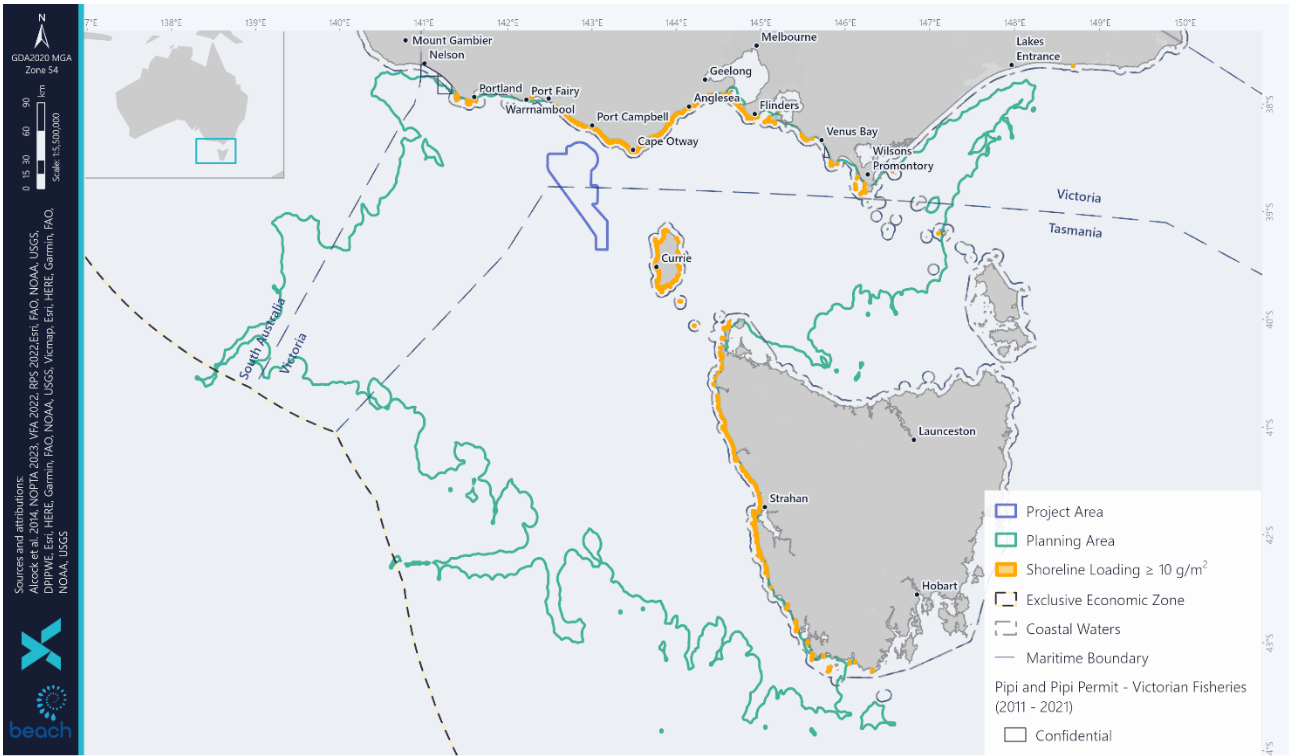


Figure 86: Pipi Fishery Number of Vessels from 2011-2021. Data obtained from VFA 2022.

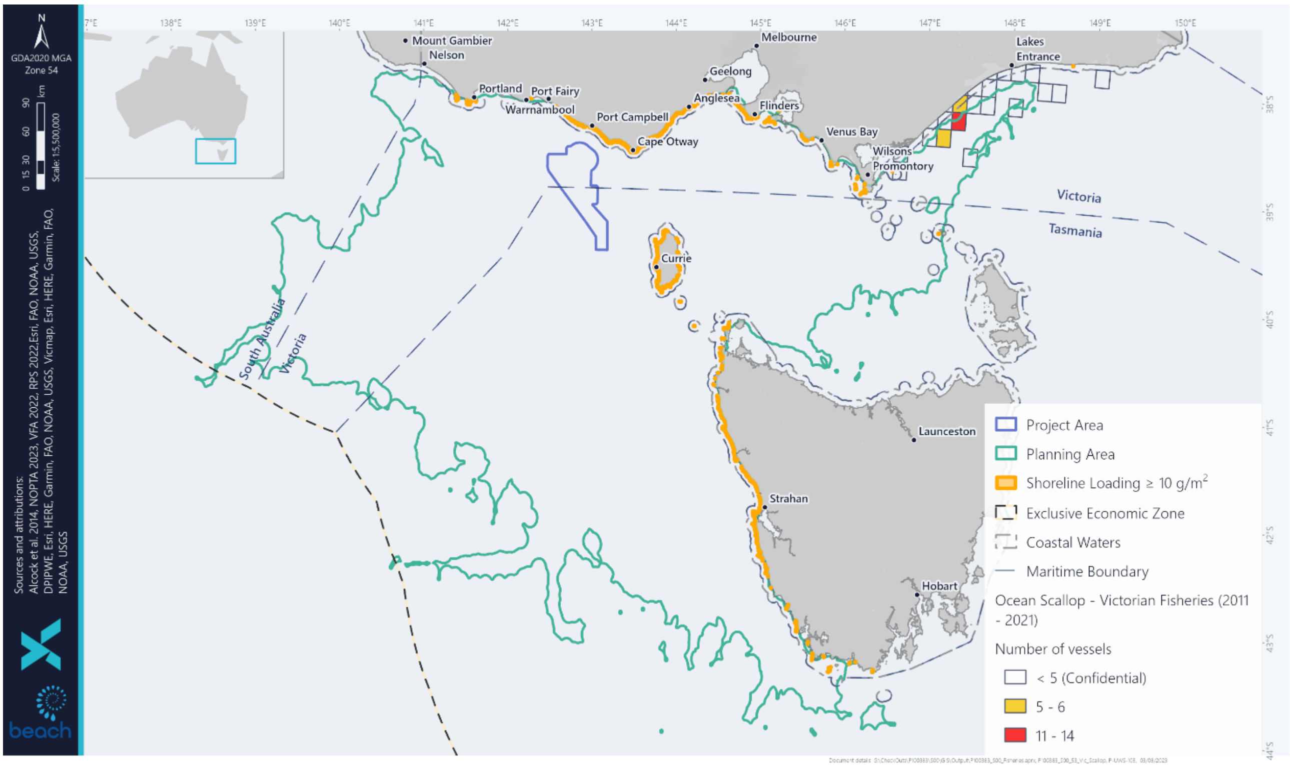


Figure 87: Ocean Scallop Fishery Number of Vessels from 2011-2021. Data obtained from VFA 2022.

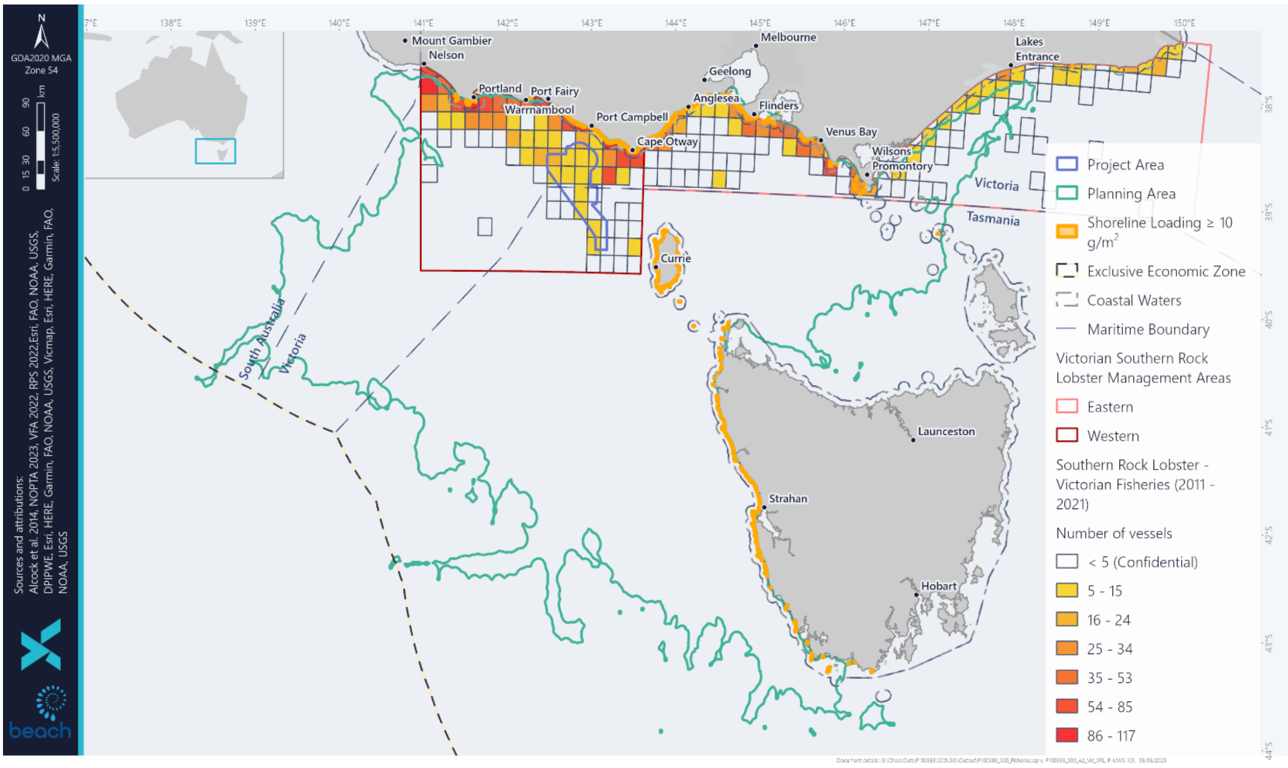


Figure 88: Southern Rock Lobster Fishery Number of Vessels from 2011-2021. Data obtained from VFA 2022.

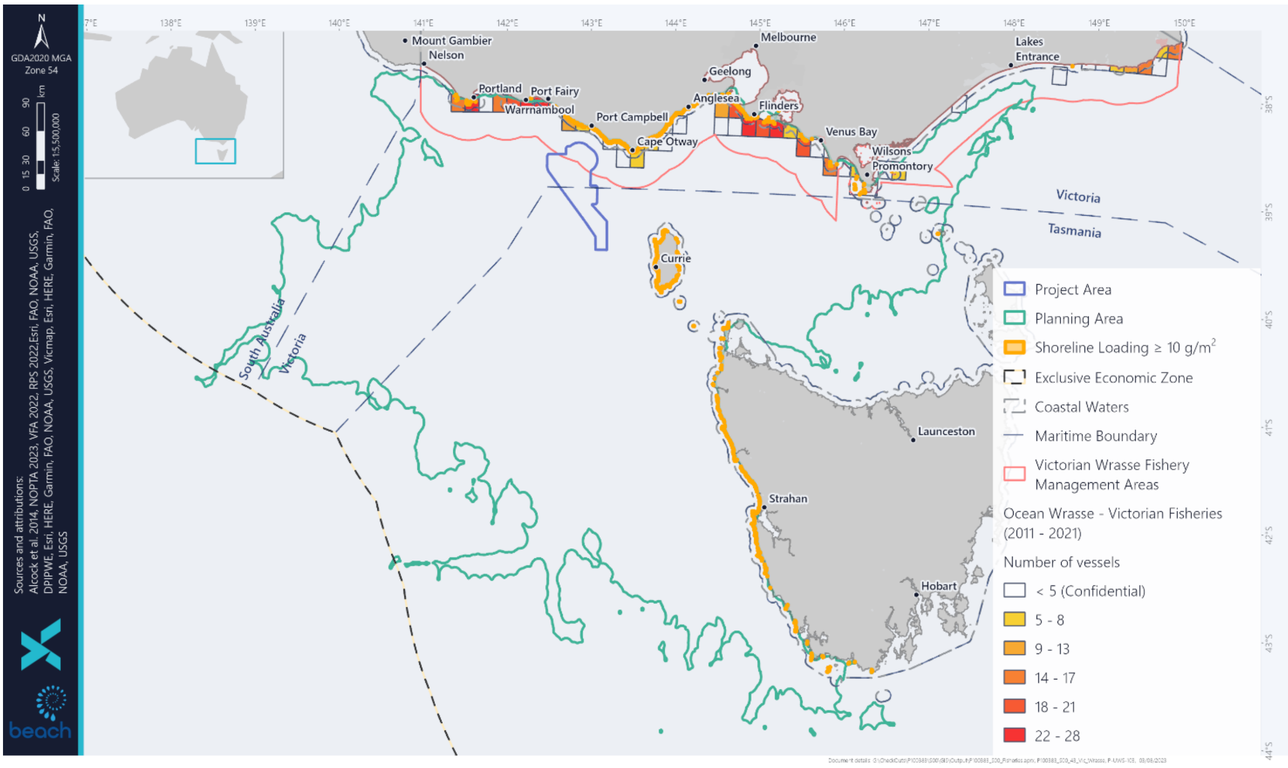


Figure 89: Wrasse (Ocean) Fishery Number of Vessels from 2011-2021. Data obtained from VFA 2022

4.5.11 Tasmanian Managed Fisheries

Fishing Tasmania manages Tasmania's commercial fisheries under the *Living Marine Resources Management Act 1995*.

All fisheries except for the Giant Crab Fishery and the Rock Lobster Fishery operate within Tasmanian waters. The Giant Crab Fishery and the Rock Lobster Fishery also operate in Commonwealth waters under an Offshore Constitutional Settlement (OCS) between the Australian Government and the Government of Tasmania.

There are eight Tasmanian state-managed commercial fisheries that may overlap the Planning Area:

- Abalone Fishery
- Commercial Dive Fishery
- Giant Crab Fishery
- Marine Plant Fishery
- Rock Lobster Fishery
- Scalefish Fishery
- Scallop Fishery
- Shellfish Fishery

Only the Rock Lobster Fishery occurs within the Project Area.

Information relating to the target species, fishing locations, landed catch, value and other relevant aspects of each fishery is detailed in **Table 42**. Data and information sources are Fishing Tasmania (2023).

Maps are also provided showing where the number of vessels reported in a Tasmanian Fishery grid between 2011 – 2021 in relation to the Project Area and/or Planning Area and for the Rock Lobster Fishery and Giant Crab Fishery for which data from Fishing Tasmania is available.

Fishery	Target species	Description	Fishing Effort Project Area	Fishing Effort Planning Area
Abalone Fishery (Northern, Western and Bass Strait Zones)	Blacklip Abalone Greenlip Abalone	The Tasmanian Abalone Fishery is the largest wild abalone fishery in the world (providing ~25% of global production) and a major contributor to the local economy. Abalone are hand-captured by divers in depths between 5-30 m. Blacklip Abalone are collected around on rocky substrate around the Tasmanian shoreline and are the primary target of the fishery. Greenlip Abalone are distributed along the north coast and around the Bass Strait islands and usually account for around 5% of the total wild harvest. In 2020/21, the gross value of production of the fishery was around A$50 million from a total catch of approximately 1,000 tonnes. The jurisdictional area of the Abalone Fishery is Tasmanian State waters. The Project Area does not overlap the Abalone Fishery. The Planning Area overlaps the Northern Zone (waters around King Island), Bass Strait Zone (waters in the Northern Bass Strait Region) and Western Zone (waters along the west coast of Tasmania) of the Abalone Fishery.	No	Yes
Commercial Dive Fishery (Northern and Western Zones)	Longspined Sea Urchin Shortspined Sea Urchin Wavy Periwinkle	The Tasmanian Commercial Dive Fishery is a capture fishery that targets several different species; the main species collected being sea urchins and periwinkles. In 2020-2021 approximately 180 t of sea urchins and 2.07 t of periwinkles were harvested. Sea urchins and periwinkles accounted for 63% and 37% of the total respectively. Jurisdiction encompasses all Tasmanian State waters (excluding protected and research areas), although licence holders largely operate out of small vessels (<10 m) and effort is concentrated on the south and east costs of Tasmania around ports. The Project Area does not overlap the Commercial Dive Fishery. The Planning Area overlaps the Northern Zone of the Commercial Dive Fishery at King Island, at the north-west coast of Tasmania and in the northern Bass Strait. The Planning Area also overlaps the Western Zone of the Commercial Dive Fishery along the west coast of Tasmania.	No	Yes
Giant Crab Fishery	Giant crab	The Giant Crab Fishery is a comparatively small fishery with the annual harvest set at 20.7 tonnes but with a high landed value of around A$2 million. The fishery has been commercially targeted since the early 1990s, moving from open access to limited entry. The area of the fishery includes waters surrounding the state of Tasmania generally south of 39º12 out to 200 nm. Within the area of the fishery, most effort takes place on the edge of the continental slope in water depths between 140 m and 270 m. CPUE has declined continually since the inception of the fishery in the early 1990s indicating that it has been overfished. The TAC has been reduced to 20.7 t for 2019/120 and 2021/2022 to address the issue.	No	Yes

Fishery	Target species	Description	Fishing Effort Project Area	Fishing Effort Planning Area
		As detailed in **Figure 90** there is one grid with <6 vessels within the Project Area which is an error as it is outside the area of the fishery. **Figure 90** shows the Planning Area overlaps areas along with up to 13 active vessels. No fishing effort was identified within the Project Area. Catch effort data is considered confidential if there are less than 6 vessels active.		
Marine Plant Fishery	Bull kelp Japanese kelp	Marine plants include kelp, seaweed, seagrasses, and algae which are food and habitat for other marine species. To protect Tasmanian marine ecosystems, no marine plants may be harvested directly from the water, except in the Undaria fishery. The majority of cast bull kelp is collected from King Island. The right to harvest and process kelp on King Island was granted exclusively to Kelp Industries Pty Ltd in the mid-1970s. About 80 to 100 individuals collect cast bull kelp and transport it to the Kelp Industries plant in Currie. An average annual harvest above 3000 t (dried weight) has been produced in recent years, accounting for about 5% of the world production of alginates (i.e. the end product of dried bull kelp). The cast bull kelp harvesting on King Island generates about A$2 million annually. Comparatively minor cast bull kelp collection also occurs at two centres of operation on Tasmania’s West Coast: around Bluff Hill Point and at Granville Harbour. Japanese kelp is harvested by divers only along Tasmania’s east coast where it is already well established. The Planning Area overlaps the area where bull kelp is potentially collected from King Island.	No	Yes
Rock Lobster Fishery	Southern rock lobster	The Rock Lobster Fishery is the other major wild-caught Tasmanian fishery. For 2022-23 the Total Allowable Catch remains at 1050.7 t. Southern rock lobsters are found to depths of 150 m with most of the catch coming from inshore waters less than 100 m deep throughout state waters. The fishery is a limited entry with 312 licences. The Project Area overlaps a small area with less than 6 active vessels. Catch effort data is considered confidential if there are less than 6 vessels active. **Figure 91** shows the Planning Area overlaps areas with up to 152 active vessels.	Yes	Yes
Scalefish Fishery (northwest coast)	Multi-species and multi-gear fishery	The Scalefish Fishery is a complex multi-species fishery harvesting a range of scalefish, shark and cephalopod species. Fourteen different fishing methods are used. The highest commercial catches in 2019/20 were reported for southern calamari (85.8 t), wrasse (52.4 t), and eastern school whiting (43.7 t). Due to the fishery being under caught by 26.7% in the previous season 2020/21, the Total Allowable Catch for the 2021/22 season has increased to 30 kg quota unit. The Planning Area overlaps the Scalefish Fishery management area.	No	Yes

Fishery	Target species	Description	Fishing Effort Project Area	Fishing Effort Planning Area
Scallop Fishery	Commercial Scallop	The Scallop Fishery uses a benthic scallop dredge to target one of three species of scallop naturally occurring in Tasmania, the Commercial Scallop (Pecten fumatus). The fishery extends 200 nm from the eastern, western and southern coasts of Tasmania. In the Bass Strait, the fishery extends 3-20 nm offshore along the north coast from King Island to Flinders Island. The Planning Area overlaps the Scallop Fishery Management Area.	No	Yes
Shellfish Fishery	Katelysia Cockles Venerupis Clam Native Oyster Pacific Oyster	The Shellfish Fishery comprises specific shellfish species hand captured by divers in defined locations on the east coast of Tasmania, namely Angasi oysters in Georges Bay, Venerupis Clams in Georges Bay and Katelysia Cockles in Ansons Bay. The taking of Pacific Oysters, an invasive species, is also managed as part of the fishery but no zones apply. Pacific Oysters can be collected throughout all State waters (which includes areas within the Planning Area), as the aim of harvesting these animals is to deplete the wild population. The estimated total value of the shellfish fishery based on landings from 2001-2005 was A$345,538. The Planning Area could potentially overlap areas where Pacific Oysters are collected.	No	Yes

Table 42: Tasmanian Managed Fisheries within the Project Area and Planning Area

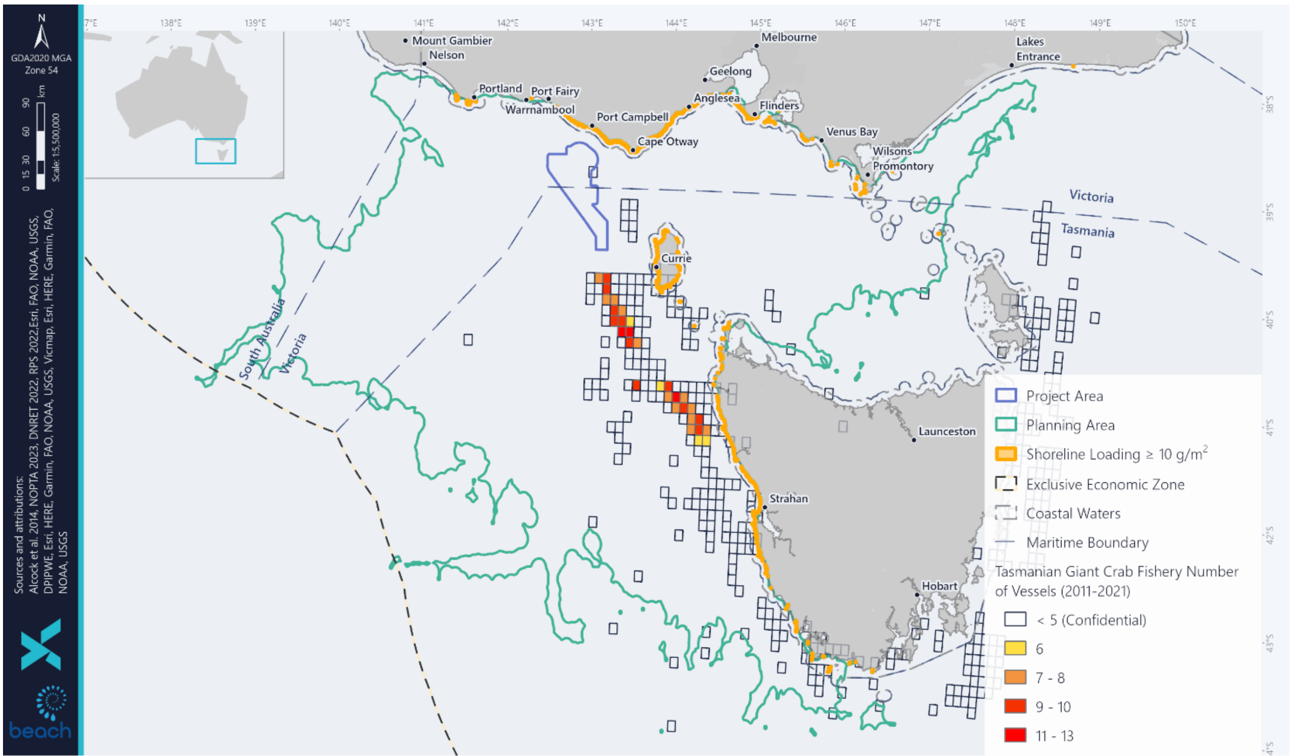


Figure 90: Tasmanian Giant Crab Fishery Number of Vessels from 2011 to 2021. Data obtained from DNRET 2022

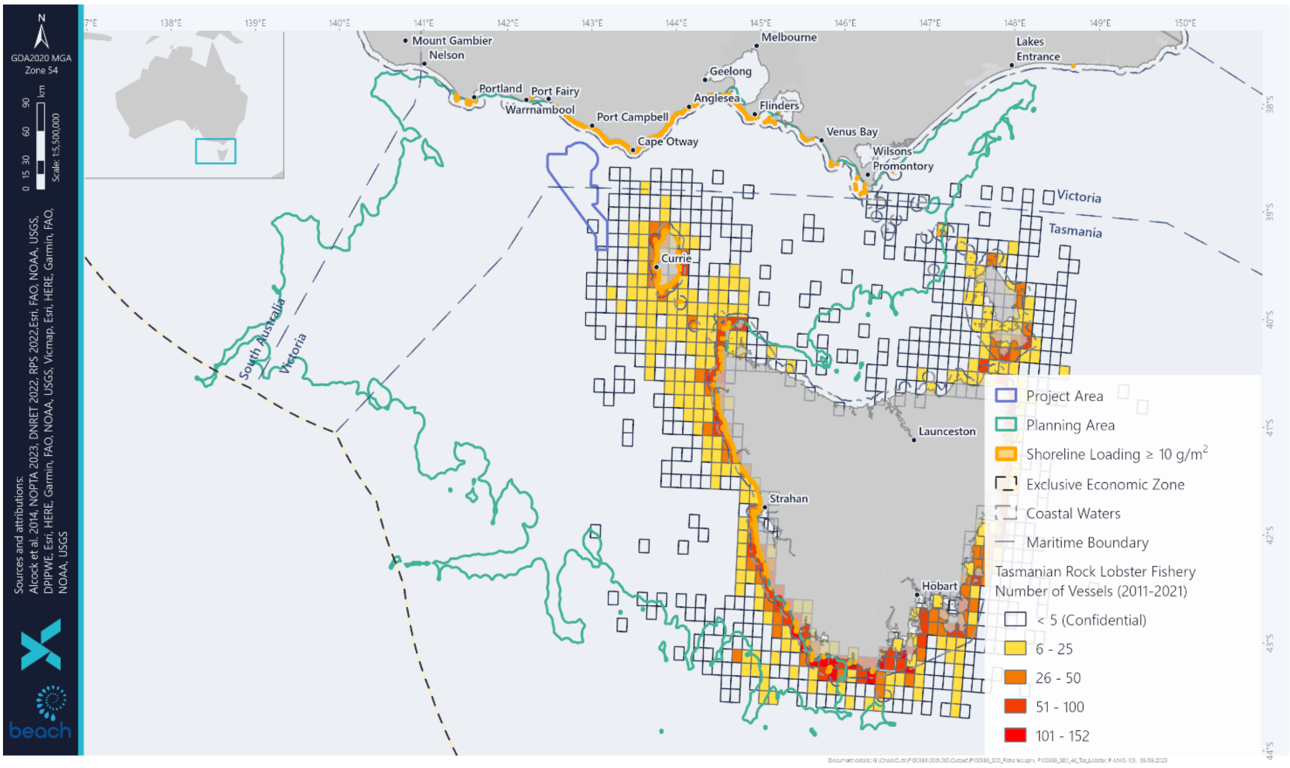


Figure 91: Tasmanian Rock Lobster Fishery Number of Vessels from 2011 to 2021. Data obtained from DNRET 2022

4.5.12 South Australian Managed Fisheries

The *Fisheries Management Act 2007* and its regulations provide the legislative framework, objectives, and guiding principles for the management of fisheries in South Australia. Management rules for commercial fisheries are provided in fisheries regulations under the Act.

The Department of Primary Industries and Regions (DPIR) is responsible for the ecologically sustainable development of South Australia's aquatic resources and the administration of the *Fisheries Management Act 2007*.

The Project Area does not overlap any South Australian Fisheries.

Data from DPIR identified that the Planning Area overlaps the following fisheries:

- Abalone Fishery
- Charter Boat Fishery
- Giant Crab Fishery
- Marine Scalefish Fishery
- Rock Lobster Fishery

Information relating to the target species, fishing locations, landed catch, value and other relevant aspects of each fishery is included in **Table 43**. Data sources are from DPIR fishing data from 2012 to 2022 for fishing block 58 which the Planning Area overlaps, and DPIR (2023), unless otherwise noted.

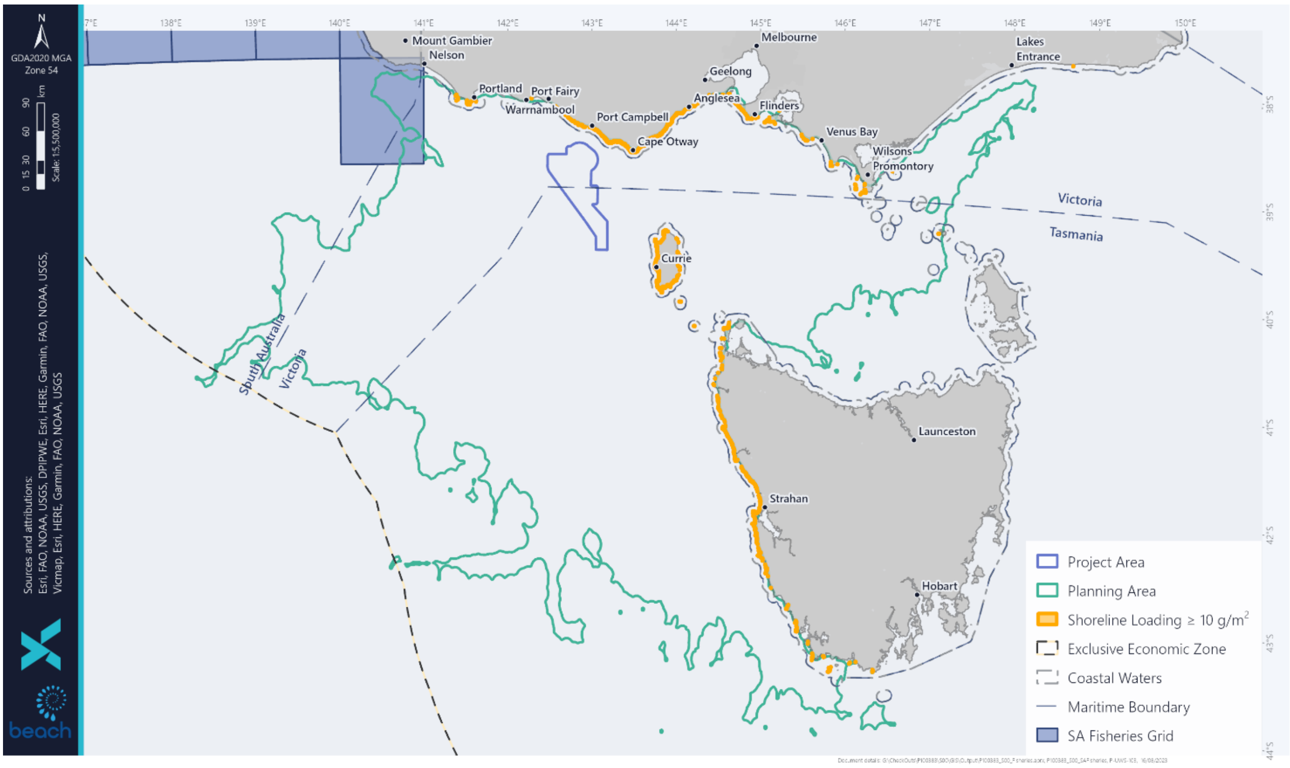


Figure 92: South Australian Fisheries Blocks within the Planning Area

Fishery	Target species	Description	Fishing Effort Project Area	Fishing Effort Planning Area
Abalone Fishery	Blacklip Abalone Greenlip Abalone	The South Australian commercial abalone fishery takes Greenlip and Blacklip Abalone that inhabit subtidal reefs out to approximately 30 m. Commercial abalone divers mostly operate from large, trailered boats. Divers use surface supplied air from the boat and may use motorised cages to mitigate physical interactions with White Sharks. The Planning Area overlaps the Southern Zone of the fishery where there have been six active licences from 2021 to 2022. Hours dived range from 921 to 1496 per year with annual catch between 101,133 to 153,491 kg.	No	Yes
Charter Boat Fishery	Various	The Charter Boat Fishery is a limited entry fishery with 82 licence holders of which 47 were active in 2020/2021. Fishing in inshore regions where water depths are < 50 m is the most frequent activity. Peak periods are between December and April (summer) and October. Seventy-eight species of fish, shark, mollusc, cephalopods, and crustacean are targeted with King George Whiting, snapper and Bight Redfish are the highest catches. The above information is from Durante et al. (2022). The Planning Area overlaps the fishery where there have been six active licences in 2019/20 but typically five or less than five licenses from 2012 to 2022.	No	Yes
Giant Crab Fishery	Giant Crab	Information from in this section is from McLeay (2022). Giant Crab (Pseudocarcinus gigas), also known as King Crab, is endemic to southern Australian waters and distributed from southern Western Australia to central New South Wales. While they occur at depths ranging from 20 to 600 m, the highest population densities are found at the edge of the continental shelf at depths of approximately 140 to 270 m. Fishers use a maximum of 100 steel-framed pots that must comply with pot dimension specifications. Commercial access to the Giant Crab resource is limited to licence holders in the Miscellaneous Fishery and Rock Lobster Fishery. Total allowable catch in the fishery is 22.1 t per year, consisting of 13.4 t in the Northern Zone and 8.7 t in the Southern Zone, with total catch ranging from 15.4 t in 202/21 to 18.4 t in 2017/218. The Giant Crab fishing season in between 1 October 31 May, with the fishing season in the Southern Zone between 1 October and 30 April, and in the Northern Zone between 1 November and 31 May. The Planning Area overlaps the southern zone of the fishery. DPIR could not provide data specific to the area that the Environmental Planning Area overlaps as all data for the Giant Crab Fishery is confidential.	No	Yes

Fishery	Target species	Description	Fishing Effort Project Area	Fishing Effort Planning Area
Marine Scalefish Fishery	King George Whiting Southern Garfish Southern Calamari	The Marine Scalefish Fishery is a multi-species and multi-gear fishery. Commercial fishing can be undertaken for more than 60 species of scalefish using a range of gear types. The Sardine Fishery is a part of the Marine Scalefish Fishery The Marine Scalefish Fishery operates in all coastal waters of South Australia between the Western Australian and Victorian border. For some species the Offshore Constitutional Settlement extends the fishery area out 200 nm to the Australian Exclusive Economic Zone miles. The fishing area includes gulfs, bays and estuaries, excluding the Coorong. The main species taken are: • King George Whiting • Southern Garfish • Southern Calamari. Those 4 species make up: • 60% of the total fishery production weight • 70% of the total fishery value. Not all species taken by this fishery are scalefish. Other species include squid, worms, sharks. In 2020 there were >300 licences in the fishery. Total annual catches of primary species decline from 2,089 t in 2001 to 807 t in 2020. The Planning Area overlaps the fishery where there have been 15 active licences in 2012/13 to less than 5 in 2021/22.	No	Yes
Rock Lobster Fishery	Southern Rock Lobster	The Rock Lobster Fishery is based on the capture of Southern Rock Lobster (Jasus edwardsii). Other species are permitted to be landed and sold, including Giant Crabs and octopus. Rock lobsters are commercially harvested with pots that are set overnight. Rock lobster licence holders may also harvest marine scalefish as endorsed on their licence. The Environmental Planning Area is within the fishery Southern Zone which is closed from 31 May to 1 October. The total reported 2020 logbook catch was 1,275.5 t (99% of TACC). The annual catch within the Planning Area ranged from 331 t to 420 t from 2012 to 2022. During this period licence holders ranged from 43 to 71.	No	Yes

Table 43: South Australian Managed Fisheries within the Project Area and Planning Area

4.5.13 Seaweed Industry

The Australian seaweed industry is small: currently valued at an estimated GVP of AUD $3 million. Of this, the majority is from one company, Kelp Industries Pty Ltd on King Island in Tasmania, who hand collect plants cast bull kelp (*Durvillea pototorum*) on the beaches from predominantly the west coast of the island, predominantly for export to a large alginate manufacturer and for use in biofertiliser products (Australian Seaweed Institute 2023). Australia Bureau of Statistics (ABS) data shows seaweed exports from Australia are valued at $1.5 million for non-human consumption and it is assumed that this is almost entirely from Kelp Industries exports.

Besides Kelp Industries, other seaweed collectors in Tasmania include Kelpomix and TasKelp. There are also licenses for wild harvest of the invasive species of Undaria in Tasmania (KaiHo Ocean Treasure) and some in Victoria (Australian Seaweed Institute 2023).

The harvesting of native seaweed in Victorian marine waters is prohibited without a permit (s. 112(2) *Fisheries Act 1995*) and licences enabling seaweed aquaculture are not currently available in Victoria (VFA 2023a).

While there are numerous research projects taking place or being planned, currently there are two projects in Tasmania (Australian Seaweed Institute 2023). The first, is a CRC-P project involving collaboration with Tassal, Spring Bay Seafoods and University of Tasmania (UTAS). This project aims to demonstrate the benefits of Kelps as part of an integrated multitrophic aquaculture approach. The second is a research collaboration between UTAS and Huon Aquaculture in Storm Bay that will also yield its first harvest in late 2020.

4.6 First Nations

4.6.1 Methodology to Identify Cultural Values and Sensitivities

The definition of environment in the OPGGS(E)R includes the people and communities, heritage value of places, and their social, economic, and cultural features. Specifically for First Nations peoples, this includes cultural heritage and sea country values which, in accordance with Indigenous tradition, may be a spiritual and cultural connection that may be affected by the activity.

Beach recognises First Nations Groups and their deep spiritual and cultural connection to the environment. The cultural values and features within the Project and Planning Areas are addressed in this section.

The description of the environment for cultural features and values was developed through:

- Consultation with First Nations groups with connection to Sea Country in the Project and Planning Areas
- Review of available publications by First Nations Groups relating to Sea Country.
- Engagement of Extent Heritage Pty Ltd (Extent), a specialist archaeological consulting firm, to undertake a literature review and review of Beach's assessment.

Through these processes, and in particular, consultation with First Nations Groups, Beach is confident that the cultural heritage values, and cultural features and sensitivities of First Nations groups within the Project and Planning Areas have been identified.

4.6.2 Recognition of First Nations Groups

First Nation Groups and Traditional Owners and connection to Country is recognised through contemporary laws such as the Commonwealth *Native Title Act (1993)*, as well as various State laws and agreement making (e.g. *Traditional Owner Settlement Act 2010* (Vic) and Aboriginal Heritage Acts).

While connection to Country for some First Nations Groups has been formally recognised through native title, other First Nations Groups and their connection and rights to land and sea is recognised through relevant State legislation.

A review of the statutory laws, rights and recognition conferred to First Nations Peoples within the Planning Area is summarised in the below sections.

4.6.2.1 Native Title

The Commonwealth *Native Title Act 1993* is an Australia-wide native title scheme with the following key objectives:

- Providing for the recognition and protection of native title.
- Establishing a mechanism for determining claims to native title.
- Establishing ways in which future dealings affecting native title (future acts) may proceed.

Native Title is the formal recognition that Aboriginal and Torres Strait Islander people have rights and interests to land and waters according to their traditional law and customs.

A key principle for native title determination is for First Nation's people to establish and prove that Indigenous people have an unbroken and current connection to their lands and waters and in practicing their culture from the time of European settlement.

Native title can be granted with non-exclusive or exclusive rights to lands and waters. Non-exclusive native title can include, for example, the right to live and camp on an area, and hunt and fish, and can co-exist with the rights of other land users. In sea areas, only non-exclusive native title can be recognised as exclusive native title is considered inconsistent with other common law rights regarding marine access and navigation (Native title 2010).

The Federal Court of Australia fist recognised native title over the sea for the Traditional Owners of Croker Island in Arnhem Land in 1998 (Tribunal File No. DCD 1998/001). Since the Crooker Islands Seas native title determination, (non-exclusive) native title in sea country has been recognised along Australia's coastline through numerous claims and determinations under the Native Title Act 1993.

A search of the National Native Title Tribunal (the Tribunal) database identified the following native titles claims and consent determinations within the Planning Area.

4.6.2.1.1 Victoria

Eastern Maar People

The Eastern Maar People made application to the Federal Court of Australia for a native title claim which was accepted and registered on 20 March 2013 (Tribunal File No. VC2012/001). A consent determination by the Federal Court of Australia recognising the native title rights for the Eastern Maar Peoples was registered on 28 March 2023 (Tribunal File No. VCD2023/001). The native title area is located in south-western Victoria near

Port Fairy along the Great Ocean Road, up to Ararat in the north, and to Colac in the East and extends seaward 100 m from the mean low-water mark of the coastline (NNTT 2016).

The determination recognises Eastern Maar's non-exclusive right to access, use, and protect public land in accordance with their traditional law and custom. The Eastern Maar First Nations Corporation (EMAC) is the registered native title body corporate under the *Corporations (First Nations and Torres Strait Islander) Act 2006* and manages the native title rights for the Eastern Maar Peoples.

Gunditjmara - Part A

A consent determination recognising the native title rights of the Gunditjmara People was registered on 30 March 2007 (Tribunal File No. VCD2007/001) over 140,000 hectares in South-west Victoria (Figure 93). The determination recognises Gunditjmara People's native title rights and interests in traditional lands and waters and provides non-exclusive rights to access, use, and protect public land in accordance with their traditional law and custom. The Gunditj Mirring Traditional Owners Aboriginal Corporation (GMTOAC) is the registered native title body corporate under the *Corporations (First Nations and Torres Strait Islander) Act 2006* and manages the native title rights for the Gunditjmara Peoples.

Gunditjmara and Eastern Maar

On 27 July 2011, the Federal Court of Australia determined (Tribunal File No. VCD2011/001) that both the Traditional Owners represented by GMTOAC and the EMAC are the native title holders for the land and waters between the Shaw and Eumeralla Rivers from Deen Maar (including Yambuk) to Lake Linlithgow (Figure 93). The native title includes Deen Maar (Lady Julia Percy Island) which holds deep and significant cultural association for Traditional Owners.

Wadawurrung People

A native title claim application was registered for the Wadawurrung People on 24 July 2023 (Tribunal File No. VC2022/002). The claim area covers land and waters covering about 12,510 km^2 on the southern coast of Victoria (Figure 93). The application area is located southeast of Ararat and extends towards the coast around Sugarloaf, Geelong, and Port Phillip Bay.

Gunaikurnai People.

A determination by the Federal Court of Australia recognising the native title rights of the Gunaikurnai People over parts of the determination area was registered on 22 October 2010 (Tribunal File No. VCD2010/001). This determination area exists outside but adjacent to the Planning Area.

The area covers the land and waters, including sea country, from Wilsons promontory to Newmerella, and includes the culturally significant Nooramunga Marine & Coastal Park and Lakes Entrance and connected wetlands. The Gunaikurnai Land & Waters Aboriginal Corporation is the registered native title body corporate under the *Corporations (Aboriginal and Torres Strait Islander) Act 2006* and manages the native title rights for the Gunaikurnai People.

4.6.2.1.2 Tasmania

There are no native title areas in Tasmania, however, there are five Indigenous Protected Areas on the islands of the Furneaux Group in Bass Strait adjacent but not within the Planning Area.

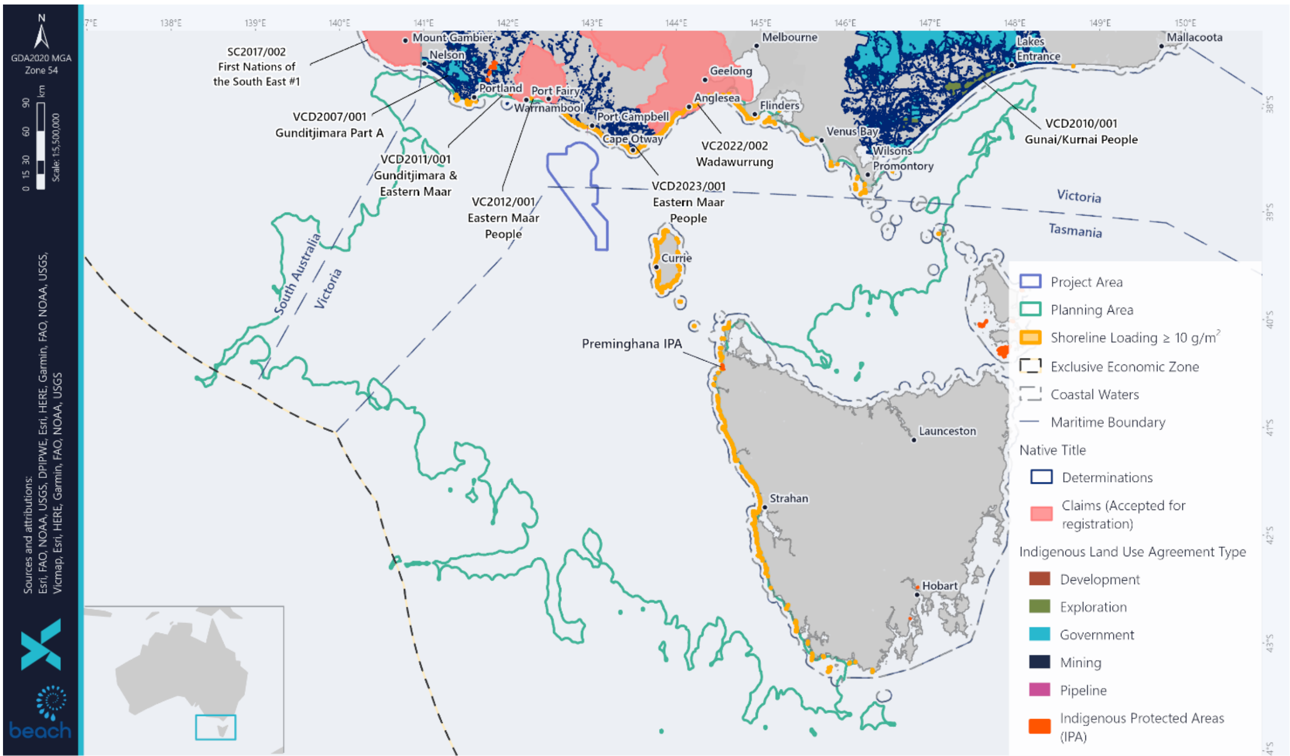


Figure 93: Native Title, Indigenous Protected Areas, and Indigenous Land Use Agreements within the Planning Area

4.6.2.2 Registered Aboriginal Parties

As an operator in Victoria, Beach is also cognisant of the *Aboriginal Heritage Act 2006* (Vic) (AHA 2006 VIC) that recognises a Registered Aboriginal Party (RAP) as the Traditional Owner Corporation to manage and protect First Nations cultural heritage over their Country including coastal and onshore waters. The AHA 2006 VIC recognises RAPs as the primary guardians, keepers and knowledge holders of First Nations cultural heritage and the primary source of advice and knowledge on matters relating to First Nations places or objects in the appointed RAP region.

The following groups are recognised RAPs within the Planning Area described in this OPP:

- Eastern Maar Aboriginal Corporation
- Gunaikurnai Land and Waters Aboriginal Corporation
- Gunditj Mirring Traditional Owners Aboriginal Corporation
- Wadawurrung Traditional Owners Aboriginal Corporation

Figure 94 details the location of these Registered Aboriginal Parties.

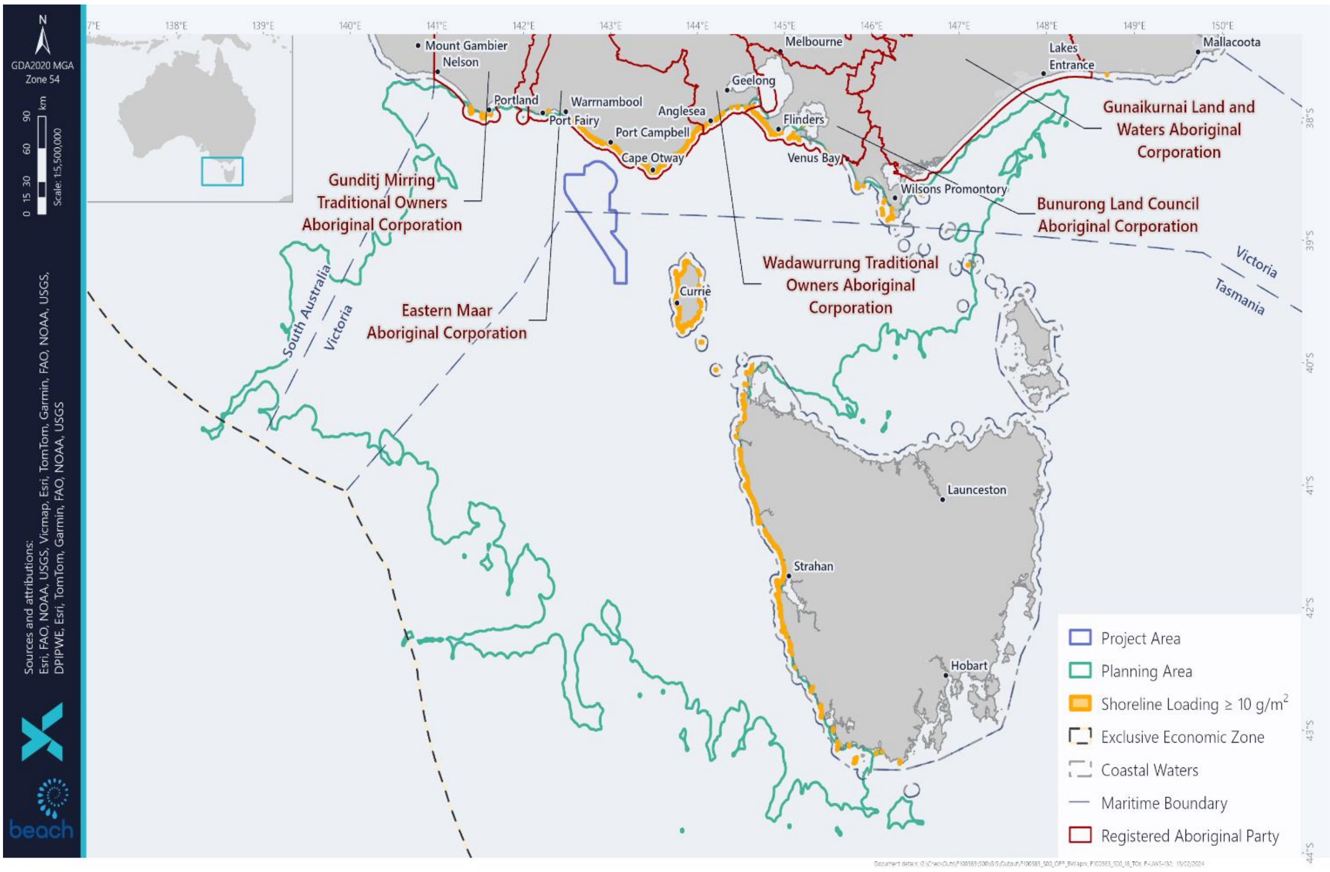


Figure 94: Registered Aboriginal Parties within the Planning Area

4.6.2.3 Indigenous Land Use Agreements

An Indigenous land use agreement (ILUAs) is a voluntary agreement between a native title group and other parties on the use and management of land and waters. ILUAs are established by the *Native Title Act 1993*.

No registered ILUAs were identified within the Project Area. The following ILUAs have been identified in the Planning Areas

- VI2006/004: Gunditj Mirring and State of Victoria.
- VI2010/001: Gunditj Mirring Non-Extinguishment Principle ILUA.
- VI2015/002: Gunditjmara – SEAGAS Port Campbell VIC to Torrens Island SA Pipeline ILUA.
- VIA1999/001: BHPP – Minerva.
- VIA2000/004: Blairgowrie.

4.6.2.4 Land Rights

Most states and territory have legislation which sets out land rights arrangements with First Nations and Torres Strait Islander peoples within their jurisdiction. In most cases the statutory land rights legislation do not extend to marine areas. An exception is under the *Traditional Owner Settlement Act 2010* (Vic) which provides the possibility of agreements to extend to marine areas.

4.6.2.4.1 Victoria

In Victoria, the *Traditional Owner Settlement Act 2010 (Vic)* was developed as an alternative approach to the native title process that recognises traditional owners' relationship to land and provides certain rights on Crown land.

The Gunaikurnai People entered into an agreement with the State of Victoria under the *Traditional Owner Settlement Act 2010* (Vic). An agreement to commence negotiate a recognition and settlement agreement between the Eastern Maar and the Victorian Government under the *Traditional Owner Settlement Act 2010* was announced in 2017 (Justice and Community Safety (Vic), 2023).

In Victoria, the *Aboriginal Nations Heritage Act 2006 (Vic)* recognises a Registered Aboriginal Party as the Traditional Owner to manage and protect First Nations cultural heritage over their Country including coastal and onshore waters.

4.6.2.4.2 South Australia

In South Australia, the *Aboriginal Land Trust Act 2013 (SA)* is land rights legislation that provides for land to be acquired, held, and managed by the Aboriginal Lands Trust. No land rights have been granted or agreed under the relevant SA legislation within the Project or Planning Areas.

4.6.2.4.3 Tasmania

Tasmania does not have a First Nations land rights legislative regime. Rather, under the *Aboriginal Act 1995* (Tas), grants of land parcels of historic or cultural significance ‘to promote reconciliation with the Tasmanian Aboriginal community’ may be made and vested in the Aboriginal Land Council of Tasmania. Some islands in the Bass Strait and adjacent to the Planning Area, such as Badger Island and Clarke Island, were returned to the Tasmanian First Nations community under the *Aboriginal Lands Act 1995*.

4.6.2.5 Indigenous Protected Areas

Indigenous Protected Areas (IPAs) are areas of land and sea managed by First Nations groups through their custodianship and stewardship obligations for Country. IPAs deliver biodiversity conservation outcomes for the benefit of all Australians, through voluntary agreements the Traditional Owners of land or sea and the Australian Government. The IPA program has a dual purpose of achieving conservation obligations and providing sustainable uses to deliver social, cultural, and economic benefits for local Indigenous communities. Indigenous People are active participants in the management of IPAs through land and sea ranger programs and other custodian and management activities.

No IPAs were identified in the Project Areas. There are several IPAs that overlap with the Planning Areas (Figure 94) and are described below.

4.6.2.5.1 Preminghana IPA

Bordering Tasmania and the Southern Ocean, Preminghana was dedicated an IPA in 1999. Covering 524 ha of land in the north-west, it protects historic First Nations engraving sites and the endangered Preminghana daisy (NIAA 2023b). Preminghana is a property of great significance to the Tasmanian First Nations community. The significance of Preminghana for the First Nations community reaches back to the dawn of time, and community ownership and management was only briefly interrupted by recent colonisation (TAC 2015). Prior to its return to the First Nations community the land was used for sheep and cattle grazing, and large areas were damaged and had become overgrown with weeds. There was also damage to middens and sand dunes (TAC 2015).

Nevertheless, Preminghana retained its significant natural and cultural values. It is also home to a number of threatened plant and animal species. In addition to the engravings a further 53 sites have been recorded at Preminghana including middens, artefacts scatters and quarries where stone tool materials were sourced (TAC 2015), though these engravings and artefacts are not within the Planning Area.

The indigenous community of Preminghana published a Healthy Country Plan 2015 (TAC 2015). Preminghana contains a number of fauna species considered to be important to the First Nations community, including the Orange-bellied parrot which migrates as a whole through the site twice annually, most likely feeding in the coastal saltmarsh, grasslands, heath and moorlands.

4.6.2.5.2 Future Sea Country IPAs

The Australian Government, through DCCEEW, is expanding the IPA program. In 2021-22 the Australian Government announced a program to expand the IPA network to include coastal and marine areas (the Sea Country IPA Program). Through the Sea Country IPA Program, the Australian Government is seeking to strengthen the conservation and protection of the marine and coastal environments, while creating employment and economic opportunities for Indigenous People (DCCEEW 2024).

Of the ten future Sea Country IPA consultation projects announced in 2022, three are located within the Planning Area (DCCEEW 2024).

Gunditjmara Sea Country IPA, Victoria (Gunditj Mirring Traditional Owners First Nations Corporation with Eastern Maar First Nations Corporation)

The IPA consultation area is located in south-west Victoria from the Convincing Ground north-east of Portland to Yambuk Lakes in the east. The area includes volcanic plains, rivers, coast, estuaries, and coastal wetlands, and is an important breeding place and nursery for fish, eels, and birds, including nationally listed species. The area's waters encompass sites of national geological and geomorphological importance, and habitat for threatened marine animal species. The area also incorporates important cultural sites such as Deen Maar Island, which has a central role in the creation story of Gunditjmara Country. Whilst Budj Bim is located outside of the Project and Planning Areas, the Sea Country IPA Program will allow Traditional Owners to further protect the Budj Bim Cultural Landscape with activities including implementation of on land/sea management activities; community employment and capacity building; sharing and documentation of traditional knowledge; and the development and enhancement of regional partnerships.

Nanjit to Mallacoota Sea Country IPA, Victoria (Gurnaikurnai Land and Waters First Nations Corporation)

The IPA consultation area is in coastal waters of the Gippsland region in Victoria. The area comprises numerous marine and coastal parks and includes the Ramsar listed Gippsland Lakes and Raymond Island, a highly significant cultural site. A Junior Sea Country Ranger program will bring young Traditional Owners to work with and learn from senior rangers and Elders. IPA staff will participate in a Mulloway monitoring program to learn migratory patterns and health condition of this culturally important fish species, as well as undertake research to identify opportunities to protect and enhance habitat for Australian bass and estuary perch. Gurnaikurnai Land and Waters First Nations Corporation will continue to identify and map land-based sites of cultural significance, building on the historical accounts of First Nations People in the region.

Tayaritja (Bass Strait Islands) Sea Country IPA, Tasmania (Tasmanian Aboriginal Centre)

The IPA consultation area is located in north-east Tasmanian waters and will link five existing island IPAs and other islands (including the Badger, Chappell, and Clarke Islands IPAs). The area includes Ramsar wetlands and ecologically significant coastal habitats. IPA staff will rehabilitate, restore, monitor, and evaluate ecologically significant marine ecosystems, helping to protect threatened marine animals and seabirds and over 120 plant species. The project includes implementation of a cultural burning program and a pest animal and weed management program aimed at maintaining healthy coastal ecosystems.

4.6.3 Cultural Values and Sensitivities

4.6.3.1 Country and Sea Country Overview

Country is a cultural landscape, it includes the tangible (cultural heritage) and intangible (song, creation stories and cultural practices). First Nations cultural concepts are firmly intertwined with the nature of the environment, of Country. Country describes all aspects of place, environment, spirituality, law, and identity. Part of Country that extends into the oceans is known as Sea Country. Values of Country differ between First Nations groups, and not all First Nations groups and communities in Australia hold the same belief systems as formational pillars of their community or spirituality. Differences can be due to aspects of post-colonialism, such as dispossession, genocide, and cultural practice restrictions.

Due to the varied culture and history of First Nations groups, and in particular owing to various degrees of dispossession and removal from country, loss of connection, and continuation of culture, the responses of First Nations communities to caring for and talking about Country are different throughout Australia. These individualised but community-based beliefs and values contribute to the need for a varied and responsive approach to managing cultural (tangible and intangible) values.

A cultural landscape is about both pre-colonial and contemporary interactions between humans and the physical environment including non-human animals, plants, physical structures, ancestors, song lines, trade routes and other significant cultural connections to Country. Cultural landscapes are reflections of how First Nations people engaged with Country, as they see that landscape features are not just physical features, their understanding is that the landscape intrinsically connects the past and the present to people, stories, and history.

Smyth and Isherwood (2016) describe Sea Country as all estuaries, beaches, bays, and marine areas collectively, within a traditional estate. Sea Country contains evidence of the ancient mystical events by which all geographic features, animals, plants, and people were created. Sea Country contains sacred sites and contains tracks (or song lines) along which mythological beings travelled during the creation period (Smyth and Isherwood 2016). The sea, like the land, is integral to the identity of First Nations groups. Connection to Sea Country is accompanied by a complexity of cultural rights and responsibilities. Formal recognition of Sea Country rights lags considerably compared to land rights; this could be for a range of reasons including conflicting perspectives and opinions on traditional custodianship of land and how far it extends (Smyth and Isherwood 2016).

Coastal areas were amongst the most densely populated areas, due to abundance of resources. Sea Country, as it does on land, has been found to contain evidence of the ancient Dreamtime events by which all geographic features, animals, plants, and people were created. Sea Country may contain sacred sites, which may be related to these creation events, and it contains tracks (or Songlines) along which ancestral beings travelled during the creation period. Sea Country has a continuing cultural value because of the connection to creation and dreaming stories, ceremonial sites, and places of occupation.

Country is the term often used by First Nations people to describe the lands, waterways, and seas to which they are connected. The term contains complex ideas about law, place, custom, language, spiritual belief, cultural practice, material sustenance, family, and identity (AIATSIS 2022). Sea Country also known as Saltwater Country extends into the Project and Planning Areas.

4.6.3.2 First Nations Groups Sea Country within the Project and Planning Area

There are First Nations groups with Native Title recognition in areas adjacent the Project and Planning Areas. However, it is important to also acknowledge and respect the intangible cultural values and sensitivities that exist for other First Nations groups described in this section that are not directly adjacent to the Project Area, due to the interconnectedness of marine ecosystems and existences of various marine fauna and flora and intangible cultural values.

The land adjacent the Project and Planning Areas is the traditional land of the Eastern Maar Peoples legally represented by the EMAC. EMAC is both a Registered Aboriginal Party and a Recognised Native Title Prescribed Body Corporate. Eastern Maar land extends north to Ararat and encompasses Port Fairy, Warrnambool, Port Campbell, and other areas along the Great Ocean Road. It also extends 100 m out to sea from low tide and therefore includes the iconic Twelve Apostles (EMAC 2024). Based on consultation, Eastern Maar have always had a close connection with Sea Country which has nourished and supported their ancestors for thousands of years. Sea Country for Eastern Maar holds significant Dreaming stories, telling the story of their ancestors movement across Country. Harvesting of eel, or "*Kooyang",* is incredibly important to the Eastern Maar today and remains a cultural practice handed down from their ancestors.

The land adjacent the Planning Area includes the traditional lands of the Wadawurrung people. Sea Country, or "*Warre*" for Wadawurrung extends from Painkalac Creek at Aireys Inlet, east into Port Phillip Bay and to the Werribee River and to the north as far as Mt Emu and Fiery Creeks (Clark 1990). Based on consultation, for the Wadawurrung peoples, *Warre*, holds the stories and footprints of their ancestors, with *Warre* being a place to meet, trade, share meals and practice ceremony. Eel, or *Beniyak,* have cultural significance to the Wadawurrung peoples.

The Wadawurrung native title claim and registration decision (Tribunal File No. VC2022/002) state that the claimants see Wadawurrung country and its waters as an anatomical being, with its head to the south, spine to the east, feet to the north and the arms lying along the Otway coast. This posture and orientation is replicated in traditional burial practices. Names of places in Wadawurrung language also follow the same theme and are named after body parts, like spine, head, tongue, or elbow. The Wadawurrung 'see our *Dja* land and *Warre* sea Country as all one' (WTOAC 2020).

Also adjacent to the Planning Area is the lands and Sea Country of the Gunditjmara. Gunditjmara recognise four types of landscape across their Country Sea Country, as one of the four, "*Koonang Mirring*" is defined by the meeting of salt and fresh water. Abundant in shellfish, fish, and birds, it also has a history of conflict and violence between the Gunditjmara and colonial settlers. Koonang Mirring includes the submerged landscape and the place where the spirits of Gunditjmara ancestors cross the sea to Deen Maar (CoA 2017b).

The Bunurong First Nations peoples are the Traditional Owners of the Victorian land adjacent to the Planning Area. They are represented by the Bunurong Land Council Aboriginal Corporation (BLCAC). Bunurong Country extends from the Werribee river to Wilsons Promontory includes some of the submerged land bridge to Tasmania. Through consultation with Beach, BLCAC advised that Sea Country is very significant for cultural practices and ceremony. Eels hold special cultural significance for the Bunurong people.

The Project and Planning Areas are also adjacent to lutruwita (Tasmania) The palawa (Tasmanian First Nations) are the Traditional Owners of lutruwita (Tasmania). Palawa people have inhabited Tasmania for at least 35,000 years. At the end of the last ice age the sea level rose, and Tasmania became isolated from the mainland of Australia. They survived in the changing landscape partly due to their ability to harvest aquatic resources, such as seals and shellfish. Following conflict between the European colonists and the Tasmanian First Nation peoples, many were relocated to missions on Bruny Island, Flinders Island, and other sites, and finally to Oyster Cove. Through consultation with Department of Premier and Cabinet and Department of

Aboriginal Affairs Tasmania, Beach understands that kelp, whales, and mutton birds hold special cultural significance for First Nations peoples on mainland Tasmania, King Island and Flinders Island.

4.6.3.3 Sea Country Values

The Planning Area overlaps the South-east Marine Region. Indigenous uses and values within the South-east Marine Region are described in Sea Country - an Indigenous Perspective (NOO 2002). Specifically, Indigenous activities described in the South-east Marine Region Profile (CoA 2015c) state:

Most parts of coastal Australia are of continuing cultural and spiritual significance to Indigenous people, many of whom engage in subsistence hunting, fishing and gathering and depend directly on marine resources for food. Through their involvement in commercial activities, many Indigenous people also depend on marine resources for their income.

Fishing is an important part of Indigenous culture, and a variety of methods and equipment are used, including hand gathering, lines, rods and reels, nets, traps and spears. Indigenous fishing targets a range of species of fish, shellfish, crabs and worms that are used for food, medicine or bait. Abalone, crab and lobster harvesting are important Indigenous fisheries. Indigenous people in south-eastern Australia engage in fishing and shellfish collecting on a regular basis and are involved in commercial fishing activities.

Indigenous people in the South-east Marine Region have articulated particular aspirations in terms of access rights and traditional use of marine resources, participation in management processes, and participation in the fishing sector.

First Nations people’s interests in the South-east Marine Region, are diverse and complex. Indigenous people live around the region in major cities, regional centres, small towns and on First Nations land. Coastal areas of southeast Australia were amongst the most densely populated regions of pre-colonial Australia. These highly populated areas provided an abundance of marine and other resources. However, we know that many have been displaced from the coastal areas (NOO 2002).

It is recognised that spiritual corridors extend from terrestrial areas into nearshore and offshore waters, that a number of marine animals are totems for Indigenous people, and that songlines pass through marine parks.

4.6.3.4 Sea Country Values - Resources

4.6.3.4.1 Adornment and Function

Frequently, tangible resources, such as food items, animal and plant species, and other resources, such as stone, bone and wood, are also tied strongly to intangible elements of First Nations culture. First Nations people of Tasmania, the Palawa, were noted for creating durable and waterproof containers of sea-kelp threaded and dried to shape on wooden handles. In addition, shells were collected and worn as adornment. Throughout south-eastern Australia, reports of seaweed use include for cultural and ceremonial activity, medicine, clothing, food, fishing, and domestic/shelter uses (Thurstan et. al 2017). The Wadawurrung, for example, used “pink seaweed” as a poultice for jellyfish stings (Lane 1980).

Other fish and shellfish species have been noted by community during consultation, including abalone, cockles, and rock lobster (crayfish). The Eastern Maar have noted the migration routes of crustaceans as of notable significance. The Wadawurrung mention that crayfish, mussels, oysters, pipis, and fish provided important bush tucker, medicines, and other resources. Fish were caught using hooks, nets, and traps (WTOAC 2020). Other species were specifically not eaten or associated with other custom, for example, the Stingray (*Baalangurk)* was not eaten by the Kurnai (Howitt n.d.). Swans were hunted with boomerangs and spears, whilst other birds were caught in nets woven from plant fibres (WTOAC 2020).

4.6.3.4.2 Eels

It has been well documented that the Gunditjmara employed complex systems of aquaculture, comprising channels, weirs, and dams, to harvest *kooyang* (eels) on their Country (CoA 2017b). The migration of juvenile eels from freshwater to the ocean to mature and breed is integral to the survival of the species, and their physical health is inherently tied to the spiritually of the Gunditjmara. The aquaculture system is an economic and social base for Gunditjmara society (CoA 2017b). Eels and their migration are also held in social and cultural significance by the Eastern Maar, as neighbours to the Gunditjmara sharing many similar beliefs of their significance. Other coastal and river groups, including the Wadawurrung (buniya) and Bunurung, also utilised eels as an important resource and seek to protect their migration along rivers, creeks, and into the oceans. Section 4.4.9.3.2 provides more details on eels.

The Kulin and Kurnai Dreaming Story of Lo-an includes Lo-an and his wife Lo-an-tuka surviving mostly on eels cooked in a *marin-a-thung* (earth oven) on the Yarra flats. After finding a feather on his chest, Lo-an with Lo-an-tuka proceeded to follow the breeze to find the swans that the feather had come from and walked to the shores of Western Port. They camped for a long time feeding on swans and continued following the coastline to Corner Inlet. The Kulin believe they became the stars Sirius and Canopis. The Kurnai believe Lo-an is upon his mountain and looks out towards to sea, watching over the people (Massola 1968).

4.6.3.4.3 Whales

Through consultation, whales and whale migration have been noted as of significance by coastal groups in Victoria. Eastern Maar have noted the migration routes of the southern right and blue whale as of social and cultural importance. The same whale species are similarly noted by the Gunditjmara and Wadawurrung.

First Nations communities in the south-east of Australia often saw whales as spirits that transformed when they entered the water, creating a respectful relationship between whales and First Nations communities. Whale hunts took place from small, shore-based vessels, and targeted smaller animals (Eldridge 2015).

First Nations methods of hunting may have included using fire and smoke to lure the whales to the coast and bays (Eldridge 2015), and the opportunistic utilisation of beached whales also occurred, which may have prompted periods of intense gathering of people and ceremony like those observed by early settlers such as Henty (Eldridge 2015). In Howitt's notes on the Kurnai, whales are called *Ganda* - 'Dead whales thrown up by the sea were supposed to have been killed by the *Mrarts* [ghost or spirit] and birds called *Yauruk* [or *Yara-wuk*] and sent ashore. The *Mrarts* then communicated to the *Biraaks* who told the Kurnai where to go and find the *Ganda*. (Howitt n.d.).

The Gunaikurnai have noted bottlenose dolphin at Lakes Entrance, and the significance of dolphins is echoed by the Wadawurrung. Wesson (2001) notes that 'the souls of prominent community leaders [were] reincarnated as dolphins and orcas'.

4.6.3.5 Sea Country Intangible Values

Landforms and landscape features in and surrounding watery places are known to hold particular significance for First Nations coastal communities. Islands off the Southern Ocean coastline have cultural importance to First Nations people as Islands of the Dead and are frequently connected to the shore by journey-after-death stories (Draper 2015).

For example, the Gunditjmara of Western Victoria seasonally occupied the caves and escarpments in the coastal limestone karst formation. These caves at Cape Bridgewater are associated with *Bunjil* who descended from the caves where he resided to walk along the shoreline (Bonwick 1858). The Gunditjmara believe that 'Bunjil, their creator and eagle and his brother Pallian ascended to the sky from Deen Maar in a sheet of flame after creating the land and sea and all living things' (Draper 2015). Mathews (1904) noted that the Gunditjmara buried their dead on the mainland with their heads pointed to Deen Maar island where their souls would be transported to await reincarnation. Dawson (1881) records that a haunted cave, Tarn wirring 'road of the spirits', is believed to form a passage between the mainland and the island, and the good spirit 'Put put cheptech' conveys the spirit from the island to the clouds. Other Islands in south-eastern Australia, such as Kangaroo Island (*Karta*), hold similar stories.

Contact and post-contact places are also noted to be in or adjacent to Sea Country, and these include sites of massacre and dispossession. The site of the Convincing Ground massacre (1833/34), where a group of whalers murdered Gunditjmara over ownership of a stranded whale, is located north of Allestree on the Portland coast. This place continues to be a place of great sorrow for the community. Other coastal massacre sites include on the Aire River Estuary at Cape Otway (1846), Eurmerella (1842), Freshwater Creek (1843) Twofold Bay (1806), and Cape Grimm (1828) (Newcastle University 2024). Missionary activity and forced removal of First Nations people in Tasmania resulted in detainment of First Nations people on Flinders Island (at Wybalenna). Other First Nations groups were taken to Swan Island and Gun Carriage Island. This detainment resulted in significant loss of life, and a loss of culture, language, and connection.

4.6.3.5.1 Law, Spirituality and Songlines

Intangible heritage refers to the cultural assets, cultural knowledge and intellectual property collectively held by First Nations and may involve practices, oral traditions, ancestral narratives, performing arts, local knowledges and practices concerning nature, the environment, and the universe. Intangible cultural heritage performs an important function of safeguarding to recognise and protect knowledge and skills that are transmitted through it from one generation to the next.

Songlines are described as short songs pertaining to the travels and exploits of ancestral beings during the Dreamtime. These songs are usually sung in association with a ritual activity, particularly dancing (Tonkinson 1972). Songlines are stories ancestral beings which includes creation stories, they are multipurpose the stories educate and uphold traditional lore, they are also communication and trade routes. (Fuller & Busill 2021).

Understanding First Nations songlines and stories also means understanding the Dreaming. Often described as the 'Dreamtime', or 'deep time', recognising the existence of Dreamtime beyond the Western concept of past, present, and future.

First Nation's people around Australia have long had a strong connection to whales, which has significance as totemic ancestors to some groups. The arrival of whales along Australia's coastline marked the arrival of the "elders of the sea", which follows a songline or ancient memory code, that traces the journeys of ancestral spirits as they created the land, animals, and lore.

In Victoria, *Koontapool* (southern right whales) occur along the coastlines of south-west Victoria in Gunditjmara Sea Country to feed and birth. These *Koontapool Woorrkngan Yakeen* (Whale Birthing Dreaming Sites), are in coastal bay areas from Port Campbell to Portland, including Warrnambool. These places on Gunditjmara Country are known resting and feeding sites for mothers and calves and are directly related to *Gunditjmara Neey*n (midwives), explaining why Gunditjmara is a Matrilineal Nation. (DCCEEW 2022a).

A Kulin Dreaming story includes Angel Cave (between Port Philip and Western Port) where "One Day Bunjil, the All Father, was walking upon the sea, when suddenly there rose a great storm. Bunjil walked to the rocky shore and spoke to it, and immediately the shore rose up into a cliff and the cave was made before his eyes. Bunjil stepped into it and sheltered there till the storm was over' (Massola 1968).

A Kurnai Dreaming story of Port Albert includes the sick frog, Tide-lek, who drank all the water from the land. He didn't feel sick anymore, but he felt bad for leaving the people with nothing to drink. He walked across

Port Albert one day and everyone tried to make him laugh to regurgitate the water, but they all failed until No-yang (the eel) danced on his tail and Tide-lek laughed and the land flooded. Many people died or were marooned, forming the islands. The pelican saved people with a large canoe. As part of this Dreaming Story, the pelican also formed the white pipe-clay used for ceremony at White Rock, the southernmost Island of the Seal Group east of Wilsons Promontory (Massola 1968).

In the south coast of NSW, the following Dreaming story is recorded. 'Long ago Daramulan lived on the earth with his mother Ngalalba. Originally the earth was bare and 'like the sky, as hard as a stone', and the land extended far out where the sea is now. There were no men or women, but only animals, birds, and reptiles. He placed trees on the earth. After Kaboka, the thrush, had caused a great flood on the earth, which covered all of the east coast country, there were no people left, except some who crawled out of the water onto Mount Dromedary… 'then Daramulan went up to the sky, where he lives and watches the actions of men. It was he who first made the Kuringal and the bull-roarer, the sound of which represents his voice. He told the Yuin what to do, and he gave them the laws which the old people have handed down from father to son to this time…' (Howitt 1904).

As part of the Kurnai creation stories the first man and woman were Borun the pelican, and Tuk the musk duck (VACL 2014). Totemic Species are spiritually important and can be bestowed in a number of ways – through family relations or through ceremony. Randall Mumbler, from the Eurobodalla region, for example, discusses that '… Fish are more likely to be ceremonial totems; it is not common to have a fish as a totem… I have certain species that I can't fish for or eat. These rules have been placed upon me through ceremony and so I stay away from them. There are certain fish that my brother and I never eat. That is also like a conservation thing…it keeps that species alive…" Randal Mumbler (in Donaldson 2012).

The Eastern Maar discuss their connection to Sea Country noting that the sea was 'central to our culture, economy, and survival. The coastline is home to sites that are important for our Dreaming - Three Sisters Rocks and Deen Maar (Lady Julia Percy Island) where our Ancestors leave the earth. Our connection with our Sea Country extends well beyond the current shoreline to the edge of the continental shelf. While this area is under the sea today, we occupied it for thousands of years and rising sea levels have not washed away the history, physical evidence or our connection (EMAC 2015).

4.6.3.6 Submerged Cultural Heritage and Landscapes

First Nations peoples in Victoria have occupied, used, and managed sea country for thousands of years, including areas now submerged by sea level rise since time immemorial. An understanding of submerged landscapes and sea level changes may be evident from stories from First Nations groups, "Indigenous peoples still relate to land that was inundated by sea during the last ice age and regard it as their own" (NOO 2002b).

The lava flows of the World Heritage listed Budj Bim Cultural Landscape (which is outside of the Project and Planning Areas) have recently, through ocean scanning methods, been revealed to extend into the sea. The mapping of this geological formation allows the Gunditjmara to connect to Sea Country in new ways assisted by modern technology, as a supplement to their traditional knowledge and ancient connection to the sea. There is potential that early cultural deposits relating to aquaculture systems have been preserved in association with this formation, and as stated above evidence of this kind is highly significant to Gunditjmara.

4.6.3.7 Conservation and Contemporary Cultural Values

It is frequently raised by First Nations communities that ecological protection and sustainability is integral to First Nations cultural and contemporary values. Sea Country Plans, such as those completed by the Gunaikurnai (GLAWAC 2015), Wadawurrung (WTOAC. 2020), and Eastern Maar (EMAC 2015), highlight the importance of approaches that protect and enhance the environment, including biodiversity, coastal erosion, management of sea level rise and addressing climate change impacts. Goals include managing impacts to whale migration, bird and bat nesting and migration (such as the microbat, bent-wing bat, and orange-bellied parrot), protection of environmentally fragile resources such as seagrass and kelp fields, as well as securing habitat for threatened species such as the leafy seadragon.

'Increased pollution from coastal communities, agricultural and industrial run off is changing the sea hydrology and choking our sea life with plastics. Our Warre is being overused and heating up with climate changes. We are seeing the loss of our kelp forests and dramatic changes in sea life which we all depend upon' (WTOAC 2020).

'Our coastal dunes are layered with living places and hearths from the many generations of our ancestors living, harvesting, sharing meals, trading in these living places, and practicing ceremony here. We have the largest stretch of registered cultural sites in Australia along our coastline. Our fish traps, which were used to catch the abundant fish, have survived the storms and sea level changes. Ochre pits of different colours are dotted along our sandstone and limestone cliffs and headlands. Our sandy beaches, rock pools, rocky platforms and reefs were and continue to be places of abundance for harvesting food and resources like crustaceans, shellfish, and kelp' (WTOAC 2020).

Seals, or Bithaui or Gurnun in Kunai (Howitt n.d.), are noted by the Gunaikurnai as a significant species, and habitat for fur seals at Wilsons Promontory Marine National Park is identified as an important resource to be protected, particularly due to the reliance of species on both the land and sea for different life cycle stages. It is therefore considered important that programs for environmental management consider both land and marine environments, as they are interconnected and must be managed as a whole to ensure success (GLAWAC 2015).

Through the processes identified above, and in particular, consultation with First Nations Groups, Beach is confident we have identified the cultural heritage values, and cultural features and sensitivities of First Nations groups identified within the Project and Planning Areas.

4.6.4 Assessment of Potential Impacts and Risks to Cultural Values and Sensitivities

Sections 6 and 7 evaluate the environmental impacts and risks of the Project and identifies where First Nations cultural values and sensitivities may be potentially affected. Where a potential impact to First Nations cultural values and sensitivities has been identified, details of the control measures, if required, to reduce impacts and risks from the Project are of an acceptable level and as low as reasonably practicable are provided.

5. Environmental Impact and Risk Assessment Methodology

5.1 Overview

This section outlines the environmental impact and risk assessment methodology used for the assessment of Project activities in this OPP. The methodology is consistent with the Australian and New Zealand Standard for Risk Management (AS/NZS ISO 31000:2018, Risk Management – Principles and Guidelines). **Figure 95** outlines this risk assessment process.

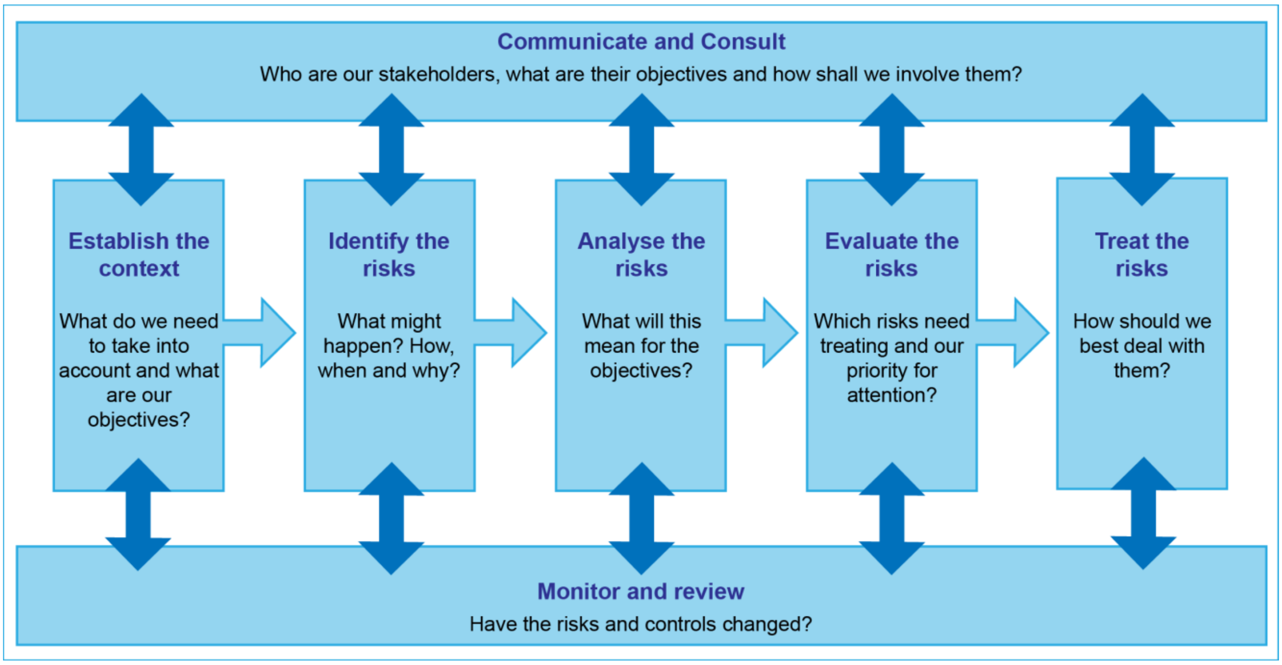


Figure 95: Risk assessment process

5.2 Definitions

Definitions of the term used in the risk assessment process are detailed in **Table 44**.

Term	Definition
Activity	Refers to a ‘petroleum activity’ as defined under the OPGGS(E)R as: petroleum activity means operations or works in an offshore area undertaken for the purpose of: • exercising a right conferred on a petroleum titleholder under the Act by a petroleum title; or, • discharging an obligation imposed on a petroleum titleholder by the Act or a legislative instrument under the Act.
Consequence	The consequence of an environmental impact is the potential outcome of the event on affected receptors (particular values and sensitivities). Consequence can be positive or negative
Control measure	Defined under the OPGGS(E)R as a system, an item of equipment, a person or a procedure, that is used as a basis for managing environmental impacts and risks
Emergency condition	An unplanned event that has the potential to cause significant environmental damage or harm to MNES. An environmental emergency condition may, or may not, correspond with a safety incident considered to be a Major Accident Event
Environmental aspect	An element or characteristic of an operation, product, or service that interacts or can interact with the environment. Environmental aspects can cause environmental impacts

Term	Definition
Environmental impact	Defined under the OPGGS(E)R as any change to the environment, whether adverse or beneficial, that wholly or partially results from an activity
Environmental performance outcome	Defined under the OPGGS(E)R as a measurable level of performance required for the management of environmental aspects of an activity to ensure that environmental impacts and risks will be of an acceptable level.
Environmental performance standard	Defined under the OPGGS(E)R as a statement of the performance required of a control measure
Environmental risk	An unplanned environmental impact has the potential to occur, due either directly or indirectly from undertaking the activity
Likelihood	The chance of an environmental risk occurring
Measurement criteria	A verifiable mechanism for determining control measures are performing as required
Residual risk	The risk remaining after control measures have been applied (i.e. after risk treatment).

Table 44: Definition of terms for risk assessment

5.3 Communicate and Consult

Beach has been operating in the Otway Basin for numerous years and has undertaken extensive consultation with relevant person(s) (stakeholders) to obtain information about their functions, activities and interests and to assess how the Project and associated activities may impact on these. This information has been used to inform the impact and risk assessment in the OPP.

The stakeholder consultation process is described in detail in Section 10.

5.4 Establish the Context

The first step in the risk assessment process (outlined in **Figure 96**) is to establish the context. This involves:

- Understanding the regulatory framework in which the activity takes place (described in the in Section 2 – Environmental Legislation and Other Requirements)
- Defining the activities that will cause impacts and create risks (outlined in Section 3 – Description of the Project)
- Understanding concerns of stakeholders and incorporating those concerns into the design of the activity where appropriate (outlined in Section 10 - Stakeholder Consultation)
- Describing the environment in which the activity takes place (described in Section 4 – Description of the Environment)

Once the context has been established, the hazards of the activity can be identified, along with the impacts and risks of these hazards. This process is described in the following sections.

5.5 Identify the Impacts and Risks

This step seeks to identify the impacts and risks to be managed. It involves considering the objectives and the uncertainties of the internal and external context and identifying what might happen, when and where it might happen and why and how it can happen. In general, the process for identifying risks involves identifying the following:

- Sources of impact or risk

- Areas of impact
- Events and other uncertainties and their causes
- Potential consequences

Impacts and risks are differentiated as follows:

Impacts result from planned events – there will be consequences (known or unknown) associated with the event occurring and there is little or no uncertainty. Impacts are an inherent part of the activity. For example, sound and light will be generated during the activity and this will have consequences for marine life.

For impacts, only a consequence is assigned (likelihood is irrelevant given that the event does occur).

Risks result from unplanned events – there may be consequences if an unplanned event occurs. Risks are not an inherent part of the activity. For example, a hydrocarbon spill may occur if the activity vessel collides with another vessel, but this is not a certainty. The risk of this event is determined by multiplying the consequence of the impact (using factors such as the type and volume of hydrocarbons and the nature of the receiving environment) by the likelihood of this event happening (which may be determined objectively or subjectively, qualitatively or quantitatively).

5.6 Analyse the Impacts and Risks

Risk analysis involves developing an understanding of the impacts or risks. Risk analysis provides an input to risk evaluation and to decisions on whether risks need to be treated, and on the most appropriate risk treatment strategies and methods. Risk analysis can also provide an input into making decisions where choices must be made, and the options involve different types and levels of risk.

Beach's risk analysis process is described below:

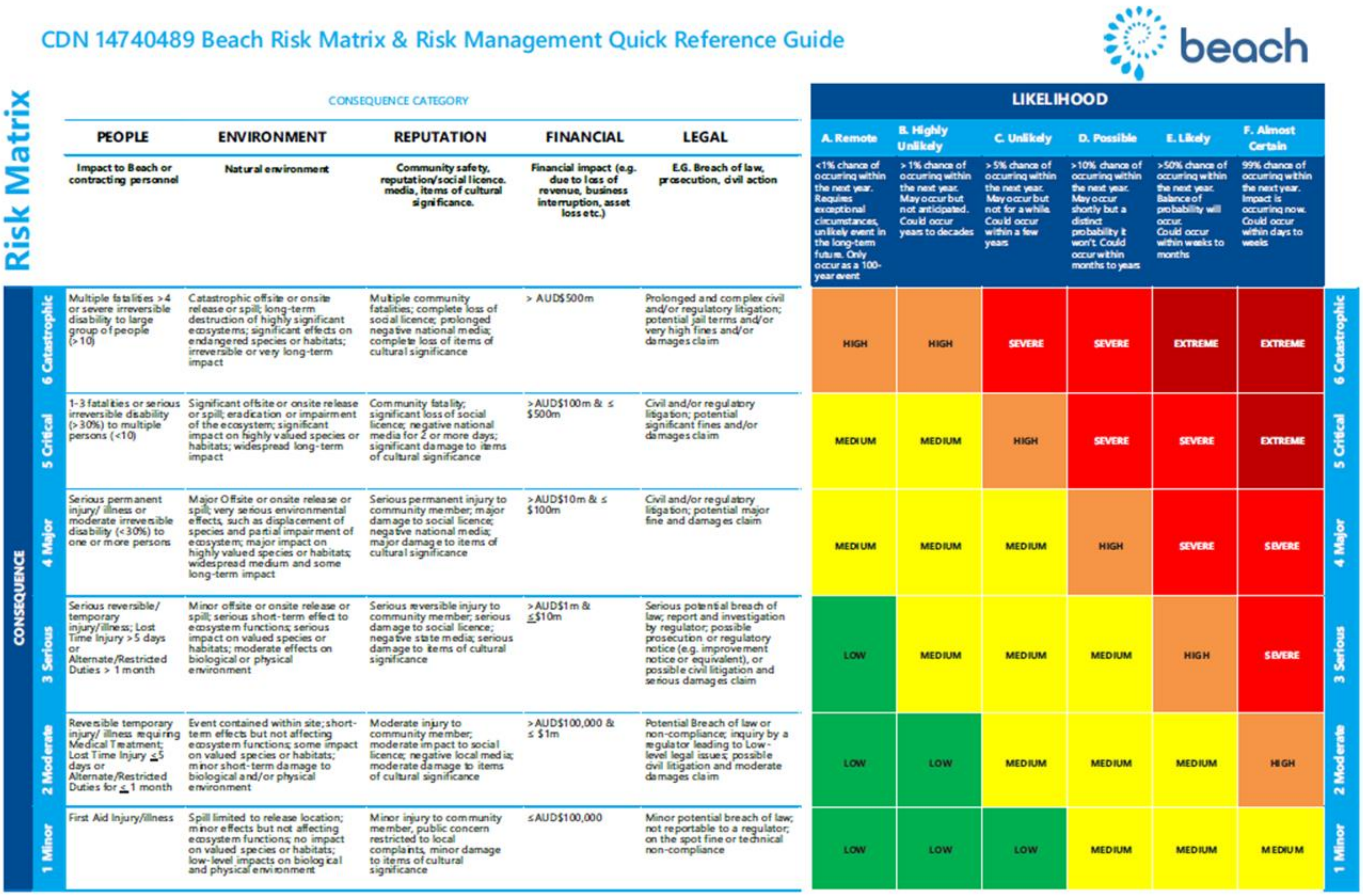
- Establish criteria for an acceptable level of impact or risk
- Determine the maximum credible consequence arising from the impact or risk without introducing additional controls. This determination is provided in the risk assessment tables throughout Section 7 and 8
- Adopt controls for each impact or risk
- Undertake an assessment of the consequence of the impact or risk, corresponding to the maximum credible impact across the consequence categories (**Figure 96**) considering the controls identified and their effectiveness
- Identify the likelihood of occurrence of those consequences ('remote' through to 'almost certain'), considering the controls identified and their effectiveness, as outlined in **Figure 96**
- For risks, multiply the consequence and likelihood to determine the overall risk raking, outlined in **Figure 96**

5.7 Evaluate and Treat the Potential Impacts and Risks

The following steps are undertaken using the Beach OEMS Element 8, BSTD 8.1 Risk Management Standard, Risk Matrix (**Figure 96**) to evaluate the potential impacts and risks:

- Identify the consequences of each potential environmental impact, corresponding to the maximum credible impact.
- For unplanned events, identify the likelihood (probability) of unplanned environmental impacts occurring.

- For unplanned events, assign a level of risk to each potential environmental impact using the risk matrix.
- Identify control measures to manage potential impacts and risks to as low as reasonably practicable (ALARP) and an acceptable level (
- Establish environmental performance standards for each of the identified control measures.
- Environmental performance outcomes (EPO) (or objectives) are developed to provide a measurable level of performance for each environmental hazard



CDN 14740489 Beach Risk Matrix & Risk Management Quick Reference Guide

beach

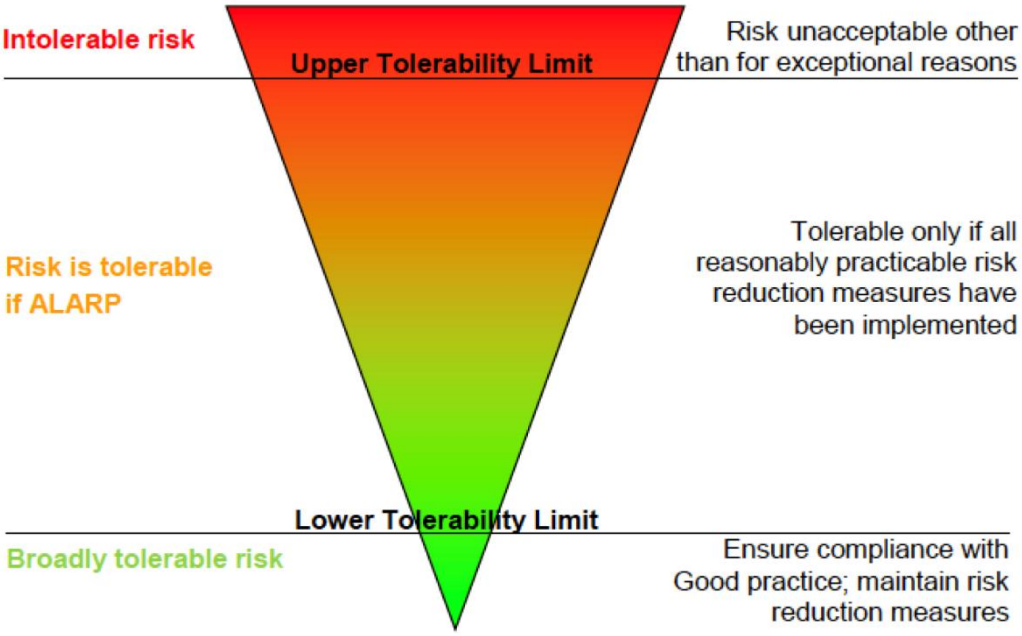
Risk Matrix

CONSEQUENCE	CONSEQUENCE CATEGORY					LIKELIHOOD					
	PEOPLE	ENVIRONMENT	REPUTATION	FINANCIAL	LEGAL	A. Remote	B. Highly Unlikely	C. Unlikely	D. Possible	E. Likely	F. Almost Certain
	Impact to Beach or contracting personnel	Natural environment	Community safety, reputation/social licence. media, items of cultural significance.	Financial impact (e.g. due to loss of revenue, business interruption, asset loss etc.)	E.G. Breach of law, prosecution, civil action	<1% chance of occuring within the next year. Requires exceptional circumstances, unlikely event in the long-term future. Only occur as a 100-year event	> 1% chance of occuring within the next year. May occur but not anticipated. Could occur years to decades	> 5% chance of occuring within the next year. May occur but not for a while. Could occur within a few years	>10% chance of occuring within the next year. May occur shortly but a distinct probability it won't. Could occur within months to years	>50% chance of occuring within the next year. Balance of probability will occur. Could occur within weeks to months	99% chance of occuring within the next year. Impact is occuring now. Could occur within days to weeks
6 Catastrophic	Multiple fatalities >4 or severe irreversible disability to large group of people (>10)	Catastrophic offsite or onsite release or spill; long-term destruction of highly significant ecosystems; significant effects on endangered species or habitats; irreversible or very long-term impact	Multiple community fatalities; complete loss of social licence; prolonged negative national media; complete loss of items of cultural significance	> AUD$500m	Prolonged and complex civil and/or regulatory litigation; potential jail terms and/or very high fines and/or damages claim	HIGH	HIGH	SEVERE	SEVERE	EXTREME	EXTREME
5 Critical	1-3 fatalities or serious irreversible disability (>30%) to multiple persons (<10)	Significant offsite or onsite release or spill; eradication or impairment of the ecosystem; significant impact on highly valued species or habitats; widespread long-term impact	Community fatality; significant loss of social licence; negative national media for 2 or more days; significant damage to items of cultural significance	>AUD$100m & ≤ $500m	Civil and/or regulatory litigation; potential significant fines and/or damages claim	MEDIUM	MEDIUM	HIGH	SEVERE	SEVERE	EXTREME
4 Major	Serious permanent injury/ illness or moderate irreversible disability (<30%) to one or more persons	Major Offsite or onsite release or spill; very serious environmental effects, such as displacement of species and partial impairment of ecosystem; major impact on highly valued species or habitats; widespread medium and some long-term impact	Serious permanent injury to community member; major damage to social licence; negative national media; major damage to items of cultural significance	>AUD$10m & ≤ $100m	Civil and/or regulatory litigation; potential major fine and damages claim	MEDIUM	MEDIUM	MEDIUM	HIGH	SEVERE	SEVERE
3 Serious	Serious reversible/ temporary injury/illness; Lost Time Injury >5 days or Alternate/Restricted Duties > 1 month	Minor offsite or onsite release or spill; serious short-term effect to ecosystem functions; serious impact on valued species or habitats; moderate effects on biological or physical environment	Serious reversible injury to community member; serious damage to social licence; negative state media; serious damage to items of cultural significance	>AUD$1m & ≤$10m	Serious potential breach of law; report and investigation by regulator; possible prosecution or regulatory notice (e.g. improvement notice or equivalent), or possible civil litigation and serious damages claim	LOW	MEDIUM	MEDIUM	MEDIUM	HIGH	SEVERE
2 Moderate	Reversible temporary injury/ illness requiring Medical Treatment; Lost Time Injury ≤5 days or Alternate/Restricted Duties for ≤ 1 month	Event contained within site; short-term effects but not affecting ecosystem functions; some impact on valued species or habitats; minor short-term damage to biological and/or physical environment	Moderate injury to community member; moderate impact to social licence; negative local media; moderate damage to items of cultural significance	>AUD$100,000 & ≤ $1m	Potential Breach of law or non-compliance; inquiry by a regulator leading to Low-level legal issues; possible civil litigation and moderate damages claim	LOW	LOW	MEDIUM	MEDIUM	MEDIUM	HIGH
1 Minor	First Aid Injury/illness	Spill limited to release location; minor effects but not affecting ecosystem functions; no impact on valued species or habitats; low-level impacts on biological and physical environment	Minor injury to community member, public concern restricted to local complaints, minor damage to items of cultural significance	≤AUD$100,000	Minor potential breach of law; not reportable to a regulator; on the spot fine or technical non-compliance	LOW	LOW	LOW	MEDIUM	MEDIUM	MEDIUM

Figure 96: Beach risk matrix

5.7.1 Demonstration of ALARP

The ALARP principle (CER, 2015) states that it must be possible to demonstrate that the cost involved in reducing the risk further would be grossly disproportionate to the benefit gained. The ALARP principle arises from the fact that infinite time, effort and money could be spent attempting to reduce an impact or risk to zero. This concept is shown diagrammatically in **Figure 97**.



Source: CER (2015).

Figure 97: The ALARP Principle

Beach's approach to demonstrating ALARP includes:

- Systematically identifying and assessing all potential environmental impacts and risks associated with the activity
- Where relevant, applying industry 'good practice' controls to manage impacts and risks
- Assessing the effectiveness of the controls in place and determining whether the controls are adequate according to the 'hierarchy of controls' principle
- For higher order impacts and risks, implementing further controls if feasible and reasonably practicable to do so

5.7.2 Residual Impact and Risk Levels

5.7.2.1 Lower-order Environmental Impacts and Risks

NOPSEMA defines lower-order environmental impacts and risks as those where the environment or receptor is not formally managed, less vulnerable, widely distributed, not protected and/or threatened and there is confidence in the effectiveness of adopted control measures.

Impacts and risks are considered lower-order and ALARP when, using the Beach risk matrix (**Table 45**), the impact consequence is rated as ‘minor’ or ‘moderate’ or risks are rated as ‘low’, ‘medium’ or ‘high’. In these cases, applying ‘good industry practice’ is sufficient to manage the impact or risk to ALARP.

5.7.2.2 Higher-order Environmental Impacts and Risks

NOPSEMA defines higher-order environmental impacts and risks as those that are not lower order risks or impacts (i.e., where the environment or receptor is formally managed, vulnerable, restricted in distribution, protected or threatened and there is little confidence in the effectiveness of adopted control measures).

Impacts and risks are considered higher-order when, using the Beach risk matrix (**Table 45**) the impact consequence is rated as ‘serious’, ‘major’, ‘critical’ or ‘catastrophic’, or when the risk is rated as ‘severe’ or ‘extreme’ . In these cases, further controls must be considered as per Section 6.5.3.

Consequence ranking	**Minor**	**Moderate**	**Serious**	**Major**	**Critical**	**Catastrophic**
	Planned operation	Broadly acceptable	Tolerable if ALARP		Intolerable	
Residual impact category	Lower order impacts		Higher order impacts			
Risk ranking	**Low**	**Medium**	**High**	**Severe**	**Extreme**	
Unplanned event	Broadly acceptable	Tolerable if ALARP		Intolerable		
	Residual risk category	Lower order risks			Higher order risks	

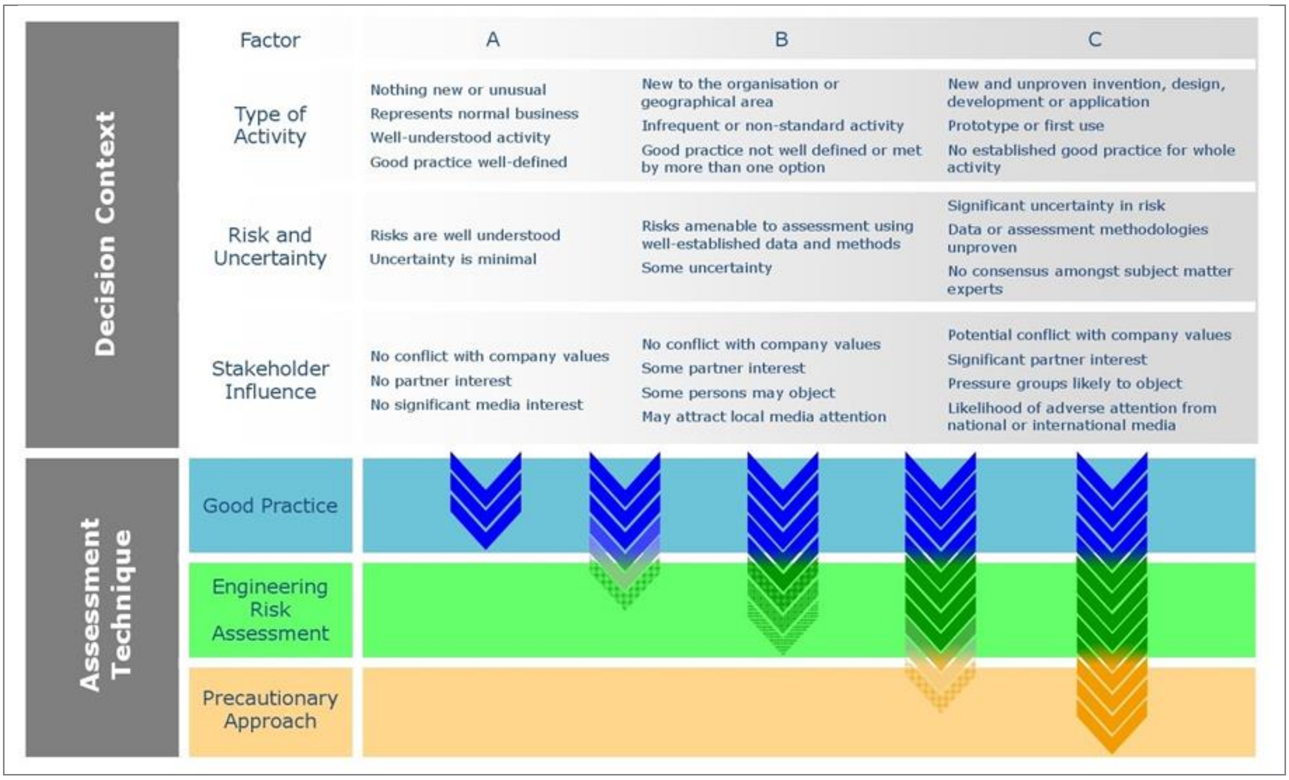
Table 45: ALARP Determination for Consequence (Planned Operations) and Risk (Unplanned Events)

5.7.3 Uncertainty of Impacts and Risks

Based upon the level of uncertainty associated with the impact or risk, the following framework, adapted from the Guidance on Risk Related Decision Making (Oil & Gas UK, 2014).

Figure 98 provides the decision-making framework to establish ALARP.

This framework provides appropriate tools, commensurate to the level of uncertainty or novelty associated with the impact or risk (referred to as the Decision Type A, B or C, see **Table 46**). The decision type is selected based on an informed decision around the uncertainty of the risk.



Decision Context			
Factor	A	B	C
Type of Activity	Nothing new or unusual Represents normal business Well-understood activity Good practice well-defined	New to the organisation or geographical area Infrequent or non-standard activity Good practice not well defined or met by more than one option	New and unproven invention, design, development or application Prototype or first use No established good practice for whole activity
Risk and Uncertainty	Risks are well understood Uncertainty is minimal	Risks amenable to assessment using well-established data and methods Some uncertainty	Significant uncertainty in risk Data or assessment methodologies unproven No consensus amongst subject matter experts
Stakeholder Influence	No conflict with company values No partner interest No significant media interest	No conflict with company values Some partner interest Some persons may object May attract local media attention	Potential conflict with company values Significant partner interest Pressure groups likely to object Likelihood of adverse attention from national or international media

Figure 98: OGUK (2014) Decision Support Framework

Decision type	Decision-making tools
A	Good industry practice Identifies the requirements of legislation, codes and standards that are to be complied with for the activity. Applies the ‘Hierarchy of Controls’ philosophy, which is a system used in the industry to identify effective controls to minimise or eliminate exposure to impacts or risks. Identifies further engineering control standards and guidelines that may be applied over and above that required to meet the legislation, codes and standards.
B	In addition to decision type A: Engineering risk-based tools Engineering risk-based tools to assess the results of probabilistic analyses such as modelling, quantitative risk assessment and/or cost benefit analysis to support the selection of control measures identified during the risk assessment process.
C	In addition to decision type A and B: Precautionary Principle Application of the Precautionary Principle is to be applied when good industry practice and engineering risk-based tools fail to address uncertainties.

Table 46: ALARP decision-making based upon level of uncertainty

The decision-making tools outlined **Table 46** are explained further below.

5.7.3.1 Good Practice

In the absence of an Australian definition, the OGUK (2014) and the Irish Commission for Energy Regulation (CER) (2015) define 'Good Practice' as:

The recognised risk management practices and measures that are used by competent organisations to manage well-understood hazards arising from their activities.

NOPSEMA has not endorsed any 'approved codes of practice' or standards to give them a legal status in terms of good practice. Good practice is taken to refer to any well-defined and established standard or codes of practice adopted by an industrial/occupational sector, including 'learnings' from incidents that may yet be incorporated into standards.

Good practice can also be used as the generic term for those standards for controlling risk that have been judged and recognised as satisfying the law when applied to a particular relevant case in an appropriate manner. For this OPP, sources of good practice, adapted from CER (2015) are the relevant:

- Commonwealth and state legislation and regulations (outlined in Sections 2.4 and 2.6)
- Government policies and guidance (outlined in Section 2.5)
- Industry standards (outlined in Section 2.5 and Section 2.6)
- International conventions (outlined in Section 2.7)

Good practice also requires that hazard management is considered in a hierarchy, with the concept being that it is inherently safer to eliminate a hazard than to reduce its frequency or manage its consequences (CER, 2015). This being the case, the 'Hierarchy of Controls' philosophy is applied to reduce the risks associated with hazards.

5.7.3.2 Engineering Risk Assessment

All impacts and risks that require assessment beyond that of good practice (i.e., decision type A) are subject to an engineering risk assessment.

Engineering risk-based tools can include, but are not limited to, engineering analysis (e.g., structural, fatigue, mooring, process simulation) and consequence modelling (e.g., ship collision, dropped object) (CER, 2015). A cost-benefit analysis to support the selection of control measures identified during the risk assessment process may also be undertaken.

5.7.3.3 Precautionary Principle

All impacts and risks that do meet decision type A or type B and require assessment beyond that of good practice and engineering risk assessment are subject to the 'Precautionary Principle'. CER (2015) states that if the assessment, taking account of all available engineering and scientific evidence, is insufficient, inconclusive or uncertain, then the precautionary principle should be adopted in the hazard management process. While there is no globally-recognised definition of the Precautionary Principle, it is generally accepted to mean:

Uncertain analysis is replaced by conservative assumptions which will increase the likelihood of a risk reduction measure being implemented.

The degree to which this principle is adopted should be commensurate with the level of uncertainty in the assessment and the level of danger (hazard consequences) believed to be possible.

Under the precautionary principle, environmental considerations are expected to take precedence over economic considerations, meaning that an environmental control measure is more likely to be implemented. In this decision context, the decision could have significant economic consequences to an organisation.

5.8 Demonstration of Acceptability

A key outcome of the OPP process is to inform a conclusion as to whether the impacts and risks will be of an 'acceptable' or 'unacceptable' level. Beach considers a range of factors to demonstrate the acceptability of the environmental impacts and risks, including:

- The principles of ecologically sustainable development (ESD);
- Other requirements (e.g. laws, policies, standards, conventions etc.), including significant impacts to MNES;
- Internal context; and
- External context.

5.8.1 Principles of Ecologically Sustainable Development

Based on Australia's National Strategy for Ecologically Sustainable Development (Council of Australian Governments, 1992), Section 3A of the EPBC Act defines ecologically sustainable development as:

Using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained and the total quality of life, now and in the future, can be increased.

The principles of ecologically sustainable development as defined under the EPBC Act are provided in **Table 47** and describes how this OPP aligns with these principles.

Principle		OPP demonstration
A	Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.	This principle is inherently met through the OPP assessment process.
B	If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.	Serious or irreversible environmental damage resulting from the activity has been eliminated through the project design (see Section 3). None of the residual impacts is rated higher than 'minor' and none of the residual risks is rated higher than 'medium.' Scientific certainty has been maximised by employing Planning Area/ EMBA as a risk assessment boundary.
C	The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.	The OPP assessment methodology ensures that impacts and risks from the activity are managed to be ALARP and acceptable levels.
D	The conservation of biodiversity and ecological integrity should be a fundamental consideration in decision making.	This principal is considered for each hazard in the adoption of environmental controls (i.e., environmental performance outcomes and environmental performance standards) that aim to minimise environmental harm. There is a strong focus in this OPP on conserving biodiversity and ecological integrity by understanding the marine environment and commercial fishing activity in and around the project area (Section 5) and implementing controls to minimise impacts and risks (Section 7).
E	Improved valuation, pricing and incentive mechanisms should be promoted.	This principle is not relevant to this activity.

Table 47: Assessment of ecologically sustainable development principles

5.8.2 Other Requirements

Other requirements includes compliance with relevant legislation, government policies and guidelines, international agreements and industry best practice.

Given this OPP forms the basis for NOPSEMA’s assessment of matters protected under Part 3 of the EPBC Act in Commonwealth waters, particular attention is paid to MNES (Section 2.3) with acceptability demonstrated if:

- significant impact criteria (**Table 48**) are not exceeded; and
- impacts and risk are not inconsistent with published guidance material from DAWE, including species management plans, recovery plans and conservation advice (Section 2.3.1).

Category	Significant Impact Criteria
Listed Critically Endangered and Endangered species	An action is likely to have a significant impact on critically endangered or endangered species if there is likelihood that it will: • Lead to a long-term decrease in the size of a population • Reduce the area of occupancy of the species • Fragment an existing population • Adversely affect habitat critical to the survival of a species • Disrupt the breeding cycle of a population • Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline • Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat • Introduce disease that may cause the species to decline, or • Interfere with the recovery of the species.
Listed Vulnerable Species	An action is likely to have a significant impact on vulnerable species if there is a likelihood that it will: • Lead to a long-term decrease in the size of an important population • Reduce the area of occupancy of an important population • Fragment an existing important population into two or more populations • Adversely affect habitat critical to the survival of a species • Disrupt the breeding cycle of a population • Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline • Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat • Introduce disease that may cause the species to decline, or • Interfere substantially with the recovery of the species.
Listed Migratory Species	An action is likely to have a significant impact on migratory species if there is likelihood that it will: • Substantially modify, destroy or isolate an area of important habitat for a migratory species • Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or

Category	Significant Impact Criteria
	• Seriously disrupt the lifecycle of an ecologically significant proportion of the population of a migratory species.
Wetlands of International Importance	An action is likely to have a significant impact on a wetland of international importance if there is likelihood that it will result in: • Areas of wetland being destroyed or substantially modified • A substantial and measurable change in the hydrological regime of the wetland • The habitat or lifecycle of native species dependent upon the wetland being seriously affected • A substantial and measurable change in the water quality of the wetland which may adversely impact on the biodiversity, ecological integrity, social amenity or human health, or • An invasive species that is harmful to the ecological character of the wetland being established in the wetland.
Commonwealth Marine Area	An action is likely to have a significant impact on the environment in a Commonwealth Marine Area if there is likelihood that it will: • Result in a known or potential pest species becoming established in the Commonwealth marine area • Modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity on a Commonwealth marine area results • Have a substantial adverse effect on a population of a marine species or cetacean including its life cycle and spatial distribution • Result in a substantial change in air quality or water quality which may adversely impact on biodiversity, ecological integrity4F[1], social amenity or human health • Result in persistent organic chemicals, heavy metals, or other potentially harmful chemicals accumulating in the marine environment such that biodiversity, ecological integrity, social amenity or human health may be adversely affected, or • Have a substantial adverse impact on heritage values of the Commonwealth marine area, including damage or destruction of an historic shipwreck.

Table 48: MNES Significant impact criteria defined in the Significant Impact Guidelines published by the DoEE (DoE 2013a).

5.8.3 Internal Context

The internal context relates to alignment with Beach's policies, objectives, environmental risk management framework, internal standards, procedures, technical guidance and opinions of internal stakeholders.

5.8.4 External Content

The external context relates to consultation undertaken with Relevant Persons (Section 10) both during historic activities and in the process of preparing this OPP. Impacts and risks will be acceptable if merits of claims or objections raised by Relevant Persons are adequately assessed and where relevant additional controls are adopted to manage concerns.

---

[1] [1] In the context of the activities covered by this OPP, a change to ecological integrity is considered to take into account broadscale, long term impacts to the ecosystem. With regards to the Commonwealth marine environment, the Project area is located in open offshore waters and the seabed is generally characterised by soft sediments. These characteristics are typical of the offshore Otway Basin."

5.8.5 Acceptable Levels of Impact and Risk

The acceptable levels of impacts and risks to environmental receptors that are applied in the impact and risk assessments to determine and demonstrate acceptability are summarised in **Table 49** and are based on the MNES Significant impact criteria.

Significance as defined by the Commonwealth marine environment significant impact criteria in Matters of National Environmental Significance -Significant impact guidelines 1.1. EPBC Act (Department of the Environment 2013).

Receptor sub-category	Acceptable level of impact
Physical environment	
Water and sediment quality	No substantial[1] change in water and sediment quality within 1km of the source, which may adversely impact on biodiversity, ecological integrity, social amenity or human health. This includes: No accumulation of persistent organic chemicals, heavy metals, or other potentially harmful chemicals in the marine environment such that biodiversity, ecological integrity, social amenity or human health may be adversely affected.
Air quality	No change in air quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health
GHG emissions	Gas is provided to communities sustainably in a manner which is consistent with the Australian government's strategy for meeting the objectives of the Paris Agreement and the global response to the threat of climate change. GHG emissions are monitored and reported as required under the National Greenhouse and Energy Reporting (NGER) scheme.
Ecosystem, communities and habitats	
Benthic communities	No significant impact to benthic habitats from project activities.
Coastlines	No significant impact to environmental values of coastlines
Key ecological features	No significant impact to environmental values of Key Ecological Features
Threatened ecological communities	No significant impact to Threatened ecological communities
Fish	No mortality or injury to threatened or migratory MNES fauna Activities are undertaken in manners that are not inconsistent with conservation management plans, conservation advice, recovery plans and threat abatement plans published by the DoEE. No significant impacts to EPBC Act listed threatened or migratory species.
Marine mammals	
Marine Reptiles	
Birds	
Socio-economic and cultural environment	
Commonwealth marine area	No impacts to ecological values
Marine Parks	No impact to the values of Marine Parks
World heritage properties	No impacts to world heritage values
National heritage places	No impacts to world national heritage values
Commonwealth heritage places	No impacts to Commonwealth heritage values
Declared Ramsar wetlands	No impacts to ecological values of Ramsar wetlands

Receptor sub-category	Acceptable level of impact
Other marine users	No interfere with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted. Temporary displacement from the project area during construction is acceptable. Permanent exclusion from gazetted petroleum exclusion zones is acceptable.
Commercial fisheries	No adverse impacts to resource stocks resulting in a demonstrated direct loss of income.
Tourism and recreation	No negative impacts to nature-based tourism resources resulting in a demonstrated loss of income.
Marine archaeology	No disturbance of historical shipwrecks.

Table 49: Summary of acceptable levels of impact for environmental receptors that may be affected by the activities considered in this OPP

6. Environmental Impact Evaluation – Planned Activities

6.1 Physical Presence – Interaction with Other Users (Socio-economic)

6.1.1 Hazard Description

The presence of vessels and subsea infrastructure within the Project Area has the potential to displace other marine users. This includes affecting activities and access to areas associated with fishing, tourism, defence, commercial shipping and other oil and gas activities in the region.

The following petroleum safety zones will be gazetted for the life of the Otway project:

- 500m around the Thylacine platform (already in place due to Otway Operations); and
- 500m around wellheads and OGPP tie-in locations
- In addition, third party vessels will be asked to avoid 500m temporary exclusion zones during drilling and installation activities.

6.1.2 Impact Source

Activities which may interact with other marine users include:

Stage	Activity
Operations	Physical presence of subsea infrastructure
Support Operations (all stages)	MODU operations; vessel operations; helicopter operations

6.1.2.1 Operations

Subsea infrastructure required for the extraction and export of hydrocarbons will be on the seabed for the life of the project.

6.1.2.2 Support Operations

Support operations associated with all stages of the development may interact with other marine users through the displacement of their activities. The type and number of vessels in the project area at any one time, and the duration of presence, will differ depending on the project stage. Usually there will be no more than three vessels operating simultaneously, however, it is possible that for short periods of time drilling may overlap with installation activities. In this case five vessels could be operating together for a short period of time (up to two days).

MODU anchors could be prelaid and may be in place for up to three months prior to the MODU entering the field. Surface buoys associated with the anchors will be in place until the MODU is anchored on location. These can be up to 2 km from the well location and will have a navigation light.

Helicopters will be used during all stages of the development in order to transport personnel to and from the MODU and support vessels.

6.1.3 Impact Analysis and Evaluation

6.1.3.1 Potential impacts

Socioeconomic receptors identified most at risk from the physical presence of the MODU, vessels and subsea infrastructure are:

- Commonwealth & State managed fisheries
- Tourism and recreation
- Industry

6.1.3.2 Commonwealth and State Managed Fisheries

Beach has studied catch effort and consulted extensively with fisheries as part of its ongoing operations in the area. Four Commonwealth Fisheries with catch effort overlap the Project Area:

- Bass Strait Central Zone Scallop Fishery (Bass Strait CZSF)
- Eastern Tuna and Billfish Fishery (ETBF)
- Southern and Eastern Scalefish and Shark Fishery (SESSF)
- Southern Squid Jig Fishery.

Four State Managed Fisheries with catch effort overlap the project area:

- Victorian Rock Lobster Fishery
- Victorian Giant Crab Fishery
- Tasmanian Rock Lobster Fishery
- Tasmanian Giant Crab Fishery

Effort is low. Giant crabs inhabit the continental slope at approximately 200 m depth which is outside the water depths (of the Project Area).

Beach commissioned a report from SETFIA on Trawl and Gillnet fishing activity (SEFTIA 2019) that confirmed:

- trawl fishing in the SESSF Commonwealth Trawl Sector (CTS) board trawl sub-sector does not occur in the project area as the grounds are too rough.
- gillnet fishing in the SESSF Gillnet Hook and Trap (GHaT) Sector does not seem to occur within the project area.
- there is no SESSF CTS Danish seine sub-sector fishing in the project area.
- there is a clear separation of these commercial fishers and oil/gas in the project area.

Beach will continue consultation and, as with all activities, will provide stakeholders prior notification of operations and their timings. We will also request the formal issue of Notice to Mariners prior to activities commencing.

Gazetted petroleum safety zones around the wells will remove the risk of snagging and damaging fishing equipment as vessels will be excluded from these areas. The location of the flowline and umbilicals outside the PSZs will be clearly marked on marine charts and fishers will be made aware of their positions to avoid.

Beach's Fair Ocean Access Procedure was developed with input from commercial fishing industry organisations (Bass Strait Scallop Industry Association, Scallop Fisherman's Association of Tasmania, South East Trawl Fishing Industry Association and Tasmanian Seafood Industry Council. The procedure details the process whereby a commercial fisher can claim compensation for an economic loss associated with Beach's offshore activities where impacts cannot be avoided

Given the above, the impact from the physical presence of project infrastructure on the fishing industry is likely to be minor. The impact is therefore acceptable.

6.1.3.3 Industry

The project area includes major shipping routes (Section 4.5.5). During drilling and installation activities, commercial vessels will be requested to avoid precautionary zones around the MODU and construction vessels. They will also be required to avoid the 500m petroleum safety zones around the wells. Any required deviations would be minor and thus have negligible impact on travel times or fuel use of commercial vessels. All infrastructure will be identified on navigational charts and through Notice to Mariners advice. Vessel and MODU activities associated with the existing Otway Gas Development have been ongoing for over 10 years and to date there has been no interactions or incidents.

Aerial users may be temporarily displaced by helicopter movements from the mainland to the facilities. Helicopters currently access the Thylacine platform once per week and to date there have been no negative interactions. As there are no other manned petroleum facilities in the area, impacts are anticipated to be minimal.

Minor disturbance to industry stakeholders may occur during the project life. However prior notification through stakeholder consultation and the issuing of a notice to mariners will inform other users of operations to minimise impacts on their activities.

6.1.3.4 Tourism and Recreation

Interaction with recreational fishing and tourism is considered unlikely due to the offshore location of the project area) and the lack of emergent features.

6.1.3.5 Cultural Values and Sensitivities

First Nation cultural activities could be affected by restricted access to an area within the Project Area.

The extent of the impact is predicted to be 500 m from the rig while on location. The consequence is assessed as Minor (1) and is of an acceptable level based on:

- No First Nation cultural activities have been identified to occur within the Project Area via stakeholder consultation or during Beach's current Otway or Bass Operations.
- Notices to Mariners will be issued for the Drilling Program and First Nation's people or groups are consulted in relation to the Project activities as detailed in Section 10 of this OPP.

6.1.4 Impact Evaluation Summary

The risk assessment for the displacement of, or interference with third-party vessels, is summarised in **Table 50**.

Summary	
Summary of impact	The physical presence of a MODU, various vessels and subsea infrastructure could displace or interfere with other marine users.
Extent and duration of impact	For the life of the project, there will be mandatory 500 m petroleum safety zones gazetted around wellheads and OGPP tie in locations, from which third-party users will be prohibited entry. During drilling and installation activities there will be a temporary 500m exclusion zones around the MODU and construction vessel from which third-party users will be prohibited entry) for campaigns of up to in the order of 30 to 60 days duration.
Level of certainty of risks	Beach has a high level of certainty about the risk to other users. To address any residual uncertainty, Beach will continue stakeholder consultation and request issue of Notice to

Summary	
	Mariners prior to activities commencing. These will inform stakeholders of operations and minimise impacts on activities.
Risk decision framework context	A – nothing new or unusual, represents business as usual, well understood activity, good practice is well defined.
Impact consequence (inherent)	
Minor	
Controls	
CM01 Navigation safety	All vessels operating within the project area will adhere to the navigation safety requirements including: • International Regulations for Preventing Collisions at Sea 1972 • Chapter 5 of International Convention for the Safety of Life at Sea 1974 • International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978 • Navigation Act 2012 and any subsequent Marine Orders that specify standards for crew training and competency, navigation, communication, and safety measures
CM02 Notifications	The Australian Hydrographic Office will be notified of the Project activities and installed subsea infrastructure prior to commencement to facilitate the issuing of Notice to Mariners and maintain nautical charts. Relevant stakeholders are notified prior to the activity so that third party marine users are aware of vessel location and timing.
CM03 Fair Ocean Access Procedure	Beach's Fair Ocean Access Procedure was developed with input from commercial fishing industry organisations. The procedure details the process whereby a commercial fisher can claim compensation for an economic loss associated with Beach's offshore activities where impacts cannot be avoided. An information sheet on the procedure is available in Appendix D.
CM04 Stakeholder consultation	Beach will undertake consultation with relevant persons for all petroleum activities in accordance with the OPGGS (Environment) Regulations and detailed in Section 10 of this OPP.
CM05 Petroleum safety zones	The Project will comply with OPGGS Act 2006 – Section 616(2) petroleum safety zones, which includes establishment and maintenance of petroleum safety zones around wells, offshore structures or equipment which prohibits vessels entering without written consent.
CM06 Temporary exclusion zones	500m temporary exclusion zones will be established and maintained around drilling and installation activities.
CM07 Decommissioning	Decommissioning of Project facilities in compliance with Section 572 of the OPGGS Act.
Impact consequence (residual)	
Minor	
Environmental Performance Outcomes	
EPO1:	No interference with other marine users to a greater extent than is necessary for the exercise of right conferred by the titles granted.
EPO2:	Commercial marine users are not economically disadvantaged as a result of Project activities
Demonstration of Acceptability	
Principles of ESD	ESD principles are met as the Otway development will not impinge upon the rights of other parties to access environmental resources (e.g., commercial fishers). Planning is Integrating social and equitable considerations for other marine users (Principle A).

Summary		
Internal context	Policy compliance	Beach Environmental Policy objectives are met through this environmental impact assessment.
	Management system compliance	Section 9 describes the implementation strategy that will be employed to comply with management system.
External context	Stakeholder engagement is being carried out as part of this OPP process. Beach operates the existing Otway project and has established good relations with both onshore and offshore stakeholders. Engagement with stakeholders will continue throughout all aspects of the Project to build and maintain trust with stakeholders and the local community and minimise community and stakeholders concern and impacts where practicable.	
Legislative context	The EPOs and control measures align with the requirements of: • OPGGS Act 2006 (Cth). ○ Section 280 – requires that a person carrying on activities in an offshore area under the permit, lease, licence, authority or consent must carry out those activities in a manner that does not interfere with navigation or fishing (among others). • Navigation Act 2012 (Cth). • Chapter 6 (Safety of navigation), particularly Part 3 (Prevention of collisions). • AMSA Marine Orders Part 21 (Safety of Navigation and Emergency Procedures). • AMSA Marine Orders Part 27 (Safety of Navigation and Radio Equipment). • AMSA Marine Order Part 30 (Prevention of Collisions).	
Industry practice	The consideration and adoption of the controls outlined in the Environmental management in the upstream oil and gas industry (IOGP-IPIECA, 2020), demonstrates that best practice is being implemented. • Develop exclusion zones in consultation with key stakeholders, including local fishing communities; raise awareness of exclusion zones with all stakeholders. • Issue a 'Notice to Mariners' through the relevant government agencies, detailing the area of operations. • Ensure all vessels adhere to International Regulations for Preventing Collisions at Sea (COLREGS), which set out the navigation rules to be followed to prevent collisions between two or more vessels. • Optimise vessel use to ensure the number of vessels required and length of time that vessels are on site is as low as practicable.	
Acceptability outcome	Acceptable	

Table 50: Risk assessment for the displacement of or interference with third-party vessels

6.2 Physical Presence – Seabed Disturbance

6.2.1 Hazard Description

Several activities associated with the Project will result in seabed disturbance. These have the potential to impact on marine receptors due to:

- physical removal or disturbance of seabed sediments
- increase in turbidity of the water column near the seabed

- physical injury or death of benthic fauna

These impacts will be localised to the activity and will be short term.

6.2.2 Impact Source

Activities which may interact with the seabed are summarised in **Table 51**.

Stage	Activity
Seabed surveys	Geotechnical survey – sediment sampling
Drilling	MODU anchoring
Installation and Pre-commissioning	Installation of subsea infrastructure
Operations	Inspection, maintenance and repair
Decommissioning	Removal of subsea infrastructure Plug and abandonment of wells
Support Operations	Vessel anchoring

Table 51: Activities which may interact with seabed

6.2.2.1 Seabed surveys

Geotechnical surveys may be required to collect data to inform installation activities, in order to confirm the seabed sediments. Seabed disturbance can result from placing survey equipment on the seafloor, or when collecting seabed samples.

Geotechnical surveys typically involve in-situ testing and piston/push sampling. Following sampling, all equipment is withdrawn from the seabed. A small hole (<1m^2) may remain, which will rapidly collapse and infill with the movement of surface sediments in ocean current given the highly mobile seabed of the region.

6.2.2.2 Drilling

The MODU selected for undertaking drilling operations will be either a jack-up or a semi-submersible drilling unit. If a semi-submersible MODU is selected, the MODU will use a mooring system to remain in position, whilst if a jack-up MODU is selected, the MODU will be fixed in position by three spud cans at the base of each leg. Mooring of a semi-submersible will result in the largest footprint.

Each mooring will consist of:

- 8 to 12 anchors, each covering an area of approximately 30 - 60 m^2.
- 8 to 12 x 2500 m lengths chain (Chain width of ~0.3m) resulting in total disturbance area of 7,200m^2.

Thus, the total area per well is up to approximately 9,720m^2 (0.0097km^2)

The top-hole section of each well will be drilled riserless (with seawater scuffs) with drill cuttings discharged in the near vicinity of the hole. Drill cuttings from the bottom hole sections will be discharge at the sea surface from the MODU after being processed and will disperse further and settle on to the seabed well within the 0.0097km^2 estimated for the semi-submersible seabed disturbance footprint.

6.2.2.3 Installation and Commissioning

Subsea infrastructure, including umbilicals, flowlines and subsea structures (wellheads, manifolds, skids), will be placed on the seabed resulting in seabed disturbance directly below the equipment. Localised placement of stabilisation material may be required to assure stability adjacent to well and structure tie-in locations.

The installation of subsea infrastructure required for the project will generate turbidity when placed on the seafloor. This will result in minor and temporary changes only.

The total extent of seabed footprint required for the installation of seabed infrastructure for the initial development is estimated at approximately 68,750m^2 (0.07km^2). This includes stabilisation support at tie in points if required. This total area is subject to refinement during the design process and drilling campaign outcomes however it represents a conservative approach of each potential exploration and appraisal well being tied back including the longest potential flowline and umbilical route of approximately 65km in length for the most southerly potential well in T/30P being tied into the Thylacine platform.

The seabed disturbance footprint for future drilling and tiebacks is estimated as approximately 60,500m^2 (0.06km^2) based on the conservative approach of each additional future well being tied back with tieback routes being within 10km of existing infrastructure tie in points.

6.2.2.4 Operations

Inspection, maintenance and repair activities may result in small areas of disturbance to the seabed due to placement of stabilisation mattresses and disturbance to sediments around the infrastructure. This will result in highly localised and temporary turbidity and sedimentation.

The use of an ROV or AUV during may result in temporary seabed disturbance and suspension of sediment as a result of working close to, or occasionally on, the seabed. ROV use close to or on the seabed is limited to that required for effective and safe subsea activities. The footprint of a typical ROV and AUV is 2.5 m × 1.7 m (4.25m^2).

6.2.2.5 Decommissioning

The area of seabed disturbance for decommissioning will be similar to the area of planned seabed disturbance, for drilling of the wells and installation of infrastructure. Following well abandonment, wellheads will be cut below seabed and removed to eliminate seabed disturbance from scouring.

6.2.2.6 Support Operations

While vessel anchoring in deeper waters is unlikely, there may be occasions where support vessels anchor in shallower waters, while working on the flowline routes, for example to conserve fuel. Should this be required, the level of seabed disturbance is dependent on the anchoring, however, use of a single anchor could result in a total disturbance area of up to 1300 m.

The estimated seabed disturbance for the initial development and future tiebacks is provided in Table 52.

Facility/Infrastructure	**Approximate Area of Disturbance (km^2)**
Initial Development	
Semi-submersible drilling rig – anchors and mooring lines (7 wells)	0.07
Subsea infrastructure – based on all initial 7 drilling campaign wells tied back and includes: • Infield infrastructure of wellheads, manifolds, skids, stabilisation support • 135km total for tieback routes of flowlines and umbilicals	0.07
Total Area for initial development	0.14
Future Tiebacks	

Facility/Infrastructure	**Approximate Area of Disturbance (km²)**
Semi-submersible drilling rig – anchors and mooring lines (10 wells)	0.10
Subsea infrastructure – based on 10km tie-back routes for all additional 10 wells and includes: • Infield infrastructure of wellheads, manifolds, skids, stabilisation support • 100km total for tieback routes of flowlines and umbilicals	0.06
Total Area for future tiebacks	0.16

Table 52: Estimated area of seabed disturbance

6.2.3 Impact Analysis and Evaluation

6.2.3.1 Potential impacts

Seabed disturbances generated by the Project have the potential to result in the following impacts within the project area:

- change in water quality
- change in habitat.
- injury / mortality to fauna.
- socio economic impacts

The area that may be affected is restricted to the seabed and overlying water. Receptors most at risk are benthic habitat and communities (epifauna and infauna).

The Project Area is 3,248 km^2 and the estimated footprint of subsea disturbance of the initial development is up to 0.07 km^2 (less than 0.003% of the Project Area) and a total of up to 0.06 km^2 for future tieback (less than 0.003% of the Project Area). The Project Area has been designed to not include the deeper waters off the continental shelf and to avoid potential overlap with the Zeehan Marine Park with a minimum 1km buffer applied.

The seabed in the project area consists predominantly of carbonate rich coarse to medium sands with areas of exposed limestone substrate. Epifauna is patchy and provides refuge for a range of infauna consisting of amphipods, isopods, polychaete worms and molluscs.

Activities may result in the mortality of benthic habitat directly below installed infrastructure. These benthic habitats and associated organisms are well represented in the region. They will remain viable and are expected to recolonise through recruitment from adjacent undisturbed areas. No species or ecological communities listed as threatened under the Environmental Protection and Biodiversity Conservation Act 1999 (the EPBC Act) are present.

Subsea infrastructure may contribute to available habitat through the introduction of additional hard substrate required by some benthic organisms for anchoring. Over time this colonisation can lead to development of a biofouling community which may provide foraging resources for pelagic fish species and artificial reefs potentially supporting fish aggregations (Forteath et al. 1982; Gallaway et al. 1981; Todd et al. 2016).

Displacement of sediments may occur during subsea equipment deployment and installation, and through sediment excavation and levelling. This will result in temporary, localised plumes of suspended sediment and subsequent redeposition that could result in smothering of benthic habitat and communities in the immediate vicinity.

A study on the recovery of seabed following bottom trawling activities identified faster recovery times for coarse sediment (sand) compared to fine sediment regions (Hiddink et al, 2017). Dernie et al (2003) identified that benthic community recovery times following physical disturbance in finer sediment habitats varied from 64 days for low intensity disturbances and up to 208 days for higher intensity disturbance. It is expected that the seabed disturbance following the removal of anchors and other equipment associated with the Project will be consistent with low intensity disturbances.

During anchoring activities there is the potential for soft sediments to be suspended into the water column which may affect benthic communities through a decrease in water quality or light penetration. Given the hydrodynamics in open ocean areas such as the Project area, the area of decreased water quality is expected to be localised and temporary as soft sediments would settle out of the water column relatively quickly.

The impact on benthic communities is considered to be minor given the sparse cover, small footprint relative to the region, short duration of sedimentation and expected recovery through recolonisation.

Seabed disturbance has the potential to result in a change to benthic habitat and subsequently to associated benthic species. There are two commercially fished marine benthic invertebrate species present in the Project area which could be indirectly susceptible to seabed disturbance: the giant crab and the southern rock lobster. Benthic invertebrates such as these two species are mobile species and so generally less vulnerable than sessile taxa to sedimentation as they are able to move to areas with less sediment accumulation or by more efficiently removing particles (Fraser et al, 2017). Due to the spatial area of the seabed which may be disturbed within the wider extent of available fishing grounds and short duration of the activity and any sedimentation, impacts to benthic commercial species are predicted to be localised and insignificant at population level.

As described in Section 4.6, Sea Country connection extends far beyond the current shoreline and so the Project area overlaps Sea Country. Disturbance of the seabed has the potential to interfere with First Nations submerged cultural heritage.

The implementation of underwater cultural heritage assessments within potential areas of disturbance in the Project area (CM11) will ensure any cultural heritage values are not impacted.

Seabed disturbance is assessed as having a Minor (1) potential consequence to socioeconomic values.

6.2.4 Impact Evaluation Summary

The impact assessment for seabed disturbance is presented in **Table 53**.

Summary	
Summary of impacts	Localised impact from physical disturbance within the footprint of the Project. Impact is expected to be limited given the sparse cover of benthic communities and expected recovery through recolonisation.
Extent of impact	Localised – around individual points of disturbance. Initial development area of disturbance is less than 0.003% of the Project Area and less than 0.003% for future tiebacks.
Duration of impacts	Temporary – disturbed areas will return to pre-impact conditions through recolonisation.
Level of certainty of impacts	HIGH – Benthic habitats within the project area are widespread and typical of the region.
Impact decision framework context	A – well understood activity, good practice is well defined.

<table>
<tr><th colspan="3">Summary</th></tr>
<tr><td colspan="3">Impact Consequence (inherent)</td></tr>
<tr><td colspan="3">Minor</td></tr>
<tr><td colspan="3">Controls</td></tr>
<tr><td>CM07 Decommissioning</td><td colspan="2">Decommissioning of Project facilities in compliance with Section 572 of the OPGGS Act</td></tr>
<tr><td>CM08 Project Execution Plans</td><td colspan="2">Infrastructure will be positioned on the seabed within design footprint to reduce seabed disturbance</td></tr>
<tr><td>CM09 MODU and Vessel Anchoring Plan</td><td colspan="2">A MODU and vessel anchoring plan will identify suitable areas for anchors to be placed within the Project Area</td></tr>
<tr><td>CM10 Seabed assessments</td><td colspan="2">Seabed assessments undertaken of each well location and tie-back route prior to final selection to identify seabed composition, benthic habitats and communities and ensure areas of high relief outcrops, reefs, sponge beds, maritime archaeology, submerged cultural heritage and landscapes are avoided where practicable within technical and safety constraints</td></tr>
<tr><td>CM11 Cultural heritage assessments</td><td colspan="2">Imagery and data from seabed surveys and assessments will be provided to appropriately qualified underwater archaeologists to identify any maritime archaeological and submerged cultural heritage and landscapes and inform protection priorities, management measures and reporting requirements.</td></tr>
<tr><td colspan="3">Impact Consequence (residual)</td></tr>
<tr><td colspan="3">Minor</td></tr>
<tr><td colspan="3">Environmental Performance Outcomes</td></tr>
<tr><td>EPO3</td><td colspan="2">Seabed disturbance is limited to planned well and infrastructure locations within the Project area</td></tr>
<tr><td>EPO4</td><td colspan="2">No impact to submerged cultural heritage</td></tr>
<tr><td>EPO5</td><td colspan="2">No death or injury to marine fauna, including listed threatened or migratory species, from Project activities</td></tr>
<tr><td>EPO6</td><td colspan="2">Decommissioning of Project facilities in compliance with Section 572 (3) of the Offshore Petroleum and Greenhouse Gas Storage (OPGGS) Act 2006</td></tr>
<tr><td colspan="3">Demonstration of Acceptability</td></tr>
<tr><td>Principles of ESD</td><td colspan="2">Management of seabed disturbance from Otway is consistent with the principles of ESD as:
• there is no threat of serious or irreversible environmental damage,
• environmental resources within the project area will not be significantly impacted and biological diversity and ecological integrity will be maintained.</td></tr>
<tr><td rowspan="2">Internal context</td><td>Policy compliance</td><td>Beach Environmental Policy objectives are met through this environmental impact assessment.</td></tr>
<tr><td>Management system compliance</td><td>Section 9 describes the implementation strategy employed for this activity.</td></tr>
<tr><td>External context</td><td colspan="2">Stakeholder engagement is being carried out as part of this OPP process.
Beach operates the existing Otway project and has established good relations with both onshore and offshore stakeholders. Engagement with stakeholders will continue throughout all aspects of the Project to build and maintain trust</td></tr>
</table>

Summary	
	with stakeholders and the local community and minimise community and stakeholders concern and impacts where practicable.
Legislative context	The EPOs and control measures align with the requirements of: • OPGGS Act 2006 (Cth): ○ Section 460(2) – a person carrying on activities in an offshore area under the permit must carry out those activities in a manner that does not interfere with...the conservation of the resources of the sea and seabed to a greater extent than is necessary for the reasonable exercise of the rights and performance of the duties of the first person. • Significant impact criteria (refer Table 41 in Section 5.8.2) • EPBC Management/Recovery Plans and Conservation Advice (refer Table 5 in Section 2.3.1)
Industry practice	The consideration and adoption of the controls outlined in the Environmental management in the upstream oil and gas industry (IOGP-IPIECA, 2020), demonstrates that best practice is being implemented. • Consider sensitive marine habitats. • Reduce footprint
Acceptability outcome	**Acceptable**

Table 53: Impact assessment for seabed disturbance

6.3 Emissions – Light

6.3.1 Hazard Description

There will be no permanent lighting associated with the Project. Project vessels involved in the various project stages on temporary basis will be the only light sources, in addition, flaring may be required during well intervention or drilling activities, which is short term as it is limited to 1-2 days per well within infrequent drilling campaigns.

The MODU and project vessels will have external lighting to support safe navigation and operations at night, with project activities planned to be conducted 24 hours a day. All offshore facilities and vessels must meet maritime and operational safety lighting requirements, as specified by Safety Case assessments under the OPGGS Act and relevant legislation, such as the Navigation Act 2012. Artificial light will result in light spill to the surrounding marine environment.

Light is known to attract sensitive species, in turn affecting predator-prey dynamics. This may result in collision, entrapment, stranding and grounding on offshore infrastructure, and disorientation or interference with navigation from usual migration routes (DoEE, 2020).

6.3.2 Impact Source

Lighting will be required and therefore emitted during the following stages and activities:

Stage	Activity
Drilling and completion	Well unload and production testing (contingent)

Stage	Activity
Support Operations (all stages)	MODU operation; Vessel operation

6.3.2.1 Drilling

Flaring associated with well flowback during the potential testing of the wells via the drilling rig may occur in the initial or future drilling campaigns if the base case of unloading the wells to the OGP is not feasible.

The duration of flaring is in the order of 1-2 days for each well.

6.3.2.2 Support Operation (all stages)

External lighting will be required on vessels and the MODU for safe navigation and night-time work operations. Halogens, fluorescent and metal halide lights are generally used offshore. These emit white light and would be similar to lighting used by other offshore mariners (i.e. shipping and fishing).

6.3.3 Impact Analysis and Evaluation

For the light assessment, the identification of light sensitive receptors was undertaken within two light EMBAs, 20km for routine light and 50km for flaring light. These EMBAs cover routine light emissions from both MODU and vessels, and light emissions from flaring during drilling from any location in the Project Area.

The EMBA for routine light emissions is based on the National Light Pollution Guidelines for Wildlife (the Guidelines) (Commonwealth of Australia 2023). The guidelines recommend undertaking a light impact assessment where important habitat for list species sensitive to light are located within 20 km of the light source. The 20 km threshold provides a precautionary limit based on observed effects of sky glow on marine turtle hatchlings demonstrated to occur at 15-18 km and fledgling seabirds grounded in response to artificial light 15 km away (Commonwealth of Australia 2023). Seabird grounding, as described in Rodriguez et al (2014), relates to impacts of onshore fixed light sources such as streetlights and buildings and the effect this can have on young fledgling birds making their first flight from their nests to the open ocean.

This 20 km light EMBA adopted is considered to be highly conservative based on the following studies. These studies used a MODU as the basis for assessing routine light emissions from MODU and vessels given the MODU would be the largest and tallest piece of infrastructure used:

- A light assessment study was undertaken for the Otway Exploration Drilling Campaign (Xodus, 2023) located in the Bass Strait in an area directly adjacent to the Project Area of this OPP. The study predicted that the area of potential impact from lighting would be up to 9 km from the MODU as there was no measurable changes to ambient light intensity levels beyond this distance.
- A light assessment study was undertaken for the Browse FLNG development (Woodside, 2014) to assess the likely light density levels from a MODU. This study predicted light density levels at representative of background levels beyond 12.6 km from the MODU.

The EMBA for flaring light emissions of 50 km was based on the following:

- The light assessment study undertaken for the Otway Exploration Drilling Campaign (Xodus, 2023) located in the Bass Strait in an area directly adjacent to the Project Area predicted the area of potential impact from lighting from flaring would be up to 49 km from the MODU as there was no measurable changes to ambient light intensity levels beyond this distance.

- Shell (2009) estimated that light from production flaring activities can be detected as far as 51 km from the source. Similarly, an assessment by Woodside (2014) for the Browse FLNG development reported that the maximum distance at which production flaring under routine operational conditions was detectable was 47.9 km.

6.3.3.1 Potential Impacts

The predicted environmental impacts from light emissions are changes in ambient light leading to changes in fauna behaviour, through attraction or avoidance of light-sensitive species.

For the light impact assessment, the process outlined in The National Light Pollution Guidelines for Wildlife is used.

The guidelines identify marine turtles, seabirds and migratory shorebirds as potentially being impacted by artificial light to a level significant enough to require assessment. In addition to this, impacts on fish/plankton and coastal communities are assessed.

The guidelines detail that important habitats are those areas necessary for an ecologically significant proportion of a listed species to undertake important activities such as foraging, breeding, roosting or dispersal. For this assessment the two light EMBAs were used to identify any areas where turtles, shorebirds and seabirds may be foraging, breeding, roosting, or migrating. The EPBC Protected Matters Report for these EMBAs are in Appendix E.

For the purposes of this OPP, species listed as Threatened under the EPBC Act that are likely to occur in the light EMBAs were considered to have conservation significance warranting further assessment in this section. Likely occurrence was determined by the PMST Reports or through designation of a BIA.

6.3.3.1.1 Fish and Plankton

Normal working lights on marine research vessels—and, by implication, lights from other sources including fishing boats, cargo vessels, recreational watercraft, jetties and oil and gas platforms—have been shown to cause zooplankton and their vertebrate predators to descend away from the surface; these effects occurred at depths of up to 200 m, and up to 200 m horizontally from the light source (Berge et al. 2020). Since most zooplankton need to ascend to forage on phytoplankton near the water's surface, light pollution may lead to an overall reduction in zooplankton, with cascading effects on their predators, and so on up the food chain (DCCEEW 2022).

Fish may be directly or indirectly attracted to lights. Experiments using light traps have found that some fish and zooplankton species are attracted to light sources (Meekan et al. 2001), with traps drawing catches from up to 90 m (Milicich et al. 1992). Lindquist et al (2005) concluded from a study of larval fish populations around an oil and gas platform in the Gulf of Mexico that an enhanced abundance of clupeids (herring and sardines) and engraulids (anchovies), both of which are highly photopositive, was caused by the platforms' light fields. The concentration of organisms attracted to light results in an increase in food source for predatory species and marine predators are known to aggregate at the edges of artificial light halos. Shaw et al (2002), in a similar light trap study, noted that juvenile tunas (Scombridae) and jacks (Carangidae), which are highly predatory, may have been preying upon concentrations of zooplankton attracted to the light field of the platforms. This could potentially lead to increased predation rates compared to unlit areas however considered negligible given the temporary nature of the light emissions associated with the Project.

6.3.3.1.2 Seabirds and Shorebirds

The EPBC Act PMST reported the presence of 77 species of birds within the routine light and/or flaring EMBAs (Appendix E). Of these, 49 bird species have a EPBC threatened status, including 7 listed as Critically

Endangered (curlew sandpiper (Calidris ferruginea), eastern curlew (Numenius madagascariensis), orangebellied parrot (Neophema chrysogaster), swift parrot (Lathamus discolor), regent honeyeater (Anthochaera phrygia), King Island scrubtit (Acanthornis magna greeniana) and plains-wanderer (Pedionomus torquatus), with 28 listed as Vulnerable and 14 Endangered. 19 BIAs for bird species have been identified within the light EMBAs (Figures 99 to 102).

The physical aspects of light that have the greatest impact on seabirds include intensity and colour (wavelength). Seabirds and shorebirds perceive light slightly differently. In general, all seabirds are sensitive to violet – blue wavelengths (Capuska et al. 2011), long wavelengths when using their photopic vision (daylight adapted), and short wavelengths when using scotopic vision (dark adapted) (CoA 2023). Most seabirds will be more attracted to very bright, high intensity lights, regardless of the colour (Raine et al. 2007). Numerous, albeit often conflicting, reports exist on the attractiveness of wavelengths for seabirds. There is however a consensus that white light has the greatest effect as it contains all wavelengths of light (Rich and Longcore 2006).

Seabirds may be attracted to the light glow from the MODU and support vessels. Bright lighting can disorientate birds, thereby increasing the likelihood of seabird injury or mortality through collision with the vessel, or mortality from starvation due to disrupted migration or foraging at sea (Wiese et al. 2001). Disorientation may also result in entrapment, stranding, grounding, and interference with navigation (CoA 2023). Whilst all bird species are vulnerable to the effects of lighting, seabirds active at night while migrating, foraging, or returning to colonies are most at risk (CoA 2023). The National Light Pollution Guidelines for Wildlife also noted that artificial light may provide enhanced capability for seabirds to forage at night. However, this more likely associated with coastal areas. Whilst the flaring EMBA will overlap a limited amount of coastline, the increased light level will be for short durations (up to 48 hours per well for up to 7 wells in the initial drilling campaign and up to 10 potential future wells).

In general, young birds (fledglings) are more likely to become disorientated by artificial light sources as they are more vulnerable to the effects than adults. Fledglings have been observed being affected by lights up to 15 km away, with counts of fledgling mortalities from grounding shown to be largely underreported (Rodriguez et al. 2014). Artificial lights are thought to override the natural cues from the moon and star light on the horizon, which has the potential to attract fledging seabirds back onshore after reaching the sea (Warham 1996), or to prevent fledging's from imprinting the location of their natal colony prior to migration (CoA 2023). Furthermore, fledglings may not undertake their first flight if their nesting habitat never becomes dark (CoA 2023). The impacts of artificial light upon the viability of breeding seabird populations are largely unknow (Griesemer and Holmes 2011).

The Wildlife Conservation Plan for Seabirds (DCCEEW 2020) lists light pollution as a threat with minor consequence (individuals affected but no population level impacts expected). For most species, the threat of light pollution relates to disturbance to critical behaviours (such as nesting or roosting) on land.

The PMST Report (Appendix E) identified 13 species of albatross and 6 petrel species which have a presence or have BIAs within the routine light and/or flaring light EMBAs (Figures 99-102). Whilst the National Recovery Plan for Albatrosses and Petrels (2022) (DCCEEW 2022e) identifies light emissions as a threat, it classifies marine infrastructure interactions including those associated with artificial light as having no risk category priority and affecting 'Nil' species in Australian jurisdiction.

Seven albatross species were identified with foraging BIAs within both of the light EMBAs. All species are migratory with widespread distributions throughout the Southern hemisphere and have been shown to travel large distances when foraging. For example, the wandering albatross (Diomedea exulans) has been shown to cover distance between 3,600 and 15,000 km in a single foraging trip during incubation periods during the breeding season which commences early November on subantarctic islands (Jouventin and Weimerskirch

1990) (see Figure 101). The recognised foraging BIAs for albatross species generally covers large areas. For example, the entire South-east Marine region is recognised as a foraging BIA for the Indian yellow-nosed (Thalassarche carteri), Campbell (Thalassarche impavida) and the black-browed albatross species (Figure 100).

One species of albatross, listed as Endangered, has a foraging BIA overlapped by both of the light EMBAs (the shy albatross) (Figure 101). The shy albatross is the only albatross species endemic to Australia, with a wide distribution across the southern oceans (OEH 2022). Adult shy albatrosses predominantly occur in waters adjacent to Tasmania and southern Australia (Abbott et al. 2006b) with the largest light footprint (50 km around the Project Area during flaring) overlapping less than 1% of their likely foraging areas. Light emissions are not listed as a threat to the shy albatross within the Conservation Advice for the species (DAWE 2022b)

The remaining albatross species with foraging BIAs overlapped by both of the light EMBAs are Vulnerable and, including the antipodean (Diomedea antipodensis), and the Buller's albatross (Thalassarche bulleri platei). The antipodean albatross forages widely in the open water within the south-west Pacific Ocean, the Southern Ocean and the Tasman Sea (DoE 2022). The light EMBAs overlaps the foraging BIAs, with the largest light footprint (50 km around the Project area during flaring) overlapping less than 1% of the foraging BIAs (see Figure 99). Non-breeding males were shown to have the largest range, foraging off the coast of Chile, Antarctica and in the tropical South Pacific. The Buller's albatross is a non-breeding visitor to Australia, predominantly foraging within the Pacific Ocean and the Tasman Sea, although foraging distribution on this species is poorly known (DoE 2022). The light EMBAs overlap the foraging BIAs, with the largest light footprint (50 km around the Project area during flaring) overlapping less than 1% of the foraging BIAs (see Figure 99).

A further six species of albatross have been identified within the PMST Report which do not have foraging or breeding BIAs that overlap either of the light EMBAs. Two are listed as Endangered (greyheaded albatross (Thalassarche chrysostoma) and northern royal albatross (Diomedea sanfordi)) and four as Vulnerable. Whilst the grey-headed albatross has a circum-global distribution in the Southern Hemisphere, it breeds on subantarctic island colonies from September to late May (DoE 2022) and forages primarily away from the continental shelf (Prince et al. 1998). The northern royal albatross feeds regularly in Tasmanian and South Australian waters (Garnett & Crowley 2000), however individuals are also known to disperse to the south-west Atlantic off Argentina, the eastern south Pacific near Chile, the southern Indian Ocean, and southeast Australia (DEWHA 2009).

Petrel species have a widespread distribution throughout the Southern hemisphere, with wide, recognised foraging areas. Two migratory petrel species the white-faced storm-petrel (Pelagodroma marina) and the common diving-petrel (Pelecanoides urinatrix) have foraging BIAs that overlap the light EMBAs. The whitefaced storm petrels are widely distributed throughout Australia, with the Australian population estimated to be about 25 % of the global population (DSEWPaC 2011a). The light EMBAs overlap the foraging BIA, with the largest light footprint (50 km around the Project area during flaring) overlapping less than 1% of the foraging BIAs (see Figure 101). The species is migratory, moving from their temperate breeding grounds to tropical and subtropical locations in late March (Underwood and Bunce 2004). There is limited information on whether the species forages at night, however, other species within the family of Procellariidae, such as the white-bellied storm-petrel (Fregetta grallaria grallaria), have been identified to (DoE 2022; Hutton 1991).

The common-diving petrel is the only species with a foraging BIA to overlap both of the light EMBAs which is confirmed to forage at night, occasionally identified to forage on vertically migrating plankton (Brooke 2004) The species typically forages in the near-shore areas around their breeding colonies before migrating to tropical locations in January (Brooke 2004; del Hoyo et al. 1992). The common diving petrel's foraging BIA is overlapped by the light EMBAs with the largest light footprint (50 km around the Project area during flaring) overlapping less than of 2% of the foraging BIA (see Figure 100). In general, they undertake a unimodal foraging trip duration strategy (consistent short daily foraging trips) during both incubation and chick-rearing periods, unlike other small seabirds within their family (Fromant et al. 2021). However, studies on common-diving petrels within the Bass Strait have shown higher foraging efforts compared to other populations (with foraging trips averaging 71 ± 3 km), potentially due to the sparse distribution of prey (mostly coastal krill) (Formant et al. 2021). There is potential for light emissions from the activity to overlap with the occasional foraging times of the common diving petrel. There is currently no recovery plan or conservation advice available for this species.

A further five petrel species were identified within the PMST Report but do not have BIAs that overlap either of the light EMBAs. Two are listed as Endangered (southern giant-petrel (Macronectes giganteus) and Gould’s petrel (Pterodroma leucoptera)).

The majority of albatross and petrel species are known to forage during the day and are less active at night due to the reduced ability to see and capture prey (Phalan et al. 2007). Therefore, foraging activity is unlikely to be affected due to a change in ambient light. Albatross and giant petrel species have a wide distribution in southern Australian waters where they exhibit a broad range of foraging behaviours and diverse diets. Therefore, a localised change in ambient light as a result of the Project is unlikely to affect foraging behaviour. A change in ambient light is also unlikely to cause behavioural changes or result in injury/mortality to albatrosses or petrel species.

The light EMBA PMST Reports (Appendix E) identified two species of shearwaters which have BIAs within the light EMBAs (short-tailed shearwater (Ardenna tenuirostris) and wedge-tailed shearwater (Ardenna pacifica)) neither of which have a threatened status listing.

Short-tailed shearwaters are known to alternate short foraging trips with long foraging trips within Australian waters during the breeding season (Berlincourt & Arnould 2015). Some long foraging trips can take up to 17 days, with individuals travelling large distances to the Polar Frontal Zone to forage (Weimerskirch and Cherel 1998). When present in Australian waters (September to May) the species are known to typically forage during daylight, returning to the colonies after feeding at night (AAD 2020). The foraging BIA for the short-tailed shearwater is overlapped by both light EMBAs with the largest light footprint (50 km around the Project area during flaring) overlapping less than 3% of the foraging BIAs (Figure 100). The breeding BIA is also overlapped by the flaring EMBA (Figure 100). This species has multiple breeding sites recognised on numerous islands off Victoria and Tasmania during the breeding season (Baker and Hamilton 2013). The closest breeding location is located approximately 30 km from the Project area (see Figure 100). As flaring will only be intermittent and temporary (48 hours per well) these emissions are not expected to cause behavioural impacts or injury/mortality to the species. There is no recovery plan or conservation advice available for this species and light has not been identified as a threat.

The wedge-tailed shearwater is listed as a marine and migratory species. The foraging BIA of the species was overlapped by both EMBAs. The species have been recorded to predominantly forage during the day and form large aggregations referred to as ”rafts” just offshore from their breeding colony just on dusk and enter and leave the colony at night to avoid predators (Warham 1996). A breeding BIA is also overlapped by the light EMBAs (Figure 101). This species breeds colonially in summer throughout its known range, typically on vegetated islands (DoE 2020g). Light impacts will only be intermittent and temporary and therefore are not expected to cause impact at a population level. A change in ambient light within the EMBAs is unlikely to cause behavioural changes or result in injury/mortality to the wedge-tailed shearwater. No recovery plan or conservation advice exists for the species, and light has not been identified as a threat to the wedge-tailed shearwater (DoE 2020).

An additional two species of shearwater were identified within the PMST Reports (Appendix E) but neither have foraging or breeding BIAs that overlap the light EMBAs or are listed as threatened. Shearwater species have a wide distribution in southern Australia and a localised change in ambient light within the EMBAs is unlikely to affect foraging behaviours or cause injury/mortality.

The Critically Endangered eastern curlew (Numenius madagascariensis) has been identified within the EPBC PMST Report for the light EMBAs (Appendix E). The species undertakes long annual migratory flights to breeding sites in Russia and north-eastern China and returns to Australian waters in August (DoE 2022). The eastern curlew has widespread distribution in coastal regions within the north-east and south of Australia, including Tasmania (Birdlife 2022b). Within Australia, the eastern curlew is known to inhabit intertidal coastal habitats, such as mudflats, estuaries, and sheltered coasts and bays (Birdlife 2022b).

No BIAs or habitat critical to the survival of the species were identified within the light EMBAs. Given its habitat preferences, this species is unlikely to occur within the light EMBAs other than potentially overflying during migration, with the northern migration to breeding sites starting in late February and March-April, and the southern migration to Australian waters occurring during August and September (Marchant and Higgins 1993). A change in ambient light within the EMBAs is unlikely to cause behavioural changes or result injury/mortality to the eastern curlew.

The Critically Endangered curlew sandpiper (Calidris ferruginea) has been identified within the EPBC PMST Report for the light EMBAs (Appendix E). The curlew sandpiper has a widespread distribution throughout Australia, with records confirming the species presence in all states and territory, including King Island. Population numbers have demonstrated numerous declines globally, with south-east Tasmania numbers decreasing by 100% between 1973 – 2014 (Woehler pers. Comm. (2014) in DoE 2022). A large portion of this global decline is attributed to the ongoing loss of mudflats within the Yellow Sea, a key migration staging site, and local coastal development and activities causing disturbance (DoE 2022). The species mainly occurs in intertidal mudflats within sheltered coastal areas where they forage on invertebrates, and less often inland, near lakes, dams, and waterholes (DoE 2022). No BIAs or habitat critical to the survival of the species were identified within the light or flaring EMBAs. Given its habitat preferences, this species is unlikely to occur within the light EMBAs other than overflying during migration, arriving in south-eastern Australia in late August, and starting the migration North again in March (DoE 2022). A change in ambient light within the EMBAs is unlikely to cause behavioural changes or result injury/mortality to the curlew sandpiper.

The foraging BIA for the black faced cormorant (Phalacrocorax fuscescens) was identified within the light and flaring EMBA with the largest light footprint (50 km around the Project area during short-term flaring) overlapping less than 1% of the total foraging BIA. The species is endemic to Southern Australia and is associated with a wide foraging range, from coastal waters, sheltered bays, islets, to coastline rivers along the coasts of Tasmania and Victoria (DoE 2015a). The species are known to breed on rocky islands (del Hoyo et al. 1992) with the closest breeding location located approximately 30 km from the Project area (Figure 99). Breeding can occur throughout the year for the black-faced cormorant within Australia (Birdlife 2022d); however, studies on colonies within south-eastern Australia have reported peak breeding to occur in late winter (July), suggested as a strategy to avoid the high ambient temperatures associated in the region during summer (Taylor et al. 2013). The breeding BIA for this species overlaps with the flaring EMBA. Flaring impacts will only be intermittent and temporary and therefore not expected to cause impact at a population level. A change in ambient light within the EMBAs is unlikely to cause behavioural changes or result in injury or mortality to the black-faced cormorant.

A foraging and breeding BIA for the little penguin (Eudyptula minor) was identified within the flaring EMBA (Figure 100). Despite the colony of little penguins at Manly, Sydney Harbour, being protected as an endangered population, the Australian population is considered stable at approximately one million birds

(Birdlife 2022c). The species is known to exhibit a wide foraging range, with individuals able to spend weeks away at sea foraging (McCutcheon et al. 2011). The closest breeding aggregation areas exist at Christmas Island located of off nearby King Island approximately 30 km from the Project area (see Figure 100) and at Lady Julia Percy Island and Middle Island. Breeding typically occurs from September to February. Studies suggest that penguins were habituated to artificial lights and were unaffected by a 15 lux increase in artificial illumination (Rodriguez et al. 2016). However, when exposed to artificial light, fledglings can be disoriented and grounded and are vulnerable to collision with infrastructure when disoriented (Rodríguez et al. 2017). The breeding BIA for the species only overlaps with the flaring EMBA, and a change in ambient light levels from flaring operations will only be intermittent and temporary (48 hours per well), and not expected to cause impact at a population level. Therefore, a change in ambient light within the EMBAs is unlikely to cause behavioural changes or result in injury/mortality to the little penguin.

The Critically Endangered great knot (Calidris tenuirostris) has been identified within the EPBC PMST Report (Appendix E). This species breeds in the northern hemisphere and undertakes biannual migrations along the East Asian-Australasian Flyway where majority of the population will winter along the northern coast of Australia (TSSC 2015f). Although it has been recorded around the entirety of the Australian coastline the great knot is much less common along the southern Australian coastline (TSSC 2015f). This species is expected to be present within Australia between August and March where it can be found in sheltered coastal habitats with large intertidal mudflats (TSSC 2015f). No BIAs or habitat critical to the survival of the species were identified within the light EMBAs. Given its habitat preferences, this species is unlikely to occur within the light EMBAs. Therefore, a change in ambient light is unlikely to cause behavioural changes or result in injury/mortality to the great knot.

The Critically Endangered swift parrot (Lathamus discolor) has been identified within the EPBC PMST Report (Appendix E). During summer, it breeds in colonies in blue gum forest of south-east Tasmania with infrequent breeding also occurring in north-west Tasmania. The entire population migrates to the mainland for winter where it disperses widely (DoE 2022).

No BIAs or habitat critical to the survival of the species were identified within the light of flaring EMBAs. Given its habitat preferences, this species is unlikely to occur within the light or flaring EMBAs other than overflying during migration. Therefore, a change in ambient light within the EMBAs is unlikely to cause behavioural changes or result in injury/mortality to the swift parrot.

The Critically Endangered King Island scrubtit (Acanthornis magna greeniana) has been identified within the EPBC PMST Report (Appendix E). This species has limited distribution on King Island and tends to be restricted to areas of mature swamp paperbark forest that occur in flat, low lying and poorly drained swamps (DoE 2022). No BIAs or habitat critical to the survival of the species were identified within the light EMBAs. Given its habitat preferences, this species is unlikely to occur within the light EMBAs. Therefore, a change in ambient light is unlikely to cause behavioural changes or result in injury/mortality to the King Island scrubtit.

The Critically Endangered regent honeyeater (Anthochaera phrygia) has been identified within the EPBC PMST Report (Appendix E). This species typically inhabits the inland slopes of the Great Dividing Range and is commonly associated with box-ironbark eucalypt woodland and dry sclerophyll forest; however, it sometimes utilises lowland coastal forest (DoE 2015f). The species movement patterns are thought to be dictated by the flowering of specific eucalypt species as their diets are primarily made up of nectar. No BIAs or habitat critical to the survival of the species were identified within the light EMBAs. Given its habitat preferences, this species is unlikely to occur within the light EMBAs. Therefore, a change in ambient light is unlikely to cause behavioural changes or result in injury/mortality to the regent honeyeater.

The Critically Endangered plains-wanderer (Pedionomus torquatus) has been identified within the EPBC PMST Report (Appendix E). This sedentary species typically inhabits sparse grasslands and are capable of breeding within their first year (DoE 2015g). No BIAs or habitat critical to the survival of the species were identified within the light EMBAs. Given its habitat preferences, this species is unlikely to occur within the light EMBAs. Therefore, a change in ambient light is unlikely to cause behavioural changes or result in injury/mortality to the plains-wanderer.

The likely distribution and probable migration route identified for the Critically Endangered orange-bellied parrot (Neophema chrysogaster) overlap the light and flaring EMBA boundaries, with the largest light footprint (50 km around the Project area during flaring) overlapping the likely distribution by less than 5% and the probable migration route by less than 6% (Figure 102). No BIAs or areas deemed as habitat critical to the survival of the species were identified within the light or flaring EMBAs.

The orange-bellied parrot is a ground feeding parrot which breeds in south-west Tasmanian. They migrate from Tasmania to Victoria between late February and early April (Australian Museum 2022b). In Victoria, the orange-bellied parrot mostly occurs in sheltered coastal habitats, such as bays, lagoons and estuaries, or, rarely, saltworks. The parrot's breeding habitat is restricted to south-west Tasmania, where breeding occurs from November to mid-January mainly within 30 km of the coast (Brown and Wilson, 1980). During winter, on mainland Australia, orange-bellied parrots are found mostly within 3 km of the coast (DELWP 2016).

The 2022-23 breeding season showed a record number of 74 orange-bellied parrots return to breeding grounds and production of 59 fledglings, the third highest fledgling production since 2004 (NRE Tasmania 2023). It is estimated that approximately 139 individuals will have migrated north from the breeding grounds at the end of the 2022-23 breeding season, again just shy of the 140 individuals estimated to have migrated north the past season (DPIPWE 2022; DPC 2023). Figure 102 displays the orange-bellied parrot presence and migration routes as detailed in the Species of National Environmental Significance Distributions (public grids) (DAWE 2021) and the National Recovery Plan for the Orange-bellied Parrot Neophema chrysogaster (DELWP 2016).

The National Recovery Plan for the Orange bellied Parrot (DELWP 2016) identifies that the behaviour of this species may be modified by the presence of barriers such illuminated structure and boats, with the impacts of barriers greatest where they occur on migration routes, though there is little more than anecdotal evidence to support this. The Project Area only slightly overlaps the migration route of the orange-bellied parrot and, as such, the activities of the MODU and vessels when undertaking the petroleum activity do not present the same risk as that associated with illuminated structures or illuminated boats within the migration route. Impacts associated with flaring, which will not occur within the migration route but rather may change ambient light in the area, will be temporary and of short duration. Therefore, a change in ambient light is unlikely to cause behavioural changes or result in injury/mortality to the orange-bellied parrot.

The Vulnerable hooded plover (eastern) (Thinornis rubricollis rubricollis) has been identified within the EPBC PMST Report (Appendix E). The hooded plover (eastern) inhabits ocean beaches, particularly wide beaches backed by dunes with large amounts of seaweed, creek mouths and inlet entrances. It may also occur on near-coastal saline and freshwater lakes and lagoons, tidal bays and estuaries, on rock platforms, or on rocky or sandy reefs close to shore (Marchant & Higgins, 1993; Garnett et al., 2011). No BIAs or habitat critical to the survival of the species were identified within the light EMBAs. Whilst the hooded plover may occur within the light EMBAs, light is not listed as a threat to the species. Therefore, a change in ambient light is unlikely to cause behavioural changes or result in injury/mortality to the hooded plover.

The residual consequence severity of light and flaring impacts on birds is assessed as Minor based on:

- Lighting on survey vessels, the MODU and support vessels will be limited to that which is required for navigational and safety purposes and of a temporary nature (up to 30 days per campaign).

- The flaring light EMBA overlaps breeding BIAs for five species (short-tailed shearwater, black-faced cormorant, common diving petrel, wedge-tailed shearwater and little penguin). The impact from flaring will be intermittent and temporary (approximately 48 hours per well) and is therefore not expected to interrupt breeding behaviours or cause impact at a population level.
- The common diving petrel was identified as the only seabird confirmed to forage at night. This nocturnal species partakes in unimodal foraging trips during breeding periods and is particularly susceptible to coastal light impacts when returning to or leaving the nesting colony which may result in a disruption to adult nest attendance (CoA 2023). Artificial light has been noted to potentially provide enhanced capability for seabirds foraging at night (CoA 2023).
- Light EMBAs were limited to overlapping less than 1% of the foraging BIAs. Given the large areas typically covered by foraging individuals, and the transient nature of the species, light impacts are not expected to cause significant impacts to foraging behaviours.
- Light emissions are identified as a threat in the National Recovery Plan for albatrosses and petrels (2022) (DCCEEW 2022e) but classifies marine infrastructure interactions including those associated with artificial light as having no risk category priority and affecting 'Nil' species in Australian jurisdiction
- Light pollution is listed as a threat to seabirds in the Wildlife Conservation Plan for Seabirds (DCCEEW 2020), with potential for consequences affecting individuals but not whole populations). Light emissions will be managed in a manner to not contravene the objectives of this plan.
- Light emissions will be managed in a manner to not impact on the recovery of the orange-bellied parrot as per the recovery plan (DELWP 2016):
- Illuminated structures and illuminated boats have been identified as a potential barrier to migration and movement for the orange-bellied parrot (DELWP 2016). The Project area does not overlap the migration route of the orange-bellied parrot and, as such, the activities of the MODU and vessels when undertaking the petroleum activity do not present the same risk as that associated with illuminated structures or illuminated boats within the migration route. This critically endangered species may migrate over the flaring light EMBA from February-April and when returning in November. Impacts associated with flaring, which will not occur within the migration route but rather may change ambient light in the area, will be temporary and of short duration and are not expected to interrupt migration behaviours or cause impact at a population level for this species.

6.3.3.1.3 Marine Reptiles

Artificial light can disrupt turtle nesting and hatching behaviours and is listed as a key threat in the Recovery Plan for Marine Turtles in Australia (CoA 2017). Although listed turtle species may occur within the routine light and flaring EMBAs, no biologically important behaviours, BIAs, or habitat critical to survival for marine turtles were identified (Appendix E). Consequently, population level impacts to marine turtles from routine light and flaring emissions are not predicted to occur.

The consequence severity of light and flaring impacts for marine reptiles is assessed as Minor based on:

- Artificial light is listed as a key threat in the Recovery Plan for Marine Turtles in Australia (CoA 2017), however, no biologically important behaviours, BIAs, or habitat critical to survival for marine turtles were identified within the light or flaring EMBAs.

6.3.3.1.4 Coastal Communities

Light and flaring associated with offshore exploration activities has been assessed to have the potential to impact on coastal communities.

Light pollution associated with offshore mining operations (including oil and gas) and other offshore activities is listed as a pressure on the conservation values of the South-east Marine Reserve Network within the South-east Commonwealth Marine Reserves Network Management Plan (2013-2023) (DNP 2013). However, the management plan does not list tourism as being impacted.

Light emissions as a result from routine operations are expected to have a minor impact on coastal communities and will be indistinguishable from other marine traffic within the area and given the temporary nature of the light emissions associated with the Project. Given the maximum predicted duration for drilling at each location is 30-40 days, the low levels of ambient light changes from the routine light will be short-term and fully recoverable.

There are several coastal communities and areas conducive to tourism located on the Victorian coast which are within the Flaring EMBA. Emissions as a result of short-term flaring (up to 48 hours per well) are expected to have a negligible impact on coastal communities.

6.3.3.1.5 Cultural Values and Sensitivities

Based on Section 4.6, First Nations cultural values and sensitivities, being birds, fish and eels, have been identified as potentially affected by light:

This section has assessed the predicted environmental impact to these receptors. Based on that assessment the residual consequence to cultural values and sensitivities from light is assessed as Moderate (2).

Light has not been identified as an impact to submerged cultural heritage.

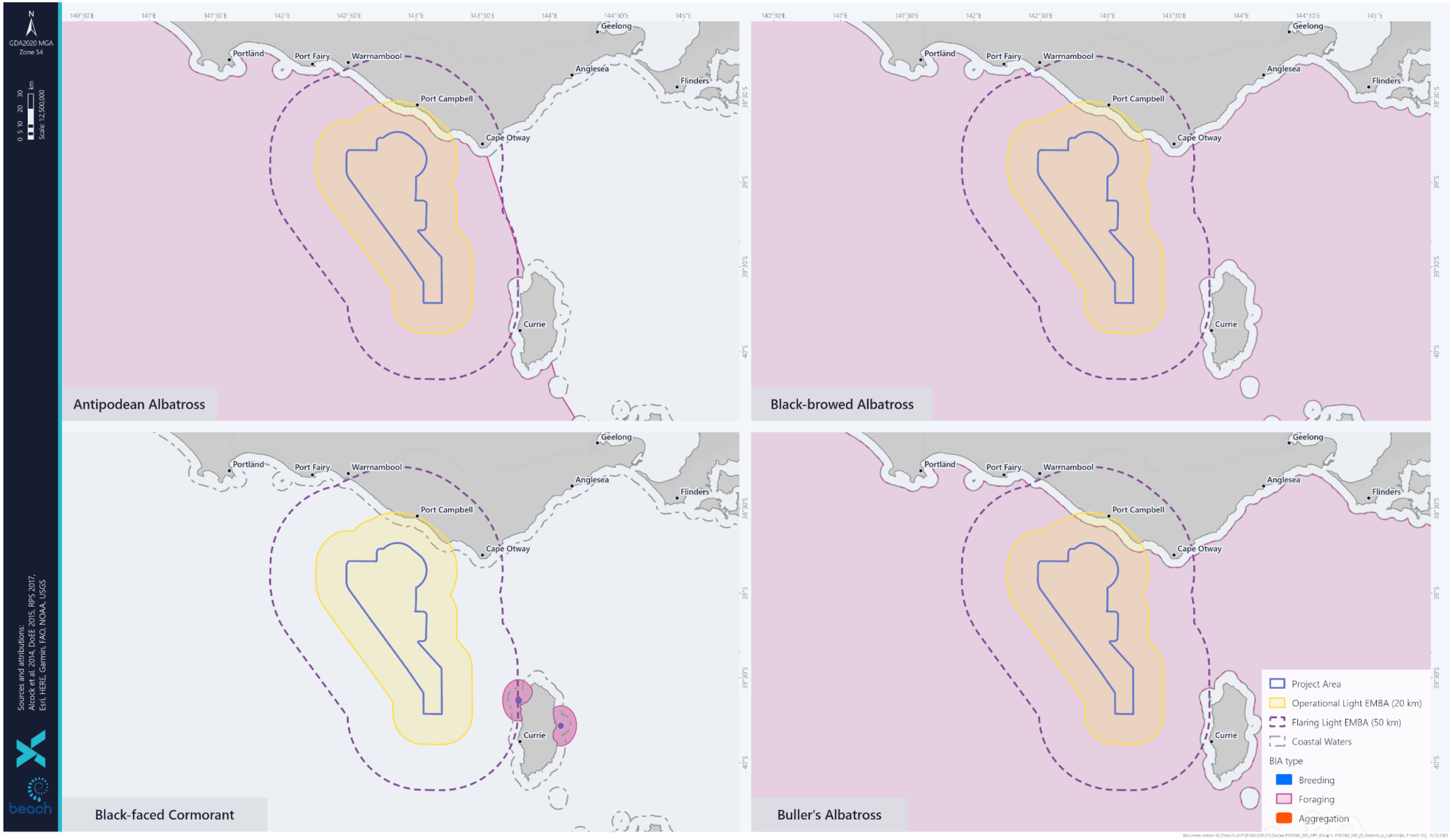


Figure 99: Light EMBAs and BIAs for Antipodean Albatross, Black Browed Albatross, Bullers Albatross, Black-faced Cormorant

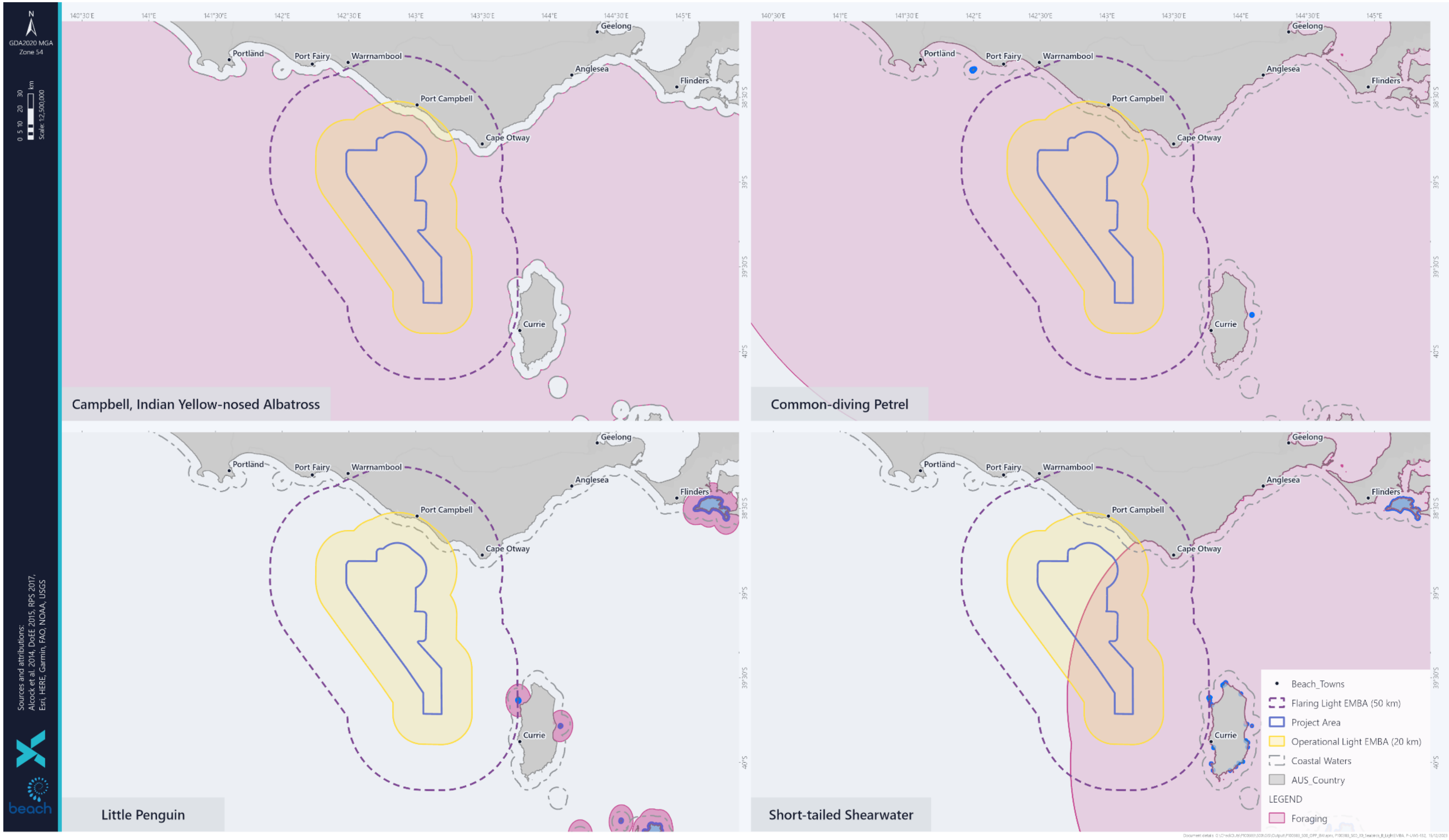


Figure 100: Light EMBAs and BIAs for Campbell Albatross, Indian Yellow-nosed Albatross, Common-diving petrel, Little Penguin

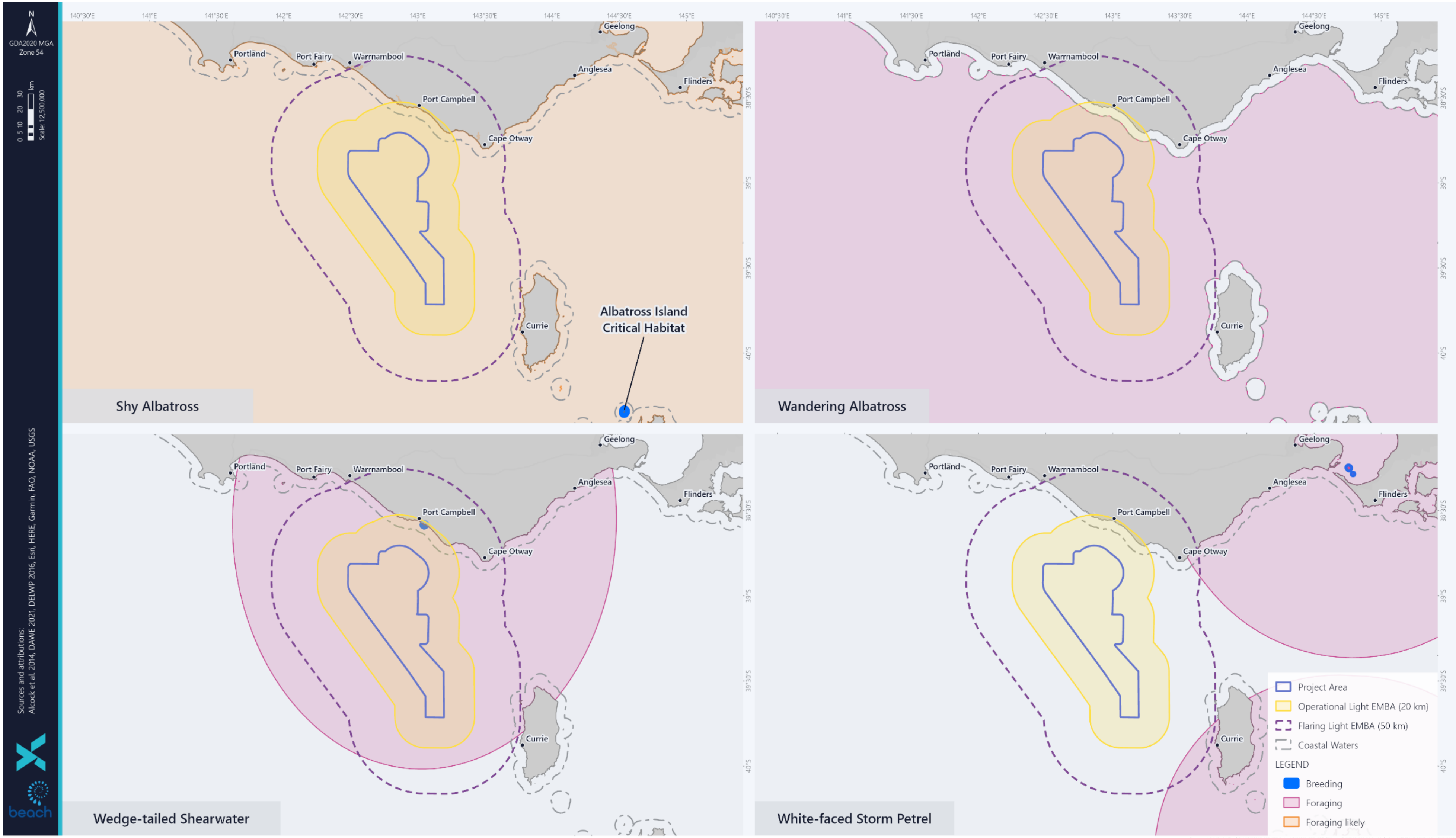


Figure 101: Light EMBAs and BIAs for Shy Albatross, Wandering Albatross, Wedge-tailed Shearwater, White-faced Storm Petrel

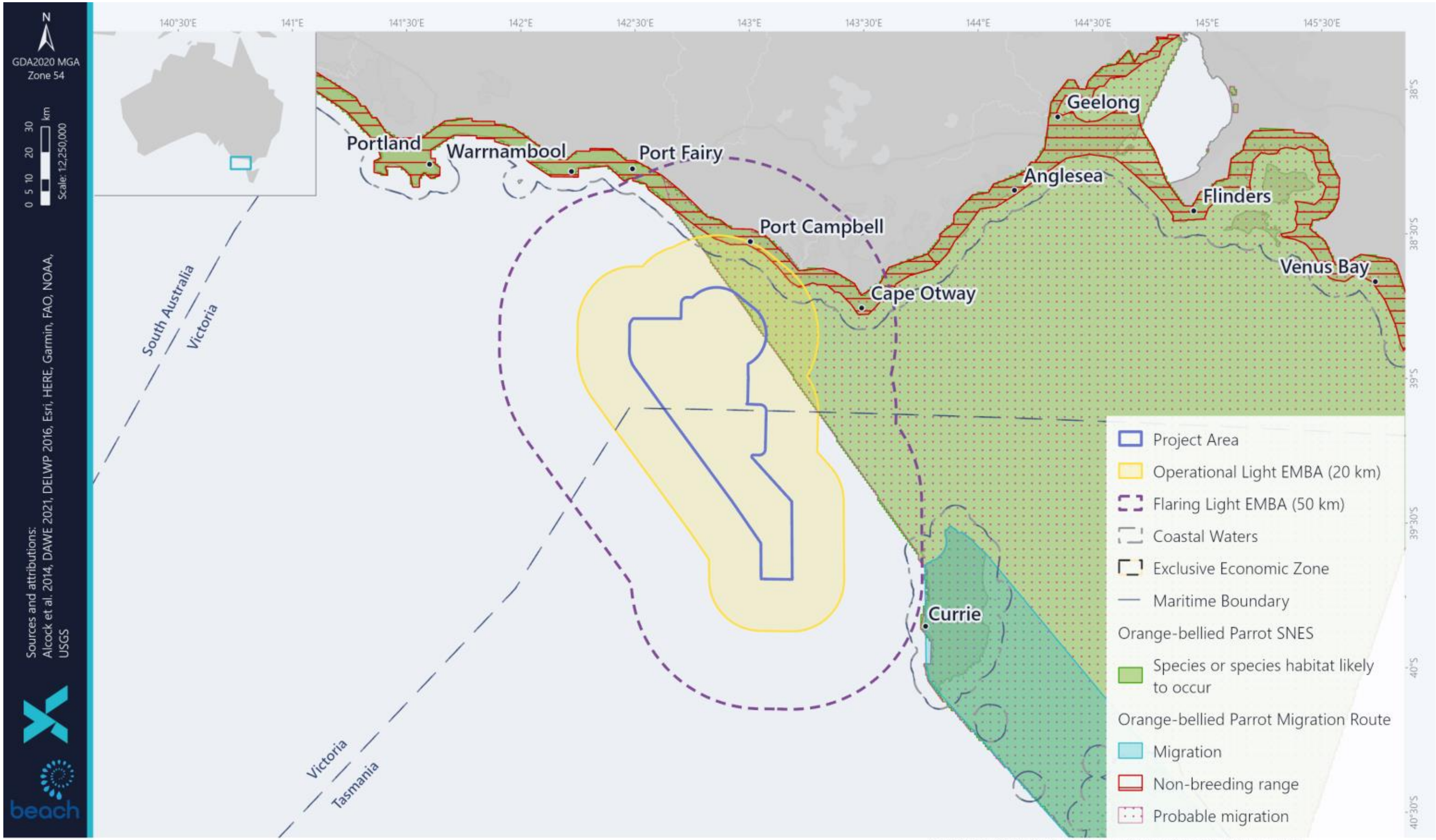


Figure 102: Light EMBAs and Orange-bellied Parrot SNES, Migration route

6.3.4 Impact Evaluation Summary

The impact assessment for light emissions from the Project are presented in **Table 54**.

Summary	
Summary of impacts	Artificial light may act as an attractant to light-sensitive species (e.g., seabirds, fish, zooplankton), in turn affecting predator-prey dynamics (due to attraction to or disorientation from light).
Extent of impacts	The extent of the area potentially impacted by light emissions has been assessed as up to 50km for flaring and routine light for 20km, however this will only occur on a temporary basis for short periods of time and there are no permanent lit structures associated with this Project. During MODU and vessel operations lighting levels will be reduced to acceptable levels through implementation of controls and limiting of light to only that required for navigational, safety and emergency requirements.
Duration of impacts	Light impacts are temporary only lasting for the duration of each activity (1-2 days per well for flaring; between 30-60 days per well for MODU and vessel presence for each campaign)
Level of certainty of impacts	The impacts of light glow on marine fauna are relatively well known. Uncertainty shall be addressed in activity specific Environment Plans through adaptive management during the activities.
Impact decision framework context	A – well understood activity, good practice is well defined. Despite this the precautionary principle has been applied.
Impact Consequence (inherent)	
Moderate	
Controls	
CM12 MODU and vessel lighting	MODU and vessel lighting will be limited to the minimum required for navigational and safety requirements, with the exception of emergency events
CM13 Light Management Procedure	MODU and vessels will implement a Light Management Procedure as per the National Light Pollution Guidelines (Commonwealth of Australia, 2020) for Project activities. The Light Management Procedure will detail mitigations to manage light based on the information in the Seabird Light Mitigation Toolbox and Beach Energy’s Vessel Light Management Procedure Guidance (CDN/ID 19012450)
Impact Consequence (residual)	
Minor	
The potential consequence of light emissions is assessed as minor. Wildlife potentially vulnerable to light (ie seabirds and marine turtles) are highly unlikely to be disrupted, nor displaced from important habitat and will be able to continue critical behaviours such as foraging and reproduction. T	
Environmental Performance Outcomes	
EPO5	No death or injury to marine fauna, including listed threatened or migratory species, from Project activities
EPO7	Biologically important behaviours within or outside a BIA can continue while Project activities are being undertaken
Demonstration of Acceptability	
Principles of ESD	EPOs for artificial light emissions align with the principles of ESD:

Summary		
	• Artificial light emissions from Project activities will not degrade biological diversity or ecological integrity of the Commonwealth marine area and significant impacts to MNES are not anticipated to occur.	
Internal context	Policy compliance	Beach Environmental Policy objectives are met through this environmental impact assessment.
	Management system compliance	Section 9 describes the implementation strategy employed for this activity.
External context	Stakeholder engagement is being carried out as part of this OPP process Beach operates the existing Otway project and has established good relations with both onshore and offshore stakeholders. Engagement with stakeholders will continue throughout all aspects of the Project to build and maintain trust with stakeholders and the local community and minimise community and stakeholders concern and impacts where practical.	
Legislative context	The EPOs and control measures align with the requirements of: • Navigation Act 2012 (Cth): ○ Part 3 (Prevention of Collisions). ○ AMSA Marine Orders Part 21 (Safety of Navigation and Emergency Procedures). ○ AMSA Marine Orders Part 27 (Safety of Navigation and Radio Equipment). ○ AMSA Marine Orders Part 30 (Prevention of Collisions). • Significant impact criteria (refer Table 41 in Section 5.8.2) • EPBC Management/Recovery Plans and Conservation Advice (refer Table 5 in Section 2.3.1) and following details: Light emissions will be managed in accordance with the National Light Pollution Guidelines for Wildlife (CoA 2023). Light pollution is identified as a threat in the Wildlife Conservation Plan for Seabirds (CoA 2020b) and details that the National Light Pollution Guidelines for Wildlife (CoA 2023) provide a framework for assessing and managing these impacts around susceptible listed wildlife. Light emissions will be managed in accordance with the National Light Pollution Guidelines for Wildlife (CoA 2023). Artificial light is identified as a threat in the National Recovery Plan for Albatrosses and Petrels (CoA 2022a). No actions specific to light are identified. The Approved Conservation Advice for Sternula nereis nereis (Australian fairy tern) (DSEWPaC 2011c) does not identify light as a threat. The National Recovery Plan for the Neophema chrysogaster (Orange-bellied parrot) (DELWP 2016a) identifies illuminated boats and structures as a threats with the action of assess the risk from barriers on the migration route. Manage threat if the risk rating warrants action. This requirement is met by this impact assessment and the implementation of CM#13 Lighting Management Procedure. There are no other recovery plans, conservation advice or listing advice for birds within the light EMBA.	
Industry practice	The consideration and adoption of the controls outlined in the documents below demonstrates that best practice is being implemented	
	Environmental management in the upstream oil and gas industry (IOGP-IPIECA, 2020)	Light emissions – minimise external lighting to that required for navigation and safety, limit occurrence and flaring duration (where possible).
Acceptability outcome	Acceptable.	

Table 54: Impact assessment for light emissions

6.4 Emissions – Underwater Sound

6.4.1 Hazard Description

Underwater sound refers to the noise generated from human activity. Activities associated with the Project may produce noise both in the air and under the water. Noise emitted to air dissipates rapidly and is not a concern due to the distance offshore. Underwater noise travels further and can have a variety of affects on marine fauna, particularly whales.

Sound is altered as it propagates away from the source to receptors in the marine environment. Factors influencing propagation include the bathymetry and composition of the seabed and the temperature and salinity of the water column. The physical processes affecting sound along its propagation path are attenuation due to geometric spreading, reflection, scattering at the sea surface and seabed, refraction due to sound speed gradients, and absorption by seawater. A given sound emitted in different locations, or in the same location at different times, may therefore be detectable for varying distances, depending on regional and temporal changes in sound propagation conditions (Richardson et al. 1995).

To assess potential impacts from noise emissions it is necessary to understand how underwater sound is measured and referenced. Sound travels as a wave with the amplitude of the wave related to the amount of acoustic energy it carries, or how loud the sound will appear to be. **Figure 103** shows a representative sound wave and the sound measures used in this assessment. **Table 55** provides definitions of the sound measures and other sound related terms used in this assessment.

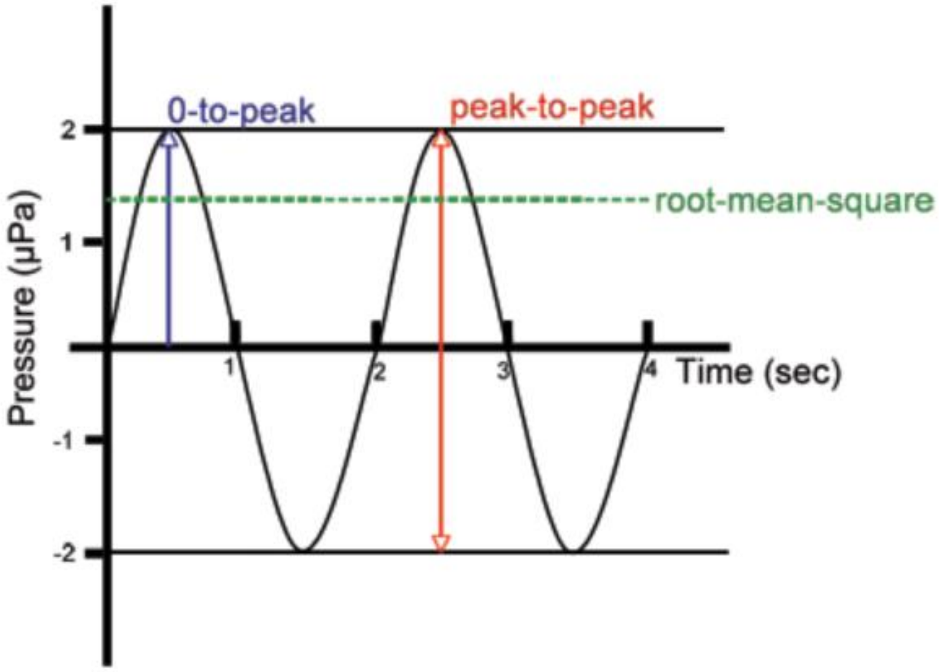


Figure 103: Representative Sound Wave and Sound Measures

Term	Definition
0-to-peak or Peak sound pressure level (PK)	The peak pressure, also called the 0-to-peak pressure, is the range in pressure between zero and the greatest pressure of the signal. It is represented by PK and the unit dB re 1 µPa and summarised as dB PK.
Peak-to-peak sound pressure level (PK-PK)	The peak-to-peak pressure is the range in pressure between the most negative pressure and the most positive pressure of the signal. It is represented by PK-PK and the unit dB re 1 µPa or dB re 1 µPa2m2 and summarised as dB PK-PK.
Permanent threshold shift (PTS)	Permanent loss of hearing sensitivity caused by excessive noise exposure.
Received sound levels	The sound level measured at a receiver.
Root mean square sound pressure level (SPL)	The root-mean-square pressure is the square root of the average of the square of the pressure of the sound signal over a given duration. It is represented by sound pressure level (SPL) and the unit dB re 1 µPa and summarised as dB SPL.
Sound exposure level (SEL)	A measure of the sound energy that considers both received level and duration of exposure. SEL is specified in terms of either single pulse (SEL) or a defined accumulation period (SELcum). For this assessment 24hrs has been used for the accumulation period and is shown as SEL24h. Units are dB re 1 µPa2·s or dB re 1 µPa2m2s.
Source sound level	The sound pressure level or sound exposure level measured 1 metre from a theoretical point source that radiates the same total sound power as the actual source.
Temporary threshold shift (TTS)	Temporary loss of hearing sensitivity caused by excessive noise exposure.

Table 55: Sound Terminology

Underwater noise is also divided into two categories, with different metrics used to describe the sound levels in decibels:

- continuous – continuous noise is a continual non-pulsed sound that can be transient (short duration) but without the rapid rise-time (pulse) (Southall et al. 2007), examples are vessel and drilling operations; and
- impulsive – impulsive noise is a series of pulsed sound events that are brief, broadband, atonal and transient, an example is acoustic emissions from geophysical equipment and discharges of air guns during vertical seismic profiling.

6.4.2 Impact Source

The following activities associated with the Project have been identified as noise generating:

Stage	Activity	Noise type
Seabed survey	Geophysical survey equipment	Impulsive
Drilling	Drilling and completions – MODU Vertical seismic profiling (if used)	Continuous Impulsive
Installation	Pipelay/construction vessel undertaking installation of subsea infrastructure	Continuous
Operations	Pipelay/construction vessel undertaking inspection, maintenance, and repair (IMR)	Continuous
Support operations (all stages)	OSV transit, resupply	Continuous

Stage	Activity	Noise type
Plug and abandonment of wells	Plug and abandonment of wells – MODU Including subsea cutting and removal of wellhead	Continuous

6.4.2.1 Impulsive Noise Sources

6.4.2.1.1 Geophysical survey equipment

Geophysical equipment emitting sound energy include echo sounders, side scan sonar, and sub-bottom profilers. Side-scan sonar and echo sounders emit high frequency waves that are absorbed rapidly in the water column and are outside the range of most sensitive marine fauna including low-frequency cetaceans, fish, and turtles (Austin et al., 2013).

A single-beam echo sounder (SBES) typically has a frequency range between 120 and 710 kHz and a maximum sounding rate of 20 Hz. The beam width varies between 10 (120 kHz) and 2.8 (710 kHz). The single beam bathymetry received sound exposure level typically does not exceed 160 dB.

The frequency range of the multi-beam echo sounder (MBES) is typically 200–500 kHz (classified as high frequency) with a maximum angular coverage of 160°. The maximum source levels are about 236–242 dB re 1 µPa @ 1 m for the 1° and 2° beams (DoC, 2016).

Side scan sonar (SSS) typically operates in the 100–500 kHz frequency range (classified as high frequency). The maximum source levels are about 210-220 dB re 1µPa @ 1 m (DoC, 2016).

Acoustic emissions from sub-bottom profiler (SBP) are typically in the frequency range of 0.05 to 12 kHz, with peak sound pressure level (SPL) of up to 220 dB re 1µPa @ 1 m. There are three different types of SBP, which exhibit a trade-off of in resolution versus depth of penetration based on the frequency of the acoustic signal:

- CHIRP – uses an FM signal across a full range of frequencies, typically either 2-16 kHz or 4-24 kHz (low to high frequency). The maximum source levels of a CHIRP are about 200– 205 dB re 1 µPa @ 1 m (DoC, 2016).
- High-frequency boomers – the typical frequency spectrum of boomer systems ranges between 0.2 and 10 kHz, with an effective bandwidth of 1 to 10 kHz (low to high frequency). The sound source level can vary from 100 to 220 dB re 1 µPa @ 1 m.
- Medium-frequency sparkers – the generated frequencies are generally between 50 Hz (0.05 kHz) and 4 kHz (low to high frequency). The source level is typically between 215 and 225 dB re 1 µPa @ 1 m.

6.4.2.1.2 Vertical Seismic Profiling (VSP)

VSP is a standard well logging technique that is routinely used to collect geophysical measurements within well bores. VSP is not expected to be used in relation to the OGV drilling campaign but may be used on future wells. VSP typically involves the use of a seismic energy source (e.g. a single air gun or a small air gun array) suspended in the water column and a receiver (e.g. hydrophone or geophone) suspended within the well bore. The seismic source may be suspended directly below the drilling rig or may be offset (e.g. suspended behind a vessel). Vertical seismic profiling typically required noise emissions between 8 hours and 24 hours per well.

The VSP source (typically in the order of 450 cubic inches (cui)) is expected to generate a noise level around 216 dB re 1 µPa (SPL) @ 1 m, with most noise concentrated at low (<100 Hz) frequencies. Empirical measurements of an equivalent airgun array (440 cui) undertaken by Curtin University of Marine Science and Technology (CMST, 2013) demonstrated that the source would attenuate to 160 dB re 1 µPa2.s (SEL) within 500 m, equating to a total of 56 dB attenuation over 500 m. Matthews (2012) indicates that airguns with a

250 cui source that is discharged about five times at 20 second intervals, sound levels of approximately 238 dB re 1 µPa (PK) are generated at 1 m (Matthews, 2012), with frequencies less than 200 Hz. Sound levels are expected to attenuate rapidly to about 180 dB re 1 µPa (PK) within 100 m (Matthews, 2012).

6.4.2.2 Continuous Noise Sources

6.4.2.2.1 Drilling

MODUs are expected to produce low-intensity continuous sound during drilling operations. Drilling sound usually exhibits tones below 2 kHz, with harmonics present to 10 kHz and can vary between operations. Underwater noise levels from jack-up and semi-submersible MODUs during routine drilling operations (i.e. excluding vertical seismic profiling) are generally less than 130 to 160 dB re 1 µPa, and noted as being considerably lower than noise emissions from support vessels (McCauley 1998; Todd and White 2012).

Sound levels from the Ocean Onyx semi-submersible MODU drilling in the Otway Basin, representative of drilling associated with the Project, indicated source levels ranging from 162 – 180 dB re 1 µPa (SPL) with broadband frequency between 0.01 and 30 kHz (**Figure 104**) which is higher and more conservative than the literature cited above.

The MODU selected for the OGV drilling campaign has thruster assisted capability. This capability could assist in reducing fatigue on the mooring system and could assist the MODU during transit. This system generates variable non-impulsive sound during the infrequent operation of one or a number of thrusters in response to feedback from the mooring system. A review of 33 months of historical operational data from the North Sea indicates thrusters are typically not active (>96% of the time) and utilisation is otherwise limited to low loads across a few thrusters for short periods, (typically hours) in response to metocean conditions.

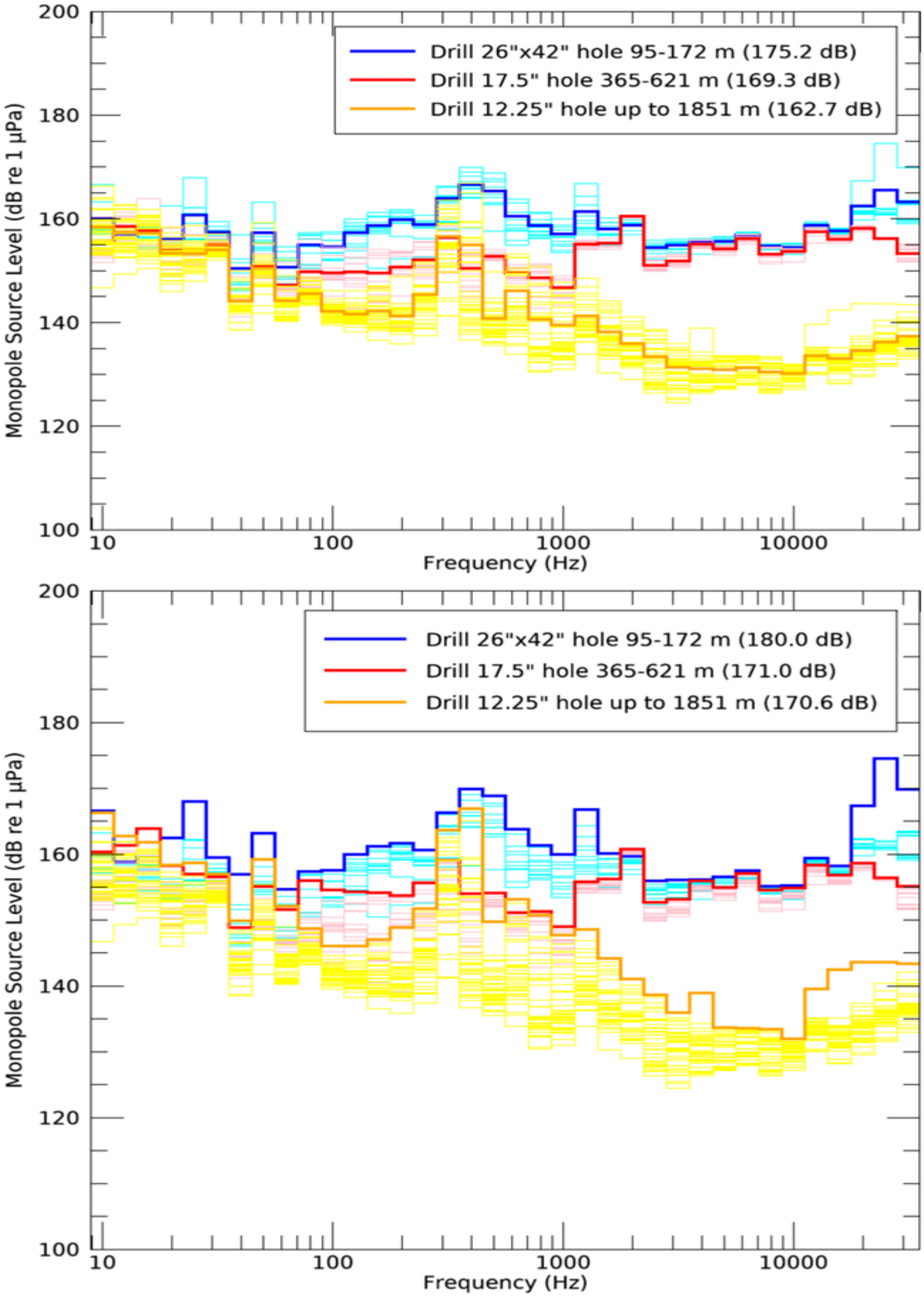


Figure 104: Mean (top) and maximum (bottom) source level and spectra for Ocean Onyx Mobile Offshore Drilling Unit (MODU) averaged over three different drilling depths (from McPherson et al (2021).

6.4.2.2.2 Vessel Noise

Underwater noise emissions from vessels may occur during installation, IMR and vessel transit/resupply activities.

The noise emissions are produced mainly by propeller and thruster cavitation, with a smaller fraction of noise produced by sound transmitted through the hull, such as by engines, gearing, and other mechanical systems. Acoustic emissions from thrusters when the vessel is keeping station under dynamic positioning have the greatest potential for impact due to relatively loud source levels.

For vessels in transit, Hannay et al. (2004), Richardson et al. (1995) and McPherson et al (2021) indicate source levels ranging from 165 to 185 dB re 1 µPa (SPL). For a vessel under dynamic positioning, Stroot et al (2022a) present measurements indicating source levels at 185 dB re 1 µPa (SPL) with broadband frequency between 0.01 and 30 kHz.

The type and number of vessels in the Project Area at any one time, and the duration of presence, will differ depending on the project stage. Drilling will be supported by up to three vessels, one of which will always be on standby but not necessarily on dynamic positioning. The other two will sail to and from port with supplies.

Subsea flowline and infrastructure installation will involve a pipelay/construction vessel on site for in the order of up to 30 to 60 days. Whilst laying pipe or installing subsea equipment these will operate continuously on dynamic positioning but not necessarily on full power. Support vessels will sail to and from port with supplies.

6.4.2.2.3 Helicopters

Helicopters will enter the project area for short periods of time to undertake crew change or other personnel transfer activities. The main acoustic source associated with helicopters is the impulsive noise from the main rotor. Dominant tones in noise spectra from helicopters are generally below 500Hz (Richardson et al. 1995). The level of underwater sound from helicopters is affected by helicopter altitude, aspect and strength of noise emitted, and the receiver depth, water depth and other variables (Richardson et al. 1995).

The angle at which the line from the aircraft and receiver intersects the water surface Is important. In calm conditions, at angles greater than 13° from the vertical, much of the sound is reflected and does not penetrate the water (Richardson et al, 1995). Therefore, strong underwater sounds are detectable for a period roughly corresponding to the time the helicopter is within a 26° cone above the receiver. Richardson et al. (1995) reports figures for a Bell 214 helicopter (stated to be one of the noisiest) being audible in air for 4 minutes before it passed over underwater hydrophones, but detectable underwater for only 38 seconds at 3 m depth and 11 seconds at 18 m depth. The maximum received level was 109 dB re 1µPa2.s.

Due to their short duration and near surface impacts only, helicopter noise emissions are not considered to be a credible source of noise impact and will not be evaluated further.

6.4.2.2.4 Decommissioning

Removal of subsea infrastructure will be evaluated at end of field life with the complete removal of all infrastructure. being the base case in accordance with Section 572 of the OPGGS Act. Acoustic emissions may be caused by removal methods such as mechanical cutting. This noise is considered comparable to noise generated by MODU whilst drilling; therefore, assessment of drilling noise is considered an appropriate proxy for noise generated during decommissioning operations.

The primary noise generating activity of well plug and abandonment activities during decommissioning is noise generated by the MODU.

6.4.2.3 Modelling Studies

6.4.2.3.1 Continuous noise sources

JASCO Applied Sciences (JASCO) undertook an acoustic modelling study of underwater sound levels associated with drilling, installation, IMR and vessel transit activities in the Project Area at two locations within the Project Area, Artisan and Thylacine fields at water depths ranging from 71m to 102m (Koessler and McPherson 2021 Appendix F).

The modelling for drilling was based on the Ocean Onyx semi-submersible MODU drilling in the Otway Basin which is representative of the drilling associated with the Project. The modelled scenario for drilling was resupply with an OSV on DP during MODU drilling operations as this is expected to be the highest noise level produced during drilling.

The modelling for a large pipelay/construction vessel undertaking installation as well as inspection, maintenance and repair activities was based on the Skandi Singapore and would be a representative sized vessel to undertake these activities. The approach used to estimate sound levels under dynamic positioning (DP) is based upon vessels under transit and is an approximation based on the Maximum Continuous Rating (MCR). The scenario selected to represent installation and IMR activities was the combined sound levels of two pipelay vessels on DP approximately 10km distant from each other within the Project area. One vessel located at Thylacine North-1 laying pipe and another vessel at Geographe-1 operating a subsea cutting tool. This is considered to be representative of any simultaneous operations associated with Project installation or IMR activities.

The modelling for an Offshore supply vessel (OSV) was based on the Siem Offshore VS491, currently being used for supply vessel for the Otway Offshore Operations. The scenario selected was the OSV on standby for 24 hours.

The Thylacine Field location in 102m water depth was selected to estimate sound levels that would be representative of potential activity locations within the Project Area that are on the shelf given that this depth encompasses the middle shelf geomorphic zone of the Otway region between 70 and 130m (refer Section 4.3.3) and resulted in higher sound levels and when compared to the results from Artisan Field.

An additional modelling study (Ryan and Koessler 2023, Appendix G) was undertaken for both drilling and vessel activities at the most southerly identified potential well location at 156m water depth to enable adequate representation of deeper shelf edge (deep shelf geomorphic zone) locations at between 130 and 180m water depth (refer Section 4.3.3).

From this additional study, the Installation and IMR sound levels at shelf edge locations can be reasonably inferred. The results for drilling and vessel sources at the shelf edge location indicates that the distances to noise thresholds can be up to a maximum150% greater than the distances to thresholds for locations on the shelf with the distance to the marine mammal behaviour threshold of 7.98km for on the shelf sites increases to 19.6km for shelf edge locations.

Based on this the results for Installation & IMR at the shelf location of Thylacine have been conservatively increased by 150% to represent shelf edge locations. Where modelling at shelf locations did not predict the noise effect criteria being reached, it is considered unlikely that the criteria would be reached for shelf edge locations. If this did occur, it would be at small distances that are encompassed by the larger defined sound EMBAs for continuous sound sources of the Project.

The modelling study scenarios selected for the impact assessment of continuous sources are described in Table 56

Beach Otway Development Acoustic Monitoring Report (McPherson et al, 2021) was included in this OPP as Attachment H given that the Beach Otway Project: Additional and Revised Modelling Study (Koessler and McPherson, 2021) refers to it for a detailed description of the employed modelling method and input parameters.

The modelling studies assessed distances from activities where underwater sound levels reached exposure criteria corresponding to various levels of potential impact to marine fauna. The marine fauna considered was based on a review of receptors that may be impacted by continuous sound, these were marine mammals, turtles, and fish. The exposure criteria selected for the modelling and the impact assessment were selected as they have been accepted by regulatory agencies and because they represent current best available science (Koessler et al. 2020, Matthews et al. 2020).

6.4.2.3.2 Impulsive noise sources

Beach commissioned JASCO Applied Sciences (JASCO) to undertake acoustic modelling to assist in understanding the potential acoustic impact of geophysical survey equipment and VSP on key regional receptors in the Project Area.

Based on a review of the geophysical equipment used for the seabed survey it was identified that the boomer and SBP were most relevant to the assessment of potential impacts to receptors, due to their operating frequencies and source sound levels. The modelling approach accounted for the acoustic emission characteristics of a representative boomer (AP3000) and SBP (Edgetech X-star system).

The modelling study was undertaken at six locations within the Project Area including the Artisan, Geographe and Thylacine fields at water depths ranging from 71m to 130m (McPherson and Wood 2017 Appendix I). Further modelling was undertaken at four of the sites to obtain maximum ranges to updated impact thresholds for cetaceans and pinnipeds (Wood and McPherson 2019, Appendix J). The locations and water depths are considered representative of the Project Area with the exception of the deeper areas on the shelf edge.

The sound levels at shelf edge locations for geophysical and VSP sources can be reasonably inferred from the additional modelling study of drilling and vessel noise that was undertaken the shelf edge at 156m water depth to enable adequate representation of deeper shelf edge locations (deep shelf geomorphic zone) at between 130 and 180m water depth (refer Section 6.4.2.3.1). The results for drilling sources at the shelf edge location indicates that the distances to noise thresholds are up to a maximum of 150% greater than the distances to thresholds for locations on the shelf with the distance to the marine mammal behaviour threshold of 7.98km for on the shelf sites increasing to 19.6km for shelf edge sites.

Based on this the results for distance to noise effect criteria from geophysical and VSP sources have been conservatively increased by 150% to represent shelf edge locations. Where modelling at shelf locations did not reach noise effect criteria, it is considered unlikely that they would be reached for shelf edge locations and if this was to occur, the distances would be small and well within the larger defined sound EMBAs for geophysical surveys and VSP used for the impact assessment.

Scenario	Scenario number	Well area(s)	Description	Study title
Drilling + Resupply	A5	Thylacine North-1	MODU Drilling + 4hr OSV Resupply for shelf locations (70-130m)	Beach Otway Project: Additional and Revised Modelling Study (Koessler and McPherson, 2021)
Drilling + Resupply – shelf edge	3	Well Location South	MODU Drilling + 4hr OSV Resupply Ops for shelf edge locations (130-180m)	Beach Otway Project: Additional Modelling at Well Location South (Connell and Koessler, 2023)
Installation and IMR	15	Thylacine North-1 + Geographe-4	Vessel stationary, operating on DP (Thylacine North-1) + Vessel stationary, operating on DP + ROV cutting tool (Geographe-4) (June) - shelf locations (70-130m)	Beach Otway Project: Additional and Revised Modelling Study (Koessler and McPherson, 2021)
Installation and IMR – shelf edge	N/A	Well Location South	Vessel stationary, operating on DP (Thylacine North-1) + Vessel stationary, operating on DP + ROV cutting tool (Geographe-4) (June) – shelf edge locations (130-180m).	N/A – inferred from the highest increase in distances to noise effect criteria from shelf to shelf edge locations (150%)
Vessel standby/ transit	A3	Thylacine North-1	OSV vessel on standby for 24 hrs – shelf locations (70-130m)	Beach Otway Project: Additional and Revised Modelling Study (Koessler and McPherson, 2021)
Vessel standby/ transit – shelf edge	3	Well Location South	OSV vessel on standby for 24 hrs – shelf edge locations (130-180m)	Beach Otway Project: Additional Modelling at Well Location South (Connell and Koessler, 2023)

Table 56: Modelling study scenarios selected for the impact assessment of continuous sources

6.4.3 Impact Analysis and Evaluation

6.4.3.1 Overview

Underwater sound can impact marine fauna in six main ways:

- Inducing stress, which can be acute or chronic and affect health and behaviour.
- Masking or interfering with other biologically important sounds (including vocal communication, echolocation, signals and sounds produced by predators or prey).
- Disturbance leading to behavioural changes or displacement of fauna. The occurrence and intensity of disturbance is highly variable and depends on a range of factors relating to the animal and situation.
- Injury to hearing or other organs. Hearing loss may be temporary (TTS) or permanent threshold shift (PTS).
- Mortality and mortal injury – immediate or delayed death either due to injury or substantially reduced fitness.
- Cumulative or chronic effects; repeated or long-term exposure to noise leading to additive severity of noise-induced effects.

Elevated underwater sound can result in changes to marine fauna behaviour by masking or interfering with other biologically important sounds, including vocal communication, echolocation, signals and sounds produced by predators or prey, and through disturbance leading to behavioural changes or displacement from important areas (Richardson et al. 1995). The sensitivity of fauna behaviour to elevated noise levels vary, with individual responses often being influenced by the present behaviour, such as reproductive behaviours, foraging or migration.

Exposure to sufficiently intense sound may lead to an increased hearing threshold. If this shift is reversed and the hearing threshold returns to normal, the effect is called a temporary threshold shift (TTS). Southall et al., 2007 defined TTS as a threshold shift of 6 dB above the normal hearing threshold. If the threshold shift does not return to normal, permanent threshold shift (PTS) has occurred. Threshold shifts can be caused by acoustic trauma from a very intense sound of short duration, as well as from exposure to lower level sounds over longer time periods (Houser et al.,2017).

Where the functions, interests or activities of other marine users involve marine fauna, any effect to fauna presence or abundance may indirectly impact these users. The potential impact may occur for the duration of the noise emission; however, following cessation of the activity, long term changes in fauna abundance or distribution are not expected. Given the location of the Project Area and short-term nature of the more significant noise generating activities, changes to the functions, interests or activities of other users, such as commercial fisheries, from acoustic emissions are not expected.

6.4.3.2 Impulsive Noise Sources

Underwater acoustic emissions associated with the geophysical survey and VSP will be impulsive.

Receptors that may be impacted by impulsive noise include:

- Plankton
- Marine Invertebrates
- Fish

- Marine Mammals
- Marine reptiles
- Other users (i.e., commercial fisheries)

Acoustic modelling was used to assess potential impacts to receptors from underwater acoustic emissions associated with the geophysical survey and VSP activities. The modelled received sound levels were compared to defined noise effect criteria a detailed in **Table 57**, as determined by scientific research and academic papers, for the identified receptors. In lieu of any noise criteria specific to geophysical surveys, criteria that is applied to seismic surveys have been used.

Receptor	Noise Effect Criteria	Boomer Maximum Distance (m)	Boomer Maximum Distance – shelf edge (m)	SBP Maximum Distance (m)	SBP Maximum Distance – shelf edge (m)	VSP Maximum Distance (m)	VSP Maximum Distance – shelf edge (m)	Noise Effect Criteria Reference
Plankton: mortality/potential mortal injury	>207 dB PK or 210 dB SELcum	1.6 NR	4 NR	0.3 NR	0.8 NR	NR NR	NR NR	Popper et al. 2014
Invertebrates: effect at the seafloor	186–190 dB SEL 192–199 dB SEL_{24h} 209–212 dB PK-PK	NR NR NR	NR NR NR	NR NR NR	NR NR NR	NR NR NR	NR NR NR	Day et al. 2016
Invertebrates: no effect at seafloor	202 dB PK-PK	NR	NR	NR	NR	185	470	Payne et al. 2008
Lobster: no effect at seafloor	183 dB SEL	NR	NR	NR	NR	NR	NR	McCauley and Duncan 2016
Squid: behavioural	166 dB SPL	36	90	NR	NR	1,550	3,900	McCauley et al. 2000
Fish (swim bladder): mortality/potential mortal injury	>207 dB PK or 207 dB SELcum	1.6 NR	4	0.3 NR	0.8 NR	NR NR	NR NR	Popper et al. 2014
Fish (swim bladder): recoverable injury	>213 dB PK or >216 dB SELcum	0.6 NR	1.5	0.1 NR	0.3 NR	NR NR	NR NR	Popper et al. 2014
Fish (no swim bladder): mortality/ potential mortal injury	>213 dB PK or >219 dB SELcum[1]	0.6 NR	1.5 NR	0.1 NR	0.3 NR	NR NR	NR NR	Popper et al. 2014
Fish (no swim bladder): recoverable injury	>213 dB PK or >216 dB SELcum	0.6 NR	1.5 NR	0.1 NR	0.3 NR	NR NR	NR NR	Popper et al. 2014
Fish (swim bladder or no swim bladder): TTS	>186 dB SELcum	NR	NR	NR	NR	NR	NR	Popper et al. 2014
Turtle: behavioural	166 dB SPL	36	90	NR	NR	1,550	3,900	NSF 2011
Turtle: mortality/potential mortal injury	>207 dB PK or 210 dB SELcum	1.6 NR	4 NR	0.3 NR	0.8 NR	NR NR	NR NR	Popper et al. 2014
Marine mammals: Behavioural	160 dB SPL	145	360	2	5	2,560	6,500	NOAA 2019
Low-frequency cetaceans: PTS (humpback; pygmy blue whales)	219 dB PK 183 dB SEL_{24h}	NR NR	NR NR	NR NR	NR NR	NR NR	NR NR	Southall et al. 2019
Low-frequency cetaceans: TTS (humpback; pygmy blue whales)	213 dB PK 168 dB SEL_{24h}	NR 10	NR 25	NR 10	NR 25	NR NR	NR NR	Southall et al. 2019
High-frequency cetaceans: PTS (dolphins, beaked whales, sperm whales)	230 dB PK 185 dB SEL_{24h}	NR NR	NR NR	NR NR	NR NR	NR NR	NR NR	Southall et al. 2019
High-frequency cetaceans: TTS (dolphins, beaked whales, sperm whales)	224 dB PK 170 dB SEL_{24h}	NR NR	NR NR	NR NR	NR NR	NR NR	NR NR	Southall et al. 2019
Very-high-frequency cetaceans: PTS (pygmy; dwarf sperm whales)	202 dB PK 155 dB SEL_{24h}	4.5 NR	11 NR	0.6 NR	1.5 NR	NR NR	NR NR	Southall et al. 2019
Very-high-frequency cetaceans: TTS (pygmy; dwarf sperm whales)	196 dB PK 140 dB SEL_{24h}	8.9 NR	22 NR	1.2 NR	3 NR	NR NR	NR NR	Southall et al. 2019
Pinnipeds: PTS (sea lions; seals)	232 dB PK 203 dB SEL_{24h}	NR NR	NR NR	NR NR	NR NR	NR NR	NR NR	Southall et al. 2019
Pinnipeds: TTS (sea lions; seals)	226 dB PK 188 dB SEL_{24h}	NR NR	NR NR	NR NR	NR NR	NR NR	NR NR	Southall et al. 2019

Table 57: Noise effect criteria and maximum received sound levels for impulsive sources

6.4.3.2.1 Plankton

There is no data or studies that indicate geophysical survey and VSP equipment acoustic emissions impact plankton. In lieu of any data the noise effect criteria from the American National Standards Institute (ANSI) accredited report of sound exposure guidelines for fishes and sea turtles (Popper et al. 2014) is used.

Table 57 details the noise effect criteria from Popper et al. (2014) and the distances at which modelling estimated they could be reached for plankton. In summary:

- The noise effect criteria for injury to plankton for the boomer is predicted at a maximum distance of 4 m and 0.8 m for the SBP for the peak sound pressure level (PK) while the noise effect criteria based on the sound exposure level (SEL) is not reached.
- Neither noise effect criteria are reached for the VSP.

Based on these distances the mortality or mortal injury impacts to plankton (including fish eggs and larvae) will be well below natural mortality rates, which are very high, as report by Tang et al. (2014) of daily mortality rates of 11.6% (average minimum) to 59.8% (average maximum). In a review of mortality estimates (Houde and Zastrow 1993) the mean mortality rate for marine fish larvae was equivalent to a loss of 21.3% per day. In the experiment undertaken by McCauley et al. (2017) zooplankton mortality rate background levels were 19%.

Richardson et al (2017) notes that for seismic surveys, which would also apply to geophysical surveys and VSP operations, zooplankton communities can begin to recover in number during a survey, such that a continuous decline in zooplankton throughout the survey is unlikely and parts of the survey area would be replenished with zooplankton as the survey progresses. Impacts to phytoplankton, the food source for zooplankton, are not predicted and such they are still available for zooplankton to graze on.

Predicted impacts to plankton do not remove them from the food web and as such the nutrients and energy they contain are retained within the ecosystem. Even after plankton die, their carcasses remain in the water column for several days where they are scavenged before any remaining carcasses sink to the seafloor to be consumed by opportunistic benthic organisms (Kirillin et al. 2012, Tang et al. 2014, Dubovskaya et al. 2015). Thus, impacts to primary production and ecosystem function are not predicted.

The area of predicted impact overlaps the pygmy blue whale high density, known and possible foraging BIAs. Foraging is associated with the timing of the Bonney Coast Upwelling and the presence of the krill. Mortality or mortal injury effects to krill does not impact on pygmy blue whales being able to feed on them as the krill will still be available within the water column. In addition, any impacts to krill are likely to be within natural mortalities rates thus not effecting the availability of krill available for foraging.

Impacts to the Bonney Coast Upwelling and its role it plays in ecosystem function and productivity is not predicted as:

- Impacts to phytoplankton are not predicted
- Mortality or mortal injury effects to zooplankton are within natural mortality rates and zooplankton communities can begin to recover during the geophysical survey such that a continuous decline in zooplankton throughout the duration of the survey is not anticipated and parts of the survey area would be replenished as the survey progressed
- Mortality or mortal injury effects to zooplankton, including krill, does not impact on marine fauna being able to feed on them as they will still be available within the water column

6.4.3.2.2 Marine Invertebrates

There has been a number of comprehensive reviews of seismic noise impacts to invertebrates such as Carroll et al. (2017) and Edmonds et al. (2016). Available literature suggests particle motion, rather than sound pressure, is a more important factor for crustacean and bivalve hearing. There are currently no defined noise effect criteria for invertebrates and hence the results from the Day et al. (2016) study on acoustic impacts from seismic exposure on southern rock lobsters (*Jasus edwardsii*) are typically used. The study found that sub-lethal effects, relating to impairment of reflexes, damage to the statocysts and reduction in numbers of haemocytes (possibly indicative of decreased immune response function), were observed after exposure to measured received sound levels of:

- Single-pulse SEL: 186–190 dB re 1 µPa2.s
- Accumulated SEL: 192–199 dB re 1 µPa2.s
- Peak-peak pressure: 209–212 dB re 1 µPa

Payne et al (2007) found no effects to the American lobster (Homarus americanus) in righting time or haemolymph biochemistry but a possible reduction in calcium after exposure to received noise levels of 202 dB re 1 µPa (PK-PK). Thus, the Payne et al (2007) level is applied as a no effect criteria. This assessment also used the no effect level proposed by McCauley and Duncan (2016) for rock lobsters of accumulated SEL 183 dB re 1 µPa2.s.

Table 57 details that the sound levels from the representative boomer and SBP do not reach any of the effect or no effect criteria for invertebrates at the seafloor. The VSP sound levels reached the no effect criteria within 470m of the source.

The VSP source is short term, being in the order of up to 24 hours duration per well. The drilling is not being undertaken in any relevant commercial fishery areas or sensitive habitats for invertebrates or benthic communities.

McCauley et al. (2000) assessed the effects of air gun noise on caged squid (*Sepioteuthis australis*). No sub-lethal injury or mortality as a result of exposures in this study was observed. Several squid showed alarm responses to the start-up of an airgun by firing their ink sacs and/or jetting away from the source, but this was not observed for similar or greater levels if the signal was ramped up. General habituation was observed with a decrease in alarm responses with subsequent exposures. During the trial the squid showed avoidance to the airgun by keeping close to the water surface at the end of the cage furthest from the airgun (within the sound shadow). McCauley suggests a threshold of 166 SPL would give an indication of the extent of disruption of a seismic survey by significant alteration in swimming patterns.

Table 57 details that the noise effect criteria at which a behavioural alteration of swimming patterns may occur is predicted within 3.9km of the VSP, 90m of the boomer and not reached for the SBP.

This potential squid behavioural impact extent of 3.9km for the VSP is short term, being in the order of up to 24 hours duration per well. The drilling is not being undertaken in any relevant commercial fishery areas or sensitive habitats for invertebrates or benthic communities.

Based on this, no mortality or injury effects to invertebrates including commercial squid, rock lobster and giant crab species are predicted with potential impacts limited to short term and localised behavioural affects with a Minor consequence ranking assigned.

6.4.3.2.3 Fish

Noise effect criteria for fish are based on the presence of a swim bladder. Typically, site-attached, and demersal fish have a swim bladder, whereas pelagic fish do not. As noise effect criteria for sharks does not currently exist, they are assessed as fish without swim bladders. Noise effect criteria used in this assessment for fish are from the American National Standards Institute (ANSI) accredited report of sound exposure guidelines for fishes and sea turtles (Popper et al. 2014). These guidelines defined quantitative effect criteria for three types of immediate effects:

- Mortality, including injury leading to death
- Recoverable injury, including injuries unlikely to result in mortality, such as hair cell damage and minor haematoma
- TTS

Table 57 details the noise effect criteria from Popper et al. (2014) and the distances at which modelling estimated they could be reached for fish with and without a swim bladder. In summary:

- The noise effect criteria for mortality/potential mortal injury from the boomer is predicted for fish with a swim bladder at a maximum distance of 4m and for fish without a swim bladder at 1.5m
- The noise effect criteria for recoverable injury is predicted for fish with a swim bladder and without a swim bladder at a maximum distance of 1.5m from the boomer
- The noise effect criteria for TTS for fish with and without a swim bladder was not reached
- No noise effect criteria for fish with or without a swim bladder was predicted to be reached from the VSP

Studies to date have not shown mortality in relation to potential impact to fish from impulsive noise, though prolonged or extreme exposure to high-intensity, low-frequency sound, may lead to physical damage such as threshold shifts in hearing or barotraumatic ruptures (Carroll et al. 2017). Based on the modelling and the fact that the geophysical surveys and VSP will not result in prolonged or extreme exposure to fish it is unlikely that injury impacts to fish would occur with a Minor consequence ranking assigned.

Eels that have important cultural value to First Nations may also migrate through the Project or Planning Areas (Section 4.4.9.3.2). Eels that may migrate through the Otway shelf to deeper waters are not predicted to be impacted as a study by Koster et al. 2021 tracked 16 shortfinned eels found that the average speed was 30.8 ± 7.3 km/day while eels were on the continental shelf and 29.7 ± 11.1 km/day while in deep water. Thus, migrating eels are unlikely to be impacted based on the small distances to the sound exposure criteria (4m) and the distance eels travel while migrating.

6.4.3.2.4 Marine Turtles

Noise effect criteria used in this assessment for injury to turtles are from the ANSI accredited report of sound exposure guidelines for fishes and sea turtles (Popper et al. 2014). Table 57 details the noise effect criteria from Popper et al. 2014 and the distances at which modelling estimated they could be reached. In summary:

- The noise effect criteria for injury to turtles was reached within only 4m for the boomer and 0.8m for the SBP for the peak sound pressure level (PK) and the noise effect criteria based on the sound exposure level (SEL) is not reached
- There was no potential injury effects from the VSP

Based on limited data regarding noise levels that illicit a behavioural response in turtles, the United States National Marine Fisheries Service criterion of 166 dB re 1 µPa (SPL) is typically applied (NFS 2011) and is detailed in the Recovery Plan for Marine Turtles in Australia (CoA 2017b).

This behavioural noise effect criteria is predicted at a maximum distance of 3.9km from the VSP, 90m from the boomer but was not reached for the SBP.

Three marine turtle species may occur within the Project Area however no BIAs or habitat critical to the survival of the species are present. Impacts to turtles are likely to be restricted to short term and highly localised behavioural avoidance from the VSP source. VSP is short term, being in the order of up to 24 hours duration per well, and this extent is within that of the potential for seabed disturbance around the MODU due to anchor footprint (2km). Behavioural impacts to turtles would be temporary and unlikely to have a significant impact on individuals or at a population level with a minor consequence ranking assigned.

6.4.3.2.5 Marine Mammals

Noise effect criteria used in this assessment for impacts to marine mammals from impulsive noise activities are based on the following:

- The National Oceanic and Atmospheric Administration (NOAA 2019) acoustic threshold for behavioural effects in marine mammals of 160 dB re 1 µPa (SPL). Whilst the newly published Southall et al. (2021) provides recommendations and discusses the nuances of assessing behavioural response, the authors do not recommend new numerical thresholds for onset of behavioural responses for marine mammals
- Southall et al. (2019) for the onset of PTS and TTS. These criteria are based on dual acoustic criteria for impulsive sounds that included peak pressure level thresholds and SEL_{24h} thresholds, where the subscripted 24h refers to the accumulation period for calculating SEL.

Secondary effects in marine mammals, such as masking, are poorly understood. Threshold levels cannot yet be applied in the same way as they can for direct sound effects, therefore a qualitative approach must be taken (Erbe et al. 2016). For the purpose of this evaluation, behavioural effect thresholds (as per NOAA 2019) are adopted as a conservative threshold for secondary effects i.e. masking (Hawkins and Popper 2017).

Table 57 details the noise effect criteria and the distances at which modelling estimated they could be reached.

Low Frequency Cetaceans

Several low frequency cetaceans may occur within the Project Area. Foraging behaviours were identified for the blue, fin, pygmy right and sei whales; no other important behaviours were identified. The following impulsive noise source EMBAs intersect the migration BIA for the southern right whale (**Figure 105**) and foraging BIAs for the pygmy blue whale (**Figure 106**):

- Geophysical Sound Behaviour (360m)
- VSP Sound Behaviour (2.6km)
- VSP Sound Behaviour – shelf edge (6.5km)

The reproduction BIA for the southern right whale does not overlap the Project area.

These EMBAs are based on the greatest distances from the activity where noise effect criteria are reached for impulsive noise sources, being for marine mammal behaviour.

For low-frequency cetaceans the modelling results showed the following:

- For low-frequency cetaceans the noise effect criteria for PTS is not reached and for TTS is only reached at 25m for the 24-hour cumulative SEL
- The acoustic threshold for behavioural effects is predicted at a maximum of 2m from the SBP, 360m from the boomer, 2.56km for VSP operations and 6.5km for VSP operations in shelf edge locations.

It is not feasible that a low-frequency cetacean, even if foraging, resting, or migrating would be within 25m of a moving geophysical survey vessel for 24 hours.

Predicted impacts would, therefore, be limited to short term and localised behavioural responses such as avoidance of the area while the geophysical survey (360m) or VSP (2.56 on shelf and 6.5km on shelf edge) is undertaken.

The consequence is assessed as Minor for fin, pygmy right and sei whales as there are no biologically important behaviours or BIAs identified within the predicted ensonified area.

The fin and sei whale's conservation advice (TSSC 2015e, TSSC 2015f) has a consequence rating for anthropogenic noise and acoustic disturbance as minor with the extent over which the threat may operate as moderate-large. The pygmy right whale Species Profile and Threats Database (DotEE 2020a) in lieu of no conservation advice, does not identify anthropogenic noise and acoustic disturbance as a threat.

The consequence is assessed as Moderate for southern right and pygmy blue whales as the activity area overlaps BIAs for these species.

Further detailed impact evaluation on Blue whales and Southern right whales, including the interaction with Conservation Management Plans relevant to both the impulsive and continuous noise sources of the Project. is addressed in Section 6.4.3.3.

High Frequency Cetaceans

High frequency cetaceans such as dolphins, sperm whales and beaked whales may occur in the Project Area, but no BIAs or biologically important behaviours were identified.

- The noise effect criteria for TTS and PTS for these species was not reached
- The extent of the area of where high frequency cetaceans may be impacted behaviourally by noise is predicted to be 360m for surveys and 2.56km for VSP operations in shelf locations and 6.5km on shelf edge locations.

Impacts to high-frequency cetaceans are likely to be limited to avoidance behavioural where they may move away from the vessel as it is undertaking the geophysical survey or MODU while undertaking VSP.

The area of impact is not within a BIA or habitat critical to the survival of a high frequency cetacean species and thus impacts are unlikely to have a significant impact on individuals or at a population level.

Based on this, the consequence ranking of potential impacts of impulsive noise to high frequency cetaceans is considered Minor.

Very High Frequency Cetaceans

Very high frequency cetaceans, such as pygmy and dwarf sperm whales, may occur in the Project Area but no BIAs or biologically important behaviours were identified.

- The maximum distance for the PTS noise effect criteria is 4.5m and 22m for TTS
- The extent of the area of where very high frequency cetaceans may be impacted behaviourally by noise is predicted to be 360m for surveys and 2.56km for VSP operations in shelf locations and 6.5km for shelf edge locations.

Impacts to very high frequency cetaceans are likely to be limited to avoidance behavioural where they may move away from the vessel as it is undertaking the geophysical survey or VSP operations.

The area of impact is not within a BIA or habitat critical to the survival of a very high frequency cetaceans species and thus impacts are unlikely to have a significant impact on individuals or at a population level.

Based on this, the consequence ranking of potential impacts of impulsive noise to very high frequency cetaceans is considered Minor.

Pinnipeds

The Australian and New Zealand fur-seals may occur in the Project Area but no BIAs or haul out areas were identified.

- The noise effect criteria for TTS and PTS for these species was not reached
- The extent of the area of where pinnipeds may be impacted behaviourally by noise is predicted to be 360m for surveys and 2.56km for VSP operations in shelf locations and 6.5km for shelf edge locations.

Impacts are likely to be limited to avoidance behavioural where they may move away from the vessel as it is undertaking the geophysical survey or VSP operations.

The area of impact is not within a BIA or habitat critical to the survival of pinniped species and thus impacts are unlikely to have a significant impact on individuals or at a population level.

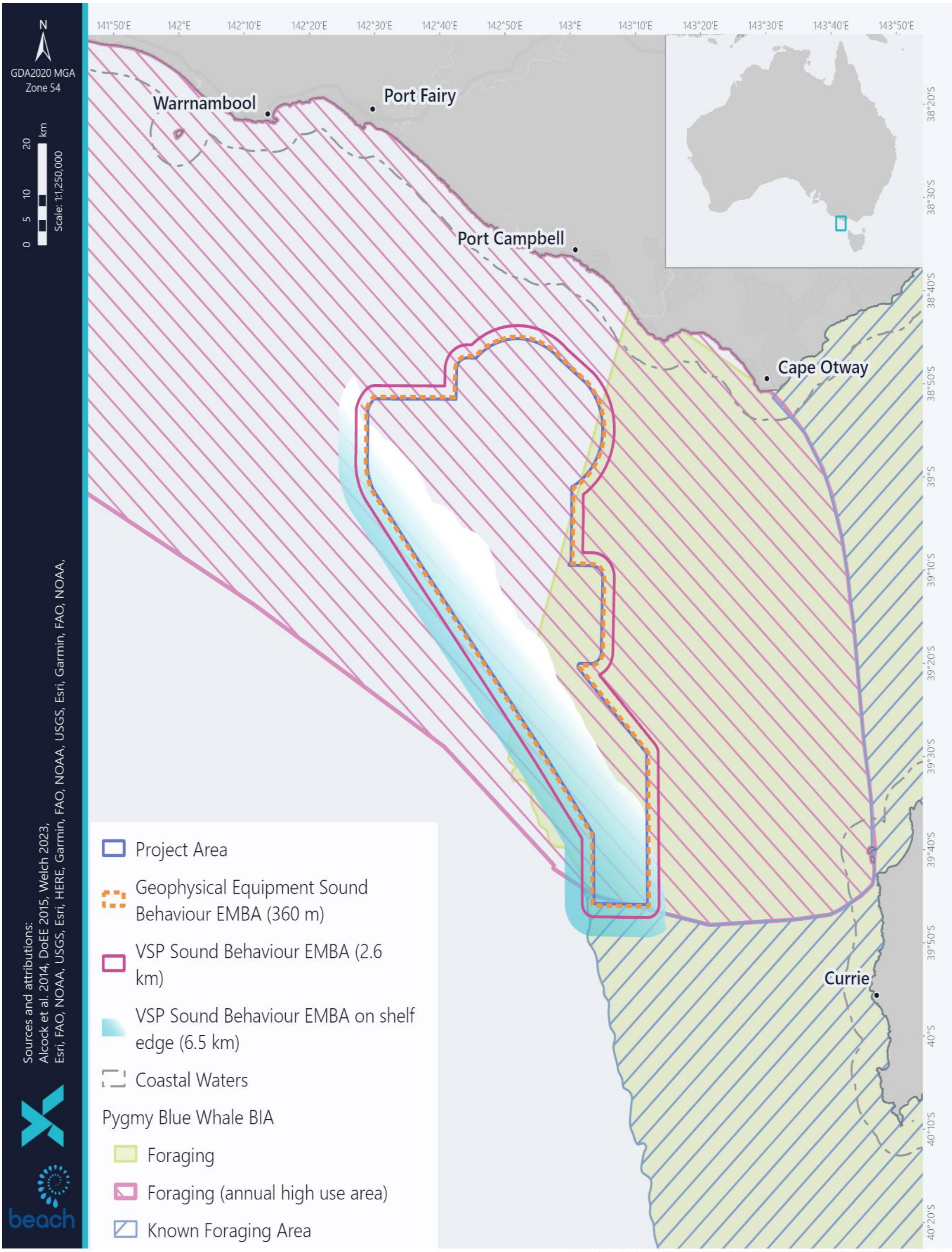
Based on this, the consequence ranking of potential impacts of impulsive noise to pinnipeds is considered Minor.

Cultural Values and Sensitivities

The following cultural values and sensitivities from Section 4.6.3 have been identified as potentially affected by sound and the potential impacts have been assessed within this Section 6.4.3:

- Eels
- Fish
- Dolphins
- Blue whales
- Southern right whales
- Seals

In addition, underwater sound has not been identified as an impact to submerged cultural heritage.



Document details: G:\CheckOuts\P100383\S00\GIS\Output\P100383_S00_OPP_BW.aprx, P100383_S00_37_PBWSoundImpulsive, P-UWS-132,15/12/2023

Figure 105: Impulsive Sound Behaviour EMBAs and Blue Whale BIAs

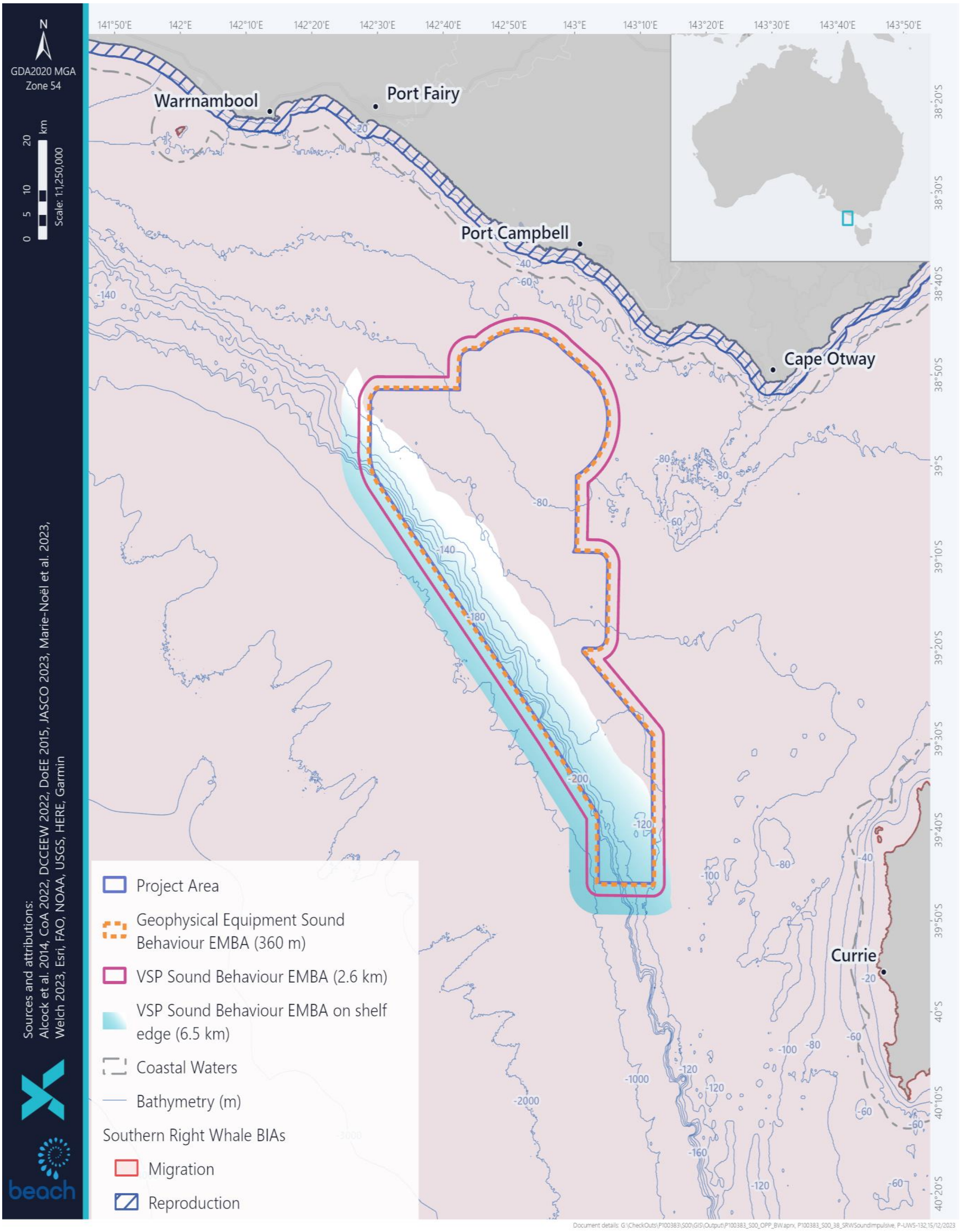


Figure 106: Impulsive Sound Behaviour EMBAs and Southern Right Whale BIAs

6.4.3.3 Continuous Noise Sources

Underwater acoustic emissions associated with the drilling, installation, IMR and vessel activities will be continuous.

The marine fauna considered was based on a review of receptors that may be impacted by continuous sound, these were marine mammals, turtles, and fish.

To assess potential impacts to receptors from underwater sound associated with continuous sources from the Project, acoustic modelling was used to predict received underwater sound levels. The modelled received sound levels where then compared to defined noise effect criteria, as determined by scientific research and academic papers, for the identified receptors.

Where several modelled scenarios are representative of drilling, installation, IMR or vessel activities, such as where location or season have been varied in the modelling parameters, the furthest distance to the exposure criteria has been selected for the evaluation of potential impacts

6.4.3.3.1 Fish

Popper et al. (2014) details that there is no direct evidence of mortality or potential mortal injury to fish from ship sound emissions. Popper et al. (2014) details that risks of mortality and potential mortal injury, and recoverable injury impacts to fish with no swim bladder (sharks) or where the swim bladder is not involved in hearing is low and that TTS in hearing may be a moderate risk near (tens of metres) the vessel. For fish with a swim bladder involved in hearing risks of mortality and potential mortal injury impacts is low. However, some evidence suggests that fish sensitive to acoustic pressure show a recoverable loss in hearing sensitivity, or injury when exposed to high levels of sound and Popper et al. (2014) details SPL criteria for fish with a swim bladder involved in hearing.

Table 58 details the criteria and modelled distances to the effect criteria for fish as follows:

- The 48 hr recoverable injury threshold was reached within 50m for drilling and not reached for the other activities
- The 12 hr TTS criteria was reached within 150m for drilling, 40m for Installation and IMR, and not reached for vessel resupply activities.

Surveys within the Project Area (Ramboll 2020, Appendix C) concluded that the seafloor in the surveyed area is unmodified marine sediment which supports a patchy complex of branchy epibiota and is typical of what is expected at shallow and middle shelf zones. Fauna associated with this type of habitat included amphipods, isopods, polychaete worms and molluscs. The survey also identified areas of rock outcrops. Based on available data, the presence of habitat which support site-attached fish within the Project Area cannot be ruled out.

The existing studies focus on the shallow and middle shelf zones of up to approximately 130m water depth. Beach commits to undertaking further seabed assessments of the deep shelf and upper slope zones (from approximately 130m to 180m water depth) located predominantly in the southern and western portions of the Project Area. These assessments will enable the seabed composition, benthic habitats and communities to be identified for locations where seabed disturbance activities such as drilling may take place, allowing final well location selection to avoid areas of high relief outcrops, reefs and sponge beds (CM#10).Based on this commitment, it is unlikely that fish species would be present within these distances from the activities for periods of over 12 or 48 hours and therefore injury and TTS impacts are not predicted.

Further seabed assessments will be undertaken of the deep shelf and upper slope zones (from approximately 130m to 200m water depth) located predominantly in the southern and western portions of the Project Area.

These assessments will enable the seabed composition, benthic habitats and communities to be identified for locations where seabed disturbance activities such as drilling and infrastructure installation may take place

The West Tasmanian Canyons, where there are fish nurseries and the potential for site-attached fish was identified as being within the Project Area to a minor extent. The KEF is located on the continental slope where Project activities are not planned and is not within the potential area of impact for continuous noise.

Behavioural impacts are more likely such as moving away from the MODU or vessel. There are no habitats or features within the Project Area that would restrict fish and sharks from moving away from the activities.

The white shark is known to occur within the Project Area but there are no BIAs or critical habitats. The Recovery Plan for the White Shark (DSEWPaC 2013a) does not identify underwater acoustic emissions as a threat.

Impacts to fish, including sharks, would be limited to behavioural impacts such as startle response or avoidance behaviour near the MODU or vessel. Thus, behavioural impacts to fish would be temporary and unlikely to have a significant impact on individuals or at a population level.

Temporary avoidance behaviour may occur near the vessel for commercial fish species; however, recovery would occur once the activities have ceased after up to between 30-60 days each. Based on the small area of impact and that displaced fish would still be available to be caught, impacts to commercial fishing are not predicted.

Based on this, the consequence ranking of potential impacts to fish is considered Minor.

Eels that have important cultural value to First Nations may also migrate through the Project or Planning Areas (Section 4.4.9.3.2). Eels that may migrate through the Otway shelf to deeper waters are not predicted to be impacted as a study by Koster et al. 2021 tracked 16 shortfinned eels found that the average speed was 30.8 ± 7.3 km/day while eels were on the continental shelf and 29.7 ± 11.1 km/day while in deep water. Thus, migrating eels are unlikely to be impacted based on the small distances to the sound exposure criteria (up to 150m) and the distance eels travel while migrating.

6.4.3.3.2 Marine Turtles

The Recovery Plan for Marine Turtles in Australia (CoA 2017b) identifies noise interference as a threat to turtles. It details that exposure to chronic (continuous) loud noise in the marine environment may lead to avoidance of important habitat.

Popper et al. (2014) details that there is no direct evidence of mortality or potential mortal injury to sea turtles from ship sound emissions.

Popper et al. (2014) found that there was insufficient data available to propose a quantitative exposure guideline or criteria for marine turtles for continuous sound such as those generated by vessels and instead suggested general distances to assess potential impacts. Using semi-quantitative analysis, Popper et al. (2014) suggests that there is a low risk to marine turtles from shipping and continuous sound except for TTS near (10s of metres) to the sound source, and masking at near, intermediate (hundreds of metres) and far (thousands of metres) distances and behaviour at near and intermediate distances from the sound source.

Finneran et al. (2017) presented revised thresholds for turtle PTS and TTS for continuous sound. Table 59 details the criteria and modelled distances to them (Koessler and McPherson 2021. Appendix F) as follows:

- The 24hr PTS criteria was reached within 50m of drilling, 20m of installation and IMR, and not reached for OSV transit

- The 24hr TTS criteria was reached within 160m of drilling, 80m of installation and IMR, and 30m for OSV transit

Three marine turtle species may occur within the Project Area although no BIAs or habitat critical to the survival of the species were identified.

The Recovery Plan for Marine Turtles in Australia (CoA 2017b) details that exposure to chronic (continuous) loud noise in the marine environment may lead to avoidance of important habitat and no marine turtle important habits are located within the area that maybe impacted.

Low numbers of marine turtles are predicted in the Project Area and therefore impacts would be limited to a small number of individuals and over a temporary period of up to between 30-60 days for each activity and at a localised extent (160m).

Based on this, the consequence ranking of potential impacts to marine turtles is considered Minor.

6.4.3.3.3 Marine Mammals

Noise effect criteria used in this assessment for impacts to marine mammals are based on:

- NOAA (2019) acoustic threshold for behavioural effects in marine mammals of 120 dB re 1 µPa (SPL). Whilst the newly published Southall et al. (2021) provides recommendations and discusses the nuances of assessing behavioural response, the authors do not recommend new numerical thresholds for onset of behavioural responses for marine mammals
- NMFS (2018) exposure criterion for the onset of temporary hearing TTS and PTS for marine mammals based on their frequency hearing range. NMFS (2018) details that after sound exposure ceases or between successive sound exposures, the potential for recovery from hearing loss exists, with PTS resulting in incomplete recovery and TTS resulting in complete recovery. The NMFS (2018) exposure criteria are based on a cumulative SELs over a period of 24 hours

Secondary effects in marine mammals, such as masking, are poorly understood. Threshold levels cannot yet be applied in the same way as they can for direct sound effects, therefore a qualitative approach must be taken (Erbe et al. 2016). For the purpose of this evaluation, behavioural effect thresholds (as per NOAA 2019) are adopted as a conservative threshold for secondary effects i.e. masking (Hawkins and Popper 2017).

Table 60 details the furthest modelled distance of each activity to the criteria for each marine mammal hearing group.

Low Frequency Cetaceans

Several low frequency cetaceans may occur within the Project Area. Foraging behaviours were identified for the blue, fin, pygmy right and sei whales; no other important behaviours were identified. The continuous noise source sound behaviour EMBAs for marine mammals of 7.98km and for marine mammals on shelf edge of 19.6km intersect the migration BIA for the southern right whale (**Figure 107**) and foraging BIAs for the pygmy blue whale (**Figure 108**). These EMBAs are based on the greatest distances from the activity where noise effect criteria are reached for continuous noise sources.

For low-frequency cetaceans the modelling results showed the following:

- The 24hr PTS criteria is reached within 180m from drilling and 100m from drilling on shelf edge, 60m from installation/IMR and 150m for installation/IMR on shelf edge, and not reached for OSV standby/transit.

- The 24hr TTS criteria is reached within 1.31km from drilling and 1.48km from drilling on shelf edge, 660m from installation/IMR and 1.65km for installation/IMR on shelf edge, not reached for OSV standby/transit and 10m for OSV standby/transit on shelf edge.
- The behavioural criteria is reached within 7.89km from drilling and 19.6km from drilling on shelf edge, 2.98km from installation/IMR and 6.5km from installation/IMR on shelf edge, 380m for OSV standby/transit and 410m from OSV standby/transit on shelf edge.

The consequence is assessed as Minor for fin, pygmy right and sei whales as there are no biologically important behaviours or BIAs identified within the sound EMBAs.

The fin and sei whale's conservation advice (TSSC 2015e, TSSC 2015f) has a consequence rating for anthropogenic noise and acoustic disturbance as minor with the extent over which the threat may operate as moderate-large. The pygmy right whale Species Profile and Threats Database (DotEE 2020a) in lieu of no conservation advice, does not identify anthropogenic noise and acoustic disturbance as a threat.

The consequence is assessed as Moderate for southern right and pygmy blue whales as the activity area overlaps BIAs for these species.

Blue whales

Foraging behaviour for blue whales has been identified in the area where the PTS, TTS and behavioural criteria is reached for Project activities. On the advice of Gill (2020), all blue whales are assumed to be foraging.

The Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c) requires that 'anthropogenic noise in BIAs will be managed such that any blue whale continues to utilise the area without injury and is not displaced from a foraging area'. The Guidance on Key Terms within the Blue Whale Conservation Management Plan (Commonwealth of Australia, 2021) defines the requirements of this action as "to ensure that any blue whale can continue to forage with a high degree of certainty in a Foraging Area, and that any blue whale is not displaced from a Foraging Area".

The Guidance on Key Terms within the Blue Whale Conservation Management Plan (Commonwealth of Australia, 2021) suggests a whale could be displaced from a foraging area if stopped or prevented from foraging, caused to move on when foraging, or stopped or prevented from entering a foraging area. A whale is considered to be displaced from a foraging area if foraging behaviour is disrupted, regardless of whether the whale can continue to forage elsewhere within that foraging area (Commonwealth of Australia, 2021).

A precautionary approach has been taken in the assessment of possible displacement from a foraging area BIA by using conservative assumptions so as to ensure that control measures will be implemented. The inherent severity of potential impact from the activity is assessed as Moderate because:

- An assessment of Beach's MFO data collected between February 2021 and March 2022 for the ongoing drilling and installation campaign was undertaken. Activities included drilling and construction at the Artisan well location and activities in the Geographe and Thylacine fields A summary of findings include:
  - Of the 127 blue whales that were observed to enter the 3,000 m management zone, 70 (55%) were observed to move towards the MODU (following first detection) and 57 (45%) were observed to move away from the MODU. This indicates that blue whales are not being displaced.
  - Published detection functions (Williams et al. 2016) and conservative assumptions were used to estimate blue whale densities in the management zones applied (0-500, 501-1,500, 1,501-2,000, 2,001-3,000, >3,000 m). If underwater noise was displacing blue whales, it would be

    expected less whales would be observed in the zones closest to the underwater noise. The expected densities of blue whales based on the detection function most closely matching the Lead MFOs advice indicated there was no difference in expected densities between any of the management zones (mean of 6.21 blue whales/km2).

    - The expected densities of blue whales based on the conservative detection functions showed similar results for the 0-500 and 501-1,500 m zones (means of 7.27 and 7.73 blue whales/km2). However, they showed mean expected densities of 18.70 blue whales/km2 and 22.91 blue whales/km2 for the 1,501-2,000 and 2,001-3,000 m zones. Even if the conservative functions are used there is still no detectable difference in expected densities of blue whales in the 0-500 and 501-1,500 m zones, which conservatively means that blue whales are not displaced within 1,500 m of the noise source.

- The Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c) details that shipping and industrial noise are classed as a 'minor' consequence (defined as: individuals are affected but no affect at a population level).
- The activities will be of a short duration (up to 30-40 days per campaign)
- The area within the largest behavioural distance EMBA represents less than 4% of the BIA.
- Adopted controls for Project noise sources will prevent possible PTS, TTS and displacement impacts to pygmy blue whale that may be foraging.
- The largest sound EMBA is ~50 km from the Bonney coast upwelling KEF, which is a known feeding aggregation area (Gill et al. 2011; McCauley et al. 2018). The sound EMBAs are within an area where the occurrence of an upwelling event between 2002 and 2016 was assessed as very unlikely with an upwelling frequency of <10% (Huang and Wang 2019). Thus, blue whale foraging is likely to be opportunistic within the sound EMBAs
- Aerial surveys in the Otway region (2001 – 2007) recorded mean blue whale group size of 1.3±0.6 per sighting (Gill et al., 2011), meaning that pods do not have high numbers.
- Attard et al. (2017) showed that pygmy blue whales travel widely between the two known foraging areas (Bonney coast upwelling and Perth Canyon) and that records suggest that this population of blue whales may visit diverse, widespread areas for feeding during the austral summer, including perhaps the southern Indian Ocean and sub-Antarctic region, and travel to winter breeding grounds in the Indonesian region where they may also feed.
- The Commonwealth of Australia (2021) guidance regarding the definition of 'displaced from a foraging area' states that mitigation measures must be implemented to reduce the risk of displacement occurring during operations where modelling indicates that behavioural disturbance within a foraging area may occur. The implementation of the control measures, including Whale Management Plans for each relevant Project activity, means that blue whale displacement from a foraging area is unlikely to occur. As such, the activity will be managed in a manner that is not inconsistent with the Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015c), specifically Action Area A.2.

Southern right whales

Migration behaviour for southern right whales has been identified in the area where the PTS, TTS and behavioural criteria is reached for Project activities.

The inherent severity of potential impact from the activity is assessed as moderate due to the following:

- The activities will be of a short duration (up to 60 days per campaign).
- The area within the behavioural distance EMBA represents less than 1% of the BIA.
- The noise effect criteria thresholds are not reached at the southern right whale reproduction BIA and are ~10km away at the closest point
- The activity is not being undertaken within the coastlines areas of south-west Victoria in Gunditjmara Sea Country where southern right whale feed and birth or the Whale Birthing Dreaming Sites in coastal bay areas from Port Campbell to Portland, including Warrnambool (DCCEEW 2022a). Noise impacts to southern right whales in these sites are not predicted.
- Low numbers of SRW are predicted in and around the activity area based on aerial surveys in the Otway region (2002 – 2013), which recorded 12 groups of SRW consisting of 52 individuals (Gill et al., 2015). None were observed away from the coast, which Gill et al (2015) noted is consistent with winter habitat preferences.
- SRW are a highly mobile migratory species that travel thousands of kilometres between habitats used for essential life functions (DSEWPC, 2012a). Along the Australian coast, individual SRW use widely separated coastal areas (200–1,500 km apart) within a season, indicating substantial coast-wide movement. The longest movements are undertaken by non-calving whales, though calving whales have also been recorded at locations up to 700 km apart within a single season (DSEWPC, 2012a).
- The Conservation Management Plan for the Southern Right Whale (DSEWPaC 2012a) identifies acute industrial and vessel noise as a threat that is classified as a minor consequence which is defined as individuals are affected but no affect at a population level. The Draft National Recovery Plan for the Southern Right Whale (DCCEEW 2022a) identifies industrial noise as a Moderate consequence and vessel noise as Minor consequence.
- Anthropogenic noise will be managed such that SRW are not deterred from calving nor displaced from the emerging aggregation area. The EPOs and control measures, including Whale Management Plans for each relevant Project activity, ensure that SRW will continue to utilise the emerging aggregation area; and movements are not deterred in and out of the migration area. The activity will be managed in a manner that is not inconsistent with this conservation objective of the Conservation Management Plan for the Southern Right Whale (DSEWPC, 2012a).
- The activity can be managed to ensure that it will not be inconsistent with the Draft National Recovery Plan for the Southern Right Whale (DCCEEW 2022a) that details that actions within and adjacent to southern right whale BIAs and habitat critical to the survival of the species, should demonstrate that it does not prevent any southern right whale from utilising the area or cause injury (TTS and PTS) and/or disturbance. Adopted controls will prevent possible PTS, TTS and displacement impacts to southern right whales.

High Frequency Cetaceans

High frequency cetaceans such as dolphins, sperm whales and beaked whales may occur in the Sound behaviour EMBAs for continuous noise sources of 7.98km and 19.6km for shelf edge locations, but no BIAs or biologically important behaviours were identified.

For high frequency cetaceans the modelling results showed the following:

- The 24hr PTS criteria is reached within 50m from drilling and drilling on shelf edge, 20m for installation/IMR and 50m from installation/IMR on shelf edge, and not reached for OSV standby/transit
- The 24hr TTS criteria is reached within 160m from drilling and 80m from drilling on shelf edge, 90m for installation/IMR and 225m from installation/IMR on shelf edge, and not reached for OSV standby/transit
- The behavioural criteria is reached within 7.89km from drilling and 19.6km from drilling on shelf edge, 2.98km from installation/IMR and 6.5km from installation/IMR on shelf edge, 380m for OSV standby/transit and 410m from OSV standby/transit on shelf edge.

It is unlikely that a high frequency cetacean would be within the PTS and TTS extent distances of a MODU or vessel for in excess of 24 hours.

Predicted impacts would be limited to behavioural response such as avoidance of the area for a small number of individuals, not population level, while the activities are being undertaken for a temporary period of up to between 30-60 days.

Based on this, the consequence ranking of potential impacts of continuous noise to high frequency cetaceans is considered Minor.

Very High Frequency Cetaceans

Very high frequency cetaceans, such as pygmy and dwarf sperm whales, may occur in the Sound behaviour EMBAs for continuous noise sources of 7.98km and 19.6km for shelf edge locations, but no BIAs or biologically important behaviours were identified.

For very high frequency cetaceans the modelling results showed the following:

- The 24hr PTS criteria is reached within 260m from drilling and 170m from drilling on shelf edge, 120m for installation/IMR and 300m for installation/IMR from shelf edge, and not reached for OSV transit
- The 24hr TTS criteria is reached within 1.16km from drilling and 1.53km from drilling on shelf edge, 870m for installation/IMR and 2.18km from installation/IMR on shelf edge, not reached for OSV transit and 10m from OSV standby/transit.
- The behavioural criteria is reached within 7.89km from drilling and 19.6km from drilling on shelf edge, 2.98km from installation/IMR and 6.5km from installation/IMR on shelf edge, 380m for OSV standby/transit and 410m from OSV standby/transit on shelf edge.

It is unlikely that a very high frequency cetacean would be within the PTS and TTS extent distances of a MODU or vessel for in excess of 24 hours.

Predicted impacts would be limited to behavioural response such as avoidance of the area for a small number of individuals, not population level, while the activities are being undertaken for a temporary period of up to between 30-60 days.

Based on this, the consequence ranking of potential impacts of continuous noise to very high frequency cetaceans is considered Minor.

Otariid Seals

Otariid seals, such as the Australian sea lion and Australian and New Zealand fur seals may occur within the Sound behaviour EMBAs for continuous noise sources of 7.98km and 19.6km for shelf edge locations, but no BIAs or biologically important behaviours were identified.

For otariid seals the modelling results showed the following:

- The 24hr PTS criteria is reached within 50m from drilling and 30m from drilling on shelf edge, 10m for installation/IMR and 25m from installation/IMR on shelf edge, and not reached for OSV transit
- The 24hr TTS criteria is reached within 90m from drilling and 50m from drilling on shelf edge, 20m for installation/IMR and 50m for installation/IMR on shelf edge, and not reached for OSV transit
- The behavioural criteria is reached within 7.89km from drilling and 19.6km from drilling on shelf edge, 2.98km from installation/IMR and 6.5km from installation/IMR on shelf edge, 380m for OSV standby/transit and 410m from OSV standby/transit on shelf edge.

It is unlikely that an otariid seal would be within the PTS and TTS extent distances of a MODU or vessel for in excess of 24 hours.

Predicted impacts would be limited to behavioural response such as avoidance of the area for a small number of individuals, not population level, while the activities are being undertaken for a temporary period of up to between 30-60 days.

Based on this, the consequence ranking of potential impacts of continuous noise to otariid seals is considered Minor (1).

Cultural Values and Sensitivities

The following cultural values and sensitivities from Section 4.6.3 have been identified as potentially affected by sound and the potential impacts have been assessed within this Section 6.4.3:

- Eels
- Fish
- Dolphins
- Blue whales
- Southern right whales
- Seals

Underwater sound has not been identified as an impact to submerged cultural heritage.

Fish (swim bladder)	SPL (Lp; dB re 1 µPa)	Drilling + Resupply	Drilling + Resupply – shelf edge	Installation/IMR	Installation/IMR – shelf edge	OSV standby/transit	OSV standby/transit – shelf edge
Recoverable injury	170 dB SPL (48h)	50m	20m	NR	NR	NR	NR
TTS	158 dB SPL (12h)	150m	110m	40m	100m	NR	NR

Table 58: Noise effect criteria and modelled distances to the criteria for fish

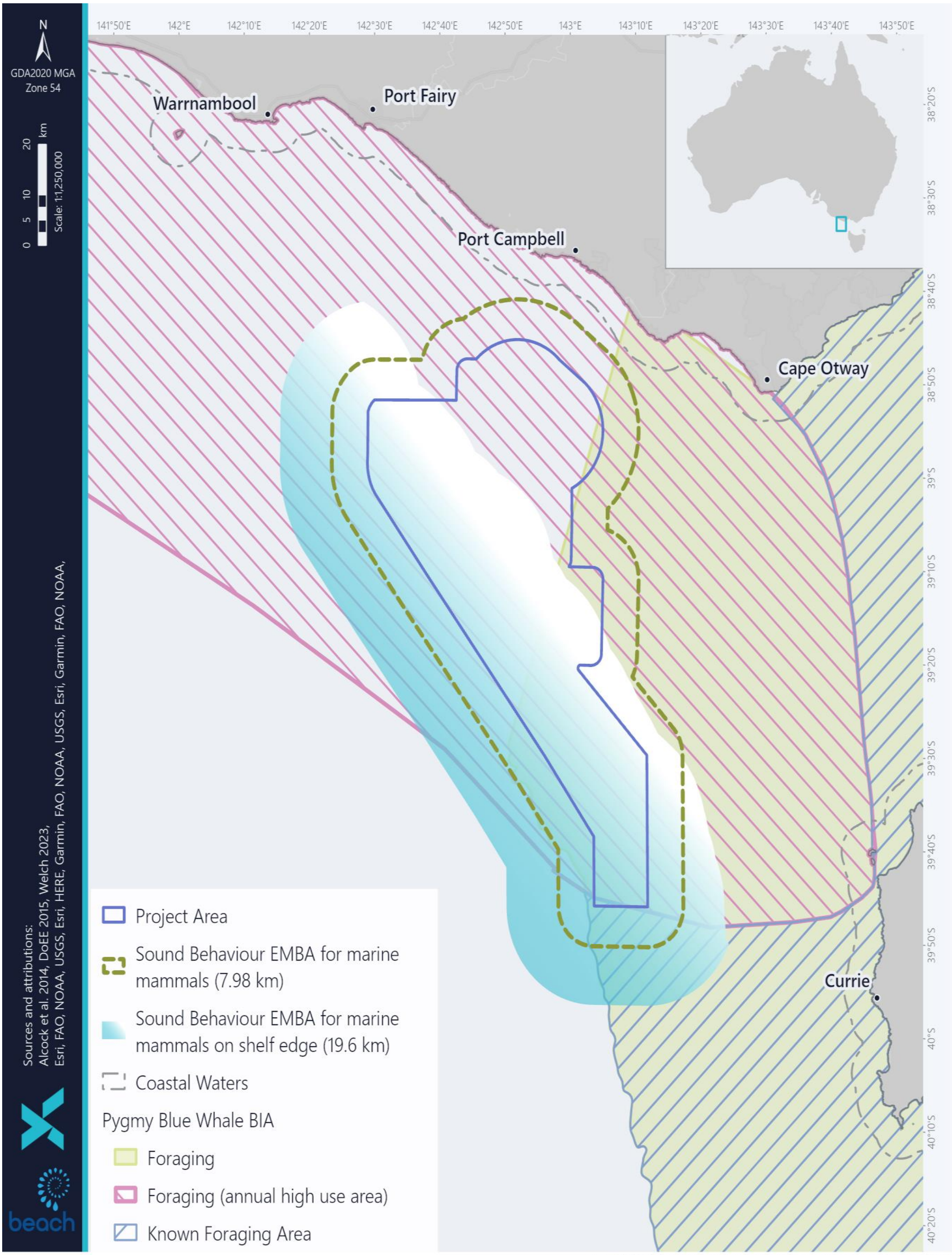
Marine Turtles	SEL24h threshold (dB re 1 µPa²·s)	Drilling + Resupply	Drilling + Resupply – shelf edge	Installation/IMR	Installation/IMR – shelf edge	OSV standby/transit	OSV standby/transit – shelf edge
PTS	220	50m	50m	20m	50m	NR	NR
TTS	200	160m	80m	80m	200m	NR	NR

Table 59: Noise effect criteria and modelled distances to the criteria for marine turtles

Marine Mammal Hearing Group	SEL_{24h} threshold (dB re 1 µPa²·s)	Drilling + Resupply	Drilling + Resupply – shelf edge	Installation/IMR	Installation/IMR – shelf edge	OSV standby/transit	OSV standby/transit – shelf edge
				PTS			
Low-frequency cetaceans	199	180m	100m	60m	150m	NR	NR
High-frequency cetaceans	198	50m	50m	20m	50m	NR	NR
Very-high-frequency cetaceans	173	260m	170m	120m	300m	NR	NR
Otariid seals	219	50m	30m	10m	25m	NR	NR
				TTS			
Low-frequency cetaceans	179	1.31km	1.48km	660m	1.65km	NR	10m
High-frequency cetaceans	178	160m	120m	90m	225m	NR	NR

Marine Mammal Hearing Group	SEL_{24h} threshold (dB re 1 µPa^2·s)	Drilling + Resupply	Drilling + Resupply – shelf edge	Installation/IMR	Installation/IMR – shelf edge	OSV standby/transit	OSV standby/transit – shelf edge
Very-high-frequency cetaceans	153	1.16km	1.53km	870m	2.18km	NR	10m
Otariid seals	199	90m	50m	20m	50m	NR	NR
Behaviour							
Marine mammals	120 SPL	7.89km	19.6km	2.98km	6.5 km	380m	410m

Table 60: Noise effect criteria and modelled distances to the criteria for marine mammals



Document details: G:\CheckOuts\P100383\S00\GIS\Output\P100383_S00_OPP_BW.aprx, P100383_S00_34_PBWSound, P-UWS-132,15/12/2023

Figure 107: Pygmy Blue Whale BIAs and Continuous Sound Behaviour EMBAs

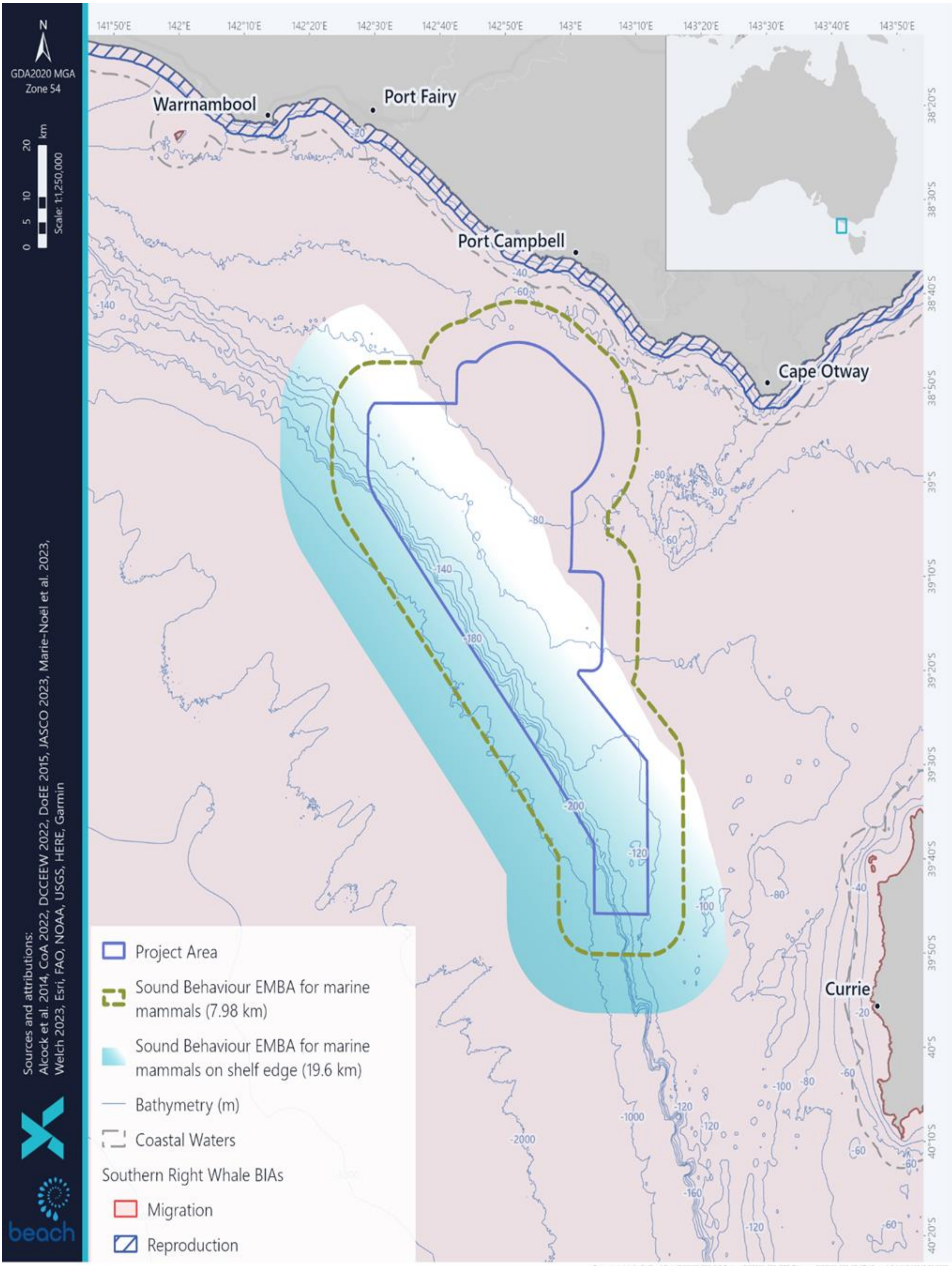


Figure 108: Southern Right Whale BIAs and Continuous Sound Behaviour EMBAs

6.4.4 Impact Evaluation Summary

Table 61 presents the impact assessment for the generation of underwater noise.

Summary	
Summary of impacts	Noise has the potential to cause change in fauna behaviour, injury, mortality, and hearing impairment (TTS and PTS)
Extent of impacts	Underwater noise that could potentially impact marine fauna will be generated during impulsive source activities (geophysical surveys, VSP operations) with a predicted maximum extent of impact (behavioural disturbance threshold for whales) of up to 2.56km. Underwater noise that could potentially impact marine fauna will be generated during continuous source activities (drilling, installation and IMR and vessel transit) with a predicted maximum extent of impact (behavioural disturbance threshold for whales) of up to 7.89km.
Duration of impacts	Noise will be intermittent for the duration of Project activities. VSP operations are in the order of up to 24hrs per well. Geophysical surveys, drilling, installation and IMR are in the order of up to 30-60 days duration per campaign.
Level of certainty of impacts	Level of certainty of impacts is high. Best available science has been used to determine potential impacts and conservative noise criteria applied to model and assess ranges of impact for various receptors.
Impact decision framework context	**Decision Context: Type C** A Decision context Type C has been selected for this aspect and the precautionary approach has been applied for assessment and mitigation of impacts.
Impact Consequence (inherent)	
Serious	
Controls	
CM14 EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans	All vessels will adhere to EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans in relation to distances to cetaceans. Helicopters will adhere to EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans in relation to distances to cetaceans
CM15 Geophysical Survey Whale Management Procedure	Development and implementation of a whale management procedure for geophysical surveys using a boomer or SBP that will include the following: • pre-start-up visual observations. Visual observations for the presence of whales carried out at least 30 minutes out to a distance of at least 300m from the source before startup of the boomer or SBP. • if during the prestart visual observation period, a whale is sighted within 300 m of the vessel the equipment activation will be delayed until the whale has moved outside of the 300 m zone or 30 minutes has lapsed since the last whale sighting within 300 m. • SBP equipment will not be started at night if there have been three or more delays to the start-up of the equipment due to whales in the previous 24 hours. • use of suitably trained personnel and/or Marine Mammal Observers (MMO) • once the survey has commenced CM#14 applies where the vessel is required to maintain a 300 m distance to all whales.

Summary	
CM16 VSP Whale Management Procedure	Development and implementation of a whale management procedure for VSP activities that complies with 'Standard Management Procedures' set out in EPBC Act Policy Statement 2.1 – Interaction between Offshore Seismic Exploration and Whales: Industry Guidelines (DEWHA 2008c) (or the contemporary requirements at the time of the activity), including: • pre-start-up visual observations. • start-up and normal operating procedures, including a process for delayed start-up/recommencement, should whales be sighted. • night time and low visibility procedures • use of suitably trained personnel and/or Marine Mammal Observers (MMO)
CM17 Drilling Whale Management Procedure	Development and implementation of a whale management procedure for drilling activities which details a framework for minimising noise impacts to whales and a procedure to be implemented to ensure impacts and risks are reduced to ALARP. This will include: • pre-start-up visual observations. • start-up and normal operating procedures, including a process for delayed start-up/recommencement, should whales be sighted. • night time and low visibility procedures • use of suitably trained personnel and/or Marine Mammal Observers (MMO)
CM18 Vessel Whale Management Procedure	Development and implementation of a whale management procedure for installation, IMR and vessel transit/resupply activities which details a framework for minimising noise impacts to whales and a procedure to be implemented to ensure impacts and risks are reduced to ALARP. This will include: • pre-start-up visual observations. • start-up and normal operating procedures, including a process for delayed start-up/recommencement, should whales be sighted. • night time and low visibility procedures • use of suitably trained personnel and/or Marine Mammal Observers (MMO)
CM19 Noise Assessments	Acoustic noise assessments of significant noise generating activities associated with the Project will be detailed in relevant activity specific Environment Plans prior to activities commencing. The EPs will detail the sound levels and distances to noise effect criteria, with the mitigations required to ensure the Environmental Performance Outcomes of this OPP are met and the impact is ALARP and acceptable.
Impact Consequence (residual)	
Moderate	
Environmental Performance Outcomes	
EPO5	No death or injury to marine fauna, including listed threatened or migratory species, from Project activities
EPO7	Biologically important behaviours within or outside a BIA can continue while Project activities are being undertaken
EPO8	Underwater sound emissions in biologically important areas will be managed such that any whale, including blue and southern right whales, continue to utilise the area without injury, and are not displaced from a foraging area
Demonstration of Acceptability	

Summary		
Principles of ESD	ESD principles are met as the precautionary principle has been applied with the most recent scientific literature and international guidelines on noise impacts (Popper et al. 2014, NOAA 2018, Southall et al. 2019, Finneran et al. 2017) applied to ensure latest research and knowledge were considered in the evaluation of environmental impacts. Mitigation measures will be put in place to ensure no serious of irreversible environmental damage to protected marine fauna.	
Internal context	Policy compliance	Beach Environmental Policy objectives are met through this environmental impact assessment.
	Management system compliance	Section 10 describes the implementation strategy employed for this activity.
External context	Stakeholder engagement is being carried out as part of this OPP process Beach operates the existing Otway project and has established good relations with both onshore and offshore stakeholders. Engagement with stakeholders will continue throughout all aspects of the Project to build and maintain trust with stakeholders and the local community and minimise community and stakeholders concern and impacts where practicable. Underwater noise emissions are not expected to result in impacts to stakeholders, such as commercial fishers. The science of underwater noise is continually evolving. Any new guidance or advice will be assessed and incorporated into adaptive management plans prepared for activity specific EPs.	
Legislative context	The EPOs and control measures align with the requirements of: • EPBC Regulations 2000 – Part 8 Division 8.1 – Interacting with cetaceans. • Significant impact criteria (refer Table 41 in Section 5.8.2) • EPBC Management/Recovery Plans and Conservation Advice (refer Table 5 in Section 2.3.1) and the following detail. Underwater acoustic emissions will: • Not impact on the recovery of marine turtles as per the Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia, 2017b) and Approved Conservation Advice for Dermochelys coriacea (leatherback turtle) (DEHWA, 2008) • Be managed such that any blue whale continues to utilise the area without injury and is not displaced from a foraging area (Commonwealth of Australia, 2015b). • Not impact the recovery of the blue whale as per the Conservation Management Plan for the Blue Whale (Commonwealth of Australia 2015b). • Not impact southern right whale established or emerging aggregation BIAs or the migration and resting on migration BIA (Commonwealth of Australia 2015b). • Not impact the recovery of the southern right whale as per the Conservation Management Plan for the Southern Right Whale (DSEWPaC, 2012a) or draft National Recovery Plan for the Southern Right Whale (DCCEEW 2022a). • Not impact the recovery of the white shark as per the Recovery Plan for the White Shark (DSEWPaC, 2013a). Actions from the Conservation Management Plan for the Blue Whale (Commonwealth of Australia 2015b) applicable to the activity in relation to assessing and addressing anthropogenic noise have been addressed as per the following: • The effect of anthropogenic noise on blue whale behaviour has been assessed. • Anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilise the area without injury and is not displaced from a foraging area. It has been demonstrated that the activity can be conducted in a manner that is consistent with the conservation management plan and will not result in injury or displacement of pygmy blue whales from a foraging BIA.	

Summary		
	Actions from the draft National Recovery Plan for the Southern Right Whale (DCCEEW 2022a) applicable to the activity in relation to assessing and addressing anthropogenic noise have been addressed as per the following: • Anthropogenic noise in biologically important areas will be managed such that it does not prevent any southern right whale from utilising the area or cause injury (TTS and PTS) and/or disturbance. • Ensure environmental assessments associated with underwater noise generating activities include consideration of national policy (e.g., EPBC Act Policy Statement 2.1) and guidelines related to managing anthropogenic underwater noise and implement appropriate mitigation measures to reduce risks to Southern Right Whales to the lowest possible level. The effects of anthropogenic noise from the activity on southern right whales are addressed and consideration made of national policy and guidelines relevant to vessels. • Quantify risks of anthropogenic underwater noise to Southern Right Whales, including behavioural disturbance, changes to vocalisations, and physiological effects to whales. This The effects of anthropogenic noise from Project activities on southern right whales has been assessed.	
Industry practice	The consideration and adoption of the controls outlined in the documents below demonstrates that best practice is being implemented	
	Environmental management in the upstream oil and gas industry (IOGP-IPIECA, 2020)	The controls consider the management measures listed for construction in Section 4.4.1 of the guidelines, which include: • Considering sensitive locations and times of year for critical activities of species that are present. • Using MMOs
Acceptability outcome	Acceptable	

Table 61: Impact assessment for underwater noise

6.5 Emissions – Atmospheric Emissions

6.5.1 Hazard Description

Atmospheric emissions refer to the release of gases, particles, and other substances into the air from vessel engines, generators and fixed and mobile deck equipment. These emissions have the potential to impact on air quality and human health, as well as contribute to climate change (refer to Section 6.6 for discussion on climate change). Examples of atmospheric emissions include carbon dioxide, methane, sulphur dioxide, nitrogen oxides, and particulate matter.

Emissions associated with the Project are unlikely to impact on health or amenity due to the remote location and rapid dispersion and dilution offshore. NO2 is the main emission that poses a threat to receptor health NO2 emissions from routine MODU power generation for an offshore project was previously modelled by BP (BP, 2013). The model demonstrated that atmospheric emissions generated by MODU operations may increase ambient NO2 concentrations by 1 μg/m^3 (0.001 ppm) within 10 km of the source and 0.1 μg/m^3 (0.0001 ppm) within 40 km of the source. This represents an increase of 2% over typical background concentrations within 40 km, with air quality remaining well below the WHO air quality guideline for NO2 of 40 μg/m^3 annual mean. As, it is considered conservative to use the above studies to justify potential impacts to receptors.

Rapid dispersion and dilution will also ensure that seabirds and other fauna are not exposed to concentrated plumes from vessel exhaust points. The impact associated with these emissions is a minor and temporary decrease in air quality. Atmospheric emissions associated with operations on the Thylacine platform are not expected to increase.

6.5.2 Impact Source

Atmospheric emissions will be generated by the following activities:

Activity	
Drilling and completion	Well unload and production testing (flaring)
Support activities	MODU operations, Vessel operations

6.5.2.1 Drilling

During well unload and production testing, reservoir gas is sent via the production separator to be flared. Well unload and testing will generally only occur once for each well for up to 48 hours.

6.5.2.2 Support Activities

During all stages of the development, atmospheric emissions will be released to the surrounding environment from the MODU and support vessels via the use of fuel for onboard generators and engine operation to generate power. Fuel will be marine diesel oil (MDO) or marine gas oil (MGO).

6.5.3 Impact Analysis and Evaluation

6.5.3.1 Potential Environmental Impacts

Air quality within the project area is expected to be high and typical to that of an unpolluted offshore environment. Emissions generated during activities will be similar to that generated during other activities undertaken in the region and result in a localised decrease in air quality at the point of release. Released emissions will dissipate quickly through wind action. Concentrations of air emissions are not expected to be above the National Environment Protection (Ambient Air Quality) Measure levels at any point throughout the development.

Atmospheric emissions from flow-back and well testing are not predicted to result in a substantial change to air quality within the local air shed given the dry gas is expected to readily combust via the flare package high-efficiency burner head.

Given the limited duration and intermittent nature of flaring operations of up to two days per well approximately three months apart, and the rapid dispersion of air emissions close to the source, no substantial or cumulative impacts to air quality within the local airshed are predicted.

There are no Management Plans, Recovery Plans or Conservation Advice related specifically to air quality.

Given that a change in ambient air quality will be highly localised and will return rapidly to background levels after emissions cease. Impact is assessed as Minor (1).

6.5.4 Impact Evaluation Summary

Table 62 presents the impact assessment for atmospheric emissions.

Summary	
Summary of Impacts	Reduction in air quality due to gaseous emissions and particulates from diesel combustion.

<table>
<tr><th colspan="3">Summary</th></tr>
<tr><td>Extent of impacts</td><td colspan="2">Localised</td></tr>
<tr><td>Duration of impacts</td><td colspan="2">Temporary - duration of activity (emissions are rapidly dispersed and diluted).</td></tr>
<tr><td>Level of certainty of impact</td><td colspan="2">HIGH – the impacts of atmospheric emissions are well known.</td></tr>
<tr><td>Impact decision framework context</td><td colspan="2">A – nothing new or unusual, represents business as usual, well understood activity, good practice is well defined.</td></tr>
<tr><td colspan="3">Impact Consequence (inherent)</td></tr>
<tr><td colspan="3">Minor</td></tr>
<tr><td colspan="3">Controls</td></tr>
<tr><td>CM20 MARPOL Annex VI (Prevention of Air Pollution from Ships),</td><td colspan="2">Vessels and MODU will comply with MARPOL Annex VI (Prevention of Air Pollution from Ships), the Navigation Act 2012, the Protection of the Sea (Prevention of Pollution from Ships) Act 1983 and Marine Orders – Part 97: Marine Pollution Prevention – Air Pollution (appropriate to vessel class) for emissions from combustion of fuel including:
• valid International Air Pollution Prevention (IAPP) certificate and a current international energy efficiency certificate
• Ship Energy Efficiency Management Plan (SEEMP) as per MARPOL 73/78 Annex VI
• engine NOx emission levels will comply with Regulation 13 of MARPOL 73/78 Annex VI
• use low sulphur content fuel oil/diesel (≤0.5% m/m S) or an approved measure that achieves an equivalent air quality outcome..</td></tr>
<tr><td>CM21 Emissions Monitoring</td><td colspan="2">Measure, monitor or estimate facility fuel and flare emissions (in accordance with the National Pollutant Inventory) to inform and optimise management practices and minimise environmental impact of emissions.</td></tr>
<tr><td colspan="3">Impact Consequence (residual)</td></tr>
<tr><td colspan="3">Minor</td></tr>
<tr><td colspan="3">Environmental Performance Outcomes</td></tr>
<tr><td>EPO9</td><td colspan="2">No substantial reduction of air quality within local airshed caused by atmospheric emissions produced from Project activities</td></tr>
<tr><td colspan="3">Demonstration of Acceptability</td></tr>
<tr><td>Principles of ESD</td><td colspan="2">Management measures will be put in place to reduce the environmental risk from atmospheric emissions to ALARP. Impact to air quality will be insignificant throughout the life of the Project</td></tr>
<tr><td>Internal context</td><td>Policy compliance</td><td>Beach Environmental Policy objectives are met through this environmental impact assessment.</td></tr>
<tr><td></td><td>Management system compliance</td><td>Section 9 describes the implementation strategy employed for this activity.</td></tr>
<tr><td>External context</td><td colspan="2">Stakeholder engagement is being carried out as part of this OPP process
Beach operates the existing Otway project and has established good relations with both onshore and offshore stakeholders. Engagement with stakeholders will continue throughout all aspects of the Project to build and maintain trust with stakeholders and the local community and minimise community and stakeholders concern and impacts where practicable.</td></tr>
<tr><td>Legislative context</td><td colspan="2">EPOs and control measures align with the requirements of:
• <i>Navigation Act 2012 (Cth):</i>
○ Section 4 (Prevention of Pollution).</td></tr>
</table>

Summary		
	○ AMSA Marine Order Part 79 (Marine pollution prevention – air pollution). - *Protection of the Sea (Prevention of Pollution by Ships) Act 1983 (Cth)*: ○ Part IIID (Prevention of Air Pollution). ○ AMSA Marine Orders Part 97 (Air Pollution), enacting MARPOL Annex VI (especially Regulations 6, 14, 16). - NEPM Ambient Air Quality Standards (National Environment Protection Council, 1998) as well as with the proposed draft NEPM Ambient Air Quality Standard (National Environment Protection Council, 2019) - Significant impact criteria (refer Table 41 in Section 5.8.2) - EPBC Management/Recovery Plans and Conservation Advice (refer Table 5 in Section 2.3.1)	
Industry practice	The consideration and adoption of the controls outlined in the documents below demonstrates that best practice is being implemented	
	Environmental management in the upstream oil and gas industry (IOGP-IPIECA, 2020)	The EPS listed in this table meet the relevant mitigation measures listed for offshore activities with regard to Section 4.4.3 - Combustion emissions; - Use of high efficiency equipment to minimise power demand. - Selection of low sulphur diesel. - Regular plant maintenance. - Regular maintenance and emission control devices on vehicles and machinery.
Acceptability outcome	**Acceptable**	

Table 62: Impact assessment from atmospheric emissions

6.6 Emissions – Greenhouse Gases

6.6.1 Hazard Description

Greenhouse gas (GHG) emissions are associated with global warming and climate change. GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6) and specified types of hydrofluorocarbons and perfluorocarbons. GHGs trap heat in the Earth's atmosphere, leading to an increase in the planet's average temperature. This can lead to a variety of negative effects, including more extreme weather events, sea level rise, ocean acidification and changes in the distribution of plant and animal species. These changes can cause harm to human populations and ecosystems and could potentially have severe economic and social consequences.

6.6.2 Impact Source

The following activities may generate GHG emissions:

Stage	Activity
Drilling and completion	Well unload and production testing (flaring)
Production	Gas processing (fuel use, reservoir CO2, fugitive emissions) Well intervention
Support Activities (all stages)	MODU operations, Vessel operations

Stage	Activity
Decommissioning	Plug and abandonment of wells

6.6.2.1 Drilling

Drilling will be carried out using a MODU. During well unload and production testing activities, the well is flowed to remove contaminants, including drilling or completions fluids and debris from the formation. These contaminants are flowed back via the OGPP to the onshore production separator, and the reservoir gas is flared. Unloading and production testing the well to the MODU for the Project is not intended, however, is provided for in this OPP as a contingency in the event it is required for technical and feasibility reasons. This may result in up to approximately 65MMscf of gas per day being flared for between one and two days per well.

Note there may be a potential requirement to cold vent formation gas during Drilling. Refer to Section 3.8.2.5 for further details regarding this activity.

During drilling fugitive emissions will result from releases from process vents, system upsets and accidents.

6.6.2.2 Production

During production, reservoir fluids will be extracted, transported via the OGPP to the OGP for processing. The OGP supplies gas to the domestic market in south-east Australia. GHG emissions will be produced during processing, transport and end use of sold products.

Well intervention and workovers may be required during Production. Flaring may be required as part of well intervention, similar to drilling. If well intervention is required, it will be infrequent, and if flaring is required, the estimated duration is one to two days per well. During well intervention, unloading and testing the well to the MODU is not intended however is provided for in this OPP as a contingency in the event it is required for technical and feasibility reasons. This may result in up to approximately 65MMscf of gas per day being flared for between one and two days per well. During well intervention, small volumes of gas may need to be transferred back to the OGP. The frequency of well intervention and workover activities depends on well performance, objective criticality, MODU/vessel availability and regulatory requirements with one well every 7 years being estimated based on historical interventions.

During production, fugitive emissions may occur from Project and existing infrastructure.

GHG emissions will also be generated from the processing of Project hydrocarbons, and from the transportation and use of sold products.

6.6.2.3 Support Activities

GHG emissions will be produced from combustion of fuel for power generation and propulsion on the MODU and support vessels during all phases.

6.6.2.4 Decommissioning

During well P&A, GHG emissions may occur due to unloading the well to the MODU is not intended however is provided for in this OPP as a contingency in the event it is required for technical and feasibility reasons. This may result in up to approximately 65MMscf of gas per day being flared for between one and two days per well.

Note there may be a potential requirement to cold vent formation gas during P&A operations. Refer to Section 3.8.2.5 for further details regarding this activity.

6.6.3 Impact Analysis and Evaluation

6.6.3.1 Greenhouse Gas Emissions Assessment

Beach commissioned Xodus to undertake a Greenhouse Gas emissions quantification assessment for the Project (Xodus 2023b, Appendix K).

All emissions factors and energy content figures used to predict emissions were sourced from the NGER (Measurement) Determination 2008 and the API Compendium of GHG Emissions Methodologies (API 2009).

Emissions estimates are based on current Project definition and assumptions, current control measures, with inputs from the nature of the feed gas, and the efficiency and processes of the existing facilities.

Emissions are categorised as direct or indirect Project emissions:

- Direct emissions: GHG emissions directly emitted within the Project boundary from sources owned or controlled by the Project.
- Indirect emissions: GHG emissions from sources not owned or operated by the Project, including embodied carbon from materials and equipment used within the boundary of the Project; and GHG emissions owned by the Project but is transferred outside the boundary of the Project to the Otway Development, e.g., reservoir CO_2, or the broader economy, e.g., sold products.

The activities and sources that emit GHG emissions over the lifecycle of the Project are outlined Table 63.

Category	Phase	Sub-Category	Source / Activities
Project Direct Emissions	Drilling and Completions; Production	Flaring & Venting	Well unload, well testing. Well intervention
	Production	Combustion Fugitive Emissions	Use of formation gas for electricity generation Fugitive emissions from wells and flowlines, including flow through Thylacine platform
Project Indirect Emissions	Support Activities (all stages)	Vessels	Variations of fleet including MODU and support vessels and helicopters required for: • Drilling • Installation • Inspection, Maintenance and Repair (IMR) • Well workover, • Decommissioning
	Production	Reservoir CO_2	Reservoir CO_2 from Artisan, La Bella and future prospects emitted at OGP.
	Production	Sales Product	Transport and use of sales gas, condensate from Artisan, La Bella and future prospects.
	Drilling and Completions, Installation, Decommissioning	Materials	Wells, flowlines, subsea equipment, cement, drilling mud.

Category	Phase	Sub-Category	Source / Activities
	Production	Onshore gas processing	Estimated fuel use apportioned to the processing of well fluids from Artisan, La Bella and future prospects at OGP, including fugitive emissions. Cold venting from Thylacine platform

Table 63: Activities and sources that contribute to GHG emissions from the Project

The key inputs for the inventory assessment cover the full scope of the Project, including potential future development, as follows:

- Drilling of up to 16 wells between 2025 and 2030 (Note Artisan has been drilled, making a total of 17 wells in scope of the Project).
- Completions of up to 17 wells between 2026 and 2030.
- Installation of associated infrastructure and flowlines for up to 17 wells between 2026 and 2030.
- Operations and production over a 30-year period from the Project which includes the initial development from Artisan and La Bella fields in addition to future tiebacks from currently identified prospects in the Project Area.
- Decommissioning of up to 17 wells and associated infrastructure by 2058.

The characteristics of the hydrocarbons, including CO_2 content, from the La Bella and Artisan fields are based on samples from these fields. Compositions from nearby fields targeting similar geological formations (Artisan and Thylacine) were used as conservative and representative proxies for the future prospects for this inventory assessment (refer to Section 3.6).

The input values used in the emissions estimates are considered “credible high” values, this accounts for a range of uncertainties including extended contingencies beyond a typical schedule of an activity. Up to 17 wells, with associated infrastructure, were considered in the emissions estimates, including at Artisan, La Bella, and future prospects.

To determine the indirect emissions from the existing facilities including OGP and the Thylacine Platform, an emissions factor was developed to forecast emissions. The emission factor is estimated based on the total throughput considered in the OPP and existing facilities, i.e., the emissions factor would be higher if the forecasted throughput from the OPP is not achieved, since a similar amount of fuel gas is required to operate the facilities at a lower throughput. The emissions factor for the existing facilities is:

- For years to 2045, 40 TJ/bcf raw gas
- For years 2045 onwards, 100TJ/bcf raw gas

Additional details related to the methodology and assumptions used in the emissions estimates are provided in Appendix K.

Table 64 provides a summary of the emissions inventory results. The emissions a forecasted based on direct and indirect, with indirect emissions comprising reservoir CO_2, embodied carbon, onshore processing at OGP and sale products.

Direct Emissions Mt CO_2-e	**Indirect Emissions Mt CO_2-e**					**Total Emissions Mt CO_2-e**
	Vessels	**Reservoir CO_2**	**Embodied Carbon**	**Processing**	**Sales**	
76,971	943,537	1,723,805	158,777	1,480,737	29,845,031	34,612,218
< 1%	3%	5%	<1%	4%	87%	

Table 64: Project emissions summary

Annualised Project emissions are provided in Section 3.3 of Appendix K.

The emissions estimates do not account for ongoing emissions reduction that may be realised at OGP or by users of sold products.

The Project equates to a very small fraction of global emissions. In isolation, they will have no discernible impact on GHG concentrations in the atmosphere. Project gas is backfill for, and a replacement for, the depleting Thylacine and Geographe fields so will not result in an increase in emissions on a per annum basis.

The United Nations International Panel on Climate Change in its Sixth Assessment Report forecast the remaining carbon budgets (from 1 January 2020) for a 50% likelihood to limit global warming to a specified range of temperature increase based on pre-industrialised levels (i.e. since 1850-1900) (IPCC, 2021). These carbon budgets and the percentage of carbon budget used due to the Project are shown in Table 65.

Global surface temperature change	Estimated carbon budgets (50^{th} percentile)	Percentage of Global Carbon Budget used due to the Project (direct and indirect emissions)
1.5°C	500 $GtCO_2$	0.0068%
2.0°C	1350 $GtCO_2$	0.0025%

Table 65: Comparison of Project emissions to the global carbon budget

In 2022, Australia revised its National Determined Contribution (NDC) under the Paris Agreement to reduce GHG emissions to 43% below 2005 levels by 2030 and reaffirmed the net zero emissions by 2050 target. These targets are legislated under the Commonwealth *Climate Change Act 2022*.

The Commonwealth Government has modelled a range of annual carbon reduction scenarios. The scenario modelled that is most relevant to this assessment is the 'with additional measures', which includes policies and measures in place at the time of publication. The 'with additional measures' scenario includes the 82% renewable energy target in Australia's electricity grid by 2030 and the emissions reduction from the Safeguard Mechanism reforms (DCCEEW, 2022b). Noting that the Safeguard Mechanism regulates the OGP directly and the Project indirectly and imposes a binding requirement to net emissions reduction and net zero by 2050, consistent with Australia's NDC under the Paris Agreement (DCCEEW, 2023b). Therefore the implementation of the Project is aligned with the Paris Agreement climate goals.

The 'with additional measures' scenario can be used to develop an Australian carbon budget by summing the annual projected emissions to 2035 (the extent of the forecast), assuming a linear decline in emissions to net zero emissions between 2035 to 2050, and net zero emissions beyond 2050. This creates a carbon budget of 6428 Mt CO_2-e. The total direct and indirect GHG emissions from the Project are estimated to be approximately 0.531% of the Australian carbon budget.

6.6.3.2 Potential impact

GHG emissions generated during the Project can contribute to the overall concentration of GHG emissions in the Earth's atmosphere. This consequence evaluation considers the contribution of emissions attributed to the Project to global emissions and the potential impacts of climate change on sensitive receptors, including MNES within Australian jurisdictions.

It is important to acknowledge that climate change impacts cannot be directly attributed to any one activity, as they are the result of global GHG emissions, minus global GHG sinks, that have accumulated in the atmosphere since the industrial revolution began. Therefore, there is no direct link between GHG emissions from the Project and climate change impacts to specific ecological receptors.

Changes to production capacity, reservoir composition or process design are managed under Beach's Management of Change and Project Management Systems (depending on the complexity), both of which require an assessment of the change in safety, environment and financial risk profile brought about by the proposed change, and if material, each require revisions to the relevant EP, Safety Case and/or WOMP as a necessary step to achieve completion.

6.6.3.2.1 Climate Systems

The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6) Working Group I was released in August 2021. The IPCC states with high confidence that many extreme heat events and global surface temperature rise would not have occurred without human influence and could be irreversible for several decades to millennia (IPCC 2021).

This is reiterated in the AR6 Synthesis Report released in March 2023, "Human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming, with global surface temperature reaching 1.1°C above 1850-1900 in 2011-2020. Global greenhouse gas emissions have continued to increase over 2010-2019, with unequal historical and ongoing contributions arising from unsustainable energy use, land use and land-use change, lifestyles and patterns of consumption and production across regions, between and within countries, and between individuals (high confidence). Human-caused climate change is already affecting many weather and climate extremes in every region across the globe" (IPCC 2023).

According the AR6 Synthesis Report, heat extremes (including heatwaves) have become more frequent and more intense across most land regions since the 1950s while cold extremes have become less frequent and less severe. Marine heatwaves have approximately doubled in frequency since the 1980s. The frequency and intensity of heavy precipitation events have increased since the 1950s over most land areas for which observational data are sufficient for trend analysis. It is likely that the global proportion of major (Category 3–5) tropical cyclone occurrence has increased over the last four decades (IPCC 2023).

*6.6.3.2.2 E*cosystems

Ecosystems that are particularly susceptible to adverse effects of climate change include alpine habitats, coral reefs, wetlands and coastal ecosystems, polar communities, tropical forests, temperate forests and arid and semi-arid environments (DoEE 2019). In Australia, this includes coral reefs, alpine regions, rainforests, arid and semi-arid environments, mangroves, grasslands, temperate forests and sclerophyll forests. Future climate change (increased temperature and decreased, but more variable, rainfall) has the potential to have a range of impacts on ecological factors and threaten biodiversity in the Australian Mediterranean ecosystem (CSIRO 2017a).

Redistribution and reorganisation of natural systems, driven by climate-change, is a major threat to biodiversity (Chapman et al. 2020). A report by Australia's Biodiversity and Climate Change Advisory Group summarises the potential impacts of climate change to marine and terrestrial species, habitats, and ecosystems across Australia (Steffen et al. 2009). The impacts to taxa are outlined in Table 66 and the impacts to ecosystems in Table 67.

Extensive modelling and monitoring studies over the last twenty years provide considerable evidence that global climate change is already affecting and will continue to affect species (Hoegh-Guldberg et al. 2018) however, these impacts are likely to be highly species-dependent and spatially variable. The most frequently observed and cited ecological responses to climate-change include species distributions shifting towards the poles, upwards in elevation and shifts in phenology (earlier and later autumn life history events) (Dunlop et al. 2012). Climate change may not only change species distribution patterns but also life-history traits such as migration patterns, reproductive seasonality, and sex-ratios.

Impacts of climate change such as altering temperature, rainfall patterns and fire regimes, are likely to lead to changes in vegetation structure across terrestrial ecosystems within Australia (Table 67, Dunlop et al. 2012). Increases in fire regimes will impact Australian ecosystems altering composition structure, habitat heterogeneity and ecosystem processes. Changes in climate variability, as well as averages, could also be important drivers of altered species interactions, both native and invasive species (Dunlop et al. 2012). Climate change could result in significant ecosystem shifts, as well as alterations to species ranges and abundances within those ecosystems (Hoegh-Guldberg et al. 2018).

The IPCC Special Report describes impacts of warming above pre-industrial levels to key receptor groups including terrestrial ecosystems, mangroves, warm-water corals, unique and threatened systems, and arctic regions (Hoegh-Guldberg et. al. 2018). These receptor groups show varying sensitivity to warming conditions, with a range of responses shown at 1oC warming; from corals suffering moderate impacts, to mangroves not showing any impacts that are detectable and attributable to climate change (Hoegh-Guldberg et al. 2018). Once warming reaches 1.5oC, all receptor groups show impacts attributable to climate change with severity ranging from moderate impacts that are detectable and attributable to climate change (mangroves), to impacts that are severe and widespread (warm-water corals) (Hoegh-Guldberg et al. 2018). At the point where global temperature rise, due to climate change, reaches 2°C, increasing numbers of receptor groups suffer impacts which are high to very high, and likely to be irreversible (terrestrial ecosystems, warm-water corals, unique and threatened systems, and arctic regions) (Hoegh-Guldberg et al. 2018).

The State of the Environment (SoE) report is produced every five years by the Australian Government as a comprehensive review on the state of the Australian environment. The most recent report was released in July 2022. The SoE concluded that climate change and extreme weather events was impacting the Australian environment and especially impacting various taxa (DCCEEW 2021). In many cases, the impacts of climate change on biodiversity are exacerbated by other pressures such as land clearing and invasive species, but in some cases impacts can be unequivocally attributed to climate change. A summary of the SoE impacts from climate change is provided in Table 68.

6.6.3.2.3 Terrestrial Ecosystems

All terrestrial ecosystems are likely to be impacted by a changing climate (Table 67, Steffen et al 2009, Hughes 2011, Dunlop et al. 2012, Hoegh-Guldberg et. al. 2018). The predicted impact of climate change on these ecosystems is highly variable, both between ecosystems and within individual ecosystems (Dunlop et al. 2012). Below is a summary of potential climate change impacts to two key terrestrial ecosystems – tropical rainforests and alpine/montane areas, other terrestrial ecosystems are summarised in Table 67.

<u>Tropical Rainforests</u>

Projections of future climate changes in the wet tropics of Australia under different scenarios are outlined by McInnes (2015). It is likely that temperatures in the wet tropics will become hotter and potentially fires and cyclones will be more intense. Consequently, there is an increased probability of fires penetrating into rainforest vegetation resulting in a shift from fire-sensitive vegetation to communities dominated by fire-tolerant species; and changing rainforest disturbance regime as cyclones become more intense) (Hughes 2011, Steffen et al. 2009). Changes in the timing of seasons (e.g., extended summer) could cause change in the seasonal response of plants, and alterations to species ranges and abundances (Hoegh-Guldberg et al. 2018).

Alpine/ Montane Areas

Alpine systems are generally considered to be among the most vulnerable to future climate change (Hughes 2003). The extent of true alpine habitat in Australia is very small (0.15% of the Australian land surface) with limited high-altitude refuge (Hughes 2003). Australian alpine regions are home to a variety of alpine vertebrates who rely on snow cover for their survival. There is evidence of a reduction in populations of dusky antechinus, broad-toothed rats, and the mountain pygmy possum. The first two species are active under the snow throughout winter and are therefore subject to increased predation by foxes when snow is reduced (Hughes 2003). The pygmy possum depends upon snow cover for stable, low temperatures during hibernation (Hughes 2003).

6.6.3.2.4 Marine Ecosystems

Average sea surface temperature in the Australian region has warmed by 1.05°C since 1900, with eight of the 10 warmest years on record occurring since 2010 (BoM and CSIRO 2022). A warming ocean affects the global ocean and atmospheric circulation, the cryosphere, global and regional sea levels, and causes losses in dissolved oxygen, impacts on marine ecosystems (BoM and CSIRO 2022), including changes to species abundance, community structure and increased frequency and intensity of thermally induced coral bleaching events (CSIRO 2017a).

Oceanic warming has also served to alter ocean currents around Australia. In response to both ocean warming and stratospheric ozone depletion the East Australian Current has increased in strength by about 20% between 1978 and 2005 (Cai and Cowan 2006). Sea-surface temperatures are projected to continue to increase, with estimates of warming in the Southern Tasman Sea of between 0.6 to 0.9°C and between 0.3 to 0.6°C elsewhere along the Australian coast by 2030 (Church et al. 2006).

Global mean sea level increased by 0.20 m between 1901 and 2018. The average rate of sea level rise was 1.3 mm/year between 1901 and 1971, increasing to 1.9 mm/year between 1971 and 2006, and further increasing to 3.7 mm/ year between 2006 and 2018. Human influence was very likely the main driver of these increases since at least 1971 (IPCC 2023).

Global mean sea level is predicted to rise between 0.18 m and 0.23 m by 2050, and between 0.38 m and 0.77 m by 2100 (IPCC 2021). This global mean sea level rise is primarily caused by thermal expansion and mass loss from glaciers and ice sheets, with minor contributions from changes in land-water storage. Global mean sea level will continue to increase for centuries to millennia due to continuing deep ocean warming and ice sheet melt, and sea levels will remain elevated for thousands of years, at rates dependent on future emissions (IPCC 2023). This will lead to some coastal inundation affecting mangroves, salt marshes and coastal freshwater wetlands. Furthermore, as CO2 is gradually absorbed by oceans and fresh water, the water becomes more acidic, which increases the solubility of calcium carbonate, the principal component of the skeletal material in aquatic organisms (Steffen et al. 2009).

Below is a summary of potential climate change impacts to two key marine ecosystems - mangroves and coral reefs, other marine ecosystems are summarised in Table 67.

Mangroves

Mangrove ecosystems in Australia will face higher temperatures, increased evaporation rates and warmer oceans (McInnes 2015) as well as an associated sea-level rise (Hoegh-Guldberg et al. 2018). Modelling indicates an increased likelihood of future severe and extended droughts across parts of Northern Australia (Dai 2013). Consequently, mangrove ecosystems may increase their southern range as a result of warmer temperatures. However, higher temperatures and evaporation rates, and extended droughts could lead to die-offs in northern Australia and a change in mangrove distribution and abundance (Duke et al. 2017).

Mangrove systems should cope with rising sea-level by accumulating more peat or mud which will give them the opportunity to adjust to a rising sea level (Field 1995).

Coral Reefs

Climate change has emerged as a threat to coral reefs, with temperatures of just 1°C above the long-term summer maximum for an area over 4–6 weeks being enough to cause mass coral bleaching and mortality (Baker et al. 2008, Hoegh-Guldberg 1999, Hughes et al. 2017, Spalding and Brown 2015). Coral mortality or die off following coral bleaching events can stretch across thousands of square kilometres of ocean (Gilmour et al. 2016, Hoegh-Guldberg 1999, Hughes et al. 2017). The impacts associated with a warming ocean, coupled with increasing acidification, are expected to undermine the ability of tropical coral reefs to provide habitat for fish and invertebrates, which together provide a range of ecosystem services (e.g., food, livelihoods, coastal protection) (Hoegh-Guldberg et al. 2018). Coral reefs are projected to decline by 70–90% as a result of 1.5°C of global warming (IPCC 2023).

Taxa	Potential Vulnerability
Mammals	Narrow-ranged endemics susceptible to rapid climate change in-situ; changes in competition between grazing macropods in tropical savannas mediated by changes in fire regimes and water availability; herbivores affected by decreasing nutritional quality of foliage as a result of CO_2 fertilisation.
Birds	Changes in phenology of migration and egg-laying; increased competition of resident species; breeding of waterbirds susceptible to reduction; top predators vulnerable to changes in food supply; rising sea levels affecting birds that nest on sandy and muddy shores, saltmarshes, intertidal zones, coastal wetlands, and low-lying islands; saltwater intrusion into freshwater wetlands affecting breeding habitat.
Reptiles	Warming temperatures may alter sex ratios of species with environmental sex determination to cope with warming in-situ.
Amphibians	Frogs may be the most at-risk terrestrial taxa. Amphibians may experience altered interactions between; pathogens, predators, and fires.
Fish	Freshwater species vulnerable to reduction in water flows and water quality; limited capacity for freshwater species to migrate to new waterways; all species susceptible to flow-on effects of warming on the phytoplankton base of food webs.
Invertebrates	Expected to be more responsive than vertebrates due to short generation times, high reproduction rates and sensitivity to climatic variables.
Plants	Climate change may impact various functional dynamics of plants due to changes in; increasing CO_2, fires, plant phenology and specific environmental characteristics.

Table 66: Potential climate change impacts to taxa

Key Component of Environmental Change	Projected Impacts on Ecosystems
Coral reef	
CO_2 increases leading to increased ocean acidity	Reduction in ability of calcifying organisms, such as corals, to build and maintain skeletons.
Sea surface temperature increases, leading to coral bleaching	If frequency of bleaching events exceeds recovery time, reefs will be maintained in an early successional state or be replaced by communities dominated by microalgae.

Key Component of Environmental Change	Projected Impacts on Ecosystems
Oceanic systems (including planktonic systems, fisheries, sea mounts and offshore islands)	
Ocean warming	Many marine organisms are highly sensitive to small changes in average temperature (1-2 degrees), leading to effects on growth rates, survival, dispersal, reproduction, and susceptibility to disease.
Changed circulation patterns, including increase in temperature stratification and decrease in mixing depth and strengthening of the East Australian Current	Distribution and productivity of marine ecosystems is heavily influenced by the timing and location of ocean currents; currents transfer the reproductive phase of many organisms. Climate change may suppress upwelling in some areas and increase it in others, leading to shifts in location and extent of productivity zones.
Changes in ocean chemistry	Increasing CO_2 in the atmosphere is leading to increased ocean acidity and a concomitant decrease in the availability of carbonate ions.
Estuaries and coastal fringe (including benthic, mangrove, saltmarsh, rocky shore, and seagrass communities)	
Sea level rise	Landward movement of some species as inundation provides suitable habitat, changes to upstream freshwater habitats will have flow-on effects to species.
Increase in water temperature	Impacts on phytoplankton production will affect secondary production in benthic communities.
Savannas and grasslands	
Elevated CO_2	Shifts in competitive relationships between woody and grass species due to differential responses.
Increased rainfall in north and northwest regions	Increased plant growth will lead to higher fuel loads, in turn leading to fires that are more intense, frequent and occur over large areas.
Tropical rainforests	
Warming and changes in rainfall patterns	Increased probability of fires penetrating into rainforest vegetation resulting in shift from fire-sensitive vegetation to communities dominated by fire-tolerant species.
Changes in length of dry seasons	Altered patterns of flowering, fruiting and leaf flush will affect resources for animals.
Rising atmospheric CO_2	Differential response of different growth forms to enhanced CO_2 may alter structure vegetation
Temperate forests	
Potential increases in frequency and intensity of fires	Changes in structure and species composition of communities with obligate seeders may be disadvantaged compared with vegetative resprouters.
Warming and changes in rainfall patterns	Potential increases in productivity in areas where rainfall is not limiting; reduced forest cover associated with soil drying projected for some Australian forests.
Inland waterways and wetlands	
Reductions in precipitation, increased frequency and intensity of drought	Reduced river flows and changes in seasonality of flows.
Changes in water quality, including changes in nutrient flows, sediment, oxygen and CO_2 concentration	May affect eutrophication levels, incidence of blue-green algal outbreaks.
Sea level rise	Saltwater intrusion into low-lying floodplains, freshwater swamps and groundwater; replacement of existing riparian vegetation by mangroves.

Key Component of Environmental Change	Projected Impacts on Ecosystems
Arid and semi-arid regions	
Increasing CO_2 coupled with drying in some regions	Interaction between CO_2 and water supply critical, as 90% of the variance in primary production can be accounted for by annual precipitation.
Shifts in seasonality or intensity of rainfall events	Any enhanced runoff redistribution will intensify vegetation patterning and erosion cell mosaic structure in degraded areas. Changes in rainfall variability and amount will also impacts on fire frequency. Dryland salinity could be affected by changes in the timing and intensity of rainfall.
Warming and drying, leading to increased frequency and intensity of fires	Reduction in patches of fire-sensitive mulga in spinifex grasslands potentially leading to landscape-wide dominance of spinifex.
Alpine/Montane areas	
Reduction in snow cover depth and duration	Potential loss of species dependent on adequate snow cover for hibernation and protection from predators; increased establishment of plant species at higher elevations as snowpack is reduced.

Table 67: Potential climate change impacts to ecosystems

Receptor	Biologically Important Behaviour
Mammals	Terrestrial mammals are subject to ongoing population declines due to climate change and changes within habitats.
Birds	There is strong evidence of population declines in threatened bird species, waterbirds and migratory birds. Various extensive and persistent impacts contribute to declines, including climate change (particularly drought) and extreme events, habitat degradation, and invasive predators.
Reptiles	Reptile species in all areas of Australia have an increasing risk of extinction. Risk of extinction was recognised as primarily related to ongoing pressure from invasive predators, but compounded by pressure from habitat modification, climate change (particularly drought) and disease.
	Half of Australian freshwater turtle species are in drastic population decline due to climate change.
Amphibians	Droughts and fires are increasing pressures within habitats that impact amphibian species.
	The number of known threatened amphibian species, including those that are Critically Endangered in Australia, is increasing. Drought and fire are recognised as increasing pressures contributing to this decline.
Fish	Freshwater fish throughout Australia have more than a 50% risk of extinction in the next 20 years due to climate change and changes within freshwater habitats.
Invertebrates	Most threatened invertebrates are suffering from largescale habitat degradation and loss of biodiversity. Changes in regional temperature, humidity and rainfall impact their distribution, development and reproduction.
Plants	Habitat destruction is the leading cause of vulnerability within plant species. However, changes in temperature, rainfall and fire regimes are contributing threats to plant species.
	Alpine ecosystems and biodiversity in Australia are particularly vulnerable to climate change that affects snow depth and the spatial and temporal extent of snow, which have all declined since the late 1950s.

Table 68: Potential climate change impacts on BIAs

6.6.3.2.5 Socio-economic

Changes to climate can result in impact to social receptors that have values which include the ecological receptors previously discussed. This includes KEFs and AMPs. Climate change also impacts on the functions, interests or activities of other users which rely on ecological values, including commercial and recreational fisheries and tourism. A temperature change of between 0.9oC to 2.0oC is forecast to reduce fisheries yield as the maximum catch potential around Australia by between 3% and 10% (IPCC 2023).

6.6.3.2.6 Cultural Values and Sensitivities

Impacts to cultural heritage sites and places of spiritual importance in coastal locations may also be experienced due to rising sea levels. Sea levels have been estimated to have risen on average by 1.2 mm per year between 1920 and 2000 due to climate change (Church et al. 2006). By 2100, research is expecting sea levels to have increased by a further 18 to 59 cm in response thermal expansion and melting of icesheets (Solomon et al. 2007).

6.6.3.3 National and International Agreements and Frameworks Relevant to GHG Management

This section describes the relevant key national and international agreements and frameworks relevant to GHG management, including how these environmental requirements are relevant to the activity.

6.6.3.3.1 Paris Agreement

The United Nations Framework Convention on Climate Change came into force in 1994 and has been ratified by 197 countries. The convention established a goal of preventing dangerous anthropogenic interference with the climate system. Subordinate treaties and agreements have been ratified by parties to the convention, including the Paris Agreement, which was agreed under the convention at the 21st Conference of the Parties in 2015.

The primary purpose of the Paris Agreement is to strengthen the global response toward climate change. Specifically, the Agreement seeks to substantially reduce GHG emissions to limit the global temperature increase in this century to 2oC, while pursuing efforts to limit the increase even further to 1.5oC (UNFCCC 2020). The Paris Agreement is legally binding, and signatories are reviewed every five years with the submission of an updated national climate action plan, known as Nationally Determined Contribution (NDC).

The Paris Agreement is set up through articles (UNFCCC 2020), with each article focusing on a certain commitment. Some key articles that are committed in the Paris Agreement are:

- Article 2 – Long-term temperature goals
  - Limiting the global temperature increase to well below 2oC, with preference and most efforts toward keeping it below 1.5oC.
- Article 4 – Mitigation
  - The agreement establishes binding commitments by all parties to prepare, communicate and maintain a NDC and to pursue domestic measures to achieve said NDC.
- Article 9, 10, 11 – Finance, technology, and capacity-building support
  - Obligations of developed nations to support the efforts of developing nations to build clean and climate-resilient futures.
  - In addition to reporting on finance already provided, developed nations commit to submit indicative information on support every two years.

  - Technology framework established under the agreement, and capacity-building activities will be strengthened through inter alia, enhanced support for capacity building actions in developing nations and appropriate institutional arrangements.
  - Climate change education, training, public awareness, participation, and access to information.

Australia has ratified the Paris Agreement and has adopted NDCs that can be monitored and reported on as part of the 5-year stocktake. At the Paris conference in 2016, Australia announced its first NDC to reduce GHG emissions by 26-28% below 2005 levels by 2030. This commitment was reaffirmed in 2020 after the 5-year review and further commitments were made in 2021 to reach net-zero emissions by 2050 and inscribe low emissions technology stretch goals.

In May 2022, the elected Labor government made a goal of reducing Australia's GHG emissions by 43% below 2005 levels by 2030 and reaffirmed Australia's commitment to net zero emissions by 2050. This was lodged with the UNFCCC as an updated NDC as part of Australia's obligations under the Paris Agreement. NDCs under the Paris Agreement are legally binding, and Australia mainly focuses on Article 10 with a low-emissions technology led approach. Australia's NDCs are implemented through schemes such as the Safeguard Mechanism and the Emissions Reduction Fund and Climate Change Bill 2022, in addition to continuous monitoring and focusing on alternatives to lower overall emissions.

6.6.3.3.2 National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015

One of the key statutory instruments for regulating Australia's GHG emissions in line with Australia's NDCs under the Paris Agreement, is the National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015 (Cth) (the Safeguard Mechanism) made under the NGERS Act and administered by the Clean Energy Regulator. The Safeguard Mechanism was developed to ensure that Australia's largest greenhouse gas emitters keep their net emissions below an emissions limit (a baseline). The Safeguard Mechanism currently applies to facilities that emit more than 0.1 MtCO2-e per annum and requires annual emissions to be reported against a designated emissions 'baseline'.

Key elements of the mechanism include:

- Safeguard facilities must meet the reporting and record-keeping requirements of the NGER Act, including the Clean Energy Regulator's requirements for audits prior to baseline setting or to check compliance management.
- If a safeguard facility is likely to exceed its baseline, the responsible emitter must act, including by purchasing and/or surrendering Australian carbon credit units, to offset excess emissions.
- Penalties for non-compliance.

The Otway Gas Plant emissions are regulated under the Safeguard Mechanism through establishment of a cap (baseline) on emissions.

As the Safeguard Mechanism only applies to facilities that exceed 100,000 tonnes of Scope 1 emissions per annum, the Otway Offshore Facilities are not covered Safeguard Mechanism Facilities.

6.6.3.3.3 National Greenhouse and Energy Reporting Scheme

The NGER Scheme is a single national framework for reporting company information about GHG emissions, energy production, and energy consumption. Key NGER Scheme legislation includes the National Greenhouse and Energy Reporting Act 2007, the National Greenhouse and Energy Reporting Regulations 2008, and the National Greenhouse and Energy Reporting (Measurement) Determination 2008.

The NGER Act provides a single, national framework for the reporting and distribution of information related to GHG emissions, energy production, and energy consumption. Beach reports direct emissions associated with the Otway Offshore Operations and Otway Gas Plant under the NGER Act.

6.6.3.3.4 Intergovernmental Panel on Climate Change (IPCC) 6th Report

The IPCC released its sixth assessment consisting of four reports,

- Climate Change 2021: The Physical Science Basis, released in August 2021 (IPCC 2021)
- Climate Change 2022: Impacts, Adaptation and Vulnerability, released in February 2022 (IPCC 2022a)
- Climate Change 2022: Mitigation of Climate Change, released in April 2022 (IPCC 2022b)
- Climate Change 2023: Synthesis Report, released in March 2023 (IPCC 2023)

The four releases of the report relate climate change and anthropogenic influence as well as deduce the impact that climate change has had on ecosystems, biodiversity, humans, and cities, and inform the 2023 Global Stocktake under the United Nations Framework Convention on Climate Change. The Physical Science Basis IPCC Report, released in August 2021, was the first to unequivocally relate climate change to human influences and the use of hydrocarbon fuels. Surface temperatures have increased at a rapid rate since 1970 compared to any other 50-year period in the last 2,000 years. The rapid changes that have occurred since the industrial revolution are unprecedented, even with the research on ice boreholes and the subsequent calculations of historical CO2 concentrations. The IPCC states with high confidence that in 2019, atmospheric CO2 concentrations were higher than anytime in at least 2 million years, along with very high confidence that concentrations of CH4 and N2O far exceeding intensities from at least 800,000 years (IPCC 2021).

The sixth assessment report presents a number of scenarios to understand climate response to a range of GHG emissions levels. The best-case scenario, scenarios with very low and low GHG emissions and CO2 emissions decreases to net zero around or after 2050 (IPCC 2021), aligns with Beach's aspiration to achieve net zero Scope 1 and Scope 2 GHG emissions by 2050 and its interim target to reduce Beach GHG emissions intensity.

6.6.3.3.5 International Energy Agency World Energy Outlook

The International Energy Agency annually publishes a range of climate-related scenarios in its "World Energy Outlook" report. These scenarios model energy supply and demand under a range of different policy settings.

Three future scenarios and the resulting GHG emissions have been modelled in World Energy Outlook 2022 (IEA 2022):

- Net Zero Emissions by 2050 (NZE) Scenario
- Announced Pledges Scenario
- Stated Policies Scenario.

Common to each scenario is rising demand for energy, driven by economic and demographic forces. How this demand is met varies markedly across the scenarios, depending on the policy choices made by governments, which, in turn, shape investment decisions made by the public and private sectors, and the ways in which individual consumers meet their energy needs.

The NZE Scenario defines a set of assumptions intended to map a pathway to net zero CO2 emissions from energy and industrial processes by 2050, and to limit temperature rise to 1.5°C above pre-industrial levels. Therefore the NZE Scenario is aligned with the Paris Agreement temperature goals. As the Announced

Pledges Scenario and Stated Policies Scenario are not aligned with the objectives of the Paris Agreement, they are not considered further in this OPP.

In the NZE Scenario, limiting this temperature rise is to be achieved by reducing energy-related emissions by 1.3 Gt CO2-e on average every year until 2050. The NZE Scenario determines energy supply and demand and focusses on the actions needed by the energy sector to achieve deep reductions in energy-related emissions, alongside universal access to modern energy by 2030. It examines the measures needed to curb growth in demand including energy and materials efficiency.

The declines in fossil fuel demand in the NZE Scenario stem primarily from a major surge in clean energy investment (from around USD 1.2 trillion in recent years to USD 4.2 trillion in 2030). Some investment in existing supply projects continues in the NZE Scenario to ensure supply does not fall faster than the decline in demand.

Production of gas from the Beach Otway Gas Plant is critical in ensuring Victoria's energy security as demand for gas is expected to continue in Victoria and the south-eastern states particularly as a result of the decline in consumption of more emission intensive coal associated with the closure of coal-fired power stations. Natural gas is the cleanest burning and fastest growing fossil fuel. As a result of its lower emissions intensity, coal-to-gas switching has avoided more than 500 Mt CO2-e emissions over the 2011-2018 period, or around 750 Mt CO2-e by 2020 (IEA 2019). It is estimated that approximately 1.2 Gt of CO2 could be avoided by switching from coal to existing gas-fired plants, assuming a supportive relative pricing and government policies (IEA 2019).

6.6.3.3.6 Beach Environmental Management System Relevant to GHG Emissions

Beach's climate change framework sits within their Operations Excellence Management System (OEMS). Table 69 provides a summary of the Beach OEMS components relevant to the management of GHG emissions.

Beach OEMS Component	Description	Contribution to Managing Climate Change
Corporate Policies		
Beach Climate Change Policy	Beach's climate change policy commitments include: Measuring and reporting carbon emissions as required by regulatory requirements. Integration of climate risks into project decision-making. Evaluating investment decisions to potential changes in global climate policy and changes in climate. Setting targets to encourage innovation and drive reductions in our carbon.	This public published policy specifies that Beach's top management is expected to demonstrate leadership, commitment to, and accountability for climate change adaptation. It identifies that the Board Risk, Corporate Governance and Sustainability Committee is responsible for overseeing the effectiveness of the policy. It formally expresses specific commitments related to climate change mitigation and adaptation. All Beach policies are approved by the Board.
Environmental Policy	The relevant commitments/aspects within Beach's Environment Policy are: Establish environmental objectives and targets and implement programs to achieve them that will support continuous improvement.	Specifies that all environmental impacts will be proactively identified, assessed, and managed; and publicly reported against.

Beach OEMS Component	Description	Contribution to Managing Climate Change
	Identify, assess, and control environmental impacts of our operations by proactive management of activities and mitigation of impacts. Efficiently use natural resources and energy and engage with stakeholders on environmental issues. Publicly report on our environmental performance.	All applicable legal and other requirements will be complied with and managed via Beach's OEMS. Commits to setting environmental objectives and targets, and a program of continuous improvement.
Sustainability Policy	The relevant commitments/aspects within Beach's Sustainability Policy are: Ensuring an appropriate governance system is in place to maintain a sustainable business. Assessing and addressing material social, environmental, climate and economic risks and the impact of our operations, and integrating these considerations into business planning. Conducting business activities in an ethical and transparent manner. Setting clearly defined targets, measuring, monitoring and reporting sustainability performance to support continuous improvement. Complying with relevant legislation, standards and procedures. Providing information and training, as required, and encouraging the adoption of sustainable principles and practices.	Specifies that Beach's top management is expected to demonstrate leadership, commitment to, and accountability for climate change adaptation; and formally expresses specific commitments related to climate change mitigation and adaptation. It identifies Beach Executives and managers are responsible for leading the adoption of this policy and the integration of sustainability practices.
OEMS – Key Relevant Standards		
8.1 Risk Management Standard	Standard 8.1 defines Beach's requirements to mitigate and manage risk at all levels within the business. It defines the Risk Management Framework for identifying, understanding, managing and reporting risks. The framework defines the documents, training, tools and templates to be used, and the accountabilities to be applied in support of effective risk management. Risks to people, the environment, Beach's reputation, financial position and any legal risks are assessed through the framework. The methodology is consistent with the Australian and New Zealand Standard for Risk Management (AS/NZS ISO 31000:2018, Risk Management – Principles and Guidelines).	The potential impact of GHG emissions is assessed using Standard 8.1 and the risk assessment process described in Section 6 of this OPP.
10.1 Environment Management Standard	Beach has an Environmental Management Standard (EMS) that was issued for use in December 2020 with a review frequency of 3 years. The standard requirements that are included within the EMS include: General rules Land Disturbance, Reinstatement and Rehabilitation Biodiversity Contaminated Land Management Water Management	Within Beach's EMS, there are management standards that will directly manage climate change. Most notably under the standards for Biodiversity and Air Quality and Emissions. Where Beach can manage emissions and protection to biodiversity, they will ensure that as much as they can. Notable standards for mitigating climate change include: 10.1.3.5 – Decisions to proceed with exploration, development, operation and closure activities must consider the

Beach OEMS Component	Description	Contribution to Managing Climate Change
	Air Quality and Emissions Noise and Vibration Amenity (Dust, Odour, Visual, Lighting); and Waste	presence of, and impact on, legally designated protected areas and be recorded. 10.1.6.3 – When assessing and selecting new plant and equipment, low emissions technology must be prioritised. 10.1.6.6 – An inventory of sources of air emissions including point, fugitive and mobile related emissions must be developed and maintained.
11.1 – Sustainability Standard	Standard 11.1 operationalises the requirements established by the Company's Sustainability Policy and other associated Beach policies. The Standard includes the following requirements: Responsibility for steering the company's response on sustainability. Completion of a Sustainability Report. Monitoring market and societal trends and Beach's response to them. Risk assessments to consider social, environmental, governance and economic risks. Preparation of sustainability targets and initiatives. Linkage to Project and Risk Management Systems.	Beach's senior management is expected to demonstrate leadership, commitment to, and accountability for climate change adaptation. The Sustainability Report allows Beach to publicly report the impacts of their activities in a transparent structured way that is transparent to stakeholders and other interested parties, incorporating recommendations from the Task Force on Climate Related Disclosures. Monitoring of trends interfaces closely with risk management and setting of targets and initiatives. In alignment with BTSD 8.1 (Risk Management Standard), operational and project level risk assessments ensures the Company continues to pursue sustainable activities and projects. The Project Management System ensures that Sustainability in Design is considered during the design phase of a project life cycle.
Leadership and Accountability		
Risk, Corporate Governance and Sustainability Committee Sustainability Steering Committee	The Beach Energy Board has the Risk, Corporate Governance and Sustainability Committee (RiskCo) which provides oversight on sustainability at Beach. The Sustainability Steering Committee sits under this. It is made up of all company executives as well as the Chief Executive Officer; and oversees the management and execution of sustainability performance and risks in the business. Both committees meet on a quarterly basis to discuss sustainability risks, opportunities, projects as well as performance against the targets set out in the sustainability reports. In respect to climate change, RiskCo's purpose is to assist the Board in the following: Regularly reviewing material risks (including through detailed reviews, or deep dives) and management actions and consider that the residual risk is appropriate.	Provides management review of the system and changing circumstances in order to inform decisions on actions needed for improvement.

Beach OEMS Component	Description	Contribution to Managing Climate Change
	Monitoring and reviewing the company's policies and performance in relation to health, safety, environment, community, climate change and other sustainability matters. Developing annual sustainability reporting, including public disclosures regarding material climate change risks. Ensuring the effectiveness of the Climate Change Policy.	
Commitment to Emissions Reduction		
Net zero Scope 1 and 2 operated emissions	Beach has an aspiration to achieve net zero Scope 1 and 2 emissions by 2050. This aspiration was announced in Beach's Financial Year report 2021, the Full Year Results ASX release, as well as being stated on the company's website under "reducing emissions".	Beach is working towards this aspiration via the processes described in this document. Estimated actual operated FY22 emissions were 12% lower than FY18.
Corporate emissions reduction target	Beach has a stated, publicly available, objective to reduce company net equity emissions intensity by 35 per cent by FY30 against FY18 levels/ targets https://www.beachenergy.com.au/reducing-emissions/.	Initiatives include: LDAR surveys completed at all assets remedial actions being taken through the maintenance management system. Equity stake in Moomba CCS Project. Multiple emission reduction projects completed at operated facilities.

Table 69: Summary of the Beach OEMS components relevant to the management of GHG emissions

6.6.4 Impact Evaluation Summary

Summary	
Summary of Impacts	Emissions related to the Project will be a minor contributor to global GHG emissions and climate change.
Extent of impacts	Impact solely from the Project emissions will be minor.
Duration of impacts	Not applicable for the Project emissions in isolation
Level of certainty of impact	HIGH – the impacts of GHG emissions from the Project are well understood.
Impact decision framework context	C – The precautionary approach has been applied in this risk assessment.
Impact Consequence (inherent)	
Minor	
Controls	
CM22 Beach Sustainability Standard	General requirement within the Standard requires Beach to assess and maintain a register of opportunities to reduce: • emissions • energy consumption • venting and flaring

Summary	
	These opportunities will be included in the yearly budget cycle for review, assessment, and approval where reasonably practicable
CM23 GHG Management Plan	Beach has developed and will progressively implement its GHG Management Plan which formalises the framework and specific techniques used to ensure that GHG emission related EPOs will be met over the life of the facility. The GHG Management Plan also outlines how monitoring of Scope 3 GHG emissions attributed to Beach's Otway asset will be undertaken for the life of the activity.
CM24 GHG Emissions Monitoring	Beach is required to annually report their direct GHG emissions (Scope 1 and 2) as per the NGERS regulatory requirements. Beach will use this annual reporting process to internally compare Scope 1 GHG emissions generated by the Project and broader Otway Development against periodic, internal GHG emissions forecasts. Scope 3 emissions derived from use of product will be reviewed against those same forecasts, with this focus reflecting the proportional contribution of final product use to overall Otway asset Scope 3 emissions. Assessment of actual emissions against forecasts will feed into revised assumptions in future emissions forecasts and into the GHG Management Plan review and improvement processes.
CM25 Fugitive Leak Detection and Repair Program	Beach undertakes periodic leak detection and repair (LDAR) fugitive emissions surveys at the Otway Gas Plant and Thylacine Platform. The scope, methodology, frequency, and repair guidance is detailed in the GHG Management Pla
CM26 Preventative Maintenance System	Combustion equipment is inspected and maintained in accordance with the preventative maintenance system to ensure efficient operations
CM27 Logistics Planning	Operations planning is undertaken for supply vessel and helicopter movements, thereby minimising unnecessary travel and minimising fuel combustion
Impact Consequence (residual)	
Minor	
Environmental Performance Outcomes	
EPO10	Gas is provided to communities sustainably in a manner which is consistent with the objectives of the Paris Agreement and the global response to the threat of climate change
EPO11	Monitoring and reporting GHG emissions to the regulator under the NGER Act as required
Demonstration of Acceptability	
ESD principles	The risks and impacts from GHG emissions are aligned with the principles of ESD based on: • Global policies and actions related to GHG emissions have been considered. Australian legislation supports these policies and Beach shall comply with this legislation. • Gas will be sold into the domestic market and will provide a clean energy source to allow the transition from coal to renewables to occur in an orderly fashion. • Beach has a clear strategy to reduce emissions through a new equity reduction target of 35% by 2030 in scope 1 and 2 emissions intensity and an aspiration for net zero by 2050. The strategy seeks to limit GHG emissions through several initiatives, reporting on these initiatives and performance in annual climate change and sustainability reports. • The Safeguard Mechanism regulates the OGP and imposes a binding requirement to net emissions reduction and net zero by 2050, consistent with Australia's NDC under the Paris Agreement (DCCEEW, 2023) • The Project provides gas supply to the National Electricity Market consistent with the shortfall identified in the Australian Energy Market Operator's Gas Statement of Opportunities (AEMO, 2023). • The Project has the potential to bring significant local economic and social benefits and to Victoria more broadly. The benefits of the Project include:

Summary		
	○ A new supply of gas for consumption in the Victorian market, which equates to approximately 73 per cent of all gas consumed in Victoria in 2020 – this is likely to help to reduce pressure on domestic gas prices and assist in enhancing the economic viability of businesses. ○ Direct job creation during the construction phase ○ Indirect job creation and benefits to the local community through use of services and infrastructure to support the construction and operation of the Project ○ Royalties and taxes generated during the life of the Project, that would flow from the Project to the State of Victoria and to the Commonwealth.	
Internal context	Policy compliance	Beach Climate Change, Sustainability and Environmental Policy objectives are met through this environmental impact assessment with further detail provided in future environment plans.
	Beach GHG emission Management Plan	Requirements in the Beach Corporate GHG Emission Management Plan will cascade to the Otway Project.
	Management system compliance	The OEMS system has been, and will be, applied to management of GHG emissions. For example: • The Standard 8.1 and the Risk Matrix framework has been used to assess the potential impact of GHG emissions. • The Environmental Standard (10.1) requires low emissions technology to be prioritised when assessing and selecting new plant and equipment and an inventory of sources of air emissions including point, fugitive and mobile related emissions be developed and maintained
External context	Stakeholder engagement is being carried out as part of this OPP process Beach operates the existing Otway project and has established good relations with both onshore and offshore stakeholders. Engagement with stakeholders will continue throughout all aspects of the Project to build and maintain trust with stakeholders and the local community and minimise community and stakeholders concern and impacts where practicable.	
Legislative context	The EPOs and control measures align with the requirements of: • National Greenhouse and Energy Reporting Act 2007 (NGER Act): ○ Project will meet Australian legislative frameworks that have been established to manage GHG emissions consistent with the Climate Change Act 2022 and the Paris Agreement. ○ Beach transparently reports its GHG emissions, including fugitive methane emissions, as demonstrated in annual climate change reporting consistent with the G20’s Taskforce on Climate- related Financial Disclosures.	
Industry practice	The consideration and adoption of the controls outlined in the documents below demonstrates that best practice is being implemented	
	Environmental management in the upstream oil and gas industry (IOGP-IPIECA, 2020)	The EPS listed in this table meet the relevant mitigation measures listed for offshore activities with regard to Section 4.4.3 – Combustion emissions; • Use of high efficiency equipment to minimise power demand. • Selection of low sulphur diesel. • Regular plant maintenance. • Regular maintenance and emission control devices on vehicles and machinery.

Summary		
	Energy Management Systems (International Organization for Standardization, 2018, ISO50001)	The OEMS system and the Corporate GHG Management Plan described in Section 10 aligns to ISO50001
Acceptability outcome	Acceptable	

Table 70: Impact assessment for greenhouse gas emissions

6.7 Planned Discharge – Drill Cuttings and Fluids

6.7.1 Hazard Description

Drill cuttings are the rock and sediment brought to the surface during the process of drilling for oil and gas in offshore environments. These cuttings can include a mixture of clay, silt, sand, and rock, and can also contain small amounts of oil and other drilling fluids.

Drilling fluids, also known as drilling mud, are used to lubricate the drill bit, cool the drill, maintain the stability of the well, transport the cuttings out of the hole and control the pressure in the well. The initial drilling campaign wells will be drilled using Water Based Drilling Fluid (WBDF) with the use of Synthetic Based Drilling Fluid (SBDF) a contingency for future wells if required for technical purposes.

It is standard practice within Australia to discharge drill cuttings and water-based drilling fluids overboard. SBDF muds are recycled and strict controls placed on their discharge if used.

Potential impacts from discharging drill cuttings and fluids include:

- Smothering: Drill cuttings can cover and smother benthic organisms, such as seagrass, seaweed, and coral, which can affect their growth and survival
- Pollution: Drill cuttings can contain toxic materials, such as heavy metals, that can leach into the water and harm marine life

6.7.2 Impact Source

Drill cuttings and fluids will be discharged to the marine environment during the following stages and activities:

Stage	Activity
Drilling and completion	Drilling Well completion Well unload and testing
Operations	Well intervention and workover
Decommissioning	Plug and abandonment of wells

6.7.2.1 Drilling

Table 71 summarises the expected volumes of drill cuttings and type of drilling fluids used on each well. This is conservatively based on a directional well up to approximately 4,500m deep that is not currently planned but may be required in future drilling campaigns. The initial drilling campaign wells are planned to be drilled vertically to depths of approximately between 2,000m and 3,500m and will have lower associated cuttings and fluids discharge volumes.

During drilling of the top-hole sections of the wells, cuttings and drilling fluids will be released directly to the seabed in the vicinity of the well site (subsea) as drilling is undertaken. Following the installation of the riser within which the remainder of the well sections will be drilled through, the cuttings and associated drill fluids will be routed back to the MODU, forming a closed-circuit system.

Cuttings are then processed within the solids control equipment (SCE), with drilling fluids separated from the cuttings and recirculated back for further use. Cuttings are processed further through shale shakers and centrifuges to remove course and fine material. Processed cuttings are discharged overboard.

Fluids used during drilling operations include:

- drilling fluids
- completion fluid

Drilling fluids are planned to be water based, however, synthetic based fluids are assessed should their use be required. WBDF use seawater with pre-hydrated bentonite gel sweeps and will be discharged directly to the seabed with cuttings. The seawater may be treated with caustic soda (NaOH) and/or soda ash (Na2CO3) to increase pH and alkalinity.

If required, SBDF will be used once the riser is installed and returned to the topsides of the MODU, treated through the mud systems and reused. SBDF has increased lubricity, greater cleaning abilities with less viscosity than water-based fluids plus can withstand greater heat without breaking down. Base fluid is typically a hydrocarbon, ether, ester, or acetal as a base. Additives include:

- organophilic clays
- barite
- lime
- aqueous chloride
- rheology modifiers fluid loss control agents
- emulsifiers

Excess seawater with pre-hydrated bentonite gel sweeps and water-based fluids will be discharged to the marine environment, however no whole SBDF will be discharged into the marine environment. SBDF that is recovered from drill cuttings for re-use will be recycled or disposed of at a land-based facility or used in future drilling activities.

6.7.2.2 Well Completion, Unloading and Testing

Completion fluids are usually brines (i.e. a mixture of seawater or formation water) with additives that can include:

- chlorides (often sodium, potassium or calcium)
- bromides
- hydrate inhibitor (MEG)
- biocide
- oxygen scavenger

- viscosifiers and surfactants.

They are designed to have the proper density and flow characteristics to be compatible with the reservoir formation. Completion fluids are used to run well completions, and during wellbore clean-up, unloading nd testing during drilling.

Wellbore and casing clean-up are required at various stages of the drilling operations to ensure the contents of the well are free of contaminants before the next stage of drilling. A chemical wellbore cleanout fluid train may be used to remove residual fluids (including SBDF, if used) from the wellbore. The wellbore cleanout fluid is usually brine (similar to completion fluid) that can include several chemicals, such as biocide and surfactant. During the clean-up process, fluids are circulated back to the MODU, and, if required, analysed before they are discharged overboard. Total discharge volume of completion fluids would be up to approximately 300 m^3 per well, containing up to 16m^3 of formation water.

6.7.2.3 Decommissioning

During well P&A, discharges may occur during the operation.

Discharge of fluid in the suspended wells is to be expected. Suspension fluids are estimated to consist of corrosion inhibitor (soluble oil) and of suspension fluid (treated with dilute oxygen scavenger, preservative (Glutaraldehyde) and caustic soda) for each well. It is expected that up to approximately 100m3 of well suspension fluid per well will be discharged during the wellhead removal operation

Section milling may be required to re-establish permanent wellbore barriers, which would generate swarf. This is lifted to surface via a circulated water-based fluid system and separated for onshore disposal.

Following P&A the wellhead is cut with the use of either a mechanical cutting tool or an abrasive cutter using water and inert abrasives and removed below the mudline (~2 m). Should a mechanical cutting tool be used, the process produces <0.002 m3 per well of metal shavings (swarf) which will remain on the seabed.

WBDF used during riserless drilling and well annular fluids will be released to the marine environment when the well head is removed during abandonment. Upon wellhead removal, small volumes (up to 10 m^3) of fluid exchange between the annular spaces and the ocean may occur. The exchange will not be instantaneous as the annular spaces are small and the fluids are typically heavier than seawater. The non-instantaneous nature of the release of the well annular fluids is expected to result in rapid dilution within meters of the release.

6.7.2.4 Well Interventions

Well intervention activities may be undertaken, consisting of well workovers, wireline, logging, testing and flowback. Discharges from these activities may include:

- completion fluids associated with well testing as detailed above in Section 6.7.2.2
- well annular fluids that remain in the wellbore, or annular spaces between the casing and typically of any remaining drill fluids and may include small amounts of hydrocarbon

Project Stage	Discharge type	Discharge location	Indicative volume (per well)
Drilling	Drill cuttings	Seabed	400 m^3
		Surface	200 m3
	Drilling fluids *Seawater & pre-hydrated gel sweeps*	Seabed	2,500 m3
	WBDF	Surface	1,500 m3
	SBDF (contingency)	Surface	100 m^3
	Completion fluids	Surface	300 m^3 *(including 16m3 of formation water)*
Operations (well workovers and interventions)	Completion fluids	Surface	300 m3 *(including 16m3 of formation water)*
Decommissioning	Well annular fluid	Seabed	10 m^3
	Suspension fluids	Seabed	100 m^3

Table 71: Total expected volumes of drill cuttings and fluids discharged

6.7.3 Impact Analysis and Evaluation

6.7.3.1 Potential Impact

Drill cuttings and fluids, including WBDF, SBDF and completions fluids discharged to the marine environment have the potential to result in the following impacts:

- change in water quality
- change in sediment quality
- change in habitat

As a result of a change in water and sediment quality, further impacts may occur, which include:

- injury/mortality to fauna

Table 72 identifies the potential impacts to receptors because of a planned discharge of drill cuttings and fluids at the Project.

Impacts	**Ambient water quality**	**Ambient sediment quality**	**Plankton**	**Benthic habitats and communities**	**Fish**	**Marine mammals**	**Marine reptiles**	**Key Ecological Features**	**Commercial Fisheries**
Change in water quality	✓								
Change in sediment quality		✓							
Change in habitat				✓				✗	
Injury/ mortality to fauna			✗	✓	✗	✗	✗		
Changes to functions, interests or activities of other users								✗	✗

Table 72: Receptors potentially impacted by a Planned Discharge – Drill Cuttings and Fluids.

✓- impact is predicted to occur.
✗ - cause - effect pathway is credible, however, impact is predicted to have negligible consequence (i.e. less than Minor (1))

6.7.3.1.1 Water Quality

Following discharge of drill cuttings and fluids, key physiochemical stressors associated with a change in water quality include increased turbidity and resulting sedimentation and chemical toxicity within the water column.

During drilling of the top-hole section, discharges will occur at the seabed, resulting in a localised increase in turbidity immediately around the wellhead. The cuttings and fluids will settle rapidly within proximity to the wellhead, with finer particles (approx. 10% of the discharge volume) dispersing further within ocean currents (Hinwood et al., 1994). Although turbidity and chemical concentrations will be high around the wellhead, drill cuttings and drilling fluids are expected to settle and disperse rapidly, resulting in short term and highly localised change in water quality at the seabed.

During drilling of the remaining hole sections, the drill cuttings and fluids will be processed on the MODU. The drill cuttings will be discharged to the marine environment at the surface below the water line and the fluid treated and recycled. When discharged to the marine environment, large cuttings particles (90% of the discharge mass) generally form a plume and rapidly settle to the seafloor near to the release point (Hinwood et al., 1994), decreasing in volume and becoming patchy in distribution as distance from the source increases (Nedwed, 2006; Balcom, 2012). Cuttings may also entrain in seawater and reach neutral buoyancy. A study undertaken by Hinwood (1994) indicates that a drill cuttings and fluids plume will have diluted by a factor of at least 10,000 within 100 m of the point of discharge point. Neff (2005) also cites the 10,000-fold dilution factor within 100 m of the point of discharge point in areas where water current speeds are high (similar to that of the Project area) and indicates that within well-mixed ocean waters, drill cuttings and fluids will have diluted by over 100-fold within 10 m of the discharge point.

Drill cuttings and fluid from the bottom-hole sections will be smaller in volume and will be discharged from the surface, resulting in a wider area of deposition, but a much smaller cuttings pile depth (IOGP, 2016). Research has shown that volumes of bottom hole cuttings sharply decrease with distance from the discharge point; however, the distribution of these cuttings is generally very patchy (Nedwed, 2006; Balcom, 2012).

Dispersion of the cuttings plume is influenced by two factors: fluid type (i.e. particle size) and ocean current speed. The case studies described in Neff (2005) used WBMs and surface current speeds of 0.15–0.3 m/s. As currents in the Project Area are in excess of 1 m/s at the surface (Section 4.3.2.4), and WBMs are expected to cause the largest turbidity risk for the drilling program, the dispersion extents in Neff (2005) are considered representative.

Using the widely accepted dilution factor of 10,000 (Neff, 2005), cuttings (and adhered fluids) are expected to reach 100 mg/L within 100 m of the MODU. Using a conservative ocean current speed of 0.1 m/s (which is below average current speeds in the Project Area), these discharges are expected to disperse to 100 mg/L within ~16 minutes.

Changes in water quality associated with increased turbidity are therefore restricted to within close proximity of the discharge source, and fully within the Project area. Discharges from the surface are expected to impact a larger area than that of subsea discharges, however, volumes are much lower and drill cuttings and adhered fluids will disperse rapidly within the offshore marine environment, resulting in a relatively small footprint of water quality change. Neff (2005), states that although total drill cuttings discharge volumes associated with drilling a well are large, environmental impacts within the water column are low due to the intermittent nature of such discharges.

Discharges of drilling cuttings and fluids will also result in a change in water quality through chemical toxicity and oxygen depletion. Fluids comprise a small percentage of the total discharge of drill cuttings and fluids and may comprise of drilling fluids adhered to cuttings, completion fluids, subsea control fluids and well annular fluids. Completion fluids, subsea control fluids and well annular fluids discharged are expected to be similar to or less toxic than that of drilling fluids and will be released in smaller volumes. Because of the rapid dilution of the drilling mud and cuttings plume in the water column, harm to communities of water column flora and fauna is unlikely and has never been demonstrated (Neff, 2005). Neff (2010) states that the lack of toxicity and low bioaccumulation potential of the drilling muds means that the effects of the discharges are highly localised and are not expected to spread through the food web.

Beach will implement controls to reduce the potential impacts associated with discharges of drill cuttings and fluids. These will include chemical selection and assessment, use and discharge procedures, solid removal and treatment equipment, and equipment maintenance. Through implementation of these controls, potential impacts from planned discharge of drill cuttings and fluids will be further reduced.

Ambient water quality in the project area is expected to be high and typical of the offshore marine environment. In the high-energy shelf waters, any changes in water quality will be quickly dispersed and settle resulting in localised impacts to water quality. Planned discharges of drill cuttings and fluids will occur at both the surface and seabed, but will occur in short periods, with no long-term or continuous discharges planned. This will allow water quality to quickly recover, with no long-term changes to ambient water quality expected. Impacts to ambient water quality have been evaluated as a Minor (1) consequence.

6.7.3.1.2 Sediment Quality

Changes in sediment quality may occur as a result of the addition of toxins and sediments to the seafloor from both subsea and surface discharges. Toxins may accumulate within benthic sediment because of chemical additives within drilling fluids. Increased sedimentation because of cuttings material deposition may alter the physical characteristics of the seabed sediment profile through changes in minerology, sediment structure, particle distribution, particle flow and chemical composition. The area of thickness for seabed deposition is dependent on a range of factors including:

- fluid type adhered to cuttings (WBDF or SBDF)
- amount of fluid retained on cuttings
- particle size distribution of cuttings
- water depth
- current speed and direction at varying depths

Drill cuttings and fluids discharged during drilling operations are expected to result in the greatest change in sediment quality, as cuttings tend to clump together and settle rapidly, with thicker cuttings piles generally located downstream from the discharge. This is especially evident for SBDF. Deposition of sediments is expected to be highly localised around the well site (Neff 2005).

Several field studies for both SBDF and WBDF discharges from around the world with a variety of site and discharge characteristics are summarised in International Association of Oil and Gas Producers Report 543: ‘Environmental fate and effects of ocean discharge of drill cuttings and associated drilling fluids from offshore oil and gas operations’ (IOGP, 2016). The findings of this report are considered representative for the Project discharge given that the key inputs of fluid and cuttings volumes, current speeds and water depths expected for the Project are represented in the studies. The range of studies considered both shallower and deeper water depth locations than the Project area as well as more and less fluid and cuttings volumes and current speeds. Seven studies for SBDF and nine studies for WBDF, including one for the Minerva exploration well in the Bass Strait directly adjacent to the Project area, were referenced for the Report.

This report found the following in regard to the extent of cuttings deposition and potential impact:

- Cuttings and adhered fluids typically disperse slower and cover a wider area when WBDF are used rather than SBDF.
- Surface discharges of SBDF are generally deposited within approximately 100–200 m downstream of the discharge source for shallower water (<400 m) and up to a maximum of 1 km downstream for deeper waters with concentrations decreasing with distance from the discharge site
- WBDF cuttings discharged near to the sea surface tend to accumulate on the seafloor down current from the discharge at distances of about 100m to up to a maximum of 1.4 km.

- The Minerva exploration well study in the Bass Strait identified that cuttings were visually detected to 100 m from wellhead at 1 week post-drilling and no cuttings detected 11 months post drilling.
- For both SBDF an WBDF discharges at the seafloor; cuttings could be detected visually, or as elevated barium concentrations in benthic sediments within 10 – 150 m of the discharge, with a greater spread down-current.

Other studies support these conclusions. Increases in turbidity at the seabed from drill cutting discharges during riserless drilling (i.e. direct discharge to the seabed) are expected to be highly localised and limited to within close proximity of the source (Neff, 2005).

A study on the impacts of drilling in Bass Strait, where the Project area is located, by Terrens et al. (1998) observed biological effects within 100 m of the drilling site shortly after drilling; recovery of seabed communities across the area were reported within four months. This study found that after 11 months SBDF was not detectable in sediments, indicating that recovery of the seabed is through a combination of dispersion and biodegradation. Neff (2010) found that recolonisation of synthetic-based, mud-cuttings piles in cold-water marine environments began within one to two years of ceasing discharges, once the hydrocarbon component of the cutting piles biodegraded.

SBDF can contain components that may bioaccumulate. However, Melton et al. (2000) suggests that given the ability for organisms to oxidise and expel aromatics, hydrocarbons are not expected to bioconcentrate. The physical and chemical persistence of drill cuttings and fluids within the seafloor sediment is dependent on the energy of the seafloor (i.e. currents) and the reactivity and biodegradation rate of drilling materials.

The majority of minerals within drill cuttings are stable and insoluble within water with most organic chemicals within both WBDF and SBDF being biodegradable. Studies at three continental slope locations where drilling was undertaken in water depths between 37 and 119 m indicated that within a year, concentrations of barium reduced by 2.4% to 80% and 65% to 99% for chemicals within 100 m of the discharge source (IOGP, 2016).

Based on these studies, with a maximum distance of exposure of 1.4km for drill cuttings, a conservative exposure radius of up to 2 km is assumed for drilling discharges on the seabed associated with the Project. This indicates there is the potential for smothering impacts and potential toxicity within the expected radius of potential seabed disturbance from anchor spread.

As discussed in Section 4.3.3, a number of studies (Boreen et al. 1993, BBG 2003, CEE Consultants Pty Ltd 2003 and Ramboll 2020) have been undertaken within the Project Area within the shallow and middle shelf zones. These studies have identified the seabed is similar across these areas, consisting of carbonate rich coarse to medium sands with areas of exposed limestone substrate. This type of seabed is highly mobile making it difficult for filter feeders and soft body invertebrates to survive and establish in significant populations. Epifauna is dominated by low density, patchy assemblages of branching bryozoans, gorgonian cnidarians and sponges.

The existing studies focus on the shallow and middle shelf zones of up to approximately 130m water depth. Beach commits to undertaking further seabed assessments of the deep shelf and upper slope zones (from approximately 130m to 180m water depth) located predominantly in the southern and western portions of the Project Area. These assessments will enable the seabed composition, benthic habitats and communities to be identified for locations where seabed disturbance activities such as drilling may take place, allowing final well location selection to avoid areas of high relief outcrops, reefs and sponge beds (CM#11).

In summary, sediment quality is expected to reach pre-drilling conditions without any long-term or wide spread impacts to the local physical environment, with impacts to sediment quality evaluated as Minor (1).

6.7.3.1.3 Benthic Habitats and Communities

As a result of a change in sediment quality and/or water quality, further impacts to receptors may occur, which include a change in habitat resulting from smothering and alteration of the seabed, or exposure to toxins or chemicals in the drilling discharges.

Drill cuttings and cement discharges can physically smother seabed habitat and alter seabed substrate; and can also expose benthic habitats to chemical toxicity. Some components of WBM or SBDF are potentially bioaccumulative; though it's thought that the ability of organisms to oxidise and expel aromatics means that while hydrocarbons may be bioavailable, they are not expected to bioconcentrate (Melton et al., 2000).

An increase in SBDF in benthic sediments may lead to depletion of oxygen in surface layers, and potentially an increase in ammonia and sulphide leading to eutrophication. This can cause a change in or decrease in diversity of the benthic community (IOGP, 2016). Discharges of WBDF and NBDF cuttings can affect mobile and sessile fauna mainly by burial, changes in bottom topography,or smothering by elevated water turbidity from suspended fine clay/barite particles.

Impacts to mobile benthic fauna (e.g. crabs, shrimps, demersal fish) are not expected given their ability to avoid effected areas (IOGP, 2016). Studies (Balcom et al., 2012; IOGP, 2016) have concluded that impacts to benthic habitats and communities as a result of drill cuttings and fluids discharges are minimal, resulting in highly localised impacts with benthic environments rapidly recovering to post-drilling conditions.

Neff (2010) found that recolonisation of SBDF cuttings piles in cold-water marine environments began within one to two years of ceasing discharges, once the hydrocarbon component of the cutting piles biodegraded. Additional studies indicate that benthic infauna and epifauna recover relatively quickly (Jones 2012).

Although chemicals can usually be detected within the sediment surrounding the discharge site, impacts to benthic flora and fauna from WBDF adhered to cuttings are generally subtle, although the presence of drill-fluids in the seabed close to the drilling location (<500 m) can usually be detected chemically (Cranmer, 1988; Neff et al. 1989; Hyland et al. 1994; Daan and Mulder, 1996; Currie and Isaacs 2005; OSPAR, 2009, Bakke et al 2013).

A change in benthic habitats and communities as a result of planned discharges of drill cuttings and fluids is unlikely. Given that epifaunal communities are likely well represented in the region and that the footprint of the potential impact is small in comparison with the spatial extent of these communities in the Southeast Marine Region, there is a high level of confidence that drill cuttings and fluids will not destroy, fragment or isolate these communities nor modify or disturb substantial areas of habitat. Given the localised impact and sparse populations that may be affected the consequence is rated Minor (1).

6.7.3.1.4 Plankton

A reduction in water quality through increased turbidity and increased toxicity, caused by the discharge of drill cuttings and fluids within the project area, will have a negligible effect on plankton populations at a measurable level. Jenkins and McKinnon (2006) identified suspended sediment concentrations greater than 500 mg/L will likely result in a measurable impact to larvae species of most fish species, with concentrations of 100 mg/L effecting larvae species of most fish if exposed to for longer than 96 hours. Previous studies (Neff, 2010) showed discharges of cuttings and fluids could reach 100 mg/L within 100 m of the MODU within approximately 16 minutes, assuming a conservative 0.1 m/s current speed. Changes in water quality associated with increased turbidity are therefore restricted to within proximity of the discharge source.

Plankton have a patchy distribution linked to localised and seasonal productivity that produces sporadic bursts in populations (CoA, 2015c). Plankton distribution in the project area is expected to be highly variable both spatially and temporally and are likely to comprise characteristics of tropical, southern Australian, central Bass Strait and Tasman Sea distributions. A change in water quality at levels that may illicit acute toxicity to plankton as a result of drill cuttings and fluids is likely to be limited to within 100 m of the MODU (limited to within the project area) and therefore unlikely to lead to injury or mortality of plankton at a measurable level and will not result in a change in the viability of the population or ecosystem dynamics during regional upwelling events or otherwise. Therefore, no impacts to plankton from drill cuttings or fluids discharges are expected.

6.7.3.1.5 Fish, Marine Mammals and Marine Reptiles

Marine fauna found in the water column, such as fish, marine mammals and marine reptiles, are expected to actively avoid discharge plumes and associated turbidity within the water column. Neff et al. (2000) states that drill cuttings are of little risk to water column biota due to Water Based Drilling Fluid having low toxicity levels and will be rapidly diluted near the source.

As drill cuttings and fluid discharges within the project area will be localised and rapidly diluted plus fish, marine mammals and marine reptile species will be transitory in nature, the impacts of these discharges will be negligible and are therefore not discussed further. All activities will be conducted in accordance with management actions outlined in the relevant recovery plans.

One species of shark (white shark) listed as Vulnerable and two species (mako and mackerel hark) listed as migratory that may occur within the area. The project area is situated within a BIA distribution area for the white shark and are therefore likely to occur within the area. No habitat critical to the survival of the white shark or behaviours were identified. The Recovery Plan for the White Shark (*Carcharodon carcharias*) (DSEWPaC, 2013b) does not identify waste discharges as a threat. All fish species listed are highly mobile, therefore, none are expected to be affected by planned discharges.

Commercial fishing within the project area has been identified as being low and fish species highly mobile, therefore, none are expected to be affected by a planned discharge of drilling cutting and fluids.

Rock lobster and giant crab fishing occurs in low numbers within the project area. Data from the project area Otway project area Seabed Survey (Fugro, 2019; Ramboll, 2020) did not identify any rocky reefs or outcrops that would be rock lobster habitats. Giant crabs inhabit the continental slope at approximately 200 m depth which is outside the water depths (65 – 110 m) of the project area.

Therefore, impacts to commercial fisheries from planned discharge of drill cuttings and fluids are not a credible threat.

Three species of marine mammal listed as Vulnerable (sei whale, fin whale, humpback whale) and two species listed as Endangered (blue whale, southern right whale) are known or likely occur within the project area which intersects a foraging BIA for the pygmy blue whale.

The Conservation Management Plans for the Blue Whale (CoA, 2015b) and Southern Right Whale (DSEWPaC, 2012a) identifies acute and chronic chemical discharges as a threat mainly in relation to hydrocarbon spills and bioaccumulation of pollutants. Pollution (persistent toxic pollutions) is identified as a minor threat for the sei whale (Approved Conservation Advice for Balaenoptera borealis (Sei Whale) [TSSC, 2015f]) and fin whale (Approved Conservation Advice for Balaenoptera physalus (Fin Whale) [TSSC, 2015h]). Based on the low level of toxicity in the wastewater and discharges over 30 to 40 days at a location, bioaccumulation of pollutants is not predicted.

The Recovery Plan for Marine Turtles in Australia, (CoA, 2017) identifies chemical and terrestrial discharge as a threat, although this is mostly in relation to pollution from agricultural, terrestrial industrial and domestic sources. There are three marine turtle species with potential to be present, however no BIAs or habitat critical to the survival of the marine turtle species occur within the project area.

As impacts to fish, marine mammals and marine reptiles from drill cuttings and fluids are considered negligible, impacts have not been evaluated further.

A change in water quality as a result of planned discharge of drill cuttings and fluids are unlikely to lead to injury or mortality of marine fauna at a measurable level and will not result in a change in the viability of the population or ecosystem. Therefore, mortality or injury to marine fauna from planned discharge of drill cuttings and fluids are not predicted.

6.7.3.1.6 Protected Areas and Key Ecological Features

Zeehan AMP is 1km from the Project area boundary and 4km from the nearest potential well location, given that a 3km buffer is applied to account for anchoring of the MODU. No impacts from drill cuttings or fluids are expected within the Zeehan AMP with the maximum extent of spread from the discharge source of 1.4km.

One KEF, West Tasmanian Canyons, was identified as being within the Project Area to a minor extent. The KEF is located on the continental slope where Project activities are not planned and not within the potential area of impact for drill cuttings and fluids.

6.7.3.1.7 Cultural values and Sensitivities

As described in Section 4.6, Sea Country connection extends far beyond the current coastline and includes the Project Area. Drill cuttings and fluid discharges will be intermittent and without any long-term impacts to sediment or water quality. In addition, impacts to marine fauna (including eels and southern right whales) that have cultural value to First Nations people are not predicted.

Discharges to the seabed has the potential to interfere with First Nations submerged cultural heritage. The implementation of underwater cultural heritage assessments within potential areas of disturbance in the Project area (CM#11) will ensure any cultural heritage values are not impacted.

Thus the consequence is assessed as Minor (1) to water quality and ecological receptors and therefore is assessed as Minor (1) for associated cultural values.

6.7.4 Impact Evaluation Summary

Table 73 summarises the impact evaluation for drill cuttings and fluids.

Summary	
Summary of impacts	Low level decrease in water quality in the near vicinity of the discharge. Localised change in seabed habitat. Full recovery expected over time.
Extent of impacts	Localised – within 2km of the release.
Duration of impacts	Short term
Level of certainty of impacts	There is high level of certainty on the predicted impacts from drill cuttings and fluids, including: • Impact and fate in the environment. • toxicity of individual components within the drilling fluids; and • likely distribution of cuttings on the seabed.

Impact decision framework context	A – nothing new or unusual, represents business as usual, well understood activity, good practice is well defined.	
Impact Consequence (inherent)		
Minor		
Control		
CM10 Seabed assessments	Seabed assessments undertaken of each well location and tie-back route prior to final selection to identify seabed composition, benthic habitats and communities and ensure areas of high relief outcrops, reefs, sponge beds, maritime archaeology, submerged cultural heritage and landscapes are avoided where practicable within technical and safety constraints	
CM11 Cultural heritage assessments	Imagery and data from seabed surveys and assessments will be provided to appropriately qualified underwater archaeologists to identify any maritime archaeological and submerged cultural heritage and landscapes and inform protection priorities, management measures and reporting requirements.	
CM28 Well design	All wells to be drilled with WBDF, with SBDF only to be used where technical requirements preclude the use of WBDF	
CM29 Chemical selection process	A process for chemical selection will be implemented to ensure chemicals used are environmentally acceptable whilst also meeting technical requirements	
CM30 Drilling fluid inventory	Drilling fluids inventory will be developed and tracked to reduce discharge of excess powders, brines, and drilling fluids	
CM31 Solids control equipment	If SBDF is used, drill cuttings will be processed on the MODU to recover and reduce residual SBDF content prior to overboard discharge	
CM32 Minamata convention	Drilling fluids will have concentrations of mercury and cadmium less than 1 mg/kg and 3 mg/kg respectively in stock barite (WBM and SBM)	
Impact Consequence (residual)		
Minor		
Environmental Performance Outcomes		
EPO4	No impact to submerged cultural heritage	
EPO5	No death or injury to marine fauna, including listed threatened or migratory species, from Project activities	
EPO12	No impact to water and sediment quality outside of 2km of the discharge location	
Demonstration of Acceptability		
ESD principles	The risks and impacts from discharge of drilling fluids and cuttings are consistent with the principles of ESD: • the environmental values and sensitivities within the project area are not expected to be substantially impacted, and • the precautionary principle has been applied, habitat surveys of the existing environment have been undertaken and additional surveys committed to in aid of verifying the habitat where knowledge gaps were identified (including in the southern portion of the Project area in permit T/30P) and controls will be put in place to ensure the most environmentally friendly chemicals are used and the quantity discharges to the environment is minimised.	
Internal context	Policy compliance	Beach Environmental Policy objectives are met through this environmental impact assessment.
	Management system compliance	Section 9 describes the implementation strategy employed for this activity.

External context	Stakeholder engagement is being carried out as part of this OPP process Beach operates the existing Otway project and has established good relations with both onshore and offshore stakeholders. Engagement with stakeholders will continue throughout all aspects of the Project to build and maintain trust with stakeholders and the local community and minimise community and stakeholders concern and impacts where practicable.	
Legislative context	The EPOs and control measures align with the requirements of: • OPGGS Act 2006 (Cth) Section 460(2) – a person carrying on activities in an offshore area under the permit must carry out those activities in a manner that does not interfere with the conservation of the resources of the sea and seabed to a greater extent than is necessary for the reasonable exercise of the rights and performance of the duties of the first person. • Significant impact criteria (refer Table 41 in Section 5.8.2) • EPBC Management/Recovery Plans and Conservation Advice (refer Table 5 in Section 2.3.1) • The Minimata Convention covers all aspects of the life cycle of mercury, controlling and reducing mercury across a range of products, processes and industries. Australia ratified the Minamata Convention on 7 December 2021. Countries that have ratified the Convention are bound by international law to put controls in place to manage emissions, releases and disposal of mercury and mercury compounds. At present there are no specific guidelines regarding acceptable levels of mercury waste in drilling fluids. The discharge of drill fluids and cuttings to the marine environment is considered to be standard practice in industry. Barite contamination, with mercury and cadmium, will be managed in accordance with IFC EHS Guidelines – Offshore Oil and Gas Development (2015) that represent good international industry practice.	
Industry practice	The consideration and adoption of the controls outlined in the documents below demonstrates that best practice is being implemented	
	Environmental management in the upstream oil and gas industry (IOGP-IPIECA, 2020)	The controls consider the management measures listed for construction in Section 4.5.8 of the guidelines, which include: Well count and design optimised to reduce the generation of drill cuttings and drill fluids Select drilling fluid components to include the least ecotoxic options available that are suitable for the project Recover drilling muds and return to the drill rig. Retain, store and transfer to shore for disposal of SBDF (note that discharge overboard of WBDF is standard practice). Solids control equipment available onboard the drill rig to reduce the amount of residual drill fluids on cuttings prior to discharge If discharge to sea is the only feasible option: The depth of water below the discharge outlet should be sufficient to allow acceptable dispersion of the cuttings to occur.
Acceptability outcome	Acceptable	

Table 73: Impact assessment for drill cuttings and fluids discharge

6.8 Planned Discharge – Cement

6.8.1 Hazard Description

The cement used in offshore drilling is typically a blend of Portland cement, water, and various additives that are designed to improve its performance under the high pressures and temperatures. Planned discharge of cement has the potential to result in:

- increased turbidity of the water column from surface discharges; and
- smothering of benthic habitat and fauna from seabed discharges.

6.8.2 Impact Source

Throughout the Project, stages and activities which utilise cement and which may interact with other receptors include:

Stage	Activity
Drilling	Cementing operations
Operations	Well intervention and workovers
Decommissioning	Plug and abandonment of wells

6.8.3 Impact analysis and evaluation

6.8.3.1 Water quality

Cement slurry discharge from the rig is not expected to result in excessive turbidity as it will stick together and deposit rapidly to the seabed. BP (2013) modelled a large cement discharge of ~78m^3 over a one-hour period and found that, within two hours of discharge, suspended solid concentrations within the plume, which was 150 m horizontal and 10 m vertical, ranged between 5–50 mg/L. Four hours after discharge concentrations were <5 mg/L.

The chief chemical components Portland cement are calcium, silica, alumina and iron. Calcium is derived from limestone, marl or chalk, while silica, alumina and iron come from the sands, clays and iron ore sources. Other raw materials may include shale, shells and industrial by products such as mill scale. All these products are inert and will, therefore, pose little or no risk to the environment. Similarly, chemical additives used will be selected to ensure low risk to the environment.

6.8.3.2 Benthic habitats

It is estimated that approximately 15 m^3 of cement will be discharged to seabed per well which has the potential to smother and alter the benthic substrate permanently.

Modelling undertaken by de Campos et al. (2017) showed average deposition of 0.05 mg/m^2 of cement material on the seabed from a release of 18 m^3 of cement wash water. Chevron (2018) indicated that planned cement discharges from overflow during drilling operations may affect the seabed around the well to a radius of ~10 – 50 m. This is an area of 0.007 km^2 for an individual well which is an insignificant area when compared to the expanse of the seabed present in the Otway Basin.

Cement is typically inert and is considered to poses little or no risk to the environment. CIN (2005) states that once cement has set it is essentially inert and not likely to have chronic toxicity effects.

The environmental survey undertaken for the Otway Gas Development (Ramboll, 2020) concluded that sediments in the project area had a high ORP (oxidation-reduction potential) and low or undetectable levels of toxicants indicating an unmodified seabed environment. No species or ecological communities listed as threatened under the EPBC Act were observed.

Given the alteration of the seabed, albeit for a very localised area (within 50m of the well) in non-threatened benthic habitats, the consequence was ranked Minor (1).

6.8.3.3 Plankton, Fish, Marine Mammals and Marine Reptiles

Marine fauna found in the water column, such as fish, marine mammals and marine reptiles, are expected to actively avoid discharge plumes and associated turbidity and toxicity within the water column. A reduction in water quality and increased turbidity through the discharge of cement at the well locations within the project area is unlikely to result in injury or mortality of fauna.

Plankton have a patchy distribution linked to localised and seasonal productivity that produces sporadic bursts in populations (CoA, 2015c). Plankton distribution in the project area is expected to be highly variable both spatially and temporally and are likely to comprise characteristics of tropical, southern Australian, central Bass Strait and Tasman Sea distributions. A change in water quality as a result of cement is unlikely to lead to injury or mortality of plankton at a measurable level and will not result in a change in the viability of the population or ecosystem dynamics during regional upwelling events or otherwise. Therefore, no impacts to plankton from cement discharges are expected and are not discussed further.

Cement discharges will have negligible impacts on plankton populations, therefore indirect impacts to higher trophic levels are very unlikely.

One species of shark (white shark) listed as Vulnerable and two species (mako and mackerel hark) listed as migratory may occur within the area. Given the Australian grayling predominantly inhabits coastal freshwater streams, this species is unlikely to occur with the project area. The project area is situated within a BIA distribution area for the white shark and are therefore likely to occur within the area. No habitat critical to the survival of the white shark or important behaviours were identified. Interactions with white sharks are very unlikely due to their migratory nature and distance of the project area from the preferred foraging areas around Bonney upwelling and shelf environments in and deeper oceanic waters. The Recovery Plan for the White Shark (*Carcharodon carcharias*) (DSEWPaC, 2013b) does not identify cement discharges or equivalent as a threat. As these species would be transient impacts are not predicted due to the low toxicity of the suspended solids and rapid dilution.

A number of species of marine mammals listed as Vulnerable and Endangered known or may occur within the project area. The project area intersects a foraging BIA for the pygmy blue whale and the core current coastal range for the southern right whale.

The Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015b) identifies acute and chronic chemical discharges as a threat mainly in relation to oil spills and bioaccumulation of pollutants. Based on the low level of toxicity associated with the cement and intermittent nature of discharge whilst drilling bioaccumulation of pollutants is not predicted.

The Conservation Management Plan for the Southern Right Whale (DSEWPaC, 2012a) identifies acute and chronic chemical discharges as a threat but details that as they do not feed in Australian waters impact of toxins from chemical discharges is likely to be low. It details that they are more likely to be impacted in coastal aggregation area which the project area is not within. Based on the low level of toxicity associated with the cement and intermittent nature of discharge whilst drilling bioaccumulation of pollutants is not predicted.

Pollution (persistent toxic pollutions) is identified as a minor threat for the sei whale (Approved Conservation Advice for Balaenoptera borealis (Sei Whale) [TSSC, 2015f]) and fin whale (Approved Conservation Advice for

Balaenoptera physalus (Fin Whale) [TSSC, 2015h]). Based on the low level of toxicity associated with cement and intermittent nature of discharge whilst drilling persistent toxicity is not predicted.

The Approved Conservation Advice for Megaptera novaeangliae (Humpback Whale) (TSSC 2015g) does not identify pollution or chemical discharges as a threat.

The EPBC PMST Report (project area) identifies a number of turtle species of turtle listed as Vulnerable or Endangered that may occur within the project area. The Recovery Plan for Marine Turtles in Australia, (CoA, 2017) identifies chemical and terrestrial discharge as a threat, although this is mostly in relation to pollution from agricultural, terrestrial industrial and domestic sources. No BIAs or habitat critical to the survival of the marine turtle species occur within the project area. Based on the low level of toxicity associated with cement and intermittent nature of discharge whilst drilling persistent toxicity is not predicted.

A change in water quality as a result of planned discharge of cement is unlikely to lead to injury or mortality of marine fauna at a measurable level and will not result in a change in the viability of the population or ecosystem.

6.8.3.3.1 Cultural values and Sensitivities

As described in Section 4.6, Sea Country connection extends far beyond the current coastline and includes the Project Area. Cement discharges will be intermittent, low toxicity and without any long-term impacts to sediment or water quality. In addition, impacts to marine fauna (including eels and southern right whales) that have cultural value to First Nations people are not predicted.

Discharges to the seabed has the potential to interfere with First Nations submerged cultural heritage. The implementation of underwater cultural heritage assessments within potential areas of disturbance in the Project area (CM#11) will ensure any cultural heritage values are not impacted.

Thus the consequence is assessed as Minor (1) to water quality and ecological receptors and therefore is assessed as Minor (1) for associated cultural values.

6.8.4 Impact Evaluation Summary

Table 74 summarises the impact evaluation for cement discharge.

Summary	
Summary of impacts	The discharge of cement will result in localised short-term impacts to water and sediment quality. Seabed habitat in the well locations consist of soft sediment communities and is widespread and well represented in the region. Any loss of habitat is therefore insignificant.
Extent of impacts	Localised – within 50 m of well centres.
Duration of impacts	Sporadic discharges of cement from the MODU for the duration of drilling activity.
Level of certainty of impacts	Based on observations from previous wells and discharge modelling there is high level of certainty on the predicted impacts from cement, including: • Cement dispersion; • toxicity of individual components within the cement; and • likely distribution of overspill on the seabed.
Impact decision framework context	A – nothing new or unusual, represents business as usual, well understood activity, good practice is well defined.
Impact Consequence (inherent)	
Minor	
Controls	
CM10 Seabed assessments	Seabed assessments undertaken of each well location and tie-back route prior to final selection to identify seabed composition, benthic habitats and communities and ensure areas of high relief outcrops, reefs, sponge beds, maritime archaeology, submerged cultural heritage and landscapes are avoided where practicable within technical and safety constraints
CM11 Cultural heritage assessments	Imagery and data from seabed surveys and assessments will be provided to appropriately qualified underwater archaeologists to identify any maritime archaeological and submerged cultural heritage and landscapes and inform protection priorities, management measures and reporting requirements.
CM29 Chemical selection process	A process for chemical selection will be implemented to ensure chemicals used are environmentally acceptable whilst also meeting technical requirements.
CM33 Cementing program	Cementing programs shall be developed to minimise the amount of cement discharged to the marine environment, including the minimisation of excess cement discharge upon completion of the drilling program.
Impact Consequence (residual)	
Minor	
Environmental Performance Outcomes	
EPO4	No impact to submerged cultural heritage
EPO5	No death or injury to marine fauna, including listed threatened or migratory species, from Project activities
EPO13	No impact to water and sediment quality outside of 50m of the discharge location
Demonstration of Acceptability	
ESD Principles	The risks and impacts from discharge of drilling fluids and cuttings are consistent with the principles of ESD:

Summary		
	• the environmental values and sensitivities within the project area are not expected to be substantially impacted, and • the precautionary principle has been applied, habitat surveys of the existing environment have been undertaken and additional surveys committed to in aid of verifying the habitat present where knowledge gaps were identified (including in the southern portion of the Project area in permit T/30P) and controls will be put in place to ensure low toxicity additives are used and the quantity discharges to the environment is minimised.	
Internal context	Policy compliance	Beach Environmental Policy objectives are met through this environmental impact assessment.
	Management system compliance	Section 9 describes the implementation strategy employed for this activity.
External context	Stakeholder engagement is being carried out as part of this OPP process Beach operates the existing Otway project and has established good relations with both onshore and offshore stakeholders. Engagement with stakeholders will continue throughout all aspects of the Project to build and maintain trust with stakeholders and the local community and minimise community and stakeholders concern and impacts where practicable.	
Legislative context	The EPOs and control measures align with the requirements of: • OPGGS Act 2006 (Cth) Section 460(2) – a person carrying on activities in an offshore area under the permit must carry out those activities in a manner that does not interfere with the conservation of the resources of the sea and seabed to a greater extent than is necessary for the reasonable exercise of the rights and performance of the duties of the first person. • Significant impact criteria (refer Table 41 in Section 5.8.2) • EPBC Management/Recovery Plans and Conservation Advice (refer Table 5 in Section 2.3.1)	
Industry practice	The consideration and adoption of the controls outlined in the documents below demonstrates that best practice is being implemented	
	Environmental management in the upstream oil and gas industry (IOGP-IPIECA, 2020)	Controls consider the management measures listed for drilling in Section 4.5.8 of the guidelines, which include: Excess bulk cement (and additives) discharge to be controlled as follows: • Volume of cement to be used for each well to be planned to minimise excess bulk at the end of campaign and volumes discharged into the ocean • Excess cement discharged at the end of the campaign to be mixed as lean as possible to ensure good dispersion • Where practicable, release of excess cement to be at times of high tide/strong currents
Acceptability outcome	Acceptable	

Table 74: Impact assessment for cement discharge

6.9 Planned Discharge – Commissioning and Operational Fluids

6.9.1 Hazard Description

A number of fluids associated with commissioning and operations will be discharged to the ocean. These have the potential for localised changes to water quality which may impact the pelagic marine environment.

6.9.2 Impact Source

Stages of the Project which will result in liquid discharges include:

Stage	**Activity**
Drilling	Blow-out preventer installation and function testing
Installation	Commissioning and Hydrotest
Operations	Valve actuation
Decommissioning	Plug and abandonment of wells

6.9.2.1 Drilling and Decommissioning

During drilling (and well P&A), hydraulic control fluids will be released during BOP functioning and pressure testing. Function tests are generally undertaken every 7 days and will release ~ 2,200 L of potable water with 1 – 3% water-soluble control fluid. Pressure tests are generally undertaken every 21 days and may release small volumes of water-soluble fluids. In addition to this, BOP fluids are released whenever the riser is unlatched resulting in an additional release of fluids to the environment.

Hydraulic control fluids are water-based, low toxicity and readily biodegradable. On discharge they dilute rapidly in the open water environment to concentrations below which could possibly cause environmental harm. The extent of the impact is predicted to be within tens of metres from the MODU with a duration of hours whilst the BOP is being tested. The severity is assessed as Minor (1) based on:

- BOP hydraulic fluid is of low toxicity, readily biodegradable and low potential for bioaccumulation.
- discharges will rapidly disperse in the marine environment.
- no sensitive resident receptors were identified within the area that may be affected.

6.9.2.2 Hydrotesting

Flowlines are filled with inhibited seawater and subjected to test pressures that will meet design code requirements, typically significantly above any pressures seen during operation. Hydrotesting will result in the release of treated seawater being released to the marine environment.

The chemicals added to the treated seawater will result in the discharge of residual chemicals to the marine environment. These chemicals may include biocides, dyes, corrosion inhibitors and scale inhibitors; these residual chemicals may result in a temporary decrease in water quality in the water column affected by the discharge. This decrease in water quality may result in impacts to marine biota.

6.9.2.3 Operations

During the operations stage the only planned discharge is from the actuation of subsea valves or maintenance and repair of hydraulic leads where small volumes of hydraulic fluid (~2 L) are released. Based on the existing Otway Development it is estimate that the volume discharged from the additional Development valves would be ~ 4 m3 per year. These fluids are typically low toxicity and biodegradable and would dissipate rapidly within the water column. Thus, impacts to water quality will be negligible.

6.9.3 Impact Analysis and Evaluation

6.9.3.1 Hydrotest discharge modelling

Beach commissioned a modelling study (RPS, 2023a) to better understand the potential fate of discharged hydrotest water in the environment; the report is provided as Appendix L. The modelling study conservatively assumed a discharge volume of 120% of the longest potential flowline of 65km between the prospect in the southern portion of the T/30P permit and Thylacine platform, being in the order of 5,700m3.

The discharge location was selected as the prospect in the southern portion of the T/30P permit as it is considered “worst-case” due to the higher sensitivity of the receiving environment, including the close proximity to the Zeehan AMP.

The biocide concentration was the parameter modelled, as this component of the treated seawater has the greatest potential for environmental impacts. The modelling was based on the concentration of biocide at the time of discharge assumed to be 550 ppm; this is a conservative assumption as the actual concentration is expected to be significantly lower than this. The modelling also assumed the biocide is not consumed in the environment (i.e. it does not get consumed as it reacts with material); which is an additional conservative assumption upon which the modelling results are based.

An impact threshold of 1 ppm of biocide was defined; it was assumed that concentrations below this threshold would not result in significant environmental impacts. This threshold is consistent with published acute toxicity test data for aquatic species for typical biocides that may be used. For example, the Wheatstone Project Offshore Facilities and Produced Formation Water Discharge Management Plan: Stage 1 (Chevron, 2015) identified an acute toxicity threshold of 1 ppm for Hydrosure, a representative biocide product. The Safety Data Sheet for Hydrosure O-3670R states the 96-hour LC5027 as 3.09 mg/L (3.09 ppm) for fish in marine waters, with a 48-hour EC5028 of 5.66 mg/L (5.66 ppm) for aquatic invertebrates (Champion Technologies, 2013). Sano et al (2005) assessed the potential toxicity effects of glutaraldehyde, another representative biocide, and reported a 24-hour LC50 of 4.7 mg/L (4.7 ppm) for the aquatic invertebrate *Ceriodaphnia dubia*. Note that ecotoxicological studies are typically undertaken using constant doses for periods ranging from 24 to 96 hours under controlled conditions. This approach is in contrast to the natural environment, where the concentration and exposure durations can vary widely. For the purpose of this assessment, selection of an impact threshold of 1 ppm provides a conservative basis to evaluate the potential effects of biocide in the receiving environment.

The near-field modelling results showed that treated seawater would initially project upward at a 45-degree angle due to diffuser orientation and high exit velocity. Once the plume lost its momentum, the plume descended slightly till it was neutrally buoyant with the ambient water and then mixed laterally due to ambient currents. The far-field modelling results indicate that for the 99th and 100th percentile analysis (i.e. 99% and 100% of the time), the maximum distances from the Release Location to the predicted dilutions of 1:550 (i.e. 1 mg/L which represents the impact threshold concentration/trigger value) contour were 20m and 156 m, respectively (**Figure 109**). Based on the 95th percentile analysis (or 95% of the time), the 1:550 dilution was achieved very close to the release location (20 m)

Ambient water quality in the project area is expected to be high and typical of the offshore marine environment. Any discharge will quickly disperse in the receiving environment resulting in localised, short term minor impact to water quality.

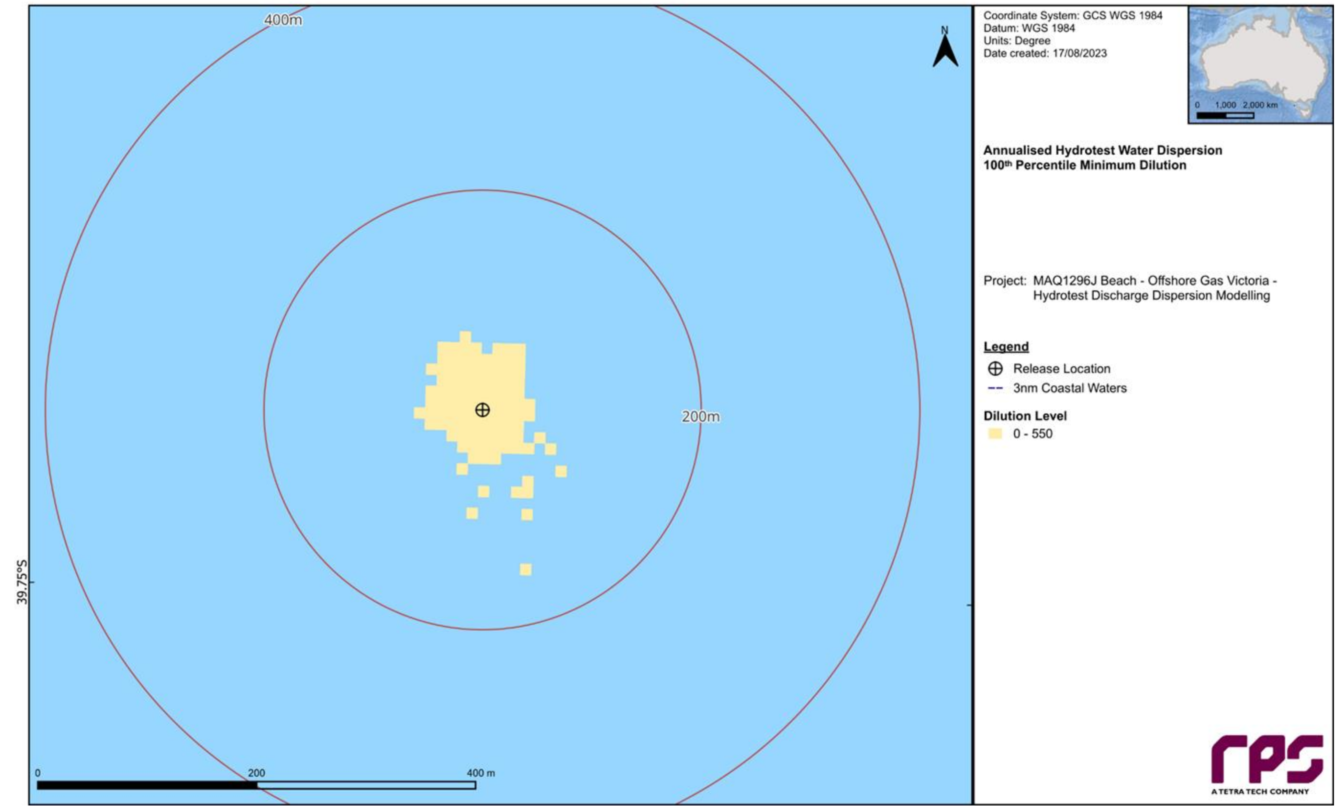


Figure 109: Predicted 100th percentile concentrations of the hydrotest discharge up until 550 dilutions (1 ppm)

6.9.3.2 Potential impacts

6.9.3.2.1 Physical Environment

Water quality

The treated seawater discharge will result in localised and temporary reduction in water quality around the release location.

Sediment quality and benthic communities

The plume could potentially spread to contact the seabed. The chemicals proposed for use in the hydrotest water will not persist in the environment. They will be readily biodegradable and have no potential for bioaccumulation so little or no impact is anticipated.

6.9.3.2.2 Ecosystems, Communities and Habitats

Plankton

Plankton drifting passed the outlet at the time of discharge may be exposed to elevated concentrations of treated seawater. However, dilution of the plume is rapid and the concentration that the organism is exposed to will continually reduce with dispersion. Plankton are widely distributed throughout the region, and, in the context of their lifecycle, impacts will be short term and negligible.

Benthic communities

The plume could potentially spread to contact the seabed, indicating the potential for effect on the benthic habitat. There may be localised impact, however, this will be short term. Benthic communities are broadly represented in the region and would regenerate rapidly through local recruitment. No protected or sensitive benthic habitats have been identified with the potential to be exposed.

Marine Mammals, Pelagic and Demersal Fish, Marine reptiles, Sharks and rays

If present, motile animals could pass through the plume, however, exposure will most likely be at low concentration and for short durations. Given the chemical's purpose as a biocide, it selectively targets simpler life forms so much higher concentrations would be required to elicit an effect on more developed species. For example, for the proprietary package Hydrosure the NOEC for a fish species is 12.5 mg/L compared to 1.3 mg/L for algae (Chevron, 2015). Modelling demonstrated that concentrations within the plume vary both temporally and spatially, rarely exceeding instantaneous concentrations of 10 mg/L.

Threatened Species and Ecological Communities

There are no gazetted breeding grounds or sensitive habitats (including habitat critical to the survival of species) for EPBC-listed species in the Project Area. Moreover, no marine mammal, turtle, pelagic fish, demersal fish, shark or ray aggregations areas have been identified within the near vicinity of discharge locations.

Most threatened and/or migratory fauna species that could be present are air breathing vertebrates, which are unlikely to be directly affected as their skin is relatively impermeable and they breathe air. Hence, direct impacts from the hydrotest discharge are not considered credible. Non-air breathing species are not anticipated to be present in significant numbers nor be exposed to discharge concentrations that may adversely impact on individuals. With controls in place, impacts to the above fauna are predicted to be negligible.

Key Ecological Features

The discharge plume is not predicted to impact upon KEFs.

6.9.3.2.3 Socioeconomic and Cultural Environment

Australian Marine Parks

The Zeehan AMP is 1km for the Project Area and not predicted to be exposed to the hydrotest discharges of 156 m extent.

Commercial Fisheries

As discussed above, there will little or no impact to fish. The hydrotest discharge is short term and is highly unlikely to affect commercial fisheries.

Cultural Values and Sensitivities

As described in Section 4.6, Sea Country connection extends far beyond the current coastline and includes the Project Area. Commissioning and operational fluid discharges will be intermittent, localised and without any long-term impacts to sediment or water quality. In addition, impacts to marine fauna (including eels and southern right whales) that have cultural value to First Nations people are not predicted.

Discharges to the seabed has the potential to interfere with First Nations submerged cultural heritage. The implementation of underwater cultural heritage assessments within potential areas of disturbance in the Project area (CM#11) will ensure any cultural heritage values are not impacted.

Thus the consequence is assessed as Minor (1) to water quality and ecological receptors and therefore is assessed as Minor (1) for associated cultural values.

6.9.4 Impact Evaluation Summary

Table 75: summarises the impact evaluation for planned commissioning and operational discharges.

Summary	
Summary of impacts	Reduction in water quality in the near vicinity of the discharge, however, high dilution rates will reduce contaminant concentrations to levels below which could possibly result in acute or chronic toxic effects. Little or no risk of bioaccumulation, bioconcentration or trophic transfer of chemicals.
Extent of impacts	Localised – hydrotest discharge within 200 metres of the release. Operational discharges within tens of metres.
Duration of impacts	Short term
Level of certainty of impacts	There is high level of certainty on predicted dilution rates and impacts from planned commissioning and operational discharges.
Impact decision framework context	A – nothing new or unusual, represents business as usual, well understood activity, good practice is well defined.
Impact Consequence (inherent)	
Minor	
Controls	
CM10 Seabed assessments	Seabed assessments undertaken of each well location and tie-back route prior to final selection to identify seabed composition, benthic habitats and communities and ensure areas of high relief outcrops, reefs, sponge beds, maritime archaeology, submerged cultural heritage and landscapes are avoided where practicable within technical and safety constraints
CM11 Cultural heritage assessments	Imagery and data from seabed surveys and assessments will be provided to appropriately qualified underwater archaeologists to identify any maritime archaeological and submerged cultural heritage and landscapes and inform protection priorities, management measures and reporting requirements.
CM29 Chemical selection process	A process for chemical selection will be implemented to ensure chemicals used are environmentally acceptable whilst also meeting technical requirements
CM34 Hydrotest assessment	Hydrotest assessments will be detailed in the relevant activity specific EPs developed during the detailed engineering and design studies of the Project. The EPs will detail the hydrotesting requirements including the definition of discharge characteristics (ie chemical additives and concentrations), discharge locations and volumes, methodology and species impact thresholds
Impact Consequence (residual)	
Minor	
Environmental Performance Outcomes	
EPO4	No impact to submerged cultural heritage
EPO14	No impact to water and sediment quality outside of 200m of the discharge location
EPO5	No death or injury to marine fauna, including listed threatened or migratory species, from Project activities
Demonstration of Acceptability	

Summary		
ESD Principles	The risks and impacts are consistent with the principles of ESD: • environmental values and sensitivities within the project area will not be impacted, and • the precautionary principle has been applied, through the use of chemical selection procedures that will ensure the most environmentally friendly chemicals are used and the quantity discharges to the environment is minimised.	
Internal context	Policy compliance	Beach Environmental Policy objectives are met through this environmental impact assessment.
	Management system compliance	Section 9 describes the implementation strategy employed for this activity.
External context	Stakeholder engagement is being carried out as part of this OPP process. Beach operates the existing Otway project and has established good relations with both onshore and offshore stakeholders. Engagement with stakeholders will continue throughout all aspects of the Project to build and maintain trust with stakeholders and the local community and minimise community and stakeholders concern and impacts where practicable.	
Legislative context	The EPOs and controls align with the requirements of: • OPGGS Act 2006 (Cth) Section 460(2) – a person carrying on activities in an offshore area under the permit must carry out those activities in a manner that does not interfere with...the conservation of the resources of the sea and seabed to a greater extent than is necessary for the reasonable exercise of the rights and performance of the duties of the first person. • Significant impact criteria (refer Table 41 in Section 5.8.2) • EPBC Management/Recovery Plans and Conservation Advice (refer Table 5 in Section 2.3.1)	
Industry practice	The consideration and adoption of the controls outlined in the documents below demonstrates that best practice is being implemented	
	Environmental management in the upstream oil and gas industry (IOGP-IPIECA, 2020)	The controls consider the management measures listed for hydrotest in Section 4.5.4 of the guidelines, which include: • Minimise the volume of hydrotest water offshore by testing equipment at an onshore site prior to loading the equipment onto the offshore facilities • Reduce the need for chemicals by minimising the time that test water remains in the equipment or pipeline • Chemical additives selected for environmental performance (i.e., dose concentration, toxicity, biodegradability, bioavailability, and bioaccumulation potential), while maintaining the technical requirements ○ Send offshore pipeline hydrotest water to onshore facilities for treatment and disposal, where practical
Acceptability outcome	Acceptable	

Table 75: Impact assessment for planned commissioning and operational discharges

6.10 Planned Discharge – Routine Operational Wastes from Vessels

6.10.1 Hazard Description

Routine operational wastes from the MODU and vessels include:

- cooling water;
- brine;
- deck drainage;
- bilge;
- sewage;
- grey water; and
- putrescible wastes.

Without controls, these discharges can contain contaminants such as oil, heavy metals, and bacteria that can harm marine life and degrade water quality. Putrescible waste can result in increased nutrients and possible changes in behaviour if fauna habituate to this food source. Cooling water and brine can also have an impact on the local marine environment, by altering the temperature and salinity of the surrounding waters.

Whilst there is the potential for impact, these discharges are subject to IMO regulations so most will undergo treatment prior to discharge. On release to the environment, they will rapidly dilute resulting in only localised and temporary impacts. The maximum extent of potential impact is conservatively predicted to be within 500 m of the MODU or vessels.

6.10.2 Impact Source

All stages involving MODU and vessel activities will discharge waste waters and putrescible waste.

6.10.3 Impact analysis and Evaluation

6.10.3.1 Cooling Water and Desalination Unit Waste

Cooling water is seawater used for non-contact, once through cooling of various machinery on the vessels and MODU. Seawater is extracted through intakes and circulated through heat exchanges and then discharged at elevated temperatures back to the sea. Desalination unit waste is residual high-concentration brine, associated with the process of creating freshwater from seawater. The concentrate is similar to sea water in chemical composition, however, anion and cation concentrations are higher. Brine discharges are typically 20 to 50% higher in salinity than the intake seawater (depending on the desalination process used).

Both discharges may contain low concentrations of chemical additives such as scale inhibitors and biocides (typically chlorine) used to mitigate biofouling on condenser tubes and intake and discharge conduits. These chemicals are usually consumed during the inhibition process resulting in little or no residual chemicals remaining upon discharge. Toxicity changes to water quality are limited and will be restricted to within proximity of the discharge source where concentrations are highest.

Cooling water will be less dense than the ambient water and will tend to remain at the surface. In contrast brine water density is greater and will tend to sink through the water column. Discharge rates are relatively low and temperature and salinity differentials will breakdown rapidly in the receiving environment.

Modelling undertaken by Woodside for its Torosa South-1 drilling program predicted that discharge water temperature decreases quickly as it mixes with the receiving waters, with discharge temperature being less than 1°C above ambient within 100 m (horizontally) of the discharge point, and 10 m vertically (Woodside 2014). Torosa South-1 was in ~ 44 m water depth within a low current environment. The Otway Basin is a far more energetic oceanic environment, so mixing is likely to be more rapid. Any impact will therefore be local to the release points with no cumulative impact anticipated.

6.10.3.2 Deck Drainage

Deck drainage refers to any wastewater generated from deck washing, spillage, rainwater, and runoff from drains, including drip pans and wash areas. When this water contacts oil-coated surfaces, the water becomes contaminated. Oil and grease are the primary pollutants identified in the deck drainage waste stream (USEPA 1993). In addition to oil, various other chemicals used in drilling operations might be present in deck drainage. Such chemicals could include drilling fluids, ethylene glycol, lubricants, fuels, biocides, surfactants, detergents, corrosion inhibitors, cleaners, solvents, paint cleaners, bleach, dispersants, coagulants, and any other chemical used in the daily operations of the facility (Dalton, Dalton, and Newport 1985).

Contaminated waters will drain to a bilge/slops tank for treatment prior to discharge. Chemical selection procedures will be used to control the use of deck washdown detergents.

6.10.3.3 Treated Bilge

Bilge water is a collective term for fluid which comes from machinery and storage areas. The bilge system is designed to safely collect, contain and dispose of oily water from hazardous areas so that discharge of hydrocarbons to the marine environment is avoided. These fluids may contain contaminants such as oil, detergents, solvents, chemicals and solid waste, typically at low levels.

Vessels operations undertaken as a part of this activity will adhere to the Navigation Act 2012, MARPOL and the various Marine Orders (as appropriate to vessel class) enacted under this Act. Bilge water will be processed via an oil-in-water separator (OWS), before being discharged into the sea, to reduce any oily residue to below 15 ppm. Residual oil will be retained onboard for onshore disposal.

Modelling by Shell (Shell, 2010) indicates that upon release, hydrocarbon and other chemical concentrations are rapidly diluted and expected to reduce below Predicted No Effect Concentration (PNEC) within less than 100 m of the discharge. That is, the concentration of any bilge or deck drainage discharge will rapidly fall below levels which could impact the marine environment.

6.10.3.4 Sewage, greywater and putrescible waste

Sewage is waste discharged from toilets and urinals and treated with a marine sanitation device. The discharge is subject to secondary treatment and consists of chlorinated effluent. Greywater is waste from sinks, showers, laundries, safety showers, eyewash stations, and galleys. This can include kitchen solids, detergents, cleansers, oil and grease. Putrescible waste refers to solid food waste.

Sewage, grey water and putrescible waste generated onboard the vessels and MODU are commonly discharged to the marine environment. Volumes will vary, however, based on activities it is estimated that between 5 – 15 m^3 of sewage and greywater and up to 1 m^3 of putrescible waste could be generated per day. This waste will be treated prior to discharge to the environment as per guidelines under the MARPOL 73/78 Annex IV and Protection of the Sea (Prevention of Pollution from Ships) Act 1983.

Discharged particulate matter in the form of macerated food plus sewage and greywater may result in an increase in turbidity and nutrient levels. However, this increase will be localised and temporary as discharges will be diluted and dispersed by wave action and local currents with organics subject to predation from local fauna.

Previous monitoring of wastewater discharges has demonstrated that a 10 m^3 sewage discharge over 24 hrs from a stationary source in shallow water, reduced to approximately 1% of its original concentration within 50 m of the discharge location (Woodside 2008). Beyond this nitrogen, phosphorous and metal concentrations were below background levels. Other studies have quantified the high levels of dilution received by wastewater discharges, which are in the order of approximately 200,000–640,000 for effluents discharged behind large ships (USEPA, 2002; Loehr et al., 2006). The discharge and subsequent level of dilution was shown to be acceptable for mitigating localised toxicity impacts to marine fauna from changes in water quality.

NERA Reference Case for Sewage, Grey Water and Putrescible Waste Discharges (NERA, 2019) determined that sewage and greywater discharge volume up to 150 m^3/day is expected to remain within the nominal mixing zone boundary of 500 m around fixed facilities. As the volume estimated to be discharged per day from the vessels and MODU are below this discharge level the use of 500 m as the extent of impact is reasonable and likely to be conservative.

6.10.3.5 Impact Summary

These discharges are intermittent, low volume, low toxicity and on release to the environment will rapidly dilute resulting in only localised and temporary impacts. The maximum extent of potential impact is conservatively predicted to be within 500 m of the MODU or vessels and a Minor (1) consequence.

As described in Section 4.6, Sea Country connection extends far beyond the current coastline and includes the Project Area. These discharges will be intermittent, localised and without any long-term impacts to sediment or water quality. In addition, impacts to marine fauna (including eels and southern right whales) that have cultural value to First Nations people are not predicted.

Discharges to the seabed has the potential to interfere with First Nations submerged cultural heritage. The implementation of underwater cultural heritage assessments within potential areas of disturbance in the Project area (CM#11) will ensure any cultural heritage values are not impacted.

Thus the consequence is assessed as Minor (1) to water quality and ecological receptors and therefore is assessed as Minor (1) for associated cultural values.

6.10.4 Impact Evaluation Summary

Table 76 summarises the impact evaluation for wastewater and putrescible discharges.

Summary	
Summary of impacts	Low level decrease in water quality in the near vicinity of the discharge. Full recovery expected over time.
Extent of impacts	Localised – within 500 m of the discharge.
Duration of impacts	Intermittent and temporary
Level of certainty of impacts	There is high level of certainty on predicted dilution rates and impacts from vessel discharges.
Impact decision framework context	A – nothing new or unusual, represents business as usual, well understood activity, good practice is well defined.
Impact Consequence (inherent)	

Summary	
Minor	
Controls	
CM10 Seabed assessments	Seabed assessments undertaken of each well location and tie-back route prior to final selection to identify seabed composition, benthic habitats and communities and ensure areas of high relief outcrops, reefs, sponge beds, maritime archaeology, submerged cultural heritage and landscapes are avoided where practicable within technical and safety constraints
CM11 Cultural heritage assessments	Imagery and data from seabed surveys and assessments will be provided to appropriately qualified underwater archaeologists to identify any maritime archaeological and submerged cultural heritage and landscapes and inform protection priorities, management measures and reporting requirements.
CM29 Chemical selection process	A process for chemical selection will be implemented to ensure chemicals used are environmentally acceptable whilst also meeting technical requirements.
CM35 Marine orders	All wastewater discharges will comply with relevant MARPOL 73/78, Navigation Act 2012, Protection of the Sea (Prevention of Pollution) Act 1983 and subsequent Marine Order requirements (as appropriate for vessel classification): Marine Order 91 (Marine Pollution Prevention – Oil), which implements Annex I of MARPOL 73/78, including (as required by vessel class): • Machinery space bilge/oily water shall have IMO-approved oil filtering equipment (oil/water separator) with an on-line OIW monitoring device • OIW content to be less than 15 ppm prior to discharge. • A deck drainage system capable of controlling the content of discharges for areas of high risk of fuel/oil/grease or hazardous chemical contamination. • Valid International Oil Pollution Prevention Certificate. Marine Order 95 (Marine Pollution Prevention – Garbage), which implements Annex V of MARPOL 73/78, including: • Garbage management plan in place. • Garbage record book maintained onboard. Marine Order 96 (Marine Pollution Prevention – Sewage), which implements Annex IV of MARPOL 73/78, including (as required by vessel class): • a valid International Sewage Pollution Prevention Certificate, • an IMO-approved sewage treatment plant, • a sewage comminuting and disinfecting system, a sewage holding tank sized appropriately to contain all generated waste (sewage and grey water), • discharge of sewage will occur at a moderate rate while vessel is proceeding (more than 4 knots).
Impact Consequence (residual)	
Minor	
Environmental Performance Outcomes	
EPO4	No impact to submerged cultural heritage
EPO15	No impact to water and sediment quality outside of 500m of the discharge location
EPO5	No death or injury to marine fauna, including listed threatened or migratory species, from Project activities
Demonstration of Acceptability	

Summary		
ESD Principles	The risks and impacts from discharge of drilling fluids and cuttings are consistent with the principles of ESD: • the impact will be localised and environmental values and sensitivities will not be impacted, • the precautionary principle has been applied, habitat surveys of the existing environment have been undertaken and additional surveys committed to in aid of verifying the habitat where knowledge gaps were identified (including in the southern portion of the Project area in permit T/30P) and controls will be put in place to ensure the most environmentally acceptable chemicals are used.	
Internal context	Policy compliance	Beach Environmental Policy objectives are met through this environmental impact assessment.
	Management system compliance	Section 9 describes the implementation strategy employed for this activity.
External context	Stakeholder engagement is being carried out as part of this OPP process Beach operates the existing Otway project and has established good relations with both onshore and offshore stakeholders. Engagement with stakeholders will continue throughout all aspects of the Project to build and maintain trust with stakeholders and the local community and minimise community and stakeholders concern and impacts where practicable.	
Legislative context	The EPOs and control measures align with the requirements of: • Commonwealth Protection of the Sea (Prevention of Pollution from Ships) Act 1983 – Section 26F (implements MARPOL Annex I) • Commonwealth Navigation Act 2012 – Chapter 4 (Prevention of Pollution) • AMSA Marine Orders Part 91 (Marine Pollution Prevention –Oil) 2014 • AMSA Marine Order 95 (Marine pollution prevention — garbage) 2018 • Significant impact criteria (refer Table 41 in Section 5.8.2) • EPBC Management/Recovery Plans and Conservation Advice (refer Table 5 in Section 2.3.1)	
Industry practice	The consideration and adoption of the controls outlined in the below-listed guidelines and codes of practice demonstrates that Best Practice Environmental Management is being implemented	
	Environmental management in the upstream oil and gas industry (IOGP-IPIECA, 2020)	The management measures developed for this hazard are in line with the management measures listed for offshore marine use in Section 4.5.4 of the guidelines: • Chemical additives are selected for environmental performance. • Vessels must have an IOPP Certificate (for vessels >400 gross tonnes) and equipped with MARPOL/IMO-compliant oil/water treatment system (as appropriate to vessel class). • Hydrocarbon and chemical storage areas are to be bunded with no residues/spills permitted to enter the overboard drainage system unless it first goes through a closed drainage treatment system. • Vessels to maintain an Oil Record Book (applicable to vessels >400 gross tonnes), including the discharge of dirty ballast or cleaning water. • Discharge into the sea of oil or oily mixtures is prohibited except when the OIW of the discharge without dilution does not exceed 15 ppm. For support vessels, discharge of treated oily water to only occur when a vessel is enroute.

Summary		
		- Contaminated deck drainage and bilge water to be contained and treated prior to discharge in accordance with EHS Guidelines for Offshore Oil and Gas Development 2015. If treatment to this standard is not possible, these waters should be contained and shipped to shore for disposal. - Extracted hydrocarbons from oil-in water separator systems to be stored in suitable containers and transported to shore for treatment and/or disposal by a certified waste oil disposal contractor.
	Environmental, Health and Safety Guidelines for Offshore Oil and Gas Development (World Bank Group, 2015)	Guidelines met with regard to: - Other wastewaters (item 44). Grey and black water should be treated in an appropriate on-site marine sanitary treatment unit in compliance with MARPOL. - Other wastewaters (item 44). Food waste from the kitchen should, at a minimum, be macerated to acceptable levels and discharged to sea, in compliance with MARPOL requirements. - Cooling water (items 41 & 42). Antifouling chemical dosing to prevent marine fouling of cooling water systems should be carefully considered and appropriate screens to be fitted to the seawater intake to avoid entrainment and impingement of marine flora and fauna. The cooling water discharge depth should be selected to maximise mixing and cooling of the thermal plume to ensure it is within 3°C of ambient seawater temperature within 100 m of the discharge point. - Desalination brine (item 43). Consider mixing desalination brine from the potable water system with cooling water or other effluent streams. - Other wastewaters (item 44). Bilge waters from machinery spaces in vessels should be routed to the closed drain system or contained and treated before discharge to meet MARPOL requirements. Deck drainage water should be routed to separate drainage systems. This includes drainage water from process and non-process areas. All process areas should be bunded to ensure that drainage water flows into the closed drainage system.
	APPEA Code of Environmental Practice (2008)	The management measures listed in this table meet the following offshore development and production objectives: - To reduce the impact on benthic communities to ALARP and to an acceptable level. - To reduce the volume of wastes produced to ALARP and an acceptable level.
Acceptability outcome	**Acceptable**	

Table 76: Impact evaluation for wastewater and putrescible discharges

7. Environmental Risk Evaluation - Unplanned Events

7.1 Invasive Marine Species

7.1.1 Hazard Description

Invasive marine species are non-native plants, animals and microorganisms that have been introduced, either intentionally or unintentionally, to a new marine environment and can establish and spread, causing harm to the local ecosystem, economy, and human well-being. Within Australia, over 250 exotic marine species have been introduced with most having little impact, but some species have become aggressive pests in certain locations (DoA, 2019b). Typical habitats of the ten species currently listed on the Marine Pest website (DoA, 2019b) are shallow marine water areas. Highly disturbed environments (such as marinas) are more susceptible to colonisation than open-water environments (Paulay et al., 2002).

Some examples of invasive marine species include the European green crab, Asian kelp, northern pacific seastar and the red lionfish. These species can have a significant negative impact on native species and ecosystem functioning, First Nations cultural values and sensitivities, as well as economic impacts on fishing and other industries.

Introductory pathways for IMS include:

- ship ballast water
- hull fouling
- niche areas such as anchor lockers, bilges, sea chests or internal seawater systems (DAFF, 2003)

All Project stages involving MODU and vessel operations therefore have the potential to introduce IMS. Vessels may be required to adjust their ballast during installation, loading and offloading operations to maintain stability, balance and trim. During the uptake of ballast water from the surrounding environment in an international or domestic location, it is possible for a vessel to take in water that contains planktonic biota, including holoplankton, gametes, spores and larvae. This biota may then be discharged at the vessel's new location during ballast water exchange.

IMS may also be imported in biofouling communities via biofouling on vessel hulls and in damp or fluid-filled spaces (niche areas) such as anchor lockers, bilges, sea chests or internal seawater systems (DAFF, 2003).

7.1.2 Risk Analysis and Evaluation

Successful IMS colonisation requires the following three stages (Marine Pest Sectoral Committee, 2018):

- colonisation and establishment of the marine pest on a vector (vessel, equipment or structure) in a donor region (a home port, harbour or coastal project site where a marine pest is established)
- survival of the settled marine pests on the vector during the voyage from the donor to the recipient region
- colonisation (for example, by reproduction or dislodgement) of the recipient region by the marine pest, followed by successful establishment of a viable new local population.

The risk of an IMS being able to successfully establish itself will depend on depth, distance from the coast, water movement and latitude. The probability of successful IMS settlement and recruitment will decrease in well mixed, deep ocean waters away from coastal habitats (Geiling, 2014). An IMS travelling through several latitudes will also have to survive significant temperature and salinity changes.

Receptors most at risk, either as residents or migrants, are:

- Benthic fauna (because of their limited ability to move to other suitable areas);
- Benthic habitat; and
- Pelagic fish.

Marine pest species can also deplete fishing grounds and aquaculture stock, with between 10% and 40% of Australia's fishing industry being potentially vulnerable to marine pest incursion (AMSA, n.d). The introduction of the Northern Pacific seastar (*Asterias amurensis*) in Victorian and Tasmanian waters was linked to a decline in scallop fisheries. Similarly, the ability of the New Zealand screw shell (*Maoricolpus roseus*) to reach densities of thousands of shells per square metre has presented problems for commercial scallop fishers (MESA, 2017). The ABC (2000) reported that the New Zealand screw shell is likely to displace similar related species of screw shells, several of which occupy the same depth range and sediment profile.

Other impacts include damage to marine and industrial infrastructure, such as encrusting jetties and marinas or blocking industrial water intake pipes. By building up on vessel hulls, they can slow vessels down and increase fuel consumption.

Biosecurity is managed under the *Biosecurity Act 2015 (Cth.).* Strict controls are in place to prevent the introduction of IMS, which the project will abide by. The Australian Ballast Water Management Requirements (DAWR, 2018) provides Australia's commitment to the International Convention for the Control and Management of Ships' Ballast Water and Sediments (Ballast Water Convention) (IMO, 2017). This provides guidance on how vessel operators should manage ballast water when operating within Australian seas to comply with the Biosecurity Act 2015. The National Biofouling Management Guidelines for the Petroleum Production and Exploration Industry (Marine Pest Sectoral Committee, 2018) provides recommendations for the management of biofouling hazards by the petroleum industry.

Given the impact of a successful IMS colonisation has the ability to significantly impact local species and thus change local epifauna and infauna populations permanently, the consequences have been evaluated as Serious. However, it is considered such an event is Remote due to the unfavourable conditions within the Project Area required for colonisation and the controls in place.

7.1.3 Risk Evaluation Summary

Table 77 presents the risk assessment for the introduction of IMS.

Summary	
Summary of risks	Reduction in native marine species diversity and abundance, displacement of native marine species, socio-economic impacts on commercial fisheries and changes to conservation values of protected areas.
Extent of risk	Localised (isolated locations if there is no spread) to widespread (if colonisation and spread occurs).
Duration of risk	IMS is mainly relevant to installation activities.
Level of certainty	The threat posed by invasive marine species is well known and strict regulatory requirements are in place to control the risk. With these regulatory controls in place, we have a high level of certainty that project activities will not introduce invasive marine species.
Risk decision framework context	A – nothing new or unusual, represents business as usual, well understood activity, good practice is well defined.
Risk Assessment (inherent)	

Consequence	Likelihood	Risk rating
Serious	**Highly Unlikely**	**Medium**

Controls

CM10 Seabed assessments	Seabed assessments undertaken of each well location and tie-back route prior to final selection to identify seabed composition, benthic habitats and communities and ensure areas of high relief outcrops, reefs, sponge beds, maritime archaeology, submerged cultural heritage and landscapes are avoided where practicable within technical and safety constraints
CM11 Cultural heritage assessments	Imagery and data from seabed surveys and assessments will be provided to appropriately qualified underwater archaeologists to identify any maritime archaeological and submerged cultural heritage and landscapes and inform protection priorities, management measures and reporting requirements.
CM36 IMS Management Plan	Implementation of Beach IMS Management Plan which includes the following minimum requirements: • compliance with relevant Australian legislation and current regulatory guidance • outline of when an IMS risk assessment is required and the associated inspection, cleaning and certification requirements • implementation of management measures commensurate with the level of risk based on outcomes if the IMS risk assessment, such as inspections, cleaning and movement restrictions • anti-fouling prevention measures, including vessels (of appropriate class) having a valid International Anti Fouling Systems (IAFS) Certificate
CM37 Australian Ballast Water Management Requirements	The MODU and vessels fulfil the requirements of the Australian Ballast Water Management Requirements (DAWR, 2020, v8). This includes requirements to: • Carry a valid Ballast Water Management Plan (BWMP). • Submit a Ballast Water Report (BWR) through the Maritime Arrivals Reporting System (MARS). • If intending to discharge internationally sourced ballast water, submit BWR through MARS at least 12 hours prior to arrival. • If intending to discharge Australian sourced ballast water, seek a low-risk exemption through MARS. • Hold a Ballast Water Management Certificate (BWMC). • Ensure all ballast water exchange operations are recorded in a Ballast Water Record System (BWRS)

Risk Assessment (residual)

Consequence	Likelihood	Risk rating
Serious	**Remote**	**Low**

Environment Performance Outcomes

EPO4	No impact to submerged cultural heritage
EPO16	No introduction and establishment of known or potential Invasive Marine Species from Project activities

Demonstration of Acceptability

ESD Principles	EPOs are aligned with the principles of ESD: • Extensive controls are in place to prevent the introduction of invasive marine species and the threat of serious or irreversible environmental damage.

	• The ability for an invasive marine species to establish itself is highly unlikely due to the open ocean area and the seabed habitat.	
Internal context	Policy compliance	Beach Environmental Policy objectives are met through this environmental impact assessment.
	Management system compliance	Section 9 describes the implementation strategy employed for this activity.
External context	Stakeholder engagement is being carried out as part of this OPP process Beach operates the existing Otway project and has established good relations with both onshore and offshore stakeholders. Engagement with stakeholders will continue throughout all aspects of the Project to build and maintain trust with stakeholders and the local community and minimise community and stakeholders concern and impacts where practicable.	
Legislative context	The EPOs and control measures align with the requirements of: • *Biosecurity Act* 2015 (Cth): ○ Chapter 4 (Managing biosecurity risk). ○ Chapter 5, Part 3 (Management of discharge of ballast water). • *Protection of the Sea (Harmful Anti-fouling Systems) Act* 2006 (Cth): ○ Part 2 (Application or use of harmful anti-fouling systems). ○ Part 3 (Anti-fouling certificates and anti-fouling declarations). ○ Marine Order 98 (Marine pollution – anti-fouling systems). • OPGGS Act 2006 (Cth) Section 460(2) – a person carrying on activities in an offshore area under the permit must carry out those activities in a manner that does not interfere with the conservation of the resources of the sea and seabed to a greater extent than is necessary for the reasonable exercise of the rights and performance of the duties of the first person. • Significant impact criteria (refer Table 41 in Section 5.8.2) • EPBC Management/Recovery Plans and Conservation Advice (refer Table 5 in Section 2.3.1)	
Industry practice	The consideration and adoption of the controls outlined in the below-listed codes of practice and guidelines demonstrates that Best Practice Environmental Management is being implemented.	
	Environmental management in the upstream oil and gas industry (IOGP-IPIECA, 2020)	Management measures are in line with the introduction of IMS in Section 4.7.6 of the guidelines: • Developing an IMS Management Plan (where applicable). • Complying with the International Convention on the Control of Harmful Anti-fouling Systems on Ships. • Ensuring vessels of appropriate class have IFAS certificates. • Ensuring compliance with local regulatory guidelines.
	Best Available Techniques Guidance Document on Upstream Hydrocarbon Exploration and Production (European Commission, 2019)	There are no guidelines for offshore activities with regard to minimising the risk of introducing IMS.
	Environmental, Health and Safety Guidelines for Offshore Oil and Gas Development (World Bank Group, 2015)	There are no guidelines regarding preventing the introduction of IMS.

	APPEA Code of Environmental Practice (2008)	Management measures are in line with offshore development and production objectives: To reduce the risk of introduction of marine pests to ALARP and to an acceptable level. To reduce the impacts to benthic communities to ALARP and to an acceptable level.
	Offshore Installations - Quarantine Guide (DAWR, 2019, v1.3)	Management measures are in line with guidance for ballast water and biofouling management in the DAWR guide.
	Australian Ballast Water Management Requirements (DAWR, 2020, v8)	Management measures are in line with guidance for ballast water and biofouling management in the DAWR guide.
	Anti-Fouling and In-Water Cleaning Guidelines (DoA, 2015).	Management measures are in line with guidance for ballast water and biofouling management in the DAWR guide. general guidance regarding managing fouling in the DoA/DoE guidelines, which have since been updated in the aforementioned DAWR (2019) quarantine guide.
	Guidelines for the Control and Management of Ships' Biofouling to Minimise the Transfer of Invasive Aquatic Species (IMO, 2011)	Management measures are in line with this guidance.
	National Biofouling Management Guidance for the Petroleum Production and Exploration Industry (DAFF, 2009)	Management measures are in line with this guidance.
Acceptability outcome	Acceptable	

Table 77: Risk Assessment for the introduction of IMS

7.2 Physical Presence – Interaction with Marine Fauna

7.2.1 Hazard Description

The movement and presence of the MODU and construction vessels, together with the presence of subsea equipment during the installation process, has the potential to result in collision or entanglement with megafauna (cetaceans and pinnipeds). Vessel strike could cause injury or death.

7.2.2 Risk Analysis and Evaluation

7.2.2.1 Extent and duration of risk

The extent of the risk for megafauna vessel strike or entanglement with installation equipment is the immediate area around MODU, vessels and equipment. Receptors most at risk are cetaceans (whales and dolphins) and pinnipeds (fur-seals). Duration is limited to the time vessels are in the field.

7.2.2.2 Potential Impacts

Cetaceans and pinnipeds are naturally inquisitive marine mammals that are often attracted to offshore vessels, and dolphins commonly ‘bow ride’ with offshore vessels. The reaction of whales to the approach of a vessel is quite variable. Some species remain motionless when in the vicinity of a vessel while others are known to be curious and often approach ships that have stopped or are slow moving, although they generally do not approach, and sometimes avoid, faster moving ships (Richardson et al., 1995).

Peel et al (2016) reviewed vessel strike data (2000-2015) for marine species in Australian waters and identified the following:

Whales including the humpback, pygmy blue, Antarctic blue, southern right, dwarf minke, Antarctic minke, fin, bryde’s, pygmy right, sperm, pygmy sperm and pilot species were identified as having interacted with vessels. The humpback whale exhibited the highest incidence of interaction followed by the southern right whale, and these species are likely to occur in the waters of the Project Area.

Dolphins including the Australian humpback, common bottlenose, indo-pacific bottlenose and Risso’s dolphin species were also identified as interacting with vessels. The common bottlenose dolphin exhibited the highest incidence of interaction. A number of these species may reside in or pass through the waters of the Project Area.

There were no vessel interaction reports during the period for either the Australian or New Zealand fur-seal. There have been incidents of seals being injured by boat propellers, however all indications are rather than ‘boat strike’ these can be attributed to be the seal interacting/playing with a boat, with a number of experts indicating the incidence of boat strike for seals is very low.

All turtle species present in Australian waters are identified as interacting with vessels. The green and loggerhead species exhibited the highest incident of interaction. The presence of turtles in the Project Area and surrounds is considered remote.

Collisions between vessels and cetaceans occur more frequently where high vessel traffic and cetacean habitat coincide (WDCS, 2006). There have been recorded instances of cetacean deaths in Australian waters (e.g., a Bryde’s whale in Bass Strait in 1992), though the data indicates this is more likely to be associated with container ships and fast ferries (WDCS, 2006). Some cetacean species, such as humpback whales, can detect and change course to avoid a vessel (WDCS, 2006). The Australian National Marine Safety Committee (NMSC) reports that during 2009, there was one report of a vessel collision with an animal (species not defined) (NMSC, 2010).

CoA (2015b) reports that there were two blue whale strandings in the Bonney Upwelling (western Victoria) with suspected ship strike injuries visible. When the vessels are stationary or slow moving, the risk of collision with cetaceans is extremely low, as the vessel sizes and underwater noise ‘footprint’ will alert cetaceans to its presence and thus elicit avoidance. Laist et al (2001) identifies that larger vessels moving in excess of 10 knots may cause fatal or severe injuries to cetaceans with the most severe injuries caused by vessels travelling faster than 14 knots. When vessels operate within the Project Area, they will be moving very slowly or will be stationery, so the risk associated with fast moving vessels is not an issue.

DSEWPC (2012a) notes that whale entanglement in nets and lines often causes physical damage to skin and blubber. These wounds can then expose the animal to infection. Entanglement can also result in amputation (e.g., of a flipper or tail fluke), and death over a prolonged period. The CoA (2015b) states that entanglement (in the context of fishing nets, lines or ropes) has the potential to cause physical injury that can result in loss of reproductive fitness, and mortality of individuals from drowning, impaired foraging and associated starvation, or infection or physical trauma. There is an almost negligible risk of this occurring to megafauna with tethered ROVs as the tethers are likely to break under the weight of entanglement. The Australian and

New Zealand fur-seals are highly agile species that haul themselves onto rocks and platform jackets. As such, it is likely that they will be able to avoid equipment tethered to the MODU or vessels and are unlikely to become entangled within such equipment.

The construction vessel will be largely stationary while installing the subsea equipment, thus minimising the risk of injury to megafauna. Combining this with the low likelihood of presence of SRW, humpback whales and blue whales in and around the project area, and the lack of a defined migration route for pygmy blue whales in western Bass Strait, makes it even more unlikely that vessel strike or equipment entanglement with threatened whale species will occur. The consequence is **Moderate (2)** given that some impact on valued species may occur in unlikely event of a collision

Based on Section 4.6, cultural values and sensitivities, being birds and marine mammals, have been identified as potentially affected by fauna interaction. Noting that eels and fish, and submerged cultural heritage, are not identified as at risk.

This section has assessed the predicted environmental impact to these receptors. Based on that assessment the consequence to cultural values and sensitivities from fauna interaction is assessed as Moderate (2).

7.2.3 Risk Evaluation Summary

Table 78 presents the risk summary for vessel collision with megafauna.

Summary		
Summary of risks	Injury or death of cetaceans and/or pinnipeds.	
Extent of risks	Localised (limited to individuals coming into contact with the vessel or equipment).	
Duration of risks	Limited to the time the MODU and vessels are in the field	
Level of certainty of risk	HIGH – injury may result in the reduced ability to swim and forage. Serious injury may result in death.	
Risk decision framework context	A – nothing new or unusual, represents business as usual, well understood activity, good practice is well defined.	
Risk Assessment (inherent)		
Consequence	Likelihood	Risk rating
Moderate	**Unlikely**	**Medium**
Controls		
CM14 EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans	Vessels will adhere to EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans in relation to distances to cetaceans. Helicopters will adhere to EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans in relation to distances to cetaceans	
Risk Assessment (residual)		
Consequence	Likelihood	Risk rating
Moderate	**Highly unlikely**	**Low**
Environmental Performance Outcomes		
EPO5	No death or injury to marine fauna, including listed threatened or migratory species, from Project activities	

Demonstration of Acceptability		
ESD Principles	EPOs are aligned with the principles of ESD: ● The risk of Significant impact to MNES is low ● impacts and risks from vessel movements will not credibly exceed any of the significant impact criteria ● Conservation advice, recovery plans and threat abatement plans will not be contravened.	
Internal context	Policy compliance	Beach Environmental Policy objectives are met through this environmental impact assessment.
	Management system compliance	Section 9 describes the implementation strategy employed for this activity.
External context	Stakeholder engagement is being carried out as part of this OPP process Beach operates the existing Otway project and has established good relations with both onshore and offshore stakeholders. Engagement with stakeholders will continue throughout all aspects of the Project to build and maintain trust with stakeholders and the local community and minimise community and stakeholders concern and impacts where practicable.	

Legislative context	The EPOs and control measures align with the requirements of:
	• OPGGS Act 2006 (Cth) Section 460(2) – a person carrying on activities in an offshore area under the permit must carry out those activities in a manner that does not interfere with the conservation of the resources of the sea and seabed to a greater extent than is necessary for the reasonable exercise of the rights and performance of the duties of the first person.
	• Significant impact criteria (refer Table 41 in Section 5.8.2)
	• EPBC Management/Recovery Plans and Conservation Advice (refer Table 5 in Section 2.3.1) and following details:
	Significant impact guidelines for Critically Endangered, Endangered, Vulnerable and Migratory species (Table 8 1):
	• The low speed of the construction vessels, along with the temporary nature of the activity, makes it unlikely that vessel strike or entanglement with megafauna will occur
	• If vessel strike or entanglement does occur to individual animals, this will not be a significant impact in the context of species' populations. As such, the activities will not exceed any of the significant impact criteria for Threatened and Migratory marine species
	National Strategy for Reducing Vessel Strikes on Cetaceans and other Marine Megafauna (Commonwealth of Australia 2017c):
	• Vessel movements will be aligned to 'Objective 3: Mitigation' of the Strategy by:
	  • maintaining separation of vessels and whales
	  • maintaining slow vessel speeds
	  • avoidance manoeuvres
	• This will be met by project vessels adhering to Part 8 (Interacting with cetaceans and whale watching) of the EPBC Regulations.
	Conservation advice on sei whale (Balaenoptera borealis) (TSSC 2015b)
	• The risk of vessel strikes will be managed by project vessels adhering to the EPBC Regulations 2000 – Part 8 Division 8.1 (Regulations 8.05 and 8.06) and the Australian National Guidelines for Whale and Dolphin Watching 2017.
	Conservation advice on fin whale (Balaenoptera physalus) (TSSC 2015c)	

<table>
<tr><td></td><td colspan="2">• Conservation management plan for the blue whale: A recovery plan under the Environment Protection and Biodiversity Conservation Act 1999 2015-2025 (Commonwealth of Australia 2015a)
Significant impact guidelines for Critically Endangered, Endangered, Vulnerable and Migratory species (Table 8 1)
• The risk assessment indicates that the likelihood of vessel collisions with threatened or migratory marine reptiles is Unlikely, and the consequence of any such collision would be restricted to an individual animal. As such, the petroleum activities do not exceed any of the significant impact criteria for Threatened and Migratory marine species
Recovery Plan for Marine Turtles in Australia 2017-2027 (Commonwealth of Australia 2017a)
• Project vessel collisions with turtles are inherently unlikely due to the offshore location (and resultant low densities of turtles), slow speeds of vessels and diving startle response of turtles. Furthermore, the risk of a vessel collision with a turtle will be further reduced via the application to turtles of the EPBC Regulations 2000 – Part 8 Division 8.1 (Regulations 8.05 and 8.06) and the Australian National Guidelines for Whale and Dolphin Watching 2017.
• Conservation advice on leatherback turtle (Dermochelys coriacea) (DEWHA 2008b)
Significant Impact Guidelines for the Commonwealth marine environment (Table 7 3)
• The impact assessment indicates that vessel movements will not exceed the Commonwealth Marine Environment significant impact criteria as the aspect does not pose a credible risk.</td></tr>
<tr><td>Industry practice</td><td colspan="2">The consideration and adoption of the controls outlined in the below-listed codes of practice and guidelines demonstrates that Best Practice Environmental Management is being implemented.</td></tr>
<tr><td></td><td>Environmental management in the upstream oil and gas industry (IOGP-IPIECA, 2020)</td><td>The management measures developed for this activity are in line with the management measures listed for collision with marine fauna in Section 4.7.5 of the guidelines:
• Monitoring for the presence and movement of large cetaceans and pinnipeds so that avoidance can be taken when marine fauna is observed to be on a collision course with vessels.</td></tr>
<tr><td></td><td>APPEA Code of Environmental Practice (2008)</td><td>The management measures listed in this table meet the following offshore development and production objectives:
• To reduce the risks to the abundance, diversity, geographical spread and productivity of marine species to ALARP and to an acceptable level.</td></tr>
<tr><td></td><td>The Australian Guidelines for Whale and Dolphin Watching (DoEE, 2017b)</td><td>The management measure listed in this table are aligned with the requirements of these guidelines.</td></tr>
<tr><td></td><td>National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna (DoEE, 2017c).</td><td>The management measure listed in this table are aligned with objective 3 of this strategy, which is to reduce the likelihood and severity of megafauna vessel collisions.</td></tr>
<tr><td>Industry practice</td><td colspan="2">The consideration and adoption of the controls outlined in the documents below demonstrates that best practice is being implemented</td></tr>
<tr><td></td><td>Environmental management in the upstream oil and gas industry (IOGP-IPIECA, 2020)</td><td>Proposed controls align with management measures listed for collision with marine fauna in Section 4.7.5 of the guidelines.</td></tr>
</table>

Acceptability outcome	Acceptable

Table 78: Risk assessment for vessel collision with megafauna

7.3 Accidental Discharge – Hazardous and Non-Hazardous Materials

7.3.1 Hazard Description

In the normal course of operations, small quantities of hazardous and non-hazardous materials will be handled and stored onboard the MODU and vessels. Waste will be stored until it is transported to port facilities for disposal at licensed onshore facilities. Accidental releases are possible due to crane operator error or improper storage, especially in rough ocean conditions, creating marine debris and pollution.

Non-hazardous materials include:

- Paper and cardboard
- Wooden pallets
- Scrap steel, metal and aluminium
- Glass
- Foam (e.g., ear plugs)
- Plastics (e.g., hard hats)

Hazardous materials include:

- Hydrocarbons, hydraulic oils/fluids and lubricants
- Hydrocarbon-contaminated materials (e.g., oily rags, pipe dope, oil filters)
- Batteries, empty paint cans, aerosol cans and fluorescent tubes
- Contaminated personal protective equipment (PPE)
- Laboratory wastes (such as acids and solvents)
- Larger dropped objects (that may be hazardous or non-hazardous) may be lost to the sea through accidents (e.g., crane operations) include:
    - Sea containers
    - Towed equipment
    - ROV
    - Entire skip bins/crates

7.3.2 Risk Analysis and Evaluation

7.3.2.1 Acceptability Criteria

Criteria relevant to the accidental discharge of hazardous and non-hazardous materials is that it will not result in a substantial change in water quality which may adversely impact on biodiversity, ecological integrity, social amenity or human health.

7.3.2.2 Extent and duration of risk

The extent of the impact depends on the type of waste released. Dense or solid waste will sink and might result in a localised impact whilst floating waste could be distributed over wide areas. The duration of the risk is limited to the time that the MODU and vessels are in the field.

7.3.2.3 Potential impacts

Receptors at risk to waste accidentally discharge to the marine environment are:

- Benthic fauna
- Benthic habitat (sand and reef substrates)
- Fish
- Cetaceans
- Turtles
- Pinnipeds
- Seabirds

7.3.2.4 Potential impacts

7.3.2.4.1 Non-hazardous Materials and Waste

If discharged overboard, non-hazardous materials and wastes can cause smothering of benthic habitats as well as injury or death to marine fauna or seabirds through ingestion or entanglement (e.g., plastics caught around the necks of seals or ingested by turtles, seabirds and fish). TSSC (2015b) reports that there have been 104 records of cetaceans in Australian waters impacted by plastic debris through entanglement or ingestion since 1998 (humpback whales being the main species).

Marine fauna including cetaceans, turtles and seabirds can be severely injured or die from entanglement in marine debris, causing restricted mobility, starvation, infection, amputation, drowning and smothering (DoEE, 2018a). Seabirds entangled in plastic packing straps or other marine debris may lose their ability to move quickly through the water, reducing their ability to catch prey and avoid predators, or they may suffer constricted circulation, leading to asphyxiation and death. In marine mammals and turtles, this debris may lead to infection or the amputation of flippers, tails or flukes (DoEE, 2018a). Plastics have been implicated in the deaths of a number of marine species including marine mammals and turtles, due to ingestion.

If dropped objects such as bins are not retrievable (e.g., by crane), these items may permanently smother very small areas of seabed, resulting in the loss of benthic habitat. However, as with most subsea infrastructure, the items themselves are likely to become colonised by benthic fauna over time (e.g., sponges) and become a focal area for sea life (Forteath et al. 1982; Gallaway et al. 1981; Todd et al. 2016). Seabed substrates can rapidly recover from temporary and localised impacts. The benthic habitats in the Project Area are broadly similar to those elsewhere in the region (e.g., extensive sandy seabed), so impacts to very localised areas of seabed will not result in the long-term loss of benthic habitat or species diversity or abundance.

As described in Section 4.6, Sea Country connection extends far beyond the current coastline and includes the Project Area. These accidental discharges will be intermittent, localised and without any long-term impacts to sediment or water quality. In addition, any impacts to marine fauna (including eels and southern right whales) that have cultural value to First Nations people are predicted to be minor.

Discharges to the seabed have the potential to interfere with First Nations submerged cultural heritage. The implementation of underwater cultural heritage assessments within potential areas of disturbance in the Project area (CM#11) will ensure any cultural heritage values are not impacted.

Thus the consequence is assessed as Minor (1) to water quality and ecological receptors and therefore is assessed as Minor (1) for associated cultural values.

7.3.2.4.2 Hazardous Materials and Waste

Hazardous materials and wastes released to the sea cause pollution and contamination, with either direct or indirect effects on marine organisms. For example, minor chemical or hydrocarbon spills can (depending on the volume released) impact on marine life from plankton to pelagic fish communities, causing physiological damage through ingestion or absorption through the skin. Impacts from an accidental release would be limited to the immediate area surrounding the release, prior to the dilution of the contaminant with the surrounding seawater. In an open ocean environment such as the Project Area it is expected that any minor release would be rapidly diluted and dispersed, and thus any impacts would be temporary and localised.

Solid hazardous materials, such as paint cans containing paint residue, batteries and so forth, would settle on the seabed if dropped overboard. Over time, this may result in the leaching of hazardous materials to the seabed, which could result in the adjacent substrate becoming toxic and unsuitable for colonisation by benthic fauna. The benthic habitats of the Project Area are broadly similar to those elsewhere in the region (e.g., extensive sandy seabed), so impacts to very localised areas of seabed will not result in the long-term loss of benthic habitat or species diversity or abundance.

As described in Section 4.6, Sea Country connection extends far beyond the current coastline and includes the Project Area. These accidental discharges will be intermittent, localised and without any long-term impacts to sediment or water quality. In addition, any impacts to marine fauna (including eels and southern right whales) that have cultural value to First Nations people are predicted to be minor.

Discharges to the seabed have the potential to interfere with First Nations submerged cultural heritage. The implementation of underwater cultural heritage assessments within potential areas of disturbance in the Project area (CM#11) will ensure any cultural heritage values are not impacted.

Thus the consequence is assessed as Minor (1) to water quality and ecological receptors and therefore is assessed as Minor (1) for associated cultural values.

7.3.3 Risk Evaluation Summary

Table 79 presents the risk assessment for the accidental disposal of hazardous and non-hazardous materials and waste.

Summary		
Summary of risk	Marine pollution (litter and a temporary and localised reduction in water quality), injury and entanglement of individual animals (such as seabirds and seals) and smothering or pollution of benthic habitats.	
Extent of impact	The extent of the impact depends on the type of waste released. Dense or solid waste will sink and might result in a localised impact whilst floating waste could be distributed over wide areas.	
Duration of risks	The duration of the risk is limited to the time that the MODU and vessels are in the field.	
Level of certainty of risk	HIGH – the effects of inappropriate waste discharges are well known.	
Risk decision framework context	A – nothing new or unusual, represents business as usual, well understood activity, good practice is well defined.	
Risk Assessment (inherent)		
Consequence	Likelihood	Risk rating
Minor	**Highly Unlikely**	**Low**
Controls		

CM10 Seabed assessments	Seabed assessments undertaken of each well location and tie-back route prior to final selection to identify seabed composition, benthic habitats and communities and ensure areas of high relief outcrops, reefs, sponge beds, maritime archaeology, submerged cultural heritage and landscapes are avoided where practicable within technical and safety constraints	
CM11 Cultural heritage assessments	Imagery and data from seabed surveys and assessments will be provided to appropriately qualified underwater archaeologists to identify any maritime archaeological and submerged cultural heritage and landscapes and inform protection priorities, management measures and reporting requirements.	
CM38- Waste Management Plan	Beach Waste Management Plan implemented that includes details of: • Classification and segregation of wastes • Appropriate storage of wastes • Transportation and disposal of wastes to licensed treatment and disposal facilities onshore	
CM35 Marine orders	MODU and vessels will comply with relevant MARPOL Commonwealth requirements and subsequent Marine Orders for waste discharges	
CM39 Lifting	Crane and lifting operations will comply with the following: • Lifting equipment will be inspected and certified • Preventative maintenance will be carried out • Lifting operators will be competent and qualified	
Risk Assessment (residual)		
Consequence	Likelihood	Risk rating
Minor	**Remote**	**Low**
Environmental Performance Outcomes		
EPO4	No impact to submerged cultural heritage	
EPO17	No unplanned loss of hazardous or non-hazardous materials to marine environment from Project activities	
Demonstration of Acceptability		
ESD Principles	EPO aligns with ESD principles as controls will be in place to prevent accidental release of waste or other items to the marine environment.	
Internal context	Policy compliance	Beach Environmental Policy objectives are met through this environmental impact assessment.
	Management system compliance	Section 9 describes the implementation strategy employed for this activity.
External context	Stakeholder engagement is being carried out as part of this OPP process. Beach operates the existing Otway project and has established good relations with both onshore and offshore stakeholders. Engagement with stakeholders will continue throughout all aspects of the Project to build and maintain trust with stakeholders and the local community and minimise community and stakeholders concern and impacts where practicable.	
Legislative context	The EPOs and control measures align with the requirements of: • Navigation Act 2012 (Cth): ○ Chapter 4 (Prevention of Pollution). • Marine Orders Part 47. • Marine Orders Part 94 (Marine pollution prevention – packaged harmful substances). • Marine Orders Part 95 (Marine pollution prevention – garbage). • Protection of the Sea (Prevention of Pollution from Ships) Act 1983 (Cth):	

	○ Part III (Prevention of pollution by noxious substances). ○ Part IIIA (Prevention of pollution by packaged harmful substances). ○ Part IIIC (Prevention of pollution by garbage). • OPGGS Act 2006 (Cth) Section 460(2) – a person carrying on activities in an offshore area under the permit must carry out those activities in a manner that does not interfere with the conservation of the resources of the sea and seabed to a greater extent than is necessary for the reasonable exercise of the rights and performance of the duties of the first person. • Significant impact criteria (refer Table 41 in Section 5.8.2) • EPBC Management/Recovery Plans and Conservation Advice (refer Table 5 in Section 2.3.1)	
Industry practice	The consideration and adoption of the controls outlined in the below-listed codes of practice and guidelines demonstrates that Best Practice Environmental Management is being implemented.	
	Environmental management in the upstream oil and gas industry (IOGP-IPIECA, 2020)	The management measures developed for this activity are in line with the management measures listed for hazardous waste and non-hazardous waste discharges in Sections 4.6.2 and 4.6.3 of the guidelines, which include: • Segregating hazardous and non-hazardous wastes prior to disposal. • Managing hazardous waste in accordance with their SDS and tracking it to final destination. • Not deliberately discharging waste overboard.
	Best Available Techniques Guidance Document on Upstream Hydrocarbon Exploration and Production (European Commission, 2019)	The management measures listed in this table meet these guidelines for offshore activities with regard to: • Risk management for handling and storage of chemicals (item 19). The BAT are met for the activity with regard to implementing chemical transfer procedures and ensuring chemicals are stored in separate, labelled containers.
	Environmental, Health and Safety Guidelines for Offshore Oil and Gas Development (World Bank Group, 2015)	Guidelines met with regard to: • Waste management (items 46). Materials should be segregated offshore and shipped to shore for reuse, recycling or disposal. A waste management plan should be developed and contain a mechanism allowing waste consignments to be tracked. • Hazardous materials management (item 72). Principles relate to the selection of chemicals with the lowest environmental and health risks.
	APPEA Code of Environmental Practice (2008)	The management measures listed in this table meet the following offshore development and production objectives: • To reduce the risk of any unplanned release of material into the marine environment to as low as reasonably practical and to an acceptable level.
	Guidelines for the Development of GMPs (IMO, 2012)	The GMP is developed in accordance with these guidelines.
	International Dangerous Goods Maritime Code (IMO, 2014)	The storage and handling of dangerous goods is managed in accordance with this code.

Acceptability outcome	Acceptable

Table 79: Risk assessment summary for the accidental disposal of hazardous and non-hazardous materials and waste

7.4 Loss of Containment – Hydrocarbons and Chemicals

7.4.1 Hazard Description

Activities associated with the Project have the potential to result in an accidental large-scale release of hydrocarbons or chemicals to the marine environment as follows:

- Drilling
- Support operations (MODU and vessels) for all stages
- Operations (loss of containment of subsea flowlines or umbilicals)
- Decommissioning

Guidance on the identification of worst-case credible spill scenarios is given in AMSA’s Technical Guidelines for Preparing Contingency Plans for Marine and Coastal Facilities (AMSA 2015) and Technical Report on Calculation of Worst-Case Discharge (SPE 2016). These documents were used to identify the potential significant and credible loss of containment scenarios associated with the Project as detailed in Table 80.

Scenario	Description	Worst-case release volume and rate
Vessel Collision -Marine Diesel Oil (MDO) spill	Collision between an installation, resupply or IMR vessel and third-party vessel.	Based on the types of vessel used for installation, IMR and resupply activities the loss of a largest tank volume of 600 m^3 is considered appropriate.
Flowline loss of containment – gas and condensate	Loss of containment from a flowline from the subsea facilities as a result of erosion, corrosion, or external forces (e.g. dropped object; fishing vessel interactions).	Maximum credible condensate spill volume from the longest proposed flowline is a loss of containment is up to a maximum of 141m^3
Umbilical loss of containment - MEG	Loss of containment from an umbilical from the subsea facilities as a result of erosion, corrosion, or external forces (e.g. dropped object; fishing vessel interactions).	Maximum credible MEG spill volume from subsea infrastructure loss of containment is up to in the order of 400m^3
Loss of well containment – gas and condensate	Loss of containment as a result of well integrity failure during drilling, completions, operations or well workover.	Worst case release volumes for all currently identified exploration prospects within the Project Area were calculated. The highest potential discharge volume for wells in the northern fields of the Project Area (north of Thylacine Platform) are: • 69,120m^3 over 86 days The highest potential discharge volume for wells in the southern fields of the Project Area (south of Thylacine Platform) (T/30P) are: • 97,172m^3 over 86 days

Table 80: Risk assessment summary for the accidental disposal of hazardous and non-hazardous materials and waste

7.4.2 Risk Analysis and Evaluation

7.4.2.1 Quantitative Hydrocarbon Spill Modelling

Beach commissioned RPS Group (RPS) to conduct quantitative spill modelling for the vessel collision and loss of well control spill scenarios as the worst case for both hydrocarbon types (RPS, 2023b) with the report available as Appendix M.

The flowline loss of containment scenario was not modelled due to the potential condensate volume of 141m^3 being well within the volume of the loss of well containment scenario which is considered worst case for a condensate spill.

The umbilical loss of containment scenario was not modelled due to the relatively small volume and MEG being a category ‘E’ OCNS chemical with no substitution warning, readily biodegradable with a low potential for bioaccumulation and a Minor potential impact consequence ranking.

Two release locations for both the MDO and condensate spill scenarios within the Project Area were selected to ensure a conservative assessment. Release Location North is the most northerly potential well location, and nearest to the Victorian coast, and Release Location South is the most southerly well location, nearest to the Tasmanian Coast (King Island) and Zeehan AMP.

The highest potential discharge volume for prospects in the northern titles/fields of the Project Area (north of Thylacine Platform) (VIC/P43 and VIC/P73) was used for Release Location North and the highest potential discharge volume for wells in the southern titles/fields of the Project Area (south of Thylacine Platform) (T/30P) used for Release Location South.

Thylacine fluid composition were used as a conservative analogue for the blow out scenarios.

The release duration represents the time estimated to implement a full dynamic well kill through the drilling of a relief well. This is considered the worst-case scenario for potential gas condensate releases and therefore yields the largest spatial extent that could possibly occur from the Project.

7.4.2.2 Hydrocarbon Properties

Thylacine condensate has an API of 44.3 and a density of 804.6 kg/m^3 (at 15ºC) with a viscosity value (0.87.0 cP) classifying it as a Group I (not-persistent) oil according to the International Tankers Owners Pollution Federation (ITOPF, 2020) and US EPA/USCG classifications.

The condensate is a mixture of volatile and persistent hydrocarbons with high proportions of volatile and semi- to low-volatile components. In favourable evaporation conditions, 64.0% of the oil mass should evaporate within the first 12 hours (BP < 180°C), a further 19.0% is expected to evaporate within the first 24 hours (180°C < BP < 265°C) and a further 16.0% should evaporate over several days (265°C < BP < 380°C). Approximately 1.0% of the condensate is shown to be persistent.

Marine diesel (MDO) has an API of 37.6 and a density of 829.1 kg/m^3 (at 25ºC) with a viscosity value (4.0 cP) classifying it as a Group II (light-persistent) oil according to the International Tankers Owners Pollution Federation (ITOPF, 2014) and US EPA/USCG classifications.

The MDO is a mixture of volatile and persistent hydrocarbons with high proportions of volatile and semi- to low-volatile components. In favourable evaporation conditions, about 6.0% of the oil mass should evaporate within the first 12 hours (BP < 180°C); a further 34.6% should evaporate within the first 24 hours (180°C < BP < 265°C); and a further 54.4% should evaporate over several days (265°C < BP < 380°C). Approximately 5.0% of the oil is shown to be persistent.

7.4.2.3 Hydrocarbon Exposure thresholds

In the event of an oil spill incident, the environment may be affected in several ways, depending on the concentration and duration of exposure of the environment to hydrocarbons. The hydrocarbon exposure thresholds used for the spill modelling are based on the NOPSEMA Bulletin: Oil Spill Modelling (NOPSEMA 2019) and are detailed in Table 81.

These thresholds have been used to:

- Predict potential hydrocarbon exposure at conservative (low exposure) concentrations to inform the description of the environment
- Inform the oil spill impact and risk evaluation
- Inform oil spill response planning based on the actionable thresholds of:
    - Surface moderate exposure (10 g/m^2)
    - Shoreline moderate exposure (100 g/m^2)
- Inform oil spill monitoring planning based on the low exposure thresholds.

	Threshold	Description
Surface		
Low exposure	1 g/m^2	Approximates range of socioeconomic effects and establishes planning area for scientific monitoring.
Moderate exposure	10 g/m^2	Approximates lower limit for harmful exposures to birds and marine mammals.
High exposure	50 g/m^2	Approximates surface oil slick and informs response plan.
Shoreline		
Low exposure	10 g/m^2	Predicts potential for some socio-economic impact.
Moderate exposure	100 g/m^2	Loading predicts area likely to require clean-up effort.
High exposure	1000 g/m^2	Loading predicts area likely to require intensive clean-up effort.
Dissolved*		
Low exposure	10 ppb	Establishes planning area for scientific monitoring based on potential for exceedance of water quality triggers.
Moderate exposure	50 ppb	Approximates potential toxic effects, particularly sublethal effects to sensitive species.
High exposure	400 ppb	Approximates toxic effects including lethal effects to sensitive species
Entrained*		
Low exposure	10 ppb	Establishes planning area for scientific monitoring based on potential for exceedance of water quality triggers.
High	100 ppb	As appropriate given oil characteristics for informing risk evaluation.

Table 81: Exposure and contact threshold values used for the spill modelling study

7.4.2.4 Summary of Modelling Results

The potential environmental impacts to receptors from are discussed in Tables 82 to 84 (MDO spill) and Tables 85 to 87 (Condensate LOWC) and are based on the spill modelling areas of exposure from the two release locations, detailed in Appendix M and summarised below.

7.4.2.4.1 Vessel Collision (MDO) at Release Location North

Potential extent of hydrocarbon exposure to surface waters

The maximum distance from the release location to the low (1–10 g/m2), moderate (10–50 g/m2) and high (> 50 g/m2) exposure zones was 54 km (east) during winter conditions, 19 km (south-southeast) during winter conditions and 10 km (north-northwest in summer and east in winter).

No State waters were predicted to be exposed to surface oil. No conservation values or sensitivities (Section 4.2) were identified to be exposed to surface oil at the low threshold or above.

Maximum residence time for low threshold was 2 days and moderate and high was 1 day.

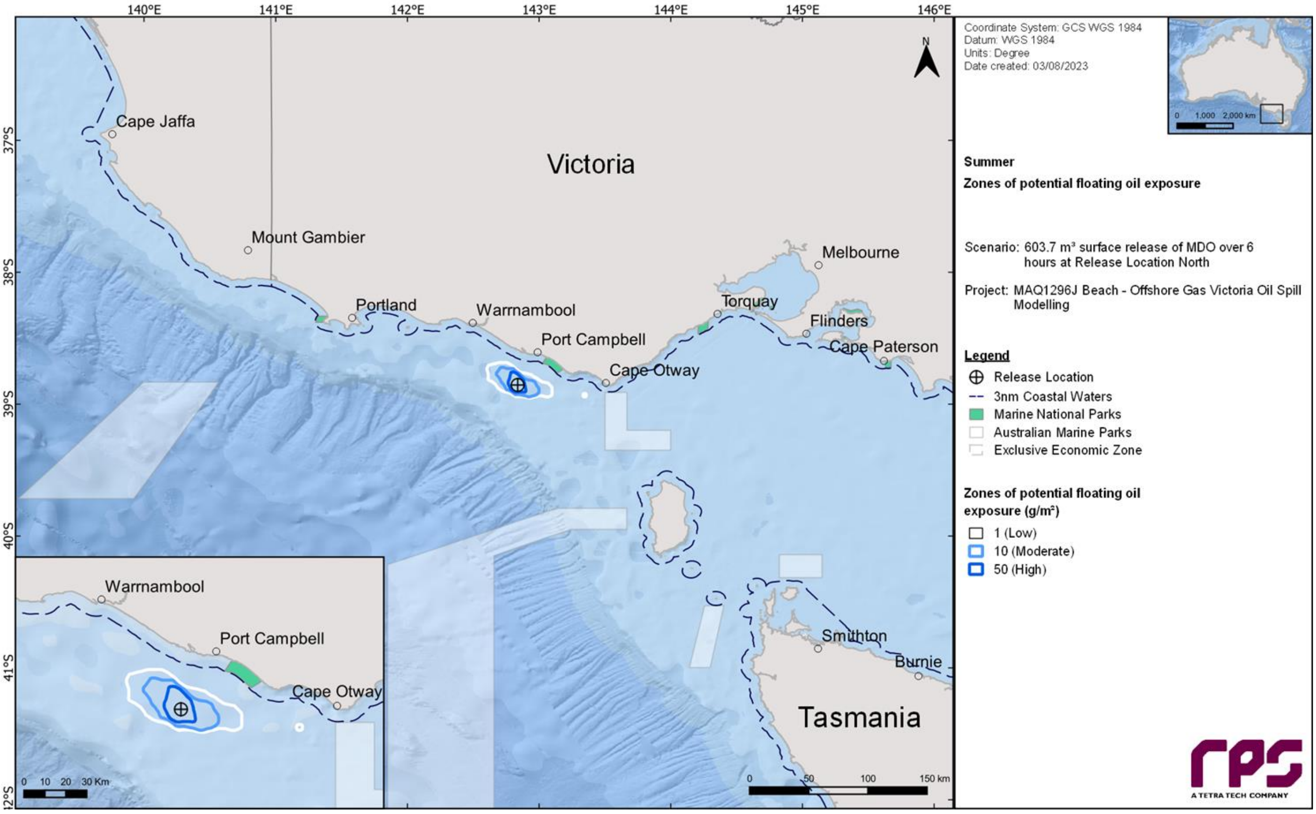


Figure 110: Floating oil exposure – MDO Release Location North (Summer)

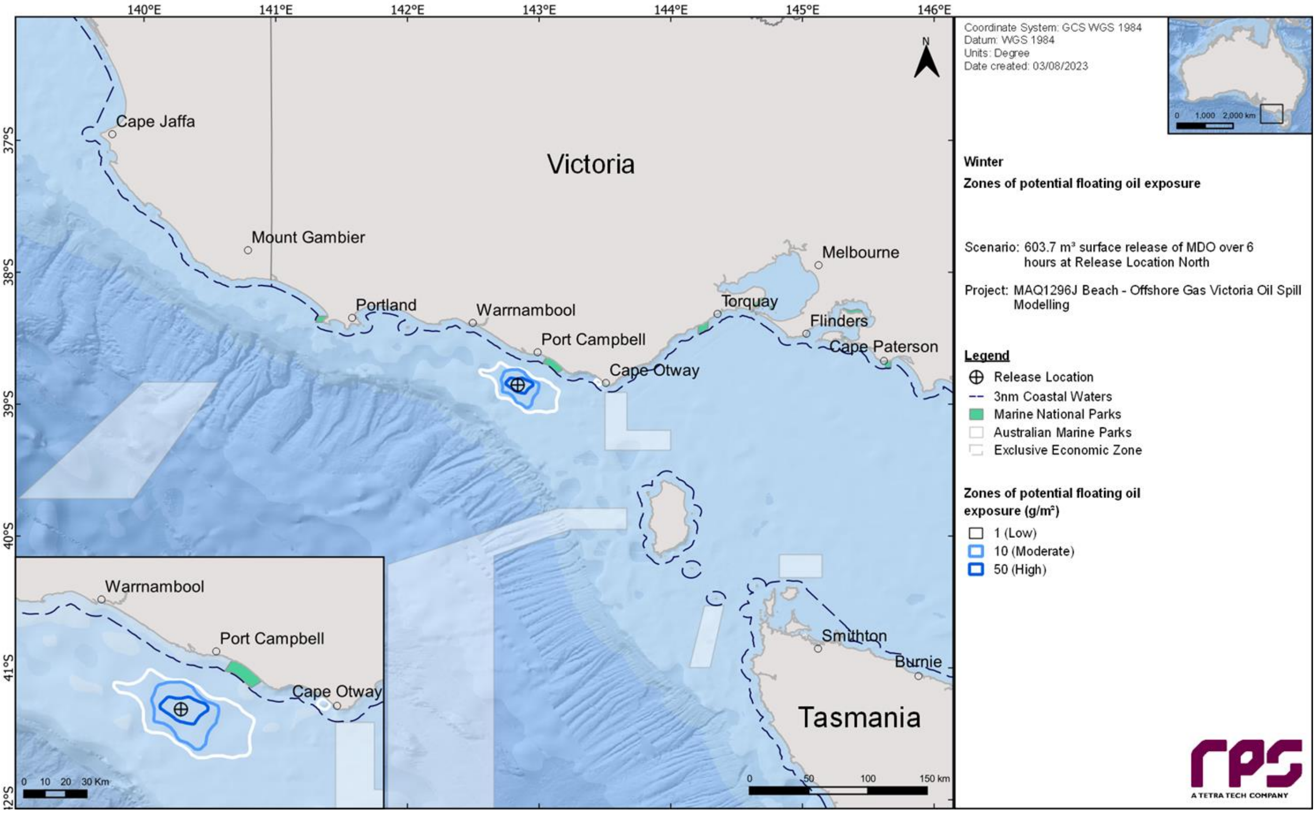


Figure 111: Floating oil exposure – MDO Release Location North (Winter)

Potential extent of hydrocarbon exposure to shorelines

The probability of accumulation to any shoreline at, or above, the low level (10 g/m2) threshold was 28% during summer conditions and 26% during winter conditions.

The maximum volume ashore for a single spill trajectory during the summer and winter conditions was 25 m3 and 35 m3, respectively, whilst the maximum length of shoreline accumulation at the low threshold was 26 km and 30 km, respectively

The minimum time before oil accumulation at, or above, the low threshold was 4 days during summer conditions, and 2 days during winter conditions

For the moderate threshold (100 g/m2), the maximum length of shoreline accumulation predicted was 9 km and 10 km during summer and winter respectively. No shoreline accumulation was predicted for the high (1,000 g/m2) threshold.

Colac Otway recorded the highest probability of shoreline accumulation at the low threshold with 24% (summer) and 20% (winter) and the largest shoreline accumulation with 24 m3 and 34 m3, respectively.

The minimum time before shoreline accumulation above the low threshold was 4 days predicted for Colac Otway and Cape Patton during summer conditions and 2 days during the winter conditions.

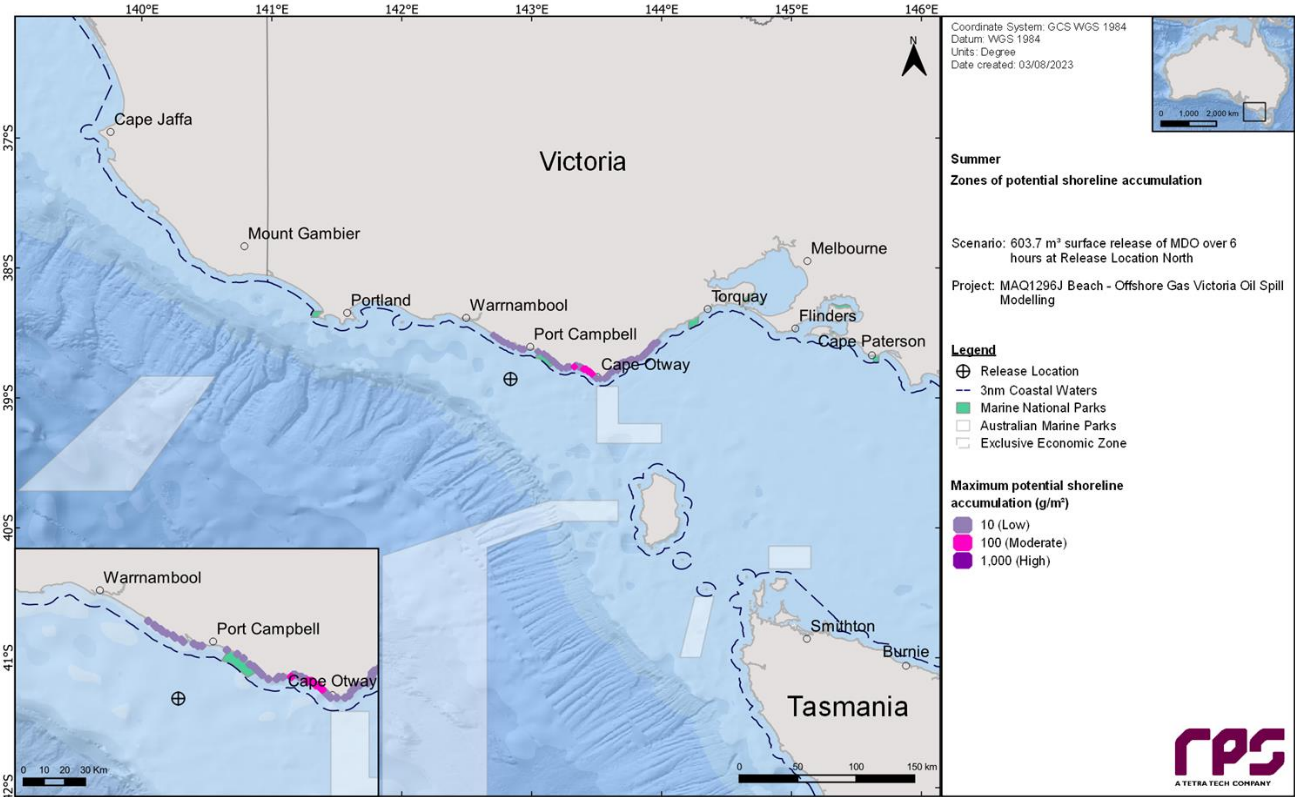


Figure 112: Shoreline oil exposure – MDO Release Location North (Summer)

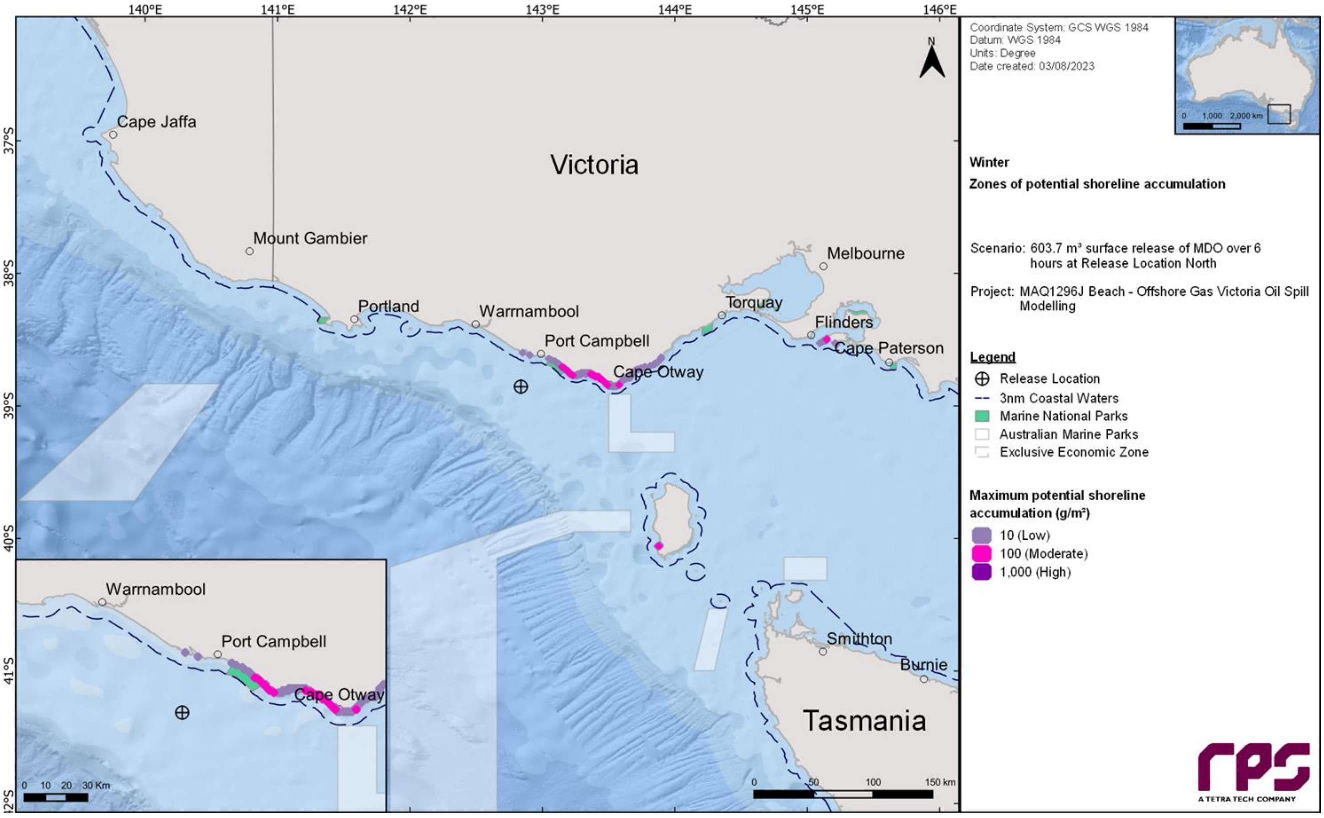


Figure 113: Shoreline oil exposure – MDO Release Location North (Winter)

Potential extent of in-water dissolved hydrocarbon exposure

At the depths of 0-10 m, during the summer and winter conditions the maximum dissolved aromatic concentrations at any given receptor was predicted to be 45 ppb and 31 ppb, respectively.

No dissolved hydrocarbon exposure at the high (400 ppb) threshold was predicted.

Victorian waters were predicted to be exposed to dissolved hydrocarbons at the low threshold with a probability of 2%.

The Apollo AMP was predicted to be exposed above the low threshold during both summer and winter conditions with 1% and 3% probability, respectively.

The maximum residence time of dissolved hydrocarbon exposure at the low and moderate thresholds was 1 day.

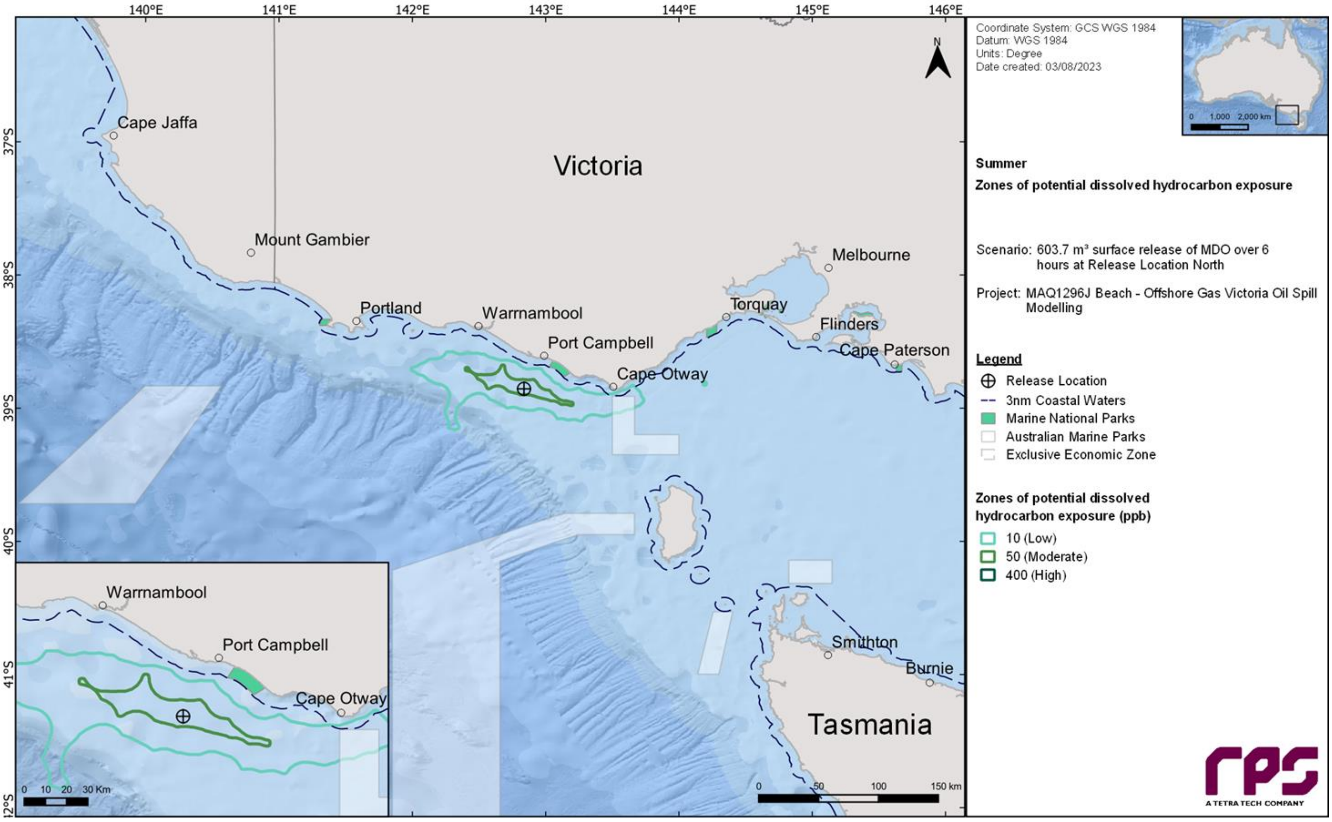


Figure 114: Dissolved oil exposure – MDO Release Location North (Summer)

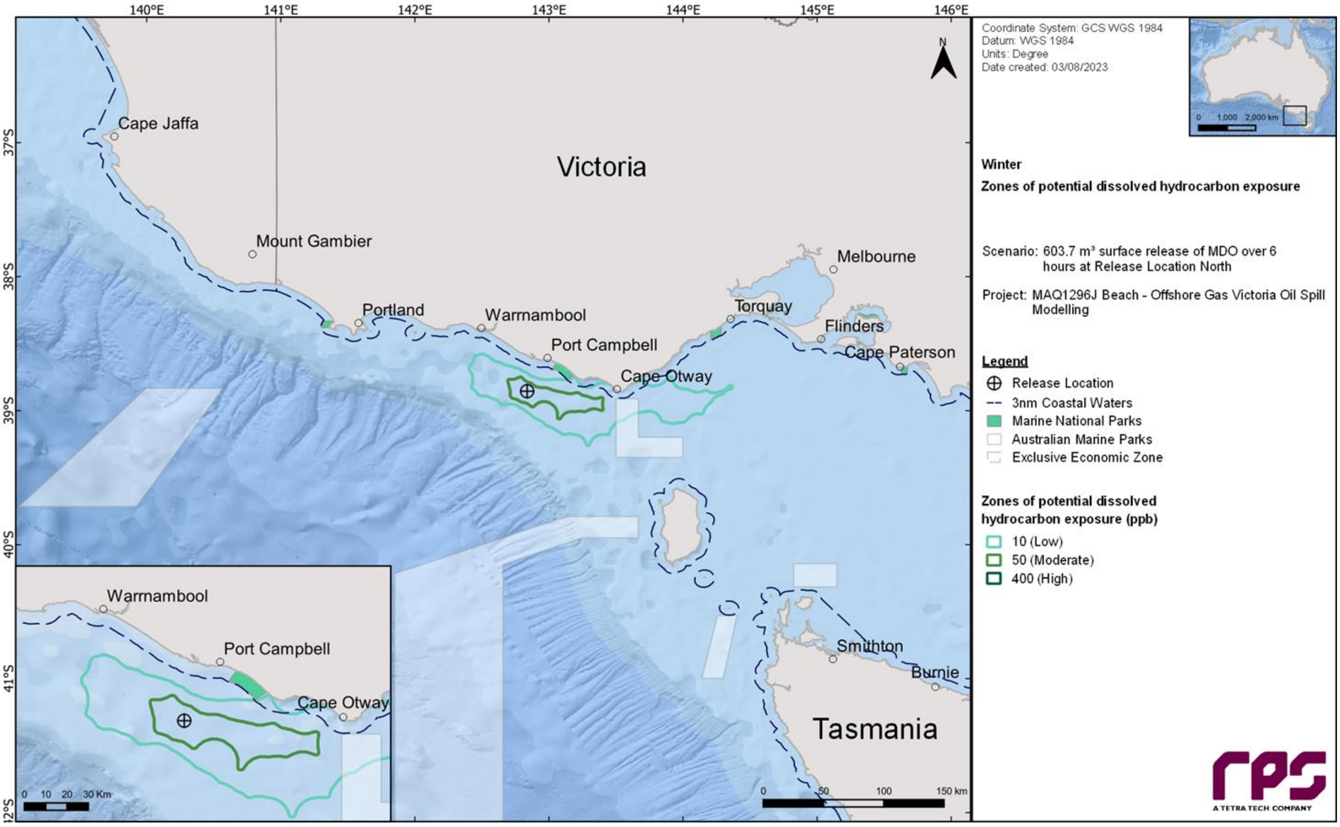


Figure 115: Dissolved oil exposure – MDO Release Location North (Winter)

Potential extent of in-water entrained hydrocarbon exposure

At the depths of 0-10 m, the maximum entrained hydrocarbon exposure during summer and winter conditions to any given receptor was 801 ppb and 1,326 ppb, respectively.

Victorian waters were predicted to be impacted with a probability of 32% above the low threshold and 7% above the high threshold.

The Apollo AMP was predicted to be impacted with a probability of 63% above the low threshold and 9% above the high threshold.

The Twelve Apostles MNP was predicted to be impacted with a probability of 9% above the low threshold and 1% above the high threshold.

The Bonney Coast Upwelling and West Tasmanian Canyons KEFs were predicted to be exposed at the low threshold with a 1% probability.

The maximum residence time of entrained hydrocarbon exposure at the low threshold was 14 days and at the high threshold was 4 days.

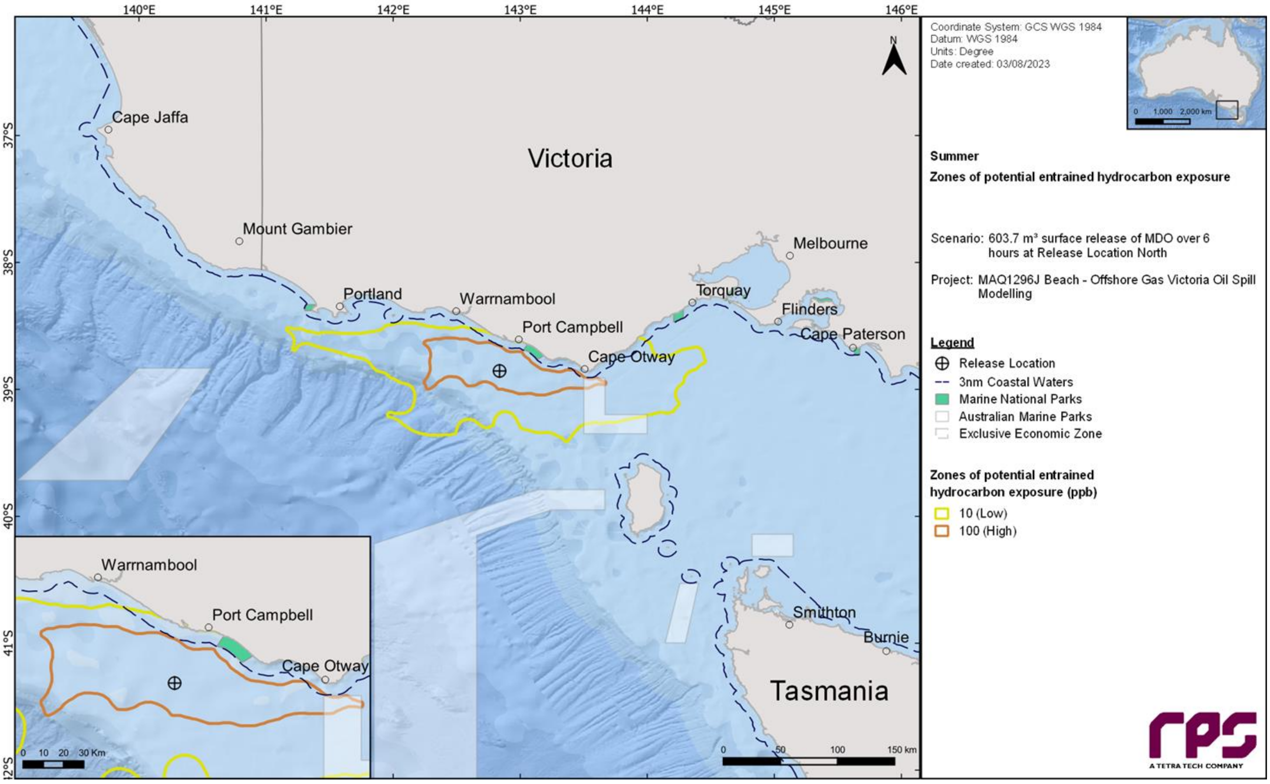


Figure 116: Entrained oil exposure – MDO Release Location North (Summer)

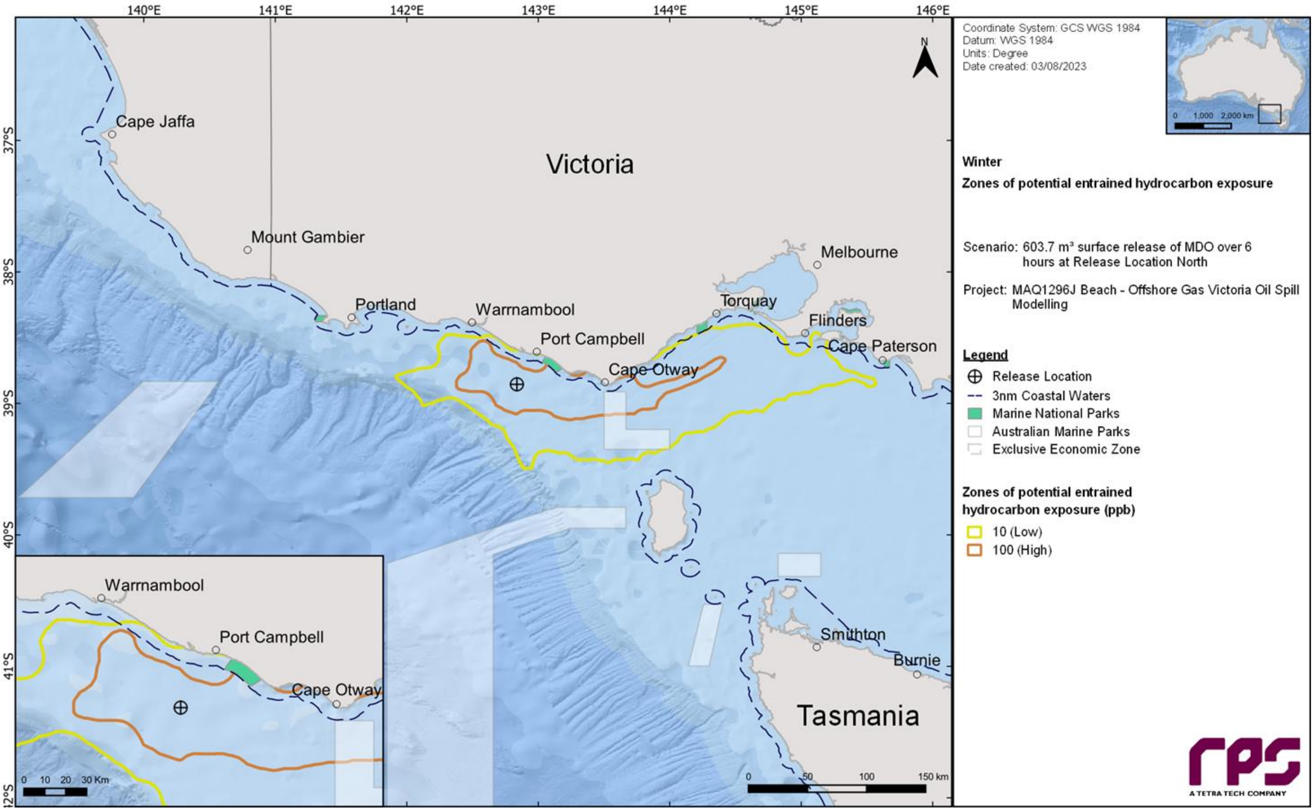


Figure 117: Entrained oil exposure – MDO Release Location North (Winter)

7.4.2.4.2 MDO at Release Location South

Potential extent of hydrocarbon exposure to surface waters

The maximum distance from the release location to the low (1–10 g/m2), moderate (10–50 g/m2) and high (> 50g/ m2) exposure zones was 57 km (south-southeast) during winter conditions, and 48 km (south-southeast) during winter conditions and 8 km (south-southeast) during both seasons respectively.

No State waters were predicted to be exposed to surface oil.

No conservation values or sensitivities (Section 4.2) were identified to be exposed to surface oil at the low threshold or above.

Maximum residence time for low threshold was 2 days and moderate and high was 1 day.

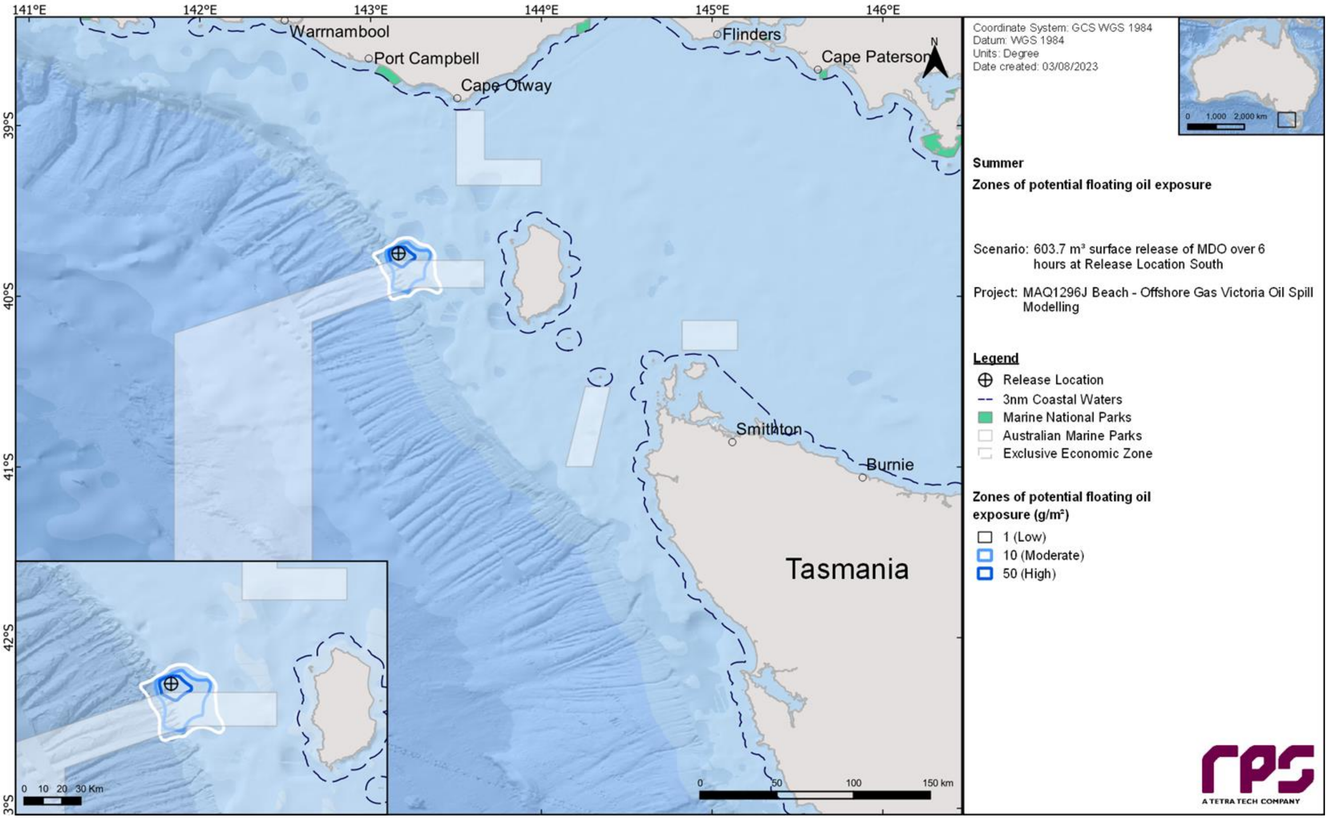


Figure 118: Floating oil exposure – MDO Release Location South (Summer)

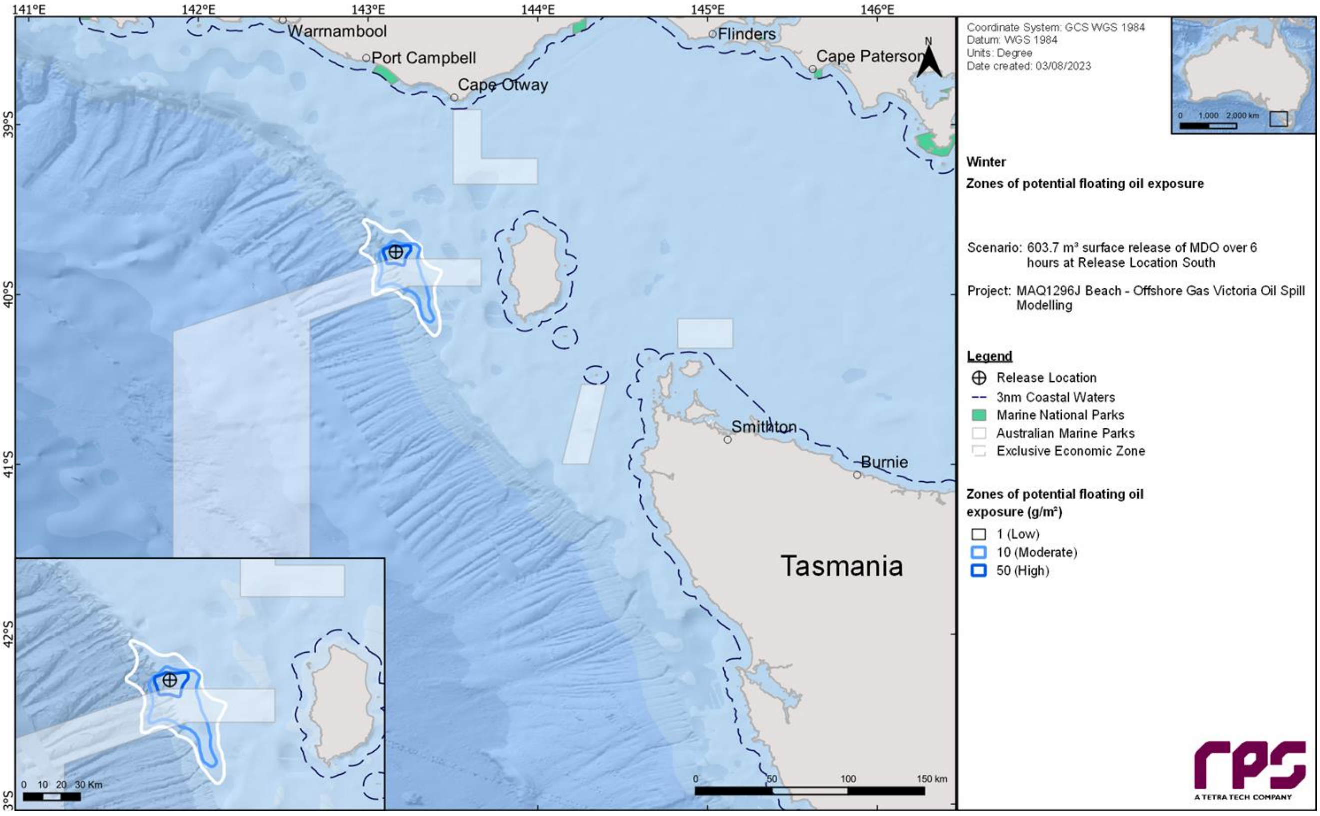


Figure 119: Floating oil exposure – MDO Release Location South (Winter)

Potential extent of hydrocarbon exposure to shorelines

The probability of accumulation to any shoreline at, or above, the low level (10 g/m2) threshold was 7% during summer conditions and 47% during winter conditions.

The maximum volume ashore for a single spill trajectory during the summer and winter conditions was 5 m3 and 29 m3, respectively, whilst the maximum length of shoreline accumulation at the low threshold was 13 km and 35 km, respectively.

Only during winter shoreline accumulation was predicted for the moderate threshold (100 g/m2), with a maximum length of shoreline predicted of 6 km at a 13% probability.

No shoreline accumulation at the high threshold (1,000 g/m2) was predicted.

The minimum time before shoreline accumulation above the low threshold was 8 days predicted for King Island during summer conditions and 4 days during the winter conditions.

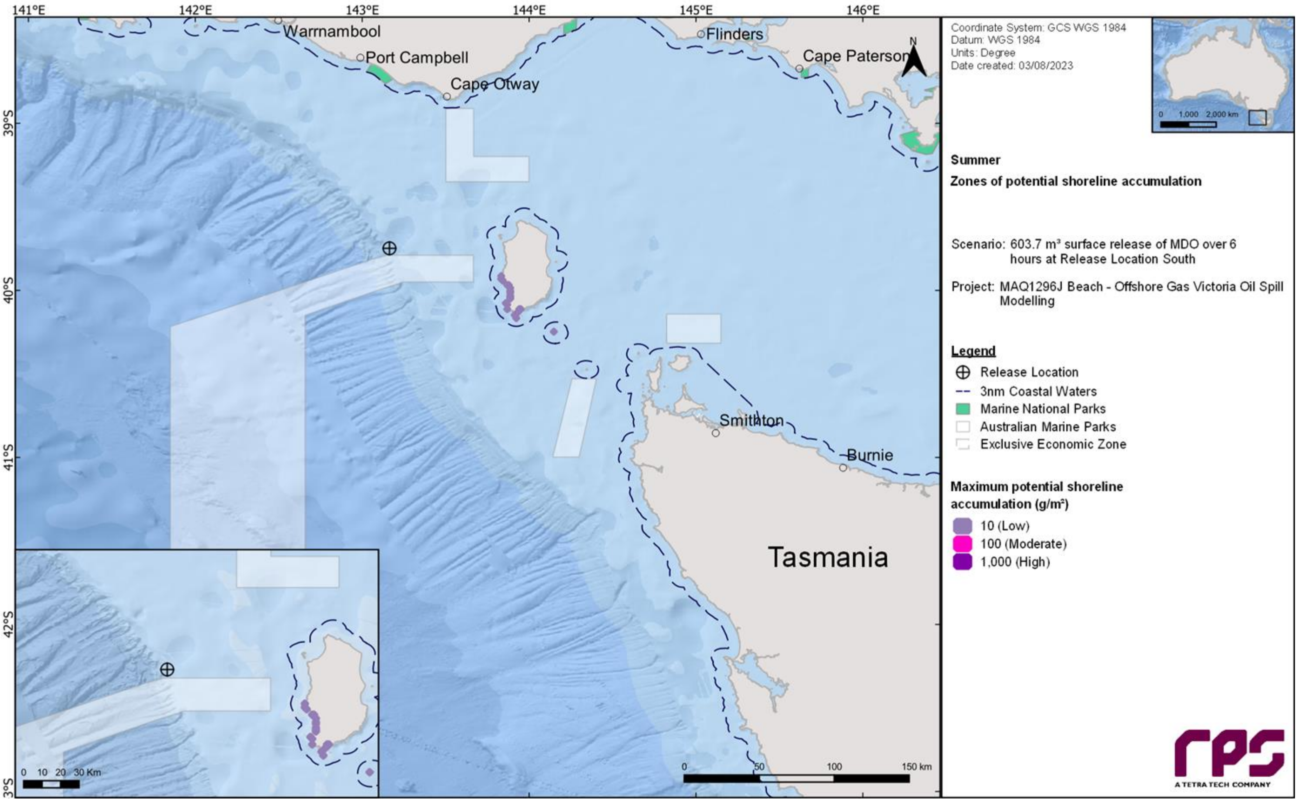


Figure 120: Shoreline oil exposure – MDO Release Location South (Summer)

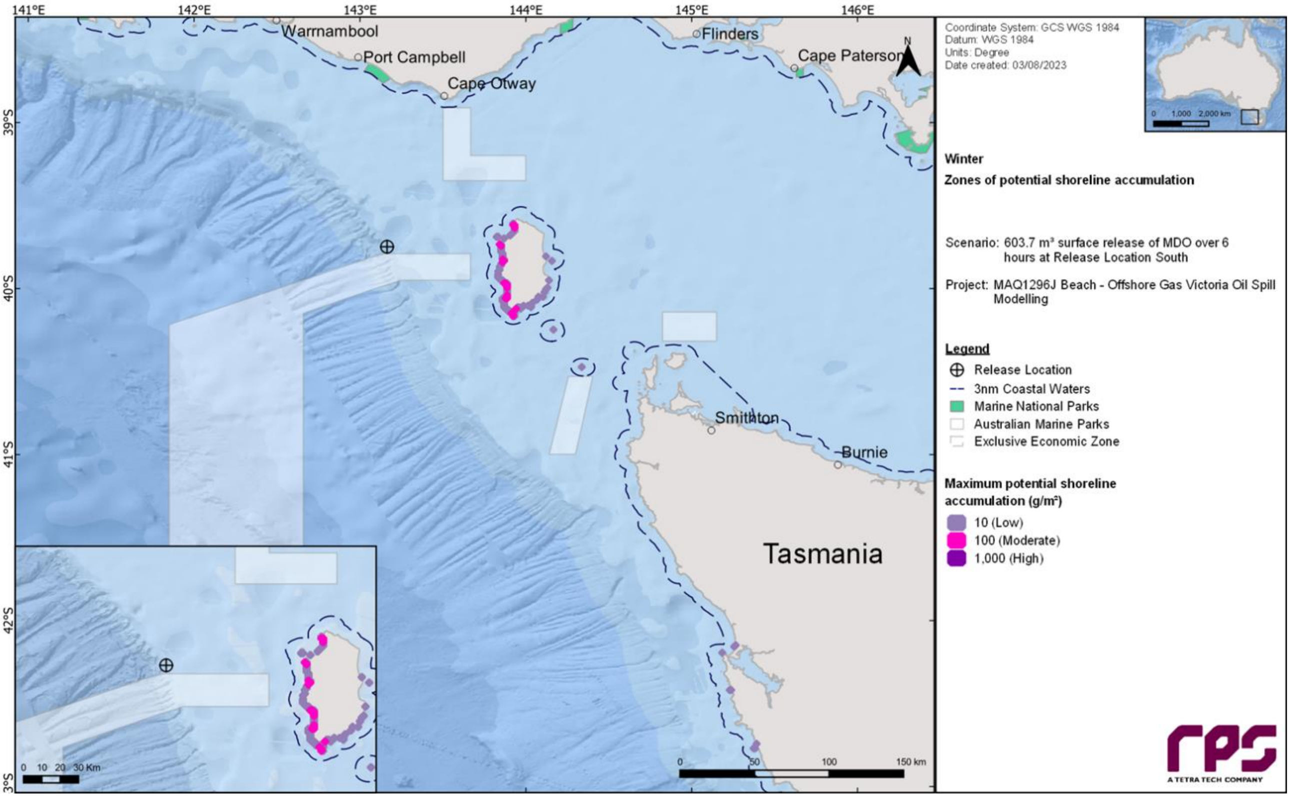


Figure 121: Shoreline oil exposure – MDO Release Location South (Winter)

Potential extent of in-water dissolved hydrocarbon exposure

At the depths of 0-10 m, during the summer and winter conditions the maximum dissolved aromatic concentrations at any given receptor was predicted to be 57 ppb and 58 ppb, respectively.

No dissolved hydrocarbon exposure at the high (400 ppb) threshold was predicted,

Tasmanian waters were predicted to be exposed to dissolved hydrocarbons above the low threshold at a 1% probability and only in Winter.

Zeehan AMP was predicted to be exposed above the low threshold at 21% and moderate threshold at 2% probabilities.

The West Tasmanian Canyons KEF was predicted to be exposed above the low and moderate thresholds at 13% and 1% probability respectively.

The maximum residence time of dissolved hydrocarbon exposure at the low and moderate thresholds was 1 day.

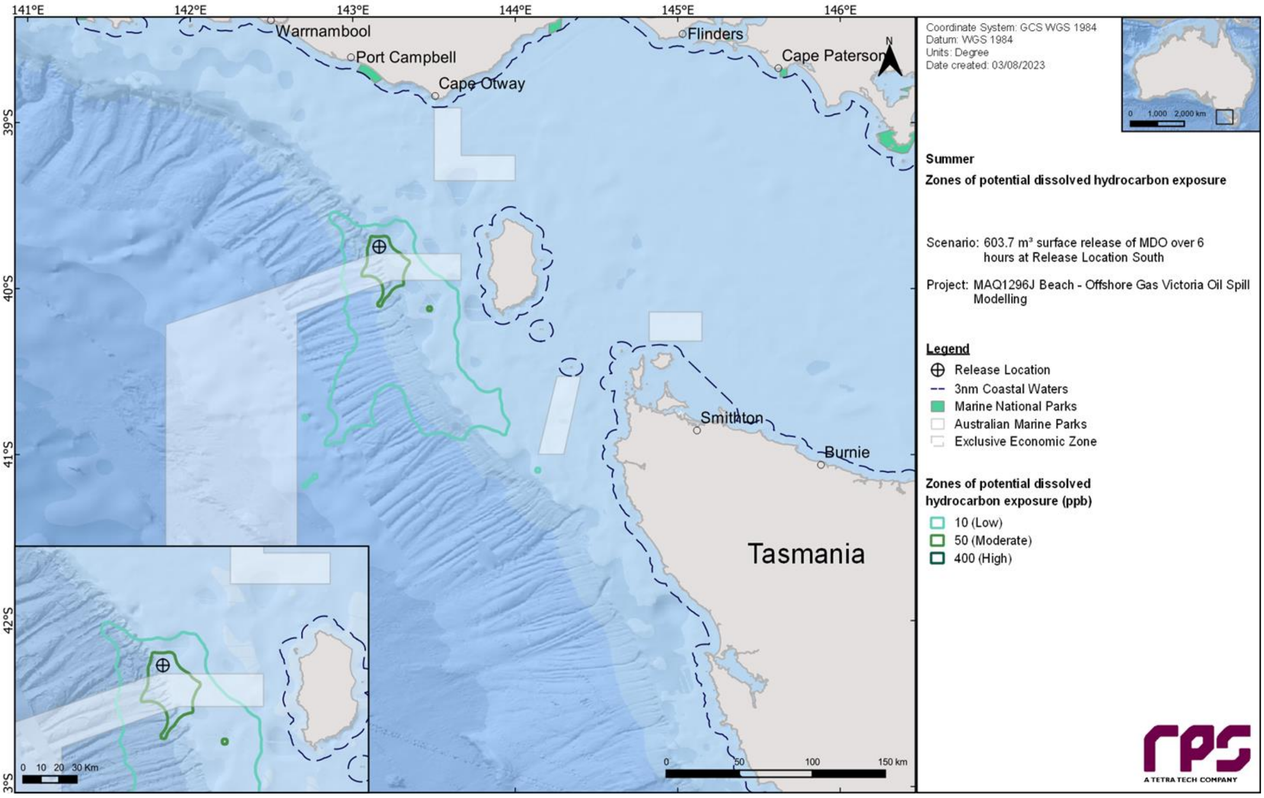


Figure 122: Dissolved oil exposure – MDO Release Location South (Summer)

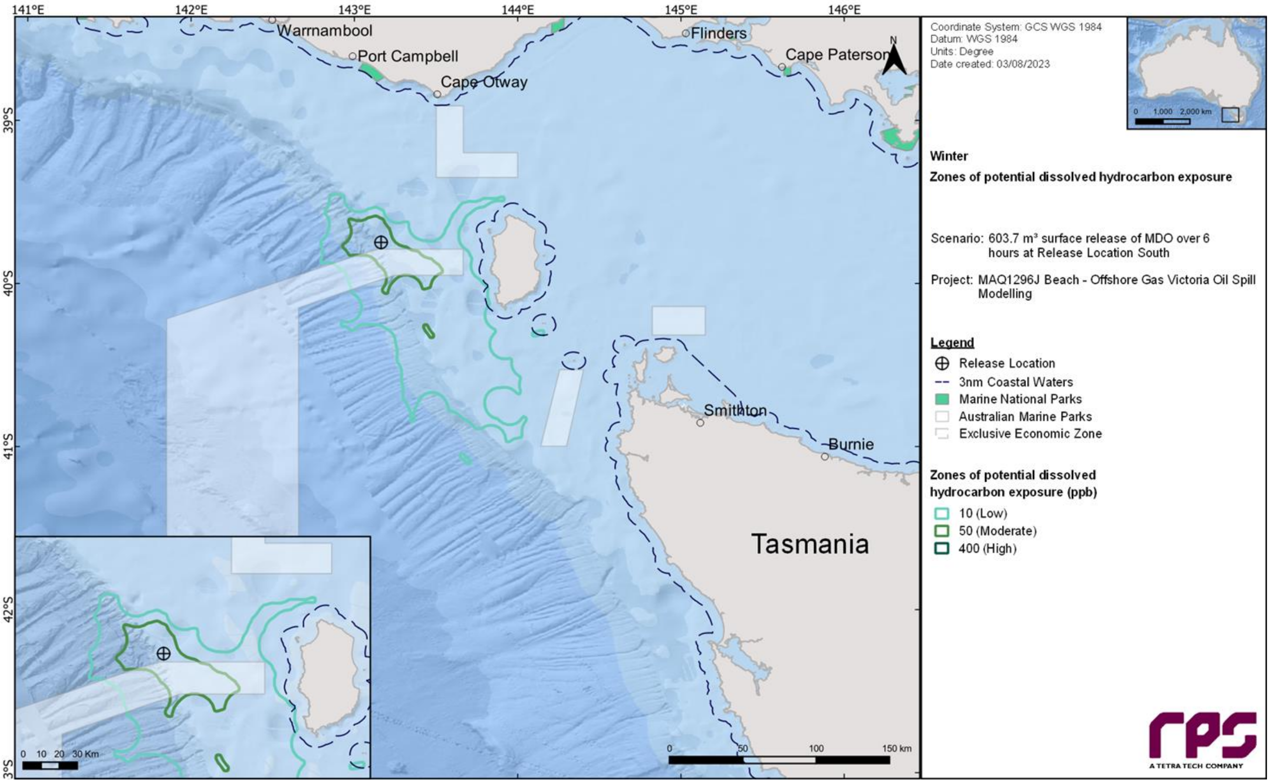


Figure 123: Dissolved oil exposure – MDO Release Location South (Winter)

Potential extent of in-water entrained hydrocarbon exposure

At the depths of 0-10 m, the maximum entrained hydrocarbon exposure during summer and winter conditions to any given receptor was 4,867 ppb and 5,489 ppb, respectively.

Tasmanian waters were predicted to be impacted with a probability of 30% above the low threshold and 2% above the high threshold.

The Apollo and Franklin AMPs were predicted to be impacted with probabilities of 1% and 4% above the low threshold respectively. The Zeehan AMP was predicted to be impacted with a probability of 86% above the low threshold and 64% above the high threshold.

The West Tasmanian Canyons KEFs was predicted to be impacted with a probability of 80% above the low threshold and 54% above the high threshold.

The maximum residence time of entrained hydrocarbon exposure at the low threshold was 14 days and at the high threshold was 4 days.

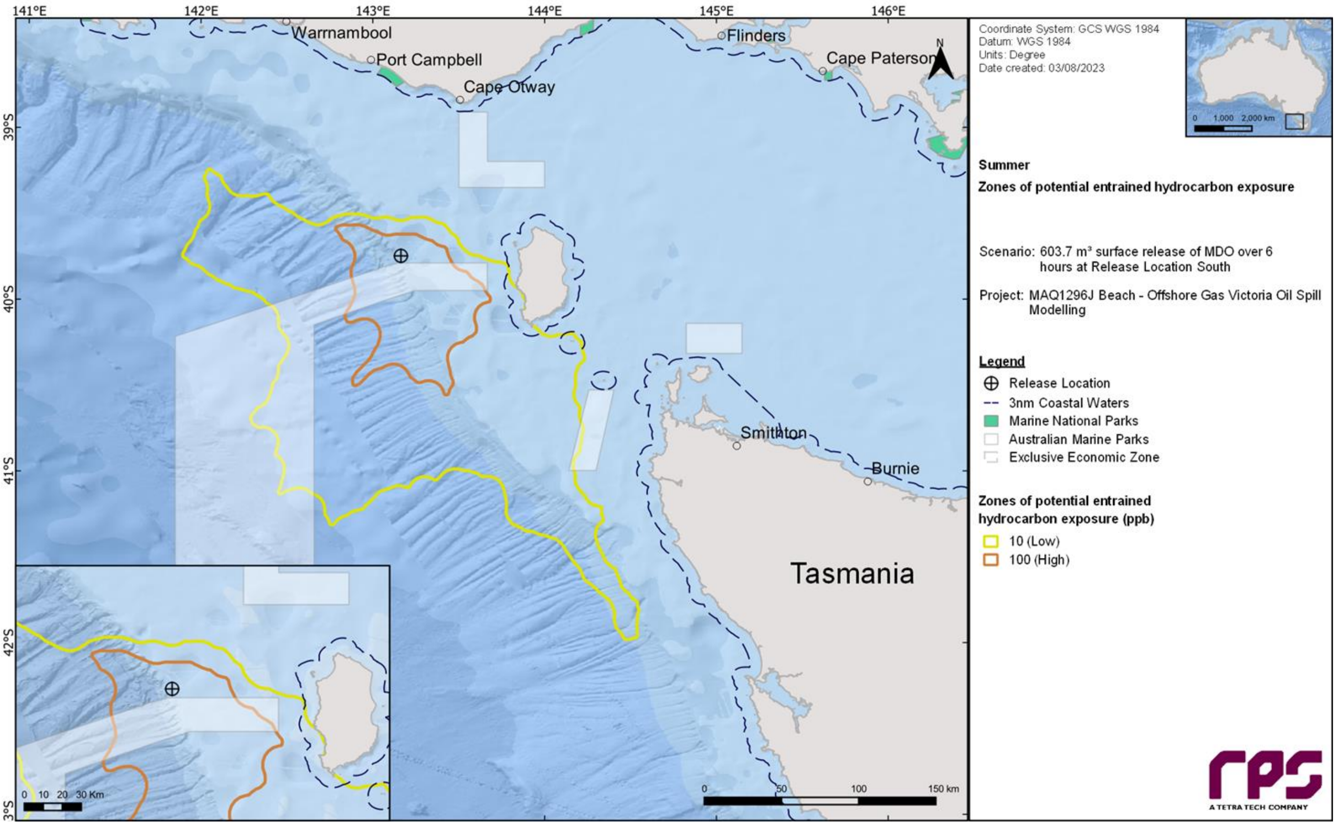


Figure 124: Entrained oil exposure – MDO Release Location South (Summer)

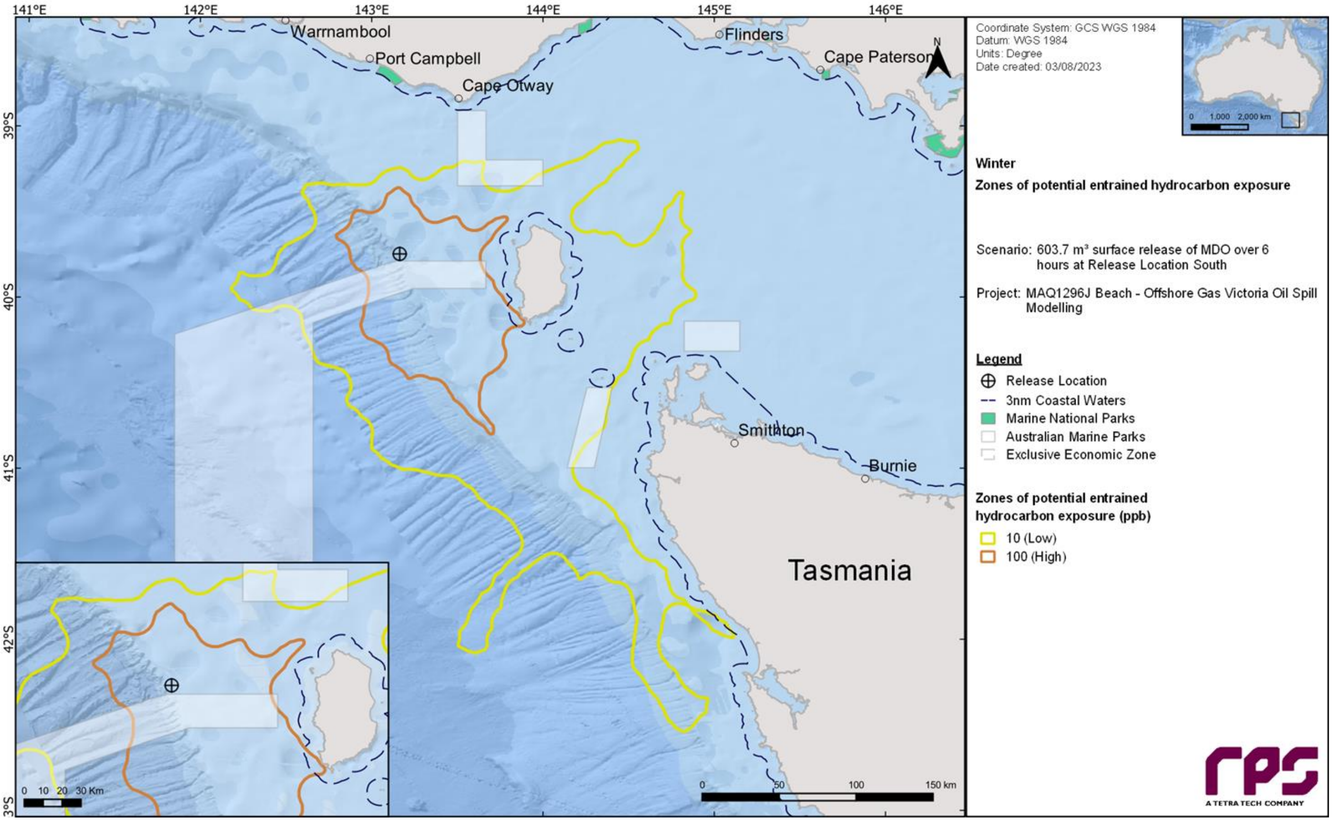


Figure 125: Entrained oil exposure – MDO Release Location South (Winter)

Sea Surface

Receptor Group	Receptor Type	Impact	Exposure Evaluation	Consequence Evaluation
Marine fauna	Seabirds	Change in fauna behaviour Injury / mortality to fauna	Several listed Threatened, Migratory and/or listed marine species have the potential to be rafting, resting, diving and feeding within between 19 and 48 km of the release locations predicted to be exposed to moderate levels of surface hydrocarbons. Foraging BIAs for several albatross species, the wedge-tailed shearwater, common diving-petrel, short-tailed shearwater and wedge-tailed shearwater are present in the areas predicted to be above moderate levels of surface hydrocarbons. Foraging and breeding BIAs for little penguins are within the planning area, but not within the predicted area of surface exposure at moderate levels. Colonies of little penguins, without defined BIAs, are known to be present along parts of Port Campbell Bay area; therefore, it is possible that little penguins may be present in the area exposed to surface hydrocarbon at moderate levels.	When first released, diesel has higher toxicity due to the presence of volatile components. Individual birds making contact close to the spill source at the time of the spill (i.e. areas of moderate concentrations >10 g/m^2 out to between 19km and 48km from the release locations) may be impacted; however, it is unlikely that many birds will be affected as volatile surface hydrocarbons are expected to evaporate over 24 hours. Seabirds rafting, resting, diving or feeding at sea have the potential to encounter areas where hydrocarbons concentrations are greater than 10 g/m^2 and due to physical oiling may experience lethal surface concentrations. As such, acute or chronic toxicity impacts (death or long-term poor health) to birds are possible but unlikely for a diesel spill because of the limited period of exposure above 10 g/m^2. Sea surface oil >10 g/m^2 (10 µm) is only predicted for the first 24 hours limiting the period when oiling may occur. Therefore, potential impact would likely be limited to individuals, however, impacts to aggregations may occur. There is the potential for serious impact on valued species or habitats with a consequence considered to be **Serious (3).**
	Marine reptiles	Change in fauna behaviour Injury / mortality to fauna	There may be marine turtles in the area predicted to be exposed to surface oil. However, there are no BIAs or habitat critical to the survival of the species within this area	Marine turtles are vulnerable to the effects of oil at all life stages. Marine turtles can be exposed to surface oil externally (i.e. swimming through oil slicks) or internally (i.e. swallowing the oil). Ingested oil can harm internal organs and digestive function. Oil on their bodies can cause skin irritation and affect breathing. The number of marine turtles that may be exposed to surface diesel is expected to be low as there are no BIAs or habitat critical to the survival of the species present; however, turtles may be transient within the area of exposure. Sea surface oil >10 g/m^2 (10 µm) is only predicted for the first 24 hrs limiting the period when oiling may occur. Therefore, potential impact would likely be limited to individuals, with population impacts not anticipated.

Receptor Group	Receptor Type	Impact	Exposure Evaluation	Consequence Evaluation
				There could be expected to be minor short-term impacts and some impact on valued species or habitats with a potential consequence considered to be **Moderate (2)**
	Pinnipeds (seals and sea lions)	Change in fauna behaviour Injury / mortality to fauna	The Australian and New Zealand fur-seals may occur within the area predicted to be exposed to moderate surface hydrocarbons >10 g/m^2. No BIAs, breeding colonies or haul outs areas are within the area of exposure. There is a foraging BIA for the Australian sea-lion but it is outside of the predicted area of surface exposure at >10 g/m^2.	Seals are vulnerable to sea surface exposures given they spend much of their time on or near the surface of the water, as they need to surface every few minutes to breathe. Exposure to surface oil can result in skin and eye irritations and disruptions to thermal regulation. Fur seals are particularly vulnerable to hypothermia from oiling of their fur. The number of seals that may be exposed to surface diesel at >10 g/m^2 is expected to be low as there are no BIAs or habitat critical to the survival of the species present; however, seals may be transient in low numbers within areas of potential surface exposure at >10 g/m$^{2.}$ Sea surface oil >10 g/m^2 (10 µm) is only predicted for the first 24 hours limiting the period when oiling may occur. Therefore, potential impact would be limited to individuals, with population impacts not anticipated. There could be expected to be minor short-term impacts and some impact on valued species or habitats with a potential consequence considered to be **Moderate (2)**
	Cetaceans (whales)	Change in fauna behaviour Injury / mortality to fauna	Several threatened, migratory and/or listed marine species have the potential to be within the area predicted to be exposed to moderate surface hydrocarbons of >10 g/m^2. BIAs for foraging for pygmy blue whales and the migration BIA for southern right whales are within the area predicted to be exposed to surface hydrocarbons >10 g/m^2	Geraci (1988) found little evidence of cetacean mortality from hydrocarbon spills; however, some behaviour disturbance (including avoidance of the area) may occur. While this reduces the potential for physiological impacts from contact with hydrocarbons, active avoidance of an area may displace individuals from important habitat, such as foraging. If whales are foraging at the time of the spill, a greater number of individuals may be present in the area where sea surface oil is present, however sea surface oil >10 g/m^2 (10 µm) is only predicted for the first 24 hours limiting the period when oiling may occur. Also, the area exposed by moderate levels of surface hydrocarbons (between 19 and 48km from the release locations) is relatively small compared to the overall distribution area of cetaceans. Given this is a relatively small area of the total foraging BIA for pygmy blue whales

Receptor Group	Receptor Type	Impact	Exposure Evaluation	Consequence Evaluation
				and migrating BIA for southern right whales, the risk of displacement to whales is considered low. Project activities could occur at any time of year. Therefore, there is potential for interaction with southern right whales given the activity window overlaps with the northern migration period of May-June, the peak breeding (July-August) and southern migration period (September-November). The activity timing overlaps with the blue whale season for migration and foraging in the impact area Visual and acoustic surveys suggest that blue whales are present in the Otway region between November to June, peaking in February and March. It is expected that foraging whales would be present in the area. As such in the event of a spill potential hydrocarbon exposure could possibly affect aggregations of blue or other foraging whale species. There is the potential for serious impact on valued species or habitats with a consequence considered to be **Serious (3).**
	Cetaceans (dolphins)	Change in fauna behaviour Injury / mortality to fauna	Several dolphin species have the potential to be within the area predicted to be exposed to moderate surface hydrocarbons of >10 g/m^2. However, there are no BIAs or habitat critical to the survival of the species	Dolphins surface to breathe air and may inhale hydrocarbon vapours or be directly exposed to dermal contact with surface hydrocarbons. Direct contact with oil can result in direct impacts to the animal, due to toxic effects if ingested, damage to lungs when inhaled at the surface, and damage to the skin and associated functions such as thermoregulation (AMSA 2010). Dolphins are highly mobile and are considered to have some ability to detect and avoid oil slicks (Geraci and St. Aubin, 1988; Smith et al, 1983). Direct surface hydrocarbon contact may pose little problem to dolphins due to their extraordinarily thick epidermal layer which is effective as a barrier to the substances found in hydrocarbons (Geraci and St. Aubin, 1990; Volkman et al., 1994). The number of dolphins exposed is expected to be low. If dolphins are foraging at the time of the spill, a greater number of individuals may be present in the area where sea surface oil is present, however due to the short duration of the surface exposure above the impact threshold (approximately 24 hrs), this is not likely.

Receptor Group	Receptor Type	Impact	Exposure Evaluation	Consequence Evaluation
				There could be expected to be minor short-term impacts and some impact on valued species or habitats with a potential consequence considered to be **Moderate (2)**
Socio-economic	Petroleum Exploration and Production	Displacement of other marine users	There are no oil and gas operations or activities within the area predicted to be exposed to surface hydrocarbons >10 g/m^2 (between 19 and 48km from the release locations).	No impact predicted as there are no non-Beach oil and gas platforms located within the area predicted to be exposed to surface hydrocarbons.
	Shipping	Displacement of other marine users	Shipping occurs within the area predicted to be exposed to surface hydrocarbons >10 g/m^2 (between 19 and 48 km from the release locations).	Vessels may be present in the area where sea surface oil is present, however, due to the short duration of the surface exposure (approximately 24 hrs) deviation of shipping traffic would be unlikely.
	Tourism and recreation (including recreational diving and recreational fisheries)	Change in aesthetic value Changes to the functions, interests or activities of other users	Marine pollution can result in reduced visual aesthetic. The modelling predicts visible surface sheen at the low threshold up to 57 km for up to 2 days. This oil may be visible as a rainbow sheen on the sea surface during calm conditions.	Visible surface hydrocarbons (i.e. a rainbow sheen) have the potential to reduce the visual amenity of the area for tourism and discourage recreational activities. There may be short-term and localised consequences, which are ranked as **Moderate (2).** Refer also to: ecological receptors above.
	Commercial fisheries	Change in aesthetic value Changes to the functions, interests or activities of other users	Commercial fishing occurs within the area predicted to be exposed to surface hydrocarbons >10 g/m^2 (between 19 and 48 km from the release locations).	Commercial fishing vessels may be present in the area where sea surface oil is present, however, due to the short duration of the surface exposure (approximately 24 hrs) deviation of vessels would be unlikely. Impacts to commercial fish and invertebrate species are not predicted from surface oil. A short-term fishing exclusion zone may be implemented. However, given the temporary nature of any surface oil and the low intensity in the area of exposure, there are unlikely to be any significant impact on fisheries in terms of lost catches (and associated income). There may be short-term and localised consequences, which are ranked as **Moderate (2)**

Receptor Group	Receptor Type	Impact	Exposure Evaluation	Consequence Evaluation
First Nations	Sea Country	Change in aesthetic value Changes to the functions, interests or activities of other users	Marine pollution can result in reduced visual aesthetic. The modelling predicts visible surface sheen at the low threshold up to 57 km for up to 2 days. This oil may be visible as a rainbow sheen on the sea surface during calm conditions.	Beach understands that First nations people are linked to the marine environment and may be affected by a change in the environment. Although no long term or permanent changes to marine environment are expected it is considered that the visual presence of floating oil may impact Sea Country at a spiritual level (ie rituals, songlines, totem species) and could affect culturally important activities such as mutton birding or affect totem fauna. There may be short-term and localised consequences, which are ranked as **Moderate (2).** Refer also to: ecological receptors above.

Table 82: Environmental impact summary from floating oil exposure (MDO spill)

<u>Shoreline</u>

Receptor Group	Receptor Type	Impact	Exposure Evaluation	Consequence Evaluation
Conservation Values and Sensitivities	National Heritage Places	Change in aesthetic value Changes to the functions, interests or activities of other users	Marine pollution can result in reduced visual aesthetic. The modelling predicts potential shoreline exposure from the Release Location North at the low and moderate thresholds at Great Ocean Road and Scenic Environs.	Visible shoreline hydrocarbons has the potential to reduce the visual amenity of the area for tourism and discourage recreational activities. The predicted minimum time for oil to reach this shoreline is 2-4 days and it is likely to have dissipated during that time. Cape Otway is exposed to substantial wave action that would further breakdown any shoreline hydrocarbons. There may be minor short-term consequences, which are ranked as **Moderate (2)**
	Nationally Important Wetlands	Change in aesthetic value Change in ecosystem dynamics Changes to the functions, interests or activities of other users	Marine pollution can result in reduced visual aesthetic. The modelling predicts potential shoreline exposure at the low threshold at Aire River/Lower Aire River Wetlands.	Visible shoreline hydrocarbons has the potential to reduce the visual amenity of the area for tourism and discourage recreational activities within protected areas. The predicted minimum time for oil to reach a shoreline is 2 to 4 days and it is likely to have dissipated during that time. Cape Otway is exposed to substantial wave action that would further breakdown any shoreline hydrocarbons. The Aire River/Lower Aire River Wetlands consist of three shallow freshwater lakes, brackish to saline marshes and an estuary on the

Receptor Group	Receptor Type	Impact	Exposure Evaluation	Consequence Evaluation
				Aire River floodplain. Depending on where the shoreline contact occurs there is a potential for shoreline oil to move into the estuary and wetlands at low concentrations which are not predicted to impact the aesthetic and ecological value of the wetlands. There may be minor short-term consequences, which are ranked as **Moderate. (2)**
	State Terrestrial Protected Area	Change in aesthetic value Change in ecosystem dynamics Changes to the functions, interests or activities of other users	Marine pollution can result in reduced visual aesthetic. The modelling predicts potential shoreline exposure at the low and moderate threshold at Great Otway National Park and the following on the west side of King Island; Cape Wickham Conservation Area, Cataraqui Point Conservation Area, Seal Rocks State Reserve and Stokes Point Conservations Area.	Visible shoreline hydrocarbons has the potential to reduce the visual amenity of the area for tourism and discourage recreational activities within protected areas. The predicted minimum time for oil to reach a shoreline is 2-4 days and it is likely to have dissipated during that time. Both Cape Otway and the west side of King Island are exposed to substantial wave action that would further breakdown any shoreline hydrocarbons. There may be minor short-term consequences, which are ranked as **Moderate (2).**
	Threatened Ecological Communities Saltmarshes	Change in ecosystem dynamics	Assemblages of species associated with open-coast salt-wedge estuaries of western and central Victoria ecological community and Subtropical and Temperate Coastal Saltmarsh may be exposure to shoreline oil at the low threshold.	Depending on where the shoreline contact occurs there is a potential for shoreline oil to move into these coastal communities at low concentrations which are not predicted to impact their ecological value of the wetlands. There may be minor short-term consequences, which are ranked as **Moderate (2).**
Threatened Species	Pinnipeds (seals and sea lions)	Injury/Mortality to fauna Change in fauna behaviour	The modelling predicts potential shoreline exposure at the low threshold at Seal Rocks on King Island which is a New Zealand fur-seal breeding colony.	Breeding colonies (used to birth and nurse until pups are weaned) are particularly sensitive to hydrocarbon spills (Higgins & Gass, 1993) however the low threshold is not considered to cause biological impact. This is ranked as **Minor (1)** consequence.

Receptor Group	Receptor Type	Impact	Exposure Evaluation	Consequence Evaluation
Socio-economic	Coastal settlements Recreation and tourism (including recreational fisheries)	Change in aesthetic value Changes to the functions, interests or activities of other users	Marine pollution can result in reduced visual aesthetic. The modelling predicts shoreline exposure at the low or moderate threshold at Cape Otway (Corangamite Shire) and on the west side of King Island.	Shoreline oil had potential for exposure on the west side of King Island and Cape Otway. The minimum time for shoreline accumulation at King Island was 7days and for Cape Otway it was 2-4 days. Visible shoreline hydrocarbons has the potential to reduce the visual amenity of the area for tourism and discourage recreational activities. The oil is likely to have dissipated. Both Cape Otway and the west side of King Island are exposed to substantial wave action that would further breakdown any shoreline hydrocarbons. There may be minor short-term consequences, which are ranked as **Moderate (2).**
	Seaweed industry	Change in ecosystem dynamics Changes to the functions, interests or activities of other users	The modelling predicts potential shoreline exposure at the low and moderate threshold in areas along the west side of King Island where bull kelp is collected.	Experiments verified the susceptibility of *Nereocystis luetkeana* (bull kelp – North America) tissue to the direct exposure to several petroleum types. Antrim et al (1995) showed that petroleum treatments resulted in visible tissue damage, with a distinct bleached line being the most visible indication of plant contact with the petroleum. Moderate to heavy colour loss, which was generally followed by rapid decay of tissue, was most pronounced in 24 h exposures to unweathered and weathered diesel. As bull kelp is collected from the shoreline there is a potential for some plants to be affected and not be suitable for collection and processing. However, given the low levels of shoreline oil predicted it is unlikely to be a significant impact on seaweed collection and associated income. There may be minor short-term consequences, which are ranked as **Moderate (2).**

Receptor Group	Receptor Type	Impact	Exposure Evaluation	Consequence Evaluation
First Nations	Sea Country Native Title	Change in aesthetic value Changes to the functions, interests or activities of other users	Marine pollution can result in reduced visual aesthetic. The modelling predicts shoreline exposure at the low and moderate threshold at Cape Otway (Eastern Maar native Title claim) and on the west side of King Island.	Beach understands that First nations people are linked to the marine environment and may be affected by a change in the environment. Although no long term or permanent changes to marine environment are expected it is considered that the visual presence of shoreline oil may impact Sea Country at a spiritual level (ie rituals, songlines, totem species) and could affect culturally important activities such as mutton birding or affect totem fauna The predicted minimum time for oil to reach a shoreline means it is likely to have dissipated during that time. Both Cape Otway and the west side of King Island are exposed to substantial wave action that would further breakdown any shoreline hydrocarbons. The relatively low volume means there may be short-term and localised consequences, which are ranked as **Moderate (2)**

Table 83: Environmental impact summary from shoreline oil exposure (MDO spill)

In Water

Receptor Group	Receptor Type	Impact	Exposure Evaluation	Consequence Evaluation
Conservation Values and Sensitivities	Australian Marine Parks	Change in values Changes to the functions, interests or activities of other users	Apollo AMP may be exposed to dissolved hydrocarbons at the low threshold for 1 day and entrained hydrocarbons at the high threshold within the upper 0 -10 m of the water column for 4 days Zeehan AMP may be exposed to dissolved hydrocarbons at the moderate threshold for 1 day and entrained hydrocarbons at the high threshold within the upper 0 -10 m of the water column for 4 days	The Apollo AMP is located in waters 80 m to 120 m deep and thus conservation values such as ecosystems, habitats and communities associated with the Western Bass Strait Shelf Transition and the Bass Strait Shelf Province and associated with the seafloor features and the wreck of the MV City of Rayville are not predicted to be impacted. The conservation value of important migration area for blue, fin, sei and humpback whales is unlikely to be impacted as these whales would be moving through the area and thus unlikely to be exposed to in water hydrocarbons within 0 -10 m of the water column for a substantial period to elicit a toxic effect. The Apollo AMP is an important foraging area for black-browed and shy albatross, Australasian gannet, short-tailed shearwater and crested tern. These seabirds forage over an extensive area and are distributed over a wide geographic range. The area of entrained hydrocarbon predicted to meet the high threshold is relatively small compared to

Receptor Group	Receptor Type	Impact	Exposure Evaluation	Consequence Evaluation
				the Bass Strait and Otway region. It is these small areas where sub-lethal and toxic effects to birds may occur. There is a low probability that seabirds would be feeding exclusively or predominantly on fish found in these areas of higher hydrocarbon thresholds, meaning there is low probability of seabirds themselves experiencing sub-lethal or toxic impacts as a result of consuming hydrocarbon-tainted fish. The Zeehan AMP is located in waters 50 m to 3,000 m deep and thus conservation values such as ecosystems, habitats and communities associated with the Tasmania Province, the West Tasmania Transition and the Western Bass Strait Shelf Transition and associated with the seafloor features are not predicted to be impacted. The conservation value of important migration area for blue and humpback whales is unlikely to be impacted as these whales would be moving through the area and thus unlikely to be exposed to in water hydrocarbons within 0 -10 m of the water column for a substantial period to elicit a toxic effect. The Zeehan AMP is also an important foraging habitat for black-browed, wandering and shy albatrosses, and great-winged and cape petrels. These seabirds forage over an extensive area and are distributed over a wide geographic range. The areas of dissolved hydrocarbon predicted to meet the moderate threshold and entrained hydrocarbon predicted to meet the high threshold are relatively small compared to the Bass Strait and Otway region. It is these small areas where sub-lethal and toxic effects to birds may occur. There is a low probability that seabirds would be feeding exclusively or predominantly on fish found in these areas of higher hydrocarbon thresholds, meaning there is low probability of seabirds themselves experiencing sub-lethal or toxic impacts as a result of consuming hydrocarbon-tainted fish. Consequently, the potential consequence to these AMPs are considered to be **Moderate (2),** as they could be expected to result in minor short-term impacts to an area of recognised conservation value.
	State Marine Protected Areas	Change in values Changes to the functions, interests	The Twelve Apostles Marine National Park may be exposed to entrained hydrocarbons	As impacts are only predicted within 0 – 10 m of the water column values such as the wreck of the Loch Ard, underwater limestone

Receptor Group	Receptor Type	Impact	Exposure Evaluation	Consequence Evaluation
		or activities of other users	at the high threshold within the upper 0 - 10 m of the water column for 4 days.	formations of arches and canyons, diverse range of encrusting invertebrates and dive sites are not predicted to be impacted. The unique limestone rock formations, including the Twelve Apostles, marine habitats representative of the Otway marine bioregion and indigenous culture based on spiritual connection to sea country and a history of marine resource use are unlikely to be impacted by entrained hydrocarbons at the low threshold. Consequently, the potential consequence to the Twelve Apostles Marine National Park is considered to be **Moderate (2),** as they could be expected to result in minor short-term impacts to an area of recognised conservation value.
	Key Ecological Features	Change in ecosystem dynamics	The West Tasmanian Canyons KEF may be exposed to dissolved hydrocarbons at the low threshold for one day and entrained hydrocarbons at the high threshold within the upper 0 -10 m of the water column for 4 days.	The West Tasmanian Canyons KEF is in water depths > 70 m and thus impacts from in-water hydrocarbons are not predicted.
Ecological	Threatened Ecological Communities	Change in ecosystem dynamics	The Giant Kelp Marine Forests of South East Australia and Subtropical and Temperate Coastal Saltmarsh may be exposed to entrained hydrocarbons at the low threshold within the upper 0 -10 m of the water column.	Entrained hydrocarbons at the low threshold are not predicted to impact on the ecological function of the Giant Kelp Marine Forests of South East Australia and Subtropical and Temperate Coastal Saltmarsh Threatened Ecological Communities.
Benthic Habitat	Algae	Change in habitat	Video surveys confirmed the presence of high density macroalgae dominated epibenthos in waters shallower than 20 m, however, it is not a dominant habitat feature in eastern Victoria (Section 4.4.3). In-water exposure (dissolved and entrained hydrocarbons) is only predicted to occur within the 0 -10 m of the water column. Macroalgae communities in 20 m water depth are not predicted to be exposed to dissolved hydrocarbons at any threshold or	NA

Receptor Group	Receptor Type	Impact	Exposure Evaluation	Consequence Evaluation
			high levels of entrained hydrocarbons at which potential impacts could occur.	
	Soft Coral	Change in habitat	Corals do not occur as a dominant habitat type within the planning area, however, their presence has been recorded around areas such as Wilsons Promontory National Park and Cape Otway . In-water exposure (dissolved and entrained hydrocarbons) is only predicted to occur within the 0 -10 m of the water column. Coral communities are not predicted to be exposed to dissolved hydrocarbons at any threshold or high levels of entrained hydrocarbons at which potential impacts could occur.	NA
	Seagrass	Change in habitat	Seagrass may be present within the area predicted to be exposed to in-water hydrocarbons as seagrass is known to occur within Twelve Apostles Marine Park which has the potential to be exposure to entrained hydrocarbons at the high threshold.	There is the potential that entrained in-water hydrocarbon exposure could result in sub-lethal impacts from smothering, more so than lethal impacts, possibly because much of seagrasses' biomass is underground in their rhizomes (Zieman et al., 1984). Potential impacts are considered to be **Moderate (2)**, as they could be expected to result in minor short-term impacts to an area of recognised conservation value.
Marine fauna	Plankton	Injury/ Mortality to fauna	Plankton are likely to be exposed to in-water hydrocarbons. Effects will be greatest in the upper 10 m of the water column and areas close to the spill source where hydrocarbon concentrations are likely to be highest.	Relatively low concentrations of hydrocarbon are toxic to both plankton including zooplankton and ichthyoplankton (fish eggs and larvae). Plankton risk exposure through ingestion, inhalation and dermal contact. Impacts would predominantly result from exposure to dissolved fractions, as larval fish and plankton are pelagic, and are moved by seawater currents. Potential impacts would largely be restricted to planktonic communities, which would be expected to recover rapidly following a hydrocarbon spill. Plankton are numerous and widespread but do act as the basis for the marine food web, meaning that an oil spill in any one location is unlikely to have long-lasting impacts on plankton populations at a regional level. Once background water quality conditions have re-established, the plankton community may take weeks to months to

Receptor Group	Receptor Type	Impact	Exposure Evaluation	Consequence Evaluation
				recover (ITOPF, 2011a), allowing for seasonal influences on the assemblage characteristics. Additionally, with the elevated nutrient loading expected during seasonal upwelling events within the Otway region (November to April), plankton are likely to recover more rapidly than when upwelling of nutrient-rich waters is less prevalent. the potential consequence to plankton are considered to be **Minor (1),** as they could be expected to result in low-level short-term and recoverable impacts.
	Marine invertebrates	Injury/ Mortality to fauna	In-water invertebrates of value have been identified to include squid, crustaceans (rock lobster, crabs) and molluscs (scallops, abalone). Impact by direct contact of in-water hydrocarbons to benthic species in the deeper areas of potential exposure are not predicted. Species located in shallow nearshore or intertidal waters may be exposed to in-water hydrocarbons low thresholds. Several commercial fisheries for marine invertebrates are within the area predicted to be exposed to moderate levels of entrained in-water hydrocarbons.	Acute or chronic exposure through contact and/or ingestion can result in toxicological risks. Larval or juvenile forms of invertebrates may be more prone to impacts (Suchanek, 1993). Localised impacts to larval stages may occur which could impact on population recruitment that year. Tainting of recreation or commercial species is considered unlikely to occur given exposure is limited to entrained hydrocarbons, however if it did it is expected to be localised and low level with recovery expected. Consequently, the potential consequence to invertebrates, including commercially fished invertebrates are considered to be **Moderate (2),** as they could be expected to result in localised and minor short-term impacts to species of value.
	Fish	Injury/ Mortality to fauna	Entrained hydrocarbon droplets can physically affect fish exposed for an extended duration (weeks to months). Effects will be greatest in the upper 10 m of the water column and areas close to the spill source where hydrocarbon concentrations are likely to be highest. Several fish communities in these areas are demersal and therefore more prevalent towards the seabed, which is not likely to be exposed). Therefore, any impacts are expected to be highly localised.	Pelagic free-swimming fish and sharks are unlikely to suffer long-term damage from oil spill exposure because dissolved/entrained hydrocarbons in water are not expected to be sufficient to cause harm (ITOPF, 2011a). Subsurface hydrocarbons could potentially result in acute exposure to marine biota such as juvenile fish, larvae, and planktonic organisms, although impacts are not expected cause population-level impacts. Consequently, the potential consequence to fish, including those commercially fished, are considered to be Moderate, as they could be expected to result in localised low-level short-term impacts to species of value.

Receptor Group	Receptor Type	Impact	Exposure Evaluation	Consequence Evaluation
			The Australian grayling spends most of its life in fresh water, with parts of the larval or juvenile stages spent in coastal marine waters, therefore it is not expected to be present in offshore waters in large numbers. There is a known distribution and foraging BIA for the white shark in the area of exposure, however, it is not expected that this species spends a large amount of time close to the surface where thresholds may be highest.	Impacts on fish eggs and larvae entrained in the upper water column are not expected to be significant given the temporary nature of the resulting change in water quality. As egg/larvae dispersal is widely distributed in the upper layers of the water column it is expected that current induced drift will rapidly replace any oil affected populations. Consequently, the potential consequence to eggs/larva are considered to be **Minor (1),** as they could be expected to result in localised low-level short-term impacts.
	Pinnipeds (seals and sea lions)	Injury/ Mortality to fauna Change in fauna behaviour	Australian and New Zealand fur-seals may occur within the area of exposure There are no identified BIAs for seals or sea lions within the area of exposure. No known breeding colonies of Australian or New Zealand fur-seals are exposed to moderate dissolved or high entrained exposure thresholds. Given the mobility of pinnipeds, there may be small numbers of seals in the areas predicted to be temporarily exposed to moderate dissolved or high entrained exposure thresholds in the water column, noting that in-water exposure (dissolved or entrained) is only predicted to occur within the upper 0 -10 m of the water column.	Exposure to moderate dissolved or high entrained exposure thresholds in the water column or consumption of prey affected by the oil may cause sub-lethal impacts to pinnipeds. Due to the temporary and localised nature of the spill, pinnipeds widespread nature, the low-level exposure zones and rapid loss of the volatile components of diesel in choppy and windy seas (such as that of the area exposed), the potential consequence to pinnipeds are considered to be **Moderate (2),** as they could be expected to result in localised and minor short-term impacts to species of recognised conservation value.
	Cetaceans (whales and dolphins)	Injury/ Mortality to fauna Change in fauna behaviour	Several threatened, migratory and/or listed marine cetacean species have the potential to be migrating, resting or foraging within the area predicted to be exposed to in-water hydrocarbons. BIAs for foraging for pygmy blue whales and the migrating BIA for southern right whales are within the area predicted to be exposed	Cetacean exposure to entrained hydrocarbons can result in physical coating as well as ingestion (Geraci and St Aubin, 1988). Such impacts are associated with ‘fresh’ hydrocarbon; the risk of impact declines rapidly as the MDO weathers. The potential for impacts to cetaceans and dolphins would be limited to a relatively short period following the release and would need to coincide with seasonal foraging or aggregation event to result in exposure to a large number of individuals, as may be the case during

Receptor Group	Receptor Type	Impact	Exposure Evaluation	Consequence Evaluation
			to moderate dissolved or high entrained exposure thresholds in the water column, noting that in-water exposure (dissolved or entrained) is only predicted to occur within the upper 0 -10 m of the water column.	seasonal upwelling events within the Otway region. However, such exposure is not anticipated to result in long-term population viability effects. A proportion of the foraging or distributed population of whales could be affected in the relatively localised area and water depth of the total foraging BIA for pygmy blue whales and migrating BIA for southern right whales. There is the potential for serious impact on valued species or habitats with a consequence considered to be **Serious (3).**
Socio-economic	Commercial and recreational fisheries	Change in ecosystem dynamics Changes to the functions, interests or activities of other users	In-water exposure to hydrocarbons may result in a reduction in commercially targeted marine species, resulting in impacts to commercial fishing and aquaculture. Actual or potential contamination of seafood can affect commercial and recreational fishing and can impact seafood markets long after any actual risk to seafood from a spill has subsided (NOAA, 2002) which can have economic impacts to the industry. Several commercial fisheries operate in the planning area and overlap the spatial extent of the water column hydrocarbon predictions	Any acute impacts are expected to be limited to small numbers of juvenile fish, larvae, and planktonic organisms, which are not expected to affect population viability or recruitment. Impacts from entrained exposure are unlikely to manifest at a fish population viability level. Any exclusion zone established would be limited to the immediate vicinity of the release point, and due to the rapid weathering of diesel would only be in place 1-3 days after release, therefore physical displacement to vessels is unlikely to be a significant impact. Consequently, the potential consequence to commercial and recreational fisheries are considered to be **Moderate (2),** as they could be expected to result in localised minor short-term impacts.
	Recreation and tourism	Change in ecosystem dynamics Changes to the functions, interests or activities of other users	Tourism and recreation are also linked to the presence of marine fauna (e.g. whales), particular habitats and locations for recreational fishing. The area between Cape Otway and Port Campbell is frequented by tourists. It is a remote stretch of coastline dominated by cliffs with remote beaches subject to the high energy wave action. Access to the entire coastline is via a 7 to 8-day walking track from Apollo Bay ending at the Twelve Apostles. Recreation is also linked to the presence of marine fauna and direct impacts to marine	Any impact to receptors that provide nature-based tourism features (e.g. whales) may cause a subsequent negative impact to recreation and tourism activities. Any impact to receptors that provide nature-based tourism features (e.g. fish and cetaceans) may cause a subsequent negative impact to recreation and tourism activities. However, impacts would be localised and for a relatively short duration. Consequently, the potential consequence to recreation and tourism are considered to be **Moderate (2),** as they could be expected to result in localised minor short-term impacts.

Receptor Group	Receptor Type	Impact	Exposure Evaluation	Consequence Evaluation
			fauna such as whales, birds, and pinnipeds can result in indirect impacts to recreational values. It is important to note that the impact from a public perception perspective may be even more conservative. This may deter tourists and locals from undertaking recreational activities. If this occurs, the attraction is temporarily closed, economic losses to the business are likely to eventuate. The extent of these losses would be dependent on how long the attraction remains closed.	
	Seaweed Industry	Change in ecosystem dynamics Changes to the functions, interests or activities of other users	In-water exposure to entrained diesel may result in a reduction in commercially targeted seaweed species. Areas along the west side of King Island where bull kelp is collected may be exposed to entrained hydrocarbons at the low threshold within the upper 0 -10 m of the water column.	Experiments verified the susceptibility of *Nereocystis luetkeana* (bull kelp – north America) tissue to the direct exposure to several petroleum types. Antrim et al (1995) showed that petroleum treatments resulted in visible tissue damage, with a distinct bleached line being the most visible indication of plant contact with the petroleum. Moderate to heavy colour loss, which was generally followed by rapid decay of tissue, was most pronounced in 24 h exposures to unweathered and weathered diesel. The study did not look at how this would affect the productivity of bull kelp. However, given the low levels of entrained hydrocarbons predicted it is unlikely to be a significant impact on seaweed collection and associated income. The relatively low volume means there may be short-term localised consequences, which are ranked as **Moderate (2).**
First Nations	Sea Country Native Title Indigenous Protected Area	Change in aesthetic value Changes to the functions, interests or activities of other users	In-water exposure to hydrocarbons is predicted along the Victorian and Tasmanian coastal waters within the planning area which is Sea Country for a number of First Nations groups and is adjacent to the Eastern Maar Native Title claim and Preminghana Indigenous Protected Area.	Section 4 details the connection First Nations people have to Sea Country which could be potentially impacted by in-water exposure to hydrocarbons. The relatively low volume means there may be short-term and localised consequences, which are ranked as **Moderate (2).**

Table 84: Environmental impact summary from in-water oil exposure (MDO spill)

7.4.2.4.3 Loss of Well Control at Release Location North

Potential extent of hydrocarbon exposure to surface waters

The maximum distance from the release location to the low (1–10 g/m2) and moderate (10–50 g/m2) exposure zones was 53 km (east) during summer conditions and 12 km (south-southeast) during winter conditions, respectively. For the high threshold (> 50 g/m2), the maximum distance from the release location was 1 km southeast (summer) and northwest (winter).

Victorian waters were predicted to be exposed to surface oil above the low threshold only, at 17% probability.

Zeehan AMP was predicted to be exposed to floating oil above low threshold at 39%, moderate threshold at 16% and high threshold at 3% probabilities.

The West Tasmanian Canyons KEF was predicted to be exposed above the low and moderate thresholds at 15% and 5% probability respectively.

Maximum residence time for low, moderate and high thresholds were 12, 5 and >1 days respectively.

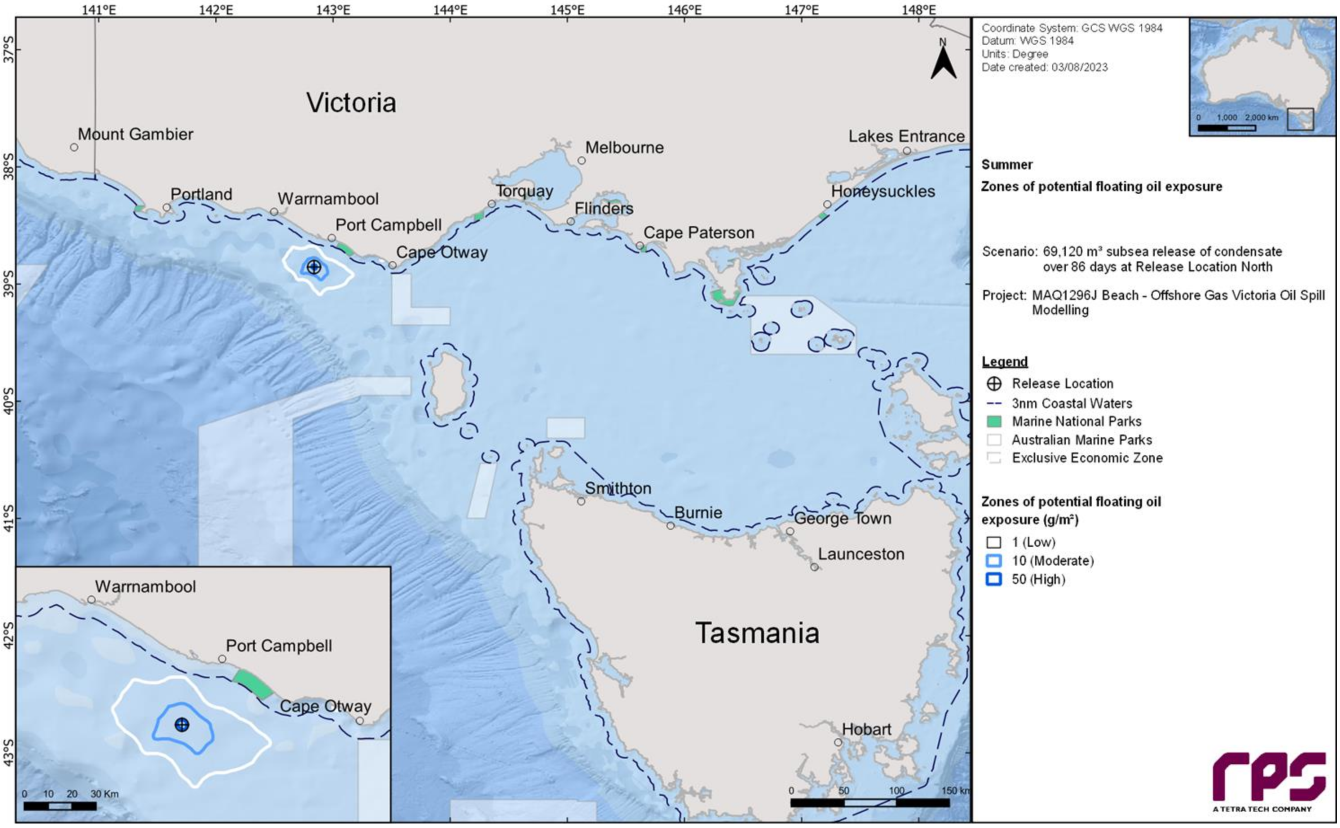


Figure 126: Floating oil exposure – Condensate (LOWC) Release Location North (Summer)

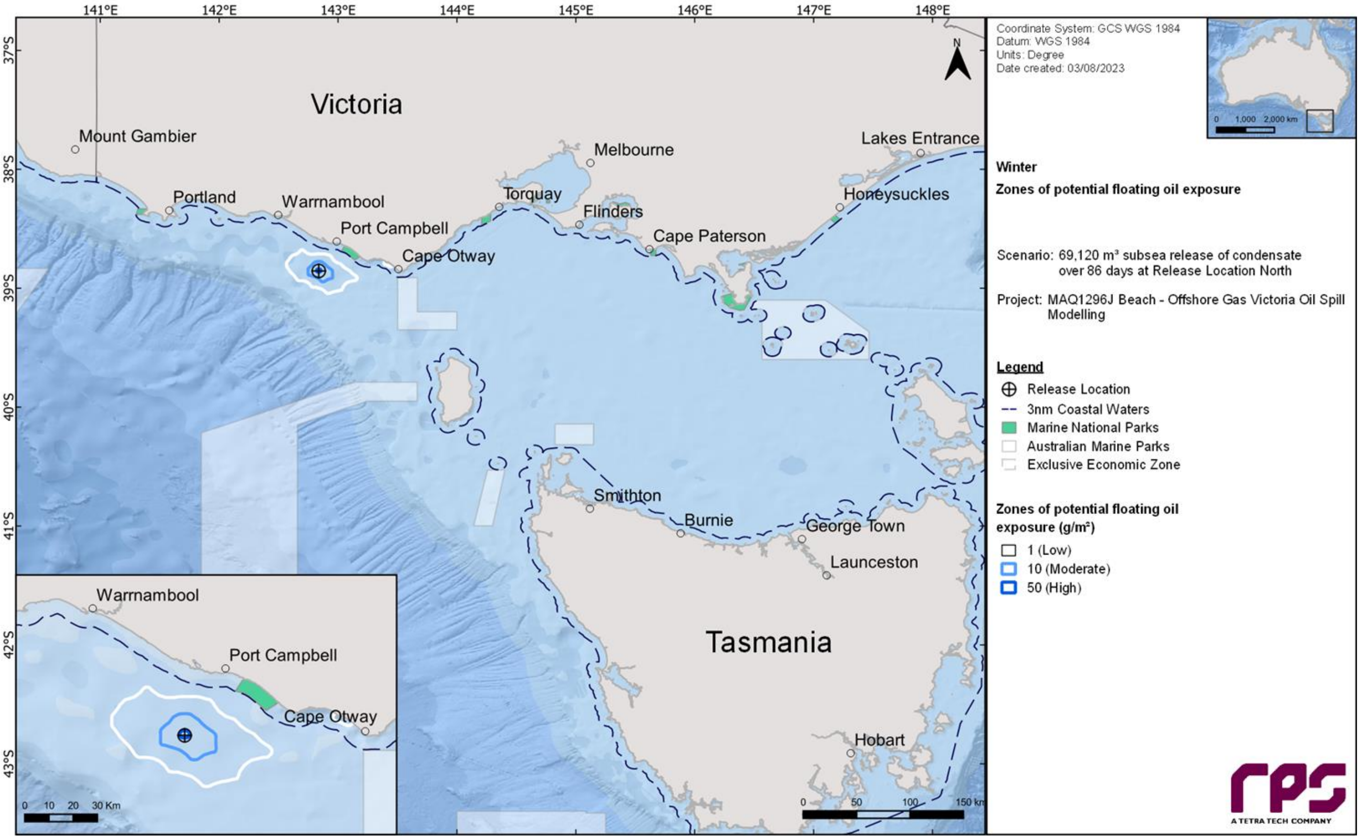


Figure 127: Floating oil exposure – Condensate (LOWC) Release Location North (Winter

Potential extent of hydrocarbon exposure to shorelines

The probability of accumulation to any shoreline at, or above, the low level (10 g/m2) threshold was 100% during summer conditions and 98% during winter conditions. The minimum time before oil accumulation at, or above, the low threshold was 5 days during summer conditions, and 4 days during winter conditions. The maximum volume ashore for a single spill trajectory during the summer and winter conditions was 112 m3 and 143 m3, respectively, whilst the maximum length of shoreline accumulation at the low threshold was 108 km and 136 km, respectively.

For the moderate threshold (100 g/m2), the maximum length of shoreline accumulation predicted was 25 km (summer) and 24 km (winter).

No shoreline accumulation was predicted for the high (1,000 g/m2) threshold.

During summer, Colac Otway shoreline and Cape Otway West Sub-LGA shoreline recorded the highest probability of shoreline accumulation at the low threshold (96% for both in summer, and 96% and 93% respectively in winter).

The minimum time before shoreline accumulation above the low threshold was 5 days predicted for Colac Otway and Cape Otway West during summer conditions and 4 days during the winter conditions predicted for Colac Otway, Corangamite, Apollo Bay, Cape Otway West and Moonlight Head.

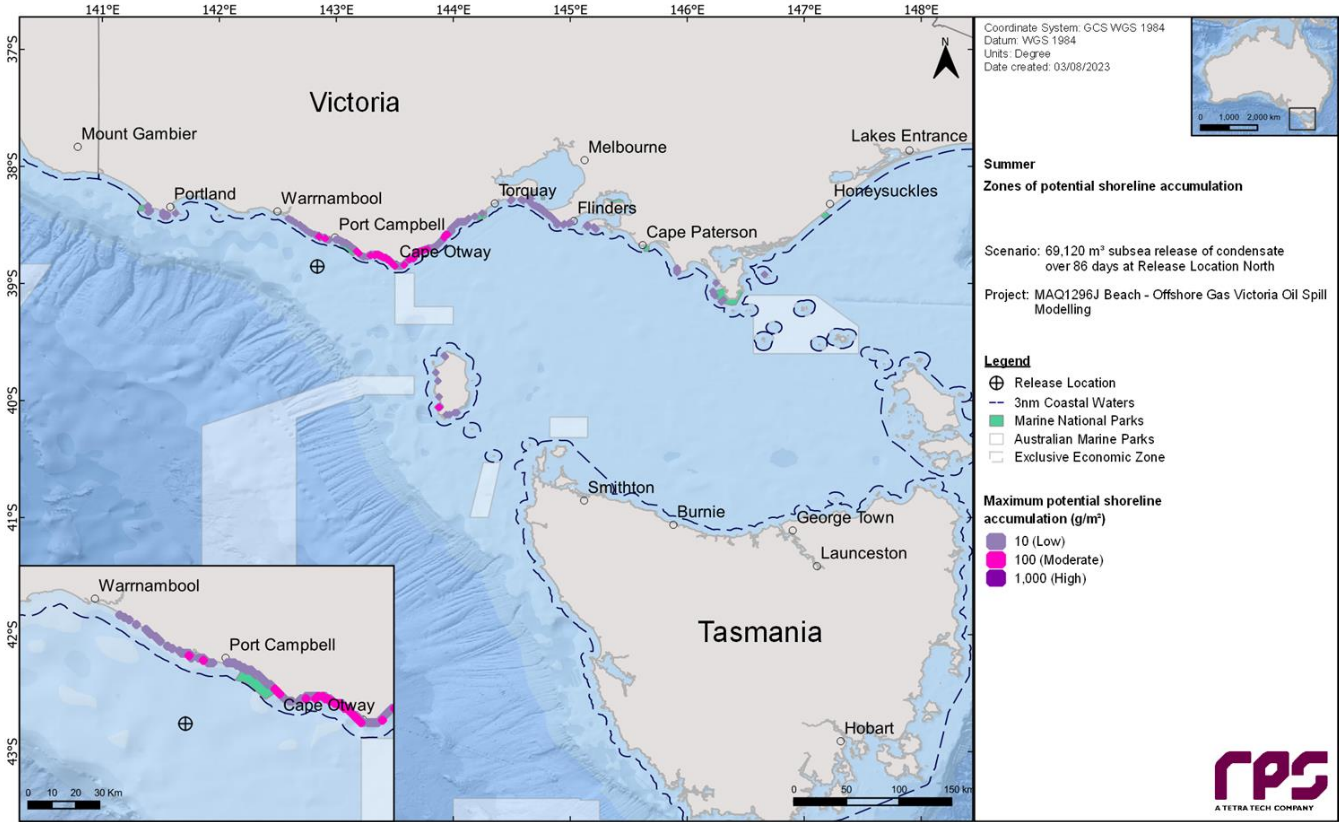


Figure 128: Shoreline oil exposure – Condensate (LOWC) Release Location North (Summer)

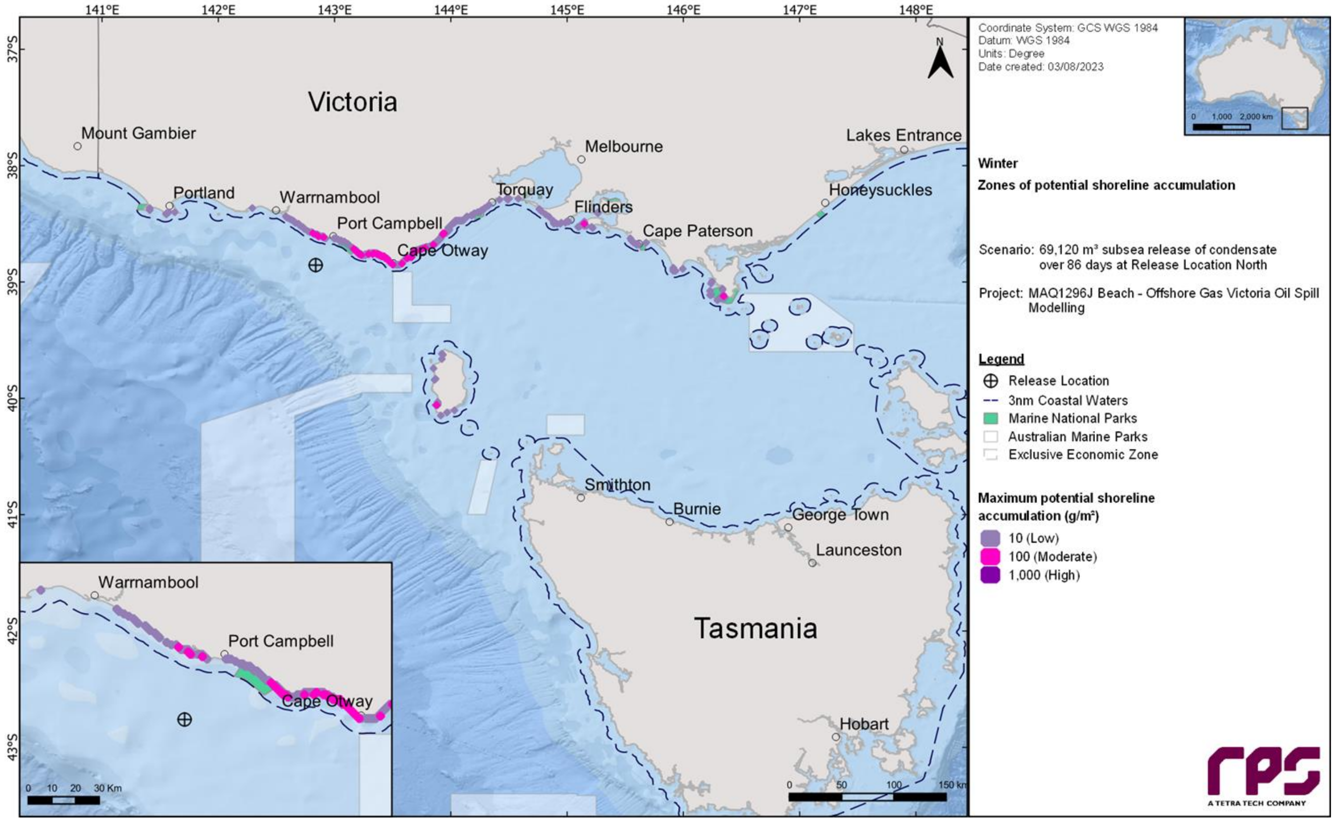


Figure 129: Shoreline oil exposure – Condensate (LOWC) Release Location North (Winter)

Potential extent of in-water dissolved hydrocarbon exposure

At the depths of 0-10 m, during the summer and winter conditions the maximum dissolved aromatic concentrations at any given receptor was predicted to be 1,396 ppb and 1,410 ppb, respectively.

Victorian waters were predicted to be exposed above the low threshold at 100%, moderate threshold at 86% and high threshold at 4% probabilities. Tasmanian waters were predicted to be exposed above the low threshold at a 2% probability.

The Apollo AMP was predicted to be impacted with a probability of 100% above the low threshold, 98% above the moderate threshold and 6% above the high threshold. Zeehan and Beagle AMPs were both predicted to be exposed above the low threshold at 6% and moderate threshold at 1% probabilities.

Twelve Apostles, Wilsons Promontory and Bunorong MNPs were predicted to be exposed above the low threshold at 75%, 7% and 1% probabilities respectively and the moderate threshold at 16%, 2% and 1% probabilities respectively. Point Addis, Port Phillip Heads and Discovery Bay MNPs were predicted to be exposed above the low threshold at 8%, 2% and 1% probabilities respectively. Mushroom Reef Marine Sanctuary and Port Phillip Bay (Western Shoreline RAMSAR sites were both predicted to be exposed above the low threshold at 1% probability, only in Winter.

The Bonney Coast Upwelling and West Tasmanian Canyons KEFs was predicted to be exposed with respective probabilities of 28% and 13% above the low threshold and 4% and 3% above the moderate threshold. The Upwelling east of Eden KEF was predicted to be exposed above the low threshold at 1% probability.

The maximum residence time of dissolved hydrocarbon exposure at the low, moderate and high thresholds were 26, 8 and <1 days respectively.

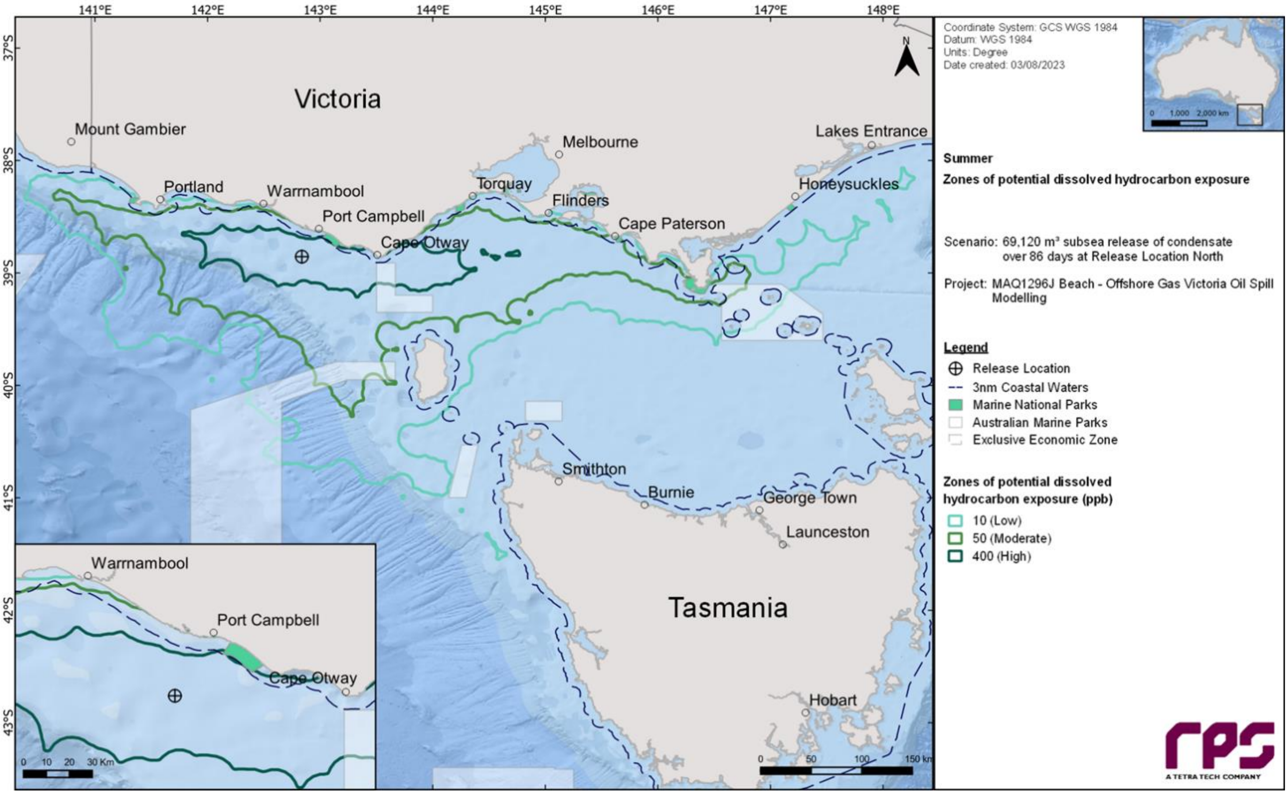


Figure 130: Dissolved oil exposure – Condensate (LOWC) Release Location North (Summer)

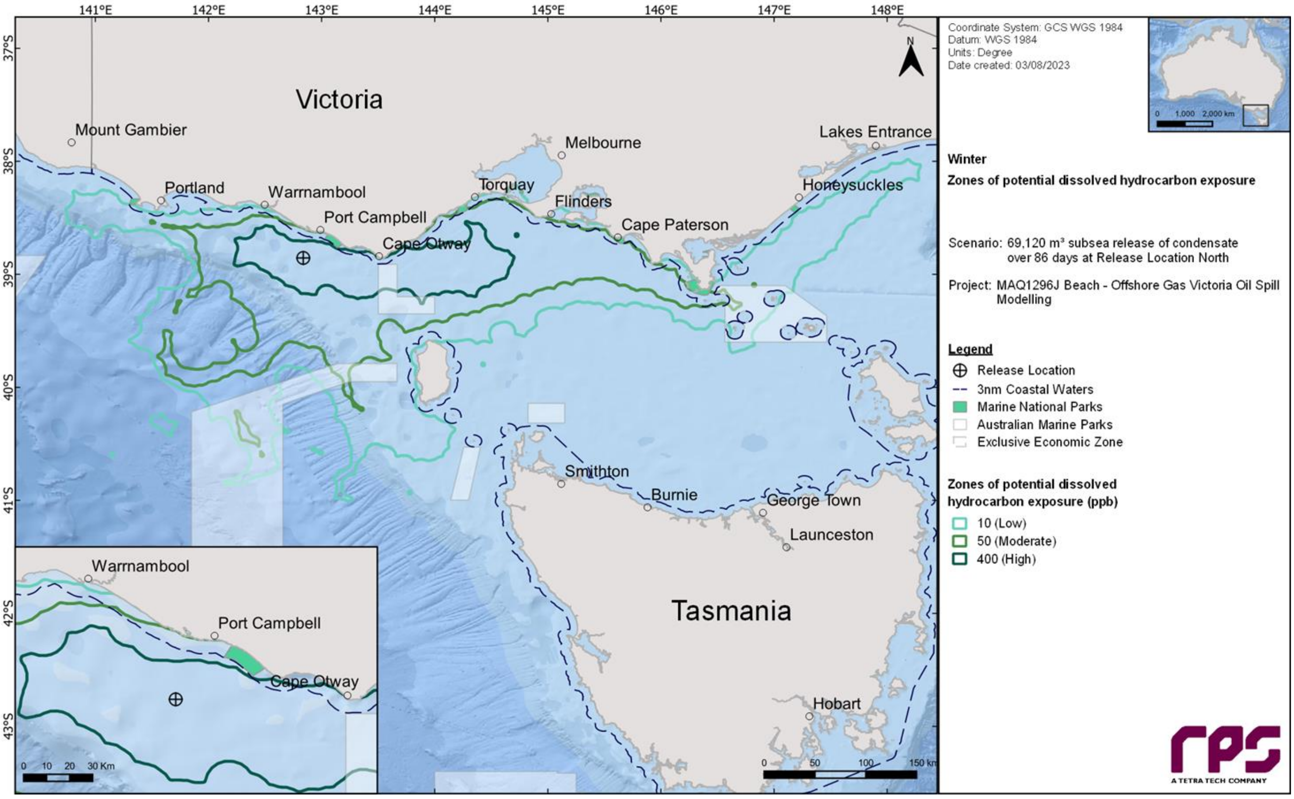


Figure 131: Dissolved oil exposure – Condensate (LOWC) Release Location North (Winter)

Potential extent of in-water entrained hydrocarbon exposure

At the depths of 0-10 m, during the summer and winter conditions the maximum entrained hydrocarbon concentrations at any given receptor were predicted to be 378 ppb and 372 ppb, respectively.

Victorian waters were predicted to be exposed above the low threshold at 2% probability. Tasmanian waters were predicted to be exposed above the low threshold at a 2% probability.

The Apollo AMP was predicted to be impacted with a probability of 100% above the low threshold and 28% above the high threshold. Zeehan and Beagle AMPs were predicted to be exposed above the low threshold at 6% and 4% probabilities respectively.

Twelve Apostles MNP was predicted to be exposed above the low threshold at 97% and above the high threshold at 1% probability. Wilsons Promontory, Point Addis, Bunorong, Port Phillip Heads and Discovery Bay MNPs were predicted to be exposed above the low threshold at 13%, 11%, 3%, 1% and 1% probabilities respectively. MNPs were predicted to be exposed above the low threshold at 8%, 2% and 1% probabilities respectively. Mushroom Reef Marine Sanctuary was predicted to be exposed above the low threshold at 7% probability, only in Winter.

The Bonney Coast Upwelling and West Tasmanian Canyons KEFs were predicted to be exposed with respective probabilities of 42% and 19% above the low threshold.

The maximum residence time of dissolved hydrocarbon exposure at the low and high thresholds were 67 and 18 days respectively.

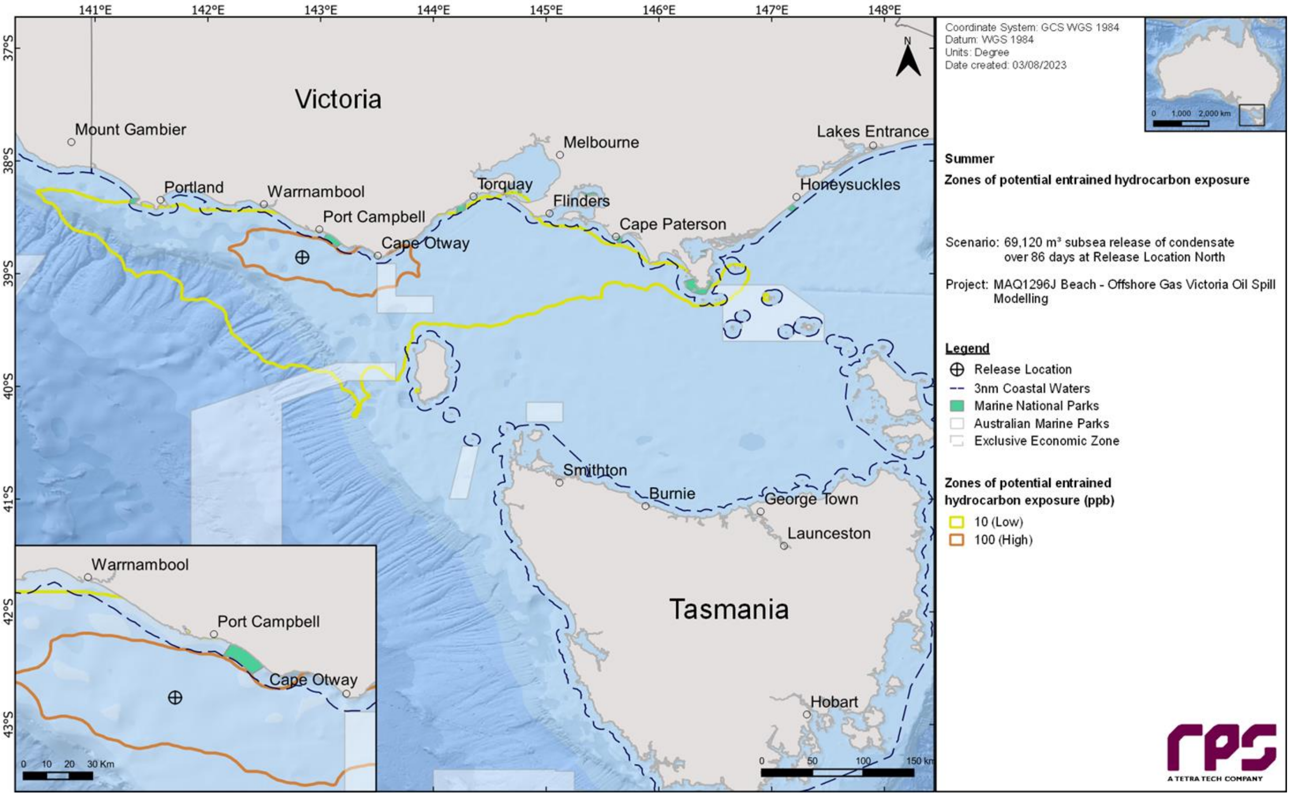


Figure 132: Entrained oil exposure – Condensate (LOWC) Release Location North (Summer)

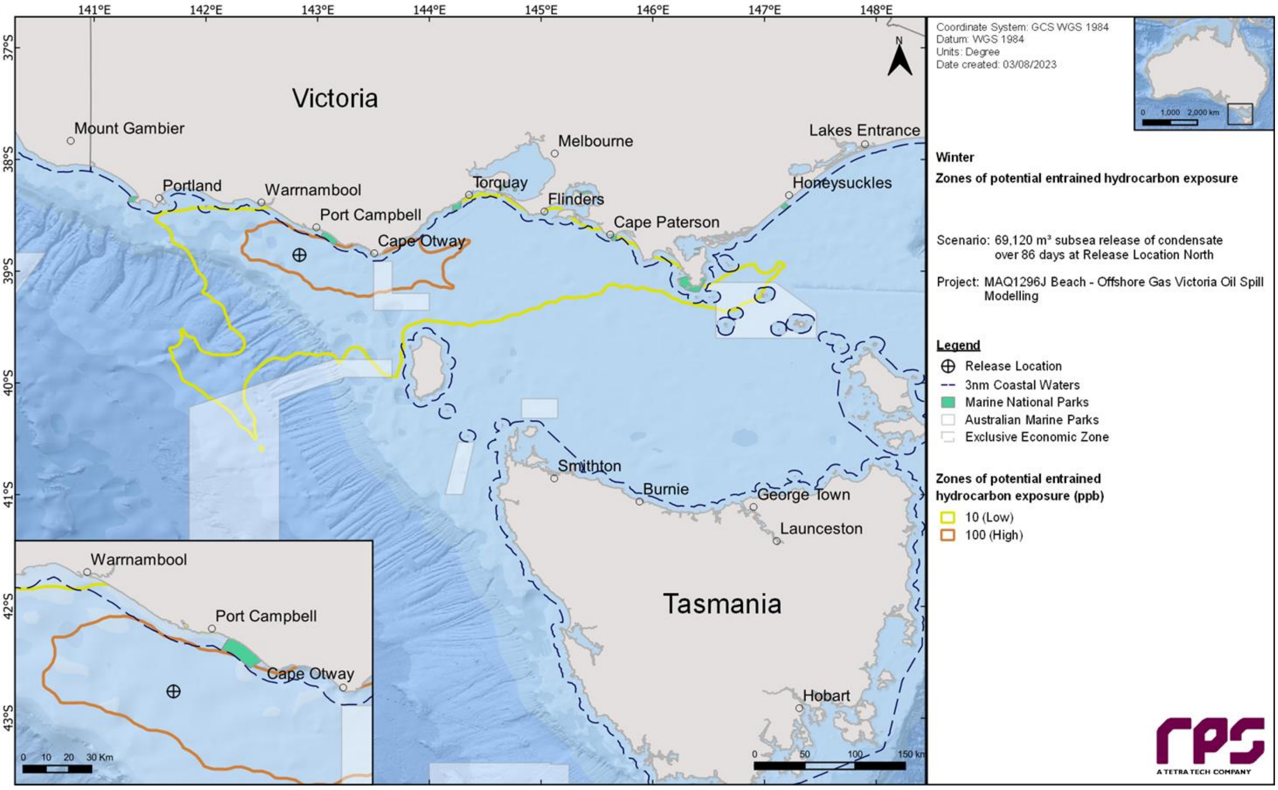


Figure 133: Entrained oil exposure – Condensate (LOWC) Release Location North (Winter)

7.4.2.4.4 Loss of Well Control at Release Location South

Potential extent of hydrocarbon exposure to surface waters

The maximum distance from the release location to the low (1–10 g/m2), moderate (10–50 g/m2) and high (>50 g/m2) exposure zones was 79 km (east-southeast) during winter conditions, 20 km (southeast) during summer conditions and 1 km (west-southwest) during summer and winter conditions, respectively.

Tasmanian waters were predicted to be exposed to surface oil above the low threshold only, at 50% probability.

Zeehan AMP was predicted to be exposed to floating oil above low threshold at 100% and moderate threshold at 96% probabilities.

The West Tasmania. Canyons KEF was predicted to be exposed above the low and moderate thresholds at 100% and 48% probabilities respectively.

Maximum residence time for low, moderate and high thresholds were 86, 64 and >1 days respectively.

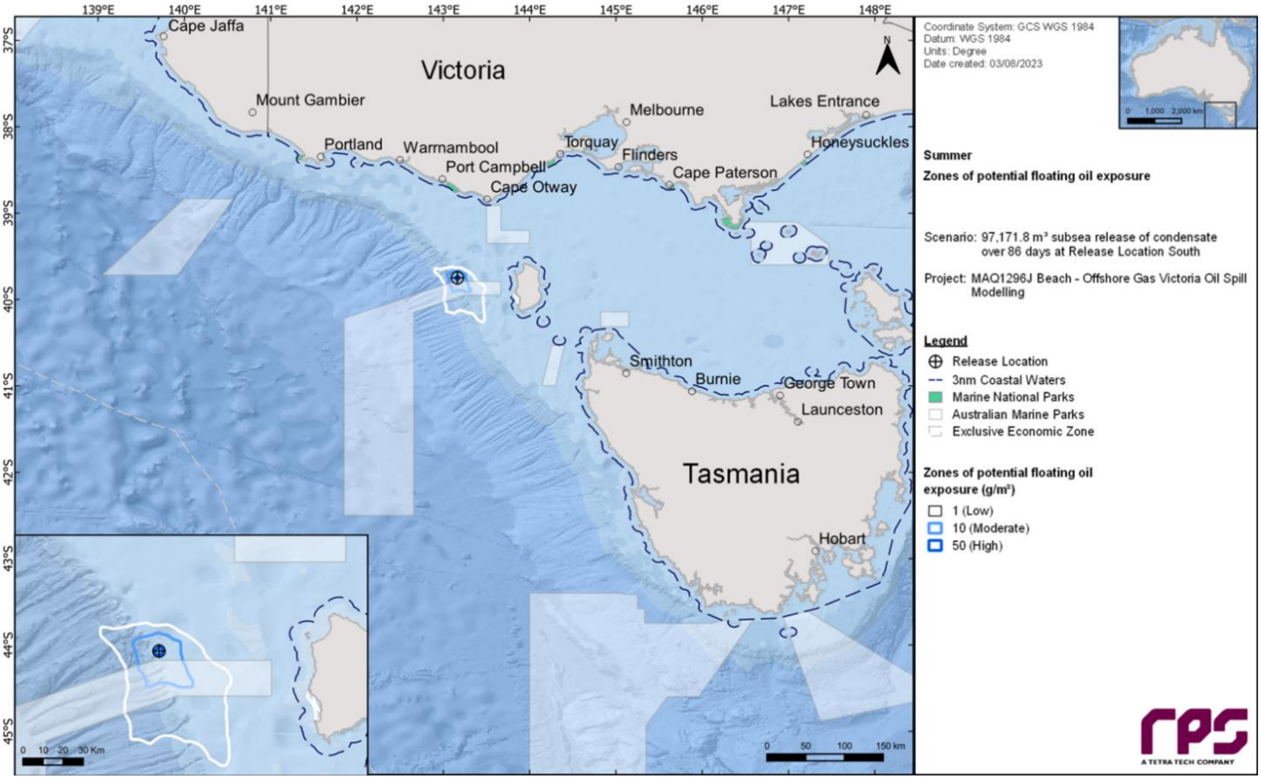


Figure 134: Floating oil exposure – Condensate (LOWC) Release Location South (Summer)

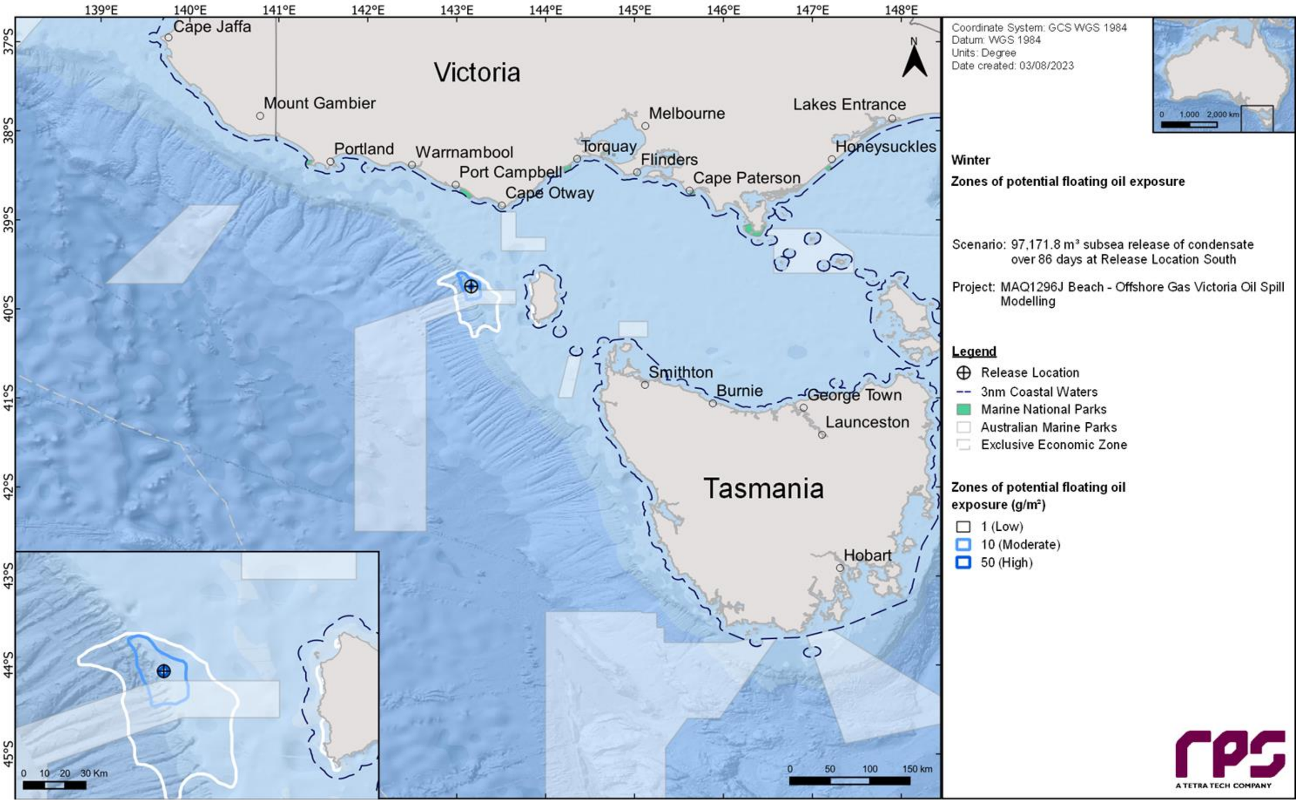


Figure 135: Floating oil exposure – Condensate (LOWC) Release Location South (Winter)

Potential extent of hydrocarbon exposure to shorelines

The probability of accumulation to any shoreline at, or above, the low level (10 g/m2) threshold was 89% during summer conditions and 100% during winter conditions. The minimum time before oil accumulation at, or above, the low threshold was 10 days during summer conditions, and 5 days during winter conditions.

The maximum volume ashore for a single spill trajectory during the summer and winter conditions was 99 m3 and 193 m3, respectively, whilst the maximum length of shoreline accumulation at the low threshold was 115 km and 138 km, respectively.

For the moderate threshold, the maximum length of shoreline accumulation was 16 km during summer and 44 km during winter.

No accumulation at the high threshold was predicted during summer, but in winter the maximum length of shoreline accumulation was predicted to be 3 km.

King Island recorded the highest probability of shoreline accumulation at the low threshold with 82% (summer) and 100% (winter). The minimum time before shoreline accumulation above the low threshold was 10 days (summer) and 5 days (winter) predicted for King Island.

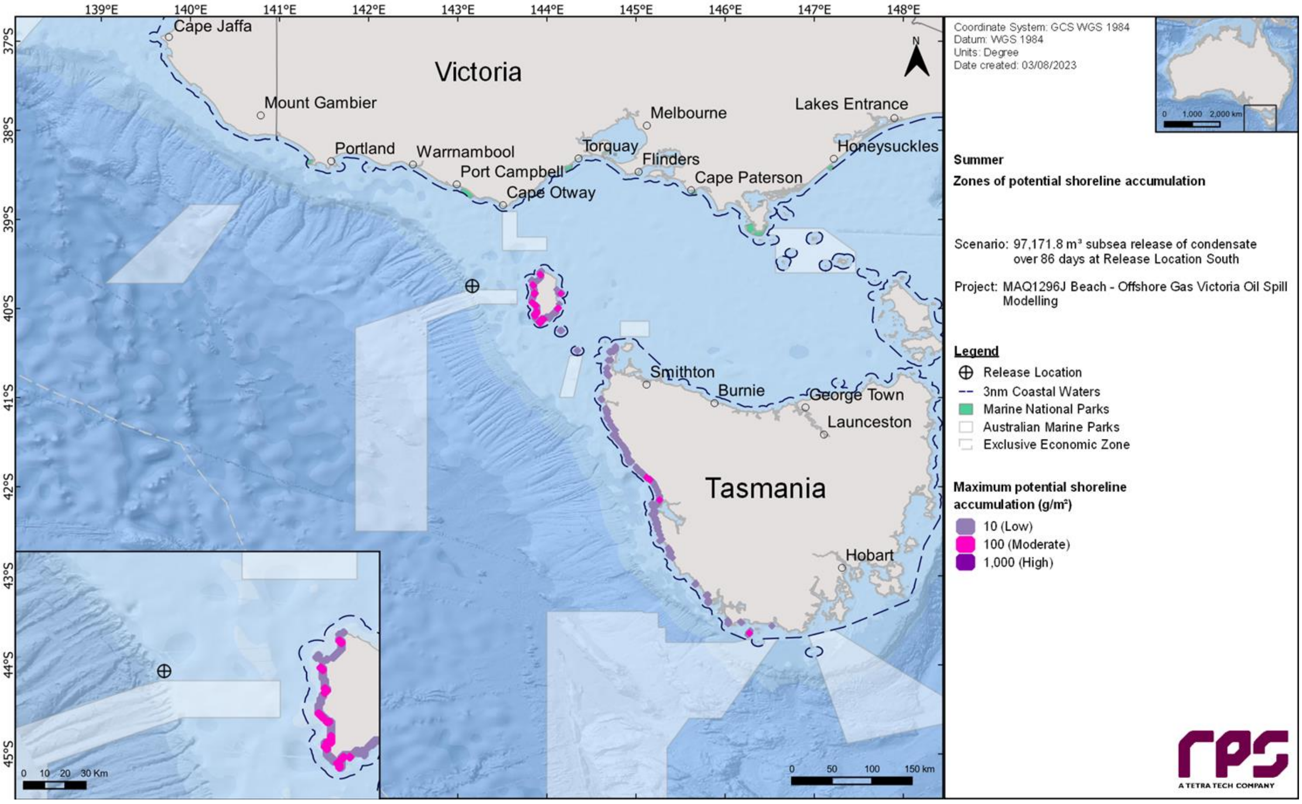


Figure 136: Shoreline oil exposure – Condensate (LOWC) Release Location South (Summer)

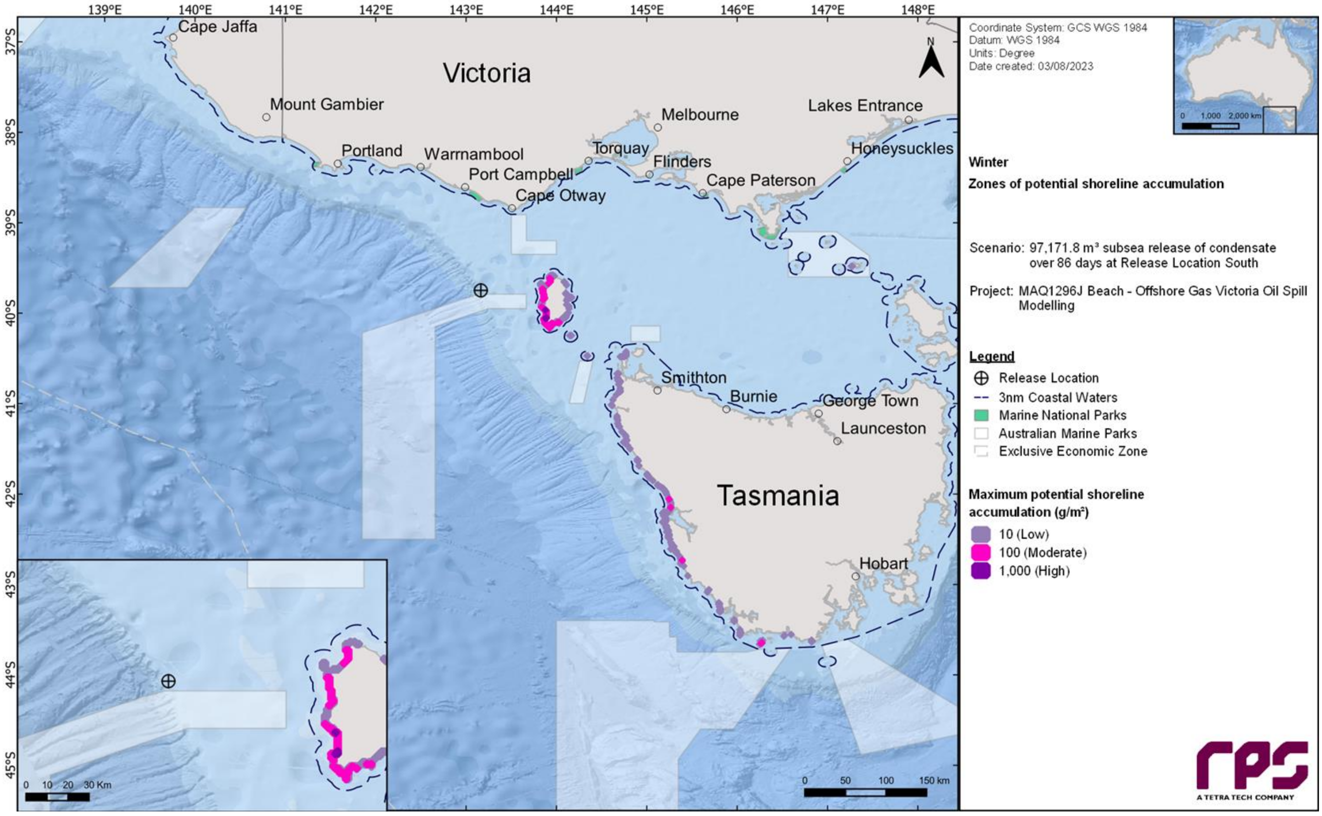


Figure 137: Shoreline oil exposure – Condensate (LOWC) Release Location South (Winter)

<u>Potential extent of in-water dissolved hydrocarbon exposure</u>

At the depths of 0-10 m, during the summer and winter conditions the maximum dissolved aromatic concentrations at any given receptor was predicted to be 1,904 ppb and 1,665 ppb, respectively.

Tasmanian waters were predicted to be exposed above the low threshold at 95%, moderate threshold at 59% and high threshold at 1% probabilities. Victorian waters were predicted to be exposed above the low threshold at a 3% probability, in Winter only.

Zeehan AMP was predicted to be exposed with a probability of 100% above the low and moderate thresholds and 42% above the high threshold. Apollo, Beagle, Boags and Franklin AMPs were predicted to be exposed above the low threshold at 7%, 1%, 12% and 68% respectively and above the moderate threshold at 1%, 1%, 3% and 11% probabilities. Tasman Fracture AMP was predicted to be exposed with a probability of 2% above the low threshold. Kent Group National Park was predicted to be exposed with a probability of 1% above the low threshold, in Winter only.

The West Tasmanian Canyons KEF was predicted to be exposed above the low and moderate threshold at 100% probability and high threshold of 32% probability. The Seamounts South and east of Tasmania KEF was predicted to be exposed above the low threshold at 1% probability, in Winter only.

The maximum residence time of dissolved hydrocarbon exposure at the low, moderate and high thresholds were 87, 17 and <1 days respectively.

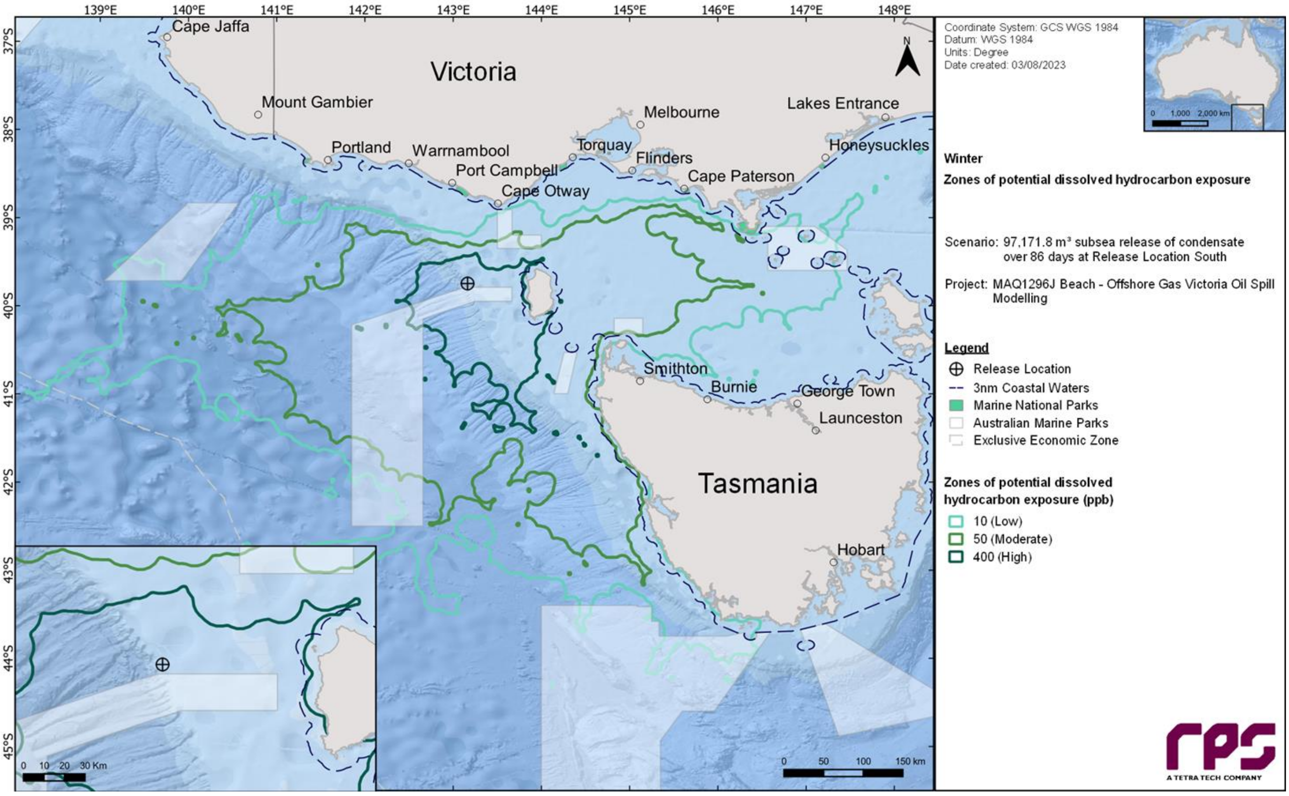


Figure 138: Dissolved oil exposure – Condensate (LOWC) Release Location South (Summer)

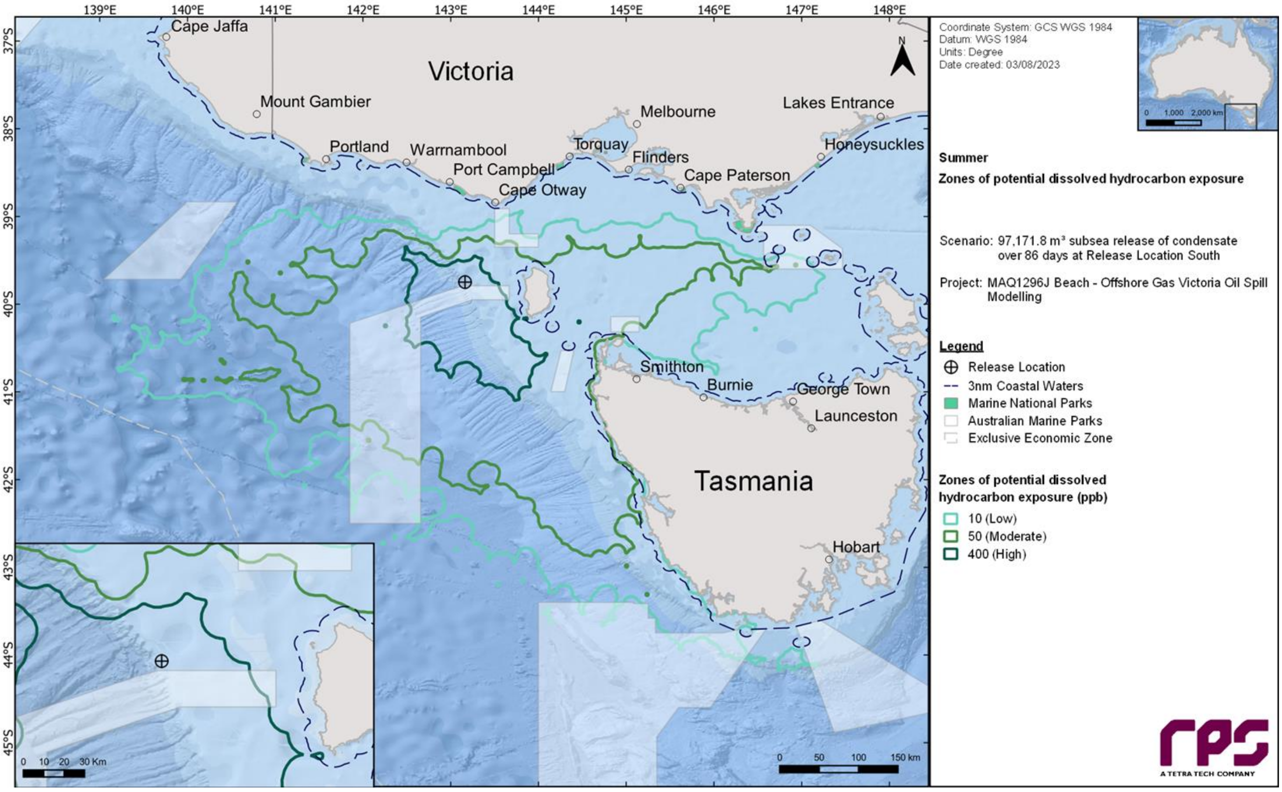


Figure 139: Dissolved oil exposure – Condensate (LOWC) Release Location South (Winter)

Potential extent of in-water entrained hydrocarbon exposure

At the depths of 0-10 m, during the summer and winter conditions the maximum entrained hydrocarbon concentrations at any given receptor were predicted to be 1,454 ppb and 1,464 ppb, respectively.

Tasmanian waters were predicted to be exposed above the low and high thresholds at 100% and 24% probabilities respectively. Victorian waters were predicted to be exposed above the low threshold at 3% probability.

Zeehan AMP was predicted to be exposed with a probability of 100% above the low and high thresholds. Apollo, Beagle, Boags, Franklin and Tasman Fracture AMPs were predicted to be exposed above the low threshold at 14%, 1%, 10%, 65% and 4% respectively.

Twelve Apostles MNP was predicted to be exposed above the low threshold at 97% and above the high threshold at 1% probability. Wilsons Promontory, Point Addis, Bunorong, Port Phillip Heads and Discovery Bay MNPs were predicted to be exposed above the low threshold at 13%, 11%, 3%, 1% and 1% probabilities respectively. Kent Group National Park was predicted to be exposed with a probability of 1% above the low threshold, in Winter only.

The West Tasmanian Canyons KEF was predicted to be exposed above the low and high thresholds at 100% probability.

The maximum residence time of entrained hydrocarbon exposure at the low and high thresholds were 94 and 15 days respectively.

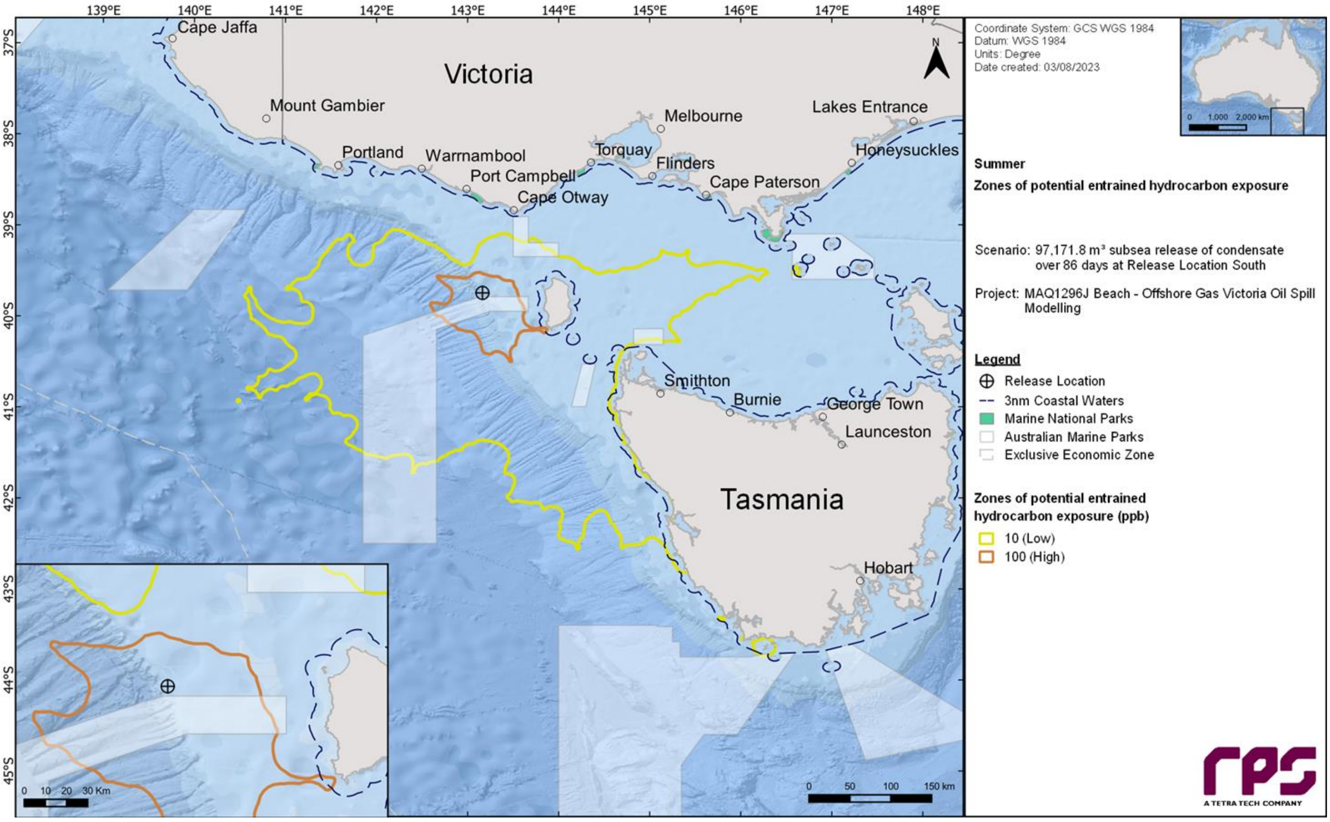


Figure 140: Entrained oil exposure – Condensate (LOWC) Release Location South (Summer)

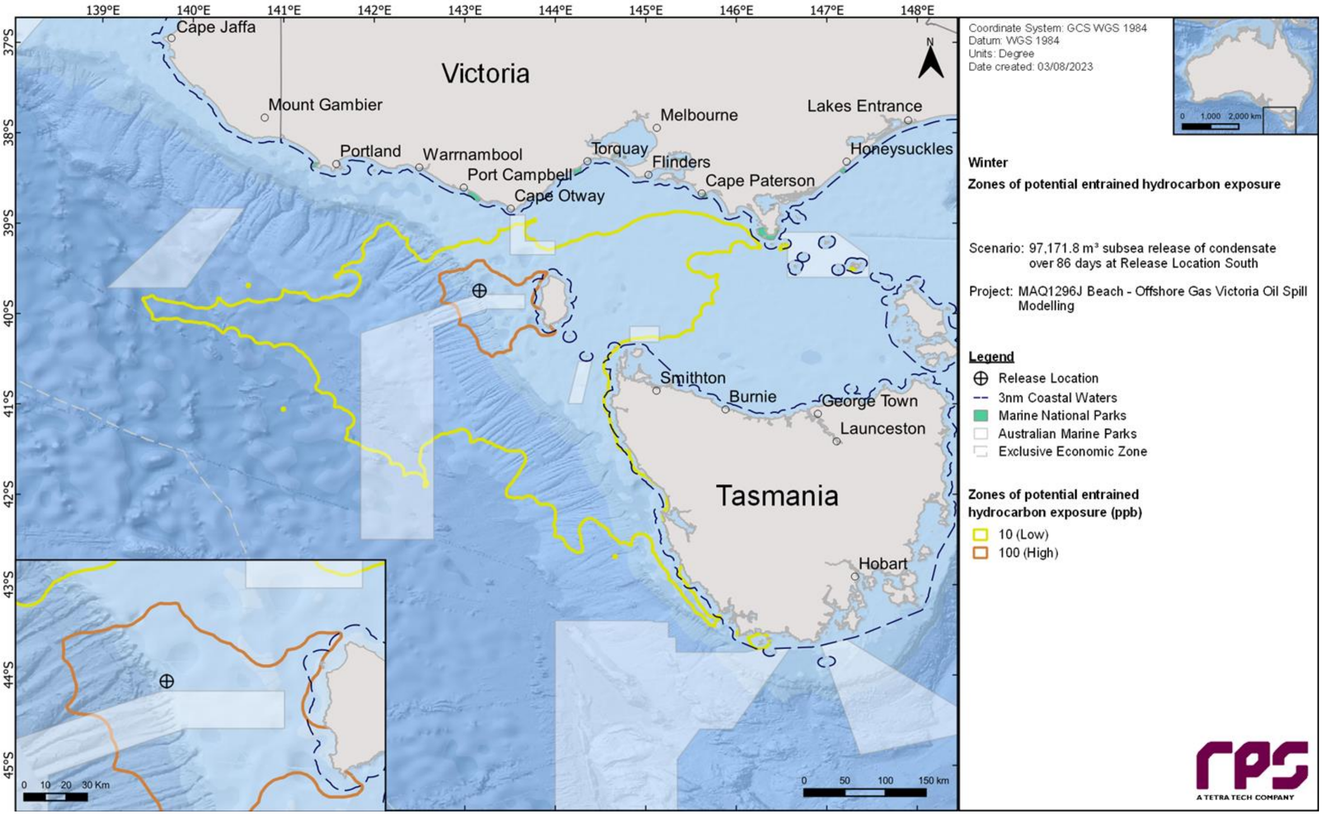


Figure 141: Entrained oil exposure – Condensate (LOWC) Release Location South (Winter)

Sea Surface Exposure

Receptor Group	Receptor Type	Impacts	Exposure Evaluation	Consequence Evaluation
Marine fauna	Seabirds	Injury / mortality to fauna Change in fauna behaviour	Several listed Threatened, Migratory and/or Listed Marine species have the potential to be rafting, resting, diving or feeding within between 12 and 20 km of the release locations predicted to be exposed to moderate levels of surface hydrocarbons Exposure at the high threshold predicted to extend only 1km from the release locations for less than one day. Foraging BIAs for several albatross species, the wedge-tailed shearwater, common diving-petrel and short-tailed shearwater and wedge-tailed shearwater within the area predicted to be exposed to moderate thresholds of surface oil.	When first released, gas condensate has higher toxicity due to the presence of volatile components. Individual birds making contact close to the spill source at the time of the spill (i.e. areas of concentrations >10g /m^2 out to between 12 and 20 km from the release locations) may suffer impacts however it is unlikely that a large number of birds will be affected. Seabirds exposed to surface hydrocarbons at moderate exposure levels may experience acute or chronic toxicity impacts, however the area of contact is relatively localised and the presence of birds is expected to be limited to foraging individuals of a transitory nature, given the absence of offshore aggregation areas and the large foraging BIAs. Consequently, the potential consequence is considered to be **Serious (3),** as they could be expected to result in serious impact on valued species or habitat.
	Marine reptiles	Injury / mortality to fauna Change in fauna behaviour	There may be transiting marine turtles within between 12 and 20 km of the release locations predicted to be exposed to moderate levels of surface hydrocarbons during winter. However, there are no BIAs or habitat critical to the survival of the species within the area predicted to be exposed to moderate thresholds of surface oil. Exposure at the high threshold predicted to extend only 1km from the release locations for less than one day.	Marine turtles are vulnerable to the effects of oil at all life stages. Marine turtles can be exposed to surface oil externally (i.e. swimming through oil slicks) or internally (i.e. swallowing the oil). Ingested oil can harm internal organs and digestive function. Oil on their bodies can cause skin irritation and affect breathing. The number of marine turtles that may be exposed to surface condensate is expected to be low as there are no BIAs or habitat critical to the survival of the species present and the localised (12-20 km from the release locations) extent of exposure above the 10 g/m^2 threshold; however, turtles may be transient within the area. Therefore, potential impact would be limited to individuals, with population impacts not anticipated. Consequently, the potential consequence is considered to be **Moderate (2),** as they could be expected to result in localised and minor short-term impacts to species of value.
	Pinnipeds (seals and sea-lions)	Injury / mortality to fauna Change in fauna behaviour	The Australian and New Zealand fur-seals may occur within 12-20km of the release locations predicted to be exposed to moderate levels of surface hydrocarbons during winter. No BIAs,	Exposure to surface oil can result in skin and eye irritations and disruptions to thermal regulation. Fur seals are particularly vulnerable to hypothermia from oiling of their fur – however the characteristics of Thylacine condensate mean this is not likely.

Receptor Group	Receptor Type	Impacts	Exposure Evaluation	Consequence Evaluation
			breading colonies or haul outs areas within the area predicted to be exposed to moderate thresholds of surface oil.	The number of pinnipeds exposed is expected to be low, with population impacts not anticipated. The potential consequence is considered to be **Moderate (2)** as they could be expected to result in short term effects and some impact on valued species or habitat.
	Cetaceans (whales)	Injury / mortality to fauna Change in fauna behaviour	Several threatened, migratory and/or listed marine species have the potential to be foraging within 12-20 km of the release locations predicted to be exposed to moderate levels of surface hydrocarbons during winter. The area of exposure overlaps a foraging BIA for pygmy blue whales and the migration BIA for southern right whale.	Geraci (1988) found little evidence of cetacean mortality from hydrocarbon spills; however, some behaviour disturbance (including avoidance of the area) may occur. While this reduces the potential for physiological impacts from contact with hydrocarbons, active avoidance of an area may displace individuals or aggregations from important habitat, such as foraging. If whales are foraging at the time of the spill, a greater number of individuals may be present in the plume, however due to the small area of the surface exposure above the impact threshold (12-20 km from release location), this is not likely. Given this is a relatively small area of the total foraging BIA for pygmy blue whales and migration BIA for southern right whales, the risk of displacement to whales is considered low. Therefore, there is potential for interaction with southern right whales given the activity window overlaps with the northern migration period of May-June, the peak breeding (July-August) and southern migration period (September-November). The activity timing overlaps with the blue whale season for migration and foraging. Visual and acoustic surveys suggest that blue whales are present in the Otway region between November to June, peaking in February and March. As such in the event of a spill potential hydrocarbon exposure could possibly affect blue or other foraging whale species. Consequently, the potential consequence is considered to be **Serious (3),** as they could be expected to result in serious impact on valued species or habitat.
	Cetaceans (dolphins)	Injury / mortality to fauna	There may be dolphins within 12-20 km of the release location predicted to be exposed to moderate levels of surface hydrocarbons	Dolphins surface to breathe air and may inhale hydrocarbon vapours or be directly exposed to dermal contact with surface hydrocarbons. Direct contact with oil can result in direct impacts to the animal, due to toxic effects if ingested, damage to lungs when inhaled at the surface,

Receptor Group	Receptor Type	Impacts	Exposure Evaluation	Consequence Evaluation
		Change in fauna behaviour	However, it is not identified as critical habitat, and there are no spatially defined aggregations within the area predicted to be exposed to moderate thresholds of surface oil.	and damage to the skin and associated functions such as thermoregulation (AMSA 2010). Dolphins are highly mobile and are considered to have some ability to detect and avoid oil slicks (Geraci and St. Aubin, 1988; Smith et al, 1983). Direct surface hydrocarbon contact may pose little problem to dolphins due to their extraordinarily thick epidermal layer which is effective as a barrier to the substances found in hydrocarbons (Geraci and St. Aubin, 1990; Volkman et al., 1994). The number of dolphins exposed is expected to be low, with population impacts not anticipated. Due to the rapid weathering of condensate, the potential exposure time is short. Consequently, the potential consequence to dolphins are considered to be **Moderate (2),** as they could be expected to result in localised minor short-term impacts to species of recognised conservation value.
Socio-economic	Petroleum Exploration and Production	Displacement of other marine users	There are no oil and gas platforms, or activities within 12-20 km of the release location predicted to be exposed to moderate levels of surface hydrocarbons	No impact predicted as there are no non-Beach oil and gas platforms located within the area predicted to be exposed to surface hydrocarbons.
	Shipping	Displacement of other marine users	Shipping may occur within 12-20 km of the release locations predicted to be exposed to moderate levels of surface hydrocarbons	Vessels may be present in the area where moderate levels of sea surface oil are predicted, however, due to small area of exposure (12-20 km) no impact is predicted.
	Tourism and recreation (including recreational diving and recreational fisheries)	Change in aesthetic value Changes to the functions, interests or activities of other users	Marine pollution can result in reduced visual aesthetic. The modelling predicts visible surface sheen at the low threshold up to 44.5 km in summer and 20.6 km in winter. This oil may be visible as a rainbow sheen on the sea surface during calm conditions.	Visible surface hydrocarbons (i.e. a rainbow sheen) have the potential to reduce the visual amenity of the area for tourism and discourage recreational activities. However, the distance from shore means there may be minor consequences and some impact, which are ranked as **Moderate (2).**
	Commercial fisheries	Displacement of other marine users	Commercial fishing may occur within 12-20 km of the release location predicted to be exposed to moderate levels of surface hydrocarbons	Commercial fishing vessels may be present in the area where moderate levels of sea surface oil are predicted, however, due to the timeframes of presence given the LOWC scenarios a **Moderate (2)** impact is assigned.

Receptor Group	Receptor Type	Impacts	Exposure Evaluation	Consequence Evaluation
First Nations	Sea Country	Change in aesthetic value Changes to the functions, interests or activities of other users	Marine pollution can result in reduced visual aesthetic. The modelling predicts visible surface sheen at the low threshold up to 79km This oil may be visible as a rainbow sheen on the sea surface during calm conditions.	Visible surface hydrocarbons (i.e. a rainbow sheen) have the potential to reduce the visual amenity of the areas of Sea Country. The distance from shore means there may be minor consequences and some impact, which is ranked as **Moderate (2).** Refer also to: ecological receptors above.

Table 85: Environmental impact summary from floating oil exposure (Condensate spill)

Shoreline Exposure

Receptor Group	Receptor Type	Impacts	Exposure Evaluation	Consequence Evaluation
Conservation Values and Sensitivities	National Heritage Places	Change in aesthetic value Changes to the functions, interests or activities of other users	Marine pollution can result in reduced visual aesthetic. The modelling predicts potential shoreline exposure at the low and moderate threshold at Great Ocean Road and Scenic Environs and Western Tasmania Aboriginal Cultural Landscape	Visible shoreline hydrocarbons has the potential to reduce the visual amenity of the area for tourism and discourage recreational activities. The predicted minimum time for oil to reach the Otway coast where the Great Ocean Road and Scenic Environs is 4days and 33 days for the coast where the where the Western Tasmania Aboriginal Cultural Landscape is located. The oil will likely be dissipated by that time The relatively short area of shoreline and low volume means there may be short-term and localised consequences, which are ranked as **Moderate (2).**
	Nationally Important Wetlands	Change in aesthetic value Change in ecosystem dynamics Changes to the functions, interests or activities of other users	Marine pollution can result in reduced visual aesthetic. The modelling predicts potential shoreline exposure at the low threshold at Aire River/Lower Aire River, Princetown and Western Post Wetlands (Section 4.2.7).	Visible shoreline hydrocarbons has the potential to reduce the visual amenity of the area for tourism and discourage recreational activities within protected areas. The predicted minimum time for oil to reach the shoreline adjacent to the River/Lower Aire River and Princetown Wetlands is 6.54 days and it is likely to have dissipated during that time. Cape Otway is exposed to substantial wave action that would further breakdown any shoreline hydrocarbons. The Aire River/Lower Aire River Wetlands consist of three shallow freshwater lakes, brackish to saline marshes and an estuary on the Aire River floodplain. Depending on where the shoreline contact occurs there is a potential for shoreline oil to move into the estuary

Receptor Group	Receptor Type	Impacts	Exposure Evaluation	Consequence Evaluation
				and wetlands at low concentrations which are not predicted to impact the aesthetic and ecological value of the wetlands. The Princetown Wetlands and upstream of the Gellibrand River mouth at Princetown Beach. Depending on where the shoreline contact occurs there is a potential for shoreline oil to move into the estuary and wetlands at low concentrations which are not predicted to impact the aesthetic and ecological value of the wetlands. Shoreline exposure of 1% during winter is predicted for Phillip Island which is within the Western Port Wetland. Minimum time for shoreline accumulation is 25.83 days. Depending on where the shoreline contact occurs there is a potential for shoreline oil to move into the wetlands at low concentrations which are not predicted to impact the aesthetic and ecological value of the wetlands. The relatively short duration and low volume means there may be short-term and localised consequences, which are ranked as **Moderate (2).**
	State Terrestrial Protected Area	Change in aesthetic value Change in ecosystem dynamics Changes to the functions, interests or activities of other users	Marine pollution can result in reduced visual aesthetic. The modelling predicts potential shoreline exposure at the low and moderate thresholds at Great Otway National Park, Phillip Island Nature Park, Port Campbell Southern Wilsons Promontory, Wilsons Promontory and Wilson Promontory Islands National Parks, and the following on the west side of King Island; Cape Wickham Conservation Area, Cataraqui Point Conservation Area, Porky Beach Conservation Area, Seal Rocks State Reserve, Stokes Point Conservations Area and West Point State Reserve.	Visible shoreline hydrocarbons has the potential to reduce the visual amenity of the area for tourism and discourage recreational activities within protected areas. The predicted minimum time for oil to reach a shoreline is 6.54 for the Victorian coast and it is likely to have dissipated during that time due to substantial wave action that would further breakdown any shoreline hydrocarbons. The predicted minimum time for oil to reach a King Island is 6.92 days it is likely to have dissipated during that time due to substantial wave action that would further breakdown any shoreline hydrocarbons. Seal Rocks on King Island is also a New Zealand fur-seal breeding colony. Consequently, the potential consequence is considered to be **Serious (3),** as they could be expected to result in serious impact on valued species or habitat.
	Threatened Ecological Communities Saltmarsh	Change in habitat Change in ecosystem dynamics	The modelling predicts potential shoreline exposure at the low , and some isolated moderate, thresholds where saltmarsh communities and the Assemblages of species associated with open-coast salt-wedge estuaries	Saltmarshes are considered to have a high sensitivity to hydrocarbon exposure. Saltmarsh vegetation offers a large surface area for oil absorption and tends to trap oil. Evidence from case histories and experiments shows that the damage resulting from oiling, and recovery times of oiled marsh vegetation,

Receptor Group	Receptor Type	Impacts	Exposure Evaluation	Consequence Evaluation
			of western and central Victoria ecological community and Subtropical and Temperate Coastal Saltmarsh Threatened Ecological Communities may be present.	are very variable. In areas of light to moderate oiling where oil is mainly on perennial vegetation with little penetration of sediment, the shoots of the plants may be killed but recovery can take place from the underground systems. Good recovery commonly occurs within one to two years (IPIECA, 1994). Consequently, the potential consequences to saltmarsh exposed to shoreline hydrocarbons is considered to be **Moderate (2),** as they could be expected to short-term and localised.
	Pinnipeds (seals and sea lions)	Injury/Mortality to fauna Change in fauna behaviour	The modelling predicts potential shoreline exposure at the low threshold at Seal Rocks on King Island which is a New Zealand fur-seal breeding colony.	Breeding colonies (used to birth and nurse until pups are weaned) are particularly sensitive to hydrocarbon spills (Higgins & Gass, 1993) and may be impacted by oil at the moderate threshold , with some isolated high threshold extents. This is ranked as **Moderate (2)** consequence.
Socio-economic	Coastal settlements Recreation and tourism (including recreational fisheries)	Change in aesthetic value Changes to the functions, interests or activities of other users	Marine pollution can result in reduced visual aesthetic. The modelling predicts shoreline exposure at the low and moderate threshold several local government areas (LGA)	Visible shoreline hydrocarbons has the potential to reduce the visual amenity of the area for tourism and discourage recreational activities. The predicted minimum time for oil to reach a shoreline is 6.54 days (Colac Otway) up to 95 days (Glennie Group) and it is likely to have dissipated during that time due to substantial wave action that would breakdown any shoreline hydrocarbons. The relatively short duration and low volume means there may be short-term and localised consequences, which are ranked as **Moderate (2).**
	Seaweed industry	Change in ecosystem dynamics Changes to the functions, interests or activities of other users	The modelling predicts potential shoreline exposure at the low and moderate threshold in areas along the west side of King Island where bull kelp is collected.	Experiments verified the susceptibility of *Nereocystis luetkeana* (bull kelp – North America) tissue to the direct exposure to several petroleum types. Antrim et al (1995) showed that petroleum treatments resulted in visible tissue damage, with a distinct bleached line being the most visible indication of plant contact with the petroleum. Moderate to heavy colour loss, which was generally followed by rapid decay of tissue, was most pronounced in 24 h exposures to unweathered and weathered diesel. As bull kelp is collected from the shoreline there is a potential for some plants to be affected and not be suitable for collection and processing. However, given the low levels of shoreline oil predicted it

Receptor Group	Receptor Type	Impacts	Exposure Evaluation	Consequence Evaluation
				is unlikely to be a significant impact on seaweed collection and associated income. The relatively low volume and limited extent of contact at the moderate threshold means there may be short-term and localised consequences, with some serious impacts to valued species or habitats and a **Serious (3).** consequence
First Nations	Sea Country Native Title	Change in aesthetic value Changes to the functions, interests or activities of other users	Marine pollution can result in reduced visual aesthetic. The modelling predicts shoreline exposure at the low threshold within Victorian Traditional Owner areas of Eastern Maar Aboriginal Corporation (and Native Title claim) and Bunurong Land Council Aboriginal Corporation. The modelling predicts shoreline exposure at the low threshold, with some limited areas of moderate threshold, on the western side of King Island and two locations within the north-west coast of Tasmania.	Visible shoreline hydrocarbons has the potential to reduce the visual amenity of Sea Country. The predicted minimum time for oil to reach a shoreline is 6.54 days for the Victorian coast, 6.92 days for King Island and 33 days for north-west Tasmania and it is likely to have dissipated during that time due to substantial wave action that would breakdown any shoreline hydrocarbons. The relatively localised extent and low volume means there may be short-term and localised consequences, which are ranked as **Moderate (2).**

Table 86: Environmental impact summary from shoreline oil exposure (Condensate spill)

In-Water Exposure

Receptor Group	Receptor Type	Impacts	Exposure Evaluation	Consequence Evaluation
Conservation Values and Sensitivities	Australian Marine Parks	Change in values Changes to the functions, interests or activities of other users	Apollo, Zeehan, Beagle Boags, Franklin and Tasman Fracture AMPs may be exposed to dissolved in water hydrocarbons at the moderate or high threshold within the upper 0 -10 m of the water column. Apollo and Zeehan AMPs were predicted to be exposed to in water entrained hydrocarbons at the moderate threshold within the upper 0 -10 m of the water column.	The Apollo AMP is located in waters 80 m to 120 m deep and thus conservation values such as ecosystems, habitats and communities associated with the Western Bass Strait Shelf Transition and the Bass Strait Shelf Province and associated with the seafloor features and the wreck of the MV City of Rayville are not predicted to be impacted. The conservation value of important migration area for blue, fin, sei and humpback whales is unlikely to be impacted as these whales would be moving through the area and thus unlikely to be exposed

Receptor Group	Receptor Type	Impacts	Exposure Evaluation	Consequence Evaluation
			Beagle, Boags, Franklin and Tasman Fracture AMPs were predicted to be exposed to in water entrained hydrocarbons at the low threshold within the upper 0 -10 m of the water column.	to in water hydrocarbons within 0 -10 m of the water column for a substantial period to elicit a toxic effect. The Apollo AMP is an important foraging area for black-browed and shy albatross, Australasian gannet, short-tailed shearwater and crested tern. These seabirds forage over an extensive area and are distributed over a wide geographic range. The areas of dissolved hydrocarbon predicted to meet the moderate or high threshold and entrained hydrocarbon predicted to meet the moderate threshold are relatively small compared to the Bass Strait and Otway region. It is these small areas where sub-lethal and toxic effects to birds may occur. There is a low probability that seabirds would be feeding exclusively or predominantly on fish found in the hydrocarbon exposed area, thus there is low probability of seabirds themselves experiencing sub-lethal or toxic impacts as a result of consuming hydrocarbon-tainted fish. The Zeehan AMP is located in waters 50 m to 3,000 m deep and thus conservation values such as ecosystems, habitats and communities associated with the Tasmania Province, the West Tasmania Transition and the Western Bass Strait Shelf Transition and associated with the seafloor features are not predicted to be impacted. The conservation value of important migration area for blue and humpback whales is unlikely to be impacted as these whales would be moving through the area and thus unlikely to be exposed to in water hydrocarbons within 0 -10 m of the water column for a substantial period to elicit a toxic effect. The Zeehan AMP is also an important foraging habitat for black-browed, wandering and shy albatrosses, and great-winged and cape petrels. These seabirds forage over an extensive area and are distributed over a wide geographic range. The areas of dissolved hydrocarbon predicted to meet the moderate or high threshold and entrained hydrocarbon predicted to meet the moderate threshold are relatively small compared to the Bass Strait and Otway region. It is these small areas where sub-lethal and toxic effects to birds may occur. There is a low probability that seabirds would be feeding exclusively or predominantly on fish found in these areas of

Receptor Group	Receptor Type	Impacts	Exposure Evaluation	Consequence Evaluation
				hydrocarbon exposure, thus there is low probability of seabirds themselves experiencing sub-lethal or toxic impacts as a result of consuming hydrocarbon-tainted fish. The Beagle AMP is located in waters 50 m to 70 m water depth and thus conservation values such as ecosystems, habitats and communities associated with the Southeast Shelf Transition and associated with the seafloor features, and shipwrecks are not predicted to be impacted. The Beagle AMP is also an important migration and resting areas for southern right whales and provides important foraging habitat for the Australian fur-seal, killer whale, great white shark, shy albatross, Australasian gannet, short-tailed shearwater, Pacific and silver gulls, crested tern, common diving petrel, fairy prion, black-faced cormorant and little penguin. These species may be impacted at the high thresholds for in water hydrocarbons. The Franklin AMP is located in waters 40 m to 150 m water depth and thus conservation values such as ecosystems, habitats and communities associated with the Tasmanian Shelf Province, Western Bass Strait Shelf Transition and associated with sea-floor features are not predicted to be impacted. The Franklin AMP is also an important foraging area for shy albatross, short-tailed shearwater, Australasian gannet, fairy prion, little penguin, common diving petrel, black-faced cormorant, and silver gull. These species may be impacted at the thresholds predicted. Consequently, the potential consequence is considered to be **Serious (3),** as they could be expected to result in serious impact on valued species or habitat.
	State Marine Protected Areas	Change in values Changes to the functions, interests or activities of other users	Twelve Apostles NP has potential for being impacted at the high threshold of in water entrained hydrocarbons. Wilsons Promontory and Bunorong NPs have the potential to be exposed at the moderate threshold of in water dissolved hydrocarbons	Impacts to Wilsons Promontory Marine National Park and Wilsons Promontory Marine Park values such as abundant and diverse marine flora and fauna, important breeding sites for a significant colony of Australian fur seals, important habitat for several threatened shorebird species, including species listed under international migratory bird agreements, outstanding landscapes, seascapes and spectacular underwater scenery, seascape, cultural

Receptor Group	Receptor Type	Impacts	Exposure Evaluation	Consequence Evaluation
			Wilsons Promontory, Point Addis, Bunorong, Port Phillip Heads and Discovery Bay MNPs were predicted to be exposed above the low threshold of in water entrained and dissolved hydrocarbons	places and objects of high traditional and cultural significance to Indigenous people, Indigenous cultural lore and interest maintained by the Gunai / Kurnai and Boonwurrung people and important maritime and other history, may be impacted by moderate threshold level of dissolved hydrocarbons. As impacts are only predicted within 0 – 10 m of the water column Twelve Apostles Marine National Park values such as the wreck of the Loch Ard, underwater limestone formations of arches and canyons, diverse range of encrusting invertebrates and dive sites are not predicted to be impacted. The unique limestone rock formations, including the Twelve Apostles, marine habitats representative of the Otway marine bioregion and indigenous culture based on spiritual connection to sea country and a history of marine resource use and may be impacted by in water hydrocarbons at the high threshold. Consequently, the potential consequence to these State Marine Protected Areas is considered to be **Serious (3)** as they could be expected to result in localised minor short-term impacts to an area of recognised conservation value.
	Key Ecological Features	Change in ecosystem dynamics	The West Tasmanian Canyons KEF may be exposed to dissolved and entrained hydrocarbons at the moderate and high thresholds within the upper 0 -10 m of the water column. Seamounts south and east of Tasmania, Upwelling east of Eden, Bonney Coast Upwelling KEFs are predicted to be exposed at the low threshold of in water hydrocarbons.	The West Tasmanian Canyons KEF is in water depths > 70 m and thus impacts from in-water hydrocarbons are not predicted. No impacts from the low threshold of in water hydrocarbons are predicted to the KEFs.
	Threatened Ecological Communities	Change in ecosystem dynamics	The following Threatened Ecological Communities may be exposed to dissolved and entrained hydrocarbons at the low threshold within the upper 0 -10 m of the water column. Assemblages of species associated with open-coast salt-wedge estuaries of western and central Victoria ecological community.	Entrained hydrocarbons at the low threshold are not predicted to impact on the ecological function of the Threatened Ecological Communities.

Receptor Group	Receptor Type	Impacts	Exposure Evaluation	Consequence Evaluation
			Giant Kelp Marine Forests of South East Australia. Subtropical and Temperate Coastal Saltmarsh.	
Benthic Habitat	Algae	Change in habitat	Video surveys confirmed the presence of high density macroalgae dominated epibenthos in waters shallower than 20 m, however, it is not a dominant habitat feature in eastern Victoria (Section 4.4.1.3). Dissolved hydrocarbons in the upper 0 – 10 m of the water column at the moderate threshold that could impact algae, have a 3% probability for exposure to Tasmanian waters and 1% for Victorian waters where waters may be shallower than 10 m. Entrained hydrocarbons in the upper 0 – 10 m of the water column at the high threshold that could impact algae are not predicted in Tasmanian waters or Victorian waters where waters may be shallower than 10 m.	Reported toxic responses to oils have included a variety of physiological changes to enzyme systems, photosynthesis, respiration, and nucleic acid synthesis (Lewis & Pryor 2013). A review of field studies conducted after spill events by Connell et al (1981) indicated a high degree of variability in the level of impact, but in all instances, the algae appeared to be able to recover rapidly from even very heavy oiling. Given the restricted range of exposure (shallow nearshore and intertidal waters only) and only the predicted moderate threshold concentrations of dissolved hydrocarbons predicted in shallow waters, any impact to algae is not expected to result in long-term or irreversible damage. Consequently, the potential consequence to algae are considered to be **Minor (1),** as they could be expected to result in localised low-level impacts.
	Soft Coral	Change in habitat	Corals do not occur as a dominant habitat type within the planning area, however their presence has been recorded around areas such as Wilsons Promontory National Park and Cape Otway where low threshold concentrations of dissolved or entrained hydrocarbons are predicted.	Exposure of entrained hydrocarbons to shallow subtidal corals has the potential to result in lethal or sublethal toxic effects, resulting in acute impacts or death at moderate to high exposure thresholds (Shigenaka, 2001). Contact with corals may lead to reduced growth rates, tissue decomposition, and poor resistance and mortality of sections of reef (NOAA, 2010). However, given the lack of coral reef formations, and the sporadic cover of hard or soft corals in mixed nearshore reef communities along the Otway coast, such impacts are considered to be limited to isolated corals. Also only low exposure thresholds are predicted at known coral habitat sites. Consequently, the potential consequence to algae are considered to be **Minor (1),** as they could be expected to result in localised low-level impacts.

Receptor Group	Receptor Type	Impacts	Exposure Evaluation	Consequence Evaluation
	Seagrass	Change in habitat	In-water exposure (dissolved or entrained) is only predicted to occur within the upper 0 – 10 m of the water column; therefore, benthic habitat within intertidal or shallow nearshore waters has the potential to be exposed. Note that the greater wave action and water column mixing within the nearshore environment will also result in rapid weathering of the condensate. Seagrass may be present within the area predicted to be exposed to in-water hydrocarbons (e.g. seagrass is known to occur within Twelve Apostles Marine Park, and areas around Warrnambool) Exposure in nearshore and intertidal areas is predicted to only be at a low thresholds for dissolved and entrained hydrocarbons.	There is the potential that exposure could result in sub-lethal impacts, more so than lethal impacts, possibly because much of seagrasses' biomass is underground in their rhizomes (Zieman et al., 1984). Exposure also can take place via uptake of hydrocarbons through plant membranes and seeds may be affected by contact with oil contained within sediments (NRDA 2012). When seagrass leaves are exposed to petroleum oil, sub-lethal quantities of the soluble fraction can be incorporated into the tissue, causing a reduction in tolerance to other stress factors (Zieman et al. 1984). The toxic components of petroleum oils are thought to be the PAH, which are lipophilic and therefore able to pass through lipid membranes and tend to accumulate in the thylakoid membranes of chloroplasts (Ren et al. 1994). Susceptibility of seagrasses to hydrocarbon spills will depend largely on distribution, with deeper communities protected from oiling under all but the most extreme weather conditions. Shallow seagrasses are more likely to be affected by dispersed oil droplets. Given the restricted range of exposure (shallow nearshore and intertidal waters only) and the predicted low concentrations of hydrocarbons predicted in these waters, any impact to seagrass is not expected to result in long-term or irreversible damage. Consequently, the potential consequence to seagrass are considered to be **Moderate (2),** as they could be expected to result in localised minor short-term impacts to habitat of recognised conservation value.
Marine fauna	Plankton	Injury / mortality to fauna	Plankton are likely to be exposed to in-water hydrocarbons within the upper 0 – 10 m of the water column. Effects will be greatest in the area close to the spill source where hydrocarbon concentrations are likely to be highest.	Relatively low concentrations of hydrocarbon are toxic to both plankton including zooplankton and ichthyoplankton (fish eggs and larvae). Plankton risk exposure through ingestion, inhalation, and dermal contact. Impacts would predominantly result from exposure to dissolved fractions, as larval fish and plankton are pelagic, and are moved by seawater currents. Potential impacts would largely be restricted to planktonic communities, which would be expected to recover rapidly following a hydrocarbon spill. Plankton are numerous and widespread but do act as the basis for the marine food web, meaning that an oil spill in any one location is

Receptor Group	Receptor Type	Impacts	Exposure Evaluation	Consequence Evaluation
				unlikely to have long-lasting impacts on plankton populations at a regional level. Once background water quality conditions have re-established, the plankton community may take weeks to months to recover (ITOPF, 2011a), allowing for seasonal influences on the assemblage characteristics. Additionally, with the elevated nutrient loading expected during seasonal upwelling events within the Otway region (November to April), plankton are likely to recover more rapidly than when upwelling of nutrient-rich waters is less prevalent. Consequently, given the limited area exposed by moderate levels of dissolved hydrocarbons, the potential consequence to plankton are considered to be **Minor (1),** as they could be expected to result in localised low-level short-term and recoverable impacts.
	Marine invertebrates	Injury / mortality to fauna	In-water invertebrates of value have been identified to include squid, crustaceans (rock lobster, crabs) and molluscs (scallops, abalone). Impact by direct contact of in-water hydrocarbons to benthic species in the deeper areas of potential exposure are not predicted as in-water exposure (dissolved or entrained) is only predicted to occur in the upper 0 – 10 m of the water column. Species located in shallow nearshore or intertidal waters may be exposed to in-water hydrocarbons low thresholds. Several commercial fisheries for marine invertebrates are within the area predicted to be exposed to moderate levels of entrained in-water hydrocarbons.	Acute or chronic exposure through contact and/or ingestion can result in toxicological risks. Larval or juvenile forms of invertebrates may be more prone to impacts (Suchanek, 1993). Localised impacts to larval stages may occur which could impact on population recruitment that year. Tainting of recreation or commercial species is considered unlikely to occur given exposure is limited to entrained hydrocarbons, however if it did it is expected to be localised and low level with recovery expected. Consequently, the potential consequence to invertebrates, including commercially fished invertebrates are considered to be **Moderate (2)** as they could be expected to result in localised short-term impacts to species of value.
	Fish	Injury / mortality to fauna	In-water exposure (dissolved or entrained) is only predicted to occur in the upper 0 – 10 m of the water column the surface layers of the water column. Several fish communities in these areas are demersal and therefore more prevalent towards the seabed, as such, exposure to these species is	Pelagic free-swimming fish and sharks are unlikely to suffer long-term damage from oil spill exposure because dissolved/entrained hydrocarbons in water are not expected to be sufficient to cause harm (ITOPF, 2010). Subsurface hydrocarbons could potentially result in acute exposure to marine biota such as juvenile fish, larvae, and planktonic organisms, although impacts are not expected cause population-level impacts.

Receptor Group	Receptor Type	Impacts	Exposure Evaluation	Consequence Evaluation
			not expected to occur. Any fish or shark species within the surface layers of the water column, may come into contact with the area of predicted exposure for in-water hydrocarbons. The Australian grayling spends most of its life in fresh water, with parts of the larval or juvenile stages spent in coastal marine waters, therefore it is not expected to be present in offshore waters in large numbers. There is a known distribution and foraging BIA for the white shark in the planning area, however, it is not expected that this species spends a large amount of time close to the surface where thresholds may be highest.	Consequently, the potential consequence to fish, including those commercially fished, are considered to be Moderate, as they could be expected to result in localised low-level short-term impacts to species of value. Impacts on eggs and larvae entrained in the upper water column are not expected to be significant given the temporary period of water quality impairment, and the limited geographical extent of the spill. As egg/larvae dispersal is extensive in the upper layers of the water column and it is expected that current induced drift will rapidly replace any oil affected populations. Impacts are assessed as temporary and localised, and therefore considered to be **Moderate (2)**
	Pinnipeds (seals and sea-lions)	Injury / mortality to fauna Change in fauna behaviour	Australian and New Zealand fur-seals may occur within the area of exposure. There are no identified BIAs for seals or sea lions within the area of exposure. No known breeding colonies of Australian or New Zealand fur-seals are exposed to moderate dissolved or high entrained exposure thresholds. Given the mobility of pinnipeds, there may be small numbers of seals in the areas predicted to be temporarily exposed to moderate dissolved or high entrained exposure thresholds in the water column, noting that in-water exposure (dissolved or entrained) is only predicted to occur within the upper 0 -10 m of the water column.	Exposure to moderate dissolved or high entrained exposure thresholds in the water column or consumption of prey affected by the oil may cause sub-lethal impacts to pinnipeds. Due to the temporary and localised nature of the spill, pinnipeds widespread nature, the low-level exposure zones and rapid loss of the volatile components of diesel in choppy and windy seas (such as that of the area exposed), the potential consequence to pinnipeds are considered to be **Moderate (2),** as they could be expected to result in localised minor short-term impacts to species of recognised conservation value.
	Cetaceans (whales and dolphins)	Injury / mortality to fauna Change in fauna behaviour	Several threatened, migratory and/or listed marine cetacean species have the potential to be migrating, resting or foraging within the area predicted to be exposed to in-water hydrocarbons. BIAs for foraging for pygmy blue whales and the migration BIA for southern right whales are within	Cetacean exposure to entrained hydrocarbons can result in physical coating as well as ingestion (Geraci and St Aubin, 1988). Such impacts are associated with 'fresh' hydrocarbon; the risk of impact declines rapidly as the oil weathers. The potential for impacts to cetaceans and dolphins would be limited to a relatively short period following the release and would need to coincide with seasonal foraging or aggregation event to

Receptor Group	Receptor Type	Impacts	Exposure Evaluation	Consequence Evaluation
			the area predicted to be exposed to moderate or high exposure thresholds in the water column, noting that in-water exposure (dissolved or entrained) is only predicted to occur within the upper 0 -10 m of the water column.	result in exposure to a large number of individuals, as may be the case during seasonal upwelling events within the Otway region. However, such exposure is not anticipated to result in long-term population viability effects. A proportion of the foraging or distributed population of whales could be affected in the relatively localised area and water depth of the total foraging BIA for pygmy blue whales and migration BIA for southern right whales. Consequently, the potential consequence is considered to be **Serious (3),** as they could be expected to result in serious impact on valued species or habitat.
Socio-economic	Commercial and recreational fisheries	Change in ecosystem dynamics Changes to the functions, interests or activities of other users	In-water exposure to hydrocarbons may result in a reduction in commercially targeted marine species, resulting in impacts to commercial fishing and aquaculture. Actual or potential contamination of seafood can affect commercial and recreational fishing and can impact seafood markets long after any actual risk to seafood from a spill has subsided (NOAA, 2002) which can have economic impacts to the industry. Several commercial fisheries operate in the planning area and overlap the spatial extent of the water column hydrocarbon predictions	Any acute impacts are expected to be limited to small numbers of juvenile fish, larvae, and planktonic organisms, which are not expected to affect population viability or recruitment. Impacts from entrained exposure are unlikely to manifest at a fish population viability level. Any exclusion zone established would be limited to the safety exclusion zone around the vicinity of the release point, and due to the rapid weathering of hydrocarbons would only be in place whilst well-control activities are enacted, therefore physical displacement to vessels is unlikely to be a significant impact. Consequently, the potential consequence to commercial and recreational fisheries are considered to be **Moderate (2)**, as they could be expected to result in localised low-level short-term impacts.
	Recreation and tourism	Changes to the functions, interests or activities of other users Change in aesthetic value	Tourism and recreation are linked to the presence of marine fauna (e.g. whales), particular habitats and locations for recreational fishing. The area between Cape Otway and Port Campbell is frequented by tourists. It is a remote stretch of coastline dominated by cliffs with remote beaches subject to the high energy wave action. Access to the entire coastline is via a 7 to 8-day walking track from Apollo Bay ending at the Twelve Apostles.	Any impact to receptors that provide nature-based tourism features (e.g. whales) may cause a subsequent negative impact to recreation and tourism activities. Any impact to receptors that provide nature-based tourism features (e.g. fish and cetaceans) may cause a subsequent negative impact to recreation and tourism activities. However, the relatively short duration, and distance from shore means there may be short-term and localised consequences, which are ranked as **Moderate (2).**

Receptor Group	Receptor Type	Impacts	Exposure Evaluation	Consequence Evaluation
			Recreation is also linked to the presence of marine fauna and direct impacts to marine fauna such as whales, birds, and pinnipeds can result in indirect impacts to recreational values. It is important to note that the impact from a public perception perspective may be even more conservative. This may deter tourists and locals from undertaking recreational activities. If this occurs, the attraction is temporarily closed, economic losses to the business are likely to eventuate. The extent of these losses would be dependent on how long the attraction remains closed.	
	Seaweed Industry	Change in ecosystem dynamics Changes to the functions, interests or activities of other users	In-water exposure to hydrocarbons may result in a reduction in commercially targeted seaweed species. Areas along the west side of King Island where bull kelp is collected may be exposed to dissolved and entrained hydrocarbons at the low threshold within the upper 0 -10 m of the water column.	Experiments verified the susceptibility of *Nereocystis luetkeana* (bull kelp – north America) tissue to the direct exposure to several petroleum types. Antrim et al (1995) showed that petroleum treatments resulted in visible tissue damage, with a distinct bleached line being the most visible indication of plant contact with the petroleum. Moderate to heavy colour loss, which was generally followed by rapid decay of tissue, was most pronounced in 24 h exposures to unweathered and weathered diesel. The study did not look at how this would affect the productivity of bull kelp. Consequently, the potential consequence is considered to be **Serious (3),** as they could be expected to result in serious impact on valued species or habitat.
First Nations	Sea Country Native Title Indigenous Protected Area	Change in aesthetic value Changes to the functions, interests or activities of other users	In-water exposure to hydrocarbons is predicted along the Victorian and Tasmanian coastal waters within the planning area which is Sea Country for a number of First Nations groups and is adjacent to the Eastern Maar Native Title claim and Preminghana Indigenous Protected Area.	Section 4 details the connection First Nations people have to Sea Country which could be potentially impacted by in-water exposure to hydrocarbons. There may be short-term and localised consequences, which are ranked as **Moderate (2)**

Table 87: Environmental impact summary from in-water oil exposure (Condensate spill)

7.4.3 Risk Evaluation Summary

Summary	
Summary of risks	Loss of well control and other worst-case scenarios are low likelihood/high consequence event (SINTEF 2001). Consequence would be Localised and temporary reduction in water quality. Potential toxicity impacts to marine life. Temporary fisheries closures.
Extent of risks	Thylacine condensate has a significant proportion of volatile components and only a small residual component. Due to this volatility, once on the water surface most of this oil will evaporate within several days of release. MDO evaporates and disperses rapidly. Possible extents of exposure in a worst-case spill scenario are shown in Section 7.4.2
Duration of risks	The condensate and MDO are non-persistent. Worst case spills are not considered to result in long-term or irreversible environmental damage or affect ecosystem functioning
Level of certainty of risks	Impacts of hydrocarbons on receptors are well researched and understood.
Risk decision framework context	C – The precautionary approach has been applied in this risk assessment: • High discharge flow rate is assumed, based on complete failure of all barriers and the well-bore remaining open for the entire duration of the spill. • The worst-case individual runs have been selected to represent the greatest extent of effect, whereas 99% of the outcomes would result in a lesser extent of effects. • The model registers a threshold exceedance if a concentration is exceeded in a grid cell on one occasion; whereas oil toxicity effects are related to prolonged exposure (often four days or more), especially at the lower concentrations.

	Risk Assessment (inherent)	
	MDO Spill	
Consequence	Likelihood	Risk rating
Major	**Unlikely**	**Medium**
	Condensate Spill	
Consequence	Likelihood	Risk rating
Major	**Highly Unlikely**	**Medium**

	Controls
CM40 WOMP	The Well Operations Management Plan (WOMP) is a regulatory requirement under the Offshore Petroleum and Greenhouse Gas Storage Act 2006 and the associated Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011. It is the primary approval document for ensuring a high standard of well integrity and details the risk assessment, critical procedures and safety mechanisms to be implemented throughout the duration of the relevant petroleum activity
CM41 MODU Safety Case	The Safety Case for the MODU is a regulatory requirement under the OPGGS Act and the associated Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011 The Safety Case identifies hazards and risks specific to drilling wells, describes how the risks are controlled and describes the safety management system in place to ensure the controls

	are effectively and consistently applied. Prevention of loss of well control and subsequent release of hydrocarbons is a key focus as this is the source of major accident events
CM42 Well Engineering and Construction Management System (WECS)	Beach Well Engineering and Construction Management System (WECS) that ensures well activities are fit for purpose with operational risks managed to a level that is as low as reasonably practicable. It also ensures that changes are made in a controlled manner, that appropriate standards are adhered to, and that a sufficiently resourced and competent organisation is in place. The Beach Operations Excellence Management System consists of Well Integrity Standard and WECS.
CM43 Workforce capability	Beach Workforce Capability Requirements Matrix to ensure Operations personnel are qualified, trained and certified as competent to operate and maintain Beach facilities
CM44 Crisis and Emergency Management	Beach's Crisis and Emergency Management Standard requires Beach to have plans, procedures and resources in place to effectively respond to crisis and emergency situations, including hydrocarbon spills
CM45 Preventative maintenance	Computerised Maintenance Management System to ensure all wells and subsea infrastructure is maintained to schedule
CM05 Petroleum safety zones	The Project will comply with OPGGS Act – Section 616 (2) petroleum safety zones, which includes establishment and maintenance of petroleum safety zones around wells, offshore structures or equipment which prohibits vessels entering without written consent
CM06 Temporary exclusion zones	500m temporary exclusion zones will be established and maintained around drilling and installation activities
CM46: SMPEP or SOPEP (appropriate to class)	In accordance with MARPOL Annex I and AMSA's MO 91 [Marine Pollution Prevention – oil], a SMPEP or SOPEP (according to class) is required to be developed based upon the Guidelines for the Development of Shipboard Oil Pollution Emergency Plans, adopted by IMO as Resolution MEPC.54(32) and approved by AMSA. To prepare for a spill event, the SMPEP/SOPEP details: • response equipment available to control a spill event; • review cycle to ensure that the SMPEP/SOPEP is kept up to date; and • testing requirements, including the frequency and nature of these tests. • reporting requirements and a list of authorities to be contacted; • activities to be undertaken to control the discharge of hydrocarbon; and • procedures for coordinating with local officials. • Specifically, the SMPEP/SOPEP contains procedures to stop or reduce the flow of hydrocarbons to be considered in the event of tank rupture.
CM47 Bunkering procedure	Bunkering procedures to manage fuel transfers that include: • Weather limits on bunkering operations • Bunkering equipment specifications and inspection • Visual observations during transfers • Emergency shutdowns
CM48 EP, OPEP and OSMP	Accepted Environment Plans (EP) Oil Pollution Emergency Plans (OPEP) and Operational and Scientific Monitoring Plans (OSMP) in place for all relevant Project activities and oil spills responded to in accordance with the plans
CM49 Oil spill modelling	Oil spill modelling and environmental risk assessments for the Project EPs and OPEPs will consider the full range of worst-case scenario LOWC consequences
CM50 Source control	Source Control Emergency Response Plans in place for all drilling activities
CM02 Notifications	The Australian Hydrographic Office will be notified of the Project activities and installed subsea infrastructure prior to commencement to facilitate the issuing of Notice to Mariners and

	maintain nautical charts. Relevant stakeholders are notified prior to the activity so that third party marine users are aware of vessel location and timing	
CM03: Fair Ocean Access Procedure	Beach's Fair Ocean Access Procedure was developed with input from commercial fishing industry organisations. The procedure details the process whereby a commercial fishers can claim compensation for an economic loss associated with Beach's offshore activities where impacts cannot be avoided, including in the event of an oil spill.	
CM01 Navigation safety	All vessels operating within the project area will adhere to the navigation safety requirements including: • International Regulations for Preventing Collisions at Sea 1972 • Chapter 5 of International Convention for the Safety of Life at Sea 1974 • International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978 • Navigation Act 2012 and any subsequent Marine Orders that specify standards for crew training and competency, navigation, communication, and safety measures.	
Risk Assessment (residual)		
MDO Spill		
Consequence	Likelihood	Risk rating
Serious	**Highly Unlikely**	**Medium**
Condensate Spill		
Consequence	Likelihood	Risk rating
Serious	**Remote**	**Low**
Environmental Performance Outcomes		
EPO4	No impact to submerged cultural heritage	
EPO5	No death or injury to marine fauna, including listed threatened or migratory species, from Project activities	
EPO18	No unplanned discharge of hydrocarbons or chemicals to the marine environment from Project activities	
EPO19	In event of an unplanned release of chemicals or hydrocarbons, spill response control measures will be implemented in accordance with accepted EP, OPEP and OSMP	
Demonstration of Acceptability		
ESD Principles	EPOs are aligned with the principles of ESD: • Extensive controls are in place to prevent a loss of well containment. • In the unlikely event of a spill, plans are in place to mitigate the impact and prevent serious or irreversible environmental damage	
Internal context	Policy compliance	Beach Environmental Policy objectives are met through this environmental impact assessment.
	Management system compliance	Section 9 describes the implementation strategy employed for this activity.
External context	Stakeholder engagement is being carried out as part of this OPP process Beach operates the existing Otway project and has established good relations with both onshore and offshore stakeholders. Engagement with stakeholders will continue throughout all aspects of	

	the Project to build and maintain trust with stakeholders and the local community and minimise community and stakeholders concern and impacts where practicable.	
Legislative context	EPOs and controls align with the requirements of: • OPGGS Act 2006 (Cth): • A Well Operations Management Plan (WOMP) must be in place for all wells. • Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011. • A WOMP will be prepared and detail well design and detail safety measures to prevent a spill. This must be accepted by NOPSEMA. • OPGGS (Environment) Regulations 2023: • Part 3 (Incidents, reports and records). • OPGGS Act 2006 (Cth) Section 460(2) – a person carrying on activities in an offshore area under the permit must carry out those activities in a manner that does not interfere with the conservation of the resources of the sea and seabed to a greater extent than is necessary for the reasonable exercise of the rights and performance of the duties of the first person. • Significant impact criteria (refer Table 41 in Section 5.8.2) • EPBC Management/Recovery Plans and Conservation Advice (refer Table 5 in Section 2.3.1)	
Industry practice	Well control equipment maintained as per Original Equipment Manufacturer (OEM) standards Well control equipment systems managed in accordance with American Petroleum Institute (American Petroleum Institute) Standard 53 The minimum functional and performance requirements and guidelines for well design, planning and execution are compliant with NORSOK D-010 Well integrity in drilling and well operations standard (2021)	
	International Oil and Gas Producers (IOGP) Report 594 - Subsea Well Source Control Emergency Response Planning Guide for Subsea Wells (January 2019).	Beach aligns with International Oil and Gas Producers (IOGP) Report 594 - Subsea Well Source Control Emergency Response Planning Guide for Subsea Wells (January 2019).
	Best Available Techniques Guidance Document on Upstream Hydrocarbon Exploration and Production (European Commission, 2019)	No guidance is provided regarding preventing or managing a loss of well control, other than having a spill contingency plan in place. An OPEP is in place for the activity.
	Environmental, Health and Safety Guidelines for Offshore Oil and Gas Development (World Bank Group, 2015)	Guidelines met with regard to: • Section 75 (Spills): Conducting a spill risk assessment, implementing personnel training and field exercises, ensuring spill response equipment is available. • Sections 76-79 (Spill response planning): A spill response plan should be prepared.
	APPEA Code of Environmental Practice (2008)	The management measures listed in this table meet the following offshore development and production objectives: • To reduce the risk of any unplanned release of material into the marine environment to ALARP and an acceptable level.
	Environmental management in the upstream oil and gas industry (IOGP-IPIECA, 2020)	Proposed controls align with management measures listed for major spill in Section 4.7.4 of the guidelines.

Acceptability outcome	Acceptable

Table 88: Risk assessment summary for the loss of containment of hydrocarbons and chemicals

8. Cumulative Impact Assessment

8.1 Overview

Cumulative environmental impacts in the context of offshore petroleum activities are successive, additive, or synergistic impacts of collectively significant activities or projects with material impacts on the environment that have the potential to accumulate over temporal and spatial scales (NOPSEMA Environment Plan Decision Making Guideline, N-04750-GL1721 A524696, Dec 2022).

The effects of past projects and activities, and currently operating projects, are captured when describing the existing condition of and any pressure or threats affecting the environment (see Section 4). This baseline condition and understanding of the capacity of the receiving environment and receptors to accommodate changes, in light of existing pressures and threats, informs the environmental impact assessments conducted in Sections 6 and 7 of this OPP.

The focus of this cumulative impact assessment is to further build on these assessments by considering the impacts of the proposed activity on key matters in conjunction with the impacts from other reasonably foreseeable future projects.

8.2 Methodology

Guidance from the United Kingdom (UK) National Infrastructure Planning Advice Note Seventeen: Cumulative effect assessment relevant to nationally significant infrastructure programs (UK 2019) and the New South Wales (NSW) Cumulative Impact Assessment Guidelines for State Significant Projects (NSW 2022), form the basis of this assessment.

Both the UK and NSW guidelines are intended to apply to large-scale national and state significant projects, respectively, with greater potential for cumulative impacts into the long-term. Consequently, the assessment process applied here has been adapted to the nature and scale of the activities associated with the Project.

8.2.1 CIA Scoping

Scoping is undertaken to identify the key environmental matters that could be materially affected by the cumulative impacts of the project and other reasonably foreseeable future projects and require a detailed CIA.

Key environmental matters are features of the environment (ecological, socio-economic, and cultural values and sensitivities) that are valued because of their rarity or importance, including the critical role they play in supporting systems which are essential for the environment, people and / or the economy (NSW 2022), for example, commercial fisheries and threatened species undertaking biologically important behaviours.

Material impacts are impacts of the project and other reasonably foreseeable future projects and activities that may not align with the defined acceptable levels, for example, threats of wide-scale, serious or irreversible damage due to cumulative impacts.

The scoping steps are detailed below, and the outcomes are in Table 91.

- Step 1: Identify the receptors that are predicted to be impacted by the project planned aspects as per the environmental impact evaluation in Section 6.
- Step 2: Define the cumulative impact acceptable level for each receptor based on the acceptable level assessment for each receptor/aspect as detailed in Section 6.

- Step 3: Define the spatial extent for the assessment based on the range and distribution of the receptor and/or where the impacts of the Project associated with the receptor overlap with impacts from other reasonably foreseeable future projects.
- Step 3: Define the temporal extent for the assessment on the when the receptor is likely or known to present within the defined spatial extent and for the period that the impact will occur.
- Step 4: Identify projects and activities that are reasonably foreseeable within the spatial and temporal extent of the assessment as detailed in Section 8.2.2.
- Step 5: Identify where there is the potential for receptors to be materially affected by the cumulative impacts of the Project and other reasonably foreseeable future projects. These receptors are then required to have a detailed CIA as per Section 8.2.3.
- Step 6: Identify the level of certainty of the scoping assessment. The certainty of the assessment is high based on the points below. If one of these is not met, then a cautious approach is undertaken, and the receptor is required to have a detailed CIA as per Section 8.2.3.
  - Impacts are well understood.
  - Impacts are relatively easy to predict using standard methods.
  - Impacts are capable of being mitigated to comply with relevant standards and to meet the acceptable level.

8.2.2 Identifying Reasonably Foreseeable Future Projects and Activities CIA Scoping

CIA considers projects and activities that are reasonably foreseeable within the spatial and temporal extent of the assessment. This defines the boundaries of the assessment by including projects and activities that have a realistic likelihood of occurring and could contribute to cumulative impacts.

To identify reasonably foreseeable future projects and activities a search was conducted of the NOPSEMA and DEECA (Vic) Environment Plan website to identify any relevant projects and activities. In addition, petroleum titleholders within the Otway Basin have been meeting regularly to discuss environmental management in the region, including processes for improved CIA, focusing on reasonably foreseeable activities. This has provided a more accurate representation of projects and activities and the potential for cumulative impacts, ensuring that relevant impacts are appropriately assessed and managed.

Reasonably foreseeable future projects and activities identified to date are detailed in Table 89.

In addition, as the existing Beach Otway Development (Beach’s current production operations at the Geographe and Thylacine gas fields) is the baseline condition, a review was undertaken to identify how the impacts associated with existing operations are anticipated to change (cumulative spatial and temporal impacts) as the Project is developed over the life of the Otway operations. Where a material change in impact for an aspect was identified the aspect was carried over to the scoping phase as per Table 90. The review is detailed in Table 92.

Projects and activities that are not reasonably foreseeable or speculative have been excluded from the assessment scope to maintain practicality and relevance in decision-making processes.

Information on projects and activities is typically accessible once consultation commences and relevant technical supporting information is submitted for public comment or assessment. Information relevant to this CIA has been discussed at the ongoing Otway Basin Petroleum Titleholder meetings. Where project/activity-specific data is not yet available, data from similar projects has been used as a proxy prior to technical information being made available. Given the similarity of impacts, there is a high level of certainty in the prediction of cumulative impacts in most cases.

Assumptions around specific timings for projects or activities have been made as there is some level of uncertainty in schedule and timing of approvals to support activities. Consequently, a conservative approach has been adopted whereby credible worst-case scenarios (e.g. concurrent activities with overlapping EMBAs) are assessed.

8.2.3 Detailed CIA

For those receptors and aspects where a potential cumulative cause-effect pathway and material impact was identified in the scoping, a detailed CIA assessment was applied in general alignment with the project-specific methodology described in Section 5. The outcome of this detailed assessment is in Table 90.

The CIA process applied to each aspect and component of the environment was:

- Identification of:
    - Receptor conservation values or values relevant to CIA e.g. EPBC Listed Threatened Species, MNES, commercial or cultural significance.
    - Legislative or other requirements relevant to the assessment.
    - Relevant threatening processes.
    - Relevant spatial extent such as BIAs, and temporal extent when receptor present including any biologically important features such as behaviours or critical life-cycle stages, timings.
    - Relevant actions from legislative or other requirements.
- Detail the baseline existing environment including pressures and condition.
- Define the cumulative impact acceptable level.
- Identification of other reasonably foreseeable future projects where the aspect overlaps the identified relevant spatial extent.
- Assessment of potential for cumulative impacts:
    - Description of potential cumulative impact.
    - Detail the level of certainty of the assessment.
    - Detail Beach’ existing control measures.
    - Comparison to acceptable level(s), and where required (reiterative process):
    - Identification of additional control measures and demonstration that cumulative impacts are as low as reasonably practicable (ALARP).
- Detailing any additional actions.

The potential cumulative impacts to the key receptors were evaluated as being Minor (1). No additional controls were identified however Beach will continue to work with other titleholders undertaking activities within the Otway Basin with the aim of identifying and minimising the potential for cumulative impacts, in addition to cooperation on monitoring and management to increase effectiveness.

Titleholder	Activity	Status	Timing Window	Potential Temporal Overlap with Project	Potential Spatial Overlap with Project
Beach Energy	Otway Operations	Exiting Operations	Ongoing	Temporal overlap of IMR campaigns and platform resupply and EMBAs with Project activities.	Spatial overlap of Otway Operations infrastructure, IMR campaigns and platform resupply and EMBAs with Project activities.
Cooper Energy	CHN Operations	Exiting Operations	Ongoing	Potential temporal overlap of IMR campaigns EMBAs with Project activities.	Potential spatial overlap of IMR campaigns EMBAs with Project activities.
Beach Energy	Drilling Decommissioning (P&A)	Proposed	2024-2027	Titleholders are part of a rig consortium which has signed an agreement with Transocean to bring a semi-submersible rig to the offshore Otway Basin in 2025. Thus, consecutive drilling/P&A activities will occur, but no concurrent drilling activities will occur.	
Cooper Energy	Drilling	Proposed	2024-2026		
Conoco Phillips	Drilling	Proposed	2024-2026 (~30-40 days per well, max 6 wells)		
Woodside Energy	Minerva Decommissioning (P&A)	Proposed	2024-2025 (< 2 months)		
CGG- Regia	Seismic Survey	Proposed	2024-2028 60 days acquisition 90 days in field One survey between November – May) or Two separate surveys April – June, and or September – November.	Consecutive drilling/P&A activities will occur. Concurrent drilling activities unlikely. Concurrent seismic operations unlikely. Consecutive seismic surveys likely. Concurrent seismic survey and drilling/P&A activities likely.	Unlikely direct spatial overlap of drilling/P&A areas. Unlikely direct spatial overlap of seismic survey areas. Possible overlap of seismic survey area and drilling/P&A activities. Unlikely overlap of sound EMBAs of concurrent seismic survey and drilling/P&A at single location. Possible overlap of light EMBAs associated with concurrent seismic survey and drilling/P&A at a single location.
TGS -NOPEC Geophysical Company	Seismic survey	Proposed	2023-2027		

Table 89: Reasonably foreseeable future projects and activities in the offshore Otway Basin

	Planned Environmental Aspects									CIA – Scoping Assessment					
Receptors	**Physical Presence - Interaction with Other**	**Physical Presence - Seabed Disturbance -**	**Emissions - Light**	**Emissions – Underwater Sound**	**Emissions - Atmospheric**	**Emissions – Greenhouse Gas**	**Discharges – Drill Cuttings and Cement**	**Discharges – Commissioning and Operations**	**Discharges - Vessels**	**Acceptable Level**	**Potential for Cumulative Impact Spatial Extent**	**Potential for Cumulative Impact Temporal Extent**	**Scoping Assessment Outcome**	**Level of Certainty of Scoping Assessment**	**Cumulative Cause-effect Pathway**
Australian Marine Parks			✓	✓						Not inconsistent with SE Marine Parks Network Management Plan.	Y Zeehan AMP	Y Activities planned to be undertaken during periods of biologically important behaviours for conservation values	The Zeehan Marine Park is overlapped by the Beach OGV Project light and sound EMBAs, the COPA Drilling Project and TGS MSS. Zeehan Marine Park values potentially impacted are by the Beach OGV light EMBA are seabirds and for the sound EMBA are migrating blue whales and humpback whales.	High	Identified for seabirds and whales and further assessment required to determine if impacts are material.
Maritime Archaeological Heritage		✓					✓			No disturbance of maritime archaeological heritage.	N Only single drilling operation at any one time	N Control Measures in place to detect and prevent interactions	The Beach OGV Project Area overlaps one known shipwreck. Other Otway Projects will overlap known maritime archaeological heritage and potentially unknown maritime archaeological heritage. Impacts to maritime archaeological heritage are not predicted from seismic surveys. Drilling and infrastructure installation activities required to undertake seabed surveys prior to seabed disturbance. Impacts to maritime archaeological heritage are not a planned event and therefore cumulative impacts are not predicted.	High	None identified
Benthic Habitats and Communities		✓					✓			Temporary, small-scale, and recoverable impacts.	N Limited to individual activity area	N Limited to weeks-months after individual activity	Beach OGV Project does not impact areas where benthic habitat and communities are a value (Key Ecological Features, Zeehan AMP or threatened ecological communities). Thus, cumulative impacts to these values are not predicted from the Beach OGV Project. The current Beach OGV Project Area is 3,248 km$^{2.}$ thus the cumulate increase will be 27.1 km^2 (< 1% of the Project Area) for the OGV Project Initial Development and 2.1 km^2 (< 0.1% of the Project Area) for any future tieback (1% for all 10 potential future well tiebacks) No seabed disturbance, inclusive of drill cuttings and cement discharges, will occur within the Beach existing OGV Development or the future development area from other reasonably foreseeable future projects in the Otway Basin based on their location and activities. There is the potential for a cumulative increase in seabed disturbance, inclusive of drill cuttings and cement discharges, from the existing and planned developments within the Otway Basin (Beach, Cooper Energy and Woodside), however, this is not predicted to be material as impacts to areas where benthic habitat and communities are a value (Key Ecological Features, AMPs or threatened ecological communities) are not predicted. In addition, seabed surveys of the shelf area where Cooper Energy, Woodside and Beach's existing development are located have identified that the seabed is highly mobile making it difficult for filter feeders and soft body invertebrates to survive and establish in significant populations.	High	Identified but impacts not material no further assessment required.
Plankton				✓			✓	✓	✓	Temporary, small-scale, and recoverable impacts.	N Limited to individual activity area with exception of multiple seismic operations	N Recovery days post activity	Discharges to the water column are not predicted to impact water quality at a cumulative scale and therefore will not impact plankton at an ecological integrity level. Continuous noise from drilling, vessel and installation operations not predicted to impact plankton. Impacts from VSP are not predicted. Impacts from geophysical surveys are predicted to result in impacts at very small scale, this is not predicted to be material to contribute to cumulative impacts.	High	None identified

	Planned Environmental Aspects									CIA – Scoping Assessment					
Receptors	**Physical Presence - Interaction with Other**	**Physical Presence - Seabed Disturbance -**	**Emissions - Light**	**Emissions – Underwater Sound**	**Emissions - Atmospheric**	**Emissions – Greenhouse Gas**	**Discharges – Drill Cuttings and Cement**	**Discharges – Commissioning and Operations**	**Discharges - Vessels**	**Acceptable Level**	**Potential for Cumulative Impact Spatial Extent**	**Potential for Cumulative Impact Temporal Extent**	**Scoping Assessment Outcome**	**Level of Certainty of Scoping Assessment**	**Cumulative Cause-effect Pathway**
Invertebrates		✓		✓			✓			Temporary, small-scale, and recoverable impacts.	N Limited to individual activity area with exception of multiple seismic operations	N Limited to weeks-months after individual activity	Continuous noise from drilling, vessel and installation operations are not predicted to impact invertebrates. Impacts from geophysical surveys to benthic invertebrates are not predicted and impacts from VSP are predicted to result in impacts at very small scale (185 m), this is not predicted to be material to contribute to cumulative impacts. Behavioural impacts to squid are predicted to occur up to 3.9km of the VSP (up to 24 hrs) and 90m for seabed surveys, this is not predicted to be material to contribute to cumulative impacts even within areas where squid fishing occurs. Impacts to benthic invertebrates from seabed disturbance including drill cuttings and cement discharge are covered in Benthic Habitats and Communities.	High	None identified
Fish and Sharks				✓						Not inconsistent with EPBC Act Management Plans and Recovery Plans; Temporary, small-scale and recoverable impacts.	N Limited to individual activity with exception of multiple seismic operations	N No periods of biologically important behaviours for sensitive species s	Impacts from VSP to fish are not predicted and impacts from geophysical surveys, drilling and installation and IMR are predicted to result in impacts at very small scale, this is not predicted to be material to contribute to cumulative impacts.	High	None identified
Birds			✓							Not inconsistent with EPBC Act Management Plans and Recovery Plans; Temporary, small-scale, and recoverable impact.	Y BIAs for sensitive species	Y Periods of biologically important behaviours for sensitive species	There is potential for cumulative impacts associated with light (flaring and vessel/rig lighting) depending on location of activities and sensitive receptors, i.e. foraging, migrating, and breeding birds.	High	Identified and further assessment required to determine if impacts are material.
Marine Reptiles			✓	✓						Not inconsistent with EPBC Act Management Plans and Recovery Plans; Temporary, small-scale, and recoverable impacts.	N No BIAs or critical habitat	N No periods of biologically important behaviours for sensitive species	No cumulative effect pathway identified. Individuals in the area are expected to be transient, with no BIAs, critical habitat, or biologically important behaviours within the Otway Basin. Lighting doesn't impact in water navigation or behaviours and impacts from noise will be temporary and recoverable. Although sound impacts are restricted to within typically 20 km around individual activities, activities may be occurring consecutively over a period of time and seismic and drilling at one location have the potential to occur concurrently.	High	None identified
Marine Mammals			✓	✓						Not inconsistent with EPBC Act Management Plans and Recovery Plans; Temporary, small-scale, and recoverable impacts.	Y BIAs for sensitive species	Y Periods of biologically important behaviours for sensitive species	There is potential for cumulative impacts associated with underwater sound depending on location of activities and sensitive receptors, i.e. foraging and migrating endangered species. Although sound impacts are restricted to within typically 10s of kms around individual activities, activities may be occurring consecutively over a period of time and seismic and drilling at one location have the potential to occur concurrently.	High	Identified and further assessment required to determine if impacts are material.
Coastal Communities and Onshore Tourism Activities			✓							Temporary, small-scale, and low intensity.	N Not predicted to see multiple activities from single vantage point (King Island, Victorian coast)	Y May be able to see different activities over time from single vantage point (King Island, Victorian coast)	Cumulative effect pathway identified, associated with visibility of different activities over time, but impacts not material. The likelihood of visibility of multiple activities from a single vantage point is considered low given the distances offshore it is not predicted that a rig and vessels would be distinguishable from other existing vessel traffic.	High	Identified but impacts not material no further assessment required
Offshore Petroleum Activities	✓									Temporary, small-scale, and low intensity.	N	N	No cumulative impact effect pathway identified. Other activities are scheduled and or operate within their own exclusions zones/petroleum titles. Notice to mariners will provide advanced warning and opportunity to plan transit route. At most avoidance of a single seismic survey vessel and towed equipment, and a single drilling location at any given time with minimal impact.	High	Identified but impacts not material no further assessment required

Receptors	Planned Environmental Aspects									CIA – Scoping Assessment					
	Physical Presence - Interaction with Other	Physical Presence - Seabed Disturbance -	Emissions - Light	Emissions – Underwater Sound	Emissions - Atmospheric	Emissions – Greenhouse Gas	Discharges – Drill Cuttings and Cement	Discharges – Commissioning and Operations	Discharges - Vessels	Acceptable Level	Potential for Cumulative Impact Spatial Extent	Potential for Cumulative Impact Temporal Extent	Scoping Assessment Outcome	Level of Certainty of Scoping Assessment	Cumulative Cause-effect Pathway
Offshore Renewable Energy Activities	✓									Temporary, small-scale, and low intensity.	N	N	No cumulative impact effect pathway identified. There are no reasonably foreseeable future projects/activities in offshore Otway Basin.	NA	None identified
Defence Activities	✓	✓								Temporary, small-scale, and low intensity.	Y Displacement from concurrent and consecutive activities	Y Displacement from concurrent and consecutive activities	Cumulative effect pathway identified but impacts not material. Industry standard controls in place such as notice to mariners will provide advanced warning and opportunity to plan transit route. At most avoiding a single seismic survey vessel and towed equipment, and a single drilling location at any given time with minimal impact. Impacts to UXO are not predicted from seismic surveys. Drilling and installation activities are required to undertake seabed surveys prior to seabed disturbance which include techniques to identify UXO. Impacts to UXO are not planned event and therefore cumulative impacts not predicted.	High	Identified but impacts not material no further assessment required
Shipping	✓									Temporary, small-scale, and low intensity.	Y Displacement from concurrent and consecutive activities	Y Displacement from concurrent and consecutive activities	Cumulative effect pathway identified but impacts not material. The area of impact is small compared to the area available for shipping. Industry standard controls in place such as notice to mariners will provide advanced warning and opportunity to plan transit route. At most avoiding a single seismic survey vessel and towed equipment, and a single drilling location at any given time with minimal impact.	High	Identified but impacts not material no further assessment required
Marine Tourism	✓									Temporary, small-scale, and low intensity.	Y Displacement from concurrent and consecutive activities	Y Displacement from concurrent and consecutive activities	Cumulative effect pathway identified but impacts not material. The area of displacement is small compared to area available for tourism. Industry standard controls in place such as notice to mariners will provide advanced warning and opportunity to plan transit route. At most avoiding a single seismic survey vessel and towed equipment, and a single drilling location at any given time with minimal impact.	High	Identified but impacts not material no further assessment required
Recreational Fishing	✓									Temporary, small-scale, and low intensity.	Y Displacement from concurrent and consecutive activities	Y Displacement from concurrent and consecutive activities	Cumulative effect pathway identified but impacts not material. The area of displacement is small compared to area available for recreational fishing. Industry standard controls in place such as notice to mariners will provide advanced warning and opportunity to plan transit route. At most avoiding a single seismic survey vessel and towed equipment, and a single drilling location at any given time with minimal impact.	High	Identified but impacts not material no further assessment required
Commercial Fisheries	✓	✓				✓	✓			Affected persons will not be worse off because of the activity.	Y Displacement from concurrent and consecutive activities	Y Displacement from concurrent and consecutive activities	Cumulative effect pathway identified. Displacement of fishers operating in fisheries with spatial extent that may be overlapped by a number of offshore activities, i.e. displaced by multiple exclusion zones (MODU and seismic survey) or different exclusion zone over time. Although displacement impacts are restricted to within typically 2 kms around individual activities, drilling may be occurring consecutively over a period of time and seismic and drilling at one location have the potential to occur concurrently. Minor behavioural disturbances are predicted to commercial fish species from underwater sound and cumulative impacts are not predicted.	High	Identified and further assessment required to determine if impacts are material.
First Nations Cultural Values and Sensitivities.	✓	✓	✓	✓		✓	✓	✓	✓	Not inconsistent with Indigenous Protected Area Plans.; Temporary, small-scale, and recoverable impacts.	Y Sea Country	Y Period of activities	As per the assessment of ecological receptors cumulative effect pathways where identified for whales and birds which have been identified as a cultural value. Impacts from Drilling and other Project activities to other cultural values identified such as fish, eels, dolphins, and seals are at a very small scale, which is not predicted to be material to contribute to cumulative impacts. Impacts to submerged cultural heritage are not predicted from the Project based on seabed surveys and cultural heritage assessments will be undertaken prior to drilling and installation activities to identify any cultural heritage for management.	High	Identified and further assessment required to determine if impacts are material.

Table 90: CIA Scoping Outcome

Aspect	**Interaction with Other Users**	**Light**		**Underwater Sound**	
Receptor	**Commercial fishers**	**Seabirds and Shorebirds**	**Orange-bellied parrot (OBP)**	**Blue whale (BW)**	**Southern right whale (SRW)**
Conservation (or other) value and Status	Socio-economic value to local communities and national economy. The Project Area overlaps where there is fishing intensity for: • SESSF: Commonwealth Trawl Sector Otter Board – Low intensity • SESSF: Commonwealth Trawl Sector Danish-seine – Low/Med intensity • Southern Squid Jig Fishery – Low intensity • Victorian Giant Crab – up to 15 vessels • Victorian Southern Rock Lobster Fishery. Up to 24 vessels • Tasmanian Rock Lobster Fishery. < 5 vessels	The following overlap the light EMBA for the Project Area. Foraging/Feeding behaviour and/or BIAs: • Antipodean, black-browed, Buller's, Campbell, Indian yellow-nosed, northern Buller's, northern royal, Salvin's, shy, southern royal, wandering, and white-capped albatrosses. • Common diving petrel northern giant petrel. • Flesh-footed, short-tailed, and wedge-tailed shearwaters. • White-fronted tern. Breeding behaviour: • Black-faced cormorant and white-bellied sea-eagle. Breeding BIA: • Wedge-tailed shearwaters. Roosting behaviour: • Little curlew, Pin-tailed snipe, Swinhoe's snipe. Short-tailed shearwater also identified cultural value.	Listed as Critically Endangered and Marine under the EPBC Act and noted as a species of cultural significance. The Project Area vessel/MODU light EMBA overlaps a small portion (~2%) of the likely distribution and probably migration route for the orange-bellied parrot.	Listed as Endangered under the EPBC Act. The Project Area and sound EMBAs overlaps the blue whale foraging annual high use area BIA.	Listed as Endangered under the EPBC Act and noted as a species of cultural significance in the draft National Recovery Plan for the Southern Right Whale (CoA 2022). The Project Area and sound EMBAs overlaps the SRW migration BIA. The Project Area and sound EMBAs do not overlap the SRW reproduction BIA.
Legislative or Other requirements	OPGGS Act 2006 (Cth).	National Recovery Plan for Albatrosses and Petrels (DCCEEW 2022e). Wildlife Conservation Plan for Seabirds (DCCEEW 2020). National Light Pollution Guidelines for Wildlife (CoA 2023).	National Recovery Plan for the Orange-bellied Parrot (DoE 2016) National Light Pollution Guidelines for Wildlife (CoA 2023).	Conservation Management Plan for the Blue Whale (DoE 2015) Guidance on key terms within the Blue Whale Conservation Management Plan (DAWE 2021a)	Conservation Management Plan for Southern Right Whale (DSEWPaC 2012b) Draft National Recovery Plan for the Southern Right Whale (CoA 2022)
Threatening Processes Relevant to Aspect	NA	Light emissions are identified as a threat in the National Recovery Plan for Albatrosses and Petrels but marine infrastructure interactions, including those associated with artificial light, are classified as having no risk category priority and affecting 'Nil' species in Australian jurisdiction. The National Recovery Plan for Albatrosses and Petrels also states that light associated with coastal developments at or adjacent to breeding sites represents a moderate threat to short-tailed shearwater. Light pollution, including from gas flaring, is listed as a threat to seabirds in the Wildlife Conservation Plan for Seabirds, with potential for consequences affecting individuals but not whole populations.	The National Recovery Plan for the Orange-bellied Parrot Illuminated boats and structures within the migration route as a barrier to migration (weak evidence for impact, moderate risk rating).	Conservation Management Plan for the Blue Whale identifies anthropogenic noise interference as a threat.	Conservation Management Plan for the Southern Right Whale and draft National Recovery Plan for the Southern Right Whale identify noise interference as a threat.
Relevant Spatial and Temporal Extent	Fishery Management Areas for the duration of the Project.	Foraging BIAs for seabirds cover either all or a large proportion of the SE Marine Bioregion. A breeding BIA for the wedge-tailed shearwater is identified Mutton Bird Island off Port Campbell. Seabird breeding behaviour and shorebird roosting behaviour is likely to occur along the coast of Victoria.	Probable Migration Route September-November (Southward); February-mid-March (northwards).	Underwater sound EMBAs overlap Foraging and Annual High use Foraging BIAs, between November to June, peaking in February and March	Overlap of underwater sound EMBAs with Migration BIA, approximately April to October.
Relevant Actions from Legislative or Other Requirements	OPGGS Act 2006 (Cth) Section 280 – requires that a person carrying on activities in an offshore area under the permit, lease, licence, authority, or consent must carry out those activities in a manner that does not interfere with navigation or fishing (among others).	National Recovery Plan for Albatrosses and Petrels: no relevant actions. Wildlife Conservation Plan for Seabirds: Mitigate against impacts of light pollution around breeding colonies.	Assess the risk of barriers, being illuminated structures or boats, on the probable migration route. Manage threat if the risk rating warrants action. National Light Pollution Guidelines for Wildlife recommend:	Conservation Management Plan for the Blue Whale states that anthropogenic noise in BIAs must be managed so that blue whales can continue to utilise the area without injury and [are] not displaced from a foraging area. DAWE	Draft National Recovery Plan for the Southern Right Whale: Actions within and adjacent to SRW BIAs and habitat critical to the survival of SRWs should demonstrate that is does not prevent any SRW from utilising the area or cause injury (PTS, TTS) and/or disturbance.

Aspect	Interaction with Other Users	Light		Underwater Sound	
Receptor	**Commercial fishers**	**Seabirds and Shorebirds**	**Orange-bellied parrot (OBP)**	**Blue whale (BW)**	**Southern right whale (SRW)**
		National Light Pollution Guidelines for Wildlife recommend: 1. Always using Best Practice Lighting Design to reduce light pollution and minimise the effect on wildlife. 2. Undertaking an Environmental Impact Assessment for effects of artificial light on listed species for which artificial light has been demonstrated to affect behaviour, survivorship or reproduction.	1. Always using Best Practice Lighting Design to reduce light pollution and minimise the effect on wildlife. 2. Undertaking an Environmental Impact Assessment for effects of artificial light on listed species for which artificial light has been demonstrated to affect behaviour, survivorship or reproduction.	(2021a) details that underwater anthropogenic noise should not: • Stop or prevent any blue whale from foraging • Cause any blue whale to move on when foraging, or • Stop or prevent any blue whale from entering a foraging area	NOTE: Legal definition of 'Should' means expected course of action or policy to be followed unless inappropriate for a particular circumstances.
Baseline Environment Condition	Fisheries overlap with existing shipping channel and area with existing oil and gas activity. Fisheries in the area historically have sustainable stock status.	Existing lighting in the area includes fishing vessels, shipping traffic, existing offshore oil and gas platform and coastal developments. The shipping channel for vessels coming from Melbourne to Tasmania is one of the busiest shipping routes in offshore Australia.	The OBP migratory route is within the shipping channel for vessels coming from Melbourne to Tasmania - one of the busiest shipping routes in offshore Australia.	The BIAs overlap existing shipping channel, area of high commercial fishing effort, and existing oil and gas activity.	The BIAs overlap existing shipping channel, area of high commercial fishing effort, and existing oil and gas activity.
Acceptable Level	Commercial fishers are not economically disadvantaged as a result of oil and gas activities in the offshore Otway Basin.	Cumulative light does not impact breeding for seabirds, or roosting colonies for shorebirds, or populations of other species that forage in the area.	Light from cumulative sources does not affect migration of the orange-bellied parrot at a population level.	The activity will be carried out in a manner that will not be inconsistent with the Conservation Management Plan for the Blue Whale such that blue whales can continue to utilise the area without injury and [are] not displaced from a foraging area.	The activity will be carried out in a manner that will not be inconsistent with the draft National Recovery Plan for the Southern Right Whale (DCCEEW 2022a) such that actions within and adjacent to SRW BIAs should demonstrate that it does not prevent any SRW from utilising the area or cause injury (TTS and PTS) and/or disturbance.
Other Reasonably Foreseeable Projects/ Activities Relevant to Aspect	SESSF: Commonwealth Trawl Sector Otter Board, SESSF: Commonwealth Trawl Sector Danish-seine and Southern Squid Jig Fishery potential cumulative impact from exclusion zones associated with: • One seismic survey occurring concurrently with drilling/P&A activities and/or Project installation activities. • Consecutive drilling/P&A activities and/or Project installation activities. • Project infrastructure. Victorian Giant Crab and Southern Rock Lobster Fisheries potential cumulative impact from exclusion zones associated with: • Two successive seismic surveys. • One seismic survey occurring concurrently with drilling/P&A activities and/or Project installation activities. • Consecutive drilling/P&A activities and/or Project installation activities. • Project infrastructure. Tasmanian Rock Lobster Fishery potential cumulative impact from exclusion zones associated with: • One seismic survey occurring concurrently with drilling/P&A activities and/or Project installation activities. • Consecutive drilling/P&A activities and/or Project installation activities. • Project infrastructure.	Potential for overlap with foraging BIAs and shoreline breeding and roosting areas from a single seismic survey, single drilling operation and installation or IMR activities and sequential activities. For drilling this would be a MODU with one vessel present at a drill location and one vessel transiting to port, for a seismic survey would be up to three vessels and for installation or IMR would be up to two vessels.	The probable migration route is overlap by activity light EMBAs. No illuminated structures or vessels will occur within the probable migration route. Spatial: Potential overlap between Regia seismic and 1 drilling activity with light EMBA overlapping the route - for one season (while seismic is occurring). Temporal: Consecutive drilling operations over an extended period of time may have light EMBAs that overlap the probable migration route.	With the current uncertainty on the timing of some other projects and the distance of underwater sound EMBAs, there is the potential for cumulative impact if the following occur within the migration BIA during the biologically relevant periods (nominally November to May): • Overlap between one seismic survey and one drilling activity for one season. • Consecutive drilling/P&A activities over a number of seasons. • Consecutive seismic surveys in one season or over a number of seasons.	Cumulative impacts from Beach's activities to the SRW Breeding BIA are not predicted as the Beach sound EMBAs do not overlap with this area. With the current uncertainty on the timing of some other projects and the distance of underwater sound EMBAs, there is the potential for cumulative impact if the following occur within the migration BIA during the biologically relevant periods (nominally April - October): - Overlap between one seismic survey and one drilling activity for one season. - Consecutive drilling/P&A activities over a number of seasons.
Description of Cumulative Impact (including spatial/temporal extent)	Commercial fishers may potentially be displaced within relevant Fishery Management Areas in the offshore Otway Basin by the proposed Project and other reasonably foreseeable seismic surveys and drilling/P&A activities. Drilling, seismic, installation and IMR activity exclusions will only apply while the activity is being	Potential for cumulative impacts associated within foraging BIAs and shoreline breeding and roosting areas from operational lighting associated with: • Drilling - MODU with one vessel present at a drill location and one vessel transiting to port. • Seismic survey - up to three vessels.	For seismic, cumulative impacts from light emissions on the probable migration route would be of short duration only when acquiring in the eastern side of the area at night, concurrently with a single drilling operation. Seismic program is limited to a maximum of 90 days, with 60 days of acquisition.	Without appropriate detection and actions in place there is the potential that blue whales could be exposed to underwater sound from two sources (seismic and drilling) within the foraging BIA that could result in them expending more energy to move away from the sound source to forage or restrict the area of	Without appropriate detection and actions in place there is the potential that SRWs could be exposed to underwater sound from two sources (seismic and drilling) within the migration BIA that could result in them expending more energy to move away from the sound source when migrating to and from coastal breeding areas. This could

Aspect	Interaction with Other Users	Light		Underwater Sound	
Receptor	**Commercial fishers**	**Seabirds and Shorebirds**	**Orange-bellied parrot (OBP)**	**Blue whale (BW)**	**Southern right whale (SRW)**
	undertaken and a 500 m exclusion zone will apply to wells and subsea infrastructure. Beach has undertaken previous drilling, installation, IMR and Operations in the area with little displacement to commercial fishers based on the consultation and notification controls implemented that will also be applied to the Project.	- Installation or IMR - up to two vessels. Though 20 km is used for operational lighting for the impact assessment all vessels and the MODU will have a Light Management Plan restricting the amount of light that is emitted. The cumulative impact of light emissions from Otway petroleum activities would be very low in comparison to the light emissions associated with existing shipping and fishing operations within the Otway area. In addition, the majority of these vessels are not required to operate in accordance with a Light Management Plan. Flaring may be undertaken but cumulative impacts are unlikely due to the short term nature (1 – 2 days) that it will be undertaken.	Temporal: Light EMBA from a single drilling MODU overlapping varying spatial extents of the probable migration route over a period of years. Beach has been operating in the Otway Basin and undertaking similar activities to the Project activities with no evidence of OBP presence recorded. Other operators including previous seismic surveys have also not had evidence of OBP presence recorded. OBP numbers continue to increase. The cumulative impact of light emissions from Otway petroleum activities would be very low in comparison to the light emissions associated with existing shipping and fishing operations within the migration route. In addition, the majority of these vessels are not required to operate in accordance with a Light Management Plan.	foraging. This could also occur for consecutive years whilst drilling/P&A activities are undertaken within the Otway Basin. Cumulative impacts resulting in an increase in the likelihood of PTS and TTS for foraging blue whales is not predicted due to the small distances to the PTS and TTS noise criteria for drilling activities.	also occur for consecutive years whilst drilling/P&A activities are undertaken within the Otway Basin. Cumulative impacts resulting in an increase in the likelihood of PTS and TTS for a migrating SRW is not predicted due to the small distances to the PTS and TTS noise criteria for drilling activities.
Certainty of Assessment	Given the intensity of fishing in the area, and the overlap of fishery management areas with the proposed activities of multiple titleholders, the assessment of cumulative impacts is made with a high level of predictability and certainty.	Beach has been operating in the Otway Basin and undertaking similar activities to the Project activities without incident to date of birds being attracted to MODUs or vessels. Other operators including previous seismic surveys have also not had incidents of bird attraction. Thus, the assessment of cumulative impacts is made with a high level of predictability and certainty.	There is no published information available on the sensitivity of the orange-bellied parrot to light, and only anecdotal evidence exists regarding the impact of barriers to migration (DELWP 2016a). This introduces some uncertainty into the assessment of cumulative impacts.	There is a high level of predictability and certainty in the limited potential for cumulative impacts, given the requirements in place for each activity to prevent impacts.	There is a high level of predictability and certainty in the limited potential for cumulative impacts, given the requirements in place for each activity to prevent impacts.
Existing Control Measures	A single MODU has been contracted to conduct drilling/P&A activities in the region, mitigating the potential for concurrent impacts from these activities. Titleholders overlapping fishery management areas with recorded fishing intensity are required to consult with affect parties and typically have ongoing notifications processes and a compensation protocol in place to ensure fishers are no worse off as a result of their proposed activity. CM03 Fair Ocean Access Procedure CM04 Stakeholder consultation	A single MODU has been contracted to conduct drilling/P&A activities in the region, mitigating the potential for concurrent impacts from these activities. Titleholders with light EMBAs overlapping bird foraging, breeding, or roosting BIAs or where behaviours are identified are required to have a light management plan that meets the requirements of the National Light Pollution Guidelines. CM13 Light Management Procedure	A single MODU has been contracted to conduct drilling/P&A activities in the region, mitigating the potential for concurrent impacts from these activities. Titleholders with Light EMBAs overlapping or adjacent to the OBP migration route are required to have a light management plan that meets the requirements of the National Light Pollution Guidelines. CM13 Light Management Procedure	A single MODU has been contracted to conduct drilling/P&A activities in the region, mitigating the potential for concurrent impacts from these activities. Titleholders are required to undertake their activity in a manner that is not inconsistent with the in force Conservation Management Plan for the Blue Whale. CM14 EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans CM15 Geophysical Survey Whale Management Procedure CM16 VSP Whale Management Procedure CM17 Drilling Whale Management Procedure CM18 Vessel Whale Management Procedure CM19 Noise Assessments	A single MODU has been contracted to conduct drilling/P&A activities in the region, mitigating the potential for concurrent impacts from these activities. Titleholders are required to undertake their activity in a manner that is not inconsistent with the in force Conservation Management Plan for Southern Right Whale. CM14 EPBC Regulations 2000 – Part 8 Division 8.1 interacting with cetaceans CM15 Geophysical Survey Whale Management Procedure CM16 VSP Whale Management Procedure CM17 Drilling Whale Management Procedure CM18 Vessel Whale Management Procedure CM19 Noise Assessments
Additional Control Measures / Environmental Performance Standards	Beach will undertake to continue to work with other titleholders, fishing associations and fishers, to design an application process for compensation that minimises the potential for cumulative impacts associated with commercial fishers having to make multiple applications to multiple titleholders. **ADOPT** CM#3 Fair Ocean Access Procedure	**CM02: Vessel and MODU Operating Procedures:** EPS2.2 The MODU and vessels will abide by activity exclusion zones in place for other activities in the offshore Otway Basin, to minimise the potential for cumulative impacts. EPS2.2 The MODU will conduct drilling activities at one location at a time, to minimise the potential for cumulative impacts. **CM#12 Light Management Procedure:** Beach will work with other titleholders with the aim of minimising the potential for cumulative impacts associated with light emissions, should activity timings overlap biologically important periods for light sensitive species.	**CM07: Light Management Plan:** Beach will work with other titleholders with the aim of minimising the potential for cumulative impacts associated with light emissions, should activity timings overlap biologically important periods for light sensitive species. Observations, incidents and opportunities for improvement regarding light management and bird interactions will be reported to other petroleum titleholders in the Otway Basin.	**CM13, 14,15,16,17: Whale Management Plan** Beach will work with other the Otway Basin Petroleum Titleholders with the aim of minimising the potential for cumulative impacts associated with underwater sound, should activity timings overlap biologically important periods for blue whales. Observation, incidents, and opportunities for improvement will be reported to other petroleum titleholders in the Otway Basin regarding underwater sound management and whale interactions.	**M13, 14,15,16,17: Whale Management Plan** Beach will work with other the Otway Basin Petroleum Titleholders with the aim of minimising the potential for cumulative impacts associated with underwater sound, should activity timings overlap biologically important periods for blue whales. Observation, incidents, and opportunities for improvement will be reported to other petroleum titleholders in the Otway Basin regarding underwater sound management and whale interactions.

Aspect	Interaction with Other Users	Light		Underwater Sound	
Receptor	**Commercial fishers**	**Seabirds and Shorebirds**	**Orange-bellied parrot (OBP)**	**Blue whale (BW)**	**Southern right whale (SRW)**
		Beach will report observation, incidents, and opportunities for improvement regarding light management and bird interactions to other Otway Titleholders.			
Residual Cumulative Consequence	**Minor (1)**	**Minor (1)**	**Minor (1)**	**Minor (1)**	**Minor (1)**
ALARP Achieved	Yes - The residual consequence is lower order – Minor (1). Additional control measures were considered and adopted to minimise the consequence of impacts and are considered effective and appropriate to the predicted cumulative environmental impact.	Yes - The residual consequence is lower order – Minor (1). Additional control measures were considered and adopted to minimise the consequence of impacts and are considered effective and appropriate to the predicted cumulative environmental impact.	Yes - The residual consequence is lower order – Minor (1). Additional control measures were considered and adopted to minimise the consequence of impacts and are considered effective and appropriate to the predicted cumulative environmental impact.	Yes - The residual consequence is lower order – Minor (1). Additional control measures were considered and adopted to minimise the consequence of impacts and are considered effective and appropriate to the predicted cumulative environmental impact.	Yes - The residual consequence is lower order – Minor (1). Additional control measures were considered and adopted to minimise the consequence of impacts and are considered effective and appropriate to the predicted cumulative environmental impact.
Acceptable Level Achieved	Yes – Following completion of the CIA process, the residual lower order – Minor (1) consequence is considered acceptable because: •Good practice controls are defined and will be implemented. •The activities will be managed in accordance with relevant company, Commonwealth, international, and Industry standards, guidelines, and requirements.	Yes – Following completion of the CIA process, the residual lower order –Minor (1) consequence is considered acceptable because: • Limited spatial extent of effect compared to area available for foraging. Most species forage during daylight. The National Recovery Plan states that marine infrastructure interactions, including those associated with artificial light, are classified as having no risk category priority and affecting 'Nil' species in Australian jurisdiction. • Breeding BIA for wedge-tailed shearwater would only be overlapped by flaring or operational light EMBA for short periods while flaring occurred or a vessel moved through the area. This species is not listed as threatened and periodic changes in ambient light is unlikely to cause behavioural changes or result in injury/mortality to this species. • Good practice controls are defined and will be implemented. •Adequate procedures and guidelines are in place to minimise impacts. •The activities will be managed in accordance with relevant company, Commonwealth, international, and Industry standards, guidelines and requirements.	Yes – Following completion of the CIA process, the residual lower order – Minor (1) consequence is considered acceptable because: • The impact of light emissions from a seismic vessel overlapping the light emission from a MODU are predicted to result in increases in ambient light that are short-term, fully recoverable and do not represent illuminated structures or boats within the migration route. •Light from drilling activities will only occur from a single location, with limited overlap with the probable migration route and do not represent illuminated structures or boats within the migration route. •Good practice controls are defined and will be implemented. •Adequate procedures and guidelines are in place to minimise impacts. •The activities will be managed in accordance with relevant company, Commonwealth, international, and Industry standards, guidelines and requirements.	Yes – Following completion of the CIA process, the residual lower order – Minor (1) consequence is considered acceptable because: • Titleholders are required to undertake their activity in a manner that is not inconsistent with the in force Conservation Management Plan for the Blue Whale. • Good practice controls are defined and will be implemented. •Adequate procedures and guidelines are in place to minimise impacts. •The activities will be managed in accordance with relevant company, Commonwealth, international, and Industry standards, guidelines and requirements.	Yes – Following completion of the CIA process, the residual lower order – Minor (1) consequence is considered acceptable because: • Titleholders undertaking petroleum activities in the Otway Basin are required to undertake their activity in a manner that is not inconsistent with the in force Conservation Management Plan for Southern Right Whale. • Good practice controls are defined and will be implemented. •Adequate procedures and guidelines are in place to minimise impacts. •The activities will be managed in accordance with relevant company, Commonwealth, international, and Industry standards, guidelines and requirements.

Table 91: Cumulative impact assessment outcomes

Aspect	Existing OGV Development	OGV Project	Potential Change
Physical Presence – Interaction with Other Users (Socio-economic)	Operations Existing: 500m PSZ around Thylacine platform, Geographe and Thylacine subsea wells and infrastructure and Artisan 1 well. 500 exclusion zone around geophysical and IMR vessels.	Operations Project: 500m PSZ around Thylacine platform, Geographe and Thylacine subsea wells and infrastructure and Artisan 1 well. 500 m PSZ for up to 16 wells and associated subsea infrastructure. 500 m exclusion zone around geophysical and IMR vessels.	Permanent Increase in area other marine users may be displaced from, due to new development wells. Potential increase in the period that a 500 m exclusion around geophysical and IMR vessels would be present due to an increase in subsea infrastructure. This would be an increase of days based on the small increase in area and current Operations IMR campaigns are for up to 30 days every 2 and 5 years.
		Drilling, P&A and Installation: 500 m PSZ around MODU 2 km exclusion zone around MODU (for anchors) 500 exclusion zone around geotechnical and installation vessels	Temporary increase in area other marine users may be displaced from.
Seabed Disturbance	Operations Existing: 0.055km2	Initial development (permanent disturbance based on infrastructure footprint): 0.07km^2 Future tieback (permanent disturbance based on infrastructure footprint): 0.06km^2 Total OGV development footprint: 0.13km^2	Increase in seabed disturbance due to OGV Project of 0.13km^2 (135% increase) Total disturbance (existing, initial and future) is 0.19km^2 which is less than 0.006% of the total Project Area
Light	Operations Existing: Thylacine platform and resupply vessel. Geophysical and IMR vessels.	Operations Project: Thylacine platform and resupply vessel. Geophysical and IMR vessels.	No change in permanent lighting at the Thylacine platform or resupply frequency. Potential increase in period that light associated with geophysical and IMR vessels is present due to an increase in operations area. This would be an increase of days based on the small increase in area and current Operations IMR campaigns are for up to 30 days every 2 and 5 years.
		Drilling, P&A, and installation: MODU and support vessels lighting. Flaring (1 -2 days per well). Geotechnical survey and installation vessels lighting.	Temporary increase in lighting associated with flaring and vessels/MODU for drilling, P&A, and installation. Vessel numbers low with maximum being for drilling with MODU and support vessels.
Underwater sound	Operations Existing: Thylacine platform and resupply vessel. Geophysical and IMR vessels.	Operations Project: Thylacine platform and resupply vessel. Geophysical and IMR vessels.	No change in Thylacine platform sound emissions or frequency of resupply. Potential increase in period that underwater sound associated with geophysical and IMR vessels is present due to an increase in operations area. This would be an increase of days based on the small increase in area and current Operations IMR campaigns are for up to 30 days every 2 and 5 years. Thus, this increase would not be material.
		Drilling, P&A, and installation: MODU and support vessels. Vertical seismic profiling (VSP). Geotechnical survey and installation vessels.	Temporary increase in underwater sound associated with VSP and vessels/MODU for drilling, P&A, and installation. Vessel numbers low with maximum being for drilling with MODU and support vessels.
Atmospheric emissions	Operations Existing: Thylacine platform and resupply vessel. Geophysical and IMR vessels.	Operations Project: Thylacine platform and resupply vessel. Geophysical and IMR vessels.	No change in Thylacine platform atmospheric emissions or frequency of resupply. Potential increase in atmospheric emissions from increased fuel use associated with geophysical and IMR vessels due to an increase in operations area. This increase would not be material based on the small increase in area and current Operations IMR campaigns are for up to 30 days every 2 and 5 years.
		Drilling, P&A, and installation: MODU and support vessels. Flaring (1 -2 days per well). Geotechnical survey and installation vessels.	Temporary increase in atmospheric emissions associated with flaring and vessels/MODU fuel use for drilling, P&A, and installation. This increase would not be material based on: Low vessel numbers with maximum being for drilling with MODU and support vessels. Limited duration and intermittent nature of flaring operations of up to two days per well approximately three months apart. Rapid dispersion of air emissions close to the source, no substantial or cumulative impacts to air quality within the local airshed are predicted.
Greenhouse Gas Emissions	Operations Existing: Total direct emissions (Scope 1) – 18,600 TCO2e Total indirect emissions (Scope 3) – 37 million TCO2e	Total direct emissions (Scope 1) – 76,971 TCO2e Total indirect emissions (Scope 3) – 35 million TCO2e	Increase in total emissions (Scope 1 and 3) from existing operations of 35 million TCO2 (95% increase) Increase in total emissions (Scope 1 and 3) of The OGV Project from existing operations equates to a very small fraction of global emissions. In isolation, they will have no discernible impact on GHG concentrations in the atmosphere.
Operations Fluid Discharges	Operations Existing: Well value actuation hydraulic fluids for 6 existing wells.	Operations Project: Well valve actuation hydraulic fluids for up to 16 wells.	Temporary change to water quality.

Aspect	Existing OGV Development	OGV Project	Potential Change
Drill Cuttings and Fluid Discharges Cement Discharges Commissioning Fluids Discharge	NA	Drilling, completion, and P&A fluid discharges.	Temporary change to water quality. Potential for smothering impacts and potential toxicity within an area of ~6.3 km^2 per well, within the expected seabed disturbance footprint.
Routine operational wastes from the MODU and vessels	Operations Existing: Thylacine platform and resupply vessel. Geophysical and IMR vessels.	Operations Project: Thylacine platform and resupply vessel. Geophysical and IMR vessels.	Temporary change to water quality.
		Drilling, P&A, and installation: MODU and support vessels. Geotechnical survey and installation vessels.	Temporary change to water quality.

Table 92: Cumulative impact assessment of existing OGV development and Project

9. Environmental Management Implementation Approach

9.1 Overview

The Project will be undertaken in accordance with this OPP which will be implemented via subsequent activity specific EPs.

The implementation approach described in this section provides a summary of the systems, practices and procedures used to ensure implementation of activities in accordance with this OPP, and that emergency preparedness and environmental monitoring is applied to manage risks and impacts of the Project. These will ensure the Project's environmental performance outcomes (EPOs) are achieved. Specifically, this section describes:

- Operational Excellence Management System
- Arrangements for monitoring, review and reporting of environmental performance.
- Preparedness for emergencies

9.2 Operations Excellence Management System

Beach's Operations Excellence Management System (OEMS) is the company's framework to define, align, standardise and implement company processes to manage risks and ensure successful outcomes in its operations.

The OEMS defines the minimum standards, expectations and behaviours that ensure the company operates successfully (operations excellence in all core business processes including Health & Safety, Production & Reliability, Financial & Stakeholder Management and Project Delivery). The OEMS applies to all personnel performing work within the company's jurisdiction. The OEMS will be used to implement the Project.

The OEMS provides guidance on how Beach will meet the requirements of its Environmental Policy (

Figure 142). Beach's OEMS has been developed considering Australian/New Zealand Standard ISO 14001:2016 Environmental Management Systems. The OEMS is an integrated management system and includes all HSE management elements and procedures. The OEMS is aligned with the requirements of recognised international and national standards including:

- ISO 14001 (Environmental Management)
- OHSAS 18001 (Occupational Health and Safety)
- ISO 31000 (Risk Management)
- AS 4801 (Occupational Health and Safety Management Systems)

At the core of the OEMS are 11 elements and associated standards that detail specific performance requirements that incorporate all the requirements for the implementation of the Environmental Policy (Figure 144) and management of potential HSE impacts and risks (

Figure 142 and 143). The Elements, via the nominated expectations, sponsor 30 Beach OEMS Standards, which provide more granular minimum compliance rule sets under which the company operates.

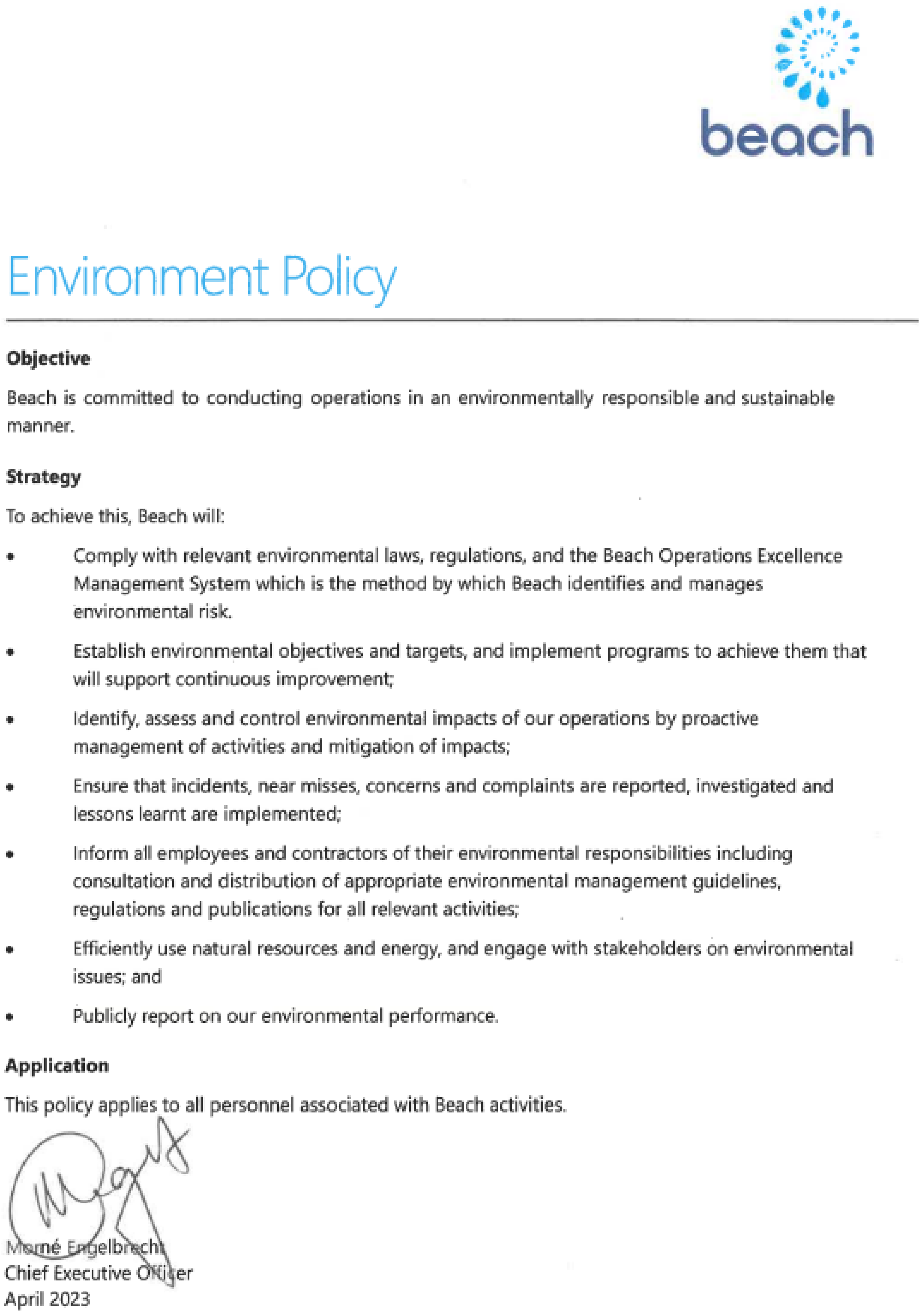
A core design feature of the OEMS is that every Standard is assigned to a General Manager/Functional Head or Executive with experience in the subject matter and/or accountability to ensure delivery of expected outcomes. OEMS Standard Owners ensure the effectiveness of their respective Standard(s) in addressing applicable risks and facilitate continuous improvement of performance and practices.

In the context of the OPP and the Project, the key Elements of the OEMS are summarised in this Section.

Figure 142: Beach Operations Excellence Management Standard (OEMS)

Element		Standard
1	Partners, Leadership and Authority	Leadership Standard
		Technical Authority Standard
		Joint Venture Management Standard
2	Financial Management and Business Planning	Integrated Planning Standard
		Phase Gate Standard
		Hydrocarbon Resource Estimation and Reporting Standard
		Financial Management Standard
3	Information Management and Legal Requirements	Regulatory Compliance Standard
		Document Management Standard
		Information Management Standard
4	People, Capability and Health	Training and Competency Standard
		Health Management Standard
5	Contracts and Procurement	Contracts and Procurement Standard
		Transport and Logistics Standard
6	Asset Management	Asset Management Standard
		Maintenance Management Standard
		Well Integrity Management Standard
		Well Construction Management Standard
		Project Management Standard
7	Operational Control	Operational Integrity Standard
		Process Safety Standard
		Management of Change Standard
8	Risk Management and Hazard Control	Risk Management Standard
		Safe Systems of Work
		Emergency and Security Management Standard
9	Incident Management	Incident Management Standard
10	Environment and Community	Environment Management Standard
		Community Engagement Standard
11	Assurance and Reporting	Sustainability Standard
		Assurance Standard

Figure 143: OEMS Elements and Standards



Environment Policy

Objective

Beach is committed to conducting operations in an environmentally responsible and sustainable manner.

Strategy

To achieve this, Beach will:

- Comply with relevant environmental laws, regulations, and the Beach Operations Excellence Management System which is the method by which Beach identifies and manages environmental risk.
- Establish environmental objectives and targets, and implement programs to achieve them that will support continuous improvement;
- Identify, assess and control environmental impacts of our operations by proactive management of activities and mitigation of impacts;
- Ensure that incidents, near misses, concerns and complaints are reported, investigated and lessons learnt are implemented;
- Inform all employees and contractors of their environmental responsibilities including consultation and distribution of appropriate environmental management guidelines, regulations and publications for all relevant activities;
- Efficiently use natural resources and energy, and engage with stakeholders on environmental issues; and
- Publicly report on our environmental performance.

Application

This policy applies to all personnel associated with Beach activities.

Morné Engelbrecht
Chief Executive Officer
April 2023

Figure 144: Beach’s Environment Policy

9.2.1 Partners, Leadership and Authority – OEMS Element 1

Element 1 focuses on ensuring the organisation is equipped, structured and supported to ensure a healthy, efficient and successful company. A summary of the roles and responsibilities under this OEMS Standard is provided in Table 92. Further roles and responsibilities will be provided in EPs for the relevant activities.

Role	Responsibilities
OEMS Standard Owner	• Each Standard is owned by a General Manager (or equivalent) with experience in the subject matter and/or accountability to ensure delivery of expected outcomes. This role is designated as an "OEMS Standard Owner" and is critical to the success of the OEMS. • The Standard Owner has overall accountability for performance of their assigned Standard
OEMS Governance Committee	• The OEMS Governance Committee will ensure periodic assessment of system performance. The Committee will support continuous improvement initiatives and assess the need for system changes, such as, additional standards and new company tools/systems. The Committee will include nominated member(s) of the Company Executive as well as Representatives from Operations and HSE&R Divisions, as a minimum.
Executive Management	• The Chief Executive Officer (CEO) is the designated owner of this standard. The Group Executive HSE&R supports the CEO for implementation aspects of the Standard. • All Group Executives are responsible for ensuring the understanding and application of this standard within their areas of responsibility, and for managing any deviations and gap closure activities.
General Manager or Equivalent	• Responsible for ensuring resources, including assets, facilities, and teams, under their control have understood the requirements and developed and implemented suitable procedures and tools to satisfy the requirements of this standard
Manager or Superintendent	• Responsible for ensuring their area of the business for which they are accountable, has understood and implemented the requirements of this standard. • Upholding and ensuring suitable discipline with respect to this standard. • Implementing or supporting an annual assurance program to report on compliance to this standard and to identify and address gaps or areas for continuous improvement.
All employees	• Responsible for understanding and following the respective procedure and requirements defined within this standard. • Responsible for escalating areas of non-conformance or areas where local practices do not meet the requirements of this standard the OPP requirements are communicated to the Project team.

Table 93: Key roles and responsibilities for the OEMS and OPP implementation

9.2.2 Information Management and Legal – OEMS Element 3

Element 3 describes the measures Beach must take to ensure ongoing compliance with regulatory and legal obligations in order to protect the Company's value and reputation, and to maintain Beach's licences to operate. Beach's ability to safely perform its duties in line with its legal obligations relies on robust management of documents and information.

9.2.2.1 Regulatory Compliance Standard

Standard 3.1 describes the responsibilities of each stakeholder and the processes for identifying, maintaining, managing and reporting Beach's regulatory compliance obligations. The Standard details the minimum requirements of a system to ensure effective Regulator engagement can be maintained across all its activities including permissions, project execution, operating and reporting.

Section 2 of this OPP details the key environmental requirements applicable to the activity. The acceptability discussion for each aspect is assessed in Sections 6 and 7 and specifically details the environmental requirements pertaining to each aspect.

9.2.3 People, Capability and Health – OEMS Element 4

Element 4 focuses on ensuring the people within the business are fully equipped with the competencies required to perform their assigned duties and are physically and mentally prepared. This element is important in protecting workers' health and is closely aligned with Standard 8.1 (Risk Management) and Standard 8.2 (Safe Systems of Work).

9.2.3.1 Training and Competency Standard

Standard 4.1 describes the minimum company requirements to ensure peoples training requirements are identified and meet the tasks they are required to perform, and that verification of competency is carried out where necessary. The Standard defines the responsibilities for ensuring suitable training programmes are available and for ensuring peoples levels of capability are maintained at the required level.

Each employee or contractor with responsibilities pertaining to the implementation of this OPP and subsequent EPs shall have the appropriate competencies to fulfil their designated role.

To ensure that personnel are aware of the environmental requirements for the activity all offshore personnel will complete an induction, as a minimum. Records of completion of the induction will be recorded and maintained. The induction will at a minimum cover:

Description of the environmental sensitivities and conservation values of the area and surrounding waters.

- Controls to be implemented to ensure impacts and risks are ALARP and of an acceptable level.
- Requirement to follow procedures and use risk assessments/ job hazard assessments to identify environmental impacts and risks and appropriate controls.
- Requirements for interactions with fishers and/or fishing equipment.
- Requirement for responding to and reporting environmental hazards or incidents.
- Overview of emergency response and spill management plans.
- Fauna sighting and vessel interaction procedures.
- Relevant Whale management Procedure.

In addition to the activity-specific induction, each employee or contractor with specific responsibilities pertaining to the implementation of this OPP and subsequent EPs shall be made aware of their responsibilities, and the specific control measures required to maintain environmental performance and legislative compliance.

9.2.4 Contracts and Procurement – OEMS Element 5

Element 5 addresses the acquiring of external services and materials, and the transportation of those materials. It ensures Beach's business interests are met while maintaining compliance with all legal obligations and retaining HSE performance as the top priority. Element 5 also documents requirements for management of land transport risks.

Beach undertakes a pre-qualification of all contractors in which their HSE systems are reviewed to ensure that the contractor's HSE management system (HSEMS) is adequate for meeting their legal obligations and has identified the significant risks and control measures related to the scope of work being undertaken for Beach. This process includes verifying evidence of HSEMS implementation.

Training and competency of contractor personal engaged to work on the activity shall be managed in accordance with the contractor's HSEMS (or equivalent).

Contractors will be assessed to ensure they have the capabilities and competencies to implement the control measures identified in Sections 6 and 7.

9.2.5 Asset Management – OEMS Element 6

The focus of Element 6 is the design, build and operation of assets. The underpinning standards reflect the importance of inherent safety in design, recognising that hazards and risk are to be reduced to ALARP in the design phase of an asset. The standards define the minimum requirement for the monitoring and assurance processes that support the ongoing safe and reliable management of an asset throughout its lifecycle. Element 6 draws heavily on the principles of process safety and is closely aligned with Elements 7 (Operational Control) and Element 8 (Risk Management).

Equipment that have been identified as a control measure for the purpose of managing potential environmental impacts and risks from the activity have an associated EPS that details the performance required as detailed in Section 6.

9.2.6 Operational Control - Element 7

Element 7 focuses on the definition of parameters, practices and procedures required to ensure adequate controls and safe execution of work at operating assets. It deals with the ongoing management of barrier integrity throughout asset lifecycle, ensuring good process safety practices are consistently deployed, and that facility changes manage holistic risk.

9.2.6.1 Management of Change Standard

Standard 7.3 defines the minimum planning and implementation requirements for technical and organisational change at Beach. It details the requirement for holistic assessment of the change, the requirement for consultation with stakeholder's dependent upon the nature of the change, and the need for clear accountability for the change. Risk associated with change is mitigated by ensuring change is appropriately approved, effectively implemented, formally assured and closed out upon completion. Any changes must be classified as either temporary or permanent.

The intent of the Management of Change (MoC) Standard is that all temporary and permanent changes to the organisation, personnel, systems, procedures, equipment, products and materials are identified and managed to ensure HSE risks arising from these changes remain at an acceptable level.

Changes to equipment, systems and documentation are managed in accordance with the MoC Standard to ensure that all proposed changes are adequately defined, implemented, reviewed and documented by suitably competent persons. This process is managed using an electronic tracking database (called 'Stature'), which provides assurance that all engineering and regulatory requirements have both been considered and met before any change is operational. The MoC process includes not just plant and equipment changes, but also documented procedures where there is an HSE impact, regulatory documents and organisational changes that impact personnel in safety critical roles.

Not all changes require a MoC review. Each change is assessed on a case-by-case basis. The potential environmental impacts and/or risks are reviewed by a member of the Beach Environment Team to determine whether the MoC review process is triggered.

Where risk and hazard review processes nominated in Section 9.2.7 identify a change in impacts, risks or controls (compared to those described and assessed in Chapter 6), and triggers a regulatory requirement to revise this OPP, the revision shall be defined, endorsed, completed and communicated in accordance with the MoC Standard.

9.2.7 Risk Management and Hazard Control – OEMS Element 8

The identification, assessment and treatment of risk is central to maintaining control of assets. Element 8 defines the means by which Beach manages all types of risk to the business. This element includes general risk management, the Safe Systems of Work by which site activities are controlled and executed, and the emergency and security arrangements in place to protect the Company from unplanned events or the attempts of others to do harm to the business.

9.2.7.1 Risk Management Standard

Standard 8.1 defines Beach's requirements to mitigate and manage risk at all levels within the business. It defines the Risk Management Framework for identifying, understanding, managing and reporting risks. The framework defines the documents, training, tools and templates to be used, and the accountabilities to be applied in support of effective risk management. Risks to people, the environment, Beach's reputation, financial position and any legal risks are assessed through the framework. The Standard defines the purpose and use of risk assessments and risk registers. The environmental risk management framework applied to the activity is described in Chapter 5 and applied to all the aspects assessed in Chapter 6 of this OPP.

Beach will undertake a review of future EPs if required in order to ensure that any changes to the activity, controls, regulatory requirements and information from research, stakeholders, industry bodies or any other sources to inform the EP are assessed using the risk management tools nominated. The review will ensure that the environmental impacts and risks of the activity continue to be reduced to ALARP and an acceptable level.

If revision of this OPP is trigged though a change in risk or controls, the revision process shall be managed in accordance with the MoC process.

Additional, or increased, impacts or risks, are identified, outside of the management of change process by the assurance process.

9.2.7.2 Emergency and Security Management Standard

Standard 8.3 defines the minimum performance requirements to effectively manage credible emergency and security events, and to enable an efficient recovery to normal operations following such an event. The Standard defines the prevention, preparedness, response and recovery principles to be applied, the organisational structures to support emergency and security measures, and the training and testing protocols that must be in place to assure Beach maintains a state of readiness.

9.2.7.2.1 Emergency Response Framework

The Beach Crisis and Emergency Management Framework consists of a tiered structure whereby the severity of the emergency triggers the activation of emergency management levels. The emergency response framework contains three tiers based on the severity of the potential impact (Emergency Response Team, Emergency Management Team and Crisis Management Team). This framework is described in the Beach Emergency Management Plan (EMP).

9.2.7.2.2 Beach Emergency Management Plan

The Beach EMP provides the standard mechanism for the Emergency Management Team (EMT) to operate from and includes guidance on effective decision-making for emergency events, identification, assessment and escalation of events and provides training and exercise requirements. The EMP provides information on reporting relationships for command, control and communications, together with interfaces to emergency services specialist response groups, statutory authorities and other external bodies. The roles and responsibilities are detailed for onshore and offshore personnel involved in an emergency, including the response teams, onshore support teams, visitors, contractors and employees. The EMP details the emergency escalation protocol depending on the nature of the emergency.

Associated with the EMP are the Emergency Response Duty Roster and Contact Lists. These documents constitute a suite of emergency response documents that form the basis for Beach’s response to an emergency situation.

9.2.7.2.3 Oil Pollution Emergency Plan

Oil spill response arrangements associated with the Project will be detailed in the relevant Offshore Oil Pollution Emergency Plan (OPEP).

The COVID-19 pandemic resulted in restrictions or measures being implemented to address the pandemic. These restrictions or measures can potentially impact oil spill response arrangements. For all Beach activities within the Otway Development area, which includes the Otway Offshore Operations, the environmental risk profile has been reviewed with respect to the commitments in EPs and OPEP.

On-Going Response Preparedness and Exercises detail the processes that Beach will undertake to ensure that oil spill response requirements can be met during operations and for IMR activities.

9.2.7.2.4 Operational and Scientific Monitoring Plan

Operational and scientific monitoring arrangement associated with the Project will be detailed within the relevant Operational and Scientific Monitoring Plan (OSMP).

9.2.7.2.5 Testing of Spill Response Arrangements

The OPEP details the oil spill response testing arrangements.

9.2.8 Incident Management – OEMS Element 9

Element 9 defines how Beach classifies, investigates, reports and learns from incidents. An incident is any unplanned event or change that results in potential or actual adverse effects or consequences to people, the environment, assets, reputation, or the community.

9.2.8.1 Incident Management Standard

The incident management standard defines the requirement for incident notification, reporting and subsequent investigation requirements. It ensures that incident classification is applied consistently across the company, and that the appropriate level of investigation and approval authority is implemented. The standard describes the requirement for identifying and assigning remedial actions, and for communicating key learnings throughout the business. As such, the standard also defines the requirement for adequate training for those persons involved in performing investigations.

The incident management standard requires that all HSE incidents, including near misses, are reported, investigated and analysed to ensure that preventive actions are taken, and learnings are shared throughout the organisation.

Incident reports and corrective actions are managed using the Beach Incident Management System.

9.2.9 Environment and Community – OEMS Element 10

Element 10 focuses on the measures the organisation must take to ensure that it upholds its reputation as a responsible and ethical company and continues its open and transparent engagements with its communities and stakeholders. Beach operates in environmentally sensitive areas, in close proximity to communities, with potential impacts on stakeholders. Beach has an obligation to ensure that potential impacts from its activities are clearly identified, minimised to ALARP and mitigated where there is an economic loss to a stakeholder directly impacted by Beach activities.

The purpose of the Environmental Management Standard is to ensure that all areas of the Company implement appropriate plans and procedures to conduct environmental management of operations in a responsible and sustainable manner.

9.2.9.1 Environmental Management Standard

An assessment of environmental aspects, effects, risks and impacts must be prepared to identify and assess impacts to the environment as a result of the Company’s operations and activities. The impact assessment must cover design, development, operation and decommissioning and meet all statutory regulatory compliance requirements. The Standard covers land disturbance, reinstatement and rehabilitation activities, and defines obligations for management of biodiversity, water systems, air quality, noise and vibration, amenities and waste.

9.2.9.2 Community Management Standard

Standard 10.2 defines the minimum requirements for the conduct of Beach and its staff within the community, and the commitments to plan and execute effective community engagement in the course of its business. Beach staff will conduct themselves as ambassadors for the company and engage positively and respectfully with the community.

The standard describes the obligation of the company to proactively engage with the community at the outset of any activity that may have an impact on that community, and to develop a stakeholder engagement plan to manage that engagement.

Stakeholder consultation specific to the activity is discussed in Section 10 of this OPP.

9.2.10 Assurance and Reporting – OEMS Element 11

Element 11 establishes that the company must apply the requirements of relevant policies, and the commitments detailed in the OEMS standards throughout its activities. An assurance process therefore exists to systematically quantify compliance with those commitments, and with the underlying procedures and systems. This Element also documents Beach's approach to sustainability and reporting company performance using established sustainability performance metrics.

9.2.10.1 Sustainability Standard

The purpose of this standard is to operationalise the requirements established by the Company's Sustainability Policy and other associated Beach policies. The standard details how Beach incorporate environmental, social and government requirements into the Board, sustainability reporting, performance monitoring and evaluation, company and project risk assessments and emissions reduction assessments and activities.

9.2.10.2 Assurance Management Standard

Standard 11.2 describes the "Three Lines of Defence" assurance model employed by Beach to govern its activities and ensure compliance with its commitments and standards. The standard defines Beach's requirements for the establishment and management of risk-based assurance activities at all levels within the company. The assurance process establishes the adequacy and effectiveness of Beach's risk controls and quantifies the status of compliance against our obligations. It ensures the organisation proactively closes any gaps in performance so it can address those issues before harm is manifested. As such, the assurance programme identifies improvement opportunities in business processes and risk controls.

The Standard describes the need to have assurance plans across the business, and for the assurance activities to take place on multiple levels of the organisation. This approach collectively ensures the operational activities Beach perform are compliant with its procedures, standards and ultimately with governing policies and legislative obligations. The holistic results of the assurance programme are reportable to the Board and Committees.

9.2.10.3 EP Assurance

An assurance process is undertaken by Beach to ensure that for the duration of the activity (Table 93):

- The environmental impacts and risks of the activity continue to be identified and reduced to a level that is ALARP.
- Control measures detailed in this OPP are effective in reducing the environmental impacts and risks of the activity to ALARP and an acceptable level.
- Environmental performance outcomes and standards set out in this OPP are being met.

Non-compliances and opportunities for improvements identified via the assurance processes in the following sections are communicated to the appropriate supervisor and/or manager to report and action in a timely manner. Tracking of non-compliances and actions is undertaken using Beach's incident management system which includes assigning a responsible person for ensuring the action is addressed and closed out. Any additional, or increased, impacts or risks identified are managed as per the Management of Change process.

Where an assurance process identifies a breach of an EPO or EPS in the EP this will be reported as a recordable incident.

Assurance Process
EP Assurance Checks covering: • EPOs, EPS and implementation strategy requirements.
Incident reviews and investigations covering: • Review of all incidents to identify any recordable incidents and reportable incidents and any additional, or increased, environmental impacts or risks. • Reporting and investigation of incidents to identify recordable and reportable incidents and any additional, or increased, environmental impacts or risks.
Environmental Impact and Risk Register to ensure impacts and risks continue to be ALARP and an acceptable level and any additional, or increased, environmental impacts or risks identified.
Activity risk review to ensure impacts and risks can be manage to ALARP and an acceptable level and any additional, or increased, environmental impacts or risks identified.
EP Performance Report covering: • Review of EPOs and EPs.
Emissions and discharge records

Table 94: Assurance Processes

9.2.10.4 Audits and Inspections

An EP assurance checklist details the assurance checks required to ensure that for the duration of the EPs:

- EPOs, EPSs and implementation strategy requirements are met.
- Controls measures are effective in reducing the environmental impacts and risks of the activity to ALARP and acceptable levels
- Any additional, or increased, impacts or risks are identified.
- Assurance Checks define the timing of these checks.

Non-compliances and opportunities for improvements identified via assurance checks or any other means are communicated to the appropriate supervisor and/or manager to report and action in a timely manner. Any additional, or increased, impacts or risks identified are managed as per the Management of Change process. Tracking of non-compliances and actions is undertaken using Beach's incident management system which includes assigning a responsible person for ensuring the action is addressed and closed out.

9.3 Emergency Preparedness and Response

Beach's Crisis and Emergency Management Standard requires Beach to have plans, procedures and resources are in place to effectively respond to crisis and emergency situations, to protect the workforce, the environment, the public and customers, and to preserve the company's assets and reputation.

For activities Beach will have in place an Emergency Response Plan which identifies emergency events, including hydrocarbon spills, and details the arrangement in place to control, coordinate and respond to those events. To support the Emergency Response Plan, Beach will have an OPEP and an OSMP covering the oil spill response and monitoring arrangements relevant to the hydrocarbon spill risk associated with the Project.

10. Stakeholder Consultation

Stakeholder consultation is an integral component of the environmental impact assessment process and has been undertaken to inform the OPP.

Beach is committed to open, on-going and effective engagement with the communities in which it operates and providing information that is clear, relevant and easily understandable. Beach welcomes feedback and is continuously endeavouring to learn from experience in order to manage our impacts and risks.

Stakeholder consultation for the Project is a component of Beach's broader consultation in the Otway region. Consultation with stakeholders began prior to the development of the OPP and will continue throughout the life of the Otway Development.

The existing Otway development commenced production in late February 2008. Woodside Energy, the titleholder at the time, undertook significant consultation with the community, non-government organisations and Government departments. Consultation has been ongoing through the change of titleholders to Origin and then Lattice. In 2017 Lattice commenced consultation in relation to the broader Otway Development. Beach then commenced consultation with stakeholders in early 2019 when they decided to progress with the Otway Development Phase 4. Through this process we have identified relevant persons and have a good understanding of issues and concerns within the region.

The OPP process includes a formal period of public consultation, for a minimum of four weeks. The OPP will be made publicly available, and the public can provide comment to NOPSEMA. Following the public comment period, Beach must demonstrate an assessment of merits of the comments, and how they have been addressed.

10.1 Consultation Objectives

The objectives of Beach's stakeholder consultation in preparation of the OPP are to:

- Identify all relevant persons for consultation.
- Engage with stakeholders in an open, transparent, timely and responsive manner.
- Provide information to stakeholders about the development including the physical, ecological, socio-economic and cultural environment that may be affected, the potential impacts that may occur and controls proposed to avoid or minimise those impacts.
- Obtain information from stakeholders in relation to if their functions, interests or activities may be affected by the development.
- Provide additional information to stakeholders who raise any objections or claims.
- Build and maintain trust with stakeholders.

10.2 Relevant Person Identification

Relevant stakeholders were identified by reviewing:

- Social receptors identified in the existing environment section.
- Existing stakeholders within Beach's stakeholder register.
- Reviewing consultation records for previous Otway Basin activities undertaken by Beach and Lattice.
- Commonwealth and State fisheries jurisdictions and fishing effort in the region.

- NOPSEMA Guideline Consultation with Commonwealth Agencies with Responsibilities in the Marine Area.

Table 94 provides a summary of relevant persons arranged by category in accordance with Regulation 11A.

This list is not exhaustive and additional relevant persons may be identified as a part of the ongoing consultation including the formal comment period.

Categories	Relevant Persons Examples
Category A Each Department or agency of the Commonwealth to which the activities to be carried out under the environment plan, or the revision of the environment plan, may be relevant	• Australian Border Force – Maritime Border Command • Australian Fisheries Management Authority (AFMA) • Australian Maritime Safety Authority (AMSA) • Department of Agriculture, Water and the Environment (DAWE); Fisheries; Biosecurity Marine Pests • Department of Defence - Australian Hydrographic Office (AHO) • Department of Defence - Infrastructure Division, Defence Support & Reform Group • Department of Industry, Science, Energy and Resources (DISER) • Director of National Parks (DNP) • Department of Climate Change, Energy, the Environment and Water – Oceans • Indigenous Land and Sea Corporation • National Native Title Tribunal
Category B Each Department or agency of a State or the Northern Territory to which the activities to be carried out under the environment plan, or the revision of the environment plan, may be relevant	• Department of Energy, Environment and Climate Action (DEECA) - VIC • Department of Infrastructure and Transport - Marine Safety SA • Department for Environment and Water South Australia - Coast Protection Board • Corangamite Catchment Management Authority • Department of Infrastructure and Transport - Marine Safety SA • Department of Natural Resources and Environment Tasmania - Biosecurity • Department of Natural Resources and Environment Tasmania - Conservation • Department of Natural Resources and Environment Tasmania - Marine/Fisheries(Fishing Tasmania) • Department of Natural Resources and Environment Tasmania - Strategic Projects and Policy • Department of Natural Resources and Environment Tasmania - Tasmania Parks and Wildlife Services • Department of Premier and Cabinet - Office of Aboriginal Affairs - (Tasmania) • Department of Primary Industries and Regions South Australia - Commercial Fishing • Department of State Growth - Mineral Resources Tasmania • Department of Transport and Planning: Marine Pollution • Victorian Fisheries Authority • Parks Victoria • Department of Primary Industries, Parks, Water and Environment (DPIPWE) • EPA Tasmania • EPA South Australia • EPA Victoria

Categories	Relevant Persons Examples
	• First Peoples – State Relations (Victoria) • Marine and Safety Tasmania • Office of the Minister for Environment • Transport Safety Victoria - Maritime Safety Victoria •
Category C The Department of the responsible State Minister, or the responsible Northern Territory Minister;	• Office of the Minister Energy and Resources
Category D A person or organisation whose functions, interests or activities may be affected by the activities to be carried out under the environment plan, or the revision of the environment plan.	• Commercial fishing • Local government authorities • Community • Environmental NGO • Marine based industries • Marine tourism/recreation • Business • Land based tourism • Education & Research organisations • Media • Native Title and Cultural Heritage / Traditional owner groups
Category E Any other person or organisation that the titleholder considers relevant.	• Member of the public or group whose functions, interests or activities are not impacted by Beach Energy activities

Table 95: Stakeholder Categories and Groups

10.3 Stakeholder Mapping to Project Impacts and Risks

An initial assessment of stakeholders’ functions, interests and activities has been undertaken, based on previous stakeholder consultation and the preliminary impact assessment conducted for the project. **Table 95** identifies the receptors and associated potential impacts relevant to each stakeholder group and identifies the planned and unplanned environmental aspects relevant to each stakeholder group. This mapping will be updated as consultation progresses.

	Receptor	Potential Impact	Cth Govt	Vic/Tas Govt	Fisheries	Recreation/ Tourism	Industry	Research/ Community Groups
Physical	Ambient light	Change in ambient light	✓	✓		✓		✓
	Ambient noise	Change in ambient noise	✓	✓				
	Water quality	Change in water quality	✓	✓	✓	✓		✓
	Sediment quality	Change in sediment quality	✓	✓	✓			✓
	Air quality	Change in air quality	✓	✓				
	Climate	Change in climate	✓	✓				✓
Ecological	Coastal habitats and communities	Change in habitat	✓	✓				✓
		Change in ecosystem dynamics	✓	✓				✓
	Benthic habitats and communities	Change in habitat	✓	✓				✓
		Change in fauna behaviour	✓	✓	✓			✓
		Injury / mortality to fauna	✓	✓	✓			✓
	Threatened Ecological Communities	Change in habitat	✓	✓				✓
	Plankton	Change in fauna behaviour	✓	✓				✓
		Injury / mortality to fauna	✓	✓		✓		✓
	Seabirds and Shorebirds	Change in fauna behaviour	✓	✓				✓
		Injury / mortality to fauna	✓	✓				✓
	Fish	Change in fauna behaviour	✓	✓		✓		✓
		Injury / mortality to fauna	✓	✓		✓		✓
	Marine mammals	Change in fauna behaviour	✓	✓				✓
		Injury / mortality to fauna	✓	✓				✓
	Marine reptiles	Change in fauna behaviour	✓	✓				✓

	Receptor	**Potential Impact**	**Cth Govt**	**Vic/Tas Govt**	**Fisheries**	**Recreation/ Tourism**	**Industry**	**Research/ Community Groups**
		Injury / mortality to fauna	✓	✓				✓
Socio-economic	Key Ecological Features	Changes to the functions, interests or activities of other users	✓	✓				✓
		Change in water quality	✓	✓				✓
		Change in habitat	✓	✓				✓
		Injury / mortality to fauna	✓	✓				✓
		Change in fauna behaviour	✓	✓				✓
	Commonwealth Heritage Places	Changes to the functions, interests or activities of other users	✓	✓				✓
	–Australian Marine Parks	Changes to the functions, interests or activities of other users	✓	✓				✓
		Change in water quality	✓	✓				✓
		Change in habitat	✓	✓				✓
		Injury / mortality to fauna	✓	✓				✓
		Change in fauna behaviour						
		Change in aesthetic value						
	State Protected Areas - Marine	Changes to the functions, interests or activities of other users	✓	✓		✓		✓
		Change in water quality	✓	✓				✓
		Change in sediment quality	✓	✓				✓
		Change in habitat	✓	✓				✓
		Injury / mortality to fauna	✓	✓				✓
		Change in aesthetic value	✓	✓		✓		✓
	State Protected Areas - Terrestrial	Changes to the functions, interests or activities of other users	✓	✓		✓		✓

Receptor	Potential Impact	Cth Govt	Vic/Tas Govt	Fisheries	Recreation/ Tourism	Industry	Research/ Community Groups
Ramsar Wetlands of International Importance	Change in habitat	✓	✓				✓
Nationally Important Wetlands	Change in habitat	✓	✓				✓
Cth Managed Fisheries	Changes to the functions, interests or activities of other users	✓	✓	✓			✓
State Managed Fisheries	Changes to the functions, interests or activities of other users	✓	✓	✓			✓
Recreation and Tourism	Changes to the functions, interests or activities of other users	✓	✓		✓		✓
	Change in aesthetic value	✓	✓		✓		✓
Industry	Changes to the functions, interests or activities of other users	✓	✓		✓	✓	✓
Heritage and cultural features	Changes to the functions, interests or activities of other users	✓	✓				✓
	Change in water quality	✓	✓		✓		✓
	Change in sediment quality	✓	✓				✓
	Change in habitat	✓	✓				✓
	Injury / mortality to fauna	✓	✓				✓
	Change in fauna behaviour	✓	✓				✓
	Change in aesthetic value	✓	✓		✓		✓

Table 96: Relevance of Receptor and Environmental Impact to Stakeholder Groups

10.4 Stakeholder Consultation Approach

10.4.1 Background

The Otway Development commenced production in late February 2008. Woodside Energy, the titleholder at the time, undertook significant consultation with the community, non-government organisations and Government departments. Consultation has been ongoing through the change of titleholders to Origin Energy and then Lattice Energy and now Beach.

In 2017 Lattice commenced consultation in relation to the Otway Development Project which included the Geographe and Thylacine subsea wells and associated seabed assessment and drilling activities. Beach then commenced consultation with stakeholders in early 2019 when they decided to progress with the Otway Development Project.

Activities for the Otway Offshore Project have run over several phases and many years, beginning with seabed assessments, drilling of exploration wells and production wells in the Geographe and Thylacine gas fields, and installation of seabed infrastructure to support tie-in of the wells to the existing Thylacine-A Platform and pipeline. Notwithstanding the requirements for separate activity EPs, Beach has undertaken a holistic approach throughout its consultations with Relevant Persons, by explaining how each activity supports the Otway Offshore Project.

Consultation with Relevant Persons has continued throughout the Otway Offshore Project, and specifically for the purpose of developing numerous EPs for those activities. Information regarding consultation for the Otway Offshore Development including production from the Thylacine subsea wells can be found in the following accepted EPs:

- Otway Offshore Operations EP (CDN/ID 17275058)
- Artisan Exploration Drilling EP (CDN/ID S4810AH717904)
- Otway Development Drilling and Well Abandonment EP (CDN/ID S4100AH717905)
- Otway Phase 5 Early Dive Installation Campaign EP (CDN/ID S4130AF725242)
- Thylacine Subsea Installation & Commissioning (T/L2 and T/L4) (CDN/ID: S4121AF728393)

These EPs, along with all Beach’s accepted EPs, can be viewed on the NOPSEMA website.

10.4.2 Project Consultation Approach

Beach, as Operator of the Project is undertaking a phased program of consultation:

- Phase 1: Consultation on the Project prior to OPP public comment period
- Phase 2: Formal consultation via the OPP public comment period
- Phase 3: Ongoing consultation for Project activities.

10.4.3 Phase 1: Initial Project Consultation

Consultation has been undertaken and is ongoing. Information provided in relation to the Project and associated activities include:

- Community Information Sessions held in:
    - Port Campbell on 24 July 2023
    - Portland 25 July 2023

  - Warrnambool 26 July 2023
  - Port Fairy 26 July 2023
  - King Island, Burnie, Lakes Entrance and Apollo Bay to follow
- Meetings:
  - Peterborough Residents Association 19 July 2023
  - Corangamite Shire Council 20 July 2023
  - Timboon Action Group 1 August 2023
  - King Island Council 17 August 2023
  - Commercial fishing peak bodies round table 30 August 2023 (Warrnambool)
  - Commercial fishers drop-in 30 August 2023 (Warrnambool)
  - Commercial fishers drop-in scheduled for 12 October 2023 (Lakes Entrance)
  - Moyne Shire Council Meeting scheduled for 17 October 2023
- Provision of information on the Beach website Offshore Gas Victoria | Beach Energy and soon to launch a dedicated online engagement hub, 'Engage Beach'
- Provision of the following OGV information sheets (provided in Appendix N) to those stakeholders listed in Table 95:
  - Offshore Gas Victoria Project Information sheet
  - OGV Seabed information sheet
  - OGV drilling activities information sheet
  - OGV P&A information sheet
- Ad-hoc requests via phone and email and provision of specific information as requested.
- Public notices published in:
  - Portland Observer
  - Warrnambool Standard
  - Colac Herald
  - Cobden Timboon Coast Times
  - The Advocate (Burnie)
  - South Gippsland Sentinel Times
  - Bairnsdale Advertiser
  - Koori Mail scheduled
  - National Indigenous Times scheduled
- First Nations engagement via a dedicated First Nations Engagement Manager
  - Provision of information sheets
  - Meetings with native title CEOs and board

  - Meetings with key community members
  - Community drop-in sessions to follow
  - Meeting with Heritage Victoria and First Peoples State Relations Victoria

10.4.3.1 Director of National Parks

Beach undertook consultation with the Director of National Parks (DNP) in accordance with the consultation requirements detailed in the NOPSEMA and Parks Australia Petroleum Activities and Australian Marine Parks: A guidance note to support environmental protection and effective consultation (N-04750 -GN1785 A620236 01/06/2023) between September and December 2023.

10.4.4 Phase 2: Project OPP Public Comment Period

The public can review and provide comment on the OPP once NOPSEMA has determined it is suitable for publication. The public comment period is determined by NOPSEMA and is a minimum of four weeks.

All public comments are provided to NOPSEMA who forward a copy of the comments received to Beach for consideration. Following the public comment period, Beach must prepare a consultation report and the final OPP for assessment by NOPSEMA. In the consultation report, Beach must summarise the comments received with an assessment of the merits of each comment, a statement of their response to each comment, and an outline of any changes made to the OPP as a result of the comment.

10.4.5 Phase 3: Ongoing Consultation

Beach will continue to consult with stakeholders on individual activities undertaken for the Project. Consultation will be undertaken as part of developing activity specific environment plans as required under the OPGGS (Environment) Regulations. This will be undertaken by:

- Identifying stakeholders that may be potentially affect by the activities.
- Determining the possible consequences of the activities on each stakeholders' functions, interests or activities from previous knowledge, reviewing any public statements by the stakeholder as to how they want to be engaged by oil and gas companies and/or consulting with stakeholders.
- Providing sufficient information, based on possible consequences and the way they would like to be consulted, for the stakeholder to be able to make an informed assessment of the possible consequences of the activity on their functions, interests or activities.
- Allowing a reasonable period of time for the stakeholder to review and respond to any information provided, typically two to four weeks.
- Providing further information requested by the stakeholder or that becomes available during the consultation period and allowed a reasonable time for the stakeholder to review and respond. Depending on the information provided this was between one to four weeks.
- Ensuring relevant stakeholders are informed about the consultation process and how their feedback, questions and concerns were considered in the EP.
- Where requested, providing activity notification and specific information such as:
  - type of activity
  - location of activity, coordinates and map
  - timing of activity: expected start and finish date and duration

  - sequencing of locations if applicable
  - vessel/rig details including call sign and contact
  - requested clearance from other vessels
  - Beach contact details

11. References

Abrahms, B., E. Hazen, E. Aikens, M.S. Savocae, J.A. Goldbogen, S.J. Bograd, M.G. Jacox, L.M. Irvine, D.M. Palacios and B. Mate. (2019). Memory and resource tracking drive blue whale migrations. Proceedings of the National Academy of Sciences (PNAS) 116(12): 5582–5587. www.pnas.org/cgi/doi/10.1073/pnas.1819031116

ABS. (2021) Australian Bureau of Statistics. https://www.abs.gov.au/

Adam, P. (1990). Saltmarsh Ecology. Cambridge University Press, Cambridge.

Advanced Geomechanics. (2011). Technical Note Origin Doc No. S4200-RU-700699.

AIATSIS. (2022). Welcome to Country. The Australian Institute of Aboriginal and Torres Strait Islander Studies. https://aiatsis.gov.au/explore/welcome-country

Andrew, N. (1999). Under Southern Seas: the Ecology of Australia's Rocky Reefs: The Ecology of Australia's Rocky Reefs. University of New South Wales Press, Sydney, Australia. (pp. 238).

Andrew, N. L., & O'Neill, A. L. (2000). Large-scale patterns in habitat structure on subtidal rocky reefs in New South Wales. Marine and Freshwater Research, 51, 255-263.

Andrews-Goff, V., Bestley, S., Gales, N. J., Laverick, S. M., Paton, D., Polanowski, A. M., Double, M. C. (2018). Humpback whale migrations to Antarctic summer foraging grounds through the southwest Pacific Ocean. Scientific Reports, 8. doi: 10.1038/s41598-018-30748-4.

Ansell, R., Gibson, R. N., & Barnes, M. (1999). Oceanography and Marine Biology: An Annual Review. Volume 37. The Dunstaffnage Marine Laboratory, Scotland.

ANZECC & ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

ANZG (2018). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Retrieved from: www.waterquality.gov.au/anzguidelines.

APPEA (2008). Code of Environmental Practice. Code_of_Environmental_Practice.pdf (appea.com.au)

API - American Petroleum Institute (2009). Greenhouse Gas Emissions Methodologies for the Oil and Natural Gas Industry. American Petroleum Institute, Washington DC, United States of America.

APPEA. (2021). Key Statistics 2021. Australian Petroleum Products and Exploration Association.

Arnould J.P.Y. & Kirkwood R. (2007). Habitat selection by female Australian fur seals (Arctocephalus pusillus doriferus). Aquatic Conservation: Marine and Freshwater Ecosystems. Vol. 17, suppl. 1, pp. S53.

Attard, C. R. M., Beheregaray, L. B., Sandoval-Castillo, J., Jenner, C. S., Gill, P. C., Jenner, M. N. M., Moller, L. M. (2018). From conservation genetics to conservation genomics: a genome- wide assessment of blue whales (Balaenoptera musculus) in Australian feeding aggregations. Royal Society Open Science, 5(1): doi: 170925.

Aulich, M. G., McCauley, R. D., Saunders, B. J., & Parsons, M. J. G. (2019) Fin whale (Balaenoptera physalus) migration in Australian waters using passive acoustic monitoring. Scientific Reports, 9:8840. doi: 10.1038/s41598-019-45321-w

Austin, M.E., A. McCrodan, C. O'Neill, Z. Li, and A.O. MacGillivray. (2013). Marine mammal monitoring and mitigation during exploratory drilling by Shell in the Alaskan Chukchi and Beaufort Seas, July–November 2012: 90-Day Report. In: Funk, D.W., C.M. Reiser, and W.R. Koski (eds.). Underwater Sound Measurements. LGL Rep. P1272D–1. Report from LGL Alaska Research Associates Inc. and JASCO Applied Sciences, for Shell Offshore Inc., National Marine Fisheries Service (US), and US Fish and Wildlife Service. 266 pp plus appendices.

Australian and New Zealand Environment and Conservation Council (ANZECC). (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. National Water Quality Management Strategy, 1: 1-7.

Australian Maritime Safety Authority (AMSA) (2015a). Technical Guidelines for Preparing Contingency Plans for Marine and Coastal Facilities. Australian Government.

Australian Museum. (2020). Orange-bellied Parrot(*Neophema chrysogaster*). https://australianmuseum.net.au/learn/animals/birds/orange-bellied-parrot-neophema-chrysogaster/

Australian Seaweed Institute (2023). https://www.australianseaweedinstitute.com.au/current-state-of-the-australian-seaweed-industry

Backhouse, G., O'Connor, J., & Jackson, J. (2008). National Recovery Plan for the Australian Grayling (Prototroctes maraena). Department of Sustainability and Environment, Melbourne.

Baker, A. N. (1985). Pygmy right whale (Caperea marginate) (Gray, 1846). In: Ridgway, S H and R. Harrison, eds. Handbook of Marine Mammals Vol. 3: The Sirenians and Baleen Whales (pp. 345-354). Academic Press, London.

Baker, C. S., Patenaude, N. J., Bannister, J. L., Robins, J., & Kato, H. (1999). Distribution and diversity of mtDNA lineages among southern right whales (Eubalaena australis) from Australia and New Zealand. Marine Biology, 134, 1–7.

Baker, G. B., Gales, R., Hamilton, S., & Wilkinson, V. (2002). Albatrosses and petrels in Australia: a review of their conservation and management. Emu, 102, 71-97.

Balcom, B. J., Graham, B. D., Hart, A. D., & Bestall, G. P. (2012). Benthic impacts resulting from the discharge of drill cuttings and adhering synthetic based drilling fluid in deep water, in: International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production. Presented at the International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, Society of Petroleum Engineers, Perth, p. SPE-157325-MS.

Ball, D., & Blake, S. (2007). Shallow water habitat mapping at Victorian Marine National Parks and Marine Sanctuaries, Volume 1: Western Victoria. Parks Victoria Technical Series No.36. Parks Victoria, Melbourne.

Bannister, J. L., Kemper, C. M., & Warneke, R. M. (1996). The Action Plan for Australian Cetaceans. Canberra: Australian Nature Conservation Agency. Retrieved from http://www.environment.gov.au/coasts/publications/cetaceans-action-plan/pubs/whaleplan.pdf.

Bannister JL. (2008). 'Great Whales' CSIRO Publishing: Collingwood.

Bannister, J. L. (2017). Project A7- Monitoring Population Dynamics of 'Western' Right Whales off Southern Australia 2015-2018. Final report to National Environment Science Program, Australian Commonwealth Government.

Barton, J., Pope, A., & Howe, S. (2012). Marine Natural Values Study Vol 2: Marine Protected Areas of the Central Victoria Bioregion. Parks Victoria Technical Series No. 76. Parks Victoria, Melbourne.

BBG (2003). Gas Project. Pipeline routes video survey report. Report by Bowman Bishaw Gorham Pty Ltd for Woodside Australia Pty Ltd.

Bilney, R. J., & Emison, W. B. (1983). Breeding of the White-bellied Sea-eagle in the Gippsland Lakes Region of Victoria, Australia. Australian Bird Watcher, 10, 61-68.

BirdLife International (2023) Important Bird Area factsheet: Wilsons Promontory Islands. Downloaded from http://datazone.birdlife.org/site/factsheet/wilsons-promontory-islands-iba-australia on 15/08/2023.

BirdLife International (2023a) Important Bird Area factsheet: Hunter Island Group. Downloaded from http://datazone.birdlife.org/site/factsheet/hunter-island-group-iba-australia on 15/08/2023.

BirdLife International (2023b) Important Bird Area factsheet: Albatross Island and Black Pyramid Rock. Downloaded from http://datazone.birdlife.org/site/factsheet/albatross-island-and-black-pyramid-rock-iba-australia on 15/08/2023

BirdLife International (2023c) Important Bird Area factsheet: King Island. Downloaded from http://datazone.birdlife.org/site/factsheet/king-island-iba-australia on 15/08/2023.

BirdLife International (2023d) Important Bird Area factsheet: King Island. Downloaded from http://datazone.birdlife.org/site/factsheet/king-island-iba-australia on 15/08/2023.

BirdLife International (2023e) Important Bird Area factsheet: Hunter Island Group. Downloaded from http://datazone.birdlife.org/site/factsheet/hunter-island-group-iba-australia on 15/08/2023.

BirdLife International (2023f) Important Bird Area factsheet: King Island. Downloaded from http://datazone.birdlife.org/site/factsheet/king-island-iba-australia on 15/08/2023.

BirdLife International (2023g) Important Bird Area factsheet: Hunter Island Group. Downloaded from http://datazone.birdlife.org/site/factsheet/hunter-island-group-iba-australia on 15/08/2023.

Blower, D. C, Pandolfi, J. M., Bruce, B. D., Gomez-Cabrera, M., & Ovenden, J. R. (2012). Population genetics of Australian white sharks reveals fine-scale spatial structure, trans - oceanic dispersal events and low effective population sizes. Marine Ecology Progress Series, 455, 229−244.

Bone, C. (1998). Preliminary investigation into leatherback turtle, Dermochelys coriacea (L.) distribution, abundance and interactions with fisheries in Tasmanian waters. Unpublished Report. Tasmanian Parks and Wildlife Service.

Bonwick J. 1858. Western Victoria, Its Geography, geology and Social condition: The narrative of an educational tour in 1857, Melbourne, Heinemann 1970.

Boon, P., Allen, T., Brook, J., Carr, G., Frood, D., Harty, C., Yugovic, J. (2011). Mangroves and Coastal Saltmarsh of Victoria, Distribution, Condition, Threats and Management. Institute for Sustainability and Innovation, Victoria University.

Boreen, T., James, N., Silson, C., & Heggi, D. (1993). Surfical cool-water carbonate sediments on the Otway continental margin, Southeastern Australia. Elsevier Science Publishers BV, Marine geology, 112, 35-56.

BP (2013). Shah Deniz Stage 2 (SD2) Project, Environmental and Social Impact Assessment. Retrieved from https://www.bp.com/en_az/caspian/sustainability/environment/env-and-social-documentation/ShahdenizESIAs/ESIA.html.

Branch, T. A., Matsuoka, K., & Miyashita, T. (2004). Evidence for increases in Antarctic blue whales based on Bayesian modelling. Marine Mammal Science, 20(4), 726-754.

Bransbury, J. (1985). Waders of littoral habitats in south-eastern South Australia. South Australian Ornithologist, 29, 180-187.

Brothers, N., Pemberton, D., Pryor, H; & Halley, V. (2001). Tasmania's Offshore Islands: seabirds and other natural features. Tasmanian Museum and Art Gallery: Hobart. ISBN 0-7246-4816-X

Bruce, B. D., Harasti, D., Lee, K., Gallen, C., & Bradford, R. (2019). Broad-scale movements of juvenile white sharks Carcharodon carcharias in eastern Australia from acoustic and satellite telemetry. Marine Ecology Progress Series, 619, 1-15. doi: 10.3354/meps12969.

Buckley, R. W. (1993). Sites of Geological and Geomorphological Significance along the Victorian Coast, Geological Survey of Victoria.

Burnell, S. R. (2001). Aspects of the reproductive biology, movements and site fidelity of right whales off Australia. Journal of Cetacean Research and Management (Special Issue 2), 89-102.

Cai, W., Cowan, T. (2006). SAM and regional rainfall in IPCC AR4 models: Can anthropogenic forcing account for southwest Western Australian winter rainfall reduction? Geophysical Research Letters 33.

Carr, G. (2003). Harmers Haven Flora and Fauna Reserve, South Gippsland – An assessment of vegetation and management issues, Ecology Australia Pty Ltd, Fairfield, Victoria.

Casper, B.M., A.N. Popper, F. Matthews, T.J. Carlson, and M.B. Halvorsen. (2012). Recovery of barotrauma injuries in Chinook salmon, Oncorhynchus tshawytscha from exposure to pile driving sound. PLOS ONE 7(6): e39593. https://doi.org/10.1371/journal.pone.0039593.

CEE Consultants Pty Ltd (2003). Otway Gas project Gas field and Subsea Pipeline Marine Biological Conditions. Existing Conditions and Impact Assessment.

Charlton, C. M. (2017) Population demographics of southern right whales (Eubalaena australis) in Southern Australia. (pp. 171) (PhD Thesis). Curtin University, Western Australia.

Chatto, R., & Warneke, R. (2000). Records of Cetacean stranding's in the Northern Territory of Australia. Beagle: Records of the Museums and Art Galleries of the Northern Territory, 16, 163-175.

Chevron (2015). Gorgon Gas Development and Jansz Feed Gas Pipeline: Reverse Osmosis Brine Disposal via Ocean Outfall Environmental Management and Monitoring Plan. Retrieved from https://australia.chevron.com/-/media/australia/our-businesses/documents/gorgon-emp-reverse-osmosis-brine-disposal-via-ocean-outfall-environmental-plan.pdf.

Chevron (2018). Wheatstone Project. Wheatstone Well Intervention and Infill Drilling Environment Plan Summary. Document ID: ABU180200939. Chevron, Perth, Western Australia.

Church, J.A., Hunter, J.R., McInnes, K.L., White, N.J. (2006). Sea-level rise around the Australian coastline and the changing frequency of extreme sea-level events. Australian Meteorological Magazine 55: 253–260.

CIN (2005). Chemical Hazard Assessment and Risk Management, for the use and discharge of chemicals used offshore. User Guide version 1.4. CHARM Implementation Network (CIN).

Clancy, G.P. (2005). The diet of the Osprey (*Pandion haliaetus*) on the north coast of New South Wales. Emu 105:87-91.

Clarke, P.A. (2001). The significance of whales to the Aboriginal people of southern South Australia. Records of the South Australian Museum. Vol. 34, no. 1, pp. 19-35.

CoA (2005). A Guide to the Integrated Marine and Coastal Regionalisation of Australia Version 4.0. Department of the Environment and Heritage, Canberra.

CoA. (2013). Matters of National Environmental Significant. Significant Impact Guidelines 1.1. Environmental Protection and Biodiversity Conservation Act 1999. Commonwealth of Australia.

CoA (2015a). Wildlife Conservation Plan for Migratory Shorebirds. Commonwealth of Australia.

CoA (2015b). Conservation Management Plan for the Blue Whale (*Balaenoptera musculus*)- A Recovery Plan under the Environment Protection and Biodiversity Conservation Act 1999.

CoA (2015c). South-east Marine Region Profile: A description of the ecosystems, conservation values and uses of the South-east Marine Region. Commonwealth of Australia.

CoA (2015d). National Conservation Values Atlas. Commonwealth of Australia, Canberra. Retrieved from http://www.environment.gov.au/webgisframework/apps/ncva/ncva.jsf.

CoA (2015e). Recovery Plan for Three Handfish Species, Commonwealth of Australia 2015.

CoA (2017a). Recovery for Marine Turtles in Australia. Commonwealth of Australia.

CoA. (2017b) Budj Bim Cultural Landscape: World Heritage Nomination. Australian Department of the Environment and Energy. https://www.environment.gov.au/system/files/pages/b42e9c8e-370d-4094-8cef-37ce503e81a3/files/budj-bim-nomination-dossier.pdf

CoA (2019). Draft National Recovery Plan for the Swift Parrot (*Lathamus discolor*). Commonwealth of Australia 2019.

CoA (2020). National Recovery Plan for the Australian Fairy Tern (*Sternula nereis nereis*). Commonwealth of Australia 2020.

CoA. (2022). National Recovery Plan for Albatrosses and Petrels. Commonwealth of Australia.

CoA. (2022a). National Recovery Plan for the Australian Painted Snipe (*Rostratula australis*). Commonwealth of Australia 2022.

Cogger, H. G., Cameron, E. E., Sadlier, R. A. & Eggler, P. (1993). The Action Plan for Australian Reptiles. Canberra, ACT: Australian Nature Conservation Agency. Retrieved from http://www.environment.gov.au/biodiversity/threatened/action/reptiles/index.html.

Compagno, L.J.V. (1984). Part 1 - Hexanchiformes to Lamniformes. FAO Species Catalogue, Vol. 4., Sharks of the World. An Annotated and Illustrated Catalogue of Sharks Known to Date. FAO Fisheries Synopsis. 4(1):1-249.

Correa, I. C. S., Tolodo, E. E. Jr., & Teledo, F. A. L. (2010). Impacts on seafloor geology of drilling disturbance in shallow waters. Environmental Monitoring Assessment, 167. 79-16. Cited in: IAOPG, 2016. Environmental fates and Effects of Ocean Discharge of Drilling Cuttings and Associated Drilling Fluids from Offshore Oil and Gas Operations. Prepared by Sanzone, D.M., Neff, J.M., Lewis, D., Vinhateriom, N., Blake, J. for International Association of Oil Gas Producers.

Cranford, T. W., & Krysl, P. (2015). Fin whale sound reception mechanisms: Skull vibration enables low-frequency hearing. PLoS ONE, 10(1), Article e0116222. https://doi.org/10.1371/journal.pone.0116222

Cranmer, G. (1988) Environmental survey of the benthic sediments around three exploration well sites. Report No 88/02. Report to the United Kingdom Offshore Operators Association. Aberdeen University Marine Studies Ltd, Aberdeen, UK, 33pp.

CSIRO (2020). State of the Climate 2020. Australian Government Bureau of Meteorology. https://www.csiro.au/en/research/environmental-impacts/climate-change/state-of-the-climate

Currie, D. R., & Isaacs, L. R. (2005) Impact of exploratory offshore drilling on benthic communities in the Minerva gas field, Port Campbell, Australia. Marine Environmental Research, 59. 217– 233.

Daan, R., & Mulder, M. (1996) On the short-term and long-term impact of drilling activities in the Dutch sector of the North Sea. ICES Journal of Marine Science, 53. 1036-1044.

Dabuleviciene, T., Kozlov, I., Vaiciute, D., Dailidiene, I. (2018). Remote sensing of coastal upwelling in the south-eastern Baltic Sea: statistical properties and implications for the coastal environment. Remote Sens. 10, 1752.

Dai, A. (2013). Increasing drought under global warming in observations and models. Nature climate change 3: 52–58.

Dawson J. 1881. Australian Aborigines: The Languages and Customs of Several Tribes of Aborigines in the Western District of Victoria, Australia. George Robertson, Melbourne.

de Campos, L. F., Paiva, P. M., Rodrigues, P. P. G. W., Ferreira, M. I. P., & Lugon, J. Jnr. (2017). Disposal of waste from cementing operation from offshore oil and gas wells building. Ciência e Natura, 39(2). 413 – 422. Retrieved from https://pdfs.semanticscholar.org/15f8/5dd7aab34c3700f8580345ed9d9eb41e18bd.pdf.

DAWE (2021). Guidance on key terms within the Blue Whale Conservation Management Plan. September 2021. https://www.awe.gov.au/sites/default/files/documents/guidance-key-terms-blue-whale-conservation-management-plan-2021.pdf. Accessed on 20 March 2022.

DCCEEW. (2022a). Draft National Recovery Plan for the Southern Right Whale. Department of Climate Change, Energy, the Environment and Water.

DCCEEW. (2022b). Sea Country Indigenous Protected Areas Program – Grant Opportunity. https://www.dcceew.gov.au/environment/land/indigenous-protected-areas/sea-country-grant-opportunity

DCCEEW (2023). Biologically important areas of regionally significant marine species. Department of Climate Change, Energy, the Environment and Water. https://www.dcceew.gov.au/environment/marine/marine-species/bias

DCCEEW. (2023a) Species Profile and Threats Database: Bonney coast upwelling. Department of Climate Change, Energy, the Environment and Water. Accessed August 2023 at: https://www.environment.gov.au/sprat-public/action/kef/view/89;jsessionid=01AD87551D0DE1B0248C8722BE137004

DCCEEW. 2024. Sea Country Indigenous Protected Areas Program - Grant Opportunity. Department of Climate Change, Energy, the Environment and Water. **https://www.dcceew.gov.au/environment/land/indigenous-protected-areas/sea-country-grant-opportunity**

DEC NSW (2006). Approved Recovery Plan for Gould’s Petrel (*Pterodroma leucoptera leucopters*). Available from: http://www.environment.gov.au/system/files/resources/ba3f6508-b2d7-4d20-9424-75b36b016c37/files/p-leucoptera.pdf

Debus, S. J. S., Baker, G., Owner, D., & Nottidge, B. (2014). Response of White-bellied Sea-Eagles Haliaeetus leucogaster to encroaching human activities at nest sites. Corella, 38(3), 53-62.

DELWP (2015) Ngootyoong Gunditj Ngootyoong Mara South West Management Plan. Department of Environment, Land, Water and Planning.

DELWP (2016). National Recovery Plan for the Orange-bellied Parrot (Neophema chrysogaster). Australian Government, Canberra.

DELWP. (2016a). Shipwreck Protection Zones. A WWW publication. Available from: http://www.dtpli.vic.gov.au/heritage/shipwrecks-andmaritime/shipwreck-protected-zones. Department of Transport, Planning and Local Infrastructure. Melbourne.

DELWP. (2017a). Glenelg Estuary and Discovery Bay Ramsar Site Management Plan Summary. Department of Environment, Land, Water and Planning, East Melbourne, Victoria.

DELWP. (2017b). Western Port Ramsar Site Management Plan. Department of Environment, Land, Water and Planning, East Melbourne.

DELWP (2017b). Department of Environment, Land, Water and Planning Flora and Fauna Guarantee Act 1988 Threatened List. DELWP, Melbourne. Retrieved from https://www.environment.vic.gov.au/__data/assets/pdf_file/0019/50239/201703-FFGThreatened-List.pdf.

DELWP. (2018). Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site Management Plan. Department of Environment, Land, Water and Planning, East Melbourne.

Dernie KM, Kaiser, MJ, Richardson EA, Warwick RM. 2003. 'Recovery of soft sediment communities and habitats following physical disturbance', Journal of Animal Ecology 72 (6) 1043-1056 (2003). Accessed December 2022.

DETG. (2015). Recovery Plan for Three Handfish Species. Canberra, ACT: Department of the Environment and the Tasmanian Government Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/recovery-plan-for-three-handfish-species.

DNP (2013). South-East Commonwealth Marine Reserves Network Management Plan 2013–23. Department of Environment Canberra, Available at: http://www.environment.gov.au/system/files/pages/de2de49a-7eed-4a70-bfbb-463f8d00f2ca/files/se-networkmanagement-plan2013-23.pdf

DoD. (2022). Categories for Unexploded (UXO) Ordnance Potential – Categorisation Criteria, Warnings and Advice – webpage. A WWW webpage accessed in December 2022 at Categories for UXO Potential https://www.whereisuxo.org.au. Department of Defence. Canberra.

DoD. (2023). Where is Unexploded Ordnance – Interactive Map. A WWW database accessed in March 2023 at https://www.whereisuxo.org.au. Department of Defence. Canberra.

DoE. (2023). Balaenoptera musculus in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat.

DoE (2023a). Pelecanoides urinatrix-Common Diving-Petrel in Species Profile and Threats Database. Department of the Environment, Canberra. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1018.

DoE (2023b). Ardenna carneipes Flesh-footed Shearwater in Species Profile and Threats Database. Department of the Environment, Canberra. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=82404.

DoE (2023b) Species Profile and Threats Database: Carcharhinus longimanus - Oceanic Whitetip Shark. Department of Climate Change, Energy, the Environment and Water. Accessed August 2023 at: https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=84108

DoE (2023c) Species Profile and Threats Database: Rhincodon typus – Whale Shark. Department of Climate Change, Energy, the Environment and Water. Accessed August 2023 at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=66680

DoE (2023d) Species Profile and Threats Database: Carcharodon carcharias – White Shark. Department of Climate Change, Energy, the Environment and Water. Accessed August 2023 at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=64470

DoE (2023e) Species Profile and Threats Database: Brachiopsilus ziebelli — Ziebell's Handfish, Waterfall Bay Handfish. Department of Climate Change, Energy, the Environment and Water. Accessed August 2023 at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=83757

DoE (2023f). Balaenoptera bonaerensis-Antarctic Minke Whale in Species Profile and Threats Database. Department of the Environment, Canberra. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=67812.

DoE (2023i). Megaptera novaeangliae-Humpback Whale in Species Profile and Threats Database. Department of the Environment, Canberra. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=38.

DoE (2023j). Physeter macrocephalus-Sperm Whale in Species Profile and Threats Database. Department of the Environment, Canberra. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59.

DoE (2023k). Dusky Dolphin (Lagenorhynchus obscurus) in Species Profile and Threats Database. Department of the Environment, Canberra. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=43.

DoE (2023l). Orcinus orca-Killer Whale in Species Profile and Threats Database. Department of the Environment, Canberra. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=46.

DoE (2023m). Chelonia mydas-Green Turtles in Species Profile and Threats Database. Department of the Environment, Canberra. Retrieved from http://www. Dermochelys coriacea environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1765.

DoE (2023n). Dermochelys coriacea-Leatherback in Species Profile and Threats Database. Department of the Environment, Canberra. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1768.

Donaldson S. 2012. Exploring Ways of Knowing Protecting and Acknowledging First Nations Totems across the Eurobodalla Shire Far South Coast NSW. Report for the Eurobodalla Shire Council First Nations Advisory Committee. Eurobodalla.

DPIPWE (2016). Tasmanian Wilderness World Heritage Area Management Plan 2016, Department of Primary Industries, Parks, Water and Environment, Hobart.

DPIPWE. (2000). Small Bass Strait Island Reserves Draft Management Plan. Parks and Wildlife Service, Department of Primary Industries, Water and Environment.

DPIPWE. (2016). Tasmanian Wilderness World Heritage Area (TWWHA) Management Plan . Department of Primary Industries, Parks, Water and Environment.

DPIPWE. (2020a). Marine Life and Their Habitats. A WWW document accessed at: https://dpipwe.tas.gov.au/conservation/the-marine-environment/fisheries-habitats. Department of Primary Industries, Parks, Water and Environment. Hobart.

DPIPWE. (2020b). Rock Lobster Fishery. A WWW database accessed at https://dpipwe.tas.gov.au/sea-fishingaquaculture/commercial-fishing/rock-lobster-fishery. Department of Primary Industries, Parks, Water and Environment. Hobart.

DPIPWE. (2020c). Shellfish Fishery. A WWW database accessed at https://dpipwe.tas.gov.au/sea-fishingaquaculture/commercial-fishing/shellfish-fishery. Department of Primary Industries, Parks, Water and Environment. Hobart.

DPIPWE. (2020d). Seaweed Fishery. A WWW database accessed at https://dpipwe.tas.gov.au/sea-fishingaquaculture/commercial-fishing/seaweed-fishery. Department of Primary Industries, Parks, Water and Environment. Hobart.

DPIPWE. (2020e). Abalone Fishery. A WWW database accessed at https://dpipwe.tas.gov.au/sea-fishing-aquaculture/commercial-fishing/abalone-fishery. Department of Primary Industries, Parks, Water and Environment. Hobart.

DPIPWE. (2020f). Scallop Fishery. A WWW database accessed at https://dpipwe.tas.gov.au/sea-fishing-aquaculture/commercial-fishing/scallop-fishery. Department of Primary Industries, Parks, Water and Environment. Hobart.

DPIPWE. (2020g). Scalefish Fishery. A WWW database accessed at https://dpipwe.tas.gov.au/sea-fishing-aquaculture/commercial-fishing/scalefish-fishery. Department of Primary Industries, Parks, Water and Environment. Hobart.

DPIPWE. (2020h). Commercial Dive Fishery. A WWW database accessed at https://dpipwe.tas.gov.au/sea-fishing-aquaculture/commercial-fishing/commercial-dive-fishery. Department of Primary Industries, Parks, Water and Environment. Hobart.

DPIPWE. (2020i). Octopus Fishery. A WWW database accessed at https://dpipwe.tas.gov.au/sea-fishing-aquaculture/commercial-fishing/octopus-fishery. Department of Primary Industries, Parks, Water and Environment. Hobart.

DPIPWE. (2013). King Island Biodiversity Management Plan. Department of Primary Industries, Parks, Water and Environment. Hobart.

DPIPWE. (2021, November 11). Offshore Aquaculture Research - Proposed Amendments. Retrieved from Sea Fishing and Aquaculture: http://dpipwe.tas.gov.au/sea-fishing-aquaculture/sustainable-fisheries-management/legislation/offshore-aquaculture-research-proposed-amendments

DPIPWE. (2021). Sea Fishing & Aquaculture. Retrieved from : https://dpipwe.tas.gov.au/sea-fishing-aquaculture

DPIPWE. (2021). Sustainable Industry Growth Plan for the Salmon Industry. Department of Primary Industry, Parks, Water and Environment.

DPIWE. (2000). Small Bass Strait Island Reserves. Draft Management Plan. Department of Primary Industries, Water and Environment.

Draper N. 2015. Islands of the dead? Prehistoric occupation of Kangaroo Island and other southern offshore islands and watercraft use by First Nations Australians. Quaternary international, 385, 229-242.

DSE (2003). Port Phillip Bay (Western Shoreline) & Bellarine Peninsula Ramsar Site Strategic Management Plan. Department of Sustainability and Environment Victoria

DSE (2004). Controlling the Northern Pacific Seastar (Asterias amurensis) in Australia. Final Report for the Australian Government Department of the Environment and Heritage. Department of Sustainability and Environment Victoria.

DSE (2008). National Recovery Plan for the Australian Grayling Prototroctes maraena. State of Victoria Department of Sustainability and Environment. East Melbourne.

DSE (2012) Marine National Parks. DSE, Melbourne.

DSEWPaC (2011a). National Recovery Plan for Threatened Albatrosses and Giant Petrels 2011-2016. Department of Sustainability, Environment, Water, Population and Communities. Australian Antarctic Division. Canberra.

DSEWPaC. (2011). Approved Conservation Advice for Sternula nereis nereis (Fairy Tern). Canberra, ACT: Department of Sustainability, Environment, Water, Population and Communities. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/82950-conservation-advice.pdf.

DSEWPaC. (2012a). Conservation Management Plan for the Southern Right Whale .2011 – 2021. Department of Sustainability, Environment, Water, Population and Communities. Australian Antarctic Division. Canberra.

DSEWPaC. (2012b). Approved Conservation Advice for Giant Kelp Marine Forests of South East Australia. Canberra, ACT: Department of Sustainability, Environment, Water, Population and Communities.

DSEWPaC (2012d). Species group report card – seabirds; Supporting the marine bioregional plan for the South-west Marine Region. Australian Government. Retrieved from https://www.environment.gov.au/system/files/pages/a73fb726-8572-4d64-9e33-1d320dd6109c/files/south-west-report-card-seabirds.pdf [10 October 2019].

DSEWPaC (2012e). Approved Conservation Advice for Thymichthys politus (red handfish). Canberra, ACT: Department of Sustainability, Environment, Water, Population and Communities. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/83756-conservation-advice.pdf.

DSEWPaC (2013). Conservation Advice for Subtropical and Temperate Coastal Saltmarsh. Canberra: Department of Sustainability, Environment, Water, Population and Communities.

DSEWPaC (2013a). Approved Conservation Advice for Rostratula australis (Australian Painted Snipe). Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/77037-conservation-advice.pdf

DSEWPaC (2013b). Recovery Plan for the Australian Sea Lion (Neophoca cinerea). Department of Sustainability, Environment, Water, Population and Communities. Commonwealth of Australia.

Duncan, A. J., Gavrilov, A. N., McCauley, R. D., Parnum, I. M., & Collis, J. M. (2013). Characteristics of sound propagation in shallow water over an elastic seabed with a thin cap-rock layer. Journal of the Acoustical Society of America, 34, 207-215.

Dunlop, R.A., M.J. Noad, R.D. McCauley, L. Scott-Hayward, E. Kniest, R. Slade, D. Paton, and D.H. Cato. (2017). Determining the behavioural dose–response relationship of marine mammals to air gun noise and source proximity. Journal of Experimental Biology 220(16): 2878-2886.

Durante LM, Smart JJ and Tsolos A. (2022). South Australian Charter Boat Fishery 2020/21. Final Report to PIRSA Fisheries and Aquaculture. South Australian Research and Development Institute (Aquatic Sciences, Adelaide. SARDI Publication No. F2007/000847-6. ARDI Research Series No.1139. 47pp.

ECC (2000). Marine, Coastal and Estuarine Investigation Final Report, Environment Conservation Council, East Melbourne.

Edmunds, M. J., Judd, A., Pickett, P. & Parks Victoria. (2010). Reef surveys at Twelve Apostles Marine National Park and the Arches Marine Sanctuary. Melbourne: Parks Victoria

Edyvane, K. (2003). Conservation, Monitoring and Recovery of Threatened Giant Kelp (Macrocystis pyrifera) Beds in Tasmania – Final Report (to Environment Australia). Department of Primary Industries, Water and Environment, Tasmania.

Eldridge R. 2015. The cultural Interactions of Aborigines with Whales, Whalers and Whaling in southwest Victoria 1828-1850. Unpublished Thesis https://researchonline.federation.edu.au/vital/access/manager/Repository/vital:10437

EMAC. 2015. Meerreengeeye Ngakeepoorryeeyt (Our Country) Plan. Eastern Maar Aboriginal Corporation.

EMAC. (2024) About - Eastern Maar Aboriginal Corporation. https://easternmaar.com.au/about/

Erbe, C., Ainslie, M. A., de Jong, C. A. F., Racca, R., & Stocker, M. (2016). The need for protocols and standards in research on underwater noise impacts on marine life. In: Popper, A.N., Hawkins, A. (eds.) The Effects of Noise on Aquatic Life II. Advances in Experimental Medicine and Biology, 875. 1265–1271.

Fandry, C. B (1983). Model for the three-dimensional structure of wind driven and tidal circulation in Bass Strait, Australian Journal of Marine Freshwater Research, 34, 121 –141.

Faulkner, R., Farcas, A. and Merchant, N. (2018). Guiding principles for assessing the impact of underwater noise. Journal of Applied Ecology. Available online at: https://doi.org/10.1111/1365-2664.13161

Finneran, J.J. (2016). Auditory weighting functions and TTS/PTS exposure functions for marine mammals exposed to underwater noise. Technical Report.

Finneran, J.J., E.E. Henderson, D.S. Houser, K. Jenkins, S. Kotecki, and J. Mulsow. (2017). Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III). Technical report by Space and Naval Warfare Systems Center Pacific (SSC Pacific). 183 p.

Fishes of Australia (2015). Family Syngnathidae. A WWW database. Available from: http://www.fishesofaustralia.net.au/home/family/34#moreinfo.

Flagstaff Hill (2015). Guide to the Historic Shipwreck Trail on Victoria's West Coast. Retrieved from www.flagstaffhill.com/media/uploads/ShipwreckTrail.pdf.

Forteath, G., Picken, B., Ralph, R. and Williams, J. (1982). Marine Growth Studies on the North Sea oil platform Montrose Alpha. Marine Ecology Progress Series 8: 61-68.

French-McCay, D. (2004). Oil spill impact modelling: Development and validation. Environmental toxicology and chemistry / SETAC. 23. 2441-56. 10.1897/03-382.

French-McCay, D. (2009). 'State-of-the-art and research needs for oil spill impact assessment modelling'. Proceedings of the 32nd Arctic and Marine Oil Spill Program (AMOP) Technical Seminar, Environment Canada, Ottawa, 601–653.

French-McCay, D. (2009). 'State-of-the-art and research needs for oil spill impact assessment modelling'. Proceedings of the 32nd Arctic and Marine Oil Spill Program (AMOP) Technical Seminar, Environment Canada, Ottawa, 601–653.

Fraser MW, Short J, Kendrick G, McLean D, Keesing J, Byrne M, Caley JM, Clarke D, Davis AR, Erftemeijer PLA, Field S, Gustin-Craig S, Huisman J, Keough M, Lavery P, Masini R, McMahon K, Mengersen K, Rasheed M, Statton J, Stoddart J, Wu P. 2017. Effects of dredging on critical ecological processes for marine invertebrates, seagrasses and macroalgae, and the potential for management with environmental windows using Western Australia as a case study, Ecological Indicators, Volume 78, 2017, Pages 229–242Fugro (2019) Artisan Site Survey Geophysical/Geotechnical Factual Report. 21 November 2019. Provided to Beach Energy Limited.

Fugro (2020a). Geophysical/Geotechnical Factual Report - Thylacine Site. Otway Offshore Well Site Survey. Victoria, Australia. 135846-52-REP-002. 27 February 2020. Provided to Beach Energy Limited.

Fugro (2020b). Geophysical/Geotechnical Factual Report - Geographe Site. Otway Offshore Well Site Survey. Victoria, Australia. 135846-52-REP-003. 19 February 2020. Provided to Beach Energy Limited.

Fuller RS and Bursill LW. 2021. Linking the Pleiades to a reawakened Black Duck Songline in Southeastern Australia. Australian Journal Of Anthropology, 32(2), 116-134

Gallaway, B.J., Martin, L.R., Howard, R.L., Boland, G.S. and Dennis, G.D. (1981). Effects on artificial reef and demersal fish and microcrustacean communities. In: Environmental Effects of Offshore Oil Production. Middleditch, B.S. (ed). Springer, New York.

Gannier, A., Drouot, V., & Gould, J. C. (2002). Distribution and the relative abundance of Sperm Whales in the Mediterranean Sea. Marine Ecology Progress Series, 243. 281 -293.

Gavrilov, A. (2012). Sesimic signal transmission, pygmy blue whale abundance and passage and ambient noise measurements during and after the Bellerive seismic survey in Bass Strait, 2011. Curtin University centre for Marine Science.

Geiling, N. (2014). Arctic Shipping: Good for Invasive Species, Bad for the Rest of Nature. Smithsonian. Available at: https://www.smithsonianmag.com/science-nature/global-warmings-unexpected-consequence-invasive-species-180951573/

Geraci, J. R. (1990). Physiologic and Toxic Effects on Cetaceans. In: Sea Mammals and Oil: Confronting the Risks. Geraci, J. R. and St. Aubin, D. J. (eds). Academic Press Inc., San Diego, California.

Geraci, J. R., & St. Aubin, D. J. (1988). Synthesis of Effects of Oil on Marine Mammals. Report to U.S. Department of the Interior, Minerals Management Service, Atlantic OCS Region, OCS Study. Ventura, California.

Gill, P. C. (2002). A blue whale (Balaenoptera musculus) feeding ground in a southern Australian coastal upwelling zone. Journal of Cetacean Research and Management, 4. 179-184.

Gill, P. C. (2020). Blue Whale Literature Review - Offshore Victoria (Otway basin/Bass Strait). Report to Beach Energy Limited. Blue Whale Study Inc.

Gill, P. C., & Morrice, M. (2003). Cetacean Observations. Blue Whale Compliance Aerial Surveys. Santos Ltd Seismic Survey Program Vic/P51 and P52. November – December 2002. Report to Santos Ltd.

Gill, P. C., Morrice, M. G., Page, B., Pirzl, R., Levings, A. H., & Coyne, M. (2011). Blue whale habitat selection and within-season distribution in a regional upwelling system off southern Australia. Marine Ecology Progress Series, 421. 243–263. Retrieved from http://www.intres.com/articles/meps_oa/m421p243.pdf.

Gill, P.C., Pirzl, R., Morrice, M. G., & Lawton, K. (2015). Cetacean diversity of the continental shelf and slope off southern Australia. The Journal of Wildlife Management, 79.

GLAWAC. 2015. Gunaikurnai Whole-of-Country Plan. Gunaikurnai Land and Waters Aboriginal Corporation. Bairnsdale, Victoria.

Goldsworthy, S. D. (2008). The Mammals of Australia. Third Edition. New Holland. Sydney.

Gomez, C., Lawson, J.W., Wright, A.J., Buren, A.D., Tollit, D. and Lesage, V. (2016). A systematic review on the behavioural responses of wild marine mammals to noise: the disparity between science and policy. Canadian Journal of Zoology 94(12): 801–819.

Green, R. H. (1969). The birds of Flinders Island. Records of the Queen Victoria Museum, 34 (pp. 1-32).

Griffin, Thompson, Bax, Hallegraeff (1997). The 1995 mass mortality of pilchards: No role found for physical or biological oceanographic factors in Australia. Australian Journal Marine Freshwater Research, 48. 27-58.

Gubili, C., Clinton, Geremy, C., Wintner, S., Mahmood, S., Demian, C., Noble, L. (2012). Application of molecular genetics for conservation of the white shark, Carcharodon carcharias, L. 1758. In: Domeier ML (ed) Global perspectives on the biology and life history of the white shark. CRC Press, Boca Raton, FLO, p 357−380.

Hale, J. (2016) Ecological Character Description Addendum - Western Port Ramsar Site. Department of Environment, Land, Water and Planning. East Melbourne.

Hannay, D., MacGillivray, A., Laurinolli, M., & Racca, R. (2004). Source Level Measurements from 2004 Acoustics Programme. Sakhalin Energy (pp. 66).

Harding, S. B., Wilson, J. R., & Geering, D. W. (2007). Threats to shorebirds and conservation actions. In: Geering, A., L. Agnew and S. Harding, eds. Shorebirds of Australia. (pp. 197-213). Melbourne, Victoria: CSIRO Publishing.

Harris, MP and Deerson, DM (1980). Seal Island, Seal Island Group Victoria. Seabird Islands No. 82. November 1980. Available from: https://absa.asn.au/wp-content/uploads/2021/10/Cor-Vol-4-Pg69-70_Seabird_No82_SealIsland_Vic.pdf

Harrison, P. L. (1999). Oil pollutants inhibit fertilization and larval settlement in the scleractinian reef coral Acropora tenuis from the Great Barrier Reef, Australia. Sources, Fates and Consequences of Pollutants in the Great Barrier Reef and Torres Strait, GBRMPA: 11-12.

Hastie, G. D., Swift, R. J., Gordon, J. C. D., Slesser, G., & Turrell, W.R. (2003). Sperm Whale Distribution and Seasonal Density in the Faroe Shetland Channel. Journal of Cetacean Research and Management, 5(3). 247-252.

Hawkins, A.D. and Popper, A.N. (2017) A sound approach to assessing the impact of underwater noise on marine fishes and invertebrates, ICES Journal of Marine Science, Volume 74, Issue 3, March-April 2017, Pages 635–651, https://doi.org/10.1093/icesjms/fsw205

Heap, A. D., & Harris, P. T. (2008). Geomorphology of the Australian margin and adjacent seafloor, Australian Journal of Earth Sciences, 55(4). 555-585.

Heisler, S., & Parry, G. D. (2007). Parks Victoria Technical Series – Number 53. Species diversity and composition of benthic infaunal communities found in Marine National Parks along the outer Victorian coast. Parks Victoria, Melbourne. Retrieved from http://parkweb.vic.gov.au/__data/assets/pdf_file/0015/314520/19_2096.pdf.

Heritage Victoria (2004). Victorian Heritage Register. Department of Infrastructure, Melbourne.

Hiddink JG, Jennings S, Sciberra M, Szostek CL, Hughes, KM, Ellis, N, Rijnsdorp AD, McConnaughey RA, Mazor T, Hilborn R, Collie JS, Pitcher CR, Amoroso RO, Parma AM, Suuronen P, Kaier MJ. 2017. 'Global analysis of depletion and recovery of seabed biota after bottom trawling disturbance'. Proc. Natl. Acad. Sci. U.S.A. 114, 8301–8306 (2017).Higgins, P. J., & Davies, S. J. J. F. (1996). Handbook of Australian, New Zealand and Antarctic Birds. Volume Three - Snipe to Pigeons. Melbourne, Victoria: Oxford University Press.

Hinwood, J. B., Poots, A. E., Dennis, L. R., Carey, J. M., Houridis, H., Bell, R. J., Ayling, A. M. (1994). Drilling activities. In: Swan JM, Neff JM, Young PC (eds) Environmental Implications of offshore oil and gas development in Australia: findings of an independent scientific review. Australian Petroleum Production and Exploration Association, Canberra, (pp. 123–207).

Hoegh-Guldberg, O., Jacob, D., Taylor, M., Bindi, M., Brown, S., Camilloni, I., Diedhiou, A., Djalante, R., Ebi, K.L., Engelbrecht, F., Guiot, J., Hijioka, Y., Mehrotra, S., Payne, A., Seneviratne, S., Thomas, A., Warren, R., Guangsheng, Z., (2018). Impacts of 1.5 C global warming on natural and human systems, in: Global Warming of 1.5° C. An IPCC Special Report. Intergovernmental Panel on Climate Change, Geneva.

Hofmeyr, G. & Gales, N. (2008). Arctocephalus pusillus. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2.

Holmes, K. W., Radford, B., Van Niel, K. P., Kendrick, G. A., & Grove, S. L. (2007). Mapping the Benthos in Victoria's Marine National Parks, Volume 4: Twelve Apostles Marine National Park. Parks Victoria Technical Series No. 43. Parks Victoria, Melbourne.

Horwood, J. (1987). The sei whale: Population biology, ecology, and management. Croom Helm, Sydney.

Hotchkin, C. and S. Parks. (2013). The Lombard effect and other noise-induced vocal modifications: Insight from mammalian communication systems. Biological Reviews 88(4): 809-824. https://doi.org/10.1111/brv.12026

Houser, D.S., W. Yost, R. Burkard, J.J. Finneran, C. Reichmuth, and J. Mulsow. (2017). A review of the history, development and application of auditory weighting functions in humans and marine mammals. Journal of the Acoustical Society of America 141(3): 1371-1413. https://doi.org/10.1121/1.4976086.

Huang Z. and Wang X.H. (2019). Mapping the spatial and temporal variability of the upwelling systems of the Australian south-eastern coast using 14-year of MODIS data, Remote Sensing of Environment. Volume 227, 2019, Pages 90-109, ISSN 0034-4257.

Hughes, L. (2003). Climate change and Australia: trends, projections and impacts. Austral Ecology28: 423- 443.

Hughes, L., (2011). Climate change and Australia: key vulnerable regions. Regional Environmental Change 11: 189–195.

Huisman, J. M. (2000). Marine Plants of Australia. University of Western Australia Press.

Hume, F., Hindell, M. A., Pemberton, D., & Gales, R. (2004). Spatial and temporal variation in the diet of a high trophic level predator, the Australian fur seal (Arctocephalus pusillus doriferus). Marine biology, 144(3). 407-415.

Hyland, J., Hardin, D., Steinhauer, M., Coats, D., Green, R., & Neff, J. (1994). Environmental impact of offshore oil development on the outer continental shelf and slope off Point Arguello, California. Marine Environmental Research, 37(2). 195-229.

IOGP (2016). Environmental fate and effects of ocean discharge of drill cuttings and associated drilling fluids from offshore oil and gas operations. Report No. 543. March 2016. International Association of Oil & Gas Producers and IPIECA. London.

IOGP-IPIECA, (2020). Environmental management in the upstream oil and gas industry. Report No. 254. August 2020. International Association of Oil & Gas Producers and IPIECA. London.

IPCC (2018). Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland, 32 pp. Global Warming of 1.5 ºC — (ipcc.ch)

IUCN. (2007) IUCN Red List of Threatened Species. International Union for the Conservation of Nature (IUCN) viewed 10 April 08, <http://www.iucnredlist.org/search/details.php/46866/summ>.

IWC. (2013). Report of the International Whaling Commission workshop on the assessment of southern right whales. J. Cetacean Res. Manage.14 (Suppl.): 439-462.

James, N. P., Reid, C. M., Bone. Y., Levings, A., & Malcolm, I. (2013). The macroalgal carbonate factory at a cool-to-warm temperate transition, Southern Australia, Sedimentary Geology, 291. 1-26.

Jenkins, G., & McKinnon, L. (2006). Port Phillip Bay Channel Deepening Project: supplemental environmental effects statement – aquaculture and fisheries.

Jones, I.S.F., & Padman, L. (1983). Semidiurnal internal tides in eastern Bass Strait. Australian Journal of Marine and Freshwater Research, 34, 159–171.

JP Kenny. (2012). Otway Phase 3 Rock Bolting Installation Procedure. Sapura Clough Doc no. 12300-50-G-0001.

Kellogg, Brown, & Root (2010). Western Port Ramsar Wetland Ecological Character Description. Report for Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC), Canberra.

Ketten, D.R. (1992). The cetacean ear: form, frequency, and evolution. In Thomas, J.A., R.A. Kastelein, and A.Y. Supin (eds.). Marine Mammal Sensory Systems. Plenum Press, New York. 53-75.

Ketten, D.R. and Bartol, S.M. (2005). Functional measures of sea turtle hearing. ONR project final report. Document Number ONR Award Number N00014-02-1-0510. Office of Naval Research (US).

Kirkman, H. (1997). Seagrasses of Australia, Australia: State of the Environment, Technical Paper Series (Estuaries and the Sea). Environment Australia, Commonwealth of Australia.

Kirkwood, R., Warneke, R.M., Arnould. J.P. (2009). Recolonization of Bass Strait, Australia, by the New Zealand fur seal, Arctocephalus forsteri. Mar. Mam. Sci. 25(2): 441–449.

Koessler, M and C. McPherson (2021). Technical Addendum – Beach Otway Project: Additional and revised modelling study. 27 August 2021.

Koessler, M, Matthews M-N R, and C. McPherson. (2020). Otway Offshore Project – Drilling Program: Assessing Marine Fauna Sound Exposures. Document 02033, Version 1.0. Technical report by JASCO Applied Sciences for Beach Energy Limited.

Koster, W.M., Aarestrup, K., Birnie-Gauvin, K., Church, B., Dawson, D., Lyon, J., O'Connor, J., Righton, D., Rose, D., Westerberg, H. and Stuart, I. (2021). First tracking of the oceanic spawning migrations of Australasian shortfinned eels (*Anguilla australis*). Scientific reports, 11(1), pp.1-13.

Laist, D. W., Knowlton, A. R., Mead, J. G., Collet, A. S., Podesta, M. (2001). Collisions between ships and whales. Marine Mammal Science, 17. 35-75.

Lane L. 1980. Records of the Victorian Archaeological Survey Number 10 June 1980, Ministry for Conservation Publication.

Last, P. R., & Stevens, J. D. (2009). Sharks and Rays of Australia. Second edition. CSIRO Publishing, Australia.

Levings, A., & Gill, P. (2011). Seasonal Winds Drive Water Temperature Cycle and Migration Patterns of Southern Australian Giant Crab Pseudocarcinus gigas. (pp. 461-478).

Lewis, R.K. (1981). Seasonal upwelling along the south-eastern coastline of South Australia. Mar. Freshw. Res. 32, 843–854.

Lewis, M., & Pryor, R. (2013). Toxicities of oils, dispersants and dispersed oils to algae and aquatic plants: Review and database value to resource sustainability. Environmental Pollution, 180. 345–367.

Limpus, C. J. (2008). A biological review of Australian Marine Turtles. 1. Loggerhead Turtle Caretta (Linneaus). Queensland Environment Protection Agency. Retrieved from http://www.epa.qld.gov.au/publications/p02785aa.pdf/A_Biological_Review_Of_Australian_Marine_Turtles_1_Loggerhead_Turtle_emCaretta_Caretta/em_Linnaeus.pdf.

Loehr, L. C., Beegle-Krause, C. J., George, K., McGee, C. D., Mearns, A. J., & Atkinson, M. J. (2006). The significance of dilution in evaluating possible impacts of wastewater discharges from large cruise ships. Marine Pollution Bulletin, 52. 681–688.

Loyn, R.H., Lane, B.A., Chandler, C and Carr, G.W. (1986). Ecology of Orange-bellied Parrots Neophema chrysogaster at their main remnant wintering site. Emu. 86:195-206.

Lutcavage, M. E., Lutz, P. L., Bossart, G. D., & Hudson, D. M. (1995). Physiologic and clinicopathologic effects of NERAcrude oil on loggerhead sea turtles. Archives of Environmental Contamination and Toxicology, 28. 417-422.

MacGillivray, A. O., Racca, R., & Li, Z. (2013). Marine Mammal Audibility of Selected Shallow-water Survey Sources. Journal of Acoustical Society of America, 135(1).

Marchant, S. & Higgins, P. J. (1993). Handbook of Australian, New Zealand and Antarctic Birds. Vol. 2. Raptors to Lapwings. Melbourne, Victoria: Oxford University Press.

Marchant, S., & Higgins, P. J. (1990). Handbook of Australian, New Zealand and Antarctic Birds. Vol. 1. Oxford University Press, Australia.

Massola A. 1968. Bunjil's Cave: Myths, Legends and Superstitions of the Aborigines of South-East Australia. Lansdown Press, Melbourne.

Mathews RH. 1904, Ethnological notes on the Aboriginal tribes of New South Wales and Victoria, Journal and Proceedings of the Royal Society of New South Wales, vol 38, p. 203-381

Matthews, M. N. R. (2012). Underwater Sound Propagation from an Airgun Array in Baffin Bay: Shell 2012 Seismic Surveys in Baffin Bay Blocks 5 and *. Version 3.0. Jasco Applied Sciences.

Matthews, M.-N. R., M.W. Koessler, and C.R. McPherson. (2020). Otway Offshore Project – Construction Program: Assessing Marine Fauna Sound Exposures. Document 02112, Version 1.0. Technical report by JASCO Applied Sciences for Beach Energy Limited.

McCauley, R. D. (2004). Underwater sea noise in the Otway Basin – drilling, seismic and blue whales. Report prepared by Centre for Marine Science and Technology, Curtin University, for Santos Ltd

McCauley, R.D., M.-N. Jenner, C. Jenner, and D.H. Cato. (1998a). Observations of the movements of humpback whales about an operating seismic survey vessel near Exmouth, Western Australia. Journal of the Acoustical Society of America 103: 2909-2909. https://doi.org/10.1121/1.422068.

McCauley, R.D., M.-N. Jenner, C. Jenner, K.A. McCabe, and J. Murdoch. (1998b). The response of humpback whales (Megaptera novaeangliae) to offshore seismic survey noise: Preliminary results of observations about a working seismic vessel and experimental exposures. Australian Petroleum Production Exploration Association (APPEA) Journal 38(1): 692-707. https://doi.org/10.1071/AJ97045.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch, et al. (2000a). Marine seismic surveys: Analysis and propagation of air- gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid. Report Number R99-15. Prepared for Australian Petroleum Production Exploration Association by Centre for Maine Science and Technology, Western Australia. 198 p. https://cmst.curtin.edu.au/wp-content/uploads/sites/4/2016/05/McCauley-et-al-Seismic- effects-2000.pdf.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch, et al. (2000b). Marine seismic surveys: A study of environmental implications. Australian Petroleum Production Exploration Association (APPEA) Journal 40(1): 692-708. https://doi.org/10.1071/AJ99048.

McCauley, R. D., & Duncan, A. J. (2001). Marine Acoustic Effects Study, Blue Whale Feeding Aggregations, Otway Basin, Bass Strait Victoria. Centre for Marine Science and Technology, Curtin University March 2001 For Ecos Consulting.

McCauley, R.D. and D.H. Cato. (2016). Evening choruses in the Perth Canyon and their potential link with Myctophidae fishes. Journal of the Acoustical Society of America 140(4): 2384-2398.

McCauley, R.D., R.D. Day, K.M. Swadling, Q.P. Fitzgibbon, R.A. Watson, and J.M. Semmens. (2017). Widely used marine seismic survey air gun operations negatively impact zooplankton. Nature Ecology & Evolution 1(7): 1-8. https://doi.org/10.1038/s41559-017-0195.McCauley, R.D., A.N. Gavrilov, C.D. Jolliffe, R. Ward, and P.C. Gill. 2018. Pygmy blue and Antarctic blue whale presence, distribution and population parameters in southern Australia based on passive acoustics. Deep Sea Research Part II 157–158: 154-168. https://doi.org/10.1016/j.dsr2.2018.09.006.

McClatchie, S., Middleton, J., Pattiaratchi, C., Currie, D., & Kendrick, G. (2006). The South-west Marine Region: Ecosystems and Key Species Groups. Department of the Environment and Water Resources. Australian Government.

McDonald, M.A., J.A. Hildebrand, and S.C. Webb. (1995). Blue and fin whales observed on a seafloor array in the Northeast Pacific. Journal of the Acoustical Society of America 98(2): 712-721. https://doi.org/10.1121/1.413565.

McInnes, K. L., & Hubbert, G. D. (2003). A numerical modelling study of storm surges in Bass Strait. Australian Meteorological Magazine 52(3).

McLeay, L. J., Sorokin, S. J., Rogers, P. J., & Ward, T. M. (2003). Benthic Protection Zone of the Great Australian Bight Marine Park: Literature Review. South Australia Marine Research and Development Institute (Aquatic Sciences), Commonwealth Department of Environment and Heritage.

McLeay. L. (2022) Stock Status Report for the South Australian Giant Crab (*Pseudocarcinus gigas*) Fishery in 2020/21. Fishery Status Report to PIRSA Fisheries and Aquaculture. South Australian Research and Development Institute (Aquatic Sciences), Adelaide. SARDI Publication No. F2011/000332-11. SARDI Research Report Series No. 1123. 20pp.

McPherson, C. and Wood, M. (2017). Otway Basin Geophysical Operations Acoustic Modelling - Acoustic Modelling for Assessing Marine Fauna Sound Exposures. Prepared for Lattice Energy on 2 November 2017. Document 01473.

McPherson, C, M. Weirathmueller, S. Denes, D. Cusano, and M. Koessler. (2020). Otway Offshore Project – Drilling Program: Pygmy Blue Whale Exposure Modelling. Document 02169, Version 1.0. Technical report by JASCO Applied Sciences for Beach Energy Limited.

McPherson, C.R., Z. Li, C.C. Wilson, K.A. Kowarski, and M. Koessler (2021). Beach Otway Development Acoustic Monitoring: Characterisation, Validation, and Marine Mammals. Document Number 02424, Version 2.0. Technical report by JASCO Applied Sciences for Beach Energy Limited.

Melton, H. R., Smith, J. P., Martin, C. R., Nedwed, T. J., Mairs, H. L., & Raught D.L. (2000). Offshore Discharge of Drilling Fluids and Cuttings – A Scientific Perspective on Public Policy. International Oil and Gas Conference, Rio, Brazil; 13-19 October 2000.

MESA. (2015). Mangroves of Australia – Distribution and Diversity. Marine Education Society of Australasia. Available from: http://www.mesa.edu.au/mangroves/mangroves01.asp.

Middleton, J.F., Bye, J.A.T. (2007). A review of the shelf-slope circulation along Australia's southern shelves: Cape Leeuwin to Portland. Prog. Oceanogr. 75, 1–41.

Myrberg, J. F., Arthur, C., Van Ruth, P., Ward, T. M., McClean, J. L, Maltrud, M. E., Middleton, S. (2007). El Nino Effects and Upwelling off South Australia. Journal of Physical Oceanography, 37(2). 458–2,477.

Miller, B. S., Kelly, N., Double, M. C., Childerhouse, S. J., Laverick, S. & Gales, N. (2012). Cruise report on SORP 2012 blue whale voyages: development of acoustic methods. Paper SC/64/SH1 1 presented to the IWC Scientific Committee.

Milton, S. L., & Lutz, P. (2003). Physiological and Genetic response to Environmental Stress. The Biology of Sea Turtles 2. CRC Press, Boca Raton (pp. 163).

Minton, C., & Deleyev, J. (2001). Analysis of recoveries of VWSG banded Caspian Terns. Victorian Wader Study Group Bulletin 2. (pp.71-75).

Möller, L.M. Double, D. Paton, C. Attard and K. Bilgmann. (2015). Satellite tagging of blue whales in southern Australian waters: examining movements and occupancy patterns to inform management decision-making. Final Report to Australian Marine Mammal Centre.

Mollet, H. F., Cliff, G., Pratt Jr, H. L., & Stevens, J. D. (2000). Reproductive Biology of the female shortfin mako, Isurus oxyrinchus Rafinesque, 1820, with comments on the embryonic development of lamnoids. Fishery Bulletin, 98. 299-318.

Mooney, A. T., Yamato, M., Branstetter, B. K. (2012). Hearing in Cetaceans: From Natural History to Experimental Biology. Biology Department, Woods Hole Oceanographic Institution, CA.

Morrice, M. G., Gill, P. C., Hughes, J., & Levings, A. H. (2004). Summary of aerial surveys conducted for the Santos Ltd EPP32 seismic survey, 2-13 December 2003. Report # WEG-SP 02/2004, Whale Ecology Group-Southern Ocean, Deakin University. unpublished.

Mustoe, S. H. (2008). Killer Whale (Orchinus orca) sightings in Victoria. Victorian Naturalist, 125(3). 76-81.

Newcastle University. 2024. Colonial Frontier Massacres, Australia, 1788 to 1930. https://c21ch.newcastle.edu.au/colonialmassacres/map.php

NOAA 2019. ESA Section 7 Consultation Tools for Marine Mammals on the West Coast (webpage), 27 Sep 2019. https://www.fisheries.noaa.gov/west-coast/endangered-species-conservation/esa-section-7-consultation-tools-marine-mammals-west . (Accessed 10 Mar 2022).

Nedwed, T., Smith, J. P., & Melton, R. (2006). Fate of Nonaqueous Drilling Fluid Cuttings Discharged from a Deepwater Exploration Well. Presented at the SPE International Health Safety and Environment Conference. Abu Dhabi, UAE, 2-4 April 2006. SPE98612.

Neff, J. M. (2005). Composition, environmental fates, and biological effects of water based drilling muds and cuttings discharged to the marine environment: a synthesis and annotated bibliography. Report prepared for the Petroleum Environmental Research Forum (PERF). Washington DC: American Petroleum Institute.

Neff, J. M. (2010). Fate and Effects of Water Based Drilling Muds and cuttings in Cold Water Environments. Neff & Associates LLC. Shell Exploration and Production Company.

Neff, J. M., Hillman, R. E., & Waugh, J. J. (1989) Bioaccumulation of trace metals from drilling mud barite by benthic marine animals. (pp. 461-479).

Neff, J. M., Mckelvie, S., Jr, R.C. (2000). Environmental impacts of synthetic based drilling fluids. Report prepared for Minerals Management Service (MMS) by Robert Ayers & Associates.

Nieblas, A.E., Sloyan, B.M., Hobday, A.J., Coleman, R., Richardson, A.J. (2009). Variability of biological production in low wind-forced regional upwelling systems: a case study off southeastern Australia. Limnol. Oceanogr. 54, 1548–1558.

NMFS (2018). Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. National Marine Fisheries Service. U.S. Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-59. (pp. 167).

NNTT. 2010. Native title: an overview. National Native Title Tribunal. http://www.nntt.gov.au/Information%20Publications/Native%20Title%20an%20overview.pdf

Noad, M. J., Dunlop, R. A., Paton, D., & Cato, D. H. (2011). Absolute and relative abundance estimates of Australian east coast humpback whales. Journal of Cetacean Research and Management, Special issue 3. 243-252.

NOO (2002). Sea Country – an Indigenous perspective. The South-east Regional Marine Plan. National Oceans Office. Hobart.

Nowacek, D., Johnson, M. and Tyack, P.L. (2004). North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alarm stimuli. Proceedings of the Royal Society of London B 271: 227–231.

NSF (2011). National Science Foundation (U.S.), U.S. Geological Survey, and [NOAA] National Oceanic and Atmospheric Administration (U.S.). 2011 Final Programmatic Environmental Impact Statement/Overseas.

environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey. National Science Foundation, Arlington, VA.

O'Hara, T., McShane, P. E., & Norman, M. (1999). Victoria. In N. L. Andrew (ed.). Under Southern Seas: the ecology of Australia's rocky reefs. (pp. 72−78). UNSW Press, Sydney (pp. 20−30).

Oil and Gas UK (2014). The UK offshore oil and gas industry guidance on risk-related decision making (Oil & Gas UK, formerly UKOOA, 2014)

Oke, P.R., Griffin, D. (2011). The cold-core eddy and strong upwelling off the coast of New South Wales in early 2007. Deep-Sea Res. II 58, 574–591.

Oke, P.R., Middleton, J.H. (2001). Nutrient enrichment off Port Stephens: the role of the East Australian Current. Cont. Shelf Res. 21, 587–606.

Owen, K., Jenner, C. S., Jenner, M. N. M., & Andrews, D. R. (2016). A week in the life of a pygmy blue whale: migratory dive depth overlaps with large vessel drafts. Animal Biotelemetry 4. 17. doi:10.1186/s40317-016-0109-4.

Pade, N. G., Queiroza, N., Humphries, N. E., Witt, M. J., Jones, C. S. Noble, L. R., & Sims D. W. (2009). First results from satellite-linked archival tagging of porbeagle shark, Lamnanasus: Area fidelity, wider-scale movements and plasticity in diel depth changes. Journal of Experimental Marine Biology and Ecology, 370(1-2). 64–74.

Pardini, A. T., Jones, C. S., Scholl, M. C., & Noble, L. R. (2000). Isolation and characterization of dinucleotide microsatellite loci in the great white shark, Carcharodon carcharias. Molecular Ecology 9. 1176–1178.

Parks, S.E., C.W. Clark, and P.L. Tyack. (2007). Short-and long-term changes in right whale calling behavior: The potential effects of noise on acoustic communication. Journal of the Acoustical Society of America 122(6): 3725-3731. https://doi.org/10.1121/1.2799904.Version 1.1 92

Parker, D. (1978). Observations of Whales on ANARE Voyages between Australia and Antarctica. Australian Wildlife Research, 5(1), 25-39.

Parks Victoria (1998). French Island National Park Management Plan.

Parks Victoria (1998a) Mornington Peninsula National Park and Arthurs Seat State Park Management Plan.

Parks Victoria (1998). The Port Campbell National Park and Bay of Islands Coastal Park Management Plan. Parks Victoria, Melbourne. Retrieved from http://parkweb.vic.gov.au/explore/parks/port-campbell-national-park.

Parks Victoria (2002a). Corner Inlet Ramsar Site Strategic Management Plan. Parks Victoria, Melbourne.

Parks Victoria (2002b). Wilsons Promontory National Park Management Plan. Parks Victoria, Melbourne.

Parks Victoria (2003). Cape Liptrap Coastal Park Management Plan. Parks Victoria, Melbourne.

Parks Victoria (2005a). Corner Inlet Marine National Park Management Plan. Parks Victoria, Melbourne.

Parks Victoria (2005b). Management Plan for Point Addis Marine National Park, Point Danger Marine Sanctuary and Eagle Rock Marine Sanctuary. Parks Victoria, Melbourne.

Parks Victoria (2005c). Mushroom Reef Marine Sanctuary Management Plan. Parks Victoria, Melbourne.

Parks Victoria (2005d). Point Hicks Marine National Park Management Plan. Parks Victoria, Melbourne.

Parks Victoria (2006a). Wilsons Promontory Marine National Park and Wilsons Promontory Marine Park Management Plan May 2006. Parks Victoria, Melbourne.

Parks Victoria (2006b). Bunurong Marine National Park Management Plan. Parks Victoria, Melbourne.

Parks Victoria (2006c). Port Phillip Heads Marine National Park Management Plan. Parks Victoria, Melbourne.

Parks Victoria (2006d). Management Plan for Twelve Apostles Marine National Park and The Arches Marine Sanctuary. Parks Victoria, Melbourne.

Parks Victoria (2006e) Port Campbell National Park and Bay of Islands Costal Park. Parks Victoria, Melbourne.

Parks Victoria (2007a). Marengo Reefs Marine Sanctuary Management Plan. Parks Victoria, Melbourne. Retrieved from http://parkweb.vic.gov.au/__data/assets/pdf_file/0003/313347/Marengo-Reef-Marine-Sanctuary-Management-Plan.pdf.

Parks Victoria (2007b). Barwon Bluff Marine Sanctuary Management Plan. Parks Victoria, Melbourne. Retrieved from http://parkweb.vic.gov.au/__data/assets/word_doc/0005/637601/Barwon-Bluff-Marine-Sanctuary-Management-Plan-accessible-version.docx.

Parks Victoria (2007c). Merri Marine Sanctuary Management Plan. Parks Victoria, Melbourne. Retrieved from http://parkweb.vic.gov.au/explore/parks/merri-marine-sanctuary.

Parks Victoria (2007d) Yaringa Marine National Park, French Island Marine National Park and Churchill Island Marine National Park Management Plan, Parks Victoria

Parks Victoria (2012). Parks Victoria Marine Protected Areas Program Plan 2012-2014. Parks Victoria, Melbourne.

Parks Victoria (2012a). Cape Howe Marine National Park Visitor Guide. Parks Victoria, Melbourne.

Parks Victoria (2012b). Parks Victoria Technical Paper Series No. 79. Marine Natural Values Study (Vol 2). Marine Protected Areas of the Flinders and Twofold Shelf Bioregions.

Parks Victoria (2013). Mornington Peninsula National Park and Arthurs Seat State Park Management Plan. Parks Victoria, Melbourne. Retrieved from http://parkweb.vic.gov.au/explore/parks/mornington-peninsula-national-park.

Parks Victoria (2015). NgootyoongGunditj Ngootyoong Mara South West Management Plan. Parks Victoria, Melbourne. Retrieved from http://parkweb.vic.gov.au/explore/parks/discoverybay-coastal-park.

Parks Victoria (2016a). Park Management – Environment – Ecosystems – Marine – Sandy Plains. Available from: http://parkweb.vic.gov.au/park-management/environment/ecosystems/marine.

Parks Victoria (2017). Lake Connewarre Wildlife Reserve. Parks Victoria, Melbourne. Retrieved from http://parkweb.vic.gov.au/explore/parks/lake-connewarre-w.r.

Parks Victoria (2020). Yambuk Wetlands N.C.R. Parks Victoria, Melbourne. Retrieved from https://www.parks.vic.gov.au/places-to-see/parks/yambuk-wetlands-n,-d-,c,-d-,r,-d-,

Parks Victoria, (2016b). Enviroactive. Retrieved from http://www.enviroactive.com.au/wetlands/shorebirds.

Parks Victoria and DSE. (2009), Caring for Country — The Otways and You. Great Otway National Park and Otway Forest Park Management Plan, Parks Victoria and DSE, Melbourne.

Parry GD and Gason A. (2006). The effect of seismic surveys on catch rates of rock lobsters in western Victoria, Australia. Fisheries Research, 79: 272–284.

Parry, G. D., Campbell, S. J., & Hobday, D. K. (1990). Marine Resources off East Gippsland, Southeastern Australia. Technical Report No. 72. Marine Science Laboratories. Department of Conservation and Natural Resources.

Paterson A. and Wilson C. (2019). “Ngarrindjeri Whaling Narratives and Reconciliation at Encounter Bay, South Australia.” In: “New Histories of Pacific Whaling,” edited by Ryan Tucker Jones and Angela Wanhalla, RCC Perspectives: Transformations in Environment and Society 2019, no. 5, 91–97. doi.org/10.5282/rcc/8967.

Patterson, H, Bromhead, D, Galeano, D, Larcombe, J, Timmiss, T, Woodhams, J and Curtotti, R. (2022). Fishery status reports 2022, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra. CC BY 4.0. https://doi.org/10.25814/gx9r-3n90.

Paulay, G., Kirkendale, L., Lambert, G., & Meyer, C. (2002). Anthropogenic Biotic Interchange in a Coral Reef Ecosystem: A Case Study from Guam. Pacific Science, 56(4).

Payne, J., Andrews, C., Fancey, L., Cook, A., Christian, J. (2007). Pilot study on the effects of seismic air gun noise on lobster (Homarus americanus). Fisheries and Oceans Canada.

Payne, J., Andrews, C., Fancey, L., White, D. and Christian, J. (2008). Potential Effects of Seismic Energy on Fish and Shellfish: An Update since 2003. Report Number 2008/060. Canadian Science Advisory Secretariat.

Peel, D., Smith, J. N., & Childerhouse, S. (2016). Historical data on Australian Whale Vessel Strikes. International Whaling Commission. SC/66b/HIM/05 Rev 1).

Pegler, J. M. (1983). A brief survey of the water birds in the Shoalhaven-Crookhaven estuary. Australian Birds, 17. 38-42.

Pirzl, R., Patenaude, N. J., Burnell, S., & Bannister, J. (2009). Movements of southern right whales (Eubalaena australis) between Australian and subantarctic New Zealand populations. Marine Mammal Science, 25. 455-461.

Pizzey, G., & Knight, F. (1999). The Graham Pizzey and Frank Knight Field Guide to the Birds of Australia. Pymble, Sydney: Angus and Robertson.

Plotkin, P.T., Wicksten, M.K., & Amos, A. F. (1993). Feeding ecology of the loggerhead sea turtle Caretta in the northwestern Gulf of Mexico. Marine Biology, 115(1).

Plummer, A., Morris, L., Blake, S., & Ball, D. (2003). Marine Natural Values Study, Victorian Marine National Parks and Sanctuaries. Parks Victoria Technical Series No. 1, Parks Victoria, Melbourne.

Popper, A. (2018). Potential for Impact of Cumulative Sound Exposure on Fishes During a Seismic Survey. Produced for Santos Ltd. Bethany 3D Seismic Survey Environment Plan Summary.

Popper, A. N., M. E. Smith, P. A. Cott, B. W. Hanna, A. O. MacGillivray, M. E. Austin, and D. A. Mann. (2005). Effects of exposure to seismic airgun use on hearing of three fish species. J. Acoust. Soc. Am. 117:3958-3971.

Popper, A. N., Hawkins, A. D., Fay, R. R., Mann, D. A., Bartol, S., Carlson, T. J., Løkkeborg, S. (2014). Sound exposure guidelines for fishes and sea turtles. Springer Briefs in Oceanography, 10(1007). 978-3.

Ports Australia. (2022). Trade Statistics Financial Year 2018 – 2019. https://www.portsaustralia.com.au/resources/trade-statistics

Prideaux, G. (2017). Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities. Convention on Migratory Species of Wild Animals, Bonn.

Przeslawski, R., Bruce, B., Carroll, A., Anderson, J., Bradford, R., Durrant, A., Williams, S. (2016). Marine Seismic Survey Impacts on Fish and Invertebrates: Final Report for the Gippsland Marine Environmental Monitoring Project. Record 2016/35. Geoscience Australia, Canberra.

PWS. (2000). Small Bass Strait Island Reserves Draft Management Plan October 2000. Parks and Wildlife Service, Department of Primary Industries, Water and Environment.
PWS. (2000). Lavinia Nature Reserve (Ramsar Site) Management Plan 2000 (Draft). Parks and Wildlife Service Department of Primary Industries, Water and Environment, Hobart, Tasmania, 2000. Retrieved from https://www.parks.tas.gov.au/file.aspx?id=6601 [11 October 2019].

Quinn, D. J. (1969). The White-breasted Sea-Eagle in Western Port, Victoria. Australian Bird Watcher, 3. 162-165.

Ramboll. (2020). Environmental Survey: Otway Basin. Ramboll New Zealand Limited.

Reilly, S. B., Bannister, J. L., Best, P. B., Brown, M., Brownell Jr., R. L., Butterworth, D. S., Zerbini, A. N. (2008). ***Balaenoptera acutorostrata***. In: IUCN 2008. 2008 IUCN Red List of Threatened Species.

Richardson, W. J., Greene, C. R., Maime, C. I., & Thomson, D. H. (1995). Marine Mammals and Noise. Academic Press, San Diego, California. Cited in Wyatt. R. 2008. Joint Industry Programme on Sound and Marine Life. Review of Existing Data on Underwater Sounds Produced by the Oil and Gas Industry, Issue 1. Seiche Measurements Ltd., Great Torrington. Retrieved from https://gisserver.intertek.com/JIP/DMS/ProjectReports/Cat1/JIP-Proj1.4_Soundsinventory_Seiche_2008.pdf.

Richardson, W.J. (ed,). (1997). Northstar marine mammal monitoring program, 1996: Marine mammal and acoustical monitoring of a seismic program in the Alaskan Beaufort Sea. Rep. frOID LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for BP Explor. (Alaska) Inc., Anchorage, AK, and Nat. Mar. Fish. Serv., Anchorage, AK, and Silver Spring, MD

Richardson A.J., Matear RJ and Lenton A. (2017). Potential impacts on zooplankton of seismic surveys. CSIRO, Australia. 34 pp.

Robinson, S., Gales, R., Terauds, A., & Greenwood, M. (2008). Movements of fur seals following relocation from fish farms. Aquatic Conservation: Marine and Freshwater Ecosystems, 18(7). 1189-1199.

Rogers P. (2011). Habitat use, movement and dietary dynamics of pelagic sharks in coastal and shelf ecosystems

Ross, P., Minchinton, T., & Ponder, W. (2009). The ecology of molluscs in Australian saltmarshes. In: Australian Saltmarsh Ecology. (ed.. N Saintilan). CSIRO Publishing, Victoria.

Roughan, M., Middleton, J.H. (2004). On the East Australian Current: variability, encroachment, and upwelling. J. Geophys. Res. 109, C07003.

RPS (2014). Marine Fauna Observer's Report during Enterprise 3D Marine Seismic Survey 30 October 2014 to 9 November 2014. Report prepared by RPS for Origin Energy Resources Ltd. Perth.

Runcie, J., Macinnis-Ng, C., & Ralph, P. (2019). The toxic effects of petrochemicals on seagrasses. Literature review. Retrieved from https://www.researchgate.net/publication/252133825_The_toxic_effects_of_petrochemicals_on_seagrasses_Literature_review.

Sanderson, J. C. (1997). Subtidal Macroalgal Assemblages in Temperate Australian Coastal Waters. Australia: State of the Environment, Technical Paper Series (Estuaries and the Sea). Environment Australia, Commonwealth of Australia.

Saunders, D. L., & Tzaros, C. L. (2011). National Recovery Plan for the Swift Parrot Lathamus discolour. Birds Australia. Melbourne.

Schahinger, R.B. (1987). Structure of coastal upwelling events observed off the south-east coast of South Australia during February 1983-April 1984. Mar. Freshw. Res. 38, 439–459.

SGCS (2003). Waders in the Inverloch Area. South Gippsland Society. http://www.sgcs.org.au/leaflets/Waders_Inverloch.pdf

Shaughnessy, P. D. (1999). The Action Plan for Australian Seals. CSIRO Wildlife and Ecology, Natural Heritage Trust, Environment Australia.

Shepherd, S. A., & Edgar, G. J. (2012). Living Reefs: the Ecology of southern Australian Reefs. CSIRO Publishing.

Skira, I. J., Brothers, N. P., & Pemberton, D. (1996). Distribution, abundance and conservation status of Short-tailed Shearwaters Puffinus tenuirostris in Tasmania, Australia. Marine Ornithology, 24. 1–14.

Smith, J., Jones, D., Travouillon, K., Kelly, N., Double, M., & Bannister, J. L. (2019) Monitoring Population Dynamics of 'Western' Right Whales off Southern Australia 2018-2021 - Final Report on activities for 2018. Report to the National Environmental Science Program, Marine Biodiversity Hub. Western Australian Museum (lead organisation).

Smith, T. G., Geraci, J. R. and St. Aubin, D. J. (1983). Reaction of bottlenosed dolphins, Tursiops truncates, to a controlled oil spill. Canadian Journal of Fisheries and Aquatic Science 40(9): 1522-1525.

Smyth, D. and Isherwood, M. (2016). Protecting sea country: Indigenous people and marine protected areas in Australia. Big, Bold and Blue: Lessons from Australia's marine protected areas, pp.307-325.

Solomon, S., Manning, M., Marquis, M., Qin, D., (2007). Climate change 2007-the physical science basis: Working group I contribution to the fourth assessment report of the IPCC. Cambridge University Press

South East Trawl Fishing Industry Association (SETFIA) (2019). Report to Beach Energy on trawl and gillnet fishing activity around Beach Energy's proposed Otway offshore project. Report to Beach Energy. (pp. 7).

Southall, B. L., Bowles, A. E., Ellison, W.T., Finneran, J. J., Gentry, R. L., Greene, C. R., Miller, J. H. (2007). Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. Aquatic Mammals, 33(4). 411-521.

Southall, B.L., T. Rowles, F. Gulland, R.W. Baird, and P.D. Jepson. 2013. Final report of the Independent Scientific Review Panel investigating potential contributing factors to a 2008 mass stranding of melon-headed whales (Peponocephala electra) in Antsohihy, Madagascar.

Southall, B.L., D.P. Nowaceck, P.J.O. Miller, and P.L. Tyack. (2016). Experimental field studies to measure behavioral responses of cetaceans to sonar. Endangered Species Research 31: 293-315. https://doi.org/10.3354/esr00764.

Southall, B.L., J.J. Finneran, C.J. Reichmuth, P.E. Nachtigall, D.R. Ketten, A.E. Bowles, W.T. Ellison, D.P. Nowacek, and P.L. Tyack. (2019). Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. Aquatic Mammals 45(2): 125-232. https://doi.org/10.1578/AM.45.2.2019.125.

Southall, B.L., D.P. Nowacek, A.E. Bowles, V. Senigaglia, L. Bejder, and P.L. Tyack. (2021). Marine Mammal Noise Exposure Criteria: Assessing the Severity of Marine Mammal Behavioral Responses to Human Noise. Aquatic Mammals 47(5): 421-464.

Steffen, W., A Burbridge, L. Hughes, R. Kitching, D. Lindenmayer, W. Musgrave, S.I. Staford, P. Werner. (2009). Australia's Biodiversity and Climate Change: A strategic assessment of the vulnerability of Australia's Biodiversity to climate change. CSIRO Publishing.

Stephenson L.H. (1991). Orange-bellied Parrot Recovery Plan: Management Phase. Tas. Dept Parks, Wildlife & Heritage.

Stevens R. (2021). On the Tail of the Eel. ABC News Story Lab. https://www.abc.net.au/news/2021-05-29/eel-migration-from-victoria-to-tropical-spawning-grounds/100142688

Stroot, D.H., M.W. Koessler, and C.R. McPherson. 2022a. Beach Energy Yolla Drilling Campaign: Acoustic Modelling for Assessing Marine Fauna Sound Exposures. Document 02741, Version 3.0 DRAFT. Technical report by JASCO Applied Sciences for Beach Energy.

Stroot, D.H., M.W. Koessler, and C.R. McPherson. 2022b. Bass Strait Mobile Offshore Drill Unit Modelling Study. Document 02751, Version 3.0 DRAFT. Technical Memo by JASCO Applied Sciences for Beach Energy.

Suchanek, T. H. (1993). Oil Impacts on Marine Invertebrate Populations and Communities. Amer. Zool. 33: 510-523.

Taylor, I. R., & Roe, E. L. (2004). Feeding ecology of little terns Sterna albifrons sinensis in south-eastern Australia and the effects of pilchard mass mortality on breeding success and population size. Marine and Freshwater Research, 55. 799-808.

TAC. 2015. Preminghana Healthy Country Plan 2015. Tasmanian Aboriginal Centre Inc.

Terrens, G. W., Gwyther, D., & Keogh, M. J. (1998). Environmental Assessment of Synthetic-based Drilling Mud Discharges to Bass Strait, Australia. APPEA Journal. V38: Part 1. Proceedings of the APPEA Conference, Canberra, 8-11 March 1998.

Thiele, K. (1977). Sightings from land of the sooty albatross. South Australian Ornithologist, 27(7). 259.

Thomsen, M. S., Wernberg, T., Engelen, A. H., Tuya, F., Vanderklift, M.A., & Holmer, M. (2012). A Meta-Analysis of Seaweed Impacts on Seagrasses: Generalities and Knowledge Gaps. PLoS ONE 7(1). Retrieved from https://doi.org/10.1371/journal.pone.0028595.

Thursby, G. B., & Steele, R. L. (2003). Toxicity of arsenite and arsenate to the marine macroalga Champia parvula (rhodophyta). Environmental Toxicology and Chemistry, 3(3). 391-397.

Thurstan, RH, Brittain, Z, Jones, DS, Cameron, E, Dearnaley J and Bellgrove A. (2017). Aboriginal uses of seaweeds in temperate Australia: an archival assessment. Journal of Applied Phycology (2018) 30:1821–1832 https://doi.org/10.1007/s10811-017-1384-z

Todd, V.L.G., Warley, J.C., and Todd, I.B. (2016). Meals on Wheels? A decade of megafaunal visual and acoustic observations from offshore oil & gas rigs and platforms in the North and Irish seas. PloS one 11.

Tonkinson R. 1972. Da:Wajil: a western desert aboriginal rainmaking ritual (T). Retrospective Theses and Dissertations, 1919-2007. University of British Columbia.

Tormosov, D. D., Mikhalev, Y. A., Best, P. B., Zemsky, V. A., Sekiguchi, K., & Brownell, Jr, R. L. (1998). Soviet catches of southern right whales, Eubalaena australis, 1951-1971; biological data and conservation implications. Biology Conservation. 86(2). 185-97.

Torres, L.G., D.R. Barlow, T.E. Chandler and J.D. Burnett. 2020. Insight into the kinematics of blue whale surface foraging through drone observations and prey data. PeerJ 8:e8906. http://doi.org/10.7717/peerj.8906.

TPAWS (2000). Small Bass Strait Island Reserves Draft Management Plan, October 2000. Retrieved from https://www.parks.tas.gov.au/file.aspx?id=6388.

TSSC. (2004). Commonwealth Listing Advice on *Raja sp*. L (Maugean Skate), viewed 10 April 08, <http://www.environment.gov.au/biodiversity/threatened/species/maugeanskate.html>.

TSSC. (2012). Commonwealth Listing Advice on Giant Kelp Marine Forests of South East Australia. Department of Sustainability, Environment, Water, Population and Communities. Canberra, ACT: Department of Sustainability, Environment, Water, Population and Communities

TSSC (2015a). Approved Conservation Advice for *Pterodroma mollis* (soft-plumaged petrel). Department of the Environment. Retrieved from http://www.environment.gov.au/biodiversity/threatened/species/pubs/1036-conservation-advice-01102015.pdf.

TSSC (2015b). Approved Conservation Advice for *Pachyptila subantarctica* (Fairy prion (Southern)). Department of the Environment. Retrieved from http://www.environment.gov.au/biodiversity/threatened/species/pubs/64445-conservation-advice-01102015.pdf.

TSSC (2016). Conservation Advice *Mirounga leonina* Southern Elephant Seal. Canberra: Department of the Environment and Energy

TSSC (2016a). Approved Conservation Advice *Limosa lapponica menzbieri* Bar-tailed godwit (northern Siberian). Threatened Species Scientific Committee. Canberra: Department of the Environment. Retrieved from http://www.environment.gov.au/biodiversity/threatened/species/pubs/86432-conservation-advice-05052016.pdf.

TSSC (2016b). Conservation Advice *Limosa lapponica baueri* Bar-tailed godwit (western Alaskan). Threatened Species Scientific Committee. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/86380-conservation-advice-05052016.pdf.

TSSC (2016c). Conservation Advice for *Charadrius leschenaultia* (Greater Sand Plover). Retrieved from http://www.environment.gov.au/biodiversity/threatened/species/pubs/877-conservation-advice-05052016.pdf.

TSSC (2018). Approved Conservation Advice (including Listing Advice) for the Assemblages of species associated with open-coast salt-wedge estuaries of western and central Victoria ecological community. Retrieved from www.environment.gov.au/biodiversity/threatened/communities/pubs/132-conservation-advice.pdf.

TSSC (2019). Approved Conservation Advice for *Botaurus poiciloptilus* (Australasian Bittern). Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1001

Van de Kam, J., Ens, B., Piersma T., & Zwarts, L. (2004). Shorebirds: An illustrated behavioural ecology. Utrecht, Holland: KNNV Publishers.

VACL. 2014. Nyernila: Listen Continuously. Victorian Aboriginal Corporation for Languages. Creative Victoria, Melbourne.

VFA. (2017) Victorian Eel Fishery Management Plan 2017. Victorian Fisheries Authority.

VFA (2022a) Eel Fishery. Victorian Fisheries Authority. https://vfa.vic.gov.au/commercial-fishing/commercial-fisheries/eels

VFA (2022b) Short-finned eel. Victorian Fisheries Authority. https://vfa.vic.gov.au/education/fishspecies/short-finned-eel

VFA (2022c) Long-finned eel. Victorian Fisheries Authority. https://vfa.vic.gov.au/education/fish-species/long-finned-eel

VFA (2023) Kelp Forests Poster website. Accessed 15.3.2023 https://vfa.vic.gov.au/education/featured/teachers-resource/kelp-forests-poster

VFA (2023a). Seaweed Aquaculture. https://vfa.vic.gov.au/aquaculture/seaweed-aquaculture

Volkman, J.K., Miller, G.J., Revill, A.T. and Connell, D.W. (1994). Oil Spills. In: Environmental implications of offshore oil and gas development in Australia: The finidings of an independent scientific review. Swam, J.M., Neff, J.M. and Young, P.C. (eds) Australian Petroleum Exploration Association, Sydney, New South Wales.

Wartzok, D. and D.R. Ketten. (1999). Marine Mammal Sensory Systems. (Chapter 4) In Reynolds, J. and S. Rommel (eds.). Biology of Marine Mammals. Smithsonian Institution Press, Washington, DC. pp. 117-175.

Watson, M., Westhorpe, I., Bannister, J., Hedley, S., & Harcourt, R. (2015). Final report on the assessment of numbers and distribution of southern right whales in Southeast Australia. Report to the Australian Marine Mammal Centre.

Watson, M., Stamation, K., Charlton, C., & Bannister, J. (2021). Calving rates, long-range movements and site fidelity of southern right whales (*Eubalaena australis*) in south-eastern Australia. Journal of Cetacean Research and Management. 22-2021 pp. 17-28.

Weilgart, L.S. (2007). The impacts of anthropogenic ocean noise on cetaceans and implications for management. Canadian Journal of Zoology 85: 1091–1116.

Wesson S, 2001. First Nations Whalers of Twofold Bay. NSW National Parks and Wildlife Service and Bega, Eden and Merrimans Aboriginal Forests Management Committee. NSW.

WGCMA (2003). West Gippsland Native Vegetation Plan. West Gippsland Catchment Management Authority.

WGCMA (2014). Corner Inlet Ramsar Site Management Plan. West Gippsland Catchment Management Authority. Retrieved from https://www.wgcma.vic.gov.au/wp-content/uploads/2015/01/WaterStrategy2014-2022-web-pt4.pdf.

WGCMA (2015). Powlett River Estuary Management Plan. West Gippsland Catchment Management Authority, Traralgon, Victoria.

Williams, A., Bax, N. J., Kloser, R. J., Althaus, F., Barker, B., & Keith, G. (2009). Australia's deep-water reserve network: implications of false homogeneity for classifying abiotic surrogates of biodiversity. ICES Journal of Marine Science, 66. 214–224.

Willis, J., Hobday, A.J. (2007). Influence of upwelling on movement of southern bluefin tuna (T*hunnus maccoyii*) in the Great Australian Bight. Mar. Freshw. Res. 58, 699–708.

Woodside. (2003). Environmental Impact Statement/Environmental Effects Statement: Otway Gas Project. Woodside Backhouse, G., O'Connor, J., & Jackson, J. (2008). National Recovery Plan for the Australian Grayling (*Prototroctes maraena*). Department of Sustainability and Environment, Melbourne. Energy Ltd., Perth, Australia.

Woodside (2014) Browse FLNG Development, Draft EIS, EPBC 2013/7079, November 2014, Woodside Energy, Perth WA.

Woodward, B.L., J.P. Winn and F.E. Fish. (2006). Morphological specialisations of baleen whales associated with hydrodynamic performance and ecological niche. Journal of Morphology 267:1284–1294.

WTOAC. 2020. Paleert Tjaara Dja. Let's make Country good together 2020-2030. Wadawurrung Country Plan. Wadawurrung Traditional Owners Aboriginal Corporation. Geelong, Victoria

Xodus (2023a). T/49P Otway Drilling EP - Light Emissions and Line of Sight Modelling (Ref: P-100273-S00-A-REPT-003)

Xodus (2023b). Otway Development GHG Emissions Report (Ref: 100383-S01-A-REPT-001)

Zieman, J. C., Orth, R., Phillips, R. C., Thayer, G. W., & Thorhaug, A. (1984). The effects of oil on seagrass ecosystems. In: Cairns J, Buikema AL (eds) Restoration of habitats impacted by oil spills. Butterworth-Heinemann, Boston, MA. (pp. 37−64).

Appendix A: Protected Matters Report for the Project Area

Australian Government

Department of Climate Change, Energy,
the Environment and Water

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 16-Aug-2023

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance (Ramsar	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	39
Listed Migratory Species:	39

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at https://www.dcceew.gov.au/parks-heritage/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	61
Whales and Other Cetaceans:	27
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	2
Habitat Critical to the Survival of Marine Turtles:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	None
Regional Forest Agreements:	None
Nationally Important Wetlands:	None
EPBC Act Referrals:	30
Key Ecological Features (Marine):	1
Biologically Important Areas:	18
Bioregional Assessments:	None
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside a Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area.

Feature Name
EEZ and Territorial Sea

Listed Threatened Species [Resource Information]

Status of Conservation Dependent and Extinct are not MNES under the EPBC Act.
Number is the current name ID.

Scientific Name	Threatened Category	Presence Text
BIRD		
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area

Scientific Name	Threatened Category	Presence Text
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Halobaena caerulea Blue Petrel [1059]	Vulnerable	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Neophema chrysogaster Orange-bellied Parrot [747]	Critically Endangered	Migration route likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat may occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat likely to occur within area
Pterodroma leucoptera leucoptera Gould's Petrel, Australian Gould's Petrel [26033]	Endangered	Species or species habitat may occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche bulleri platei Northern Buller's Albatross, Pacific Albatross [82273]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche chrysostoma Grey-headed Albatross [66491]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Scientific Name	Threatened Category	Presence Text
FISH		
Hoplostethus atlanticus		
Orange Roughy, Deep-sea Perch, Red Roughy [68455]	Conservation Dependent	Species or species habitat likely to occur within area
Prototroctes maraena		
Australian Grayling [26179]	Vulnerable	Species or species habitat may occur within area
Seriolella brama		
Blue Warehou [69374]	Conservation Dependent	Species or species habitat known to occur within area
Thunnus maccoyii		
Southern Bluefin Tuna [69402]	Conservation Dependent	Species or species habitat likely to occur within area
MAMMAL		
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Eubalaena australis		
Southern Right Whale [40]	Endangered	Species or species habitat known to occur within area
REPTILE		
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
SHARK		
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Centrophorus uyato listed as Centrophorus zeehaani		
Little Gulper Shark [68446]	Conservation Dependent	Species or species habitat likely to occur within area
Galeorhinus galeus		
School Shark, Eastern School Shark, Snapper Shark, Tope, Soupfin Shark [68453]	Conservation Dependent	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

Scientific Name	Threatened Category	Presence Text
Migratory Marine Birds		
Ardenna carneipes		
Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Foraging, feeding or related behaviour likely to occur within area
Ardenna grisea		
Sooty Shearwater [82651]		Species or species habitat may occur within area
Diomedea antipodensis		
Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora		
Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans		
Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area

Scientific Name	Threatened Category	Presence Text
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche chrysostoma Grey-headed Albatross [66491]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area

Scientific Name	Threatened Category	Presence Text
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Migratory Marine Species		
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour may occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eubalaena australis as Balaena glacialis australis Southern Right Whale [40]	Endangered	Species or species habitat known to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat likely to occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]		Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat likely to occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species

[Resource Information]

Scientific Name	Threatened Category	Presence Text
Bird		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Ardenna carneipes as Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Foraging, feeding or related behaviour likely to occur within area
Ardenna grisea as Puffinus griseus Sooty Shearwater [82651]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area overfly marine area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area overfly marine area

Scientific Name	Threatened Category	Presence Text
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area overfly marine area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Halobaena caerulea Blue Petrel [1059]	Vulnerable	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Neophema chrysogaster Orange-bellied Parrot [747]	Critically Endangered	Migration route likely to occur within area overfly marine area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Pachyptila turtur Fairy Prion [1066]		Species or species habitat may occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat likely to occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Species or species habitat may occur within area
Stercorarius antarcticus as Catharacta skua Brown Skua [85039]		Species or species habitat may occur within area
Sterna striata White-fronted Tern [799]		Foraging, feeding or related behaviour likely to occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche bulleri platei as Thalassarche sp. nov. Northern Buller's Albatross, Pacific Albatross [82273]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche chrysostoma Grey-headed Albatross [66491]	Endangered	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Fish		
Heraldia nocturna Upside-down Pipefish, Eastern Upside-down Pipefish, Eastern Upside-down Pipefish [66227]		Species or species habitat may occur within area
Hippocampus abdominalis Big-belly Seahorse, Eastern Potbelly Seahorse, New Zealand Potbelly Seahorse [66233]		Species or species habitat may occur within area
Hippocampus breviceps Short-head Seahorse, Short-snouted Seahorse [66235]		Species or species habitat may occur within area
Histiogamphelus briggsii Crested Pipefish, Briggs' Crested Pipefish, Briggs' Pipefish [66242]		Species or species habitat may occur within area
Histiogamphelus cristatus Rhino Pipefish, Macleay's Crested Pipefish, Ring-back Pipefish [66243]		Species or species habitat may occur within area
Hypselognathus rostratus Knifesnout Pipefish, Knife-snouted Pipefish [66245]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Kaupus costatus Deepbody Pipefish, Deep-bodied Pipefish [66246]		Species or species habitat may occur within area
Leptoichthys fistularius Brushtail Pipefish [66248]		Species or species habitat may occur within area
Lissocampus caudalis Australian Smooth Pipefish, Smooth Pipefish [66249]		Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish [66251]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Mitotichthys semistriatus Halfbanded Pipefish [66261]		Species or species habitat may occur within area
Mitotichthys tuckeri Tucker's Pipefish [66262]		Species or species habitat may occur within area
Notiocampus ruber Red Pipefish [66265]		Species or species habitat may occur within area
Phycodurus eques Leafy Seadragon [66267]		Species or species habitat may occur within area
Phyllopteryx taeniolatus Common Seadragon, Weedy Seadragon [66268]		Species or species habitat may occur within area
Pugnaso curtirostris Pugnose Pipefish, Pug-nosed Pipefish [66269]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Solegnathus robustus Robust Pipehorse, Robust Spiny Pipehorse [66274]		Species or species habitat may occur within area
Solegnathus spinosissimus Spiny Pipehorse, Australian Spiny Pipehorse [66275]		Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish, Gulf Pipefish, Peacock Pipefish [66276]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Stipecampus cristatus Ringback Pipefish, Ring-backed Pipefish [66278]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Vanacampus phillipi Port Phillip Pipefish [66284]		Species or species habitat may occur within area
Vanacampus poecilolaemus Longsnout Pipefish, Australian Long-snout Pipefish, Long-snouted Pipefish [66285]		Species or species habitat may occur within area
Mammal		
Arctocephalus forsteri Long-nosed Fur-seal, New Zealand Fur-seal [20]		Species or species habitat may occur within area
Arctocephalus pusillus Australian Fur-seal, Australo-African Fur-seal [21]		Species or species habitat may occur within area
Reptile		

Scientific Name	Threatened Category	Presence Text
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat may occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area

Whales and Other Cetaceans

[Resource Information]

Current Scientific Name	Status	Type of Presence
Mammal		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Berardius arnuxii Arnoux's Beaked Whale [70]		Species or species habitat may occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour may occur within area

Current Scientific Name	Status	Type of Presence
Delphinus delphis Common Dolphin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat known to occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Globicephala melas Long-finned Pilot Whale [59282]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia sima Dwarf Sperm Whale [85043]		Species or species habitat may occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat likely to occur within area
Lissodelphis peronii Southern Right Whale Dolphin [44]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]		Species or species habitat likely to occur within area
Mesoplodon bowdoini Andrew's Beaked Whale [73]		Species or species habitat may occur within area

Current Scientific Name	Status	Type of Presence
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area
Mesoplodon hectori Hector's Beaked Whale [76]		Species or species habitat may occur within area
Mesoplodon layardii Strap-toothed Beaked Whale, Strap-toothed Whale, Layard's Beaked Whale [25556]		Species or species habitat may occur within area
Mesoplodon mirus True's Beaked Whale [54]		Species or species habitat may occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat likely to occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Australian Marine Parks

[Resource Information]

Park Name	Zone & IUCN Categories
Zeehan	Multiple Use Zone (IUCN VI)
Zeehan	Special Purpose Zone (IUCN VI)

Extra Information

EPBC Act Referrals			[Resource Information]
Title of referral	Reference	Referral Outcome	Assessment Status
Otway Astrolabe 3D Marine Seismic Survey, Otway Basin	2012/6421		Completed
Controlled action			
Casino Gas Field Development	2003/1295	Controlled Action	Post-Approval
Otway Development	2002/621	Controlled Action	Post-Approval
Schomberg 3D Marine Seismic Survey	2007/3754	Controlled Action	Completed
VICP61 2D Marine Seismic Survey	2008/4075	Controlled Action	Completed
Not controlled action			
Exploration drilling for liquid/gaseous hydrocarbons	2004/1681	Not Controlled Action	Completed
INDIGO Central Submarine Telecommunications Cable	2017/8127	Not Controlled Action	Completed
Not controlled action (particular manner)			
'Moonlight Head' 3D seismic survey, VIC/P38(V), VIC/P43 and VIC/RL8	2005/2236	Not Controlled Action (Particular Manner)	Post-Approval
2D Marine Seismic Survey	2005/2295	Not Controlled Action (Particular Manner)	Post-Approval
2D Seismic Survey	2003/1214	Not Controlled Action (Particular Manner)	Post-Approval
3D marine seismic survey near King Island	2004/1461	Not Controlled Action (Particular Manner)	Post-Approval
Astrolabe 3D Marine Seismic Survey	2011/6048	Not Controlled Action (Particular Manner)	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
BHPBilliton Otway 3D Seismic Survey	2007/3443	Not Controlled Action (Particular Manner)	Post-Approval
Deepwater Sorell Basin 2001 Non-Exclusive 2D Seismic Survey	2001/156	Not Controlled Action (Particular Manner)	Post-Approval
Drill and Profile Exploration Well Somerset 1, License Area T34P	2009/5037	Not Controlled Action (Particular Manner)	Post-Approval
Geographe-A gas exploration well	2000/82	Not Controlled Action (Particular Manner)	Post-Approval
INDIGO Marine Cable Route Survey (INDIGO)	2017/7996	Not Controlled Action (Particular Manner)	Post-Approval
La Bella 3D Marine Seismic Survey, Otway Basin, VIC	2012/6683	Not Controlled Action (Particular Manner)	Post-Approval
Otway Basin Exploration Drilling Campaign, Vic	2011/6125	Not Controlled Action (Particular Manner)	Post-Approval
Santos Otway 3d Seismic VIC/P44	2007/3367	Not Controlled Action (Particular Manner)	Post-Approval
Schomberg 3D Marine Seismic survey	2007/3868	Not Controlled Action (Particular Manner)	Post-Approval
Southern Margins T/35P and T/36P 3D Seismic Surveys	2007/3817	Not Controlled Action (Particular Manner)	Post-Approval
Strike Oil NL Seismic Surveys	2000/107	Not Controlled Action (Particular Manner)	Post-Approval
Surface Geochemical Exploration Program, TAS	2010/5780	Not Controlled Action (Particular	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
		Manner)	
Thylacine-A Exploration Well	2000/81	Not Controlled Action (Particular Manner)	Post-Approval
Undertake a three dimensional marine seismic survey	2010/5700	Not Controlled Action (Particular Manner)	Post-Approval
Vic/P37(v) and Vic/P44 3D marine seismic survey	2003/1102	Not Controlled Action (Particular Manner)	Post-Approval
VIC P44 Gas Exploration Wells	2002/662	Not Controlled Action (Particular Manner)	Post-Approval
Vic-P51 and Vic-P52 2D seismic survey	2002/811	Not Controlled Action (Particular Manner)	Post-Approval
Referral decision			
VICP61 2D Marine Seismic Survey	2008/3975	Referral Decision	Completed

Key Ecological Features [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
West Tasmania Canyons	South-east

Biologically Important Areas

Scientific Name	Behaviour	Presence
Seabirds		
Ardenna pacifica Wedge-tailed Shearwater [84292]	Foraging	Likely to occur
Ardenna tenuirostris Short-tailed Shearwater [82652]	Foraging	Known to occur
Diomedea exulans (sensu lato) Wandering Albatross [1073]	Foraging	Known to occur

Scientific Name	Behaviour	Presence
Diomedea exulans antipodensis Antipodean Albatross [82269]	Foraging	Known to occur
Pelecanoides urinatrix Common Diving-petrel [1018]	Foraging	Known to occur
Thalassarche bulleri Bullers Albatross [64460]	Foraging	Known to occur
Thalassarche cauta cauta Shy Albatross [82345]	Foraging likely	Likely to occur
Thalassarche chlororhynchos bassi Indian Yellow-nosed Albatross [85249]	Foraging	Known to occur
Thalassarche melanophris Black-browed Albatross [66472]	Foraging	Known to occur
Thalassarche melanophris impavida Campbell Albatross [82449]	Foraging	Known to occur
Sharks		
Carcharodon carcharias White Shark [64470]	Distribution	Likely to occur
Carcharodon carcharias White Shark [64470]	Distribution	Known to occur
Carcharodon carcharias White Shark [64470]	Distribution (low density)	Likely to occur
Carcharodon carcharias White Shark [64470]	Known distribution	Known to occur
Whales		
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Distribution	Known to occur
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Foraging	Likely to be present
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Foraging (annual high use area)	Known to occur

Scientific Name	Behaviour	Presence
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Known Foraging Area	Known to occur

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact us page.

Department of Climate Change, Energy, the Environment and Water
GPO Box 3090
Canberra ACT 2601 Australia
+61 2 6274 1111

Appendix B: Protected Matters Report for the Planning Area

Australian Government

Department of Climate Change, Energy,
the Environment and Water

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 16-Aug-2023

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	1
National Heritage Places:	5
Wetlands of International Importance (Ramsar	7
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	2
Listed Threatened Ecological Communities:	13
Listed Threatened Species:	159
Listed Migratory Species:	81

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at https://www.dcceew.gov.au/parks-heritage/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Lands:	58
Commonwealth Heritage Places:	8
Listed Marine Species:	131
Whales and Other Cetaceans:	32
Critical Habitats:	1
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	9
Habitat Critical to the Survival of Marine Turtles:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	203
Regional Forest Agreements:	3
Nationally Important Wetlands:	25
EPBC Act Referrals:	255
Key Ecological Features (Marine):	4
Biologically Important Areas:	37
Bioregional Assessments:	1
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

World Heritage Properties [Resource Information]

Name	State	Legal Status
Tasmanian Wilderness	TAS	Declared property

National Heritage Places [Resource Information]

Name	State	Legal Status
Historic		
Great Ocean Road and Scenic Environs	VIC	Listed place
Point Nepean Defence Sites and Quarantine Station Area	VIC	Listed place
Quarantine Station and Surrounds	VIC	Within listed place
Indigenous		
Western Tasmania Aboriginal Cultural Landscape	TAS	Listed place
Natural		
Tasmanian Wilderness	TAS	Listed place

Wetlands of International Importance (Ramsar Wetlands) [Resource Information]

Ramsar Site Name	Proximity
Corner inlet	Within Ramsar site
Gippsland lakes	Within 10km of Ramsar site
Glenelg estuary and discovery bay wetlands	Within Ramsar site
Lavinia	Within Ramsar site
Piccaninnie ponds karst wetlands	Within 10km of Ramsar site
Port phillip bay (western shoreline) and bellarine peninsula	Within Ramsar site
Western port	Within Ramsar site

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside a Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area.

Feature Name
EEZ and Territorial Sea

Feature Name
EEZ and Territorial Sea

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.
Status of Vulnerable, Disallowed and Ineligible are not MNES under the EPBC Act.

Community Name	Threatened Category	Presence Text
Alpine Sphagnum Bogs and Associated Fens	Endangered	Community may occur within area
Assemblages of species associated with open-coast salt-wedge estuaries of western and central Victoria ecological community	Endangered	Community likely to occur within area
Giant Kelp Marine Forests of South East Australia	Endangered	Community may occur within area
Grassy Eucalypt Woodland of the Victorian Volcanic Plain	Critically Endangered	Community known to occur within area
Karst springs and associated alkaline fens of the Naracoorte Coastal Plain Bioregion	Endangered	Community may occur within area
Lowland Native Grasslands of Tasmania	Critically Endangered	Community likely to occur within area
Natural Damp Grassland of the Victorian Coastal Plains	Critically Endangered	Community likely to occur within area
Natural Temperate Grassland of the Victorian Volcanic Plain	Critically Endangered	Community may occur within area
Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains	Critically Endangered	Community likely to occur within area
Subtropical and Temperate Coastal Saltmarsh	Vulnerable	Community likely to occur within area
Tasmanian Forests and Woodlands dominated by black gum or Brookers gum (Eucalyptus ovata / E. brookeriana)	Critically Endangered	Community likely to occur within area
Tasmanian white gum (Eucalyptus viminalis) wet forest	Critically Endangered	Community likely to occur within area
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Critically Endangered	Community likely to occur within area

Listed Threatened Species		[Resource Information]
Status of Conservation Dependent and Extinct are not MNES under the EPBC Act. Number is the current name ID.		
Scientific Name	Threatened Category	Presence Text
BIRD		
Acanthiza pusilla magnirostris listed as Acanthiza pusilla archibaldi		
King Island Brown Thornbill, Brown Thornbill (King Island) [91709]	Endangered	Species or species habitat known to occur within area
Acanthornis magna greeniana		
King Island Scrubtit, Scrubtit (King Island) [82329]	Critically Endangered	Species or species habitat known to occur within area
Anthochaera phrygia		
Regent Honeyeater [82338]	Critically Endangered	Foraging, feeding or related behaviour likely to occur within area
Aphelocephala leucopsis		
Southern Whiteface [529]	Vulnerable	Species or species habitat known to occur within area
Aquila audax fleayi		
Tasmanian Wedge-tailed Eagle, Wedge-tailed Eagle (Tasmanian) [64435]	Endangered	Breeding likely to occur within area
Botaurus poiciloptilus		
Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris		
Great Knot [862]	Critically Endangered	Roosting known to occur within area
Callocephalon fimbriatum		
Gang-gang Cockatoo [768]	Endangered	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Calyptorhynchus banksii graptogyne South-eastern Red-tailed Black-Cockatoo [25982]	Endangered	Species or species habitat may occur within area
Calyptorhynchus lathami lathami South-eastern Glossy Black-Cockatoo [67036]	Vulnerable	Species or species habitat may occur within area
Ceyx azureus diemenensis Tasmanian Azure Kingfisher [25977]	Endangered	Breeding known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Climacteris picumnus victoriae Brown Treecreeper (south-eastern) [67062]	Vulnerable	Species or species habitat may occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea antipodensis gibsoni Gibson's Albatross [82270]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area

Scientific Name	Threatened Category	Presence Text
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat likely to occur within area
Fregetta grallaria grallaria White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian) [64438]	Vulnerable	Species or species habitat likely to occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat known to occur within area
Halobaena caerulea Blue Petrel [1059]	Vulnerable	Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat known to occur within area
Limosa lapponica baueri Nunivak Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Melanodryas cucullata cucullata South-eastern Hooded Robin, Hooded Robin (south-eastern) [67093]	Endangered	Species or species habitat may occur within area
Neophema chrysogaster Orange-bellied Parrot [747]	Critically Endangered	Breeding known to occur within area

Scientific Name	Threatened Category	Presence Text
Neophema chrysostoma Blue-winged Parrot [726]	Vulnerable	Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area
Pedionomus torquatus Plains-wanderer [906]	Critically Endangered	Species or species habitat likely to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat likely to occur within area
Platycercus caledonicus brownii Green Rosella (King Island) [67041]	Vulnerable	Species or species habitat known to occur within area
Pterodroma leucoptera leucoptera Gould's Petrel, Australian Gould's Petrel [26033]	Endangered	Species or species habitat may occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Breeding known to occur within area
Pycnoptilus floccosus Pilotbird [525]	Vulnerable	Species or species habitat known to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat known to occur within area
Stagonopleura guttata Diamond Firetail [59398]	Vulnerable	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Species or species habitat known to occur within area
Strepera fuliginosa colei Black Currawong (King Island) [67113]	Vulnerable	Breeding likely to occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche bulleri platei Northern Buller's Albatross, Pacific Albatross [82273]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Breeding known to occur within area
Thalassarche chrysostoma Grey-headed Albatross [66491]	Endangered	Species or species habitat may occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area

Scientific Name	Threatened Category	Presence Text
Thalassarche salvini		
Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi		
White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Thinornis cucullatus cucullatus		
Eastern Hooded Plover, Eastern Hooded Plover [90381]	Vulnerable	Species or species habitat known to occur within area
Tyto novaehollandiae castanops (Tasmanian population)		
Masked Owl (Tasmanian) [67051]	Vulnerable	Breeding known to occur within area
CRUSTACEAN		
Astacopsis gouldi		
Giant Freshwater Crayfish, Tasmanian Giant Freshwater Lobster [64415]	Vulnerable	Species or species habitat likely to occur within area
Euastacus bispinosus		
Glenelg Spiny Freshwater Crayfish, Pricklyback [81552]	Endangered	Species or species habitat likely to occur within area
FISH		
Brachiopsilus ziebelli		
Ziebell's Handfish, Waterfall Bay Handfish [83757]	Vulnerable	Species or species habitat likely to occur within area
Galaxiella pusilla		
Eastern Dwarf Galaxias, Dwarf Galaxias [56790]	Vulnerable	Species or species habitat known to occur within area
Hoplostethus atlanticus		
Orange Roughy, Deep-sea Perch, Red Roughy [68455]	Conservation Dependent	Species or species habitat likely to occur within area
Nannoperca obscura		
Yarra Pygmy Perch [26177]	Vulnerable	Species or species habitat known to occur within area
Prototroctes maraena		
Australian Grayling [26179]	Vulnerable	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Rexea solandri (eastern Australian population)		
Eastern Gemfish [76339]	Conservation Dependent	Species or species habitat likely to occur within area
Seriolella brama		
Blue Warehou [69374]	Conservation Dependent	Species or species habitat known to occur within area
Thunnus maccoyii		
Southern Bluefin Tuna [69402]	Conservation Dependent	Species or species habitat likely to occur within area
Thymichthys politus		
Red Handfish [83756]	Critically Endangered	Species or species habitat may occur within area
FROG		
Litoria aurea		
Green and Golden Bell Frog [1870]	Vulnerable	Species or species habitat likely to occur within area
Litoria raniformis		
Growling Grass Frog, Southern Bell Frog, Green and Golden Frog, Warty Swamp Frog, Golden Bell Frog [1828]	Vulnerable	Species or species habitat known to occur within area
INSECT		
Oreisplanus munionga larana		
Marrawah Skipper, Alpine Sedge Skipper, Alpine Skipper [77747]	Vulnerable	Species or species habitat known to occur within area
Synemon plana		
Golden Sun Moth [25234]	Vulnerable	Species or species habitat may occur within area
MAMMAL		
Antechinus minimus maritimus		
Swamp Antechinus (mainland) [83086]	Vulnerable	Species or species habitat known to occur within area
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Scientific Name	Threatened Category	Presence Text
Balaenoptera musculus		
Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dasyurus maculatus maculatus (SE mainland population)		
Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat known to occur within area
Dasyurus maculatus maculatus (Tasmanian population)		
Spotted-tail Quoll, Spot-tailed Quoll, Tiger Quoll (Tasmanian population) [75183]	Vulnerable	Species or species habitat known to occur within area
Eubalaena australis		
Southern Right Whale [40]	Endangered	Breeding known to occur within area
Isoodon obesulus obesulus		
Southern Brown Bandicoot (eastern), Southern Brown Bandicoot (south-eastern) [68050]	Endangered	Species or species habitat known to occur within area
Mastacomys fuscus mordicus		
Broad-toothed Rat (mainland), Tooarrana [87617]	Vulnerable	Species or species habitat known to occur within area
Miniopterus orianae bassanii		
Southern Bent-wing Bat [87645]	Critically Endangered	Breeding known to occur within area
Mirounga leonina		
Southern Elephant Seal [26]	Vulnerable	Breeding may occur within area
Neophoca cinerea		
Australian Sea-lion, Australian Sea Lion [22]	Endangered	Species or species habitat known to occur within area
Perameles gunnii gunnii		
Eastern Barred Bandicoot (Tasmania) [66651]	Vulnerable	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Perameles gunnii Victorian subspecies Eastern Barred Bandicoot (Mainland) [88020]	Endangered	Translocated population known to occur within area
Petauroides volans Greater Glider (southern and central) [254]	Endangered	Species or species habitat may occur within area
Petaurus australis australis Yellow-bellied Glider (south-eastern) [87600]	Vulnerable	Species or species habitat known to occur within area
Potorous tridactylus trisulcatus Long-nosed Potoroo (southern mainland) [86367]	Vulnerable	Species or species habitat known to occur within area
Pseudomys fumeus Smoky Mouse, Konoom [88]	Endangered	Species or species habitat may occur within area
Pseudomys novaehollandiae New Holland Mouse, Pookila [96]	Vulnerable	Species or species habitat known to occur within area
Pseudomys shortridgei Heath Mouse, Dayang, Heath Rat [77]	Endangered	Species or species habitat known to occur within area
Pteropus poliocephalus Grey-headed Flying-fox [186]	Vulnerable	Roosting known to occur within area
Sarcophilus harrisii Tasmanian Devil [299]	Endangered	Species or species habitat likely to occur within area
PLANT		
Amphibromus fluitans River Swamp Wallaby-grass, Floating Swamp Wallaby-grass [19215]	Vulnerable	Species or species habitat known to occur within area
Astelia australiana Tall Astelia [10851]	Vulnerable	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Caladenia calcicola Limestone Spider-orchid [10065]	Vulnerable	Species or species habitat likely to occur within area
Caladenia colorata Coloured Spider-orchid, Small Western Spider-orchid, Painted Spider-orchid [54999]	Endangered	Species or species habitat likely to occur within area
Caladenia dienema Windswept Spider-orchid [64858]	Endangered	Species or species habitat known to occur within area
Caladenia hastata Melblom's Spider-orchid [16118]	Endangered	Species or species habitat likely to occur within area
Caladenia insularis French Island Spider-orchid [24372]	Vulnerable	Species or species habitat likely to occur within area
Caladenia orientalis Eastern Spider Orchid [83410]	Endangered	Species or species habitat known to occur within area
Caladenia ornata Ornate Pink Fingers [76213]	Vulnerable	Species or species habitat likely to occur within area
Caladenia robinsonii Frankston Spider-orchid [24375]	Endangered	Species or species habitat likely to occur within area
Caladenia tessellata Thick-lipped Spider-orchid, Daddy Long-legs [2119]	Vulnerable	Species or species habitat known to occur within area
Centrolepis pedderensis Pedder Centrolepis, Pedder Bristlewort [12647]	Endangered	Species or species habitat likely to occur within area
Commersonia prostrata Dwarf Kerrawang [87152]	Endangered	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Corunastylis brachystachya Short-spiked Midge-orchid, Rocky Cape Midge Orchid [76410]	Endangered	Species or species habitat known to occur within area
Craspedia preminghana Preminghana Billybutton [77046]	Endangered	Species or species habitat likely to occur within area
Dianella amoena Matted Flax-lily [64886]	Endangered	Species or species habitat likely to occur within area
Diuris lanceolata Snake Orchid [10231]	Endangered	Species or species habitat known to occur within area
Dodonaea procumbens Trailing Hop-bush [12149]	Vulnerable	Species or species habitat likely to occur within area
Eucalyptus strzeleckii Strzelecki Gum [55400]	Vulnerable	Species or species habitat known to occur within area
Euphrasia collina subsp. muelleri Purple Eyebright, Mueller's Eyebright [16151]	Endangered	Species or species habitat known to occur within area
Glycine latrobeana Clover Glycine, Purple Clover [13910]	Vulnerable	Species or species habitat known to occur within area
Grevillea infecunda Anglesea Grevillea [22026]	Vulnerable	Species or species habitat known to occur within area
Haloragis exalata subsp. exalata Wingless Raspwort, Square Raspwort [24636]	Vulnerable	Species or species habitat known to occur within area
Hiya distans listed as Hypolepis distans Scrambling Ground-fern [92548]	Endangered	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Ixodia achillaeoides subsp. arenicola Sand Ixodia, Ixodia [21474]	Vulnerable	Species or species habitat known to occur within area
Lachnagrostis adamsonii Adamson's Blown-grass, Adamson's Blowngrass [76211]	Endangered	Species or species habitat may occur within area
Leiocarpa gatesii Wrinkled Buttons [76212]	Vulnerable	Species or species habitat likely to occur within area
Lepidium aschersonii Spiny Peppercress [10976]	Vulnerable	Species or species habitat likely to occur within area
Lepidium hyssopifolium Basalt Pepper-cress, Peppercress, Rubble Pepper-cress, Pepperweed [16542]	Endangered	Species or species habitat known to occur within area
Leucochrysum albicans subsp. tricolor Hoary Sunray, Grassland Paper-daisy [89104]	Endangered	Species or species habitat may occur within area
Lomatia tasmanica King's Lomatia [3745]	Critically Endangered	Species or species habitat likely to occur within area
Phaius australis Lesser Swamp-orchid [5872]	Endangered	Species or species habitat may occur within area
Pimelea spinescens subsp. spinescens Plains Rice-flower, Spiny Rice-flower, Prickly Pimelea [21980]	Critically Endangered	Species or species habitat likely to occur within area
Prasophyllum atratum Three Hummock Leek-orchid [82677]	Critically Endangered	Species or species habitat known to occur within area
Prasophyllum diversiflorum Gorae Leek-orchid [13210]	Endangered	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Prasophyllum favonium Western Leek-orchid [64949]	Critically Endangered	Species or species habitat likely to occur within area
Prasophyllum frenchii Maroon Leek-orchid, Slaty Leek-orchid, Stout Leek-orchid, French's Leek-orchid, Swamp Leek-orchid [9704]	Endangered	Species or species habitat known to occur within area
Prasophyllum litorale listed as Prasophyllum littorale Coastal Leek Orchid [55234]	Critically Endangered	Species or species habitat known to occur within area
Prasophyllum pulchellum Pretty Leek-orchid [64953]	Critically Endangered	Species or species habitat known to occur within area
Prasophyllum secutum Northern Leek-orchid [64954]	Endangered	Species or species habitat likely to occur within area
Prasophyllum spicatum Dense Leek-orchid [55146]	Vulnerable	Species or species habitat known to occur within area
Pseudocephalozia paludicola Alpine Leafy Liverwort [66441]	Vulnerable	Species or species habitat known to occur within area
Pterostylis chlorogramma Green-striped Greenhood [56510]	Vulnerable	Species or species habitat likely to occur within area
Pterostylis cucullata Leafy Greenhood [15459]	Vulnerable	Species or species habitat known to occur within area
Pterostylis rubenachii Arthur River Greenhood [64536]	Endangered	Species or species habitat known to occur within area
Pterostylis tenuissima Swamp Greenhood, Dainty Swamp Orchid [13139]	Vulnerable	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Pterostylis ziegeleri Grassland Greenhood, Cape Portland Greenhood [64971]	Vulnerable	Species or species habitat likely to occur within area
Senecio macrocarpus Large-fruit Fireweed, Large-fruit Groundsel [16333]	Vulnerable	Species or species habitat likely to occur within area
Senecio psilocarpus Swamp Fireweed, Smooth-fruited Groundsel [64976]	Vulnerable	Species or species habitat known to occur within area
Taraxacum cygnorum Coast Dandelion, Native Dandelion [2508]	Vulnerable	Species or species habitat may occur within area
Thelymitra epipactoides Metallic Sun-orchid [11896]	Endangered	Species or species habitat known to occur within area
Thelymitra matthewsii Spiral Sun-orchid [4168]	Vulnerable	Species or species habitat known to occur within area
Thesium australe Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat may occur within area
Xerochrysum palustre Swamp Everlasting, Swamp Paper Daisy [76215]	Vulnerable	Species or species habitat known to occur within area
REPTILE		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat may occur within area
Delma impar Striped Legless Lizard, Striped Snake-lizard [1649]	Vulnerable	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Lissolepis coventryi		
Swamp Skink, Eastern Mourning Skink [84053]	Endangered	Species or species habitat known to occur within area
SHARK		
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Breeding known to occur within area
Centrophorus harrissoni		
Harrisson's Dogfish, Endeavour Dogfish, Dumb Gulper Shark, Harrison's Deepsea Dogfish [68444]	Conservation Dependent	Species or species habitat likely to occur within area
Centrophorus uyato listed as Centrophorus zeehaani		
Little Gulper Shark [68446]	Conservation Dependent	Species or species habitat likely to occur within area
Galeorhinus galeus		
School Shark, Eastern School Shark, Snapper Shark, Tope, Soupfin Shark [68453]	Conservation Dependent	Species or species habitat likely to occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Zearaja maugeana		
Maugean Skate, Port Davey Skate [83504]	Endangered	Species or species habitat known to occur within area

Listed Migratory Species [Resource Information]

Scientific Name	Threatened Category	Presence Text
Migratory Marine Birds		
Anous stolidus		
Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat known to occur within area
Ardenna grisea Sooty Shearwater [82651]		Breeding known to occur within area
Ardenna tenuirostris Short-tailed Shearwater [82652]		Breeding known to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Hydroprogne caspia Caspian Tern [808]		Breeding known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Sternula albifrons Little Tern [82849]		Breeding known to occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Breeding known to occur within area
Thalassarche chrysostoma Grey-headed Albatross [66491]	Endangered	Species or species habitat may occur within area
Thalassarche eremita Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Migratory Marine Species

Scientific Name	Threatened Category	Presence Text
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour likely to occur within area
Carcharhinus longimanus Oceanic Whitetip Shark [84108]		Species or species habitat may occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Breeding known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Eubalaena australis as Balaena glacialis australis Southern Right Whale [40]	Endangered	Breeding known to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat likely to occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat likely to occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Migratory Terrestrial Species		
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Breeding known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area

Scientific Name	Threatened Category	Presence Text
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Species or species habitat known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting likely to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area

Scientific Name	Threatened Category	Presence Text
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Phalaropus lobatus Red-necked Phalarope [838]		Roosting known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Thalasseus bergii Greater Crested Tern [83000]		Breeding known to occur within area
Tringa brevipes Grey-tailed Tattler [851]		Roosting known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa incana Wandering Tattler [831]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Lands [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Commonwealth Land Name	State
Defence	
Defence - CROWS NEST CAMP - QUEENSCLIFF [21028]	VIC
Defence - CROWS NEST CAMP - QUEENSCLIFF [21029]	VIC
Defence - CROWS NEST CAMP - QUEENSCLIFF [21026]	VIC
Defence - CROWS NEST CAMP - QUEENSCLIFF [21027]	VIC
Defence - HMAS CERBERUS [20084]	VIC
Defence - HMAS CERBERUS [20099]	VIC
Defence - HMAS CERBERUS [20097]	VIC
Defence - HMAS CERBERUS [20092]	VIC
Defence - HMAS CERBERUS [20090]	VIC
Defence - HMAS CERBERUS [20103]	VIC
Defence - HMAS CERBERUS [20101]	VIC
Defence - HMAS CERBERUS [20102]	VIC
Defence - HMAS CERBERUS [20104]	VIC
Defence - HMAS CERBERUS [20100]	VIC
Defence - HMAS CERBERUS [20093]	VIC
Defence - HMAS CERBERUS [20091]	VIC
Defence - HMAS CERBERUS [20095]	VIC
Defence - HMAS CERBERUS [20094]	VIC
Defence - HMAS CERBERUS [20096]	VIC
Defence - HMAS CERBERUS [20086]	VIC
Defence - HMAS CERBERUS [20081]	VIC
Defence - HMAS CERBERUS [20083]	VIC

Commonwealth Land Name	State
Defence - HMAS CERBERUS [20082]	VIC
Defence - HMAS CERBERUS [20087]	VIC
Defence - HMAS CERBERUS [20088]	VIC
Defence - HMAS CERBERUS [20089]	VIC
Defence - HMAS CERBERUS [20085]	VIC
Defence - STAFF COLLEGE-FORT QUEENSCLIFF [21032]	VIC
Defence - STAFF COLLEGE-FORT QUEENSCLIFF [21033]	VIC
Defence - STAFF COLLEGE-FORT QUEENSCLIFF [21034]	VIC
Defence - STAFF COLLEGE-FORT QUEENSCLIFF [21030]	VIC
Defence - STAFF COLLEGE-FORT QUEENSCLIFF [21031]	VIC
Defence - SWAN ISLAND TRAINING AREA [21446]	VIC
Defence - SWAN ISLAND TRAINING AREA [21447]	VIC
Defence - SWAN ISLAND TRAINING AREA [21448]	VIC
Defence - TRAINING CENTRE (Norris Barracks) - Portsea [21025]	VIC
Defence - Training Depot, Darts RD 3305 Portland [21016]	VIC
Defence - WARRNAMBOOL TRAINING DEPOT [21111]	VIC
Defence - WEST HEAD GUNNERY RANGE [21112]	VIC
Unknown	
Commonwealth Land - [60111]	TAS
Commonwealth Land - [60115]	TAS
Commonwealth Land - [60116]	TAS
Commonwealth Land - [21491]	VIC
Commonwealth Land - [21490]	VIC
Commonwealth Land - [21492]	VIC
Commonwealth Land - [21509]	VIC
Commonwealth Land - [60112]	TAS
Commonwealth Land - [60113]	TAS

Commonwealth Land Name	State
Commonwealth Land - [21583]	VIC
Commonwealth Land - [21487]	VIC
Commonwealth Land - [22391]	VIC
Commonwealth Land - [60114]	TAS
Commonwealth Land - [60117]	TAS
Commonwealth Land - [21488]	VIC
Commonwealth Land - [21489]	VIC
Commonwealth Land - [21570]	VIC
Commonwealth Land - [21582]	VIC
Commonwealth Land - [60346]	TAS

Commonwealth Heritage Places

[Resource Information]

Name	State	Status
Historic		
Cape Sorell Lighthouse	TAS	Listed place
Cape Wickham Lighthouse	TAS	Listed place
Fort Queenscliff	VIC	Listed place
Sorrento Post Office	VIC	Listed place
Swan Island Defence Precinct	VIC	Listed place
Wilsons Promontory Lighthouse	VIC	Listed place
Natural		
HMAS Cerberus Marine and Coastal Area	VIC	Listed place
Swan Island and Naval Waters	VIC	Listed place

Listed Marine Species

[Resource Information]

Scientific Name	Threatened Category	Presence Text
Bird		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area overfly marine area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area
Ardenna carneipes as Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat known to occur within area
Ardenna grisea as Puffinus griseus Sooty Shearwater [82651]		Breeding known to occur within area
Ardenna tenuirostris as Puffinus tenuirostris Short-tailed Shearwater [82652]		Breeding known to occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Bubulcus ibis as Ardea ibis Cattle Egret [66521]		Species or species habitat may occur within area overfly marine area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area overfly marine area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area overfly marine area

Scientific Name	Threatened Category	Presence Text
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area overfly marine area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area overfly marine area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area overfly marine area
Chalcites osculans as Chrysococcyx osculans Black-eared Cuckoo [83425]		Species or species habitat known to occur within area overfly marine area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area overfly marine area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Roosting known to occur within area overfly marine area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat known to occur within area overfly marine area
Chroicocephalus novaehollandiae as Larus novaehollandiae Silver Gull [82326]		Breeding known to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area

Scientific Name	Threatened Category	Presence Text
Diomedea antipodensis gibsoni as Diomedea gibsoni Gibson's Albatross [82270]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Eudyptula minor Little Penguin [1085]		Breeding known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area overfly marine area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area overfly marine area
Gallinago stenura Pin-tailed Snipe [841]		Species or species habitat known to occur within area overfly marine area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Breeding known to occur within area
Halobaena caerulea Blue Petrel [1059]	Vulnerable	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Roosting known to occur within area overfly marine area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area overfly marine area
Hydroprogne caspia as Sterna caspia Caspian Tern [808]		Breeding known to occur within area
Larus dominicanus Kelp Gull [809]		Breeding known to occur within area
Larus pacificus Pacific Gull [811]		Breeding known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat known to occur within area overfly marine area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area overfly marine area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area overfly marine area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area

Scientific Name	Threatened Category	Presence Text
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area overfly marine area
Morus capensis Cape Gannet [59569]		Breeding known to occur within area
Morus serrator Australasian Gannet [1020]		Breeding known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area overfly marine area
Myiagra cyanoleuca Satin Flycatcher [612]		Breeding known to occur within area overfly marine area
Neophema chrysogaster Orange-bellied Parrot [747]	Critically Endangered	Breeding known to occur within area overfly marine area
Neophema chrysostoma Blue-winged Parrot [726]	Vulnerable	Species or species habitat known to occur within area overfly marine area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting likely to occur within area overfly marine area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area

Scientific Name	Threatened Category	Presence Text
Onychoprion fuscatus as Sterna fuscata Sooty Tern [90682]		Breeding known to occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Pelagodroma marina White-faced Storm-Petrel [1016]		Breeding known to occur within area
Pelecanoides urinatrix Common Diving-Petrel [1018]		Breeding known to occur within area
Phalacrocorax fuscescens Black-faced Cormorant [59660]		Breeding known to occur within area
Phalaropus lobatus Red-necked Phalarope [838]		Roosting known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area overfly marine area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat likely to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area overfly marine area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Breeding known to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Roosting known to occur within area overfly marine area

Scientific Name	Threatened Category	Presence Text
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat known to occur within area overfly marine area
Rostratula australis as Rostratula benghalensis (sensu lato)		
Australian Painted Snipe [77037]	Endangered	Species or species habitat known to occur within area overfly marine area
Stercorarius antarcticus as Catharacta skua		
Brown Skua [85039]		Species or species habitat may occur within area
Sterna striata		
White-fronted Tern [799]		Foraging, feeding or related behaviour likely to occur within area
Sternula albifrons as Sterna albifrons		
Little Tern [82849]		Breeding known to occur within area
Sternula nereis as Sterna nereis		
Fairy Tern [82949]		Breeding known to occur within area
Thalassarche bulleri		
Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche bulleri platei as Thalassarche sp. nov.		
Northern Buller's Albatross, Pacific Albatross [82273]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche carteri		
Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche cauta		
Shy Albatross [89224]	Endangered	Breeding known to occur within area
Thalassarche chrysostoma		
Grey-headed Albatross [66491]	Endangered	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Thalassarche eremita Chatham Albatross [64457]	Endangered	Foraging, feeding or related behaviour may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Thalasseus bergii as Sterna bergii Greater Crested Tern [83000]		Breeding known to occur within area
Thinornis cucullatus as Thinornis rubricollis Hooded Plover, Hooded Dotterel [87735]		Species or species habitat known to occur within area overfly marine area
Thinornis cucullatus cucullatus as Thinornis rubricollis rubricollis Eastern Hooded Plover, Eastern Hooded Plover [90381]	Vulnerable	Species or species habitat known to occur within area overfly marine area
Tringa brevipes as Heteroscelus brevipes Grey-tailed Tattler [851]		Roosting known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area overfly marine area

Scientific Name	Threatened Category	Presence Text
Tringa incana as Heteroscelus incanus Wandering Tattler [831]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area overfly marine area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area overfly marine area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area overfly marine area
Fish		
Heraldia nocturna Upside-down Pipefish, Eastern Upside-down Pipefish, Eastern Upside-down Pipefish [66227]		Species or species habitat may occur within area
Hippocampus abdominalis Big-belly Seahorse, Eastern Potbelly Seahorse, New Zealand Potbelly Seahorse [66233]		Species or species habitat may occur within area
Hippocampus breviceps Short-head Seahorse, Short-snouted Seahorse [66235]		Species or species habitat may occur within area
Hippocampus minotaur Bullneck Seahorse [66705]		Species or species habitat may occur within area
Histiogamphelus briggsii Crested Pipefish, Briggs' Crested Pipefish, Briggs' Pipefish [66242]		Species or species habitat may occur within area
Histiogamphelus cristatus Rhino Pipefish, Macleay's Crested Pipefish, Ring-back Pipefish [66243]		Species or species habitat may occur within area
Hypselognathus rostratus Knifesnout Pipefish, Knife-snouted Pipefish [66245]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Kaupus costatus Deepbody Pipefish, Deep-bodied Pipefish [66246]		Species or species habitat may occur within area
Kimblaeus bassensis Trawl Pipefish, Bass Strait Pipefish [66247]		Species or species habitat may occur within area
Leptoichthys fistularius Brushtail Pipefish [66248]		Species or species habitat may occur within area
Lissocampus caudalis Australian Smooth Pipefish, Smooth Pipefish [66249]		Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish [66251]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Mitotichthys mollisoni Mollison's Pipefish [66260]		Species or species habitat may occur within area
Mitotichthys semistriatus Halfbanded Pipefish [66261]		Species or species habitat may occur within area
Mitotichthys tuckeri Tucker's Pipefish [66262]		Species or species habitat may occur within area
Notiocampus ruber Red Pipefish [66265]		Species or species habitat may occur within area
Phycodurus eques Leafy Seadragon [66267]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Phyllopteryx taeniolatus Common Seadragon, Weedy Seadragon [66268]		Species or species habitat may occur within area
Pugnaso curtirostris Pugnose Pipefish, Pug-nosed Pipefish [66269]		Species or species habitat may occur within area
Solegnathus robustus Robust Pipehorse, Robust Spiny Pipehorse [66274]		Species or species habitat may occur within area
Solegnathus spinosissimus Spiny Pipehorse, Australian Spiny Pipehorse [66275]		Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish, Gulf Pipefish, Peacock Pipefish [66276]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Stipecampus cristatus Ringback Pipefish, Ring-backed Pipefish [66278]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Vanacampus phillipi Port Phillip Pipefish [66284]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Vanacampus poecilolaemus Longsnout Pipefish, Australian Long-snout Pipefish, Long-snouted Pipefish [66285]		Species or species habitat may occur within area
Mammal		
Arctocephalus forsteri Long-nosed Fur-seal, New Zealand Fur-seal [20]		Breeding known to occur within area
Arctocephalus pusillus Australian Fur-seal, Australo-African Fur-seal [21]		Breeding known to occur within area
Mirounga leonina Southern Elephant Seal [26]	Vulnerable	Breeding may occur within area
Neophoca cinerea Australian Sea-lion, Australian Sea Lion [22]	Endangered	Species or species habitat known to occur within area
Reptile		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat may occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area

Whales and Other Cetaceans [Resource Information]

Current Scientific Name	Status	Type of Presence
Mammal		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area

Current Scientific Name	Status	Type of Presence
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Berardius arnuxii Arnoux's Beaked Whale [70]		Species or species habitat may occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour likely to occur within area
Delphinus delphis Common Dolphin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Breeding known to occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Globicephala melas Long-finned Pilot Whale [59282]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area

Current Scientific Name	Status	Type of Presence
Hyperoodon planifrons Southern Bottlenose Whale [71]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia sima Dwarf Sperm Whale [85043]		Species or species habitat may occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat likely to occur within area
Lissodelphis peronii Southern Right Whale Dolphin [44]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]		Species or species habitat known to occur within area
Mesoplodon bowdoini Andrew's Beaked Whale [73]		Species or species habitat may occur within area
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area
Mesoplodon grayi Gray's Beaked Whale, Scamperdown Whale [75]		Species or species habitat may occur within area
Mesoplodon hectori Hector's Beaked Whale [76]		Species or species habitat may occur within area
Mesoplodon layardii Strap-toothed Beaked Whale, Strap-toothed Whale, Layard's Beaked Whale [25556]		Species or species habitat may occur within area

Current Scientific Name	Status	Type of Presence
Mesoplodon mirus True's Beaked Whale [54]		Species or species habitat may occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat likely to occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Tasmacetus shepherdi Shepherd's Beaked Whale, Tasman Beaked Whale [55]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Critical Habitats

[Resource Information]

Name	Type of Presence
Thalassarche cauta (Shy Albatross) - Albatross Island, The Mewstone, Pedra Branca	Listed Critical Habitat

Australian Marine Parks

[Resource Information]

Park Name	Zone & IUCN Categories
Tasman Fracture	Marine National Park Zone (IUCN II)
Apollo	Multiple Use Zone (IUCN VI)
Beagle	Multiple Use Zone (IUCN VI)

Park Name	Zone & IUCN Categories
Boags	Multiple Use Zone (IUCN VI)
Franklin	Multiple Use Zone (IUCN VI)
Tasman Fracture	Multiple Use Zone (IUCN VI)
Zeehan	Multiple Use Zone (IUCN VI)
Nelson	Special Purpose Zone (IUCN VI)
Zeehan	Special Purpose Zone (IUCN VI)

Extra Information

State and Territory Reserves

[Resource Information]

Protected Area Name	Reserve Type	State
Aire River	Heritage River	VIC
Aire River W.R.	Natural Features Reserve	VIC
Albatross Island	Nature Reserve	TAS
Anglesea B.R.	Natural Features Reserve	VIC
Anser Island	Reference Area	VIC
Arthur-Pieman	Conservation Area	TAS
Arthur River Rd Marrawah	Conservation Covenant	TAS
Badger Box Creek	Nature Reserve	TAS
Badger River	Regional Reserve	TAS
Bald Hills B.R.	Natural Features Reserve	VIC
Barham Paradise S.R.	Natural Features Reserve	VIC
Barwon Bluff	Marine Sanctuary	VIC
Bass Pyramid	Nature Reserve	TAS
Bats Ridge W.R	Nature Conservation Reserve	VIC
Bay of Islands Coastal Park	Conservation Park	VIC

Protected Area Name	Reserve Type	State
Bernafai Ridge	Conservation Area	TAS
Bird Island	Game Reserve	TAS
Black Pyramid Rock	Nature Reserve	TAS
Bond Tier	Regional Reserve	TAS
Bunurong	Marine National Park	VIC
Bunurong Marine Park	National Parks Act Schedule 4 park or reserve	VIC
Calder River	Reference Area	VIC
Calm Bay	State Reserve	TAS
Cape Liptrap Coastal Park	Conservation Park	VIC
Cape Nelson	State Park	VIC
Cape Patterson N.C.R	Natural Features Reserve	VIC
Cape Sorell	Historic Site	TAS
Cape Wickham	Conservation Area	TAS
Cape Wickham	State Reserve	TAS
Cataraqui Point	Conservation Area	TAS
Christmas Island	Nature Reserve	TAS
Churchill Island	Marine National Park	VIC
City of Melbourne Bay	Conservation Area	TAS
Colliers Forest Reserve	Conservation Covenant	TAS
Colliers Swamp	Conservation Area	TAS
Comeback Rd Marrawah	Conservation Covenant	TAS
Cone Islet	Conservation Area	TAS
Councillor Island	Nature Reserve	TAS
Counsel Hill	Conservation Area	TAS
Crib Point G228 B.R.	Natural Features Reserve	VIC

Protected Area Name	Reserve Type	State
Crib Point G229 B.R.	Natural Features Reserve	VIC
Crinoline Creek	Reference Area	VIC
Curdie Vale N.C.R.	Natural Features Reserve	VIC
Currie Lightkeepers Residence	Historic Site	TAS
Curtis Island	Nature Reserve	TAS
Deen Maar	Indigenous Protected Area	VIC
Deep Lagoons	Conservation Area	TAS
Devils Tower	Nature Reserve	TAS
Disappointment Bay	State Reserve	TAS
Discovery Bay	Marine National Park	VIC
Discovery Bay Coastal Park	Conservation Park	VIC
East Moncoeur Island	Conservation Area	TAS
Edna Bowman N.C.R.	Natural Features Reserve	VIC
Eldorado	Conservation Area	TAS
Fingal B.R	Natural Features Reserve	VIC
Flinders G234 B.R.	Natural Features Reserve	VIC
Flinders N.F.R.	Natural Features Reserve	VIC
Four Mile Beach	Regional Reserve	TAS
French Island	National Park	VIC
Gentle Annie	Conservation Area	TAS
Goose Lagoon W.R	Natural Features Reserve	VIC
Great Otway	National Park	VIC
Harbour Islets	Conservation Area	TAS
Harcus River Rd West Montagu	Conservation Covenant	TAS

Protected Area Name	Reserve Type	State
Harcus River Road	NRS Addition - Gazettal in Progress	TAS
Harcus River Road #4	Conservation Covenant	TAS
Harcus River Road Marrawah	Conservation Covenant	TAS
Hedditch Hill S.R.	Natural Features Reserve	VIC
Henderson Islets	Conservation Area	TAS
Hogan Group	Conservation Area	TAS
Hunter Island	Conservation Area	TAS
Jack Smith Lake W.R	Natural Features Reserve	VIC
Johanna Falls S.R.	Natural Features Reserve	VIC
Kentford Forest	Nature Reserve	TAS
Kentford Forest	Conservation Area	TAS
Kentford Rd Nugara	Conservation Covenant	TAS
Kent Group	National Park	TAS
Kilcunda N.C.R.	Natural Features Reserve	VIC
Kings Run	Private Nature Reserve	TAS
Kings Run #2	Conservation Covenant	TAS
Lady Julia Percy Island W.R.	Nature Conservation Reserve	VIC
Lake Aringa W.R	Nature Conservation Reserve	VIC
Lake Connewarre W.R	Natural Features Reserve	VIC
Lake Denison W.R	Natural Features Reserve	VIC
Lake Gillear W.R	Natural Features Reserve	VIC
Latrobe B.R.	Natural Features Reserve	VIC

Protected Area Name	Reserve Type	State
Lavinia	State Reserve	TAS
Lawrence Rocks W.R.	Nature Conservation Reserve	VIC
Lily Lagoon	Nature Reserve	TAS
Little Trefoil	Conservation Area	TAS
Lonsdale Lakes W.R	Nature Conservation Reserve	VIC
Lower Glenelg	National Park	VIC
Lower South East	Marine Park	SA
Lymwood	Conservation Covenant	TAS
Main Ridge N.C.R.	Natural Features Reserve	VIC
Marengo N.C.R.	Nature Conservation Reserve	VIC
Marengo Reefs	Marine Sanctuary	VIC
Merri	Marine Sanctuary	VIC
Millwood Road	Conservation Covenant	TAS
Mornington Peninsula	National Park	VIC
Mount Dundas	Regional Reserve	TAS
Mount Heemskirk	Regional Reserve	TAS
Mount Richmond	National Park	VIC
Mount Vereker Creek	Natural Catchment Area	VIC
Muddy Lagoon	Nature Reserve	TAS
Murkay Islets	Conservation Area	TAS
Mushroom Reef	Marine Sanctuary	VIC
Nares Rocks	Conservation Area	TAS
New Year Island	Game Reserve	TAS
Ninety Mile Beach	Marine National Park	VIC
Nooramunga Marine & Coastal Park	National Parks Act Schedule 4 park or	VIC

Protected Area Name	Reserve Type	State
	reserve	
North East Islet	Nature Reserve	TAS
Ocean Beach	Conservation Area	TAS
Parker River	Reference Area	VIC
Pegarah	Private Nature Reserve	TAS
Pegarah Forest	Conservation Covenant	TAS
Pegarah Rd King Island	Conservation Covenant	TAS
Phillip Island Nature Park	Other	VIC
Pieman River	State Reserve	TAS
Point Addis	Marine National Park	VIC
Point Danger	Marine Sanctuary	VIC
Point Nepean	National Park	VIC
Porky Beach	Conservation Area	TAS
Port Campbell	National Park	VIC
Portland H46 B.R.	Natural Features Reserve	VIC
Portland H47 B.R.	Natural Features Reserve	VIC
Port Phillip Heads	Marine National Park	VIC
Preminghana	Indigenous Protected Area	TAS
Princetown W.R	Natural Features Reserve	VIC
Queenscliff N.F.R	Natural Features Reserve	VIC
Rebecca Creek	Conservation Area	TAS
Red Hut Point	Conservation Area	TAS
Red Hut Road #1	Conservation Covenant	TAS
Red Hut Road #2	Conservation Covenant	TAS
Reef Island and Bass River Mouth N.C.R	Natural Features Reserve	VIC

Protected Area Name	Reserve Type	State
Reekara Road #1	Conservation Covenant	TAS
Reekara Road #2	Conservation Covenant	TAS
Reid Rocks	Nature Reserve	TAS
Rodondo Island	Nature Reserve	TAS
Salt Lagoon, St Leonards W.R	Nature Conservation Reserve	VIC
Sartoris Rd Nugara	Conservation Covenant	TAS
Seacrow Islet	Conservation Area	TAS
Sea Elephant	Conservation Area	TAS
Sea Elephant Bootlace	Conservation Covenant	TAS
Sea Elephant River	Conservation Covenant	TAS
Seal Islands W.R.	Nature Conservation Reserve	VIC
Seal Rocks	Conservation Area	TAS
Seal Rocks	State Reserve	TAS
Shell Islets	Conservation Area	TAS
Slaves Bay	Conservation Area	TAS
Southern Wilsons Promontory	Remote and Natural Area - Schedule 6, National Parks Act	VIC
South Rd Nugara	Conservation Covenant	TAS
Southwest	National Park	TAS
Southwest	Conservation Area	TAS
Stack Island	Game Reserve	TAS
Stokes Point	Conservation Area	TAS
Stony Creek (Otways)	Reference Area	VIC
Strahan Customs House	Historic Site	TAS
Sugarloaf Rock	Conservation Area	TAS
Sundown Point	State Reserve	TAS

Protected Area Name	Reserve Type	State
Swan Bay - Edwards Point W.R	Nature Conservation Reserve	VIC
Tambar	Conservation Covenant	TAS
Tathams Lagoon	Conservation Area	TAS
Teepookana	Regional Reserve	TAS
Temma	Conservation Covenant	TAS
The Arches	Marine Sanctuary	VIC
The Doughboys	Nature Reserve	TAS
Three Hummock Island	State Reserve	TAS
Tikkawoppa Plateau	Regional Reserve	TAS
Tin Mine Rd Loorana	Conservation Covenant	TAS
Tower Hill W.R	Natural Features Reserve	VIC
Trewalla H48 B.R.	Natural Features Reserve	VIC
Trewalla H49 B.R.	Natural Features Reserve	VIC
Trial Harbour	State Reserve	TAS
Tully River	Conservation Area	TAS
Twelve Apostles	Marine National Park	VIC
Unnamed P0176	Private Nature Reserve	VIC
Ventnor B.R.	Natural Features Reserve	VIC
Vereker Creek	Reference Area	VIC
Waratah B.R	Natural Features Reserve	VIC
Warra Creek	Regional Reserve	TAS
Welcome River	State Reserve	TAS
Welcome Swamp	Conservation Covenant	TAS
West Moncoeur Island	Nature Reserve	TAS

Protected Area Name	Reserve Type	State
West Point	State Reserve	TAS
Wicks Road Nugara	Conservation Covenant	TAS
Wild Dog B.R.	Natural Features Reserve	VIC
Wild Dog Creek SS.R.	Natural Features Reserve	VIC
Wilsons Promontory	National Park	VIC
Wilsons Promontory	Wilderness Zone	VIC
Wilsons Promontory	Marine National Park	VIC
Wilsons Promontory Islands	Remote and Natural Area - Schedule 6, National Parks Act	VIC
Wilsons Promontory Marine Park	National Parks Act Schedule 4 park or reserve	VIC
Wilsons Promontory Marine Reserve	National Parks Act Schedule 4 park or reserve	VIC
Wongarra B.R.	Natural Features Reserve	VIC
Wonthaggi G237 B.R.	Natural Features Reserve	VIC
Wonthaggi G238 B.R.	Natural Features Reserve	VIC
Wonthaggi G239 B.R.	Natural Features Reserve	VIC
Wonthaggi G240 B.R.	Natural Features Reserve	VIC
Wonthaggi G241 B.R.	Natural Features Reserve	VIC
Wonthaggi Heathlands N.C.R	Natural Features Reserve	VIC
Yambacoona	Conservation Covenant	TAS
Yambuk F.F.R.	Nature Conservation Reserve	VIC

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included. Please see the associated resource information for specific caveats and use limitations associated with RFA boundary information.

RFA Name	State
Gippsland RFA	Victoria
Tasmania RFA	Tasmania
West Victoria RFA	Victoria

Nationally Important Wetlands [Resource Information]

Wetland Name	State
Aire River	VIC
Anderson Inlet	VIC
Bungaree Lagoon	TAS
Corner Inlet	VIC
Jack Smith Lake State Game Reserve	VIC
Lake Ashwood	TAS
Lake Bantick	TAS
Lake Connewarre State Wildlife Reserve	VIC
Lake Flannigan	TAS
Lake Garcia	TAS
Lavinia Nature Reserve	TAS
Lower Aire River Wetlands	VIC
Lower Merri River Wetlands	VIC
Mud Islands	VIC
Pearshape Lagoon 1	TAS
Pearshape Lagoon 2	TAS
Pearshape Lagoon 3	TAS
Pearshape Lagoon 4	TAS
Powlett River Mouth	VIC

Wetland Name	State
Princetown Wetlands	VIC
Swan Bay & Swan Island	VIC
Tower Hill	VIC
Unnamed Wetland	TAS
Western Port	VIC
Yambuk Wetlands	VIC

EPBC Act Referrals

[Resource Information]

Title of referral	Reference	Referral Outcome	Assessment Status
Apollo Bay to Skenes Creek Coastal Trail	2022/09274		Assessment
Greater Gippsland Offshore Wind Project	2022/09379		Assessment
Greater Gippsland Offshore Wind Project Initial Marine Field Investigations	2022/09374		Completed
Otway Astrolabe 3D Marine Seismic Survey, Otway Basin	2012/6421		Completed
Seadragon Offshore Wind Farm	2022/9163		Assessment
Southern Winds Offshore Wind Project	2022/09435		Assessment
Southern Winds Offshore Wind Project Initial Marine Field Investigations	2022/09436		Completed
Spinifex Offshore Surveys	2022/09359		Completed
Controlled action			
Alston-1 petroleum exploration well, permit VIC/P44	2003/1315	Controlled Action	Post-Approval
Bald Hills Wind Farm 80 Turbines	2002/730	Controlled Action	Post-Approval
Casino Gas Field Development	2003/1295	Controlled Action	Post-Approval
City Of Greater Geelong Mosquito Control Program 2021-2030, Vic	2020/8782	Controlled Action	Further Information Request
Crib Point to Pakenham Gas Pipeline, Vic	2018/8297	Controlled Action	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Controlled action			
Dairy Farm expansion on the Woolnorth property	2013/6710	Controlled Action	Completed
DPIPWE - Arthur-Pieman Conservation Area - off-road vehicle mitigation actions	2017/8038	Controlled Action	Completed
Establishment of plantation for use of effluent water	2003/1063	Controlled Action	Completed
Gas Import Facility, Crib Point, Vic	2018/8298	Controlled Action	Completed
Gippsland Regional Port Project	2020/8667	Controlled Action	Assessment Approach
Heemskirk Windfarm Development	2002/678	Controlled Action	Completed
Kentbruck Green Power Hub, Vic	2019/8510	Controlled Action	Assessment Approach
Lonsdale Golf Club Redevelopment	2003/969	Controlled Action	Post-Approval
Mosquito Control	2005/2132	Controlled Action	Post-Approval
Otway Development	2002/621	Controlled Action	Post-Approval
Pacific Hydro (Portland) Wind Farm SW Victoria	2000/18	Controlled Action	Post-Approval
Port Phillip Bay Channel Deepening	2002/576	Controlled Action	Post-Approval
Redevelopment of post office and construction of dwellings	2007/3639	Controlled Action	Completed
Residential and Golf Course Development Project	2003/1144	Controlled Action	Post-Approval
Residential Subdivision & Infrastructure Parish of Belfast	2005/1954	Controlled Action	Completed
Schomberg 3D Marine Seismic Survey	2007/3754	Controlled Action	Completed
Star of the South Offshore Wind Farm Project	2020/8650	Controlled Action	Guidelines Issued
Strike Oil Gas Exploration Well, Otway Basin (VIC/P44)	2000/97	Controlled Action	Completed
Tarkine Forest Drive Road Upgrade	2011/6210	Controlled Action	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Controlled action			
The Tarkine Road Project	2009/5169	Controlled Action	Completed
Twelve Apostles Saddle Lookout	2019/8571	Controlled Action	Post-Approval
VIC Offshore Windfarm	2021/8966	Controlled Action	Assessment Approach
VICP61 2D Marine Seismic Survey	2008/4075	Controlled Action	Completed
Victorian Desalination Project, Bass Coast	2008/3948	Controlled Action	Post-Approval
Wind Farm Construction	2000/12	Controlled Action	Post-Approval
Wind Turbines	2001/439	Controlled Action	Completed
Yolla Gas Field (TRL1) Development	2001/321	Controlled Action	Post-Approval
Not controlled action			
2004/2005 drilling program for exploration and production (VIC 01-06, 09-11, 16, 18 & 19 and VIC/RL	2003/1282	Not Controlled Action	Completed
2D seismic survey, Petroleum Exploration Permit Area T/36P	2004/1787	Not Controlled Action	Completed
2D seismic Survey in VIC/P55, VIC/RL2 and VIC/P41	2004/1876	Not Controlled Action	Completed
accomodation units and associatedadministration and recreational facilities	2001/430	Not Controlled Action	Completed
Airey Inlet water reclamation plant to Anglesea sewerage system	2006/2539	Not Controlled Action	Completed
Alteration of Grass Maintenance Regime within Powling St Wetlands	2012/6527	Not Controlled Action	Completed
Amrit-1 exploration well	2004/1572	Not Controlled Action	Completed
Anglesea Mine South Wall Vegetation removal, Anglesea, Vic	2017/8060	Not Controlled Action	Completed
Apollo Bay Water Storage Basin, VIC	2012/6484	Not Controlled Action	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action			
Barwon Heads Rd gas pipeline installation	2006/2769	Not Controlled Action	Completed
Barwon Heads Stormwater Outfall upgrade, Victoria	2016/7650	Not Controlled Action	Completed
Beardie-1 Field wildcat oil well	2001/505	Not Controlled Action	Completed
Bluff Heights Estate Stages 2 to 4	2003/1047	Not Controlled Action	Completed
Boneo Park Equestrian Centre	2008/4639	Not Controlled Action	Completed
Capture of Juvenile Tasmanian Devils for Conservation Purposes	2007/3261	Not Controlled Action	Completed
Capture of Tasmanian Devils from Disease-Free Areas	2007/3883	Not Controlled Action	Completed
CO2 geosequestration - Otway Basin Pilot Project	2006/2699	Not Controlled Action	Completed
Communications tower extension	2003/1099	Not Controlled Action	Completed
Construct a Recycled Water Pipeline from Somers Treatment Plant to Blue Scope S	2009/4982	Not Controlled Action	Completed
Construction of Barwon Heads Bridge	2005/2375	Not Controlled Action	Completed
Construction of Infrastructure to Extract, Treat & Transfer Groundwater to Wurde	2008/4104	Not Controlled Action	Completed
construction of pump station for pump diversion from the Barham River	2003/1242	Not Controlled Action	Completed
Construction of the Edgars Road Extension, from Childs Road, Lalor to Cooper Street, Epping	2003/1135	Not Controlled Action	Completed
Cowes Primary School Gymnasium	2020/8683	Not Controlled Action	Completed
Development of Kipper gas field within Vic/L3, Vic/L4 Vic/RL2	2005/2484	Not Controlled Action	Completed
Development of Pt Nepean Quarantine Station (former) National Centre for Coasts and Climate	2008/4653	Not Controlled Action	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action			
Development of Turrum Oil Field and associated infrastructure	2003/1204	Not Controlled Action	Completed
Divestment of Norris Barracks	2003/963	Not Controlled Action	Completed
Drilling and side track completion at Baleen gas production well in Production Licence area VIC/L21	2004/1535	Not Controlled Action	Completed
Drilling of Callister-1 exploration well in VIC/P51	2004/1633	Not Controlled Action	Completed
Enterprise 1 Exploration Drilling Program, near Port Campbell, Vic	2019/8438	Not Controlled Action	Completed
Establishment of a 6 turbine windfarm near Wonthaggi	2002/820	Not Controlled Action	Completed
Exploration drilling for liquid/gaseous hydrocarbons	2004/1681	Not Controlled Action	Completed
Exploration Drilling Well Trefoil-1	2003/1058	Not Controlled Action	Completed
Fabrication and Spooling of Pipe Strings at Crib Point	2008/4127	Not Controlled Action	Completed
Ferry Service Infrastructure Development	2001/269	Not Controlled Action	Completed
Flinders Backlog Sewer Project	2005/2275	Not Controlled Action	Completed
Gas Field Development	2006/2635	Not Controlled Action	Completed
Gas Fields Development	2011/5879	Not Controlled Action	Completed
Gas Pipeline Installation	2005/2495	Not Controlled Action	Completed
Gippsland Basin Seismic Programme	2004/1866	Not Controlled Action	Completed
Golflinks Road Residential Development & Water Storage Facility at Barwon Heads	2004/1793	Not Controlled Action	Completed
Grevillea infecunda tip cuttings and soil samples	2005/1979	Not Controlled Action	Completed
Halladale and Speculant Gas Pipeline Project, North of Port Campbell, Vic	2015/7551	Not Controlled Action	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action			
Hemingway1/Oil Exploration	2001/177	Not Controlled Action	Completed
Henry-1 Exploration Well, Petroleum Permit Area VIC/P44	2005/2147	Not Controlled Action	Completed
Huxley Hill Wind Farm expansion	2005/2499	Not Controlled Action	Completed
Huxley Hill Wind Farm Expansion	2002/570	Not Controlled Action	Completed
Improving rabbit biocontrol: releasing another strain of RHDV, sthrn two thirds of Australia	2015/7522	Not Controlled Action	Completed
INDIGO Central Submarine Telecommunications Cable	2017/8127	Not Controlled Action	Completed
Installation of a 35 metre telecommunications facility at Jirrahlinga Animal San	2003/1151	Not Controlled Action	Completed
Installation of optic fibre cable from Inverloch, Victoria to Stanley, Tasmania	2002/906	Not Controlled Action	Completed
Kelly Swamp Boardwalk Construction	2010/5371	Not Controlled Action	Completed
Longtom-3 Gas Appraisal Well, VIC/P54	2005/2494	Not Controlled Action	Completed
Longtom Gas Pipeline Development, VIC/P54	2006/3072	Not Controlled Action	Completed
Maintenance and priority works to heritage buildings at Point Nepean Quarantine	2006/3151	Not Controlled Action	Completed
Maintenance dredging of Yaringa Channel	2004/1360	Not Controlled Action	Completed
Maintenance Dredging South Channel 2012	2011/6198	Not Controlled Action	Completed
Maintenance of Access Track and Weed Removal	2009/4973	Not Controlled Action	Completed
Maintenance works at Barwon Heads Bridge	2003/1199	Not Controlled Action	Completed
Marine and Freshwater Resources Institute (MAFRI) Facility	2000/121	Not Controlled Action	Completed
Marlin-Snapper Gas Pipeline Project	2006/3197	Not Controlled Action	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action			
Melville 1 Oil Exploration Well	2001/167	Not Controlled Action	Completed
Merricks Beach Backlog Sewer Project	2010/5300	Not Controlled Action	Completed
Millwood Road Gravel Quarry	2002/602	Not Controlled Action	Completed
Minerva Cut Back Project, Vic	2017/8036	Not Controlled Action	Completed
Newfield wind farm	2007/3226	Not Controlled Action	Completed
Newhaven Yacht Squadron marina extension	2004/1450	Not Controlled Action	Completed
New Water Infrastructure Upgrade, Grassy Dam, King Island	2013/6882	Not Controlled Action	Completed
Nirranda South Wind Farm Pty Ltd	2002/763	Not Controlled Action	Completed
Ocean Grove rising main 2 upgrade	2009/4978	Not Controlled Action	Completed
Ocean Grove Rising Main 2 Upgrade (OGRM2) - East Section & River Crossing	2010/5508	Not Controlled Action	Completed
Oceanlinx South Australia 1mW Greenwave Project	2012/6528	Not Controlled Action	Completed
Offshore exploration drilling within permit area VIC/P 37(v)	2004/1466	Not Controlled Action	Completed
Offshore Petroleum Exploration	2001/289	Not Controlled Action	Completed
Optic fibre cable installation - San Remo to Cowes	2005/2386	Not Controlled Action	Completed
Pipeline easement regrowth removal	2011/5817	Not Controlled Action	Completed
Point Nepean Quarantine Station (former)/Restoration of Medical Superintendent's	2006/3149	Not Controlled Action	Completed
Port Campbell Headland Walking Trail Realignment	2012/6676	Not Controlled Action	Completed
Portland Landfill Borehole Installation, Vic	2017/7886	Not Controlled Action	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action			
Port Phillip Channel Deepening Project - Trial Dredge Program	2005/2164	Not Controlled Action	Completed
Proposed replacement of existing road culvert	2013/7077	Not Controlled Action	Completed
Queenscliff Harbour Redevelopment	2004/1352	Not Controlled Action	Completed
Railway Bridge (H0151) Partial Demolition, Merri River	2010/5534	Not Controlled Action	Completed
Redevelopment Project to Upgrade and Extend the Portland Trawler Wharf	2008/4317	Not Controlled Action	Completed
Rehabilitation of Lake Connewarre State Game Reserve	2002/708	Not Controlled Action	Completed
Remedial Works to the Swan Island Bridge	2003/1129	Not Controlled Action	Completed
Remote power generation project	2005/2287	Not Controlled Action	Completed
Replacement of sewer pipelines	2002/623	Not Controlled Action	Completed
Residential/Resort/Golf Course development	2002/907	Not Controlled Action	Completed
Residential Development, 409 The Esplanade, St Leonards	2006/2950	Not Controlled Action	Completed
Residential Dwelling	2004/1896	Not Controlled Action	Completed
Ryan Corner Wind Farm	2005/2142	Not Controlled Action	Completed
Saline Recharge of meromictic Lake Fidler	2004/1334	Not Controlled Action	Completed
Spikey Beach 1, West Triton Drilling Program, Bass Basin Permit T/38P	2007/3914	Not Controlled Action	Completed
Stage 1 residential subdivision, Anna Catherine Drive	2005/1992	Not Controlled Action	Completed
Telstra optic fibre cable across Bass Strait - Sub bottom profiler Surve	2002/779	Not Controlled Action	Completed
To construct a shared trail within the Arthurs Seat Road, road reserve south side from Mornington Fl	2004/1565	Not Controlled Action	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action			
Torquay Sewerage Strategy - pipe replacement between Torquay and the Black Rock	2004/1704	Not Controlled Action	Completed
Track construction - Great Ocean Walk	2002/793	Not Controlled Action	Completed
Transfer of 90ha Point Nepean Quarantine Station from Commonwealth to Victorian	2008/4521	Not Controlled Action	Completed
Turrum Phase 2 Development Project	2008/4191	Not Controlled Action	Completed
Upgrade and Repairs to Flinders Pier	2008/4331	Not Controlled Action	Completed
Venus Bay Outfall Extension	2004/1555	Not Controlled Action	Completed
VIC-P44 Stage 2 Gas Field Development	2007/3767	Not Controlled Action	Completed
Victorian Generator Project	2005/1984	Not Controlled Action	Completed
West Triton Drilling Program - Gippsland Basin	2007/3915	Not Controlled Action	Completed
West Triton Drilling Program - Otway Basin	2007/3909	Not Controlled Action	Completed
Wind Farm Construction and Operation	2001/471	Not Controlled Action	Completed
Not controlled action (particular manner)			
'Moonlight Head' 3D seismic survey, VIC/P38(V), VIC/P43 and VIC/RL8	2005/2236	Not Controlled Action (Particular Manner)	Post-Approval
2D & 3D seismic survey T/39P	2005/2237	Not Controlled Action (Particular Manner)	Post-Approval
2D Marine Seismic Survey	2005/2295	Not Controlled Action (Particular Manner)	Post-Approval
2D Marine Seismic Survey in Permit Areas T/32P and T/33P	2002/845	Not Controlled Action (Particular Manner)	Post-Approval
2D Seismic Aquisition Survey	2008/4041	Not Controlled Action	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
		(Particular Manner)	
2D Seismic Survey	2008/3962	Not Controlled Action (Particular Manner)	Post-Approval
2D Seismic Survey	2003/1214	Not Controlled Action (Particular Manner)	Post-Approval
2D Seismic Survey	2008/4066	Not Controlled Action (Particular Manner)	Post-Approval
2D seismic survey, Petroleum Exploration Permit Area EPP27	2006/2776	Not Controlled Action (Particular Manner)	Post-Approval
2D Seismic Survey in VIC/P50 and VIC/P46	2004/1810	Not Controlled Action (Particular Manner)	Post-Approval
2D seismic survey VIC/P50	2005/2313	Not Controlled Action (Particular Manner)	Post-Approval
3D marine seismic survey near King Island	2004/1461	Not Controlled Action (Particular Manner)	Post-Approval
3D Marine Seismic Survey within Torquay Sub-basin off sthn Victoria	2012/6256	Not Controlled Action (Particular Manner)	Post-Approval
3D seismic program VIC/P38(v), VIC/P43 and VIC/RL8	2003/1137	Not Controlled Action (Particular Manner)	Post-Approval
Apache 3D seismic exploration survey	2006/3146	Not Controlled Action (Particular Manner)	Post-Approval
Aroo Chappell 3D seismic survey	2010/5701	Not Controlled Action (Particular Manner)	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
Astrolabe 3D Marine Seismic Survey	2011/6048	Not Controlled Action (Particular Manner)	Post-Approval
Bass Basin 2D and 3D seismic surveys (T/38P & T/37P)	2007/3650	Not Controlled Action (Particular Manner)	Post-Approval
Benbows Paddock residential development, Cape Bridgewater	2007/3247	Not Controlled Action (Particular Manner)	Post-Approval
Bernoulli 3D Seismic Survey	2006/3053	Not Controlled Action (Particular Manner)	Post-Approval
BHPBilliton Otway 3D Seismic Survey	2007/3443	Not Controlled Action (Particular Manner)	Post-Approval
Bitumen Storage Facility	2007/3676	Not Controlled Action (Particular Manner)	Post-Approval
Bream 3D seismic survey	2006/2556	Not Controlled Action (Particular Manner)	Post-Approval
Collection of cast bull kelp	2002/813	Not Controlled Action (Particular Manner)	Post-Approval
Construction of bridge across Barwon River	2006/2947	Not Controlled Action (Particular Manner)	Post-Approval
Construct private dwelling	2008/4234	Not Controlled Action (Particular Manner)	Post-Approval
Construct single dwelling	2008/4504	Not Controlled Action (Particular Manner)	Post-Approval
Controlled Burn, Understorey Clearance and Removal of UXO	2003/1030	Not Controlled Action (Particular	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
		Manner)	
Dalrymple 3D Seismic Survey	2010/5680	Not Controlled Action (Particular Manner)	Post-Approval
Deepwater Sorell Basin 2001 Non-Exclusive 2D Seismic Survey	2001/156	Not Controlled Action (Particular Manner)	Post-Approval
Drill and Profile Exploration Well Somerset 1, License Area T34P	2009/5037	Not Controlled Action (Particular Manner)	Post-Approval
Enterprise Three-dimensional Transition Zone Seismic Survey, Victoria	2016/7800	Not Controlled Action (Particular Manner)	Post-Approval
Exploration drilling of the Craigow-1 and Tolpuddle-1 wells	2010/5725	Not Controlled Action (Particular Manner)	Post-Approval
Fuelbreak construction	2009/4915	Not Controlled Action (Particular Manner)	Post-Approval
Gas Pipeline	2000/20	Not Controlled Action (Particular Manner)	Post-Approval
Geelong Bypass Section 3	2005/2099	Not Controlled Action (Particular Manner)	Post-Approval
Geographe-A gas exploration well	2000/82	Not Controlled Action (Particular Manner)	Post-Approval
Gippsland 2D Marine Seismic Survey - VIC/P-63, VIC/P-64 and T/46P	2009/5241	Not Controlled Action (Particular Manner)	Post-Approval
Golden Beach gas field development	2003/1031	Not Controlled Action (Particular Manner)	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
Granville Wind Farm, TAS	2012/6585	Not Controlled Action (Particular Manner)	Post-Approval
Hydrocarbon exploration wells	2003/1062	Not Controlled Action (Particular Manner)	Post-Approval
INDIGO Marine Cable Route Survey (INDIGO)	2017/7996	Not Controlled Action (Particular Manner)	Post-Approval
Inspection of project vessels for presence of invasive marine pests in Commonwealth waters off Victo	2012/6362	Not Controlled Action (Particular Manner)	Post-Approval
Labatt 3D Seismic Survey T/47P Bass Strait	2007/3759	Not Controlled Action (Particular Manner)	Post-Approval
La Bella 3D Marine Seismic Survey, Otway Basin, VIC	2012/6683	Not Controlled Action (Particular Manner)	Post-Approval
Longtom-5 Offshore Production Drilling (Vic/L29), VIC	2012/6498	Not Controlled Action (Particular Manner)	Post-Approval
Longtom South -1 Exploration Drilling	2011/6217	Not Controlled Action (Particular Manner)	Post-Approval
Luxury Cruise on the Gordon River, Tasmanian Wilderness PT 2	2006/3044	Not Controlled Action (Particular Manner)	Post-Approval
Luxury Cruise on the Gordon River, Tasmanian Wilderness WHA	2004/1846	Not Controlled Action (Particular Manner)	Post-Approval
Maintenance Dredging Program 2012-21 in Port of Melbourne	2012/6332	Not Controlled Action (Particular Manner)	Post-Approval
Marine Farming Expansion, Macquarie Harbour, TAS	2012/6406	Not Controlled Action (Particular	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
		Manner)	
Northern Fields 3D Seismic Survey	2001/140	Not Controlled Action (Particular Manner)	Post-Approval
Origin Energy Silvereye-1 Exploration Drilling Programme	2010/5702	Not Controlled Action (Particular Manner)	Post-Approval
OTE10 2D Marine Seismic Survey	2009/5223	Not Controlled Action (Particular Manner)	Post-Approval
Otway Basin Exploration Drilling Campaign, Vic	2011/6125	Not Controlled Action (Particular Manner)	Post-Approval
Pelican 3D Marine Seismic Survey, Gippsland Basin, Vic	2017/8097	Not Controlled Action (Particular Manner)	Post-Approval
Remove silt build up on existing swales around the perimeter of the Three Hummo	2010/5676	Not Controlled Action (Particular Manner)	Post-Approval
Residential Development and Associated Infrastructure at Port Fairy	2012/6687	Not Controlled Action (Particular Manner)	Post-Approval
Rockhopper-1 and Trefoil-2 Exploration Drilling in Permit Area T/18P	2009/4776	Not Controlled Action (Particular Manner)	Post-Approval
Santos 2D Seismic Survey VIC/P44 & VIC/P51	2003/1213	Not Controlled Action (Particular Manner)	Post-Approval
Santos Otway 3d Seismic VIC/P44	2007/3367	Not Controlled Action (Particular Manner)	Post-Approval
Schomberg 3D Marine Seismic survey	2007/3868	Not Controlled Action (Particular Manner)	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
SEA Gas Project transmission pipeline	2001/513	Not Controlled Action (Particular Manner)	Post-Approval
Seismic Survey	2001/206	Not Controlled Action (Particular Manner)	Post-Approval
Seismic Survey VIC-P46	2002/826	Not Controlled Action (Particular Manner)	Post-Approval
Shaw River Power Station construct gas pipeline and associated infrastructure	2009/5089	Not Controlled Action (Particular Manner)	Post-Approval
Shaw River Power Station Project - Water Supply Pipeline	2009/5091	Not Controlled Action (Particular Manner)	Post-Approval
Shearwater 2D and 3D marine seismic survey	2005/2180	Not Controlled Action (Particular Manner)	Post-Approval
Silvereye 3D Seismic Survey	2007/3551	Not Controlled Action (Particular Manner)	Post-Approval
Southern Flanks 2D Marine Seismic Survey	2010/5288	Not Controlled Action (Particular Manner)	Post-Approval
Southern Gas Pipeline Project	2002/619	Not Controlled Action (Particular Manner)	Post-Approval
Southern Margins T/35P and T/36P 3D Seismic Surveys	2007/3817	Not Controlled Action (Particular Manner)	Post-Approval
Speculant 3D Transition Zone Seismic Survey	2010/5558	Not Controlled Action (Particular Manner)	Post-Approval
Strike Oil NL Seismic Surveys	2000/107	Not Controlled Action (Particular	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
		Manner)	
Surface Geochemical Exploration Program, TAS	2010/5780	Not Controlled Action (Particular Manner)	Post-Approval
Tap Oil Ltd Molson 2D Seismic Survey T47P	2008/3967	Not Controlled Action (Particular Manner)	Post-Approval
The Enterprise 3D Seismic Acquisition Survey, Otway Basin, Vic	2012/6565	Not Controlled Action (Particular Manner)	Post-Approval
Thylacine-A Exploration Well	2000/81	Not Controlled Action (Particular Manner)	Post-Approval
Torquay Sub-basin (VIC/P62) OTE12-3D Seismic Survey	2012/6655	Not Controlled Action (Particular Manner)	Post-Approval
Undertake a three dimensional marine seismic survey	2010/5700	Not Controlled Action (Particular Manner)	Post-Approval
Upgrade of Arthur River Road	2003/930	Not Controlled Action (Particular Manner)	Post-Approval
Vic/P37(v) and Vic/P44 3D marine seismic survey	2003/1102	Not Controlled Action (Particular Manner)	Post-Approval
VIC P44 Gas Exploration Wells	2002/662	Not Controlled Action (Particular Manner)	Post-Approval
Vic-P51 and Vic-P52 2D seismic survey	2002/811	Not Controlled Action (Particular Manner)	Post-Approval
Vic-P51 and Vic-P52 3D seismic survey	2002/799	Not Controlled Action (Particular Manner)	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
Wolseley 3D seismic acquisition survey	2010/5703	Not Controlled Action (Particular Manner)	Post-Approval
Referral decision			
2D & 3D Seismic Surveys - Permit Area - VIC/P50	2008/4517	Referral Decision	Completed
3D Marine Seismic Survey	2011/6156	Referral Decision	Completed
3D Seismic Survey	2008/4014	Referral Decision	Completed
All actions taken in response to the current severe bushfires in Victoria.	2009/4787	Referral Decision	Completed
Alteration Reconstruction Restoration and Repairs to Buildings	2008/4179	Referral Decision	Completed
Beardie-1 Field wildcat oil well	2001/469	Referral Decision	Completed
Darymple 3D Seismic Survey, Petroleum Exploration Permit T/41P	2010/5322	Referral Decision	Completed
Kelly Channel Discharge, Macquarie Harbour, Tasmania	2017/8057	Referral Decision	Completed
Land clearing for stock grazing	2005/2176	Referral Decision	Completed
Longtom 5 Offshore Production Drilling (VIC/L29)	2012/6404	Referral Decision	Completed
Longtom-5 Offshore Production Drilling (Vic/L29)	2012/6413	Referral Decision	Completed
Offshore Tidal Energy Facility and Submarine Cable	2008/4480	Referral Decision	Referral Publication
Portland Wave Energy Project	2008/3946	Referral Decision	Completed
Residential Development Elizabeth Avenue, Rosebud West, VIC	2015/7603	Referral Decision	Completed
The Enterprise 3D Seismic Acquisition Survey, Otway Basin, VIC	2012/6545	Referral Decision	Completed
Upgrade of Services Infrastructure Point Nepean Quarantine Station	2008/4591	Referral Decision	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Referral decision			
VICP61 2D Marine Seismic Survey	2008/3975	Referral Decision	Completed
Wind Farm	2001/139	Referral Decision	Completed
Wolseley 3D Seismic Acquisition Survey in Permit T/32P	2010/5291	Referral Decision	Completed
Works to the buildings and surrounds at the former Point Nepean Quarantine Stati	2008/4156	Referral Decision	Completed

Key Ecological Features

[Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
Bonney Coast Upwelling	South-east
Seamounts South and east of Tasmania	South-east
Upwelling East of Eden	South-east
West Tasmania Canyons	South-east

Biologically Important Areas

Scientific Name	Behaviour	Presence
Seabirds		
Ardenna grisea Sooty Shearwater [82651]	Breeding	Known to occur
Ardenna grisea Sooty Shearwater [82651]	Foraging	Known to occur
Ardenna pacifica Wedge-tailed Shearwater [84292]	Breeding	Known to occur
Ardenna pacifica Wedge-tailed Shearwater [84292]	Foraging	Likely to occur
Ardenna tenuirostris Short-tailed Shearwater [82652]	Breeding	Known to occur
Ardenna tenuirostris Short-tailed Shearwater [82652]	Foraging	Known to occur

Scientific Name	Behaviour	Presence
Diomedea exulans (sensu lato) Wandering Albatross [1073]	Foraging	Known to occur
Diomedea exulans antipodensis Antipodean Albatross [82269]	Foraging	Known to occur
Eudyptula minor Little Penguin [1085]	Breeding	Known to occur
Eudyptula minor Little Penguin [1085]	Foraging	Known to occur
Morus serrator Australasian Gannet [1020]	Aggregation	Known to occur
Morus serrator Australasian Gannet [1020]	Foraging	Known to occur
Pelagodroma marina White-faced Storm-petrel [1016]	Breeding	Known to occur
Pelagodroma marina White-faced Storm-petrel [1016]	Foraging	Known to occur
Pelecanoides urinatrix Common Diving-petrel [1018]	Breeding	Known to occur
Pelecanoides urinatrix Common Diving-petrel [1018]	Foraging	Known to occur
Phalacrocorax fuscescens Black-faced Cormorant [59660]	Breeding	Known to occur
Phalacrocorax fuscescens Black-faced Cormorant [59660]	Foraging	Known to occur
Phalacrocorax fuscescens Black-faced Cormorant [59660]	Foraging	Likely to occur
Pterodroma mollis Soft-plumaged Petrel [1036]	Breeding	Known to occur

Scientific Name	Behaviour	Presence
Pterodroma mollis Soft-plumaged Petrel [1036]	Foraging	Known to occur
Thalassarche bulleri Bullers Albatross [64460]	Foraging	Known to occur
Thalassarche cauta cauta Shy Albatross [82345]	Breeding	Known to occur
Thalassarche cauta cauta Shy Albatross [82345]	Foraging likely	Likely to occur
Thalassarche chlororhynchos bassi Indian Yellow-nosed Albatross [85249]	Foraging	Known to occur
Thalassarche melanophris Black-browed Albatross [66472]	Foraging	Known to occur
Thalassarche melanophris impavida Campbell Albatross [82449]	Foraging	Known to occur
Sharks		
Carcharodon carcharias White Shark [64470]	Breeding (nursery area)	Known to occur
Carcharodon carcharias White Shark [64470]	Distribution	Known to occur
Carcharodon carcharias White Shark [64470]	Distribution	Likely to occur
Carcharodon carcharias White Shark [64470]	Distribution (low density)	Likely to occur
Carcharodon carcharias White Shark [64470]	Foraging	Known to occur
Carcharodon carcharias White Shark [64470]	Known distribution	Known to occur
Whales		
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Distribution	Known to occur

Scientific Name	Behaviour	Presence
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Foraging	Likely to be present
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Foraging (annual high use area)	Known to occur
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Known Foraging Area	Known to occur

Bioregional Assessments

SubRegion	BioRegion	Website
Gippsland	Gippsland Basin	BA website

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact us page.

Department of Climate Change, Energy, the Environment and Water
GPO Box 3090
Canberra ACT 2601 Australia
+61 2 6274 1111

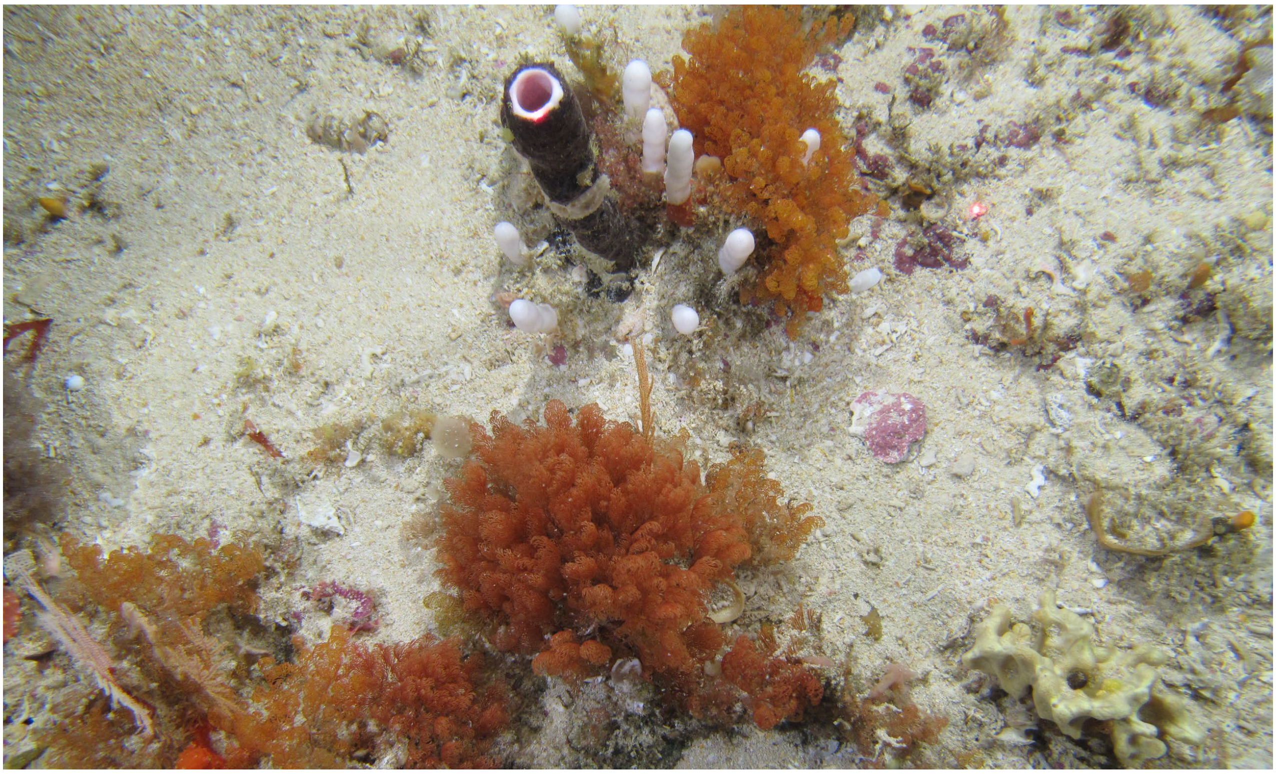
Appendix C: Otway Basin Environmental Survey Report

Intended for
Fugro Australia Pty Ltd

Document type
Report

Date
March 2020

ENVIRONMENTAL SURVEY
OTWAY BASIN



Bright ideas. Sustainable change.

ENVIRONMENTAL SURVEY
OTWAY BASIN

Project name	**Beach Energy Otway Basin Survey**
Project no.	**318000803**
Recipient	**Chris Henderson**
Document type	**Report**
Version	**Rev B**
Date	**17/03/2020**
Prepared by	**Emily Jones**
Checked by	**Dan McClary**
Approved by	**John Miragliotta**
Description	**Results of the environmental survey at Otway Basin for Beach Energy**

Ramboll
41 St Georges Terrace
Perth, WA 6000
Australia

T +61 8 9225 5199
F +61 2 9954 8150
https://ramboll.com

CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

1. INTRODUCTION

1.1 Background

This report presents the results of the environmental survey of offshore gas fields in Otway Basin for Beach Energy. Beach Energy is planning further development of the Otway offshore natural gas reserves within existing Commonwealth offshore exploration permits and production licenses. The offshore Otway Basin gas exploration and development program may include drilling up to nine wells using a contracted semi-submersible drill rig, over a 12- to 18-month period. Additional seabed infrastructure would also be installed to tie-in new wells after the drilling phase.

As part of this plan, Fugro Australia Marine Pty Ltd (Fugro) carried out offshore geophysical and geotechnical surveys and Ramboll Australia Pty Ltd (Ramboll) were contracted by Fugro to carry out the environmental survey. These activities were in Commonwealth waters approximately 32 to 80 km from Port Campbell and in water depths ranging from 70 to 104 m.

1.2 Objective

The objective of the seabed site assessments was to determine suitable locations for anchoring and rig placement for drilling operations and the installation of infrastructure to connect new production wells to the existing platform or pipeline. Several different investigation techniques were used to examine and describe the seabed, as well as identify possible hazards from man-made, natural and geological features.

1.3 Report Scope

The scope of the environmental survey carried out in Otway Basin included investigations of:
- Water quality;
- Sediment quality;
- Benthic infauna; and
- Benthic epifauna.

Water quality assessments included laboratory analyses for:
- Suspended solids
- Nutrients
- Chlorophyll *a*
- Metals/metalloids
- Hydrocarbons

Sediment quality assessments included laboratory analyses for:
- Sediment particle size
- Total organic carbon
- Nutrients
- Metals/metalloids

Infauna were microscopically examined to determine taxonomic identification to Family level and morpho-species, and abundance was recorded. The composition and percent cover of epifauna was determined from seabed photographs.

2. SURVEY LOCATIONS

These investigations were based around five survey areas including:
- Thylacine;
- Artisan;
- La Bella;
- Geographe; and
- Hercules.

Other survey areas included two Hot Tap sites identified as HTX and HTY, and five routes selected for cone penetration tests (CPT) as part of the geotechnical survey plan identified as ARGE (Artisan to Geographe), ARHTX (Artisan to HTX), ARHTY (artisan to HTY), ARLB (Artisan to La Bella) and LBGE (La Bella to Geographe).

The collection of water and sediment/infauna samples for environmental assessment was cancelled by the client for the La Bella, Geographe and Hercules survey areas. Therefore, the collection of water and sediment/infauna samples for environmental assessment occurred only at the Thylacine and Artisan survey areas. Seabed photographs were taken as planned for all survey areas and routes. It is also noted that all survey areas were largely composed of outcropping rock with or without patches of uncemented sediments. Sampling of uncemented sediments was only possible with the grab sampler (as opposed to other devices) and of limited recovery because of the limited thickness of the surficial uncemented sediments.

The survey extent within Otway Basin, including these survey areas, hot taps and survey routes, is shown Figure 1. Environmental sampling sites were located in proximity to the proposed drilling rig mooring locations. The proposed anchor points for the drilling rig are listed in Table 1. The depth at each proposed mooring location was measure at the intersection of the anchor lines (Table 1). Sampling locations are listed in Section 3 for the relevant sampling methods.

Table 1 Location of proposed anchor points (GDA94 UTM 54 S) and water depth for drilling rig sites.

Survey Area	Anchor Point	Depth at Intersection (m LAT)	Easting	Northing
Thylacine	Thylacine 1	99	661398	5657534
	Thylacine 2		662879	5658389
	Thylacine 3		662361	5659286
	Thylacine 4		660880	5658431
	Thylacine 5	104	658235	5656067
	Thylacine 6		659717	5656923
	Thylacine 7		659198	5657820
	Thylacine 8		657717	5656965
Artisan	Artisan 1	70	662783	5692700
	Artisan 2		664261	5693554
	Artisan 3		663741	5694456
	Artisan 4		662262	5693602
Geographe	Geographe 1	83	668221	5668522
	Geographe 2		669699	5669374
	Geographe 3		669179	5670278
	Geographe 4		667700	5669424
La Bella	La Bella 1	93	647914	5681579
	La Bella 2		645915	5681579
	La Bella 3		647319	5682496
	La Bella 4		646437	5680702
Hercules	Hercules 1	73	664065	5688642
	Hercules 2		662065	5688638
	Hercules 3		663547	5689516
	Hercules 4		662596	5687757

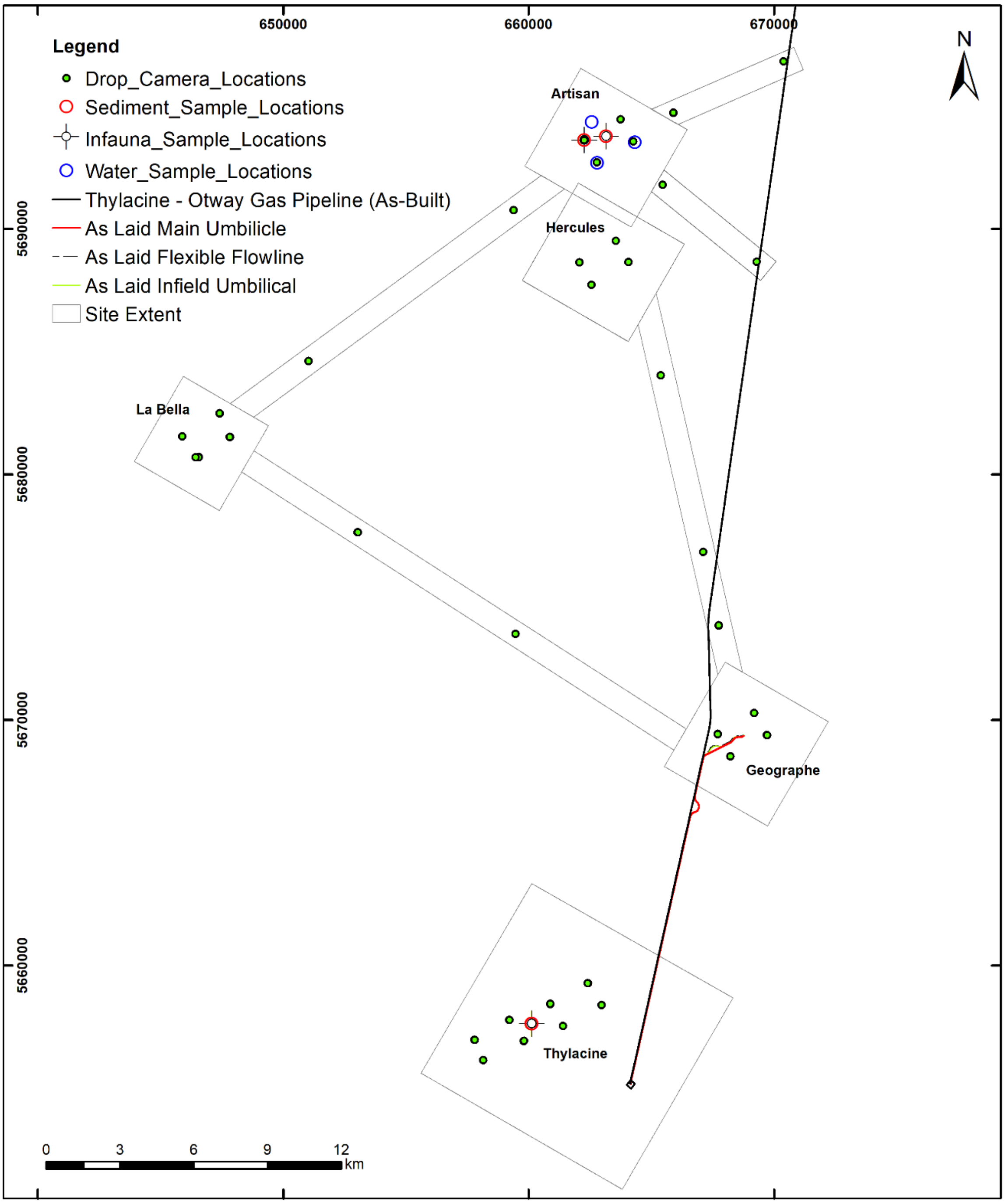


Figure 1 Locations of environmental survey site extents in Otway Basin. Provided by Fugro, April 2020.

3. METHOD

3.1 Survey Operations

The environmental survey was undertaken during several deployments from November 2019 to January 2020. The survey was carried out from the 60 m offshore supply ship *VOS SHINE*. The vessel mobilised from Portland, Victoria.

3.2 Water Quality

3.2.1 Sample Collection

Water quality samples were collected using a 2.2 L Van Dorn Beta water sampler. This sampler was used to obtain water samples from selected water depths. The sampler consisted of an open-ended, clear plastic cylinder with a rubber cap attached at each end. Before deployment, the end caps were held open, under tension, by triggers on the side of the cylinder. The sampler was attached to a rope and lowered by hand over the side of the vessel to the desired depth. A messenger weight attached to the rope was then released to trigger the end caps to close as the messenger contacted the sampler, sealing the water sample inside the cylinder. The sampler was then raised to the surface where the water sample was processed and stored for laboratory analysis.

On retrieval at the surface, the water sampler was inspected against the following sample acceptability criteria:

1. The sample bottle was full; and
2. Both end caps are fully closed; and
3. There was no obvious contamination (e.g. grease or paint chips on, or inside, the sampler).

Any sample that did not comply with these criteria was discarded and another sample was collected at the same site. All samples were recorded on the Environmental Sampling Log (Appendix 1) as per 135846-V01-01-PLA-001 Infauna Lab Testing & Reporting Plan.

Water samples were collected at two of the survey areas – at Artisan and Thylacine on 22 November 2019. Three replicate water samples were collected at each of the survey areas. The locations for water sample collection are listed in Table 2 and shown in Figure 2. Note that there is only one sampling site indicated for the Thylacine field as all samples were collected in close proximity (Figure 2 left). The process described above was carried out at each site and water samples were collected from a depth equal to half of the total water depth at that site.

Table 2 Location (GDA94 UTM 54 S) and depth of water sample collection sites.

Survey Area	Location	Replicate Sample Name	Easting	Northing	Water Depth (m)	Sample Depth (m)	Met Acceptability Criteria
Thylacine	1	1	660119	5657621	104	52	Yes
	1	2	660121	5657619	104	52	Yes
	1	3	660122	5657619	105	52.5	Yes
Artisan	1	1	662936	5692724	66	33	No
	1	2	662782	5692683	66	33	Yes
	2	1	664317	5693523	66	33	Yes
	5	1	662563	5694337	66	33	Yes

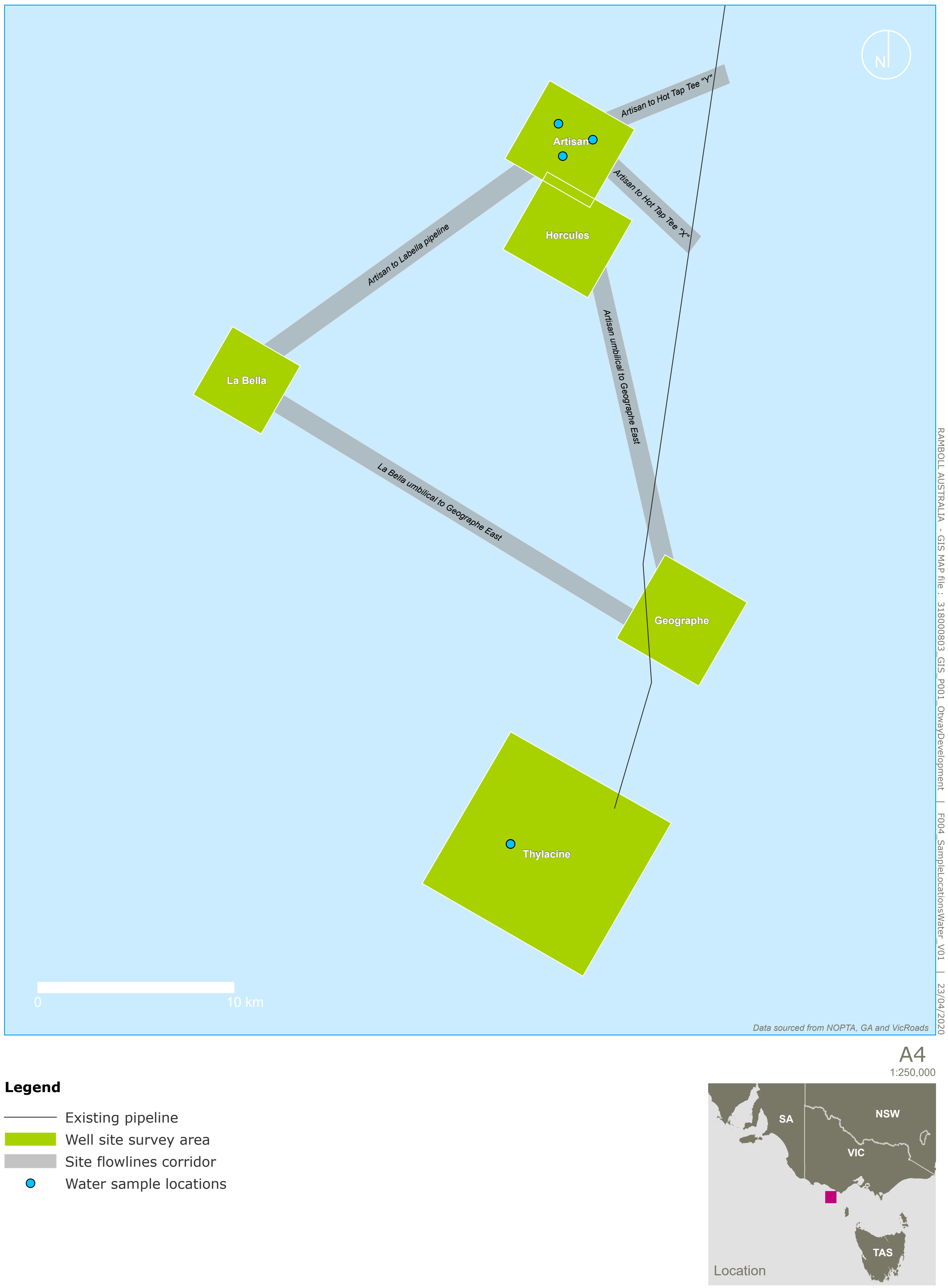


FIGURE 2 | Water sampling locations for Thylacine and Artisan survey areas.

3.2.2 Sample Processing and Analysis

Once a sample was confirmed to be acceptable for analysis, the subsamples were extracted from the water sampler and stored in pre-labelled sample jars provided by the analytical laboratory, Eurofins. The analytical laboratory was NATA accredited and accredited for compliance with ISO/IEC 17025 – Testing.

The water samples were subsampled as follows:

- 1 x 500 mL plastic bottle with no preservative
- 1 x 200 mL glass bottle with no preservative
- 1 x 60 mL plastic bottle with sulphuric acid
- 1 x 60 mL plastic bottle with nitric acid
- 2 x 40 mL glass vials with hydrogen chloride

All samples were stored in a cool, dark location prior to transfer to the laboratory.

One litre of the remaining water sample was then processed for chlorophyll analysis. A simple filtering system was set up which included a Büchner funnel with a rubber seal placed in the mouth of a conical flask and a rubber hose and vacuum hand pump attached to the side arm of the flask. Filter paper (11 µm particle retention at 98% efficiency) was used placed in the funnel and the 1L subsample was suctioned through the filtering system. The filter paper was carefully removed from the funnel using forceps, wrapped in aluminium foil, stored in a labelled sealable plastic bag and frozen prior to transfer to the laboratory.

The following measurements were then taken using a YSI EcoSense handheld meter from the remaining water sample:

- pH
- Dissolved oxygen (DO)
- Oxidation-reduction potential (ORP)
- Temperature (˚C)

Sample information was recorded on the Environmental Sample Log (Appendix 1). All sample collection and processing equipment was then rinsed in sterile demineralised water before the next sample was collected.

All water quality subsamples were recorded on the Ramboll Chain of Custody (COC) form. These subsamples were then transferred to the laboratory on the vessel's return to shore. The water quality samples were delivered to the Eurofins laboratory in Melbourne on 26 November 2019.

The water samples were analysed for the presence and concentration of these analytes:

- Total suspended solids (TSS);
- Nutrients including total nitrogen (N), total Kjeldahl nitrogen (TKN), nitrogen oxides (NOx), nitrate (NO^{-}_{3}), ammonia (NH_3), total phosphorus (TP), and total reactive phosphorus (TRP);
- Chlorophyll *a*;
- Metals/metalloids including arsenic (As), cadmium (Cd), cobolt (Co), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb), and zinc (Zn); and
- Hydrocarbons including total recoverable hydrogens (TRH), benzene, toluene, ethylbenzene and xylene compounds (BTEX), and polycyclic aromatic hydrocarbons (PAH).

The analytical methods for these analytes are included in the laboratory reports in Appendix 2.

3.3 Sediment Quality

3.3.1 Sample Collection

Seabed sediment samples were collected using a Double Van Veen grab sampler. The Double Van Veen grab is designed for sampling the top layer of consolidated sediment consisting of silt and/or sand. The capacity of each grab bucket is ~12 L. The double grab allows for comparable sampling where samples for sediment and biological analysis are required from the same location.

Prior to deployment, the jaws of both grabs were opened and fixed into position using a tension-based catch. The grab sampler was then winched over the stern of the vessel and lowered at a slow, steady rate to prevent the catch from being released too early. When the jaws made contact with the bottom, the release of tension caused the catch to be tripped, allowing the jaws to quickly close to capture the surface sediment. The quantity and quality of the sample was related to the compactness of the sediment whereby the grab sampler returned less sample content from more compacted sediments.

On retrieval at the surface, the grab sampler was inspected against the following sample acceptability criteria:

1. The jaws of the grab are closed; and
2. The surface of the sediment sample covers at least 70% of the grab; and
3. The surface of the sediment sample is undisturbed; and
4. There is no evidence of the sample being washed out; and
5. The sample is at least 20cm deep.

Samples that did not comply with these criteria were typically discarded and another sample was collected at the same site. However, some exceptions to these criteria were allowed on agreement with the client in order to obtain samples for analysis, given the difficulty of obtaining grab samples from the hard seabed substrate. Such instances are noted in the description of results in Section 4. At some sample locations a composite sample was made from several grab drops (up to three drops) to provide enough material for one sample. In these instances, the samples did not achieve a depth of 20 cm. The first sample replicate collected from the Thylacine survey area (Thylacine_1_1) was 15 cm deep and therefore did not meet the acceptance criteria; however, given the difficulty in obtaining suitable samples (owing to the hard seabed), this sample was retained for analysis as all other criteria were met and it was considered to be a useful sample by the field personnel. All samples were recorded on the Environmental Sampling Log (Appendix 1) as per 135846-V01-01-PLA-001 Infauna Lab Testing & Reporting Plan.

Sediment samples were collected at two of the survey areas – at Artisan and Thylacine on 22 November 2019. Three replicate sediment samples were to be collected at each of the survey areas, however, this was not always possible because of the compacted substrate. The resulting samples included four replicate samples from Thylacine and two replicate samples from Artisan. The locations for successful sediment sample collection are listed in Table 3 and shown in Figure 3. Note that there is only one sampling site indicated for the Thylacine field as all samples were collected in close proximity (Figure 3 left). Grab sample positions were provided by Fugro from the marine survey using Ultra Short Base Line positioning systems.

FIGURE 3 | Grab sample locations for sediment and infauna for Thylacine and Artisan survey areas.

Table 3 Location (GDA94 UTM 54 S) and depth of sediment sample collection sites.

Survey Area	Location	Sample Replicate Name	Easting	Northing	Water Depth (m)	Met Acceptability Criteria
Thylacine	1	0	660119	5657621	104	Sample was 15 cm deep, therefore not within acceptance criteria but considered suitable by field personnel. Incorrectly recorded in lab report as Location 2.
	1	1	660121	5657619	104	Yes
	1	2	660122	5657619	105	Yes
	1	3	660120	5657622	104	Yes
Artisan	1	1	663155	5693762	72	This sample was a composite of replicate samples 1, 3, 4 and 6 taken at the same location. Listed as Artisan_GS_A in lab report.
	1	2	663155	5693762	72	No
	1	3	663155	5693762	72	Composite as above.
	1	4	663155	5693762	72	Composite as above.
	1	5	663155	5693762	72	No
	1	6	663155	5693762	72	Composite as above.
	3	1	662264	5693604	75	No
	3	2	662264	5693604	72	No
	3	3	662265	5693604	73	Yes. Listed as Artisan_GS3 in lab report.
	3	4	662265	5693605	74	No sediment sample, infauna sample only.

3.3.2 Sample Processing and Analysis

Once a sample was confirmed to be acceptable for analysis, the sample was photographed, visual observations were recorded, and subsamples were extracted from the sample and stored in pre-labelled sample jars provided by the analytical laboratory.

All sediment grab samples were photographed with a sample identity plate. Notes of the uniformity of the surface, Munsell colour and odour were then recorded. The redox (reduction–oxidation reaction) potential depth (RPD) was measured using a YSI EcoSense handheld meter and probe. Redox potential is a measure of the tendency of a chemical species to acquire electrons from or lose electrons to an electrode and thereby be reduced or oxidised, respectively. Redox potential is measured in millivolts (mV). The redox potential of the sample was measured from the surface and at 10 mm increments to a depth of up to 110 mm, or until resistance was encountered when inserting the probe. The probe was rinsed in fresh water between each sample. Sample information was recorded on the Environmental Sample Log (Appendix 1).

Sediment was then extracted from one grab bucket for sediment quality sampling (with the contents of the other grab bucket being used for infauna sampling). Subsamples were collected by releasing the sample into a collection bin below the sampler. The entire sample was homogenised using a plastic scoop.

Two subsamples were stored in pre-labelled 250 mL glass sample jars for the analysis of contaminants and particle size distribution. All samples were stored in a cool, dark location prior to transfer to the laboratory. All sample collection and processing equipment was then rinsed in fresh water before the next sample was collected.

All sediment quality subsamples were recorded on the Ramboll COC form. These subsamples were then transferred to the laboratory on the vessel’s return to shore. The sediment quality samples were delivered to the Eurofins laboratory in Melbourne on 26 November 2019.

The sediment samples were analysed for the presence and concentration of these analytes:

- Sediment particle size as clay-size fraction, silt and sand;
- Total organic carbon (TOC);
- Nutrients including nitrate and nitrite, TKN, total nitrogen, phosphorus, and silicon;
- Metals/metalloids including cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), tin (Sn), and zinc (Zn).
- Hydrocarbons including Total Petroleum Hydrocarbons (TPH) , total polycyclic aromatic hydrocarbons (PAH) and BTEX (benzene, toluene, ethylbenzene and xylenes, PCBs.

The analytical methods for these analytes are included in the laboratory reports in Appendix 3.

3.4 Infauna Ecology

3.4.1 Sample Collection

Seabed sediment samples for infauna were collected using a Double Van Veen grab sampler, as described in Section 3.2.1 and at the locations presented in Table 4 and Figure 3. The critiera for accepting grab samples for infauna analysis were as described in Section 3.2.1. All samples were recorded on the Environmental Sampling Log (Appendix 1) as per 135846-V01-01-PLA-001 Infauna Lab Testing & Reporting Plan.

3.4.2 Sample Processing and Analysis

Once a sample was confirmed to be acceptable for analysis, the sample was photographed with a sample identity plate. Sediment was then extracted from one grab bucket for infauna sampling (with the contents of the other grab bucket being used for sediment quality sampling). The entire sample was released into a collection bin below the sampler and then transferred to a sample washing system where the sample was placed in a perforated bin to be mixed and rinsed with seawater. The liquified sample was then passed through a series of sieves of 1mm mesh size (top) and 500 µm mesh size (bottom). The remaining infauna and debris were then rinsed into a labelled container and preserved in ethanol at a dilution factor of 2:1 to sample volume. Where a full grab sample was collected, the contents were subsampled to a 6L sample volume to limit the time required for infauna sample processing in the laboratory.

All samples were stored in a chemical locker and were recorded on the Ramboll COC form. These samples were then transferred to the taxonomic analyst on the vessel’s return to shore. The laboratory in Gladstone, Queensland received the infauna samples in December 2019.

Infauna organisms present in the samples were identified and counted to Family morpho-species or genus level where possible. Descriptive statistics (e.g., species richness, organism abundance, diversity indices) were used to summarise the seabed biota present. This information is assessed and discussed in the context of the known communities present in the wider Otway Basin, noting the presence of any habitats/species of relevance to the EPBC Act. Multivariate measures were not used in the assessment because of the small dataset and paucity of organisms found in the samples.

Table 4 Location (GDA94 UTM 54 S) and depth of infauna sample collection sites.

Survey Area	Location	Sample Replicate Name	Easting	Northing	Water Depth (m)	Met Acceptability Criteria
Thylacine	1*	0	660119	5657621	104	Sample was 15 cm deep, therefore not within acceptance criteria but considered suitable by field personnel. Incorrectly recorded in lab report as Location 2.
	1	1	660121	5657619	104	Yes
	1	2	660122	5657619	105	Yes
	1	3	660120	5657622	104	Yes
Artisan	1	1	663155	5693762	72	No
	1	2	663155	5693762	72	No
	1	3	663155	5693762	72	No
	1	4	663155	5693762	72	Yes
	1	5	663155	5693762	72	No
	1	6	663155	5693762	72	No
	3	1	662264	5693604	75	No
	3	2	662264	5693604	72	No
	3	3	662265	5693604	73	Yes
	3	4	662265	5693605	74	Sample was 7 cm deep, therefore not within acceptance criteria but considered suitable by field personnel.

3.5 Epibenthic Ecology

3.5.1 Sample Collection

The composition and percent coverage of epifauna was assessed from photographs of the seafloor taken with the Fugro drop camera system. The drop camera system was fitted with a 14.7 megapixel (MP) Canon PowerShot G10 digital camera and a low latency, live video recorder. The system was equipped with twin lasers aimed within the camera field of view to enable calibration of the image size. The lasers were calibrated to a distance of 15 cm. The camera housing was an aluminium enclosure for use in water depths up to 300 m. A mini beacon was attached to the drop camera to accurately track locations during deployment.

The drop camera was deployed via a winch over the stern of the vessel. All data was transferred directly to the surface unit and saved into a dedicated Fugro server. A real-time video feed to the surface enabled preliminary observations of benthic fauna and substrate type to be made during operation.

At each sampling site the camera was lowered and then to three locations approximately 1-2 m apart to obtain a collection of representative samples. At least five photographs were taken at each location to provide a selection of photographs for analysis. Drop camera sites are listed in Appendix 4. Drop camera photographs were taken at all anchor points, hot tap sites and along CPT routes as shown in Figure 4. The average area of seabed in each photograph was 0.5 m^2.

3.5.2 Sample Processing and Analysis

All seafloor photographs were examined to determine their suitability for analysis, with photographs being excluded for the assessment based on the following reasons:

- Poor resolution or blurred image;
- Sediment blow out obscuring the image;
- More than a quarter of the image was in shadow or had poor lighting;
- Images were overlapping (in which case the best quality image was chosen); or
- Images were taken at oblique angles.

For each photograph, the percent coverage of epifauna was estimated and individual, mobile organisms were counted. Photographs were examined to provide a qualitative description of the epifauna communities. Sediment type and percent coverage was also estimated for each photograph.

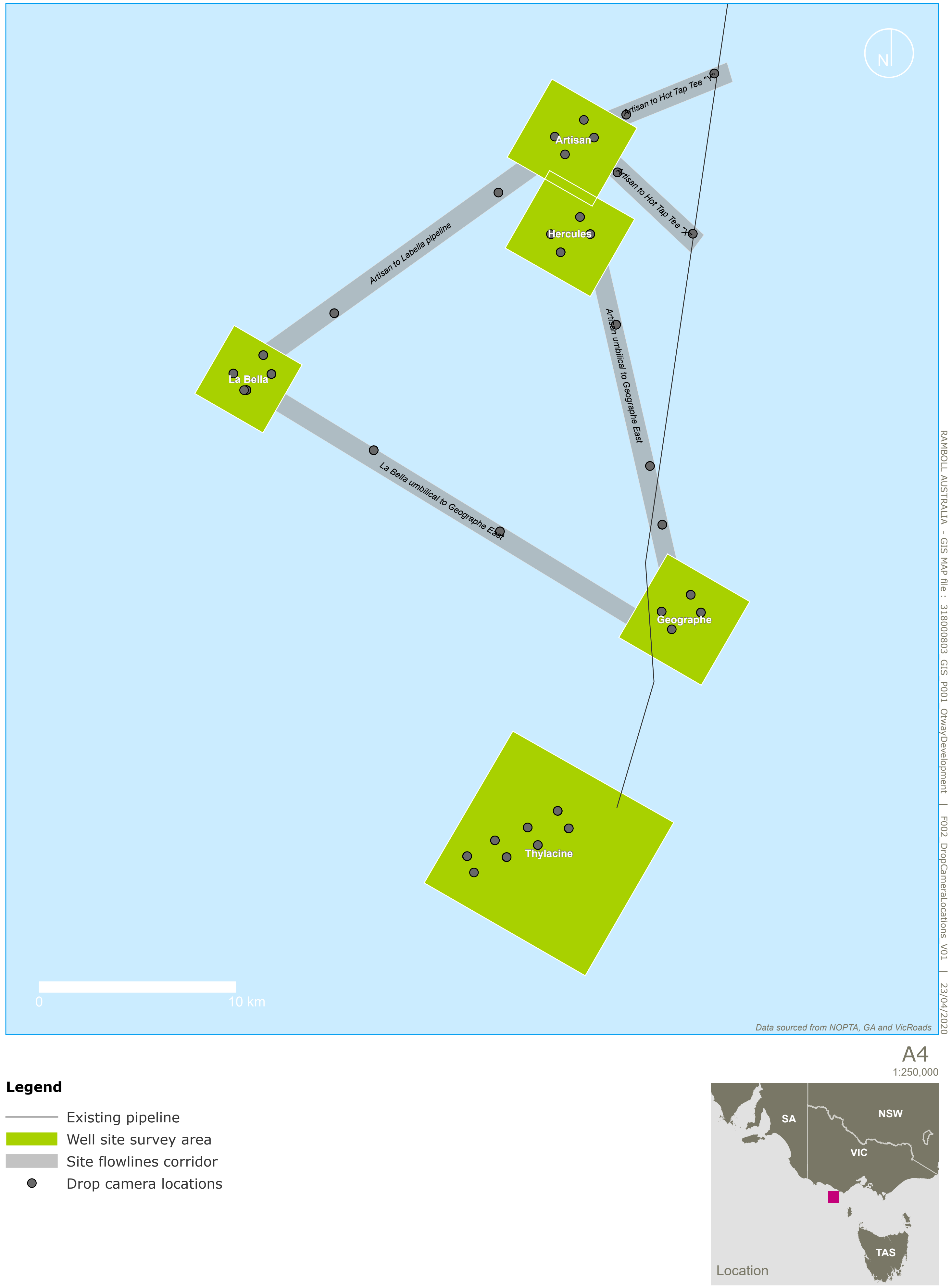


FIGURE 4 | Drop camera locations for all survey areas.

4. RESULTS

4.1 Water Quality

Measurements made *insitu* for water samples collected from the Thylacine and Artisan survey areas are presented in Table 5. Dissolved oxygen (DO) and pH were assessed against the default trigger values for physical and chemical stressors for south-east Australia for slightly disturbed ecosystems set out in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000). Trigger values are used to assess risk of adverse effects due to nutrients, biodegradable organic matter and pH in various ecosystem types.

Dissolved oxygen was between the lower and upper limits of 90 and 110% saturation for marine waters in all samples. Likewise, pH was between the lower and upper limits of 8.0 and 8.4 for all samples. The range of ORP measurements indicated a well oxygenated, ecologically healthy environment.

Table 5 Measurements made *insitu* for water samples at Thylacine and Artisan survey areas.

Sample Name	pH	DO (% saturation)	ORP (mV)
Thylacine_1_1	8.19	94.3	215.0
Thylacine_1_2	8.24	95.2	211.4
Thylacine_1_3	8.33	95.2	98.1
Artisan_1_2	8.16	94.0	172.7
Artisan_2_1	8.08	93.1	211.4
Artisan_5_1	8.34	93.8	164.5

The results of laboratory analyses for water samples from the Thylacine and Artisan survey areas are presented in Tables 6 to 11.

The analytes were compared to the relevant ANZECC (2000) – the default trigger values for physical and chemical stressors for nutrient analytes and the trigger values for toxicants at alternative levels of protection for all other analytes.

The concentration of ammonia, nitrite and reactive phosphorus was at or below LOR for all samples. Only one sample contained a concentration of nitrate-nitrite, NO^-_3, TKN and TN above the LOR. This was replicate Thylacine_1_3; however, none of the measurements exceeded ANZECC trigger values. Concentrations of TP were recorded in all samples, but all measurements were well below ANZECC trigger values. TSS was typically within the range expected for unmodified[1] marine ecosystems.

The concentrations of Cd, Cr, Co, Pb, Hg, and Ni were at or below LOR in all samples. The concentration of Cu was below, at or very close to the LOR for all samples.

The concentration of Zn against ANZECC protection level (or trigger values) is shown in Figure 5. All concentrations were below the 90% protection level but concentrations variously exceeded 95 or 99% protection levels. This result is consistent with a slightly disturbed marine system which is described in (ANZECC 2000) as an ecosystem in which biodiversity may have been affected to a

---

[1] Unmodified is a descriptive term used in reference to the quality of the environment and is used in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000). Effectively unmodified ecosystems, typically (but not always) occur in remote and/or inaccessible locations. While there are no aquatic ecosystems in Australia that are entirely without some human influence, the ecological integrity of unmodified ecosystems is regarded as intact.

small degree by human activity. Therefore, this result is likely reflective of the human activities occurring within and around the study area and the levels of environmental Zn are with a reasonable level of species protection for such an environment.

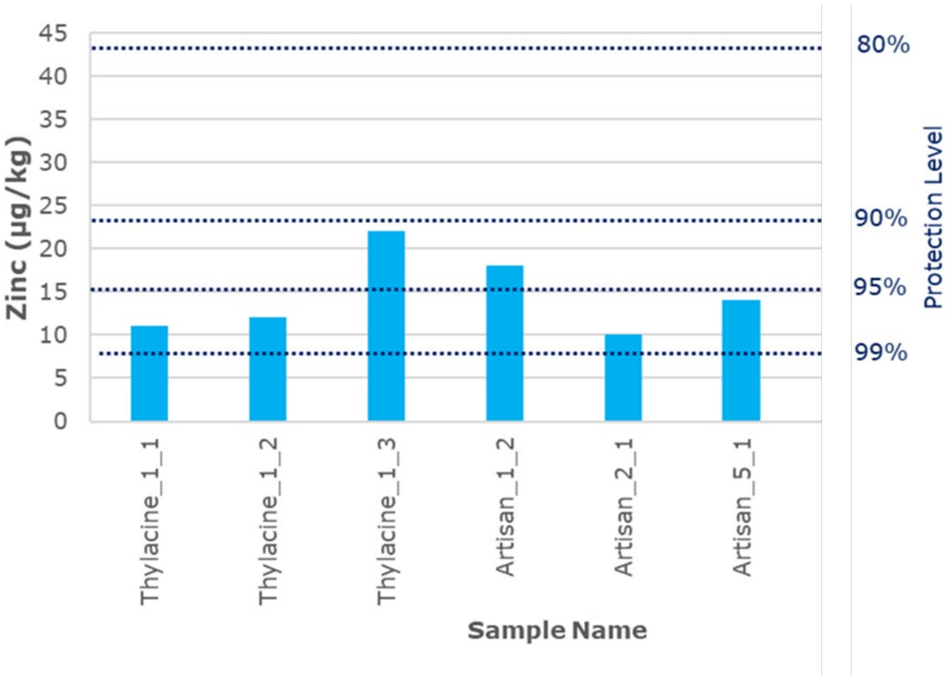


Figure 5 Concentration of Zn in water samples from Thylacine and Artisan survey areas.

BTEXs and PAHs were below the detection limit in all water samples. Very low traces of TRHs were detected in the Thylacine_1_2 water sample but were at levels of no concern. TRHs were below detection limits in all other samples. The level of chlorophyll *a* in filtered samples was below the detection level.

Table 6 Nutrients in water samples at Thylacine and Artisan survey areas.

Sample Name	mg/L								
	NH_3	Nitrate-Nitrite	NO^-_3	Nitrite	TP	RP	TKN	TN	TSS
Thylacine_1_1	< 0.01	< 0.05	0.03	< 0.02	0.03	< 0.01	< 0.2	< 0.2	3.4
Thylacine_1_2	< 0.01	< 0.05	0.02	< 0.02	0.02	< 0.01	< 0.2	< 0.2	9.7
Thylacine_1_3	< 0.01	0.10	0.10	< 0.02	0.02	< 0.01	2.4	2.5	2.4
Artisan_1_2	< 0.01	< 0.05	< 0.02	< 0.02	0.02	< 0.01	< 0.2	< 0.2	5.9
Artisan_2_1	< 0.01	< 0.05	< 0.02	< 0.02	0.01	0.01	< 0.2	< 0.2	4.6
Artisan_5_1	< 0.01	< 0.05	< 0.02	< 0.02	0.01	< 0.01	< 0.2	< 0.2	5.2

Table 7 Metals and metalloids in water samples at Thylacine and Artisan survey areas.

Sample Name	mg/L								
	Ar	Cd	Cr	Co	Cu	Pb	Hg	Ni	Zn
Thylacine_1_1	0.001	< 0.0002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.0001	< 0.001	0.011
Thylacine_1_2	0.004	< 0.0002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.0001	< 0.001	0.012
Thylacine_1_3	0.002	< 0.0002	< 0.001	< 0.001	0.002	< 0.001	< 0.0001	0.001	0.022
Artisan_1_2	0.003	< 0.0002	< 0.001	< 0.001	0.001	< 0.001	< 0.0001	< 0.001	0.018
Artisan_2_1	0.005	< 0.0002	< 0.001	< 0.001	0.001	< 0.001	< 0.0001	< 0.001	0.01
Artisan_5_1	0.010	< 0.0002	< 0.001	< 0.001	0.001	< 0.001	< 0.0001	< 0.001	0.014

Table 8 Polycyclic Aromatic Hydrocarbons (PAH) in water samples at Thylacine and Artisan survey areas.

Sample Name	mg/L					
	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo(b&j)fluoranthene
Thylacine_1_1	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Thylacine_1_2	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Thylacine_1_3	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Artisan_1_2	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Artisan_2_1	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Artisan_5_1	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Sample Name	mg/L					
	Benzo(g.h.i)perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a.h)anthracene	Fluoranthene	Fluorene
Thylacine_1_1	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Thylacine_1_2	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Thylacine_1_3	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Artisan_1_2	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Artisan_2_1	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Artisan_5_1	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Sample Name	mg/L					p-Terphenyl-d14 (%)	2-Fluorobiphenyl (%)
	Indeno(1.2.3-cd)pyrene	Naphthalene	Phenanthrene	Pyrene	Total PAH		
Thylacine_1_1	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	134	111
Thylacine_1_2	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	145	107
Thylacine_1_3	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	138	109
Artisan_1_2	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	93	109
Artisan_2_1	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	102	114
Artisan_5_1	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	101	117

Table 9 Total Recoverable Hydrocarbons (1999 NEPM Fractions) in water samples at Thylacine and Artisan survey areas.

Sample Name	mg/L				
	TRH C10-C14	TRH C10-C36 (Total)	TRH C15-C28	TRH C29-C36	TRH C6-C9
Thylacine_1_1	< 0.05	< 0.1	< 0.1	< 0.1	< 0.02
Thylacine_1_2	0.05	0.15	0.1	< 0.1	< 0.02
Thylacine_1_3	< 0.05	< 0.1	< 0.1	< 0.1	< 0.02
Artisan_1_2	< 0.05	< 0.1	< 0.1	< 0.1	< 0.02
Artisan_2_1	< 0.05	< 0.1	< 0.1	< 0.1	< 0.02
Artisan_5_1	< 0.05	< 0.1	< 0.1	< 0.1	< 0.02

Table 10 Total Recoverable Hydrocarbons (2013 NEPM Fractions) in water samples at Thylacine and Artisan survey areas.

Sample Name	mg/L							
	Naphthalene	TRH >C10-C16	TRH >C10-C16 less Naphthalene (F2)	TRH >C10-C40 (total)*	TRH >C16-C34	TRH >C34-C40	TRH C6-C10	TRH C6-C10 less BTEX (F1)
Thylacine_1_1	< 0.01	< 0.05	< 0.05	< 0.1	< 0.1	< 0.1	< 0.02	< 0.02
Thylacine_1_2	< 0.01	0.07	0.07	0.17	0.1	< 0.1	< 0.02	< 0.02
Thylacine_1_3	< 0.01	< 0.05	< 0.05	< 0.1	< 0.1	< 0.1	< 0.02	< 0.02
Artisan_1_2	< 0.01	< 0.05	< 0.05	< 0.1	< 0.1	< 0.1	< 0.02	< 0.02
Artisan_2_1	< 0.01	< 0.05	< 0.05	< 0.1	< 0.1	< 0.1	< 0.02	< 0.02
Artisan_5_1	< 0.01	< 0.05	< 0.05	< 0.1	< 0.1	< 0.1	< 0.02	< 0.02

Table 11 BTEX in water samples at Thylacine and Artisan survey areas.

Sample Name	mg/L						4-Bromofluoro-benzene (%)
	Benzene	Ethylbenzene	m&p-Xylenes	o-Xylene	Toluene	Xylenes - Total	
Thylacine_1_1	< 0.001	< 0.001	< 0.002	< 0.001	< 0.001	< 0.003	106
Thylacine_1_2	< 0.001	< 0.001	< 0.002	< 0.001	< 0.001	< 0.003	94
Thylacine_1_3	< 0.001	< 0.001	< 0.002	< 0.001	< 0.001	< 0.003	107
Artisan_1_2	< 0.001	< 0.001	< 0.002	< 0.001	< 0.001	< 0.003	94
Artisan_2_1	< 0.001	< 0.001	< 0.002	< 0.001	< 0.001	< 0.003	102
Artisan_5_1	< 0.001	< 0.001	< 0.002	< 0.001	< 0.001	< 0.003	100

4.2 Sediment Quality

The particle size distribution of marine sediments in each sample is shown in Figure 6 with data recorded in Appendix 3. The particle size is <2 µm for the clay-size fraction, 2-20 µm for the silt fraction and 20-2000 µm for the sand fraction. Note that the sample for Artisan 1_1 was a composite of up to three drops of the grab sampler. The sediment within all samples and, therefore at both survey areas, was predominantly sand with a range of 95-97% as a proportion of each sample. There was very little silt and a maximum of 4.7% for the clay-size fraction. There were no discernible trends based on the location of sample collection. The Munsell colour of all samples as 10YR 8/4.

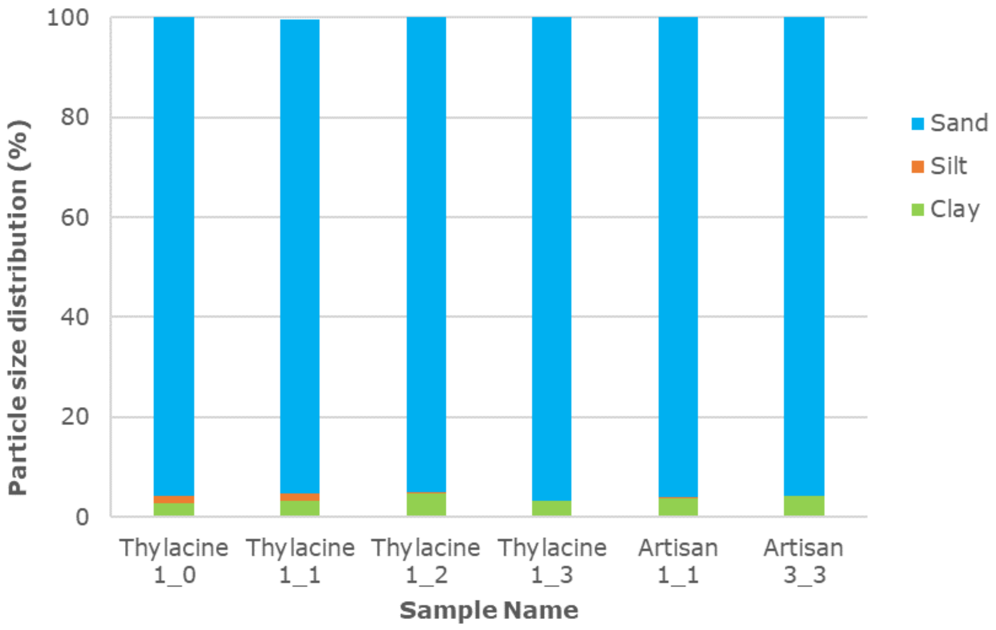


Figure 6 Particle size distribution (%) in sediment samples collected at Thylacine and Artisan survey areas.

The ORP (oxidation-reduction potential) or redox potential of sediments within the samples was measured and the results are presented in Table 12. Note that the measurement probe was inserted into the sediment until resistance prevented further insertion. Given that the substrate was predominantly sand, the probe was typically only inserted to 1-2 cm and no more than 3 cm into the sediment sample. The anoxic layer with low ORP was not detected in any of the sediments analysed and the range of measurements indicated that these sediments maintain a well oxygenated, unmodifed environment.

Table 12 Measurement of oxidation reduction potential in sediment samples at Thylacine and Artisan survey areas.

Sample Name	ORP Measurement Depth (mV)		
	1 cm	2 cm	3 cm
Thylacine_1_0	211	211	No further penetration
Thylacine_1_1	252.7	No further penetration	-
Thylacine_1_2	242.7	No further penetration	-
Thylacine_1_3	225.5	223	216.7
Artisan_1_1	Composite sample; measurement not possible		
Artisan_3_3	242.1	217.3	No further penetration

The results of nutrient analyses are shown in Table 13, Figure 7 and Figure 8. Nitrate-nitrite was not detected in any samples. There was a notable degree of variability in the samples collected in the Thylacine field, however the small number of samples means that a trend or pattern is not discernible. TOC and detectable nitrogen concentrations were slightly higher in the Artisan samples compared to the Thylacine samples. Generally, the concentrations of nutrients in the marine sediments were to be expected for this environment and type of sediment.

Table 13 Nutrients in sediment samples at Thylacine and Artisan survey areas.

Sample Name	mg/kg					Total Organic Carbon (%)
	Phosphorus	Silicon	Nitrate-Nitrite	Total Kjeldahl Nitrogen	Total Nitrogen	
Thylacine_1_0	750	850	< 5	230	230	1.3
Thylacine_1_1	620	1000	< 5	190	190	0.9
Thylacine_1_2	400	950	< 5	130	130	0.5
Thylacine_1_3	< 200	460	< 5	180	180	< 0.1
Average (± S.D.)	467.5 (± 284)	815 (± 245)	NA	183 (± 41)	183 (± 41)	1.0 (± 0.5)
Artisan_1_1	620	570	< 5	310	310	1.6
Artisan_3_3	530	810	< 5	270	270	2.4
Average (± S.D.)	575 (± 64)	690 (± 170)	NA	290 (± 28)	290 (± 28)	2.0 (± 1.0)

Level of Reporting (LOR): phosphorus 200 mg/kg; silicon 5 mg/kg; nitrate-nitrite 5 mg/kg; TKN 10 mg/kg; TN 10 mg/kg; TOC 0.1%.
S.D. = standard deviation. Note that average (± S.D.) calculations are made with half LOR where the sample result was < LOR.

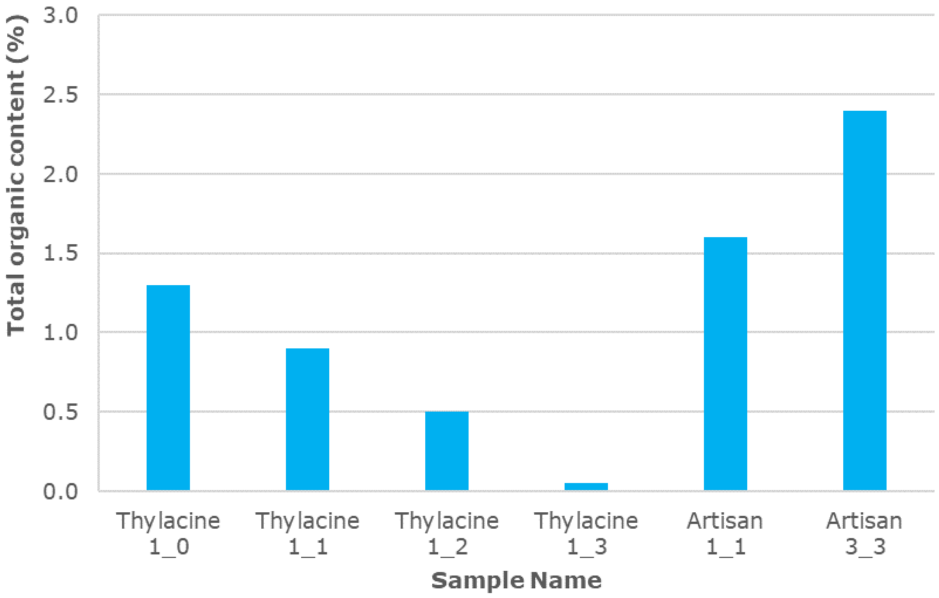


Figure 7 Total organic content (%) in sediment samples collected at Thylacine and Artisan survey areas.

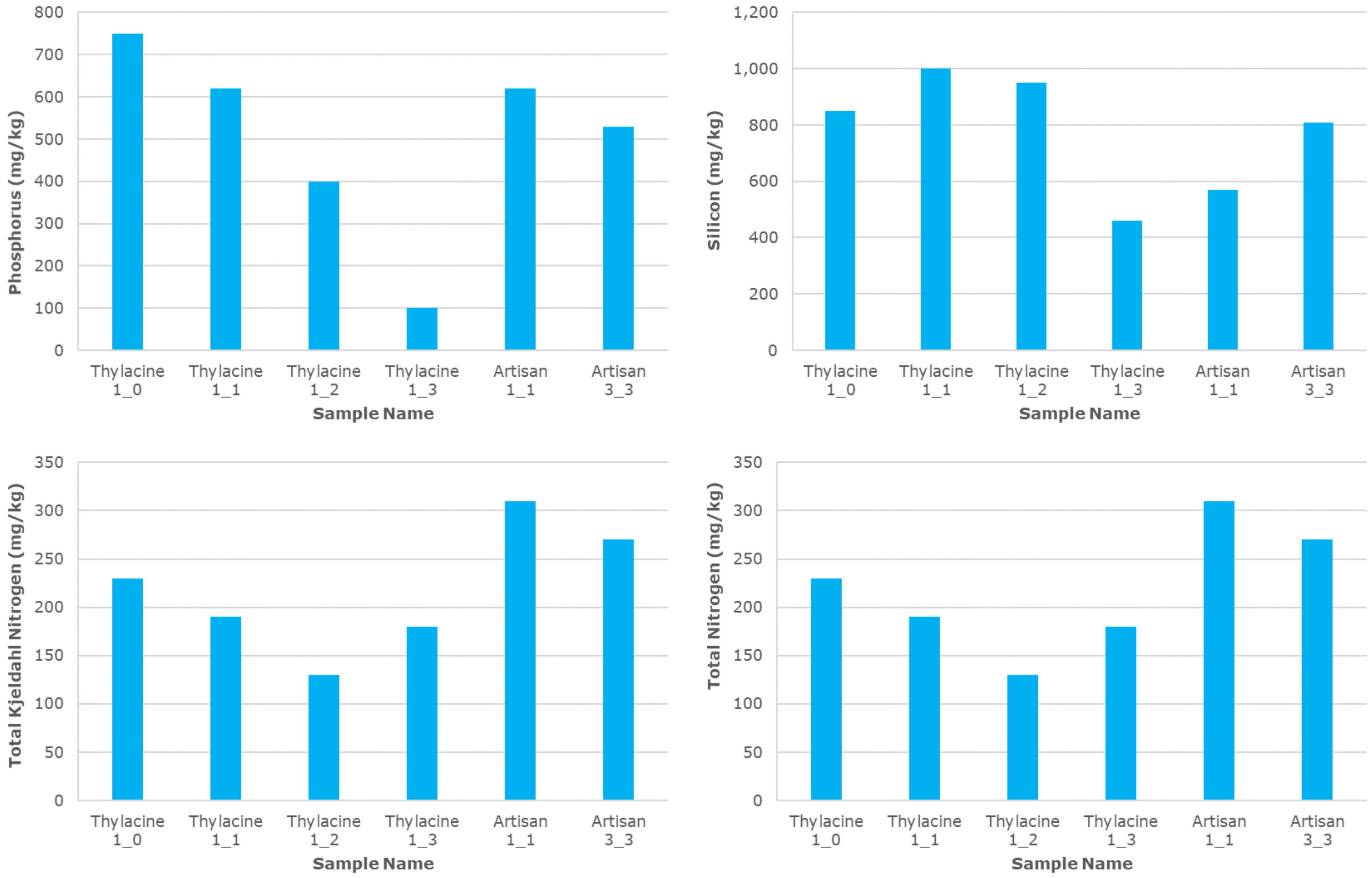


Figure 8 Nutrient concentrations (mg/kg) in sediment samples collected at Thylacine and Artisan survey areas, including phosphorus (top left), silicon (top right), total Kjeldahl nitrogen (bottom left) and total nitrogen (bottom right).

Table 14 presents the results of the analysis for metal compounds in the sediment samples. Of the inorganic compounds tested, Cd, Cu, Pb, Hg, Ni and Sn were below the detection limits (LOR) in all sediment samples. The concentration of Cr in sediments was low, and well below the Interim Sediment Quality Guidelines (ISQG) low trigger value of 80 mg/kg from the recommended sediment quality guidelines set out in ANZECC (2000). The concentration of Cr was slightly higher in the samples from Artisan than those from Thylacine. Zn was detected in two of the six samples (one sample from each field) and was well below the ISQC-Low trigger value of 200 mg/kg.

Table 14 Metals in sediment samples at Thylacine and Artisan survey areas.

Sample Name	mg/kg							
	Cd	Cr	Cu	Pb	Hg	Ni	Sn	Zn
Thylacine_1_0	< 0.4	6.2	< 5	< 5	< 0.1	< 5	< 10	7.2
Thylacine_1_1	< 0.4	6.6	< 5	< 5	< 0.1	< 5	< 10	< 5
Thylacine_1_2	< 0.4	6.4	< 5	< 5	< 0.1	< 5	< 10	< 5
Thylacine_1_3	< 0.4	< 5.0	< 5	< 5	< 0.1	< 5	< 10	< 5
Artisan_1_1	< 0.4	11	< 5	< 5	< 0.1	< 5	< 10	9.4
Artisan_3_3	< 0.4	8.1	< 5	< 5	< 0.1	< 5	< 10	< 5

Level of Reporting (LOR): Cd 0.4 mg/kg; Cr 5 mg/kg; Cu 5 mg/kg; Pb 5 mg/kg; Hg 0.1 mg/kg; Ni 5 mg/kg; Sn 10 mg/kg; Zn 5 mg/kg.

The results of laboratory analyses for hydrocarbons in sediment samples from the Thylacine and Artisan survey areas are presented in Tables 15 to 19. BTEXs, PAHs, PCBs and TRHs were either below the LOR or at levels of no concern.

Table 15 Polycyclic Aromatic Hydrocarbons (PAH) in sediment samples at Thylacine and Artisan survey areas.

Sample Name	mg/kg						
	Acenaphthene	Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo(a)pyrene TEQ (lower bound)	Benzo(a)pyrene TEQ (medium bound)
Thylacine_1_0	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.6
Thylacine_1_1	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.6
Thylacine_1_2	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.6
Thylacine_1_3	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.6
Artisan_1_1	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.6
Artisan_3_3	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	0.6

Sample Name	mg/kg						
	Benzo(a)pyrene TEQ (upper bound)	Benzo(b&j) fluoranthene	Benzo(g.h.i) perylene	Benzo(k)fluoranthene	Chrysene	Dibenz(a.h)anthracene	Fluoranthene
Thylacine_1_0	1.2	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Thylacine_1_1	1.2	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Thylacine_1_2	1.2	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Thylacine_1_3	1.2	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Artisan_1_1	1.2	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Artisan_3_3	1.2	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Sample Name	mg/kg						p-Terphenyl-d14 (%)	2-Fluorobiphenyl (%)
	Fluorene	Indeno(1.2.3-cd)pyrene	Naphthalene	Phenanthrene	Pyrene	Total PAH*		
Thylacine_1_0	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	83	79
Thylacine_1_1	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	121	92
Thylacine_1_2	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	137	87
Thylacine_1_3	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	118	97
Artisan_1_1	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	59	60
Artisan_3_3	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	147	58

Table 16 Total Recoverable Hydrocarbons (1999 NEPM Fractions) in sediment samples at Thylacine and Artisan survey areas.

Sample Name	mg/kg				
	TRH C10-C14	TRH C10-C36 (Total)	TRH C15-C28	TRH C29-C36	TRH C6-C9
Thylacine_1_0	< 20	< 50	< 50	< 50	< 20
Thylacine_1_1	< 20	< 50	< 50	< 50	< 20
Thylacine_1_2	< 20	< 50	< 50	< 50	< 20
Thylacine_1_3	< 20	< 50	< 50	< 50	< 20
Artisan_1_1	< 20	< 50	< 50	< 50	< 20
Artisan_3_3	< 20	< 50	< 50	< 50	< 20

Table 17 Total Recoverable Hydrocarbons (2013 NEPM Fractions) in sediment samples at Thylacine and Artisan survey areas.

Sample Name	mg/kg							
	Naphthalene	TRH >C10-C16	TRH >C10-C16 less Naphthalene (F2)	TRH >C10-C40 (total)*	TRH >C16-C34	TRH >C34-C40	TRH C6-C10	TRH C6-C10 less BTEX (F1)
Thylacine_1_0	< 0.5	< 50	< 50	< 100	< 100	< 100	< 20	< 20
Thylacine_1_1	< 0.5	< 50	< 50	< 100	< 100	< 100	< 20	< 20
Thylacine_1_2	< 0.5	< 50	< 50	< 100	< 100	< 100	< 20	< 20
Thylacine_1_3	< 0.5	< 50	< 50	< 100	< 100	< 100	< 20	< 20
Artisan_1_1	< 0.5	< 50	< 50	< 100	< 100	< 100	< 20	< 20
Artisan_3_3	< 0.5	< 50	< 50	< 100	< 100	< 100	< 20	< 20

Table 18 BTEX in sediment samples at Thylacine and Artisan survey areas.

Sample Name	mg/kg						4-Bromofluoro-benzene (%)
	Benzene	Ethylbenzene	m&p-Xylenes	o-Xylene	Toluene	Xylenes - Total	
Thylacine_1_0	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.3	55
Thylacine_1_1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.3	104
Thylacine_1_2	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.3	110
Thylacine_1_3	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.3	106
Artisan_1_1	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.3	62
Artisan_3_3	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.3	106

Table 19 Polychlorinated Biphenyls in sediment samples at Thylacine and Artisan survey areas

Sample Name	mg/kg								Dibutylchlorendate (%)	Tetrachloro-m-xylene (%)
	Aroclor-1016	Aroclor-1221	Aroclor-1232	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260	Total PCB*		
Thylacine_1_0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	105	86
Thylacine_1_1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	132	77
Thylacine_1_2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	139	80
Thylacine_1_3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	78	77
Artisan_1_1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	73	64
Artisan_3_3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	115	54

4.3 Infauna Ecology

The benthic infauna recorded from the grab samples are presented in Table 20. The benthic infauna identified and counted from samples collected at the Thylacine and Artisan sites were relatively depauperate in both abundance and diversity. A total of 22 morpho-species were identified, from a total of 45 organisms collected from the grab samples. The samples Thylacine_1_1 and Artisan_1_4 had the greatest infauna abundance with nine organisms in each sample (Figure 9). The samples Artisan_1_4 and Artisan_3_4 had the greatest diversity with eight morpho-species) (Figure 10), most of which were polychaete worms or crustaceans (Figure 11).

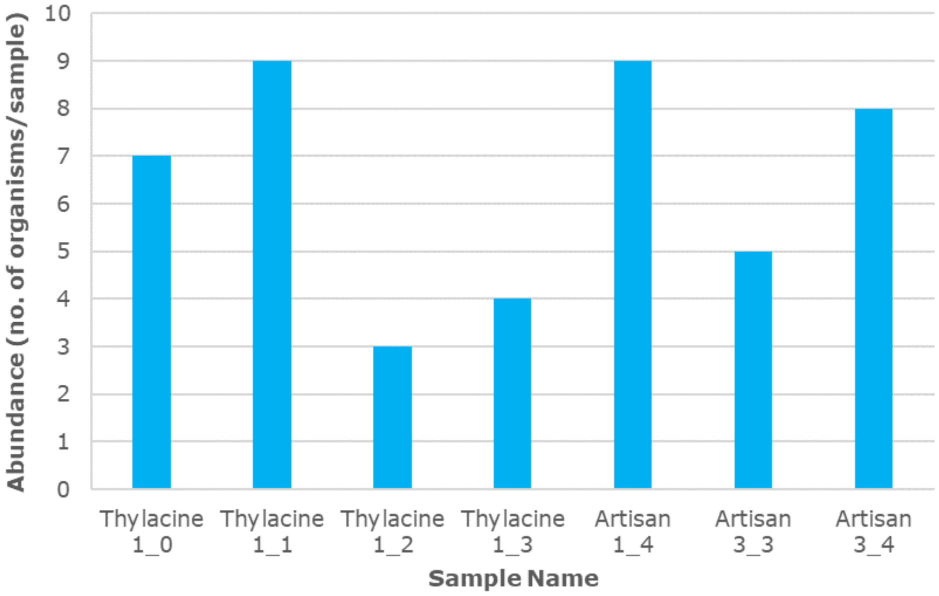


Figure 9 Abundance of benthic infauna in grab samples at Thylacine and Artisan survey areas.

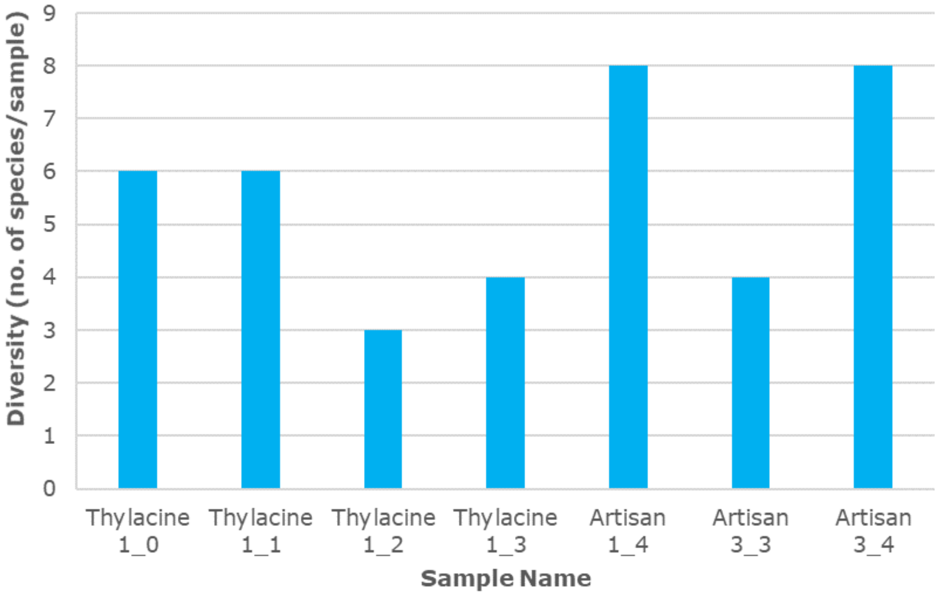


Figure 10 Diversity of benthic infauna in grab samples at Thylacine and Artisan survey areas.

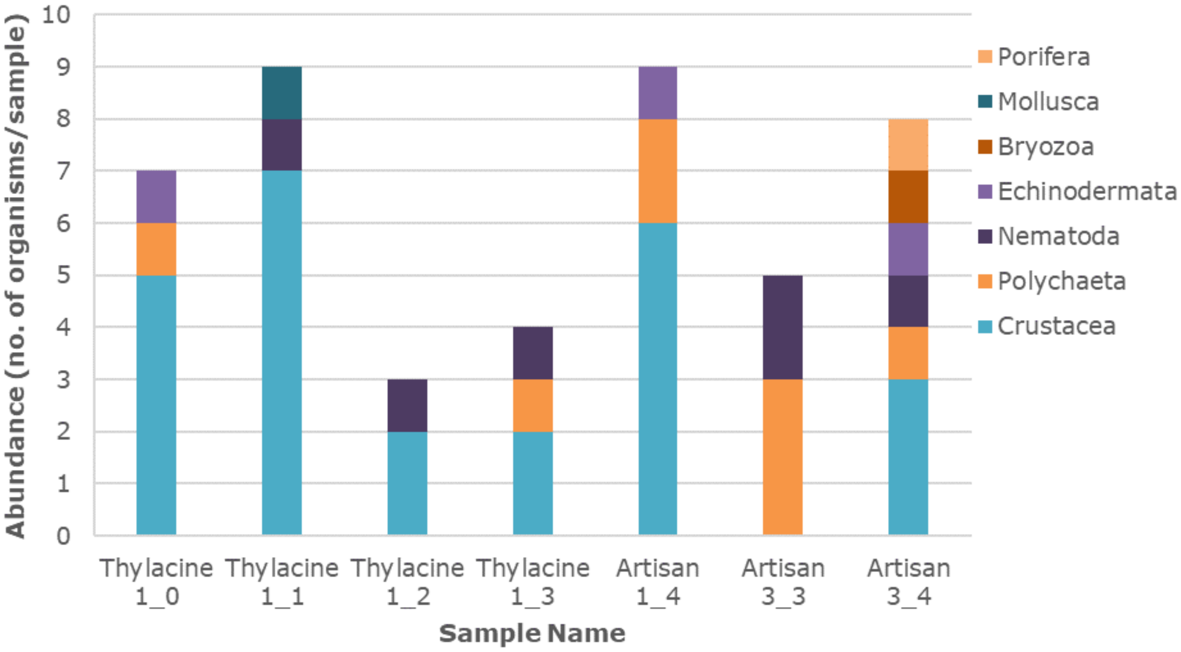


Figure 11 Abundance of benthic infauna by taxonomic group in grab samples at Thylacine and Artisan survey areas.

These results are reflective of the sedimentary environment at the Thylacine and Artisan survey areas, as described in Section 4.2. All sites were dominated by sand, which typically have a lower abundance and diversity of infauna given that this abrasive type of substrate tends to be more easily subjected to hydrodynamic conditions that move the sediment more dynamically than muddy substrates. The consequence of this is a physical environment that is not favourable for filter feeding and burrowing infauna species to inhabit. The observed species typically have a higher tolerance for dynamic environments.

There were no discernible spatial trends in the distribution of sediment particle size. Likewise, there were no clear trends in the abundance, diversity or composition of benthic infauna.

Table 20 Benthic infauna present in sediment samples collected at Thylacine and Artisan survey areas.

Phylum	Class/ Order	Family	Morpho-species	Thylacine				Artisan		
				1_0	1_1	1_2	1_3	1_4	3_3	3_4
Annelida	Polychaeta	Glyceridae	Glyceridae sp.	1			1	1	1	
		Goniadidae	Goniadidae sp.							1
		Pisionidae	Pisionidae sp.					1		
		Spionidae	Spionidae sp.						1	
		Syllidae	Syllidae sp.						1	
Crustacea	Amphipoda	Ampeliscidae	Ampeliscidae sp.		2	1				
		Ischyroceridae	Ischyroceridae sp.					1		1
		Lysianassidae	Lysianassidae sp.	2						
		Oedicerotidae	Oedicerotidae sp.		2					
		Phoxocephalidae	Phoxocephalidae sp.	1			1			
		Platyischnopidae	Platyischnopidae sp.	1		1				1
		Podoceridae	Podoceridae sp.					1		
Crustacea	Caridea	Pasiphaeidae	Pasiphaeidae sp.					1		
	Copepoda	Copepoda	Copepoda sp.					1		
	Cumacea	Bodotriidae	Bodotriidae sp.				1	2		
	Ostracoda	Ostracoda	Ostracoda sp.	1	2					
	Tanaidacea	Tanidae	Tanidae sp.		1					1
Echinodermata	Ophiuroidea	Ophiuroidea	Ophiuroidea sp.	1				1		1
Ectoprocta	Bryozoa	Bryozoa	Branching-sp.2							1
Mollusca	Gastropoda	Rissoidae	Rissoidae sp.		1					
Nematoda	Nematoda	Nematoda	Nematoda		1	1	1		2	1
Porifera	Porifera	Porifera	Solitary-Fan							1

4.4 Epibenthic Ecology

A total of 821 photographs were taken of the seafloor with the survey areas in Otway Basin. A total of 442 photographs used in this assessment (Appendix 5), with the remaining images excluded for the reasons as listed in Section 3.5.2. An average of 56 photographs were taken per survey area, 17 photographs per Hot Tap location and 15 photographs per umbilical route. Table 21 provides a summary of the number of photograph replicate samples used for the visual assessment, average (± standard deviation) for percent cover of epifauna, and total abundance of individual (and often mobile) epifauna organisms. Two example images from each survey area, Hot Tap and umbilical route are included in Appendix 6.

Figure 12 shows the average (± S.D.) percent cover of epifauna at each of the drop camera locations. Percent cover ranged from 0 to 80% of the sample photograph for all samples but on average the percent cover was typically no more than 37% cover. The seabed at Hot Tap X had the greatest average coverage of epibiota while the lowest coverage of epibiota was recorded along the CPT route between Artisan and Hot Tap Y (ARHTY) (Figure 12). Artisan and Hercules survey areas had a slighted greater coverage of epifauna, while the CPT routes between survey areas and Hot Tap Y had the least coverage of epifauna.

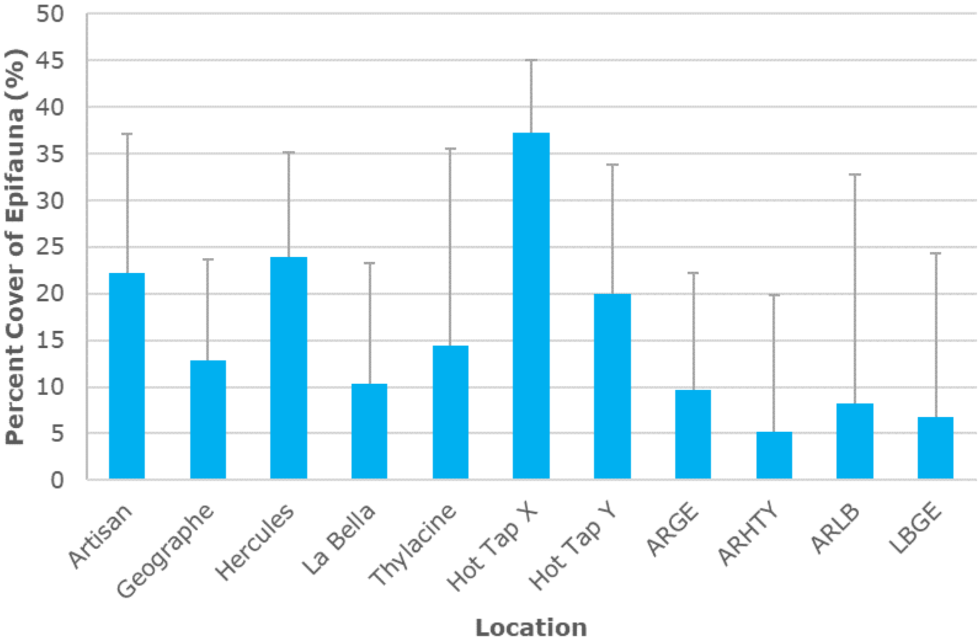


Figure 12 Percent cover of epifauna at drop camera location in Otway Basin.

Figure 13 provides information of the percent cover of epifauna at each drop camera site within these locations and shows the high variability of smaller-scale variability between drop camera sites. For example, the coverage of epifauna at most Thylacine drop camera sites was no more than 16% while at Thylacine 1 the percent cover was up 43% on average.

Of the individual epibenthic organisms, Gastropoda sp. 2 (a cone shell) and crionids (featherstars) were the most abundant (Table 21). Figure 14 shows an example of the seabed at Thylacine 1 (TH1) with a high percent cover of epifauna and a relatively high abundance of crinoids. Further examples are included in Appendix 6.

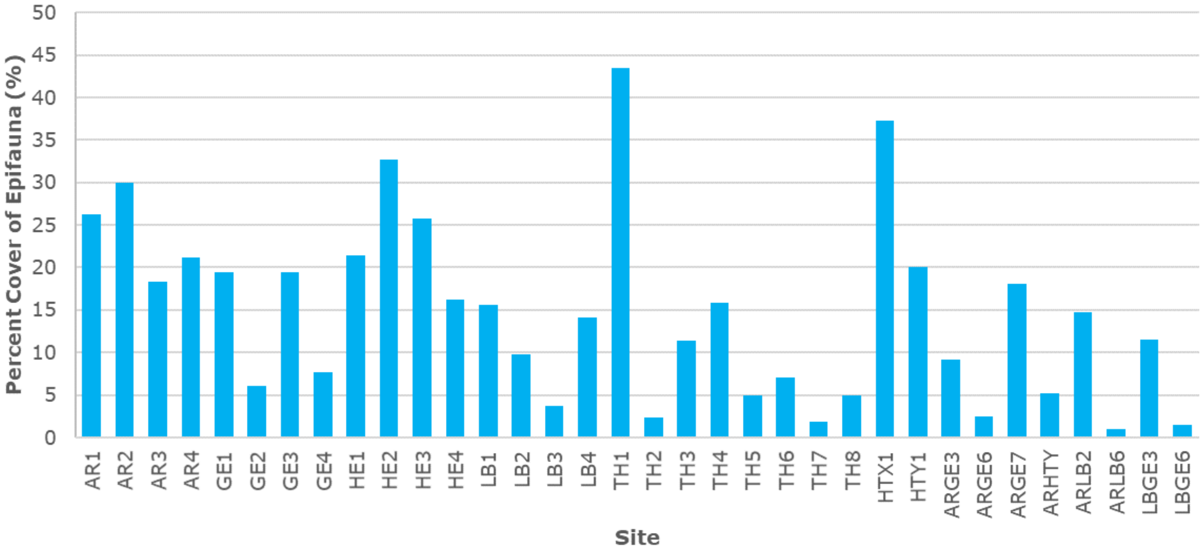


Figure 13 Percent cover of epifauna at drop camera sites in Otway Basin.

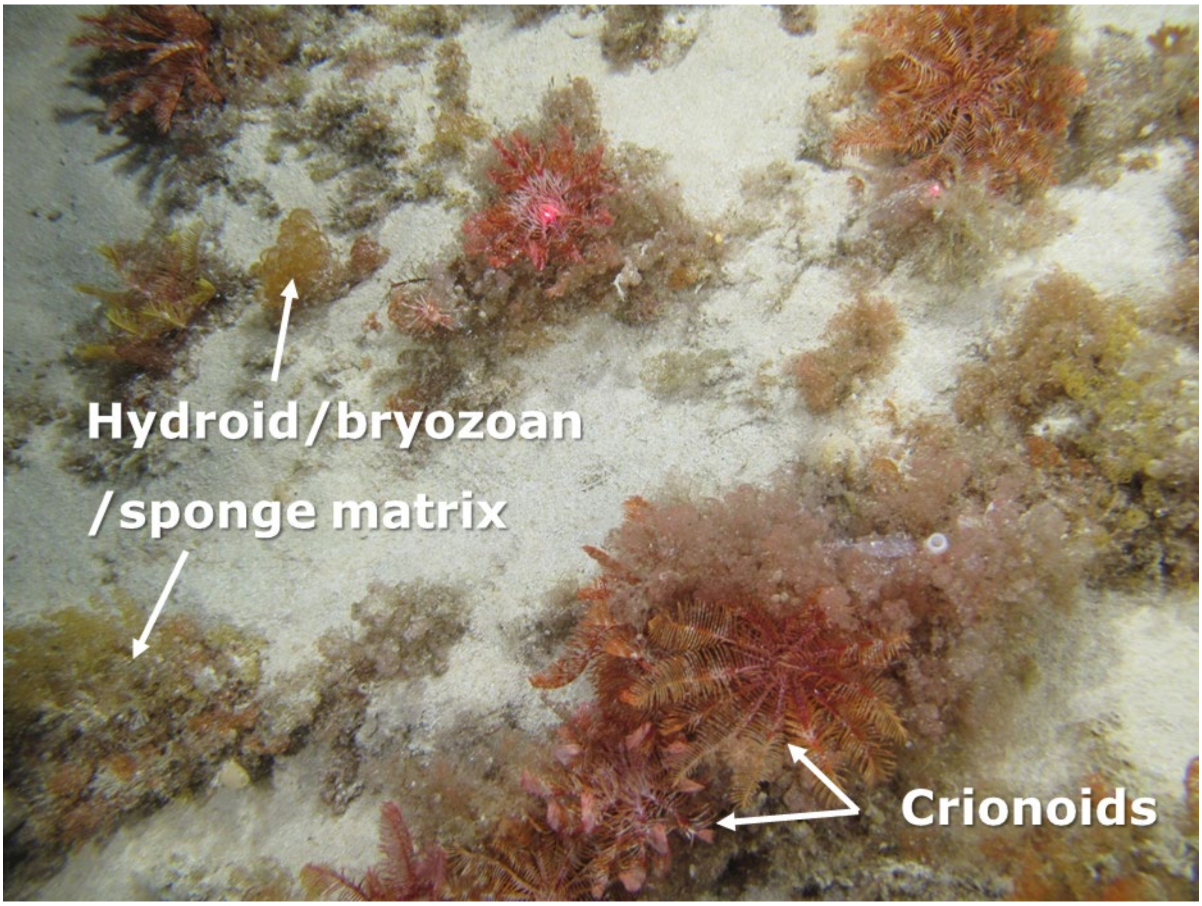


Figure 14 Example of the typical seabed epifauna with high percent cover at Thylacine 1 (TH1).

Table 21 Percent cover and total abundance of epibiota at drop camera sites.

Location	*n*	Percent cover of epifauna (%)		Total abundance of individual organisms								
				Crinoidea	Gastropoda spp.					Nudibranchia	Polychaeta	Teleostei
		Average	S.D.		Sp. 1	Sp. 2	Sp. 3	Sp. 4	Sp. 5			
AR1	4	26	15			4						
AR2	4	30	11			1						
AR3	9	18	11			1						
AR4	13	21	13			14						
GE1	9	19	21		2	2						
GE2	9	6	8		1							
GE3	9	19	14			1						
GE4	11	8	13			1						
HE1	14	21	15					2				
HE2	15	33	24		1	1		1				
HE3	14	26	18	1		2	1					
HE4	16	16	12		1							
LB1	9	16	10			1						
LB2	18	10	10									
LB3	15	4	2			4						
LB4	17	14	15			2		1				
TH1	16	43	14	40						1		
TH2	15	2	3		1	1						
TH3	21	11	7	8		7			2			
TH4	18	16	8	24								

Location	***n***	**Percent cover of epifauna (%)**		**Total abundance of individual organisms**								
				Crinoidea	**Gastropoda spp.**					**Nudibranchia**	**Polychaeta**	**Teleostei**
		Average	**S.D.**		**Sp. 1**	**Sp. 2**	**Sp. 3**	**Sp. 4**	**Sp. 5**			
TH5	1	5	-									
TH6	5	7	4									
TH7	8	2	3			1						
TH8	11	5	2			1						
HTX1	9	37	14		2	1		1				
HTY1	18	20	8			7		1	1			
ARGE3	12	9	8			6	1				1	
ARGE6	20	3	3			1						1
ARGE7	18	18	10			3		1				1
ARHTY	21	5	11	1	1	1				1		1
ARLB2	17	15	9			5	1					
ARLB6	15	1	2			7		1				
LBGE3	16	12	17			4						
LBGE6	14	1	2			1		1				

A composite, qualitative sample of epifauna from the Artisan field as examined and identified by the Benthic Australia invertebrate laboratory, with the results presented in Table 22. This epifauna was collected from grab samples at Artisan 1. This analysis shows that much of the epifauna is comprised of branching bryozoans, feather-like gorgonian cnidarians and sponges. This complex of encrusting/branching fauna provides refuge for macrofauna such as amphipods, isopods, polychaete worms and molluscs.

Table 22 Epifauna present in grab samples collected at the Artisan field.

Phylum	Class/ Order	Family	Morpho-species	Artisan_1_Epifauna
Annelida	Polychaeta	Amphinomidae	Hermodice spp.	1
		Eunicidae	Eunice spp.	1
		Phyllodocidae	Phyllodocidae sp.	1
		Syllidae	Syllidae sp.	2
		Terebellidae	Terebellidae sp.	1
Cnidaria	Alcyonacea	Alcyonacea	Gorgonian-Feather sp.	1
Crustacea	Amphipoda	Dexaminidae	Dexaminidae sp.	10
		Eusiridae	Eusiridae sp.	2
		Ischyroceridae	Ischyroceridae sp.	2
		Maeridae	Maeridae sp.1	3
			Maeridae sp.2	3
		Stegocephalidae	Stegocephalidae sp.	2
Crustacea	Isopoda	Valvifera	Valvifera sp.	1
Echinodermata	Ophiuroidea	Ophiuroidea	Ophiuroidea sp.	4
Ectoprocta	Bryozoa	Bryozoa	Branching-sp.1	7
			Branching-sp.2	2
Mollusca	Bivalvia	Glycymerididae	Glycymerididae sp.	1
	Gastropoda	c.f.Olividae	c.f.Olividae sp.	1
Porifera	Porifera	Porifera	Conglomerate-Branching sp.	3
			Conglomerate-Bulbous sp.1	4
			Conglomerate-Bulbous sp.2	2
			Solitary-Fan	4

5. DISCUSSION

The survey was conducted over in the Otway Basin covering five survey areas, two hot taps and five routes between those locations. The survey areas were located in offshore Commonwealth waters at 32 to 80 km from Port Campbell. Water depth ranged from 70 to 104 m.

The water quality at the Thylacine and Artisan survey areas indicated an undisturbed mid-depth environment, based on the six samples collected during the survey. There were low or undetectable levels of nutrients, metals/metalloids, BTEXs, PAHs and TRHs in the seawater samples. Metal and metalloids measurements were generally below ANZECC trigger values and within the range expected for unmodified, marine waters. The range of ORP measurements indicated a well oxygenated, ecologically healthy environment.

The sandy substrates described for Thylacine and Artisan survey areas are consistent with the reported description for the area of unconsolidated seabed sediments made up of carbonate sands (Barton et al., 2012; Murray-Wallace and Woodroffe, 2014). The sediment quality results were also consistent with Jones and Davies (1983) who described the grain size distribution as sand and gravel covering the entire shelf except for areas of silty sand in central Bass Strait and other locations more remote from the survey area. The authors noted a regional trend of 'reverse grading' whereby sediment tended to become coarser with distance from shore. Fine sand was reported to be the predominant sediment type along the inner shelf of Victoria and off much of Tasmania, grading seawards into medium-grain sand, and locally into coarse sand at the edge of the shelf (Jones and Davies, 1983). While the gravel fraction was not assessed, it is likely that some gravel occurs within the sediment as shown by some larger shell fragments observed in seabed photographs. Sediments had a high ORP and low or undetectable levels of toxicants indicating an unmodified seabed environment.

The Otway Basin is part of the Southeast Marine Bioregion which extends from the far south coast of New South Wales to Kangaroo Island (Commonwealth of Australia, 2015). Significant variation in seafloor features and water depth contribute to the high level of species diversity in the Region and the shelf habitats are reported to support a diverse range of species from a broad range of taxonomic groups (Commonwealth of Australia, 2015). However, there is no readily-available literature describing the seabed fauna of Otway Basin, meaning it is not possible to make a comparison of infauna and epifauna communities detected to prior studies. Most descriptions of the ecological values of the Basin or the Bioregion are at a broad scale and focus of key features such as cetaceans, birds, fisheries and macroalgae habitats (Commonwealth of Australia, 2015).

Based on the assessment of epifauna using seabed photographs, the general impression of the seafloor is of a unmodifed marine environment that supports a patchy complex of branching epibiota (i.e., bryozoans, gorgonian cnidarians and sponges). This complex was highly patchy, covering 0.25 m^2 on average but could be found in patches of at least 0.4 m^2.

A microscopic examination of a qualitative sample of this epibiota indicated that this complex of fauna provide microhabitat for a range of macrofauna such as amphipods, isopods, polychaete worms and molluscs. Such epifaunal habitats are known to provide refuge and other resources for benthic species (Jones, 2006). By comparison, there was a low abundance and diversity of infauna living within the sediment which reflects the coarse nature of the substrate. This type of substrate is highly mobile making it difficult for filter feeders and soft bodies invertebrates to survive and establish significant populations.

In summary, the epibiota on the seabed in the vicinity of the Thylacine and Artisan survey areas is representative of what is expected at depths around 70-100 m. The infauna was of relatively low abundance and diversity as expected for coarse sand substrates. No species or ecological communities listed as threatened under the Environmental Protection and Biodiversity Conservation Act 1999 (the EPBC Act) were observed.

6. REFERENCES

Barton, J.; Pope, A.; Howe S. (2012) Marine Natural Values Study Vol 2: Marine Protected Areas of the Otway Bioregion. Parks Victoria Technical series No. 75. Parks Victoria, Melbourne.

Commonwealth of Australia (2015) South-east marine region profile: A description of the ecosystems, conservation values and uses of the South-east Marine Region. 87 p. https://www.environment.gov.au/system/files/resources/7a110303-f9c7-44e4-b337-00cb2e4b9fbf/files/south-east-marine-region-profile.pdf [Accessed February 2020].

Jones, E.J. (2006) Bryozoan thickets on Otago shelf, New Zealand: a quantitative assessment of the epibenthos using underwater photography. MSc thesis. University of Otago, Dunedin, New Zealand. 213 p.

Jones, H.A.; Davies, P.J. (1983) Superficial sediments of the Tasmanian continental shelf and part of Bass Strait. Bureau of Mineral Resources, Geology and Geophysics bulletin no. 218. Canberra, Australian Government Publishing Service, 25 p.

Murray-Wallace, C.V.; Woodroffe, C.D. (2014) Quaternary sea-level changes: a global perspective. Cambridge University Press, Cambridge 484 p.

APPENDIX 1
ENVIRONMENTAL SAMPLE LOGS

SAMPLE MANAGEMENT ROUTINES

Project Code: 318000803

Project Name: Otway Offshore Development

Vessel: Vos Shine

Location: Artisan and Thylacine, Otway Basin

Sampling Team: Irene Middleton

Sampling Gear: Van Dorn 2.4L and Van Veen Double benthic grab sampler

Date: 22/11/2019

☑	**All samples are stored on board as required for the analysis**	
☒	**Once ashore samples are transported by air with the sampling team to Perth**	**Not required, samples sent directly from port to lab.**
☑	**All Chain of Costody (COC) forms are copied and saved to cloud storage prior to sample dispatch**	
☑	**Samples for contaminants analyses (metals, metalloids, hydrocarbons) are shipped by courier to EUROFINS in Melbourne with COC documentation**	
☑	**Samples for infaunal analysis are shipped via courier to Benthic Australia, Gladstone, QLD with COC documentation**	
☑	**Image data is saved in its entireity to two separate storage drives, each transported by a different team member to Ramboll's office (holding a relevant COC)**	**Only one team member transported storage drives as only one enviro team member on board at one time. Additional image data sent to Ramboll by Fugro via sercure file transfer.**
☑	**Image data is saved in its entireity to Ramboll's secure servers once back in the office (noted on COC when complete)**	

Comments:

SAMPLING LOG

Project Code: 318000803	**Project Name: Otway Offshore Development**

Vessel: VOS Shine	**Sampling Team: Irene Middleton**	**Sky/Wind: 20 knots**	**Date: 22/11/2019**
Location: Artisan	**Sampling Gear: Van Dorn 2.4L water sampler**	**Sea State: 2 m swell**	**Shift: 04:00-20:00**

Site No.	**Local Time**	**Sample No.**	**Replicate No.**	**Image ID**	**Sample Acceptable?**	**pH**	**ORP (mV)**	**Temperature (°C)**	**Dissolved oxygen (%/ppb)**	**Conductivity (uS/cm)**	**Visual Contamination**
AR 2	6:21	2	1	N/A	YES, Sampler A	8.08	172.1	13.6	93.1/7.78	497679	None
AR 1a	6:49	1	1	N/A	NO, sample rejected	-	-	-	-	-	-
AR 1b	7:11	1	2	N/A	YES, Sampler A	8.16	172.7	13.9	93.8/7.89	50112	None
AR 5	7:26	1	1	N/A	YES, Sampler A	8.34	164.5	13.4	93.8/7.89	50502	None

Comments: Sampler B was contaminated by a greasy hand print so all samples came from Sampler A. Blank samples were collected from Sampler A (labelled Blank A) and Sampler B (labelled Blank B).

SAMPLING LOG

Project Code: 318000803		**Project Name: Otway Offshore Development**	
Vessel: VOS Shine	**Sampling Team: Irene Middleton**	**Sky/Wind: 20 knots**	**Date: 22/11/2019**
Location: Artisan	**Sampling Gear: Van Veen Double benthic grab sampler**	**Sea State: 2 m swell**	**Shift: 04:00-20:00**

Site No.	Local Time	Sample No.	Replicate No.	Image ID	Sample Acceptable?	Munsell Colour	ORP (mV)	Texture / Surface or Vertical Structure	Odour (describe)	Visual Contamination	Organic Fragments /Bioturbation /other Fauna
AR_GS-1	8:36	1	1	1-5	NO, not enough material	7.5YR 8/4	-	Sand and epibenthos/sponges	None	None	Sponges, bryozoans, ascidians
AR_GS-1	9:12	1	2	-	NO, grab not triggered	-	-	-	-	-	-
AR_GS-1	9:40	1	3	6-10	YES, small sample used for composite sample	10YR 8/4	Not able to be measured for small sample	Sand, some sponge	None	None	Sponge, coral fragments and tubeworms
AR_GS-1	10:05	1	4	11-13	YES, small sample (3 cm deep) used for composite sample	10YR 8/4	176.4 at 2 cm	Sand	None	None	No sponges, just shell
AR_GS-1	10:39	1	5	14-15	NO	-	-	Only some epifauna retained for examination	None	None	Sponges and bryozoans
AR_GS-1	10:56	1	6	16-19	YES, small sample used for composite sediment sample, no infauna sampled	10YR 8/4	176.3 at 1 cm	Sand	None	None	Bryozoans and corals
AR4_GS-3_1	12:25	3	1	-	NO, grab not triggered	-	-	-	-	-	-
AR4_GS-3_2	12:45	3	2	20-21	NO, small sample (3 cm deep) for sediment only. Infauna grab not triggered	10YR 8/4	217.3 at 2 cm	Shelly sand	None	None	-

AR4_GS-3_3	13:20	3	3	22-24	YES, good sample	10YR 8/4	241.2 at 1 cm	Shelly sand	None	None	-
AR4_GS-3_4	13:30	3	4	25-26	YES, infauna only, 7 cm deep	10YR 8/4	202.3 at 1 cm	Shell coarse hash	None	None	None

Comments: Sample quality was variable and did not always meet the acceptability criteria but allowances were made to get some material for processing.

SAMPLING LOG

Project Code: 318000803	**Project Name: Otway Offshore Development**

Vessel: VOS Shine	**Sampling Team: Irene Middleton**	**Sky/Wind: 20 knots**	**Date: 22/11/2019**
Location: Thylacine	**Sampling Gear: Van Veen Double benthic grab sampler**	**Sea State: 2 m swell**	**Shift: 04:00-20:00**

Site No.	Local Time	Sample No.	Replicate No.	Image ID	Sample Acceptable?	Munsell Colour	ORP (mV)	Texture / Surface or Vertical Structure	Odour (describe)	Visual Contamination	Organic Fragments /Bioturbation /other Fauna
TH_GS1	17:12	1	0	27-30	YES, 15 cm deep	10YR 8/4	216.7 at 3 cm	Shelly and	None	None	Shell coarse, sand
TH_GS1_1	17:42	1	1	31-33	YES	10YR 8/4	211.0 at 2 cm	Shelly sand	None	None	Shell coarse, sand
TH_GS1_2	18:04	1	2	34-36	YES	10YR 8/4	252.7 at 1 cm	Shelly sand	None	None	Shell coarse, sand
TH_GS1_3	18:26	1	3	37-40	YES	10YR 8/4	242.7 at 1cm	Shelly sand	None	None	Shell coarse, sand

Comments:

SAMPLING LOG

Project Code: 318000803	**Project Name: Otway Offshore Development**

Vessel: VOS Shine	**Sampling Team: Irene Middleton**	**Sky/Wind: 20 knots**	**Date: 22/11/2019**
Location: Artisan and Thylacine	**Sampling Gear: Van Dorn 2.4L water sampler**	**Sea State: 2 m swell**	**Shift: 04:00-20:00**

Site No.	**Local Time**	**Sample No.**	**Replicate No.**	**Image ID**	**Sample Acceptable?**	**pH**	**ORP (mV)**	**Temperature (°C)**	**Dissolved oxygen (%/ppb)**	**Conductivity (uS/cm)**	**Visual Contamination**
TH_GS1	19:13	1	1	N/A	YES, Sampler A	8.19	215	13.4	94.3/8.07	No clear/steady reading	None
TH_GS1	19:30	1	2	N/A	YES, Sampler A	8.24	211.4	13.2	95.2/8.33	No clear/steady reading	None
TH_GS1	19:40	1	3	N/A	YES, Sampler A	8.33	198.1	13.2	95.2/8.16	No clear/steady reading	None

Comments:

SAMPLING LOG _REDOX MEASUREMENTS

Project Code: 318000803

Project Name: Otway Offshore Development

Recorder: Irene Middleton

Sample Acceptable: Only acceptable samples used

Date: 22/11/2019

Time (local): 0400-2000

ORP Reading Depth (mm)																					
Site No.	**Sample No.**	**Replicate No.**	**Surface**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**150**	**160**	**170**	**180**
Artisan GS	1	4	No surface measurements as hard sand surface gave indeterminate readings	176.2	176.4	No further penetration															
Artisan GS	1	6		176.3	No further penetration																
Artisan GS 3	2	1	As above	242.1	217.3	No further penetration															
Artisan GS 3	2	2	As above	241.2	No further penetration																
Artisan GS 3	2	3	As above	202.3	No further penetration																
Thylacine GS 2	1	1	As above	225.5	223.0	216.7	No further penetration														
Thylacine GS 1	1	1	As above	211.0	211.0	No further penetration															
Thylacine GS 1	1	1	As above	252.7	No further penetration																
Thylacine GS 1	1	1	As above	242.7	No further penetration																

Comments:

APPENDIX 2
WATER QUALITY LABORATORY REPORT

Certificate of Analysis

Ramboll Australia Pty Ltd
Suite 3, Level 2, 200 Adelaide Terrace
East Perth
WA 6004

NATA Accredited
Accreditation Number 1261
Site Number 1254

Accredited for compliance with ISO/IEC 17025 – Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Attention:	**Dan McClary**
Report	**690395-W**
Project name	OTWAY OFFSHORE EBS
Project ID	318000803
Received Date	Dec 04, 2019

Client Sample ID			**THYLACINE_GS1_1**	**THYLACINE_GS1_2**	**THYLACINE_G1_3**	**ARTISON_1**
Sample Matrix			**Water**	**Water**	**Water**	**Water**
Eurofins Sample No.			**M19-No38322**	**M19-No38323**	**M19-No38324**	**M19-No38325**
Date Sampled			**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**
Test/Reference	LOR	Unit				
Total Recoverable Hydrocarbons - 1999 NEPM Fractions						
TRH C6-C9	0.02	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
TRH C10-C14	0.05	mg/L	< 0.05	0.05	< 0.05	< 0.05
TRH C15-C28	0.1	mg/L	< 0.1	0.1	< 0.1	< 0.1
TRH C29-C36	0.1	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
TRH C10-C36 (Total)	0.1	mg/L	< 0.1	0.15	< 0.1	< 0.1
BTEX						
Benzene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Toluene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Ethylbenzene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
m&p-Xylenes	0.002	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
o-Xylene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Xylenes - Total	0.003	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
4-Bromofluorobenzene (surr.)	1	%	106	94	107	94
Total Recoverable Hydrocarbons - 2013 NEPM Fractions						
Naphthalene[N02]	0.01	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
TRH C6-C10	0.02	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
TRH C6-C10 less BTEX (F1)[N04]	0.02	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
TRH >C10-C16	0.05	mg/L	< 0.05	0.07	< 0.05	< 0.05
TRH >C10-C16 less Naphthalene (F2)[N01]	0.05	mg/L	< 0.05	0.07	< 0.05	< 0.05
TRH >C16-C34	0.1	mg/L	< 0.1	0.1	< 0.1	< 0.1
TRH >C34-C40	0.1	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
TRH >C10-C40 (total)*	0.1	mg/L	< 0.1	0.17	< 0.1	< 0.1
Polycyclic Aromatic Hydrocarbons						
Acenaphthene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Acenaphthylene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Anthracene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Benz(a)anthracene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Benzo(a)pyrene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Benzo(b&j)fluoranthene[N07]	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Benzo(g.h.i)perylene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Benzo(k)fluoranthene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Chrysene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Dibenz(a.h)anthracene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Fluoranthene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Fluorene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001

Client Sample ID			THYLACINE_GS1_1	THYLACINE_GS1_2	THYLACINE_G1_3	ARTISON_1
Sample Matrix			**Water**	**Water**	**Water**	**Water**
Eurofins Sample No.			**M19-No38322**	**M19-No38323**	**M19-No38324**	**M19-No38325**
Date Sampled			**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**
Test/Reference	LOR	Unit				
Polycyclic Aromatic Hydrocarbons						
Indeno(1.2.3-cd)pyrene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Naphthalene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Phenanthrene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Pyrene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Total PAH*	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
2-Fluorobiphenyl (surr.)	1	%	111	107	109	109
p-Terphenyl-d14 (surr.)	1	%	134	145	138	93
Ammonia (as N)	0.01	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Chlorophyll a	5	ug/L	< 10	< 10	< 10	< 10
Nitrate & Nitrite (as N)	0.05	mg/L	< 0.05	< 0.05	0.10	< 0.05
Nitrate (as N)	0.02	mg/L	0.03	0.02	0.10	< 0.02
Nitrite (as N)	0.02	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Phosphate total (as P)	0.01	mg/L	0.03	0.02	0.02	0.02
Phosphorus reactive (as P)	0.01	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
Total Kjeldahl Nitrogen (as N)	0.2	mg/L	< 0.2	< 0.2	2.4	< 0.2
Total Nitrogen (as N)*	0.2	mg/L	< 0.2	< 0.2	2.5	< 0.2
Total Suspended Solids Dried at 103–105°C	1	mg/L	3.4	9.7	2.4	5.9
Heavy Metals						
Arsenic	0.001	mg/L	0.001	0.004	0.002	0.003
Cadmium	0.0002	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Cobalt	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Copper	0.001	mg/L	< 0.001	< 0.001	0.002	0.001
Lead	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Mercury	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel	0.001	mg/L	< 0.001	< 0.001	0.001	< 0.001
Zinc	0.005	mg/L	0.011	0.012	0.022	0.018

Client Sample ID			ARTISON_2	ARTISON_5	BLANK A	BLANK B
Sample Matrix			**Water**	**Water**	**Water**	**Water**
Eurofins Sample No.			**M19-No38326**	**M19-No38327**	**M19-No38328**	**M19-No38329**
Date Sampled			**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**
Test/Reference	LOR	Unit				
Total Recoverable Hydrocarbons - 1999 NEPM Fractions						
TRH C6-C9	0.02	mg/L	< 0.02	< 0.02	0.03	< 0.02
TRH C10-C14	0.05	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
TRH C15-C28	0.1	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
TRH C29-C36	0.1	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
TRH C10-C36 (Total)	0.1	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
BTEX						
Benzene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Toluene	0.001	mg/L	< 0.001	< 0.001	0.003	< 0.001
Ethylbenzene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
m&p-Xylenes	0.002	mg/L	< 0.002	< 0.002	< 0.002	< 0.002
o-Xylene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Xylenes - Total	0.003	mg/L	< 0.003	< 0.003	< 0.003	< 0.003
4-Bromofluorobenzene (surr.)	1	%	102	100	96	92

Client Sample ID			**ARTISON_2**	**ARTISON_5**	**BLANK A**	**BLANK B**
Sample Matrix			**Water**	**Water**	**Water**	**Water**
Eurofins Sample No.			**M19-No38326**	**M19-No38327**	**M19-No38328**	**M19-No38329**
Date Sampled			**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**
Test/Reference	LOR	Unit				
Total Recoverable Hydrocarbons - 2013 NEPM Fractions						
Naphthalene[N02]	0.01	mg/L	< 0.01	< 0.01	< 0.01	< 0.01
TRH C6-C10	0.02	mg/L	< 0.02	< 0.02	0.03	< 0.02
TRH C6-C10 less BTEX (F1)[N04]	0.02	mg/L	< 0.02	< 0.02	0.03	< 0.02
TRH >C10-C16	0.05	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
TRH >C10-C16 less Naphthalene (F2)[N01]	0.05	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
TRH >C16-C34	0.1	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
TRH >C34-C40	0.1	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
TRH >C10-C40 (total)*	0.1	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
Polycyclic Aromatic Hydrocarbons						
Acenaphthene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Acenaphthylene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Anthracene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Benz(a)anthracene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Benzo(a)pyrene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Benzo(b&j)fluoranthene[N07]	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Benzo(g.h.i)perylene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Benzo(k)fluoranthene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Chrysene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Dibenz(a.h)anthracene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Fluoranthene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Fluorene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Indeno(1.2.3-cd)pyrene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Naphthalene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Phenanthrene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Pyrene	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Total PAH*	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
2-Fluorobiphenyl (surr.)	1	%	114	117	97	56
p-Terphenyl-d14 (surr.)	1	%	102	101	52	67
Ammonia (as N)	0.01	mg/L	< 0.01	< 0.01	0.03	< 0.01
Chlorophyll a	5	ug/L	< 10	< 10	-	-
Nitrate & Nitrite (as N)	0.05	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Nitrate (as N)	0.02	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Nitrite (as N)	0.02	mg/L	< 0.02	< 0.02	< 0.02	< 0.02
Phosphate total (as P)	0.01	mg/L	0.01	0.01	< 0.01	< 0.01
Phosphorus reactive (as P)	0.01	mg/L	0.01	< 0.01	< 0.01	< 0.01
Total Kjeldahl Nitrogen (as N)	0.2	mg/L	< 0.2	< 0.2	< 0.2	< 0.2
Total Nitrogen (as N)*	0.2	mg/L	< 0.2	< 0.2	< 0.2	< 0.2
Total Suspended Solids Dried at 103–105°C	1	mg/L	4.6	5.2	< 1	3.1
Heavy Metals						
Arsenic	0.001	mg/L	0.005	0.010	0.001	0.001
Cadmium	0.0002	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Chromium	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Cobalt	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Copper	0.001	mg/L	0.001	0.001	< 0.001	0.040
Lead	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Mercury	0.0001	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Nickel	0.001	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
Zinc	0.005	mg/L	0.010	0.014	0.021	0.032

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Eurofins | mgt Suite B4			
Total Recoverable Hydrocarbons - 1999 NEPM Fractions	Melbourne	Dec 09, 2019	7 Days
- Method: LTM-ORG-2010 TRH C6-C40			
BTEX	Melbourne	Dec 06, 2019	14 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Total Recoverable Hydrocarbons - 2013 NEPM Fractions	Melbourne	Dec 06, 2019	7 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Total Recoverable Hydrocarbons - 2013 NEPM Fractions	Melbourne	Dec 09, 2019	
- Method: LTM-ORG-2010 TRH C6-C40			
Polycyclic Aromatic Hydrocarbons	Melbourne	Dec 09, 2019	7 Days
- Method: LTM-ORG-2130 PAH and Phenols in Soil and Water			
Eurofins | mgt Suite B19E: Total N, TKN, NOx, NO2, NO3, NH3, Total P, Reactive P			
Ammonia (as N)	Melbourne	Dec 09, 2019	28 Days
- Method: LTM-INO-4200 Ammonia by Discrete Analyser			
Nitrate & Nitrite (as N)	Melbourne	Dec 09, 2019	28 Days
- Method: LTM-INO-4120 Analysis of NOx NO2 NH3 by FIA			
Nitrate (as N)	Melbourne	Dec 09, 2019	28 Days
- Method: LTM-INO-4120 Analysis of NOx NO2 NH3 by FIA			
Nitrite (as N)	Melbourne	Dec 09, 2019	2 Days
- Method: LTM-INO-4120 Analysis of NOx NO2 NH3 by FIA			
Phosphate total (as P)	Melbourne	Dec 09, 2019	28 Days
- Method: APHA 4500-P E. Phosphorus			
Phosphorus reactive (as P)	Melbourne	Dec 09, 2019	2 Days
- Method: APHA 4500-P			
Total Kjeldahl Nitrogen (as N)	Melbourne	Dec 09, 2019	7 Days
- Method: LTM-INO-4310 TKN in Waters & Soils by FIA			
Chlorophyll a	Melbourne	Dec 06, 2019	2 Days
- Method: LTM-INO-4340 Chlorophyll a in Waters			
Total Suspended Solids Dried at 103–105°C	Melbourne	Dec 09, 2019	7 Days
- Method: LTM-INO-4070 Analysis of Suspended Solids in Water by Gravimetry			
Heavy Metals	Sydney	Dec 11, 2019	180 Days
- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS			

Company Name: Ramboll Australia Pty Ltd
Address: Suite 3, Level 2, 200 Adelaide Terrace
East Perth
WA 6004

Project Name: OTWAY OFFSHORE EBS
Project ID: 318000803

Order No.:
Report #: 690395
Phone: 08 9225 5199
Fax:

Received: Dec 4, 2019 10:56 AM
Due: Dec 11, 2019
Priority: 5 Day
Contact Name: ALL INVOICES

Eurofins Analytical Services Manager : Robert Johnston

Sample Detail						Arsenic	Cadmium	Chlorophyll a	Chromium	Cobalt	Copper	Lead	Mercury	Nickel	Pheophytin*	Total Suspended Solids Dried at 103–105°C	Zinc	Eurofins | mgt Suite B4	Eurofins | mgt Suite B19E: Total N, TKN, NOx, NO2, NO3, NH3, Total P, Reactive P
Melbourne Laboratory - NATA Site # 1254 & 14271								X							X	X		X	X
Sydney Laboratory - NATA Site # 18217 & 14271						X	X		X	X	X	X	X	X			X		
Brisbane Laboratory - NATA Site # 20794 & 14271																			
Perth Laboratory - NATA Site # 23736 & 14271																			
External Laboratory																			
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**														
1	THYLACINE_GS1_1	Nov 22, 2019		Water	M19-No38322	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	THYLACINE_GS1_2	Nov 22, 2019		Water	M19-No38323	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3	THYLACINE_G1_3	Nov 22, 2019		Water	M19-No38324	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4	ARTISON_1	Nov 22, 2019		Water	M19-No38325	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	ARTISON_2	Nov 22, 2019		Water	M19-No38326	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6	ARTISON_5	Nov 22, 2019		Water	M19-No38327	X	X	X	X	X	X	X	X	X		X	X	X	X
7	BLANK A	Nov 22, 2019		Water	M19-No38328	X	X	X	X	X	X	X	X	X		X	X	X	X
8	BLANK B	Nov 22, 2019		Water	M19-No38329	X	X	X	X	X	X	X	X	X		X	X	X	X

Company Name:	Ramboll Australia Pty Ltd	**Order No.:**		**Received:**	Dec 4, 2019 10:56 AM
Address:	Suite 3, Level 2, 200 Adelaide Terrace East Perth WA 6004	**Report #:**	690395	**Due:**	Dec 11, 2019
		Phone:	08 9225 5199	**Priority:**	5 Day
		Fax:		**Contact Name:**	ALL INVOICES
Project Name:	OTWAY OFFSHORE EBS				
Project ID:	318000803				

Eurofins Analytical Services Manager : Robert Johnston

Sample Detail	Arsenic	Cadmium	Chlorophyll a	Chromium	Cobalt	Copper	Lead	Mercury	Nickel	Pheophytin*	Total Suspended Solids Dried at 103–105°C	Zinc	Eurofins | mgt Suite B4	Eurofins | mgt Suite B19E: Total N, TKN, NOx, NO2, NO3, NH3, Total P, Reactive P
Melbourne Laboratory - NATA Site # 1254 & 14271			X							X	X		X	X
Sydney Laboratory - NATA Site # 18217 & 14271	X	X		X	X	X	X	X	X			X		
Brisbane Laboratory - NATA Site # 20794 & 14271														
Perth Laboratory - NATA Site # 23736 & 14271														
Test Counts	8	8	8	8	8	8	8	8	8	5	8	8	8	8

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram
mg/L: milligrams per litre
ug/L: micrograms per litre
ppm: Parts per million
ppb: Parts per billion
%: Percentage
org/100mL: Organisms per 100 millilitres
NTU: Nephelometric Turbidity Units
MPN/100mL: Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Total Recoverable Hydrocarbons - 1999 NEPM Fractions							
TRH C6-C9	mg/L	< 0.02			0.02	Pass	
TRH C10-C14	mg/L	< 0.05			0.05	Pass	
TRH C15-C28	mg/L	< 0.1			0.1	Pass	
TRH C29-C36	mg/L	< 0.1			0.1	Pass	
Method Blank							
BTEX							
Benzene	mg/L	< 0.001			0.001	Pass	
Toluene	mg/L	< 0.001			0.001	Pass	
Ethylbenzene	mg/L	< 0.001			0.001	Pass	
m&p-Xylenes	mg/L	< 0.002			0.002	Pass	
o-Xylene	mg/L	< 0.001			0.001	Pass	
Xylenes - Total	mg/L	< 0.003			0.003	Pass	
Method Blank							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	mg/L	< 0.01			0.01	Pass	
TRH C6-C10	mg/L	< 0.02			0.02	Pass	
TRH >C10-C16	mg/L	< 0.05			0.05	Pass	
TRH >C16-C34	mg/L	< 0.1			0.1	Pass	
TRH >C34-C40	mg/L	< 0.1			0.1	Pass	
Method Blank							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	mg/L	< 0.001			0.001	Pass	
Acenaphthylene	mg/L	< 0.001			0.001	Pass	
Anthracene	mg/L	< 0.001			0.001	Pass	
Benz(a)anthracene	mg/L	< 0.001			0.001	Pass	
Benzo(a)pyrene	mg/L	< 0.001			0.001	Pass	
Benzo(b&j)fluoranthene	mg/L	< 0.001			0.001	Pass	
Benzo(g.h.i)perylene	mg/L	< 0.001			0.001	Pass	
Benzo(k)fluoranthene	mg/L	< 0.001			0.001	Pass	
Chrysene	mg/L	< 0.001			0.001	Pass	
Dibenz(a.h)anthracene	mg/L	< 0.001			0.001	Pass	
Fluoranthene	mg/L	< 0.001			0.001	Pass	
Fluorene	mg/L	< 0.001			0.001	Pass	
Indeno(1.2.3-cd)pyrene	mg/L	< 0.001			0.001	Pass	
Naphthalene	mg/L	< 0.001			0.001	Pass	
Phenanthrene	mg/L	< 0.001			0.001	Pass	
Pyrene	mg/L	< 0.001			0.001	Pass	
Method Blank							
Ammonia (as N)	mg/L	< 0.01			0.01	Pass	
Nitrate & Nitrite (as N)	mg/L	< 0.05			0.05	Pass	
Nitrate (as N)	mg/L	< 0.02			0.02	Pass	
Nitrite (as N)	mg/L	< 0.02			0.02	Pass	
Phosphate total (as P)	mg/L	< 0.01			0.01	Pass	
Phosphorus reactive (as P)	mg/L	< 0.01			0.01	Pass	
Total Kjeldahl Nitrogen (as N)	mg/L	< 0.2			0.2	Pass	
Total Suspended Solids Dried at 103–105°C	mg/L	< 1			1	Pass	
Method Blank							
Heavy Metals							
Arsenic	mg/L	< 0.001			0.001	Pass	
Cadmium	mg/L	< 0.0002			0.0002	Pass	

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Chromium	mg/L	< 0.001			0.001	Pass	
Cobalt	mg/L	< 0.001			0.001	Pass	
Copper	mg/L	< 0.001			0.001	Pass	
Lead	mg/L	< 0.001			0.001	Pass	
Mercury	mg/L	< 0.0001			0.0001	Pass	
Nickel	mg/L	< 0.001			0.001	Pass	
Zinc	mg/L	< 0.005			0.005	Pass	
LCS - % Recovery							
Total Recoverable Hydrocarbons - 1999 NEPM Fractions							
TRH C6-C9	%	94			70-130	Pass	
TRH C10-C14	%	115			70-130	Pass	
LCS - % Recovery							
BTEX							
Benzene	%	92			70-130	Pass	
Toluene	%	79			70-130	Pass	
Ethylbenzene	%	83			70-130	Pass	
m&p-Xylenes	%	76			70-130	Pass	
Xylenes - Total	%	78			70-130	Pass	
LCS - % Recovery							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	%	77			70-130	Pass	
TRH C6-C10	%	94			70-130	Pass	
TRH >C10-C16	%	107			70-130	Pass	
LCS - % Recovery							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	%	87			70-130	Pass	
Acenaphthylene	%	85			70-130	Pass	
Anthracene	%	72			70-130	Pass	
Benz(a)anthracene	%	99			70-130	Pass	
Benzo(a)pyrene	%	72			70-130	Pass	
Benzo(b&j)fluoranthene	%	72			70-130	Pass	
Benzo(g.h.i)perylene	%	75			70-130	Pass	
Benzo(k)fluoranthene	%	98			70-130	Pass	
Chrysene	%	99			70-130	Pass	
Dibenz(a.h)anthracene	%	80			70-130	Pass	
Fluoranthene	%	85			70-130	Pass	
Fluorene	%	100			70-130	Pass	
Indeno(1.2.3-cd)pyrene	%	98			70-130	Pass	
Naphthalene	%	86			70-130	Pass	
Phenanthrene	%	95			70-130	Pass	
Pyrene	%	86			70-130	Pass	
LCS - % Recovery							
Ammonia (as N)	%	100			70-130	Pass	
Nitrate & Nitrite (as N)	%	101			70-130	Pass	
Nitrate (as N)	%	101			70-130	Pass	
Nitrite (as N)	%	106			70-130	Pass	
Phosphate total (as P)	%	95			70-130	Pass	
Phosphorus reactive (as P)	%	95			70-130	Pass	
Total Kjeldahl Nitrogen (as N)	%	84			70-130	Pass	
Total Suspended Solids Dried at 103–105°C	%	98			70-130	Pass	
LCS - % Recovery							
Heavy Metals							
Arsenic	%	90			70-130	Pass	
Cadmium	%	92			70-130	Pass	

Test			Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Chromium			%	98			70-130	Pass	
Cobalt			%	100			70-130	Pass	
Copper			%	100			70-130	Pass	
Lead			%	101			70-130	Pass	
Mercury			%	96			70-130	Pass	
Nickel			%	99			70-130	Pass	
Zinc			%	98			70-130	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Spike - % Recovery									
Total Recoverable Hydrocarbons - 1999 NEPM Fractions				Result 1					
TRH C10-C14	M19-De05914	NCP	%	111			70-130	Pass	
Spike - % Recovery									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1					
TRH >C10-C16	M19-De05914	NCP	%	104			70-130	Pass	
Spike - % Recovery									
				Result 1					
Ammonia (as N)	M19-De03315	NCP	%	97			70-130	Pass	
Nitrate & Nitrite (as N)	M19-De03315	NCP	%	97			70-130	Pass	
Nitrate (as N)	M19-De03315	NCP	%	97			70-130	Pass	
Nitrite (as N)	B19-De03253	NCP	%	106			70-130	Pass	
Total Kjeldahl Nitrogen (as N)	N19-De04634	NCP	%	91			70-130	Pass	
Spike - % Recovery									
Polycyclic Aromatic Hydrocarbons				Result 1					
Acenaphthene	M19-No38324	CP	%	84			70-130	Pass	
Acenaphthylene	M19-No38324	CP	%	85			70-130	Pass	
Anthracene	M19-No38324	CP	%	74			70-130	Pass	
Benz(a)anthracene	M19-No38324	CP	%	72			70-130	Pass	
Benzo(a)pyrene	M19-No38324	CP	%	82			70-130	Pass	
Benzo(b&j)fluoranthene	M19-No38324	CP	%	79			70-130	Pass	
Benzo(g.h.i)perylene	M19-No38324	CP	%	89			70-130	Pass	
Benzo(k)fluoranthene	M19-No38324	CP	%	113			70-130	Pass	
Chrysene	M19-No38324	CP	%	106			70-130	Pass	
Dibenz(a.h)anthracene	M19-No38324	CP	%	83			70-130	Pass	
Fluoranthene	M19-No38324	CP	%	89			70-130	Pass	
Fluorene	M19-No38324	CP	%	101			70-130	Pass	
Indeno(1.2.3-cd)pyrene	M19-No38324	CP	%	82			70-130	Pass	
Naphthalene	M19-No38324	CP	%	81			70-130	Pass	
Phenanthrene	M19-No38324	CP	%	93			70-130	Pass	
Pyrene	M19-No38324	CP	%	94			70-130	Pass	
Spike - % Recovery									
				Result 1					
Phosphate total (as P)	M19-No38324	CP	%	92			70-130	Pass	
Spike - % Recovery									
Heavy Metals				Result 1					
Arsenic	M19-No38329	CP	%	95			70-130	Pass	
Cadmium	M19-No38329	CP	%	94			70-130	Pass	
Chromium	M19-No38329	CP	%	87			70-130	Pass	
Cobalt	M19-No38329	CP	%	88			70-130	Pass	
Copper	M19-No38329	CP	%	84			70-130	Pass	
Lead	M19-No38329	CP	%	90			70-130	Pass	
Mercury	M19-No38329	CP	%	80			70-130	Pass	
Nickel	M19-No38329	CP	%	85			70-130	Pass	
Zinc	M19-No38329	CP	%	88			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Duplicate									
Total Recoverable Hydrocarbons - 1999 NEPM Fractions				Result 1	Result 2	RPD			
TRH C6-C9	B19-De02116	NCP	mg/L	< 0.02	< 0.02	<1	30%	Pass	
TRH C10-C14	M19-De05913	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
TRH C15-C28	M19-De05913	NCP	mg/L	< 0.1	< 0.1	<1	30%	Pass	
TRH C29-C36	M19-De05913	NCP	mg/L	< 0.1	< 0.1	<1	30%	Pass	
Duplicate									
BTEX				Result 1	Result 2	RPD			
Benzene	B19-De02116	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Toluene	B19-De02116	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Ethylbenzene	B19-De02116	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
m&p-Xylenes	B19-De02116	NCP	mg/L	< 0.002	< 0.002	<1	30%	Pass	
o-Xylene	B19-De02116	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Xylenes - Total	B19-De02116	NCP	mg/L	< 0.003	< 0.003	<1	30%	Pass	
Duplicate									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1	Result 2	RPD			
Naphthalene	B19-De02116	NCP	mg/L	< 0.01	< 0.01	<1	30%	Pass	
TRH C6-C10	B19-De02116	NCP	mg/L	< 0.02	< 0.02	<1	30%	Pass	
TRH >C10-C16	M19-De05913	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
TRH >C16-C34	M19-De05913	NCP	mg/L	< 0.1		<1	30%	Pass	
TRH >C34-C40	M19-De05913	NCP	mg/L	< 0.1		<1	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
Ammonia (as N)	B19-De03253	NCP	mg/L	< 0.01	< 0.01	<1	30%	Pass	
Chlorophyll a	M19-De06051	NCP	ug/L	28	34	21	30%	Pass	
Nitrate & Nitrite (as N)	B19-De03253	NCP	mg/L	< 0.05	< 0.05	<1	30%	Pass	
Nitrate (as N)	B19-De03253	NCP	mg/L	0.04	0.05	34	30%	Fail	Q15
Nitrite (as N)	B19-De03253	NCP	mg/L	< 0.02	< 0.02	<1	30%	Pass	
Phosphate total (as P)	M19-De05566	NCP	mg/L	0.91	0.88	4.0	30%	Pass	
Total Kjeldahl Nitrogen (as N)	M19-De03633	NCP	mg/L	79	77	2.8	30%	Pass	
Total Suspended Solids Dried at 103–105°C	M19-De06128	NCP	mg/L	230	230	<1	30%	Pass	
Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Arsenic	M19-No38322	CP	mg/L	0.001	0.001	2.0	30%	Pass	
Cadmium	M19-No38322	CP	mg/L	< 0.0002	< 0.0002	<1	30%	Pass	
Chromium	M19-No38322	CP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Cobalt	M19-No38322	CP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Copper	M19-No38322	CP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Lead	M19-No38322	CP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Mercury	M19-No38322	CP	mg/L	< 0.0001	< 0.0001	<1	30%	Pass	
Nickel	M19-No38322	CP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Zinc	M19-No38322	CP	mg/L	0.011	0.012	9.0	30%	Pass	
Duplicate									
Polycyclic Aromatic Hydrocarbons				Result 1	Result 2	RPD			
Acenaphthene	M19-No38323	CP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Acenaphthylene	M19-No38323	CP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Anthracene	M19-No38323	CP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Benz(a)anthracene	M19-No38323	CP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Benzo(a)pyrene	M19-No38323	CP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Benzo(b&j)fluoranthene	M19-No38323	CP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Benzo(g.h.i)perylene	M19-No38323	CP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Benzo(k)fluoranthene	M19-No38323	CP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Chrysene	M19-No38323	CP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Dibenz(a.h)anthracene	M19-No38323	CP	mg/L	< 0.001	< 0.001	<1	30%	Pass	

Duplicate									
Polycyclic Aromatic Hydrocarbons				Result 1	Result 2	RPD			
Fluoranthene	M19-No38323	CP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Fluorene	M19-No38323	CP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Indeno(1.2.3-cd)pyrene	M19-No38323	CP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Naphthalene	M19-No38323	CP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Phenanthrene	M19-No38323	CP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Pyrene	M19-No38323	CP	mg/L	< 0.001	< 0.001	<1	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
N01	F2 is determined by arithmetically subtracting the "naphthalene" value from the ">C10-C16" value. The naphthalene value used in this calculation is obtained from volatiles (Purge & Trap analysis).
N02	Where we have reported both volatile (P&T GCMS) and semivolatile (GCMS) naphthalene data, results may not be identical. Provided correct sample handling protocols have been followed, any observed differences in results are likely to be due to procedural differences within each methodology. Results determined by both techniques have passed all QAQC acceptance criteria, and are entirely technically valid.
N04	F1 is determined by arithmetically subtracting the "Total BTEX" value from the "C6-C10" value. The "Total BTEX" value is obtained by summing the concentrations of BTEX analytes. The "C6-C10" value is obtained by quantitating against a standard of mixed aromatic/aliphatic analytes.
N07	Please note:- These two PAH isomers closely co-elute using the most contemporary analytical methods and both the reported concentration (and the TEQ) apply specifically to the total of the two co-eluting PAHs
Q15	The RPD reported passes Eurofins Environment Testing's QC - Acceptance Criteria as defined in the Internal Quality Control Review and Glossary page of this report.

Authorised By

Robert Johnston	Analytical Services Manager
Gabriele Cordero	Senior Analyst-Metal (NSW)
Harry Bacalis	Senior Analyst-Volatile (VIC)
Joseph Edouard	Senior Analyst-Organic (VIC)
Julie Kay	Senior Analyst-Inorganic (VIC)

Glenn Jackson

General Manager

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

Environment Testing

Certificate of Analysis

NATA Accredited
Accreditation Number 1261
Site Number 1254

Accredited for compliance with ISO/IEC 17025 – Testing
The results of the tests, calibrations and/or
measurements included in this document are traceable
to Australian/national standards.

Ramboll Australia Pty Ltd
Suite 3, Level 2, 200 Adelaide Terrace
East Perth
WA 6004

Attention:	**Dan McClary**
Report	**690387-A**
Project name	OTWAY OFFSHORE EBS
Project ID	318000803
Received Date	Dec 04, 2019

Client Sample ID			**ARTISON-1**	**ARTISON-5**	**ARTISON-2**	**THYLACINE GS1_3**
Sample Matrix			**Filter paper**	**Filter paper**	**Filter paper**	**Filter paper**
Eurofins Sample No.			**M19-No38257**	**M19-No38258**	**M19-No38259**	**M19-No38260**
Date Sampled			**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**
Test/Reference	LOR	Unit				
Chlorophyll a	10	ug/L	< 10	< 10	< 10	< 10

Client Sample ID			**THYLACINE GS1_1**	**THYLACINE GS1_2**
Sample Matrix			**Filter paper**	**Filter paper**
Eurofins Sample No.			**M19-No38261**	**M19-No38262**
Date Sampled			**Nov 22, 2019**	**Nov 22, 2019**
Test/Reference	LOR	Unit		
Chlorophyll a	10	ug/L	< 10	< 10

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Chlorophyll a	Melbourne	Nov 27, 2019	2 Days
- Method:			

Company Name:	Ramboll Australia Pty Ltd	**Order No.:**		**Received:**	Dec 4, 2019 1:54 PM
Address:	Suite 3, Level 2, 200 Adelaide Terrace East Perth WA 6004	**Report #:**	690387	**Due:**	Dec 5, 2019
		Phone:	08 9225 5199	**Priority:**	7 Day
		Fax:		**Contact Name:**	ALL INVOICES
Project Name:	OTWAY OFFSHORE EBS				
Project ID:	318000803				

Eurofins Analytical Services Manager : Swati Shahaney

Sample Detail						% Clay	% Sand	% Silt	Cadmium	Chlorophyll a	Chromium	Copper	Lead	Mercury	Nickel	Silicon (Aqua regia extractable)	Tin	Total Organic Carbon	Zinc	Moisture Set	Eurofins | mgt Suite B19A: Total N (TKN, NOx), Total P
Melbourne Laboratory - NATA Site # 1254 & 14271									X	X	X	X	X	X	X	X	X	X	X	X	X
Sydney Laboratory - NATA Site # 18217																					
Brisbane Laboratory - NATA Site # 20794						X	X	X													
Perth Laboratory - NATA Site # 23736																					
External Laboratory																					
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**																
1	THYLACINE_ GS1_3_MET1	Nov 22, 2019		Soil	M19-No38233	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
2	THYLACINE_ GS1_3_MET2	Nov 22, 2019		Soil	M19-No38234	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
3	THYLACINE_ GS1_3_PSD1	Nov 22, 2019		Soil	M19-No38235	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
4	THYLACINE_ GS1_MET2	Nov 22, 2019		Soil	M19-No38236	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
5	THYLACINE_ GS-1_MET1	Nov 22, 2019		Soil	M19-No38237	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
6	THYLACINE_	Nov 22, 2019		Soil	M19-No38238	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X

Company Name:	Ramboll Australia Pty Ltd	**Order No.:**		**Received:**	Dec 4, 2019 1:54 PM
Address:	Suite 3, Level 2, 200 Adelaide Terrace East Perth WA 6004	**Report #:**	690387	**Due:**	Dec 5, 2019
		Phone:	08 9225 5199	**Priority:**	7 Day
		Fax:		**Contact Name:**	ALL INVOICES
Project Name:	OTWAY OFFSHORE EBS				
Project ID:	318000803				

Eurofins Analytical Services Manager : Swati Shahaney

Sample Detail						% Clay	% Sand	% Silt	Cadmium	Chlorophyll a	Chromium	Copper	Lead	Mercury	Nickel	Silicon (Aqua regia extractable)	Tin	Total Organic Carbon	Zinc	Moisture Set	Eurofins | mgt Suite B19A: Total N (TKN, NOx), Total P
Melbourne Laboratory - NATA Site # 1254 & 14271									X	X	X	X	X	X	X	X	X	X	X	X	X
Sydney Laboratory - NATA Site # 18217																					
Brisbane Laboratory - NATA Site # 20794						X	X	X													
Perth Laboratory - NATA Site # 23736																					
	GS-1_PSD1																				
7	THYLACINE_GS1-2_PSD1	Nov 22, 2019		Soil	M19-No38239	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
8	THYLACINE_GS1-2_MET1	Nov 22, 2019		Soil	M19-No38240	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
9	THYLACINE_GS1-2_MET2	Nov 22, 2019		Soil	M19-No38241	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
10	THYLACINE_GS2_PSD1	Nov 22, 2019		Soil	M19-No38242	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
11	THYLACINE_GS2_MET1	Nov 22, 2019		Soil	M19-No38243	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
12	THYLACINE_GS2_MET2	Nov 22, 2019		Soil	M19-No38244	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
13	ARTISON-	Nov 22, 2019		Soil	M19-No38245	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X

Company Name: Ramboll Australia Pty Ltd
Address: Suite 3, Level 2, 200 Adelaide Terrace
East Perth
WA 6004

Project Name: OTWAY OFFSHORE EBS
Project ID: 318000803

Order No.:
Report #: 690387
Phone: 08 9225 5199
Fax:

Received: Dec 4, 2019 1:54 PM
Due: Dec 5, 2019
Priority: 7 Day
Contact Name: ALL INVOICES

Eurofins Analytical Services Manager : Swati Shahaney

Sample Detail						% Clay	% Sand	% Silt	Cadmium	Chlorophyll a	Chromium	Copper	Lead	Mercury	Nickel	Silicon (Aqua regia extractable)	Tin	Total Organic Carbon	Zinc	Moisture Set	Eurofins | mgt Suite B19A: Total N (TKN, NOx), Total P
Melbourne Laboratory - NATA Site # 1254 & 14271									X	X	X	X	X	X	X	X	X	X	X	X	X
Sydney Laboratory - NATA Site # 18217																					
Brisbane Laboratory - NATA Site # 20794						X	X	X													
Perth Laboratory - NATA Site # 23736																					
	GS_A_PAR 4																				
14	ARTISON-GS_A_PAR 3	Nov 22, 2019		Soil	M19-No38246	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
15	ARTISON-GSA_MET1	Nov 22, 2019		Soil	M19-No38247	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
16	ARTISON-GSA_PAR1	Nov 22, 2019		Soil	M19-No38248	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
17	ARTISON-GSA_MET2	Nov 22, 2019		Soil	M19-No38249	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
18	ARTISON-GSA_PAR2	Nov 22, 2019		Soil	M19-No38250	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
19	ARTISON-GS3_PAR1	Nov 22, 2019		Soil	M19-No38251	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
20	ARTISON-	Nov 22, 2019		Soil	M19-No38252	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X

Company Name: Ramboll Australia Pty Ltd
Address: Suite 3, Level 2, 200 Adelaide Terrace
East Perth
WA 6004

Project Name: OTWAY OFFSHORE EBS
Project ID: 318000803

Order No.:
Report #: 690387
Phone: 08 9225 5199
Fax:

Received: Dec 4, 2019 1:54 PM
Due: Dec 5, 2019
Priority: 7 Day
Contact Name: ALL INVOICES

Eurofins Analytical Services Manager : Swati Shahaney

Sample Detail						% Clay	% Sand	% Silt	Cadmium	Chlorophyll a	Chromium	Copper	Lead	Mercury	Nickel	Silicon (Aqua regia extractable)	Tin	Total Organic Carbon	Zinc	Moisture Set	Eurofins | mgt Suite B19A: Total N (TKN, NOx), Total P
Melbourne Laboratory - NATA Site # 1254 & 14271									X	X	X	X	X	X	X	X	X	X	X	X	X
Sydney Laboratory - NATA Site # 18217																					
Brisbane Laboratory - NATA Site # 20794						X	X	X													
Perth Laboratory - NATA Site # 23736																					
	GS3_MET1																				
21	ARTISON-GS3_PAR 4	Nov 22, 2019		Soil	M19-No38253	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
22	ARTISON-GS3_PAR 2	Nov 22, 2019		Soil	M19-No38254	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
23	ARTISON-GS3_MET 2	Nov 22, 2019		Soil	M19-No38255	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
24	ARTISON-GS3_PAR 3	Nov 22, 2019		Soil	M19-No38256	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
25	ARTISON-1	Nov 22, 2019		Filter paper	M19-No38257					X											
26	ARTISON-5	Nov 22, 2019		Filter paper	M19-No38258					X											
27	ARTISON-2	Nov 22, 2019		Filter paper	M19-No38259					X											
28	THYLACINE GS1_3	Nov 22, 2019		Filter paper	M19-No38260					X											

Company Name:	Ramboll Australia Pty Ltd	**Order No.:**		**Received:**	Dec 4, 2019 1:54 PM
Address:	Suite 3, Level 2, 200 Adelaide Terrace East Perth WA 6004	**Report #:**	690387	**Due:**	Dec 5, 2019
		Phone:	08 9225 5199	**Priority:**	7 Day
		Fax:		**Contact Name:**	ALL INVOICES
Project Name:	OTWAY OFFSHORE EBS				
Project ID:	318000803				

Eurofins Analytical Services Manager : Swati Shahaney

Sample Detail						% Clay	% Sand	% Silt	Cadmium	Chlorophyll a	Chromium	Copper	Lead	Mercury	Nickel	Silicon (Aqua regia extractable)	Tin	Total Organic Carbon	Zinc	Moisture Set	Eurofins | mgt Suite B19A: Total N (TKN, NOx), Total P
Melbourne Laboratory - NATA Site # 1254 & 14271									X	X	X	X	X	X	X	X	X	X	X	X	X
Sydney Laboratory - NATA Site # 18217																					
Brisbane Laboratory - NATA Site # 20794						X	X	X													
Perth Laboratory - NATA Site # 23736																					
29	THYLACINE GS1_1	Nov 22, 2019		Filter paper	M19-No38261					X											
30	THYLACINE GS1_2	Nov 22, 2019		Filter paper	M19-No38262					X											
Test Counts						24	24	24	24	6	24	24	24	24	24	24	24	24	24	24	24

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram
ppm: Parts per million
org/100mL: Organisms per 100 millilitres
mg/L: milligrams per litre
ppb: Parts per billion
NTU: Nephelometric Turbidity Units
ug/L: micrograms per litre
%: Percentage
MPN/100mL: Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Authorised By

Robert Johnston	Analytical Services Manager
Julie Kay	Senior Analyst-Inorganic (VIC)
Scott Beddoes	Senior Analyst-Inorganic (VIC)

Glenn Jackson
General Manager

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

APPENDIX 3
SEDIMENT QUALITY LABORATORY REPORT

Certificate of Analysis

Ramboll Australia Pty Ltd
Suite 3, Level 2, 200 Adelaide Terrace
East Perth
WA 6004

NATA Accredited
Accreditation Number 1261
Site Number 1254

Accredited for compliance with ISO/IEC 17025 – Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

NATA
WORLD RECOGNISED ACCREDITATION

Attention: **Dan McClary**

Report **690387-S**
Project name OTWAY OFFSHORE EBS
Project ID 318000803
Received Date Dec 04, 2019

Client Sample ID			**THYLACINE_GS1_3_MET1**	**THYLACINE_GS1_3_MET2**	**THYLACINE_GS1_3_PSD1**	**THYLACINE_GS1_MET2**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M19-No38233**	**M19-No38234**	**M19-No38235**	**M19-No38236**
Date Sampled			**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**
Test/Reference	LOR	Unit				
% Clay	1	%	4.7	3.1	3.3	3.7
% Sand		%	95	95	97	96
% Silt		%	< 1	1.6	< 1	< 1
Nitrate & Nitrite (as N)	5	mg/kg	< 5	< 5	< 5	< 5
Total Kjeldahl Nitrogen (as N)	10	mg/kg	130	71	110	160
Total Nitrogen (as N)*	10	mg/kg	130	71	110	160
Total Organic Carbon	0.1	%	0.5	1.8	2.7	4.8
Phosphorus	5	mg/kg	400	660	740	610
Silicon (Aqua regia extractable)	5	mg/kg	950	750	630	970
% Moisture	1	%	37	34	37	36
Heavy Metals						
Cadmium	0.4	mg/kg	< 0.4	< 0.4	< 0.4	< 0.4
Chromium	5	mg/kg	6.4	5.7	5.6	6.7
Copper	5	mg/kg	< 5	< 5	< 5	< 5
Lead	5	mg/kg	< 5	< 5	< 5	< 5
Mercury	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	5	mg/kg	< 5	< 5	< 5	< 5
Tin	10	mg/kg	< 10	< 10	< 10	< 10
Zinc	5	mg/kg	< 5	< 5	7.8	< 5

Client Sample ID			**THYLACINE_GS-1_MET1**	**THYLACINE_GS-1_PSD1**	**THYLACINE_GS1-2_PSD1**	**THYLACINE_GS1-2_MET1**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M19-No38237**	**M19-No38238**	**M19-No38239**	**M19-No38240**
Date Sampled			**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**
Test/Reference	LOR	Unit				
% Clay	1	%	2.8	1.7	4.4	3.1
% Sand		%	96	98	96	95
% Silt		%	1.4	< 1	< 1	1.5
Nitrate & Nitrite (as N)	5	mg/kg	< 5	< 5	< 5	< 5
Total Kjeldahl Nitrogen (as N)	10	mg/kg	230	210	310	190
Total Nitrogen (as N)*	10	mg/kg	230	210	310	190
Total Organic Carbon	0.1	%	1.3	0.4	1.9	0.9

Client Sample ID			THYLACINE_GS-1_MET1	THYLACINE_GS-1_PSD1	THYLACINE_GS1-2_PSD1	THYLACINE_GS1-2_MET1
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M19-No38237**	**M19-No38238**	**M19-No38239**	**M19-No38240**
Date Sampled			**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**
Test/Reference	LOR	Unit				
Phosphorus	5	mg/kg	750	870	550	620
Silicon (Aqua regia extractable)	5	mg/kg	850	940	890	1000
% Moisture	1	%	34	35	37	38
Heavy Metals						
Cadmium	0.4	mg/kg	< 0.4	< 0.4	< 0.4	< 0.4
Chromium	5	mg/kg	6.2	5.7	5.2	6.6
Copper	5	mg/kg	< 5	< 5	< 5	< 5
Lead	5	mg/kg	< 5	< 5	< 5	< 5
Mercury	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	5	mg/kg	< 5	< 5	< 5	< 5
Tin	10	mg/kg	< 10	< 10	< 10	< 10
Zinc	5	mg/kg	7.2	< 5	< 5	< 5

Client Sample ID			THYLACINE_GS1-2_MET2	THYLACINE_GS2_PSD1	THYLACINE_GS2_MET1	THYLACINE_GS2_MET2
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M19-No38241**	**M19-No38242**	**M19-No38243**	**M19-No38244**
Date Sampled			**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**
Test/Reference	LOR	Unit				
% Clay	1	%	3.9	2.5	3.3	2.9
% Sand		%	96	98	97	97
% Silt		%	< 1	< 1	< 1	< 1
Nitrate & Nitrite (as N)	5	mg/kg	< 5	< 5	< 5	< 5
Total Kjeldahl Nitrogen (as N)	10	mg/kg	260	290	180	220
Total Nitrogen (as N)*	10	mg/kg	260	290	180	220
Total Organic Carbon	0.1	%	1.4	1.7	< 0.1	0.5
Phosphorus	5	mg/kg	630	830	< 200	500
Silicon (Aqua regia extractable)	5	mg/kg	980	700	460	600
% Moisture	1	%	38	39	35	38
Heavy Metals						
Cadmium	0.4	mg/kg	< 0.4	< 0.4	< 0.4	< 0.4
Chromium	5	mg/kg	5.1	5.7	< 5	6.3
Copper	5	mg/kg	< 5	< 5	< 5	< 5
Lead	5	mg/kg	< 5	< 5	< 5	< 5
Mercury	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	5	mg/kg	< 5	< 5	< 5	< 5
Tin	10	mg/kg	< 10	< 10	< 10	< 10
Zinc	5	mg/kg	< 5	< 5	< 5	< 5

Client Sample ID			ARTISON-GS_A_PAR 4	ARTISON-GS_A_PAR 3	ARTISON-GSA_MET1	ARTISON-GSA_PAR1
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M19-No38245**	**M19-No38246**	**M19-No38247**	**M19-No38248**
Date Sampled			**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**
Test/Reference	LOR	Unit				
% Clay	1	%	< 1	< 1	3.6	3.1
% Sand		%	100	97	96	95
% Silt		%	< 1	2.9	< 1	1.5
Nitrate & Nitrite (as N)	5	mg/kg	< 5	< 5	< 5	< 5
Total Kjeldahl Nitrogen (as N)	10	mg/kg	340	370	310	250
Total Nitrogen (as N)*	10	mg/kg	340	370	310	250
Total Organic Carbon	0.1	%	< 0.1	< 0.1	1.6	0.4
Phosphorus	5	mg/kg	< 200	860	620	440
Silicon (Aqua regia extractable)	5	mg/kg	490	630	570	580
% Moisture	1	%	34	34	37	29
Heavy Metals						
Cadmium	0.4	mg/kg	< 0.4	< 0.4	< 0.4	< 0.4
Chromium	5	mg/kg	8.0	7.4	11	6.9
Copper	5	mg/kg	< 5	< 5	< 5	< 5
Lead	5	mg/kg	< 5	< 5	< 5	< 5
Mercury	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	5	mg/kg	< 5	< 5	< 5	< 5
Tin	10	mg/kg	< 10	< 10	< 10	< 10
Zinc	5	mg/kg	5.2	9.0	9.4	< 5

Client Sample ID			ARTISON-GSA_MET2	ARTISON-GSA_PAR2	ARTISON-GS3_PAR1	ARTISON-GS3_MET1
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M19-No38249**	**M19-No38250**	**M19-No38251**	**M19-No38252**
Date Sampled			**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**
Test/Reference	LOR	Unit				
% Clay	1	%	3.7	3.0	3.9	4.1
% Sand		%	96	97	96	96
% Silt		%	< 1	< 1	< 1	< 1
Nitrate & Nitrite (as N)	5	mg/kg	< 5	< 5	< 5	< 5
Total Kjeldahl Nitrogen (as N)	10	mg/kg	370	340	440	270
Total Nitrogen (as N)*	10	mg/kg	370	340	440	270
Total Organic Carbon	0.1	%	< 0.1	1.1	< 0.1	2.4
Phosphorus	5	mg/kg	460	< 200	730	530
Silicon (Aqua regia extractable)	5	mg/kg	600	520	770	810
% Moisture	1	%	34	34	36	35
Heavy Metals						
Cadmium	0.4	mg/kg	< 0.4	< 0.4	< 0.4	< 0.4
Chromium	5	mg/kg	6.0	6.4	6.6	8.1
Copper	5	mg/kg	< 5	< 5	< 5	< 5
Lead	5	mg/kg	6.9	< 5	< 5	< 5
Mercury	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	5	mg/kg	< 5	< 5	< 5	< 5
Tin	10	mg/kg	< 10	< 10	< 10	< 10
Zinc	5	mg/kg	25	5.4	< 5	< 5

Client Sample ID			**ARTISON-GS3_PAR 4**	**ARTISON-GS3_PAR 2**	**ARTISON-GS3_MET 2**	**ARTISON-GS3_PAR 3**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M19-No38253**	**M19-No38254**	**M19-No38255**	**M19-No38256**
Date Sampled			**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**
Test/Reference	LOR	Unit				
% Clay	1	%	4.8	3.5	3.6	4.0
% Sand		%	95	95	96	96
% Silt		%	< 1	1.8	< 1	< 1
Nitrate & Nitrite (as N)	5	mg/kg	< 5	< 5	< 5	< 5
Total Kjeldahl Nitrogen (as N)	10	mg/kg	310	270	150	310
Total Nitrogen (as N)*	10	mg/kg	310	270	150	310
Total Organic Carbon	0.1	%	0.6	4.9	1.6	1.8
Phosphorus	5	mg/kg	570	400	390	480
Silicon (Aqua regia extractable)	5	mg/kg	830	520	650	640
% Moisture	1	%	36	35	34	34
Heavy Metals						
Cadmium	0.4	mg/kg	< 0.4	< 0.4	< 0.4	< 0.4
Chromium	5	mg/kg	9.0	8.1	9.5	8.0
Copper	5	mg/kg	< 5	< 5	< 5	< 5
Lead	5	mg/kg	< 5	< 5	< 5	< 5
Mercury	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Nickel	5	mg/kg	< 5	< 5	< 5	< 5
Tin	10	mg/kg	< 10	< 10	< 10	< 10
Zinc	5	mg/kg	< 5	< 5	< 5	< 5

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
% Clay	Brisbane	Dec 13, 2019	0 Days
- Method: LTM-GEN-7040			
% Sand	Brisbane	Dec 09, 2019	0 Days
- Method: LTM-GEN-7040			
% Silt	Brisbane	Dec 09, 2019	0 Days
- Method: LTM-GEN-7040			
Total Organic Carbon	Melbourne	Dec 16, 2019	28 Days
- Method: LTM-INO-4060 Total Organic Carbon in water and soil			
Silicon (Aqua regia extractable)	Melbourne	Dec 06, 2019	180 Days
- Method: LTM-MET-3010 Alkali Metals Sulfur Silicon and Phosphorus by ICP-AES			
Heavy Metals	Melbourne	Dec 06, 2019	180 Days
- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS			
Total Nitrogen Set (as N)			
Nitrate & Nitrite (as N)	Melbourne	Dec 06, 2019	28 Days
- Method: LTM-INO-4120 Analysis of NOx NO2 NH3 by FIA			
Total Kjeldahl Nitrogen (as N)	Melbourne	Dec 06, 2019	28 Days
- Method: LTM-INO-4310 TKN in Waters & Soils by FIA			
Eurofins | mgt Suite B19A: Total N (TKN, NOx), Total P			
Phosphorus	Melbourne	Dec 06, 2019	180 Days
- Method: LTM-MET-3010 Alkali Metals Sulfur Silicon and Phosphorus by ICP-AES			
% Moisture	Melbourne	Nov 27, 2019	14 Days
- Method: LTM-GEN-7080 Moisture			

Company Name: Ramboll Australia Pty Ltd
Address: Suite 3, Level 2, 200 Adelaide Terrace
East Perth
WA 6004

Project Name: OTWAY OFFSHORE EBS
Project ID: 318000803

Order No.:
Report #: 690387
Phone: 08 9225 5199
Fax:

Received: Dec 4, 2019 1:54 PM
Due: Dec 5, 2019
Priority: 7 Day
Contact Name: ALL INVOICES

Eurofins Analytical Services Manager : Swati Shahaney

Sample Detail						% Clay	% Sand	% Silt	Cadmium	Chlorophyll a	Chromium	Copper	Lead	Mercury	Nickel	Silicon (Aqua regia extractable)	Tin	Total Organic Carbon	Zinc	Moisture Set	Eurofins | mgt Suite B19A: Total N (TKN, NOx), Total P
Melbourne Laboratory - NATA Site # 1254 & 14271									X	X	X	X	X	X	X	X	X	X	X	X	X
Sydney Laboratory - NATA Site # 18217																					
Brisbane Laboratory - NATA Site # 20794						X	X	X													
Perth Laboratory - NATA Site # 23736																					
External Laboratory																					
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**																
1	THYLACINE_ GS1_3_MET1	Nov 22, 2019		Soil	M19-No38233	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
2	THYLACINE_ GS1_3_MET2	Nov 22, 2019		Soil	M19-No38234	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
3	THYLACINE_ GS1_3_PSD1	Nov 22, 2019		Soil	M19-No38235	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
4	THYLACINE_ GS1_MET2	Nov 22, 2019		Soil	M19-No38236	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
5	THYLACINE_ GS-1_MET1	Nov 22, 2019		Soil	M19-No38237	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
6	THYLACINE_	Nov 22, 2019		Soil	M19-No38238	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X

Company Name:	Ramboll Australia Pty Ltd	**Order No.:**		**Received:**	Dec 4, 2019 1:54 PM
Address:	Suite 3, Level 2, 200 Adelaide Terrace East Perth WA 6004	**Report #:**	690387	**Due:**	Dec 5, 2019
		Phone:	08 9225 5199	**Priority:**	7 Day
		Fax:		**Contact Name:**	ALL INVOICES
Project Name:	OTWAY OFFSHORE EBS				
Project ID:	318000803				

Eurofins Analytical Services Manager : Swati Shahaney

Sample Detail						% Clay	% Sand	% Silt	Cadmium	Chlorophyll a	Chromium	Copper	Lead	Mercury	Nickel	Silicon (Aqua regia extractable)	Tin	Total Organic Carbon	Zinc	Moisture Set	Eurofins | mgt Suite B19A: Total N (TKN, NOx), Total P
Melbourne Laboratory - NATA Site # 1254 & 14271									X	X	X	X	X	X	X	X	X	X	X	X	X
Sydney Laboratory - NATA Site # 18217																					
Brisbane Laboratory - NATA Site # 20794						X	X	X													
Perth Laboratory - NATA Site # 23736																					
	GS-1_PSD1																				
7	THYLACINE_ GS1-2_PSD1	Nov 22, 2019		Soil	M19-No38239	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
8	THYLACINE_ GS1-2_MET1	Nov 22, 2019		Soil	M19-No38240	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
9	THYLACINE_ GS1-2_MET2	Nov 22, 2019		Soil	M19-No38241	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
10	THYLACINE_ GS2_PSD1	Nov 22, 2019		Soil	M19-No38242	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
11	THYLACINE_ GS2_MET1	Nov 22, 2019		Soil	M19-No38243	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
12	THYLACINE_ GS2_MET2	Nov 22, 2019		Soil	M19-No38244	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
13	ARTISON-	Nov 22, 2019		Soil	M19-No38245	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X

Company Name:	Ramboll Australia Pty Ltd	**Order No.:**		**Received:**	Dec 4, 2019 1:54 PM
Address:	Suite 3, Level 2, 200 Adelaide Terrace East Perth WA 6004	**Report #:**	690387	**Due:**	Dec 5, 2019
		Phone:	08 9225 5199	**Priority:**	7 Day
		Fax:		**Contact Name:**	ALL INVOICES
Project Name:	OTWAY OFFSHORE EBS				
Project ID:	318000803				

Eurofins Analytical Services Manager : Swati Shahaney

Sample Detail						% Clay	% Sand	% Silt	Cadmium	Chlorophyll a	Chromium	Copper	Lead	Mercury	Nickel	Silicon (Aqua regia extractable)	Tin	Total Organic Carbon	Zinc	Moisture Set	Eurofins | mgt Suite B19A: Total N (TKN, NOx), Total P
Melbourne Laboratory - NATA Site # 1254 & 14271									X	X	X	X	X	X	X	X	X	X	X	X	X
Sydney Laboratory - NATA Site # 18217																					
Brisbane Laboratory - NATA Site # 20794						X	X	X													
Perth Laboratory - NATA Site # 23736																					
	GS_A_PAR 4																				
14	ARTISON-GS_A_PAR 3	Nov 22, 2019		Soil	M19-No38246	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
15	ARTISON-GSA_MET1	Nov 22, 2019		Soil	M19-No38247	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
16	ARTISON-GSA_PAR1	Nov 22, 2019		Soil	M19-No38248	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
17	ARTISON-GSA_MET2	Nov 22, 2019		Soil	M19-No38249	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
18	ARTISON-GSA_PAR2	Nov 22, 2019		Soil	M19-No38250	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
19	ARTISON-GS3_PAR1	Nov 22, 2019		Soil	M19-No38251	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
20	ARTISON-	Nov 22, 2019		Soil	M19-No38252	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X

Company Name:	Ramboll Australia Pty Ltd	**Order No.:**	
Address:	Suite 3, Level 2, 200 Adelaide Terrace East Perth WA 6004	**Report #:**	690387
		Phone:	08 9225 5199
		Fax:	
Project Name:	OTWAY OFFSHORE EBS	**Received:**	Dec 4, 2019 1:54 PM
Project ID:	318000803	**Due:**	Dec 5, 2019
		Priority:	7 Day
		Contact Name:	ALL INVOICES

Eurofins Analytical Services Manager : Swati Shahaney

Sample Detail						% Clay	% Sand	% Silt	Cadmium	Chlorophyll a	Chromium	Copper	Lead	Mercury	Nickel	Silicon (Aqua regia extractable)	Tin	Total Organic Carbon	Zinc	Moisture Set	Eurofins | mgt Suite B19A: Total N (TKN, NOx), Total P
Melbourne Laboratory - NATA Site # 1254 & 14271									X	X	X	X	X	X	X	X	X	X	X	X	X
Sydney Laboratory - NATA Site # 18217																					
Brisbane Laboratory - NATA Site # 20794						X	X	X													
Perth Laboratory - NATA Site # 23736																					
	GS3_MET1																				
21	ARTISON-GS3_PAR 4	Nov 22, 2019		Soil	M19-No38253	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
22	ARTISON-GS3_PAR 2	Nov 22, 2019		Soil	M19-No38254	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
23	ARTISON-GS3_MET 2	Nov 22, 2019		Soil	M19-No38255	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
24	ARTISON-GS3_PAR 3	Nov 22, 2019		Soil	M19-No38256	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
25	ARTISON-1	Nov 22, 2019		Filter paper	M19-No38257					X											
26	ARTISON-5	Nov 22, 2019		Filter paper	M19-No38258					X											
27	ARTISON-2	Nov 22, 2019		Filter paper	M19-No38259					X											
28	THYLACINE GS1_3	Nov 22, 2019		Filter paper	M19-No38260					X											

Company Name: Ramboll Australia Pty Ltd
Address: Suite 3, Level 2, 200 Adelaide Terrace
East Perth
WA 6004

Order No.:
Report #: 690387
Phone: 08 9225 5199
Fax:

Received: Dec 4, 2019 1:54 PM
Due: Dec 5, 2019
Priority: 7 Day
Contact Name: ALL INVOICES

Project Name: OTWAY OFFSHORE EBS
Project ID: 318000803

Eurofins Analytical Services Manager : Swati Shahaney

Sample Detail						% Clay	% Sand	% Silt	Cadmium	Chlorophyll a	Chromium	Copper	Lead	Mercury	Nickel	Silicon (Aqua regia extractable)	Tin	Total Organic Carbon	Zinc	Moisture Set	Eurofins | mgt Suite B19A: Total N (TKN, NOx), Total P
Melbourne Laboratory - NATA Site # 1254 & 14271									X	X	X	X	X	X	X	X	X	X	X	X	X
Sydney Laboratory - NATA Site # 18217																					
Brisbane Laboratory - NATA Site # 20794						X	X	X													
Perth Laboratory - NATA Site # 23736																					
29	THYLACINE GS1_1	Nov 22, 2019		Filter paper	M19-No38261					X											
30	THYLACINE GS1_2	Nov 22, 2019		Filter paper	M19-No38262					X											
Test Counts						24	24	24	24	6	24	24	24	24	24	24	24	24	24	24	24

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram	**mg/L:** milligrams per litre	**ug/L:** micrograms per litre
ppm: Parts per million	**ppb:** Parts per billion	**%:** Percentage
org/100mL: Organisms per 100 millilitres	**NTU:** Nephelometric Turbidity Units	**MPN/100mL:** Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test			Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank									
% Clay			%	< 1			1	Pass	
Nitrate & Nitrite (as N)			mg/kg	< 5			5	Pass	
Total Kjeldahl Nitrogen (as N)			mg/kg	< 10			10	Pass	
Total Organic Carbon			%	< 0.1			0.1	Pass	
Method Blank									
Heavy Metals									
Cadmium			mg/kg	< 0.4			0.4	Pass	
Chromium			mg/kg	< 5			5	Pass	
Copper			mg/kg	< 5			5	Pass	
Lead			mg/kg	< 5			5	Pass	
Mercury			mg/kg	< 0.1			0.1	Pass	
Nickel			mg/kg	< 5			5	Pass	
Tin			mg/kg	< 10			10	Pass	
Zinc			mg/kg	< 5			5	Pass	
LCS - % Recovery									
% Clay			%	93			70-130	Pass	
Total Organic Carbon			%	107			70-130	Pass	
LCS - % Recovery									
Heavy Metals									
Cadmium			%	101			80-120	Pass	
Chromium			%	117			80-120	Pass	
Copper			%	118			80-120	Pass	
Lead			%	114			80-120	Pass	
Mercury			%	112			75-125	Pass	
Nickel			%	114			80-120	Pass	
Tin			%	112			80-120	Pass	
Zinc			%	116			80-120	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Spike - % Recovery									
Heavy Metals				Result 1					
Cadmium	M19-No38239	CP	%	94			75-125	Pass	
Chromium	M19-No38239	CP	%	83			75-125	Pass	
Copper	M19-No38239	CP	%	84			75-125	Pass	
Lead	M19-No38239	CP	%	87			75-125	Pass	
Mercury	M19-No38239	CP	%	101			70-130	Pass	
Nickel	M19-No38239	CP	%	85			75-125	Pass	
Tin	M19-No38239	CP	%	87			75-125	Pass	
Zinc	M19-No38239	CP	%	83			75-125	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
				Result 1	Result 2	RPD			
% Moisture	M19-De07683	NCP	%	3.0	3.0	<1	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
% Clay	M19-Oc40940	NCP	%	5.0	6.3	22	30%	Pass	
% Sand	M19-Oc40940	NCP	%	91	90	1.0	30%	Pass	
% Silt	M19-Oc40940	NCP	%	3.8	3.8	<1	30%	Pass	
Nitrate & Nitrite (as N)	M19-No38234	CP	mg/kg	< 5	< 5	<1	30%	Pass	

Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Cadmium	M19-No38238	CP	mg/kg	< 0.4	< 0.4	<1	30%	Pass	
Chromium	M19-No38238	CP	mg/kg	5.7	5.8	1.0	30%	Pass	
Copper	M19-No38238	CP	mg/kg	< 5	< 5	<1	30%	Pass	
Lead	M19-No38238	CP	mg/kg	< 5	< 5	<1	30%	Pass	
Mercury	M19-No38238	CP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Nickel	M19-No38238	CP	mg/kg	< 5	< 5	<1	30%	Pass	
Tin	M19-No38238	CP	mg/kg	< 10	< 10	<1	30%	Pass	
Zinc	M19-No38238	CP	mg/kg	< 5	< 5	<1	30%	Pass	
Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Cadmium	M19-No38239	CP	mg/kg	< 0.4	< 0.4	<1	30%	Pass	
Chromium	M19-No38239	CP	mg/kg	5.2	5.5	6.0	30%	Pass	
Copper	M19-No38239	CP	mg/kg	< 5	< 5	<1	30%	Pass	
Lead	M19-No38239	CP	mg/kg	< 5	< 5	<1	30%	Pass	
Mercury	M19-No38239	CP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Nickel	M19-No38239	CP	mg/kg	< 5	< 5	<1	30%	Pass	
Tin	M19-No38239	CP	mg/kg	< 10	< 10	<1	30%	Pass	
Zinc	M19-No38239	CP	mg/kg	< 5	< 5	<1	30%	Pass	
Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Cadmium	M19-No38248	CP	mg/kg	< 0.4	< 0.4	<1	30%	Pass	
Chromium	M19-No38248	CP	mg/kg	6.9	6.8	1.0	30%	Pass	
Copper	M19-No38248	CP	mg/kg	< 5	< 5	<1	30%	Pass	
Lead	M19-No38248	CP	mg/kg	< 5	< 5	<1	30%	Pass	
Mercury	M19-No38248	CP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Nickel	M19-No38248	CP	mg/kg	< 5	< 5	<1	30%	Pass	
Tin	M19-No38248	CP	mg/kg	< 10	< 10	<1	30%	Pass	
Zinc	M19-No38248	CP	mg/kg	< 5	6.3	54	30%	Fail	Q15
Duplicate									
				Result 1	Result 2	RPD			
Total Organic Carbon	M19-No38249	CP	%	< 0.1	< 0.1	<1	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
Q15	The RPD reported passes Eurofins Environment Testing's QC - Acceptance Criteria as defined in the Internal Quality Control Review and Glossary page of this report.

Authorised By

Robert Johnston	Analytical Services Manager
Emily Rosenberg	Senior Analyst-Metal (VIC)
Jonathon Angell	Senior Analyst-Inorganic (QLD)
Julie Kay	Senior Analyst-Inorganic (VIC)
Scott Beddoes	Senior Analyst-Inorganic (VIC)

Glenn Jackson

General Manager

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

eurofins

Environment Testing

Certificate of Analysis

NATA Accredited
Accreditation Number 1261
Site Number 1254

Accredited for compliance with ISO/IEC 17025 – Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

Ramboll Australia Pty Ltd
Suite 3, Level 2, 200 Adelaide Terrace
East Perth
WA 6004

Attention: **Serena Orr**

Report	**700321-S**
Project name	OTWAY OFFSHORE EBS
Project ID	318000803
Received Date	Feb 05, 2020

Client Sample ID			**THYLACINE_GS1_3_MET1**	**THYLACINE_GS1_3_MET2**	**THYLACINE_GS1_MET2**	**THYLACINE_GS-1_MET1**
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M20-Fe05003**	**M20-Fe05004**	**M20-Fe05005**	**M20-Fe05006**
Date Sampled			**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**
Test/Reference	LOR	Unit				
Total Recoverable Hydrocarbons - 1999 NEPM Fractions						
TRH C6-C9	20	mg/kg	< 20	< 20	< 20	< 20
TRH C10-C14	20	mg/kg	< 20	< 20	< 20	< 20
TRH C15-C28	50	mg/kg	< 50	< 50	< 50	< 50
TRH C29-C36	50	mg/kg	< 50	< 50	< 50	< 50
TRH C10-C36 (Total)	50	mg/kg	< 50	< 50	< 50	< 50
BTEX						
Benzene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Toluene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Ethylbenzene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
m&p-Xylenes	0.2	mg/kg	< 0.2	< 0.2	< 0.2	< 0.2
o-Xylene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Xylenes - Total	0.3	mg/kg	< 0.3	< 0.3	< 0.3	< 0.3
4-Bromofluorobenzene (surr.)	1	%	106	86	112	104
Total Recoverable Hydrocarbons - 2013 NEPM Fractions						
Naphthalene^{N02}	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
TRH C6-C10	20	mg/kg	< 20	< 20	< 20	< 20
TRH C6-C10 less BTEX (F1)^{N04}	20	mg/kg	< 20	< 20	< 20	< 20
TRH >C10-C16	50	mg/kg	< 50	< 50	< 50	< 50
TRH >C10-C16 less Naphthalene (F2)^{N01}	50	mg/kg	< 50	< 50	< 50	< 50
TRH >C16-C34	100	mg/kg	< 100	< 100	< 100	< 100
TRH >C34-C40	100	mg/kg	< 100	< 100	< 100	< 100
TRH >C10-C40 (total)*	100	mg/kg	< 100	< 100	< 100	< 100
Polycyclic Aromatic Hydrocarbons						
Benzo(a)pyrene TEQ (lower bound) *	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(a)pyrene TEQ (medium bound) *	0.5	mg/kg	0.6	0.6	0.6	0.6
Benzo(a)pyrene TEQ (upper bound) *	0.5	mg/kg	1.2	1.2	1.2	1.2
Acenaphthene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Acenaphthylene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Anthracene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benz(a)anthracene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(a)pyrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(b&j)fluoranthene^{N07}	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(g.h.i)perylene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(k)fluoranthene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Chrysene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5

Client Sample ID			THYLACINE_GS1_3_MET1	THYLACINE_GS1_3_MET2	THYLACINE_GS1_MET2	THYLACINE_GS-1_MET1
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M20-Fe05003**	**M20-Fe05004**	**M20-Fe05005**	**M20-Fe05006**
Date Sampled			Nov 22, 2019	Nov 22, 2019	Nov 22, 2019	Nov 22, 2019
Test/Reference	LOR	Unit				
Polycyclic Aromatic Hydrocarbons						
Dibenz(a.h)anthracene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Fluoranthene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Fluorene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Indeno(1.2.3-cd)pyrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Naphthalene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Phenanthrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Pyrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Total PAH*	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
2-Fluorobiphenyl (surr.)	1	%	97	54	83	92
p-Terphenyl-d14 (surr.)	1	%	118	81	103	121
Polychlorinated Biphenyls						
Aroclor-1016	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aroclor-1221	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aroclor-1232	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aroclor-1242	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aroclor-1248	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aroclor-1254	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aroclor-1260	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Total PCB*	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Dibutylchlorendate (surr.)	1	%	78	99	78	132
Tetrachloro-m-xylene (surr.)	1	%	77	51	55	77
% Moisture	1	%	33	35	36	32

Client Sample ID			THYLACINE_GS1-2_MET1	THYLACINE_GS1-2_MET2	THYLACINE_GS2_MET1	THYLACINE_GS2_MET2
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M20-Fe05007**	**M20-Fe05008**	**M20-Fe05009**	**M20-Fe05010**
Date Sampled			Nov 22, 2019	Nov 22, 2019	Nov 22, 2019	Nov 22, 2019
Test/Reference	LOR	Unit				
Total Recoverable Hydrocarbons - 1999 NEPM Fractions						
TRH C6-C9	20	mg/kg	< 20	< 20	< 20	< 20
TRH C10-C14	20	mg/kg	< 20	< 20	< 20	< 20
TRH C15-C28	50	mg/kg	< 50	< 50	< 50	< 50
TRH C29-C36	50	mg/kg	< 50	< 50	< 50	< 50
TRH C10-C36 (Total)	50	mg/kg	< 50	< 50	< 50	< 50
BTEX						
Benzene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Toluene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Ethylbenzene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
m&p-Xylenes	0.2	mg/kg	< 0.2	< 0.2	< 0.2	< 0.2
o-Xylene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Xylenes - Total	0.3	mg/kg	< 0.3	< 0.3	< 0.3	< 0.3
4-Bromofluorobenzene (surr.)	1	%	110	62	55	61

Client Sample ID			THYLACINE_GS1-2_MET1	THYLACINE_GS1-2_MET2	THYLACINE_GS2_MET1	THYLACINE_GS2_MET2
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M20-Fe05007**	**M20-Fe05008**	**M20-Fe05009**	**M20-Fe05010**
Date Sampled			**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**	**Nov 22, 2019**
Test/Reference	LOR	Unit				
Total Recoverable Hydrocarbons - 2013 NEPM Fractions						
Naphthalene[N02]	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
TRH C6-C10	20	mg/kg	< 20	< 20	< 20	< 20
TRH C6-C10 less BTEX (F1)[N04]	20	mg/kg	< 20	< 20	< 20	< 20
TRH >C10-C16	50	mg/kg	< 50	< 50	< 50	< 50
TRH >C10-C16 less Naphthalene (F2)[N01]	50	mg/kg	< 50	< 50	< 50	< 50
TRH >C16-C34	100	mg/kg	< 100	< 100	< 100	< 100
TRH >C34-C40	100	mg/kg	< 100	< 100	< 100	< 100
TRH >C10-C40 (total)*	100	mg/kg	< 100	< 100	< 100	< 100
Polycyclic Aromatic Hydrocarbons						
Benzo(a)pyrene TEQ (lower bound) *	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(a)pyrene TEQ (medium bound) *	0.5	mg/kg	0.6	0.6	0.6	0.6
Benzo(a)pyrene TEQ (upper bound) *	0.5	mg/kg	1.2	1.2	1.2	1.2
Acenaphthene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Acenaphthylene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Anthracene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benz(a)anthracene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(a)pyrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(b&j)fluoranthene[N07]	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(g.h.i)perylene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(k)fluoranthene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Chrysene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Dibenz(a.h)anthracene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Fluoranthene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Fluorene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Indeno(1.2.3-cd)pyrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Naphthalene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Phenanthrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Pyrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Total PAH*	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
2-Fluorobiphenyl (surr.)	1	%	87	75	79	91
p-Terphenyl-d14 (surr.)	1	%	137	88	83	57
Polychlorinated Biphenyls						
Aroclor-1016	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aroclor-1221	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aroclor-1232	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aroclor-1242	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aroclor-1248	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aroclor-1254	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aroclor-1260	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Total PCB*	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Dibutylchlorendate (surr.)	1	%	139	112	105	64
Tetrachloro-m-xylene (surr.)	1	%	80	90	86	75
% Moisture	1	%	37	35	33	35

Client Sample ID			ARTISON-GSA_MET1	ARTISON-GSA_MET2	ARTISON-GS3_MET1	ARTISON-GS3_MET 2
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M20-Fe05011**	**M20-Fe05012**	**M20-Fe05013**	**M20-Fe05014**
Date Sampled			Nov 22, 2019	Nov 22, 2019	Nov 22, 2019	Nov 22, 2019
Test/Reference	LOR	Unit				
Total Recoverable Hydrocarbons - 1999 NEPM Fractions						
TRH C6-C9	20	mg/kg	< 20	< 20	< 20	< 20
TRH C10-C14	20	mg/kg	< 20	< 20	< 20	< 20
TRH C15-C28	50	mg/kg	< 50	< 50	< 50	< 50
TRH C29-C36	50	mg/kg	< 50	< 50	< 50	< 50
TRH C10-C36 (Total)	50	mg/kg	< 50	< 50	< 50	< 50
BTEX						
Benzene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Toluene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Ethylbenzene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
m&p-Xylenes	0.2	mg/kg	< 0.2	< 0.2	< 0.2	< 0.2
o-Xylene	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Xylenes - Total	0.3	mg/kg	< 0.3	< 0.3	< 0.3	< 0.3
4-Bromofluorobenzene (surr.)	1	%	62	57	106	55
Total Recoverable Hydrocarbons - 2013 NEPM Fractions						
Naphthalene[N02]	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
TRH C6-C10	20	mg/kg	< 20	< 20	< 20	< 20
TRH C6-C10 less BTEX (F1)[N04]	20	mg/kg	< 20	< 20	< 20	< 20
TRH >C10-C16	50	mg/kg	< 50	< 50	< 50	< 50
TRH >C10-C16 less Naphthalene (F2)[N01]	50	mg/kg	< 50	< 50	< 50	< 50
TRH >C16-C34	100	mg/kg	< 100	< 100	< 100	< 100
TRH >C34-C40	100	mg/kg	< 100	< 100	< 100	< 100
TRH >C10-C40 (total)*	100	mg/kg	< 100	< 100	< 100	< 100
Polycyclic Aromatic Hydrocarbons						
Benzo(a)pyrene TEQ (lower bound) *	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(a)pyrene TEQ (medium bound) *	0.5	mg/kg	0.6	0.6	0.6	0.6
Benzo(a)pyrene TEQ (upper bound) *	0.5	mg/kg	1.2	1.2	1.2	1.2
Acenaphthene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Acenaphthylene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Anthracene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benz(a)anthracene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(a)pyrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(b&j)fluoranthene[N07]	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(g.h.i)perylene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Benzo(k)fluoranthene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Chrysene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Dibenz(a.h)anthracene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Fluoranthene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Fluorene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Indeno(1.2.3-cd)pyrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Naphthalene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Phenanthrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Pyrene	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
Total PAH*	0.5	mg/kg	< 0.5	< 0.5	< 0.5	< 0.5
2-Fluorobiphenyl (surr.)	1	%	60	77	58	67
p-Terphenyl-d14 (surr.)	1	%	59	125	147	56

Client Sample ID			ARTISON-GSA_MET1	ARTISON-GSA_MET2	ARTISON-GS3_MET1	ARTISON-GS3_MET 2
Sample Matrix			**Soil**	**Soil**	**Soil**	**Soil**
Eurofins Sample No.			**M20-Fe05011**	**M20-Fe05012**	**M20-Fe05013**	**M20-Fe05014**
Date Sampled			Nov 22, 2019	Nov 22, 2019	Nov 22, 2019	Nov 22, 2019
Test/Reference	LOR	Unit				
Polychlorinated Biphenyls						
Aroclor-1016	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aroclor-1221	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aroclor-1232	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aroclor-1242	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aroclor-1248	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aroclor-1254	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Aroclor-1260	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Total PCB*	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1
Dibutylchlorendate (surr.)	1	%	73	89	115	110
Tetrachloro-m-xylene (surr.)	1	%	64	88	54	72
% Moisture	1	%	33	30	34	34

Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Total Recoverable Hydrocarbons - 1999 NEPM Fractions	Melbourne	Feb 05, 2020	14 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Total Recoverable Hydrocarbons - 2013 NEPM Fractions	Melbourne	Feb 05, 2020	14 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Total Recoverable Hydrocarbons - 2013 NEPM Fractions	Melbourne	Feb 05, 2020	
- Method: LTM-ORG-2010 TRH C6-C40			
BTEX	Melbourne	Feb 05, 2020	14 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Polycyclic Aromatic Hydrocarbons	Melbourne	Feb 05, 2020	14 Days
- Method: LTM-ORG-2130 PAH and Phenols in Soil and Water			
Polychlorinated Biphenyls	Melbourne	Feb 05, 2020	28 Days
- Method: LTM-ORG-2220 OCP & PCB in Soil and Water (USEPA 8082)			
% Moisture	Melbourne	Feb 05, 2020	14 Days
- Method: LTM-GEN-7080 Moisture			

Company Name:	Ramboll Australia Pty Ltd	**Order No.:**		**Received:**	Feb 5, 2020 3:36 AM
Address:	Suite 3, Level 2, 200 Adelaide Terrace East Perth WA 6004	**Report #:**	700321	**Due:**	Feb 12, 2020
		Phone:	08 9225 5199	**Priority:**	5 Day
		Fax:		**Contact Name:**	Serena Orr
Project Name:	OTWAY OFFSHORE EBS				
Project ID:	318000803				

Eurofins Analytical Services Manager : Robert Johnston

Sample Detail						Polycyclic Aromatic Hydrocarbons	Polychlorinated Biphenyls	BTEX	Moisture Set	Total Recoverable Hydrocarbons
Melbourne Laboratory - NATA Site # 1254 & 14271						X	X	X	X	X
Sydney Laboratory - NATA Site # 18217										
Brisbane Laboratory - NATA Site # 20794										
Perth Laboratory - NATA Site # 23736										
External Laboratory										
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**					
1	THYLACINE_GS1_3_MET1	Nov 22, 2019		Soil	M20-Fe05003	X	X	X	X	X
2	THYLACINE_GS1_3_MET2	Nov 22, 2019		Soil	M20-Fe05004	X	X	X	X	X
3	THYLACINE_GS1_MET2	Nov 22, 2019		Soil	M20-Fe05005	X	X	X	X	X
4	THYLACINE_GS-1_MET1	Nov 22, 2019		Soil	M20-Fe05006	X	X	X	X	X
5	THYLACINE_GS1-2_MET1	Nov 22, 2019		Soil	M20-Fe05007	X	X	X	X	X
6	THYLACINE_GS1-2_MET2	Nov 22, 2019		Soil	M20-Fe05008	X	X	X	X	X

Company Name: Ramboll Australia Pty Ltd
Address: Suite 3, Level 2, 200 Adelaide Terrace
East Perth
WA 6004

Project Name: OTWAY OFFSHORE EBS
Project ID: 318000803

Order No.:
Report #: 700321
Phone: 08 9225 5199
Fax:

Received: Feb 5, 2020 3:36 AM
Due: Feb 12, 2020
Priority: 5 Day
Contact Name: Serena Orr

Eurofins Analytical Services Manager : Robert Johnston

Sample Detail						Polycyclic Aromatic Hydrocarbons	Polychlorinated Biphenyls	BTEX	Moisture Set	Total Recoverable Hydrocarbons
Melbourne Laboratory - NATA Site # 1254 & 14271						X	X	X	X	X
Sydney Laboratory - NATA Site # 18217										
Brisbane Laboratory - NATA Site # 20794										
Perth Laboratory - NATA Site # 23736										
7	THYLACINE_GS2_MET1	Nov 22, 2019		Soil	M20-Fe05009	X	X	X	X	X
8	THYLACINE_GS2_MET2	Nov 22, 2019		Soil	M20-Fe05010	X	X	X	X	X
9	ARTISON-GSA_MET1	Nov 22, 2019		Soil	M20-Fe05011	X	X	X	X	X
10	ARTISON-GSA_MET2	Nov 22, 2019		Soil	M20-Fe05012	X	X	X	X	X
11	ARTISON-GS3_MET1	Nov 22, 2019		Soil	M20-Fe05013	X	X	X	X	X
12	ARTISON-GS3_MET 2	Nov 22, 2019		Soil	M20-Fe05014	X	X	X	X	X
Test Counts						12	12	12	12	12

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

Units

mg/kg: milligrams per kilogram
mg/L: milligrams per litre
ug/L: micrograms per litre
ppm: Parts per million
ppb: Parts per billion
%: Percentage
org/100mL: Organisms per 100 millilitres
NTU: Nephelometric Turbidity Units
MPN/100mL: Most Probable Number of organisms per 100 millilitres

Terms

Dry	Where a moisture has been determined on a solid sample the result is expressed on a dry basis.
LOR	Limit of Reporting.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
LCS	Laboratory Control Sample - reported as percent recovery.
CRM	Certified Reference Material - reported as percent recovery.
Method Blank	In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water.
Surr - Surrogate	The addition of a like compound to the analyte target and reported as percentage recovery.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
USEPA	United States Environmental Protection Agency
APHA	American Public Health Association
TCLP	Toxicity Characteristic Leaching Procedure
COC	Chain of Custody
SRA	Sample Receipt Advice
QSM	US Department of Defense Quality Systems Manual Version 5.3
CP	Client Parent - QC was performed on samples pertaining to this report
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within.
TEQ	Toxic Equivalency Quotient

QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Total Recoverable Hydrocarbons - 1999 NEPM Fractions							
TRH C6-C9	mg/kg	< 20			20	Pass	
TRH C10-C14	mg/kg	< 20			20	Pass	
TRH C15-C28	mg/kg	< 50			50	Pass	
TRH C29-C36	mg/kg	< 50			50	Pass	
Method Blank							
BTEX							
Benzene	mg/kg	< 0.1			0.1	Pass	
Toluene	mg/kg	< 0.1			0.1	Pass	
Ethylbenzene	mg/kg	< 0.1			0.1	Pass	
m&p-Xylenes	mg/kg	< 0.2			0.2	Pass	
o-Xylene	mg/kg	< 0.1			0.1	Pass	
Xylenes - Total	mg/kg	< 0.3			0.3	Pass	
Method Blank							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	mg/kg	< 0.5			0.5	Pass	
TRH C6-C10	mg/kg	< 20			20	Pass	
TRH >C10-C16	mg/kg	< 50			50	Pass	
TRH >C16-C34	mg/kg	< 100			100	Pass	
TRH >C34-C40	mg/kg	< 100			100	Pass	
Method Blank							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	mg/kg	< 0.5			0.5	Pass	
Acenaphthylene	mg/kg	< 0.5			0.5	Pass	
Anthracene	mg/kg	< 0.5			0.5	Pass	
Benz(a)anthracene	mg/kg	< 0.5			0.5	Pass	
Benzo(a)pyrene	mg/kg	< 0.5			0.5	Pass	
Benzo(b&j)fluoranthene	mg/kg	< 0.5			0.5	Pass	
Benzo(g.h.i)perylene	mg/kg	< 0.5			0.5	Pass	
Benzo(k)fluoranthene	mg/kg	< 0.5			0.5	Pass	
Chrysene	mg/kg	< 0.5			0.5	Pass	
Dibenz(a.h)anthracene	mg/kg	< 0.5			0.5	Pass	
Fluoranthene	mg/kg	< 0.5			0.5	Pass	
Fluorene	mg/kg	< 0.5			0.5	Pass	
Indeno(1.2.3-cd)pyrene	mg/kg	< 0.5			0.5	Pass	
Naphthalene	mg/kg	< 0.5			0.5	Pass	
Phenanthrene	mg/kg	< 0.5			0.5	Pass	
Pyrene	mg/kg	< 0.5			0.5	Pass	
Method Blank							
Polychlorinated Biphenyls							
Aroclor-1016	mg/kg	< 0.1			0.1	Pass	
Aroclor-1221	mg/kg	< 0.1			0.1	Pass	
Aroclor-1232	mg/kg	< 0.1			0.1	Pass	
Aroclor-1242	mg/kg	< 0.1			0.1	Pass	
Aroclor-1248	mg/kg	< 0.1			0.1	Pass	
Aroclor-1254	mg/kg	< 0.1			0.1	Pass	
Aroclor-1260	mg/kg	< 0.1			0.1	Pass	
Total PCB*	mg/kg	< 0.1			0.1	Pass	
LCS - % Recovery							
Total Recoverable Hydrocarbons - 1999 NEPM Fractions							
TRH C6-C9	%	96			70-130	Pass	

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
TRH C10-C14	%	85			70-130	Pass	
LCS - % Recovery							
BTEX							
Benzene	%	100			70-130	Pass	
Toluene	%	98			70-130	Pass	
Ethylbenzene	%	91			70-130	Pass	
m&p-Xylenes	%	93			70-130	Pass	
Xylenes - Total	%	94			70-130	Pass	
LCS - % Recovery							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	%	120			70-130	Pass	
TRH C6-C10	%	91			70-130	Pass	
TRH >C10-C16	%	81			70-130	Pass	
LCS - % Recovery							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	%	109			70-130	Pass	
Acenaphthylene	%	117			70-130	Pass	
Anthracene	%	124			70-130	Pass	
Benz(a)anthracene	%	120			70-130	Pass	
Benzo(a)pyrene	%	96			70-130	Pass	
Benzo(b&j)fluoranthene	%	108			70-130	Pass	
Benzo(g.h.i)perylene	%	90			70-130	Pass	
Benzo(k)fluoranthene	%	86			70-130	Pass	
Chrysene	%	95			70-130	Pass	
Dibenz(a.h)anthracene	%	103			70-130	Pass	
Fluoranthene	%	120			70-130	Pass	
Fluorene	%	119			70-130	Pass	
Indeno(1.2.3-cd)pyrene	%	99			70-130	Pass	
Naphthalene	%	107			70-130	Pass	
Phenanthrene	%	110			70-130	Pass	
Pyrene	%	120			70-130	Pass	
LCS - % Recovery							
Polychlorinated Biphenyls							
Aroclor-1260	%	105			70-130	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Spike - % Recovery									
Total Recoverable Hydrocarbons - 1999 NEPM Fractions				Result 1					
TRH C6-C9	N20-Fe00759	NCP	%	89			70-130	Pass	
TRH C10-C14	N20-Fe03039	NCP	%	79			70-130	Pass	
Spike - % Recovery									
BTEX				Result 1					
Benzene	N20-Fe00759	NCP	%	93			70-130	Pass	
Toluene	N20-Fe00759	NCP	%	93			70-130	Pass	
Ethylbenzene	N20-Fe00759	NCP	%	84			70-130	Pass	
m&p-Xylenes	N20-Fe00759	NCP	%	86			70-130	Pass	
o-Xylene	N20-Fe00759	NCP	%	91			70-130	Pass	
Xylenes - Total	N20-Fe00759	NCP	%	88			70-130	Pass	
Spike - % Recovery									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1					
Naphthalene	N20-Fe00759	NCP	%	100			70-130	Pass	
TRH C6-C10	N20-Fe00759	NCP	%	87			70-130	Pass	
TRH >C10-C16	N20-Fe03039	NCP	%	77			70-130	Pass	
Spike - % Recovery									
Polycyclic Aromatic Hydrocarbons				Result 1					

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Acenaphthene	S20-Ja29582	NCP	%	87			70-130	Pass	
Acenaphthylene	S20-Ja29582	NCP	%	91			70-130	Pass	
Anthracene	S20-Ja29582	NCP	%	94			70-130	Pass	
Benz(a)anthracene	S20-Ja29582	NCP	%	87			70-130	Pass	
Benzo(a)pyrene	S20-Ja29582	NCP	%	113			70-130	Pass	
Benzo(b&j)fluoranthene	S20-Ja29582	NCP	%	102			70-130	Pass	
Benzo(g.h.i)perylene	S20-Ja29582	NCP	%	101			70-130	Pass	
Benzo(k)fluoranthene	S20-Ja29582	NCP	%	84			70-130	Pass	
Chrysene	S20-Ja29582	NCP	%	95			70-130	Pass	
Dibenz(a.h)anthracene	S20-Ja29582	NCP	%	105			70-130	Pass	
Fluoranthene	S20-Ja29582	NCP	%	90			70-130	Pass	
Fluorene	S20-Ja29582	NCP	%	95			70-130	Pass	
Indeno(1.2.3-cd)pyrene	S20-Ja29582	NCP	%	112			70-130	Pass	
Naphthalene	S20-Ja29582	NCP	%	128			70-130	Pass	
Phenanthrene	S20-Ja29582	NCP	%	85			70-130	Pass	
Pyrene	S20-Ja29582	NCP	%	86			70-130	Pass	
Spike - % Recovery									
Polychlorinated Biphenyls				Result 1					
Aroclor-1016	M20-Ja30810	NCP	%	88			70-130	Pass	
Aroclor-1260	M20-Ja30810	NCP	%	90			70-130	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Duplicate									
Polycyclic Aromatic Hydrocarbons				Result 1	Result 2	RPD			
Acenaphthene	M20-Fe03903	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Acenaphthylene	M20-Fe03903	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Anthracene	M20-Fe03903	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benz(a)anthracene	M20-Fe03903	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(a)pyrene	M20-Fe03903	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(b&j)fluoranthene	M20-Fe03903	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(g.h.i)perylene	M20-Fe03903	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Benzo(k)fluoranthene	M20-Fe03903	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Chrysene	M20-Fe03903	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Dibenz(a.h)anthracene	M20-Fe03903	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Fluoranthene	M20-Fe03903	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Fluorene	M20-Fe03903	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Indeno(1.2.3-cd)pyrene	M20-Fe03903	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Naphthalene	M20-Fe03903	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Phenanthrene	M20-Fe03903	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Pyrene	M20-Fe03903	NCP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
% Moisture	M20-Fe05006	CP	%	32	32	<1	30%	Pass	
Duplicate									
Polychlorinated Biphenyls				Result 1	Result 2	RPD			
Aroclor-1016	S20-Fe01881	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Aroclor-1221	S20-Fe01881	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Aroclor-1232	S20-Fe01881	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Aroclor-1242	S20-Fe01881	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Aroclor-1248	S20-Fe01881	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Aroclor-1254	S20-Fe01881	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Aroclor-1260	S20-Fe01881	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Total PCB*	S20-Fe01881	NCP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Duplicate									
Total Recoverable Hydrocarbons - 1999 NEPM Fractions				Result 1	Result 2	RPD			
TRH C6-C9	M20-Fe05012	CP	mg/kg	< 20	< 20	<1	30%	Pass	

Duplicate									
BTEX				Result 1	Result 2	RPD			
Benzene	M20-Fe05012	CP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Toluene	M20-Fe05012	CP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Ethylbenzene	M20-Fe05012	CP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
m&p-Xylenes	M20-Fe05012	CP	mg/kg	< 0.2	< 0.2	<1	30%	Pass	
o-Xylene	M20-Fe05012	CP	mg/kg	< 0.1	< 0.1	<1	30%	Pass	
Xylenes - Total	M20-Fe05012	CP	mg/kg	< 0.3	< 0.3	<1	30%	Pass	
Duplicate									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1	Result 2	RPD			
Naphthalene	M20-Fe05012	CP	mg/kg	< 0.5	< 0.5	<1	30%	Pass	
TRH C6-C10	M20-Fe05012	CP	mg/kg	< 20	< 20	<1	30%	Pass	
Duplicate									
Total Recoverable Hydrocarbons - 1999 NEPM Fractions				Result 1	Result 2	RPD			
TRH C10-C14	M20-Fe05014	CP	mg/kg	< 20	< 20	<1	30%	Pass	
TRH C15-C28	M20-Fe05014	CP	mg/kg	< 50	< 50	<1	30%	Pass	
TRH C29-C36	M20-Fe05014	CP	mg/kg	< 50	< 50	<1	30%	Pass	
Duplicate									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1	Result 2	RPD			
TRH >C10-C16	M20-Fe05014	CP	mg/kg	< 50	< 50	<1	30%	Pass	
TRH >C16-C34	M20-Fe05014	CP	mg/kg	< 100	< 100	<1	30%	Pass	
TRH >C34-C40	M20-Fe05014	CP	mg/kg	< 100	< 100	<1	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	No
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
N01	F2 is determined by arithmetically subtracting the "naphthalene" value from the ">C10-C16" value. The naphthalene value used in this calculation is obtained from volatiles (Purge & Trap analysis).
N02	Where we have reported both volatile (P&T GCMS) and semivolatile (GCMS) naphthalene data, results may not be identical. Provided correct sample handling protocols have been followed, any observed differences in results are likely to be due to procedural differences within each methodology. Results determined by both techniques have passed all QAQC acceptance criteria, and are entirely technically valid.
N04	F1 is determined by arithmetically subtracting the "Total BTEX" value from the "C6-C10" value. The "Total BTEX" value is obtained by summing the concentrations of BTEX analytes. The "C6-C10" value is obtained by quantitating against a standard of mixed aromatic/aliphatic analytes.
N07	Please note:- These two PAH isomers closely co-elute using the most contemporary analytical methods and both the reported concentration (and the TEQ) apply specifically to the total of the two co-eluting PAHs

Authorised By

Robert Johnston	Analytical Services Manager
Harry Bacalis	Senior Analyst-Volatile (VIC)
Joseph Edouard	Senior Analyst-Organic (VIC)

Glenn Jackson

General Manager

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

APPENDIX 4
DROP CAMERA SITES (GDA94 UTM 54 S)

Date	Site	Easting	Northing	Depth (m LAT)
31/10/2019	DC_AR2	664260	5693556	69.5
	DC_AR3	663741	5694457	69.6
	DC_AR4	662262	5693605	70.8
	DC_AR1	662782	5692701	70.9
20/11/2019	DC_TH5	658145	5656139	107.1
21/11/2019	DC_TH8	657791	5656967	104.9
	DC_TH8_4m	657796	5656969	104.9
	DC_TH8_8m	657800	5656972	104.9
	DC_TH6	659801	5656919	101.9
	DC_TH6_4m	659810	5656925	101.9
	DC_TH6_8m	659810	5656923	101.9
	DC_TH7	659211	5657774	103.5
	DC_TH7_4m	659213	5657774	103.5
9/12/2019	DC_TH4	660880	5658431	98.9
	DC_TH4_2m	660880	5658428	98.9
	DC_TH4_5m	660881	5658432	98.9
	DC_TH1	661398	5657534	96.8
	DC_TH1_2m	661397	5657532	96.8
	DC_TH1_5m	661397	5657539	96.8
	DC_TH2	662970	5658384	96.9
	DC_TH2_2m	662972	5658383	96.9
	DC_TH2_5m	662975	5658387	96.9
	DC_TH3	662409	5659275	98.2
	DC_TH3_2m	662412	5659274	98.2
	DC_TH3_5m	662406	5659277	98.2
25/12/2019	DC_GE1	668217	5668519	85.6
	DC_GE2	669700	5669375	85.0
	DC_GE2_2m	669703	5669375	85.0
	DC_GE2_5m	669704	5669377	85.0
	DC_GE3	669179	5670280	82.3
	DC_GE3_2m	669180	5670279	82.3
	DC_GE3_5m	669184	5670277	82.3
	DC_GE4	667699	5669424	83.4
	DC_GE4_2m	667700	5669424	83.4
	DC_GE4_5m	667704	5669422	83.4
28/12/2019	DC_LB1	647832	5681521	92.5
	DC_LB1_2m	647831	5681519	92.5
	DC_LB1_5m	647831	5681516	92.5
	DC_LB4	646558	5680703	97.8
	DC_LB4_2m	646560	5680702	97.8

Date	Site	Easting	Northing	Depth (m LAT)
	DC_LB4_5m	646560	5680700	97.8
	DC_LB4_Extra	646438	5680699	97.8
21/01/2020	DC_LB2R	645891	5681544	93.1
	DC_LB2R_2m	645889	5681543	93.1
	DC_LB2R_5m	645891	5681541	93.1
	DC_LB3R	647415	5682484	93.6
	DC_LB3R_2m	647415	5682479	93.6
	DC_LB3R_5m	647418	5682479	93.6
	DC_HE4R	662560	5687719	74.3
	DC_HE4R_1m	662560	5687719	74.3
	DC_HE4R_3m	662557	5687717	74.3
	DC_HE2	662068	5688635	74.3
	DC_HE2_1m	662066	5688636	74.3
	DC_HE2_3m	662064	5688637	74.3
	DC_HE1	664068	5688640	73.4
	DC_HE1_1m	664068	5688643	73.4
	DC_HE1_3m	664066	5688641	73.4
	DC_HE3	663548	5689514	73.8
	DC_HE3_1m	663548	5689515	73.8
	DC_HE3_3m	663544	5689514	73.8
	DC_HTX1R	669286	5688662	72.9
	DC_HTX1R_1m	669286	5688661	72.9
	DC_HTX1R_2m	669290	5688661	72.9
22/01/2020	DC_ARHTX1R	665451	5691790	70.5
	DC_ARHTX1R_2m	665452	5691788	70.5
	DC_ARHTX1R_5m	665452	5691788	70.5
29/01/2020	DC_ARHTY1R	665896	5694722	69.3
	DC_ARHTY1R_B	665895	5694725	69.3
	DC_ARHTY1R_C	665899	5694726	69.3
	DC_HTY1R_A	670385	5696817	67.9
	DC_HTY1R_B	670382	5696816	67.9
	DC_HTY1R_C	670384	5696816	67.9
	DC_ARGE3R_A	665383	5684033	76.4
	DC_ARGE3R_B	665383	5684033	76.8
	DC_ARGE3R_C	665382	5684030	76.7
	DC_ARGE3R_D	665381	5684028	76.2
	DC_ARGE6R_A	667106	5676840	76.9
	DC_ARGE6R_B	667108	5676837	74.7
	DC_ARGE6R_C	667109	5676835	77.6
	DC_ARGE7R_A	667735	5673842	79.4

Date	Site	Easting	Northing	Depth (m LAT)
30/01/2020	DC_ARGE7R_B	667735	5673845	79.4
	DC_ARGE7R_C	667736	5673849	79.4
	DC_ARLB2R_A	659391	5690760	73.6
	DC_ARLB2R_B	659390	5690760	73.6
	DC_ARLB2R_C	659391	5690757	73.6
	DC_ARLB6R_A	651030	5684616	87.1
	DC_ARLB6R_B	651030	5684615	87.1
	DC_ARLB6R_C	651031	5684613	87.1
	DC_LBGE3R_A	653038	5677641	98.5
	DC_LBGE3R_B	653039	5677640	98.5
	DC_LBGE3R_C	653040	5677638	98.5
	DC_LBGE6R_A	659466	5673506	88.2
	DC_LBGE6R_B	659467	5673504	88.2
	DC_LBGE6R_C	659468	5673503	88.2

APPENDIX 5
SEABED PHOTOGRAPH ASSESSMENT DATA

Location	Image Name	Percnet coverage of epifauna (%)	Gastropoda sp. 1	Gastropoda sp. 2	Gastropoda sp. 3	Gastropoda sp. 4	Gastropoda sp. 5	Crinoidea	Polychaeta	Nudibranchia	Teleostei
ARGE	Routes_ARGE_ARGE3R_A_00001	20									
ARGE	Routes_ARGE_ARGE3R_A_00002	10							1		
ARGE	Routes_ARGE_ARGE3R_A_00005	15		5	1						
ARGE	Routes_ARGE_ARGE3R_A_00006	25									
ARGE	Routes_ARGE_ARGE3R_A_00007	5		1							
ARGE	Routes_ARGE_ARGE3R_B_00005	15									
ARGE	Routes_ARGE_ARGE3R_B_00006	5									
ARGE	Routes_ARGE_ARGE3R_B_00007	5									
ARGE	Routes_ARGE_ARGE3R_C_00001	0									
ARGE	Routes_ARGE_ARGE3R_C_00003	5									
ARGE	Routes_ARGE_ARGE3R_C_00004	0									
ARGE	Routes_ARGE_ARGE3R_C_00005	5									
ARGE	Routes_ARGE_ARGE6R_A_00001	0									
ARGE	Routes_ARGE_ARGE6R_A_00002	0									
ARGE	Routes_ARGE_ARGE6R_A_00003	5									
ARGE	Routes_ARGE_ARGE6R_A_00004	0									
ARGE	Routes_ARGE_ARGE6R_A_00005	0									
ARGE	Routes_ARGE_ARGE6R_A_00006	0									
ARGE	Routes_ARGE_ARGE6R_A_00007	5									
ARGE	Routes_ARGE_ARGE6R_B_00001	0									
ARGE	Routes_ARGE_ARGE6R_B_00002	5									
ARGE	Routes_ARGE_ARGE6R_B_00003	5									
ARGE	Routes_ARGE_ARGE6R_B_00005	5									
ARGE	Routes_ARGE_ARGE6R_B_00006	5									
ARGE	Routes_ARGE_ARGE6R_B_00007	5									
ARGE	Routes_ARGE_ARGE6R_B_00008	0									
ARGE	Routes_ARGE_ARGE6R_B_00009	5									
ARGE	Routes_ARGE_ARGE6R_C_00001	5									
ARGE	Routes_ARGE_ARGE6R_C_00002	0									
ARGE	Routes_ARGE_ARGE6R_C_00003	5									
ARGE	Routes_ARGE_ARGE6R_C_00004	0									1
ARGE	Routes_ARGE_ARGE6R_C_00005	0		1							
ARGE	Routes_ARGE_ARGE7R_A_00001	5									
ARGE	Routes_ARGE_ARGE7R_A_00002	15									
ARGE	Routes_ARGE_ARGE7R_A_00004	10									
ARGE	Routes_ARGE_ARGE7R_A_00005	25		1							
ARGE	Routes_ARGE_ARGE7R_B_00004	5									
ARGE	Routes_ARGE_ARGE7R_B_00005	10									
ARGE	Routes_ARGE_ARGE7R_B_00006	20									
ARGE	Routes_ARGE_ARGE7R_B_00007	15									
ARGE	Routes_ARGE_ARGE7R_B_00008	20									
ARGE	Routes_ARGE_ARGE7R_B_00009	20									
ARGE	Routes_ARGE_ARGE7R_B_00011	25		1							
ARGE	Routes_ARGE_ARGE7R_B_00012	15				1					

Location	Image Name	Percnet coverage of epifauna (%)	Gastropoda sp. 1	Gastropoda sp. 2	Gastropoda sp. 3	Gastropoda sp. 4	Gastropoda sp. 5	Crinoidea	Polychaeta	Nudibranchia	Teleostei
ARGE	Routes_ARGE_ARGE7R_B_00015	25									
ARGE	Routes_ARGE_ARGE7R_C_00001	35									
ARGE	Routes_ARGE_ARGE7R_C_00002	10									
ARGE	Routes_ARGE_ARGE7R_C_00004	35									
ARGE	Routes_ARGE_ARGE7R_C_00005	5									1
ARGE	Routes_ARGE_ARGE7R_C_00006	30		1							
ARHTY	Routes_ARHTY_ARHTYR1_A_00001	0									
ARHTY	Routes_ARHTY_ARHTYR1_A_00002	0									
ARHTY	Routes_ARHTY_ARHTYR1_A_00003	20									
ARHTY	Routes_ARHTY_ARHTYR1_A_00004	25									
ARHTY	Routes_ARHTY_ARHTYR1_A_00005	0									
ARHTY	Routes_ARHTY_ARHTYR1_A_00006	0									
ARHTY	Routes_ARHTY_ARHTYR1_A_00008	0									1
ARHTY	Routes_ARHTY_ARHTYR1_A_00009	0						1			
ARHTY	Routes_ARHTY_ARHTYR1_B_00001	0									
ARHTY	Routes_ARHTY_ARHTYR1_B_00003	0									
ARHTY	Routes_ARHTY_ARHTYR1_B_00004	0									
ARHTY	Routes_ARHTY_ARHTYR1_B_00005	0									
ARHTY	Routes_ARHTY_ARHTYR1_B_00006	0									
ARHTY	Routes_ARHTY_ARHTYR1_B_00008	0									
ARHTY	Routes_ARHTY_ARHTYR1_C_00001	40	1								
ARHTY	Routes_ARHTY_ARHTYR1_C_00002	0									
ARHTY	Routes_ARHTY_ARHTYR1_C_00004	20									
ARHTY	Routes_ARHTY_ARHTYR1_C_00006	5									
ARHTY	Routes_ARHTY_ARHTYR1_C_00007	0		1							
ARHTY	Routes_ARHTY_ARHTYR1_C_00008	0									
ARHTY	Routes_ARHTY_ARHTYR1_C_00009	0								1	
ARLB	Routes_ARLB_ARLB2R_A_00001	20									
ARLB	Routes_ARLB_ARLB2R_A_00005	20									
ARLB	Routes_ARLB_ARLB2R_A_00006	20									
ARLB	Routes_ARLB_ARLB2R_A_00007	30									
ARLB	Routes_ARLB_ARLB2R_A_00008	15		1							
ARLB	Routes_ARLB_ARLB2R_A_00009	20									
ARLB	Routes_ARLB_ARLB2R_A_00010	20									
ARLB	Routes_ARLB_ARLB2R_B_00001	5									
ARLB	Routes_ARLB_ARLB2R_B_00002	20									
ARLB	Routes_ARLB_ARLB2R_B_00003	20		2	1						
ARLB	Routes_ARLB_ARLB2R_B_00004	20									
ARLB	Routes_ARLB_ARLB2R_B_00005	20									
ARLB	Routes_ARLB_ARLB2R_C_00001	5		1							
ARLB	Routes_ARLB_ARLB2R_C_00003	5									
ARLB	Routes_ARLB_ARLB2R_C_00004	0									
ARLB	Routes_ARLB_ARLB2R_C_00005	5									
ARLB	Routes_ARLB_ARLB2R_C_00006	5		1							

Location	Image Name	Percnet coverage of epifauna (%)	Gastropoda sp. 1	Gastropoda sp. 2	Gastropoda sp. 3	Gastropoda sp. 4	Gastropoda sp. 5	Crinoidea	Polychaeta	Nudibranchia	Teleostei
ARLB	Routes_ARLB_ARLB6R_A_00002	0									
ARLB	Routes_ARLB_ARLB6R_A_00003	5				1					
ARLB	Routes_ARLB_ARLB6R_A_00004	0									
ARLB	Routes_ARLB_ARLB6R_A_00005	5		1							
ARLB	Routes_ARLB_ARLB6R_B_00001	0									
ARLB	Routes_ARLB_ARLB6R_B_00002	0									
ARLB	Routes_ARLB_ARLB6R_B_00004	0									
ARLB	Routes_ARLB_ARLB6R_B_00005	0									
ARLB	Routes_ARLB_ARLB6R_B_00006	0		3							
ARLB	Routes_ARLB_ARLB6R_C_00001	0									
ARLB	Routes_ARLB_ARLB6R_C_00002	0									
ARLB	Routes_ARLB_ARLB6R_C_00003	0									
ARLB	Routes_ARLB_ARLB6R_C_00004	0									
ARLB	Routes_ARLB_ARLB6R_C_00005	0		1							
ARLB	Routes_ARLB_ARLB6R_C_00007	5		2							
Artisan	Artisan_AR1_00015	30									
Artisan	Artisan_AR1_00017	5									
Artisan	Artisan_AR1_00029	40		3							
Artisan	Artisan_AR1_00035	30		1							
Artisan	Artisan_AR2_00007	35									
Artisan	Artisan_AR2_00008	15									
Artisan	Artisan_AR2_00011	40									
Artisan	Artisan_AR2_00012	30		1							
Artisan	Artisan_AR3_00004	20									
Artisan	Artisan_AR3_00006	15									
Artisan	Artisan_AR3_00008	5									
Artisan	Artisan_AR3_00015	40									
Artisan	Artisan_AR3_00017	25									
Artisan	Artisan_AR3_00018	20		1							
Artisan	Artisan_AR3_00019	10									
Artisan	Artisan_AR3_00022	5									
Artisan	Artisan_AR3_00023	25									
Artisan	Artisan_AR4_00004	30		3							
Artisan	Artisan_AR4_00005	5									
Artisan	Artisan_AR4_00007	20		2							
Artisan	Artisan_AR4_00009	10									
Artisan	Artisan_AR4_00012	45									
Artisan	Artisan_AR4_00013	30									
Artisan	Artisan_AR4_00016	10		1							
Artisan	Artisan_AR4_00017	30		1							
Artisan	Artisan_AR4_00018	20		1							
Artisan	Artisan_AR4_00019	5		1							
Artisan	Artisan_AR4_00025	15		2							
Artisan	Artisan_AR4_00031	15		3							

Location	Image Name	Percnet coverage of epifauna (%)	Gastropoda sp. 1	Gastropoda sp. 2	Gastropoda sp. 3	Gastropoda sp. 4	Gastropoda sp. 5	Crinoidea	Polychaeta	Nudibranchia	Teleostei
Artisan	Artisan_AR4_00034	40									
Geographe	Geographe_GE1_A_00004	55									
Geographe	Geographe_GE1_A_00007	35									
Geographe	Geographe_GE1_A_00008	45		2							
Geographe	Geographe_GE1_B_00001	0									
Geographe	Geographe_GE1_B_00002	0	1								
Geographe	Geographe_GE1_B_00004	5									
Geographe	Geographe_GE1_B_00005	5									
Geographe	Geographe_GE1_C_00001	5									
Geographe	Geographe_GE1_C_00005	25	1								
Geographe	Geographe_GE2_A_00001	5									
Geographe	Geographe_GE2_A_00002	5									
Geographe	Geographe_GE2_A_00003	10	1								
Geographe	Geographe_GE2_A_00005	25									
Geographe	Geographe_GE2_B_00002	5									
Geographe	Geographe_GE2_B_00003	5									
Geographe	Geographe_GE2_C_00002	0									
Geographe	Geographe_GE2_C_00004	0									
Geographe	Geographe_GE2_C_00005	0									
Geographe	Geographe_GE3_A_00001	5									
Geographe	Geographe_GE3_A_00003	5									
Geographe	Geographe_GE3_A_00005	25									
Geographe	Geographe_GE3_B_00001	5									
Geographe	Geographe_GE3_B_00003	20									
Geographe	Geographe_GE3_B_00005	30									
Geographe	Geographe_GE3_C_00002	35									
Geographe	Geographe_GE3_C_00005	40		1							
Geographe	Geographe_GE3_C_00006	10									
Geographe	Geographe_GE4_A_00002	35									
Geographe	Geographe_GE4_A_00004	5									
Geographe	Geographe_GE4_A_00005	30									
Geographe	Geographe_GE4_A_00006	0		1							
Geographe	Geographe_GE4_B_00002	5									
Geographe	Geographe_GE4_B_00003	5									
Geographe	Geographe_GE4_B_00005	0									
Geographe	Geographe_GE4_C_00001	5									
Geographe	Geographe_GE4_C_00002	0									
Geographe	Geographe_GE4_C_00003	0									
Geographe	Geographe_GE4_C_00005	0									
Hercules	Hercules_HE1_A_00002	20									
Hercules	Hercules_HE1_A_00003	0									
Hercules	Hercules_HE1_A_00004	35									
Hercules	Hercules_HE1_A_00005	0									
Hercules	Hercules_HE1_A_00006	35									

Location	Image Name	Percnet coverage of epifauna (%)	Gastropoda sp. 1	Gastropoda sp. 2	Gastropoda sp. 3	Gastropoda sp. 4	Gastropoda sp. 5	Crinoidea	Polychaeta	Nudibranchia	Teleostei
Hercules	Hercules_HE1_B_00001	45									
Hercules	Hercules_HE1_B_00002	35									
Hercules	Hercules_HE1_B_00004	15									
Hercules	Hercules_HE1_B_00005	5									
Hercules	Hercules_HE1_C_00001	5									
Hercules	Hercules_HE1_C_00002	20									
Hercules	Hercules_HE1_C_00005	25									
Hercules	Hercules_HE1_C_00006	30				1					
Hercules	Hercules_HE1_C_00007	30				1					
Hercules	Hercules_HE2_A_00001	30				1					
Hercules	Hercules_HE2_A_00002	5									
Hercules	Hercules_HE2_A_00003	30	1								
Hercules	Hercules_HE2_A_00004	5									
Hercules	Hercules_HE2_A_00005	60									
Hercules	Hercules_HE2_A_00006	25									
Hercules	Hercules_HE2_B_00002	60									
Hercules	Hercules_HE2_B_00004	80									
Hercules	Hercules_HE2_B_00005	25		1							
Hercules	Hercules_HE2_B_00006	75									
Hercules	Hercules_HE2_C_00002	5									
Hercules	Hercules_HE2_C_00003	25									
Hercules	Hercules_HE2_C_00004	20									
Hercules	Hercules_HE2_C_00007	20									
Hercules	Hercules_HE2_C_00009	25									
Hercules	Hercules_HE3_A_00001	50									
Hercules	Hercules_HE3_A_00003	45									
Hercules	Hercules_HE3_A_00005	40		1							
Hercules	Hercules_HE3_B_00001	30									
Hercules	Hercules_HE3_B_00002	40									
Hercules	Hercules_HE3_B_00004	15									
Hercules	Hercules_HE3_B_00005	25									
Hercules	Hercules_HE3_B_00006	30		1							
Hercules	Hercules_HE3_C_00001	5									
Hercules	Hercules_HE3_C_00002	40									
Hercules	Hercules_HE3_C_00003	0						1			
Hercules	Hercules_HE3_C_00005	35			1						
Hercules	Hercules_HE3_C_00007	0									
Hercules	Hercules_HE3_C_00008	5									
Hercules	Hercules_HE4_A_00001	5									
Hercules	Hercules_HE4_A_00002	25									
Hercules	Hercules_HE4_A_00004	15									
Hercules	Hercules_HE4_A_00005	0									
Hercules	Hercules_HE4_B_00001	30									
Hercules	Hercules_HE4_B_00003	15									

Location	Image Name	Percnet coverage of epifauna (%)	Gastropoda sp. 1	Gastropoda sp. 2	Gastropoda sp. 3	Gastropoda sp. 4	Gastropoda sp. 5	Crinoidea	Polychaeta	Nudibranchia	Teleostei
Hercules	Hercules_HE4_B_00004	40									
Hercules	Hercules_HE4_B_00005	15									
Hercules	Hercules_HE4_B_00008	15									
Hercules	Hercules_HE4_B_00009	20									
Hercules	Hercules_HE4_B_00010	25									
Hercules	Hercules_HE4_C_00001	30									
Hercules	Hercules_HE4_C_00002	0									
Hercules	Hercules_HE4_C_00003	0	1								
Hercules	Hercules_HE4_C_00004	20									
Hercules	Hercules_HE4_C_00005	5									
Hot Tap X	HotTap_HTX_HTX1R_A_00006	40									
Hot Tap X	HotTap_HTX_HTX1R_B_00004	25		1							
Hot Tap X	HotTap_HTX_HTX1R_B_00005	15									
Hot Tap X	HotTap_HTX_HTX1R_B_00007	50	1								
Hot Tap X	HotTap_HTX_HTX1R_C_00002	30	1								
Hot Tap X	HotTap_HTX_HTX1R_C_00003	45									
Hot Tap X	HotTap_HTX_HTX1R_C_00005	55									
Hot Tap X	HotTap_HTX_HTX1R_C_00006	50				1					
Hot Tap X	HotTap_HTX_HTX1R_C_00007	25									
Hot Tap Y	HotTap_HTY_HTY1R_A_00001	25				1					
Hot Tap Y	HotTap_HTY_HTY1R_A_00004	20									
Hot Tap Y	HotTap_HTY_HTY1R_A_00005	25									
Hot Tap Y	HotTap_HTY_HTY1R_A_00007	40					1				
Hot Tap Y	HotTap_HTY_HTY1R_A_00009	15									
Hot Tap Y	HotTap_HTY_HTY1R_A_00010	15									
Hot Tap Y	HotTap_HTY_HTY1R_A_00013	20									
Hot Tap Y	HotTap_HTY_HTY1R_A_00014	35									
Hot Tap Y	HotTap_HTY_HTY1R_B_00001	25		1							
Hot Tap Y	HotTap_HTY_HTY1R_B_00004	20									
Hot Tap Y	HotTap_HTY_HTY1R_B_00006	10		1							
Hot Tap Y	HotTap_HTY_HTY1R_B_00008	10		5							
Hot Tap Y	HotTap_HTY_HTY1R_B_00009	15									
Hot Tap Y	HotTap_HTY_HTY1R_C_00001	25									
Hot Tap Y	HotTap_HTY_HTY1R_C_00002	15									
Hot Tap Y	HotTap_HTY_HTY1R_C_00004	15									
Hot Tap Y	HotTap_HTY_HTY1R_C_00005	20									
Hot Tap Y	HotTap_HTY_HTY1R_C_00006	10									
La Bella	LaBella_LB1_A_00001	30		1							
La Bella	LaBella_LB1_A_00004	5									
La Bella	LaBella_LB1_A_00006	30									
La Bella	LaBella_LB1_B_00008	5									
La Bella	LaBella_LB1_B_00009	5									
La Bella	LaBella_LB1_B_00013	15									
La Bella	LaBella_LB1_C_00001	15									

Location	Image Name	Percnet coverage of epifauna (%)	Gastropoda sp. 1	Gastropoda sp. 2	Gastropoda sp. 3	Gastropoda sp. 4	Gastropoda sp. 5	Crinoidea	Polychaeta	Nudibranchia	Teleostei
La Bella	LaBella_LB1_C_00003	15									
La Bella	LaBella_LB1_C_00004	20									
La Bella	LaBella_LB2_A_00014	15									
La Bella	LaBella_LB2_A_00017	10									
La Bella	LaBella_LB2_A_00021	0									
La Bella	LaBella_LB2_A_00024	10									
La Bella	LaBella_LB2_A_00026	0									
La Bella	LaBella_LB2_A_00028	0									
La Bella	LaBella_LB2_B_00029	35									
La Bella	LaBella_LB2_B_00030	20									
La Bella	LaBella_LB2_B_00033	20									
La Bella	LaBella_LB2_B_00035	15									
La Bella	LaBella_LB2_B_00036	25									
La Bella	LaBella_LB2_B_00040	5									
La Bella	LaBella_LB2_B_00041	5									
La Bella	LaBella_LB2_C_00043	5									
La Bella	LaBella_LB2_C_00044	5									
La Bella	LaBella_LB2_C_00045	0									
La Bella	LaBella_LB2_C_00047	0									
La Bella	LaBella_LB2_C_00048	5									
La Bella	LaBella_LB3_A_00001	5									
La Bella	LaBella_LB3_A_00003	0		1							
La Bella	LaBella_LB3_A_00005	5									
La Bella	LaBella_LB3_A_00007	5									
La Bella	LaBella_LB3_A_00009	5									
La Bella	LaBella_LB3_A_00010	0									
La Bella	LaBella_LB3_B_00002	5									
La Bella	LaBella_LB3_B_00004	5		1							
La Bella	LaBella_LB3_B_00006	5		1							
La Bella	LaBella_LB3_B_00007	5									
La Bella	LaBella_LB3_B_00009	0									
La Bella	LaBella_LB3_C_00002	5		1							
La Bella	LaBella_LB3_C_00003	5									
La Bella	LaBella_LB3_C_00005	5									
La Bella	LaBella_LB3_C_00007	0									
La Bella	LaBella_LB4_A_00001	0									
La Bella	LaBella_LB4_A_00003	0				1					
La Bella	LaBella_LB4_A_00005	5									
La Bella	LaBella_LB4_B_00004	5									
La Bella	LaBella_LB4_B_00005	0									
La Bella	LaBella_LB4_C_00001	0		1							
La Bella	LaBella_LB4_C_00004	0									
La Bella	LaBella_LB4_C_00005	5									
La Bella	LaBella_LB4_C_00006	0									

Location	Image Name	Percnet coverage of epifauna (%)	Gastropoda sp. 1	Gastropoda sp. 2	Gastropoda sp. 3	Gastropoda sp. 4	Gastropoda sp. 5	Crinoidea	Polychaeta	Nudibranchia	Teleostei
La Bella	LaBella_LB4_D_00001	35									
La Bella	LaBella_LB4_D_00002	25									
La Bella	LaBella_LB4_D_00003	30									
La Bella	LaBella_LB4_D_00004	15									
La Bella	LaBella_LB4_D_00005	20									
La Bella	LaBella_LB4_D_00006	25									
La Bella	LaBella_LB4_D_00007	35									
La Bella	LaBella_LB4_D_00008	40		1							
LBGE	Routes_LBGE_LBGE3R_A_00001	40									
LBGE	Routes_LBGE_LBGE3R_A_00002	45		2							
LBGE	Routes_LBGE_LBGE3R_A_00004	5									
LBGE	Routes_LBGE_LBGE3R_A_00005	5									
LBGE	Routes_LBGE_LBGE3R_A_00006	15									
LBGE	Routes_LBGE_LBGE3R_A_00008	45		1							
LBGE	Routes_LBGE_LBGE3R_B_00001	15									
LBGE	Routes_LBGE_LBGE3R_B_00002	5									
LBGE	Routes_LBGE_LBGE3R_B_00003	0									
LBGE	Routes_LBGE_LBGE3R_B_00004	0									
LBGE	Routes_LBGE_LBGE3R_B_00005	10		1							
LBGE	Routes_LBGE_LBGE3R_C_00001	0									
LBGE	Routes_LBGE_LBGE3R_C_00002	0									
LBGE	Routes_LBGE_LBGE3R_C_00003	0									
LBGE	Routes_LBGE_LBGE3R_C_00004	0									
LBGE	Routes_LBGE_LBGE3R_C_00005	0									
LBGE	Routes_LBGE_LBGE6R_A_00002	0									
LBGE	Routes_LBGE_LBGE6R_A_00003	5									
LBGE	Routes_LBGE_LBGE6R_A_00004	0									
LBGE	Routes_LBGE_LBGE6R_A_00005	5				1					
LBGE	Routes_LBGE_LBGE6R_A_00006	0									
LBGE	Routes_LBGE_LBGE6R_B_00001	0									
LBGE	Routes_LBGE_LBGE6R_B_00003	5		1							
LBGE	Routes_LBGE_LBGE6R_B_00004	5									
LBGE	Routes_LBGE_LBGE6R_B_00005	0									
LBGE	Routes_LBGE_LBGE6R_C_00001	0									
LBGE	Routes_LBGE_LBGE6R_C_00002	0									
LBGE	Routes_LBGE_LBGE6R_C_00003	0									
LBGE	Routes_LBGE_LBGE6R_C_00004	0									
LBGE	Routes_LBGE_LBGE6R_C_00005	0									
Thylacine	Thylacine_TH1_A_00002	65									
Thylacine	Thylacine_TH1_A_00003	55						9			
Thylacine	Thylacine_TH1_A_00006	25									
Thylacine	Thylacine_TH1_A_00007	20						2		1	
Thylacine	Thylacine_TH1_A_00008	30						6			
Thylacine	Thylacine_TH1_A_00009	30						3			

Location	Image Name	Percnet coverage of epifauna (%)	Gastropoda sp. 1	Gastropoda sp. 2	Gastropoda sp. 3	Gastropoda sp. 4	Gastropoda sp. 5	Crinoidea	Polychaeta	Nudibranchia	Teleostei
Thylacine	Thylacine_TH1_B_00015	45						3			
Thylacine	Thylacine_TH1_B_00016	55						3			
Thylacine	Thylacine_TH1_B_00017	60						1			
Thylacine	Thylacine_TH1_B_00018	60						5			
Thylacine	Thylacine_TH1_B_00021	55						2			
Thylacine	Thylacine_TH1_B_00023	45									
Thylacine	Thylacine_TH1_C_00028	40									
Thylacine	Thylacine_TH1_C_00029	45						3			
Thylacine	Thylacine_TH1_C_00031	25						1			
Thylacine	Thylacine_TH1_C_00033	40						2			
Thylacine	Thylacine_TH2_A_00001	0									
Thylacine	Thylacine_TH2_A_00003	0									
Thylacine	Thylacine_TH2_A_00005	5									
Thylacine	Thylacine_TH2_A_00009	5									
Thylacine	Thylacine_TH2_B_00010	5									
Thylacine	Thylacine_TH2_B_00011	0									
Thylacine	Thylacine_TH2_B_00012	0									
Thylacine	Thylacine_TH2_B_00013	5	1								
Thylacine	Thylacine_TH2_B_00014	5									
Thylacine	Thylacine_TH2_C_00015	0									
Thylacine	Thylacine_TH2_C_00016	5									
Thylacine	Thylacine_TH2_C_00017	0									
Thylacine	Thylacine_TH2_C_00018	5		1							
Thylacine	Thylacine_TH2_C_00019	0									
Thylacine	Thylacine_TH2_C_00021	0									
Thylacine	Thylacine_TH3_A_00001	15		2							
Thylacine	Thylacine_TH3_A_00003	10									
Thylacine	Thylacine_TH3_A_00004	30						4			
Thylacine	Thylacine_TH3_A_00005	25									
Thylacine	Thylacine_TH3_A_00007	20		1				1			
Thylacine	Thylacine_TH3_A_00009	20		1							
Thylacine	Thylacine_TH3_A_00010	5									
Thylacine	Thylacine_TH3_A_00011	5		2							
Thylacine	Thylacine_TH3_A_00014	10		1							
Thylacine	Thylacine_TH3_B_00015	10									
Thylacine	Thylacine_TH3_B_00018	10									
Thylacine	Thylacine_TH3_B_00020	10						1			
Thylacine	Thylacine_TH3_B_00022	10									
Thylacine	Thylacine_TH3_C_00023	15						2			
Thylacine	Thylacine_TH3_C_00024	5					1				
Thylacine	Thylacine_TH3_C_00025	5									
Thylacine	Thylacine_TH3_C_00026	10					1				
Thylacine	Thylacine_TH3_C_00027	5									
Thylacine	Thylacine_TH3_C_00030	5									

Location	Image Name	Percnet coverage of epifauna (%)	Gastropoda sp. 1	Gastropoda sp. 2	Gastropoda sp. 3	Gastropoda sp. 4	Gastropoda sp. 5	Crinoidea	Polychaeta	Nudibranchia	Teleostei
Thylacine	Thylacine_TH3_C_00031	5									
Thylacine	Thylacine_TH3_C_00033	10									
Thylacine	Thylacine_TH4_A_00005	15						3			
Thylacine	Thylacine_TH4_A_00007	15						2			
Thylacine	Thylacine_TH4_A_00008	10						1			
Thylacine	Thylacine_TH4_A_00009	10						1			
Thylacine	Thylacine_TH4_A_00010	15									
Thylacine	Thylacine_TH4_A_00011	15						4			
Thylacine	Thylacine_TH4_B_00016	30						5			
Thylacine	Thylacine_TH4_B_00018	25									
Thylacine	Thylacine_TH4_B_00019	30						3			
Thylacine	Thylacine_TH4_B_00020	20						2			
Thylacine	Thylacine_TH4_B_00022	10									
Thylacine	Thylacine_TH4_C_00023	10									
Thylacine	Thylacine_TH4_C_00024	25						1			
Thylacine	Thylacine_TH4_C_00025	15									
Thylacine	Thylacine_TH4_C_00028	20						2			
Thylacine	Thylacine_TH4_C_00029	5									
Thylacine	Thylacine_TH4_C_00030	5									
Thylacine	Thylacine_TH4_C_00033	10									
Thylacine	Thylacine_TH5_00014	5									
Thylacine	Thylacine_TH6_00003	5									
Thylacine	Thylacine_TH6_00005	5									
Thylacine	Thylacine_TH6_00006	5									
Thylacine	Thylacine_TH6_00011	5									
Thylacine	Thylacine_TH6_00016	15									
Thylacine	Thylacine_TH7_00009	0									
Thylacine	Thylacine_TH7_00012(2)	5		1							
Thylacine	Thylacine_TH7_00013(2)	5									
Thylacine	Thylacine_TH7_00014(2)	5									
Thylacine	Thylacine_TH7_00015	0									
Thylacine	Thylacine_TH7_00017	0									
Thylacine	Thylacine_TH7_00018	0									
Thylacine	Thylacine_TH7_00022	0									
Thylacine	Thylacine_TH8_00009	5									
Thylacine	Thylacine_TH8_00011	5		1							
Thylacine	Thylacine_TH8_00013	5									
Thylacine	Thylacine_TH8_00015	10									
Thylacine	Thylacine_TH8_00019	5									
Thylacine	Thylacine_TH8_00021	5									
Thylacine	Thylacine_TH8_00022	5									
Thylacine	Thylacine_TH8_00025	0									
Thylacine	Thylacine_TH8_00027	5									
Thylacine	Thylacine_TH8_00028	5									

Location	**Image Name**	**Percnet coverage of epifauna (%)**	**Gastropoda sp. 1**	**Gastropoda sp. 2**	**Gastropoda sp. 3**	**Gastropoda sp. 4**	**Gastropoda sp. 5**	**Crinoidea**	**Polychaeta**	**Nudibranchia**	**Teleostei**
Thylacine	Thylacine_TH8_00030	5									

APPENDIX 6
EXAMPLE SEABED PHOTOGRAPHS


Artisan – AR4


Artisan – AR4


Geographe – GE2


Geographe – GE4


Hercules – HE1


Hercules – HE3


La Bella – LB2


La Bella – LB4 Extra DC


Thylacine – TH2

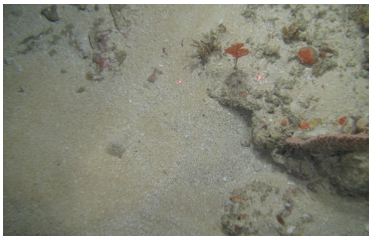

Thylacine – TH4


Thylacine – TH6


Thylacine – TH8


Hot Tap – HTX – HTX1R


Hot Tap – HTX – HTX1R


Hot Tap – HTY – HTY1R

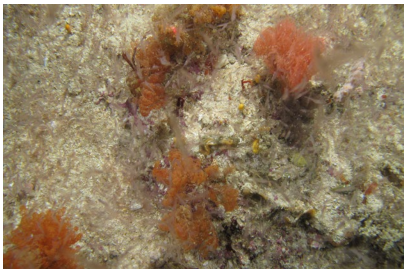

Hot Tap – HTY – HTY1R


Routes – ARGE – ARGE3R


Routes – ARGE – ARGE6R


Routes – ARGE – ARGE7R


Routes – ARHTX – ARHTX1R


Routes – ARHTX – ARHTX1R


Routes – ARHTY – ARHTY1R


Routes – ARHTY – ARHTY1R


Routes – ARLB – ARLB2R


Routes – ARLB – ARLB6R


Routes – LBGE – LBGE3R


Routes – LBGE – LBGE6R

Appendix D: Beach Fair Ocean Access Procedure Information Sheet

Fair Ocean Access

Minimising fishing impacts from offshore operations

Information Sheet | June 2021

Introduction

Licenced commercial fishers and petroleum title holders have lawful rights and obligations to carry out their activities safely and without interference. Beach is committed to *Fair Ocean Access* by minimising impacts from its offshore activities to commercial fishers.

Beach's *Fair Ocean Access Procedure* sets out commitments by Beach to genuine consultation with fishers to understand and minimise safety, environmental and economic impacts.

Where impacts cannot be minimised by Beach, and a fisher has acted to avoid risks and impacts to a Beach project, Beach's *Fair Ocean Access Procedure* includes a simple and fair process for a fisher to claim compensation for an economic loss, and a rapid approval and payment process.

Safety

Safety is Beach's first priority and operating safely will sometimes require restricted access for relatively small offshore areas over short periods. Beach will consult with fishers to seek to minimise potential disturbance to areas that are regular fishing grounds and where the fisher has no alternative fishing options.

Environmental Protection

Beach's projects are subject to stringent assessment and mitigation of potential environmental impacts. Beach must prepare Environment Plans for its offshore projects. These identify all environmental and socio-economic impacts and set out mitigation measures to reduce impacts, so they are "as low as reasonably practicable" and acceptable by regulators. Mitigation measures may include compensation where impacts on the commercial fishing industry cannot be minimised and where these impacts cause an economic loss.

Assessment of impacts includes identifying State and Commonwealth commercial fisheries that are actively fished in Beach's project areas and any biological or economic impacts to those fisheries. Consultation with commercial fishers is an important part of Beach's environmental assessment process.

Genuine consultation

Beach will consult with openness, transparency and mutual respect with fishers who may be directly impacted by Beach's projects. Beach will use its best endeavours to consult with all potentially impacted fishers during preparation of its Environment Plan for a project, and before projects commence.

Respecting the representative role of fishing associations, Beach will seek engagement with potentially impacted fishers via the relevant association. Beach will also engage directly with a fisher if they are not a member of an association, or where they request direct engagement with Beach.

Where a fishing association or fisher believes they will be impacted by a Beach project, Beach will share its fishing impact assessments, validate that with fishers, and discuss their specific circumstances with the objective of minimising potential impacts.

If project avoidance and impact minimisation is not possible, Beach will provide a copy of its full *Fair Ocean Access Procedure* and discuss mitigation options set out in the procedure, as appropriate to the individual fisher or association.

Economic loss

Beach is committed to the principle that a fisher should not suffer an economic loss as a direct result of a Beach project. Losses may occur for different reasons such as:

- reduced catch from fishing in a new area in order to avoid a Beach project
- reduced catch due to impacts to a fishery from the project activities
- steaming costs to avoid a Beach project area
- costs to repair or replace fishing gear.

Acting in good faith

Beach is committed to a fair, simple and transparent process for a fisher to claim compensation, where the fisher has consulted with Beach in good faith before a project, and provided the fisher has:

- acted to avoid risks and impacts to a Beach project
- acted to mitigate any economic losses to their business that may arise from avoiding risks and impacts to a Beach project
- evidence of fishing in the Beach project area during the same time of year as the project timing, for at least three years within the last five years, unless there are genuine fishery or fishing practice reasons for lesser periods
- historical and current catch and effort evidence and the ability to demonstrate an economic loss, as set out in Beach's *Fair Ocean Access Procedure*.

Making a claim

The *Fair Ocean Access Procedure* sets out a simple claim form and describes the evidence required for a claim, such as historical catch and effort records, current catch and effort records, and fish prices.

Claims must be made within 60 days of completion of a Beach project unless there is evidence that the project has caused an impact to the fishery which has impacted future catch and caused an economic loss.

The *Fair Ocean* Access *Procedure* sets out timeframes for the rapid assessment and payment of successful claims and for ensuring the fisher is kept informed.

Beach will nominate a single point of contact at Beach for a fisher to liaise with.

Claims and evidence will be managed in accordance with Beach's Privacy Policy which can be found on Beach's website.

If a claim is not approved, Beach will provide written reasons for the decision.

Resolving disagreements

Where a fisher and Beach cannot agree on a fisher's claim, the *Fair Ocean Access Procedure* includes steps for appointing an independent expert to resolve the matter. Beach will pay the reasonable costs of the independent expert, as set out in the *Fair Ocean Access Procedure*.

We welcome your questions and feedback

P: 1800 797 011
E: community@beachenergy.com.au

beachenergy.com.au

Appendix E: Protected Matters Report for the Light EMBAs

Australian Government

Department of Climate Change, Energy, the Environment and Water

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 14-Nov-2023

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	1
Wetlands of International Importance (Ramsar	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	2
Listed Threatened Ecological Communities:	9
Listed Threatened Species:	102
Listed Migratory Species:	65

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at https://www.dcceew.gov.au/parks-heritage/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Lands:	3
Commonwealth Heritage Places:	None
Listed Marine Species:	106
Whales and Other Cetaceans:	29
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	3
Habitat Critical to the Survival of Marine Turtles:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	42
Regional Forest Agreements:	2
Nationally Important Wetlands:	4
EPBC Act Referrals:	67
Key Ecological Features (Marine):	1
Biologically Important Areas:	27
Bioregional Assessments:	None
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

National Heritage Places [Resource Information]

Name	State	Legal Status
Historic		
Great Ocean Road and Scenic Environs	VIC	Listed place

Wetlands of International Importance (Ramsar Wetlands) [Resource Information]

Ramsar Site Name	Proximity
Western district lakes	Within 10km of Ramsar site

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside a Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area.

Feature Name
Commonwealth Marine Areas (EPBC Act)
Commonwealth Marine Areas (EPBC Act)

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.
Status of Vulnerable, Disallowed and Ineligible are not MNES under the EPBC Act.

Community Name	Threatened Category	Presence Text
Assemblages of species associated with open-coast salt-wedge estuaries of western and central Victoria ecological community	Endangered	Community likely to occur within area
Giant Kelp Marine Forests of South East Australia	Endangered	Community may occur within area
Grassy Eucalypt Woodland of the Victorian Volcanic Plain	Critically Endangered	Community known to occur within area
Natural Damp Grassland of the Victorian Coastal Plains	Critically Endangered	Community may occur within area
Natural Temperate Grassland of the Victorian Volcanic Plain	Critically Endangered	Community may occur within area
Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains	Critically Endangered	Community likely to occur within area

Community Name	Threatened Category	Presence Text
Subtropical and Temperate Coastal Saltmarsh	Vulnerable	Community likely to occur within area
Tasmanian Forests and Woodlands dominated by black gum or Brookers gum (Eucalyptus ovata / E. brookeriana)	Critically Endangered	Community likely to occur within area
Tasmanian white gum (Eucalyptus viminalis) wet forest	Critically Endangered	Community may occur within area

Listed Threatened Species [Resource Information]

Status of Conservation Dependent and Extinct are not MNES under the EPBC Act.
Number is the current name ID.

Scientific Name	Threatened Category	Presence Text
BIRD		
Acanthiza pusilla magnirostris King Island Brown Thornbill, Brown Thornbill (King Island) [91709]	Endangered	Species or species habitat may occur within area
Acanthornis magna greeniana King Island Scrubtit, Scrubtit (King Island) [82329]	Critically Endangered	Species or species habitat may occur within area
Anthochaera phrygia Regent Honeyeater [82338]	Critically Endangered	Foraging, feeding or related behaviour may occur within area
Aquila audax fleayi Tasmanian Wedge-tailed Eagle, Wedge-tailed Eagle (Tasmanian) [64435]	Endangered	Species or species habitat may occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Callocephalon fimbriatum Gang-gang Cockatoo [768]	Endangered	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Ceyx azureus diemenensis Tasmanian Azure Kingfisher [25977]	Endangered	Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat likely to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Species or species habitat known to occur within area
Climacteris picumnus victoriae Brown Treecreeper (south-eastern) [67062]	Vulnerable	Species or species habitat may occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat likely to occur within area
Fregetta grallaria grallaria White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian) [64438]	Vulnerable	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat may occur within area
Halobaena caerulea Blue Petrel [1059]	Vulnerable	Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat known to occur within area
Limosa lapponica baueri Nunivak Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Melanodryas cucullata cucullata South-eastern Hooded Robin, Hooded Robin (south-eastern) [67093]	Endangered	Species or species habitat may occur within area
Neophema chrysogaster Orange-bellied Parrot [747]	Critically Endangered	Species or species habitat known to occur within area
Neophema chrysostoma Blue-winged Parrot [726]	Vulnerable	Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area
Pedionomus torquatus Plains-wanderer [906]	Critically Endangered	Species or species habitat may occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat likely to occur within area
Platycercus caledonicus brownii Green Rosella (King Island) [67041]	Vulnerable	Species or species habitat may occur within area
Pterodroma leucoptera leucoptera Gould's Petrel, Australian Gould's Petrel [26033]	Endangered	Species or species habitat may occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat known to occur within area
Stagonopleura guttata Diamond Firetail [59398]	Vulnerable	Species or species habitat known to occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Species or species habitat known to occur within area
Strepera fuliginosa colei Black Currawong (King Island) [67113]	Vulnerable	Breeding likely to occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area

Scientific Name	Threatened Category	Presence Text
Thalassarche bulleri platei Northern Buller's Albatross, Pacific Albatross [82273]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche chrysostoma Grey-headed Albatross [66491]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Thinornis cucullatus cucullatus Eastern Hooded Plover, Eastern Hooded Plover [90381]	Vulnerable	Species or species habitat known to occur within area
FISH		
Galaxiella pusilla Eastern Dwarf Galaxias, Dwarf Galaxias [56790]	Vulnerable	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Hoplostethus atlanticus		
Orange Roughy, Deep-sea Perch, Red Roughy [68455]	Conservation Dependent	Species or species habitat likely to occur within area
Nannoperca obscura		
Yarra Pygmy Perch [26177]	Vulnerable	Species or species habitat known to occur within area
Prototroctes maraena		
Australian Grayling [26179]	Vulnerable	Species or species habitat known to occur within area
Seriolella brama		
Blue Warehou [69374]	Conservation Dependent	Species or species habitat known to occur within area
Thunnus maccoyii		
Southern Bluefin Tuna [69402]	Conservation Dependent	Species or species habitat likely to occur within area
FROG		
Litoria raniformis		
Growling Grass Frog, Southern Bell Frog, Green and Golden Frog, Warty Swamp Frog, Golden Bell Frog [1828]	Vulnerable	Species or species habitat known to occur within area
INSECT		
Synemon plana		
Golden Sun Moth [25234]	Vulnerable	Species or species habitat may occur within area
MAMMAL		
Antechinus minimus maritimus		
Swamp Antechinus (mainland) [83086]	Vulnerable	Species or species habitat known to occur within area
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area

Scientific Name	Threatened Category	Presence Text
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dasyurus maculatus maculatus (SE mainland population) Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat known to occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Breeding known to occur within area
Isoodon obesulus obesulus Southern Brown Bandicoot (eastern), Southern Brown Bandicoot (south-eastern) [68050]	Endangered	Species or species habitat known to occur within area
Mastacomys fuscus mordicus Broad-toothed Rat (mainland), Tooarrana [87617]	Vulnerable	Species or species habitat known to occur within area
Miniopterus orianae bassanii Southern Bent-wing Bat [87645]	Critically Endangered	Breeding known to occur within area
Neophoca cinerea Australian Sea-lion, Australian Sea Lion [22]	Endangered	Species or species habitat may occur within area
Petauroides volans Greater Glider (southern and central) [254]	Endangered	Species or species habitat may occur within area
Petaurus australis australis Yellow-bellied Glider (south-eastern) [87600]	Vulnerable	Species or species habitat known to occur within area
Potorous tridactylus trisulcatus Long-nosed Potoroo (southern mainland) [86367]	Vulnerable	Species or species habitat known to occur within area
Pseudomys fumeus Smoky Mouse, Konoom [88]	Endangered	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Pseudomys novaehollandiae New Holland Mouse, Pookila [96]	Vulnerable	Species or species habitat likely to occur within area
Pteropus poliocephalus Grey-headed Flying-fox [186]	Vulnerable	Roosting known to occur within area
PLANT		
Amphibromus fluitans River Swamp Wallaby-grass, Floating Swamp Wallaby-grass [19215]	Vulnerable	Species or species habitat may occur within area
Astelia australiana Tall Astelia [10851]	Vulnerable	Species or species habitat known to occur within area
Dianella amoena Matted Flax-lily [64886]	Endangered	Species or species habitat likely to occur within area
Dodonaea procumbens Trailing Hop-bush [12149]	Vulnerable	Species or species habitat may occur within area
Eucalyptus strzeleckii Strzelecki Gum [55400]	Vulnerable	Species or species habitat known to occur within area
Glycine latrobeana Clover Glycine, Purple Clover [13910]	Vulnerable	Species or species habitat known to occur within area
Haloragis exalata subsp. exalata Wingless Raspwort, Square Raspwort [24636]	Vulnerable	Species or species habitat known to occur within area
Hiya distans listed as Hypolepis distans Scrambling Ground-fern [92548]	Endangered	Species or species habitat likely to occur within area
Lepidium aschersonii Spiny Peppercress [10976]	Vulnerable	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Lepidium hyssopifolium Basalt Pepper-cress, Peppercress, Rubble Pepper-cress, Pepperweed [16542]	Endangered	Species or species habitat likely to occur within area
Prasophyllum spicatum Dense Leek-orchid [55146]	Vulnerable	Species or species habitat known to occur within area
Pterostylis chlorogramma Green-striped Greenhood [56510]	Vulnerable	Species or species habitat may occur within area
Pterostylis cucullata Leafy Greenhood [15459]	Vulnerable	Species or species habitat known to occur within area
Pterostylis tenuissima Swamp Greenhood, Dainty Swamp Orchid [13139]	Vulnerable	Species or species habitat known to occur within area
Pterostylis ziegeleri Grassland Greenhood, Cape Portland Greenhood [64971]	Vulnerable	Species or species habitat may occur within area
Senecio psilocarpus Swamp Fireweed, Smooth-fruited Groundsel [64976]	Vulnerable	Species or species habitat known to occur within area
Thelymitra epipactoides Metallic Sun-orchid [11896]	Endangered	Species or species habitat known to occur within area
Thelymitra matthewsii Spiral Sun-orchid [4168]	Vulnerable	Species or species habitat may occur within area
Thelymitra orientalis Hoary Sun-orchid [88011]	Critically Endangered	Species or species habitat may occur within area
Xerochrysum palustre Swamp Everlasting, Swamp Paper Daisy [76215]	Vulnerable	Species or species habitat likely to occur within area
REPTILE		

Scientific Name	Threatened Category	Presence Text
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat may occur within area
Delma impar Striped Legless Lizard, Striped Snake-lizard [1649]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eulamprus tympanum marnieae Corangamite Water Skink, Dreeite Water Skink [64487]	Endangered	Species or species habitat may occur within area
Lissolepis coventryi Swamp Skink, Eastern Mourning Skink [84053]	Endangered	Species or species habitat known to occur within area
SHARK		
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Centrophorus uyato Little Gulper Shark [68446]	Conservation Dependent	Species or species habitat likely to occur within area
Galeorhinus galeus School Shark, Eastern School Shark, Snapper Shark, Tope, Soupfin Shark [68453]	Conservation Dependent	Species or species habitat may occur within area

Listed Migratory Species

[Resource Information]

Scientific Name	Threatened Category	Presence Text
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Foraging, feeding or related behaviour likely to occur within area
Ardenna grisea Sooty Shearwater [82651]		Species or species habitat may occur within area
Ardenna tenuirostris Short-tailed Shearwater [82652]		Breeding known to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Sternula albifrons Little Tern [82849]		Species or species habitat may occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche chrysostoma Grey-headed Albatross [66491]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Migratory Marine Species		
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat may occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eubalaena australis as Balaena glacialis australis Southern Right Whale [40]	Endangered	Breeding known to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat likely to occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Migratory Terrestrial Species		
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Breeding known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres Ruddy Turnstone [872]		Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris alba Sanderling [875]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat likely to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Species or species habitat known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area

Scientific Name	Threatened Category	Presence Text
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting likely to occur within area
Numenius phaeopus Whimbrel [849]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Species or species habitat known to occur within area
Tringa brevipes Grey-tailed Tattler [851]		Species or species habitat known to occur within area
Tringa glareola Wood Sandpiper [829]		Species or species habitat known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Lands [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Commonwealth Land Name	State
Unknown	
Commonwealth Land - [21583]	VIC
Commonwealth Land - [21492]	VIC
Commonwealth Land - [60111]	TAS

Listed Marine Species [Resource Information]

Scientific Name	Threatened Category	Presence Text
Bird		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area overfly marine area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area
Ardenna carneipes as Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Foraging, feeding or related behaviour likely to occur within area
Ardenna grisea as Puffinus griseus Sooty Shearwater [82651]		Species or species habitat may occur within area
Ardenna tenuirostris as Puffinus tenuirostris Short-tailed Shearwater [82652]		Breeding known to occur within area
Arenaria interpres Ruddy Turnstone [872]		Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Bubulcus ibis as Ardea ibis Cattle Egret [66521]		Breeding likely to occur within area overfly marine area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris alba Sanderling [875]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area overfly marine area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area overfly marine area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area overfly marine area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known to occur within area overfly marine area
Chalcites osculans as Chrysococcyx osculans Black-eared Cuckoo [83425]		Species or species habitat likely to occur within area overfly marine area
Charadrius bicinctus Double-banded Plover [895]		Species or species habitat known to occur within area overfly marine area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Species or species habitat known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Species or species habitat known to occur within area overfly marine area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Eudyptula minor Little Penguin [1085]		Breeding known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area overfly marine area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area overfly marine area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area overfly marine area

Scientific Name	Threatened Category	Presence Text
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Breeding known to occur within area
Halobaena caerulea Blue Petrel [1059]	Vulnerable	Species or species habitat may occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Species or species habitat known to occur within area overfly marine area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area overfly marine area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat known to occur within area overfly marine area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat may occur within area overfly marine area

Scientific Name	Threatened Category	Presence Text
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area overfly marine area
Myiagra cyanoleuca Satin Flycatcher [612]		Breeding known to occur within area overfly marine area
Neophema chrysogaster Orange-bellied Parrot [747]	Critically Endangered	Species or species habitat known to occur within area overfly marine area
Neophema chrysostoma Blue-winged Parrot [726]	Vulnerable	Species or species habitat known to occur within area overfly marine area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting likely to occur within area overfly marine area
Numenius phaeopus Whimbrel [849]		Species or species habitat known to occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Phalacrocorax fuscescens Black-faced Cormorant [59660]		Breeding known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Pluvialis fulva Pacific Golden Plover [25545]		Species or species habitat known to occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Species or species habitat may occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Species or species habitat known to occur within area overfly marine area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area overfly marine area
Rostratula australis as Rostratula benghalensis (sensu lato) Australian Painted Snipe [77037]	Endangered	Species or species habitat known to occur within area overfly marine area
Stercorarius antarcticus as Catharacta skua Brown Skua [85039]		Species or species habitat may occur within area
Sterna striata White-fronted Tern [799]		Foraging, feeding or related behaviour likely to occur within area
Sternula albifrons as Sterna albifrons Little Tern [82849]		Species or species habitat may occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche bulleri platei as Thalassarche sp. nov. Northern Buller's Albatross, Pacific Albatross [82273]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area

Scientific Name	Threatened Category	Presence Text
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche chrysostoma Grey-headed Albatross [66491]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Thinornis cucullatus as Thinornis rubricollis Hooded Plover, Hooded Dotterel [87735]		Species or species habitat known to occur within area overfly marine area
Thinornis cucullatus cucullatus as Thinornis rubricollis rubricollis Eastern Hooded Plover, Eastern Hooded Plover [90381]	Vulnerable	Species or species habitat known to occur within area overfly marine area
Tringa brevipes as Heteroscelus brevipes Grey-tailed Tattler [851]		Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Tringa glareola Wood Sandpiper [829]		Species or species habitat known to occur within area overfly marine area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area overfly marine area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area overfly marine area
Fish		
Heraldia nocturna Upside-down Pipefish, Eastern Upside-down Pipefish, Eastern Upside-down Pipefish [66227]		Species or species habitat may occur within area
Hippocampus abdominalis Big-belly Seahorse, Eastern Potbelly Seahorse, New Zealand Potbelly Seahorse [66233]		Species or species habitat may occur within area
Hippocampus breviceps Short-head Seahorse, Short-snouted Seahorse [66235]		Species or species habitat may occur within area
Hippocampus minotaur Bullneck Seahorse [66705]		Species or species habitat may occur within area
Histiogamphelus briggsii Crested Pipefish, Briggs' Crested Pipefish, Briggs' Pipefish [66242]		Species or species habitat may occur within area
Histiogamphelus cristatus Rhino Pipefish, Macleay's Crested Pipefish, Ring-back Pipefish [66243]		Species or species habitat may occur within area
Hypselognathus rostratus Knifesnout Pipefish, Knife-snouted Pipefish [66245]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Kaupus costatus Deepbody Pipefish, Deep-bodied Pipefish [66246]		Species or species habitat may occur within area
Kimblaeus bassensis Trawl Pipefish, Bass Strait Pipefish [66247]		Species or species habitat may occur within area
Leptoichthys fistularius Brushtail Pipefish [66248]		Species or species habitat may occur within area
Lissocampus caudalis Australian Smooth Pipefish, Smooth Pipefish [66249]		Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish [66251]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Mitotichthys mollisoni Mollison's Pipefish [66260]		Species or species habitat may occur within area
Mitotichthys semistriatus Halfbanded Pipefish [66261]		Species or species habitat may occur within area
Mitotichthys tuckeri Tucker's Pipefish [66262]		Species or species habitat may occur within area
Notiocampus ruber Red Pipefish [66265]		Species or species habitat may occur within area
Phycodurus eques Leafy Seadragon [66267]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Phyllopteryx taeniolatus Common Seadragon, Weedy Seadragon [66268]		Species or species habitat may occur within area
Pugnaso curtirostris Pugnose Pipefish, Pug-nosed Pipefish [66269]		Species or species habitat may occur within area
Solegnathus robustus Robust Pipehorse, Robust Spiny Pipehorse [66274]		Species or species habitat may occur within area
Solegnathus spinosissimus Spiny Pipehorse, Australian Spiny Pipehorse [66275]		Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish, Gulf Pipefish, Peacock Pipefish [66276]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Stipecampus cristatus Ringback Pipefish, Ring-backed Pipefish [66278]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Vanacampus phillipi Port Phillip Pipefish [66284]		Species or species habitat may occur within area
Vanacampus poecilolaemus Longsnout Pipefish, Australian Long-snout Pipefish, Long-snouted Pipefish [66285]		Species or species habitat may occur within area
Mammal		

Scientific Name	Threatened Category	Presence Text
Arctocephalus forsteri Long-nosed Fur-seal, New Zealand Fur-seal [20]		Species or species habitat may occur within area
Arctocephalus pusillus Australian Fur-seal, Australo-African Fur-seal [21]		Species or species habitat likely to occur within area
Neophoca cinerea Australian Sea-lion, Australian Sea Lion [22]	Endangered	Species or species habitat may occur within area
Reptile		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat may occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area

Whales and Other Cetaceans [Resource Information]

Current Scientific Name	Status	Type of Presence
Mammal		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area

Current Scientific Name	Status	Type of Presence
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Berardius arnuxii Arnoux's Beaked Whale [70]		Species or species habitat may occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour likely to occur within area
Delphinus delphis Common Dolphin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Breeding known to occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Globicephala melas Long-finned Pilot Whale [59282]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia sima Dwarf Sperm Whale [85043]		Species or species habitat may occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat likely to occur within area

Current Scientific Name	Status	Type of Presence
Lissodelphis peronii Southern Right Whale Dolphin [44]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]		Species or species habitat known to occur within area
Mesoplodon bowdoini Andrew's Beaked Whale [73]		Species or species habitat may occur within area
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area
Mesoplodon grayi Gray's Beaked Whale, Scamperdown Whale [75]		Species or species habitat may occur within area
Mesoplodon hectori Hector's Beaked Whale [76]		Species or species habitat may occur within area
Mesoplodon layardii Strap-toothed Beaked Whale, Strap-toothed Whale, Layard's Beaked Whale [25556]		Species or species habitat may occur within area
Mesoplodon mirus True's Beaked Whale [54]		Species or species habitat may occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat likely to occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area

Current Scientific Name	Status	Type of Presence
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Australian Marine Parks [Resource Information]

Park Name	Zone & IUCN Categories
Apollo	Multiple Use Zone (IUCN VI)
Zeehan	Multiple Use Zone (IUCN VI)
Zeehan	Special Purpose Zone (IUCN VI)

Extra Information

State and Territory Reserves [Resource Information]

Protected Area Name	Reserve Type	State
Aire River	Heritage River	VIC
Aire River W.R.	Natural Features Reserve	VIC
Barham Paradise S.R.	Natural Features Reserve	VIC
Bay of Islands Coastal Park	Conservation Park	VIC
Brucknell Creek F.F.R	Nature Conservation Reserve	VIC
Bungador Stoney Rises N.C.R.	Natural Features Reserve	VIC
Calder River	Reference Area	VIC
Carpendeit	Reference Area	VIC
Carpendeit B.R.	Natural Features Reserve	VIC
Cataraqui Point	Conservation Area	TAS

Protected Area Name	Reserve Type	State
Christmas Island	Nature Reserve	TAS
Cooriemungle	Reference Area	VIC
Cooriemungle Creek F.R	Nature Conservation Reserve	VIC
Coradjil B.R.	Natural Features Reserve	VIC
Coradjil N.C.R.	Natural Features Reserve	VIC
Crinoline Creek	Reference Area	VIC
Curdie Vale N.C.R.	Natural Features Reserve	VIC
Ecklin South Swamp N.C.R.	Natural Features Reserve	VIC
Great Otway	National Park	VIC
Hopkins Falls S.R.	Natural Features Reserve	VIC
Jancourt N.C.R.	Natural Features Reserve	VIC
Johanna Falls S.R.	Natural Features Reserve	VIC
Lake Gillear W.R	Natural Features Reserve	VIC
Latrobe B.R.	Natural Features Reserve	VIC
Marengo N.C.R.	Nature Conservation Reserve	VIC
Marengo Reefs	Marine Sanctuary	VIC
Merri	Marine Sanctuary	VIC
New Year Island	Game Reserve	TAS
Nullawarre F.R.	Nature Conservation Reserve	VIC
Parker River	Reference Area	VIC
Porky Beach	Conservation Area	TAS
Port Campbell	National Park	VIC

Protected Area Name	Reserve Type	State
Princetown W.R	Natural Features Reserve	VIC
Stony Creek (Otways)	Reference Area	VIC
The Arches	Marine Sanctuary	VIC
Timboon I1 B.R	Natural Features Reserve	VIC
Tomahawk Creek	Reference Area	VIC
Twelve Apostles	Marine National Park	VIC
Unnamed P0126	Private Nature Reserve	VIC
Unnamed P0176	Private Nature Reserve	VIC
Wild Dog B.R.	Natural Features Reserve	VIC
Wild Dog Creek SS.R.	Natural Features Reserve	VIC

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included. Please see the associated resource information for specific caveats and use limitations associated with RFA boundary information.

RFA Name	State
Tasmania RFA	Tasmania
West Victoria RFA	Victoria

Nationally Important Wetlands [Resource Information]

Wetland Name	State
Aire River	VIC
Cobden-Terang Volcanic Craters	VIC
Lower Aire River Wetlands	VIC
Princetown Wetlands	VIC

EPBC Act Referrals [Resource Information]

Title of referral	Reference	Referral Outcome	Assessment Status
Otway Astrolabe 3D Marine Seismic Survey, Otway Basin	2012/6421		Completed
Spinifex Offshore Surveys	2022/09359		Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Controlled action			
Alston-1 petroleum exploration well, permit VIC/P44	2003/1315	Controlled Action	Post-Approval
Casino Gas Field Development	2003/1295	Controlled Action	Post-Approval
Otway Development	2002/621	Controlled Action	Post-Approval
Residential Subdivision & Infrastructure Parish of Belfast	2005/1954	Controlled Action	Completed
Schomberg 3D Marine Seismic Survey	2007/3754	Controlled Action	Completed
Strike Oil Gas Exploration Well, Otway Basin (VIC/P44)	2000/97	Controlled Action	Completed
Twelve Apostles Saddle Lookout	2019/8571	Controlled Action	Post-Approval
VICP61 2D Marine Seismic Survey	2008/4075	Controlled Action	Completed
Not controlled action			
Amrit-1 exploration well	2004/1572	Not Controlled Action	Completed
Apollo Bay Water Storage Basin, VIC	2012/6484	Not Controlled Action	Completed
CO2 geosequestration - Otway Basin Pilot Project	2006/2699	Not Controlled Action	Completed
construction of pump station for pump diversion from the Barham River	2003/1242	Not Controlled Action	Completed
Enterprise 1 Exploration Drilling Program, near Port Campbell, Vic	2019/8438	Not Controlled Action	Completed
Exploration drilling for liquid/gaseous hydrocarbons	2004/1681	Not Controlled Action	Completed
Gas Field Development	2006/2635	Not Controlled Action	Completed
Gas Fields Development	2011/5879	Not Controlled Action	Completed
Halladale and Speculant Gas Pipeline Project, North of Port Campbell, Vic	2015/7551	Not Controlled Action	Completed
Henry-1 Exploration Well, Petroleum Permit Area VIC/P44	2005/2147	Not Controlled Action	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action			
Improving rabbit biocontrol: releasing another strain of RHDV, sthrn two thirds of Australia	2015/7522	Not Controlled Action	Completed
INDIGO Central Submarine Telecommunications Cable	2017/8127	Not Controlled Action	Completed
Minerva Cut Back Project, Vic	2017/8036	Not Controlled Action	Completed
Newfield wind farm	2007/3226	Not Controlled Action	Completed
Nirranda South Wind Farm Pty Ltd	2002/763	Not Controlled Action	Completed
Offshore exploration drilling within permit area VIC/P 37(v)	2004/1466	Not Controlled Action	Completed
Port Campbell Headland Walking Trail Realignment	2012/6676	Not Controlled Action	Completed
Residential/Resort/Golf Course development	2002/907	Not Controlled Action	Completed
Stage 1 residential subdivision, Anna Catherine Drive	2005/1992	Not Controlled Action	Completed
Track construction - Great Ocean Walk	2002/793	Not Controlled Action	Completed
VIC-P44 Stage 2 Gas Field Development	2007/3767	Not Controlled Action	Completed
Victorian Generator Project	2005/1984	Not Controlled Action	Completed
Wind Farm Construction and Operation	2001/471	Not Controlled Action	Completed
Not controlled action (particular manner)			
'Moonlight Head' 3D seismic survey, VIC/P38(V), VIC/P43 and VIC/RL8	2005/2236	Not Controlled Action (Particular Manner)	Post-Approval
2D Marine Seismic Survey	2005/2295	Not Controlled Action (Particular Manner)	Post-Approval
2D Marine Seismic Survey in Permit Areas T/32P and T/33P	2002/845	Not Controlled Action (Particular Manner)	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
2D Seismic Survey	2003/1214	Not Controlled Action (Particular Manner)	Post-Approval
3D marine seismic survey near King Island	2004/1461	Not Controlled Action (Particular Manner)	Post-Approval
3D seismic program VIC/P38(v), VIC/P43 and VIC/RL8	2003/1137	Not Controlled Action (Particular Manner)	Post-Approval
Astrolabe 3D Marine Seismic Survey	2011/6048	Not Controlled Action (Particular Manner)	Post-Approval
BHPBilliton Otway 3D Seismic Survey	2007/3443	Not Controlled Action (Particular Manner)	Post-Approval
Deepwater Sorell Basin 2001 Non-Exclusive 2D Seismic Survey	2001/156	Not Controlled Action (Particular Manner)	Post-Approval
Drill and Profile Exploration Well Somerset 1, License Area T34P	2009/5037	Not Controlled Action (Particular Manner)	Post-Approval
Enterprise Three-dimensional Transition Zone Seismic Survey, Victoria	2016/7800	Not Controlled Action (Particular Manner)	Post-Approval
Geographe-A gas exploration well	2000/82	Not Controlled Action (Particular Manner)	Post-Approval
Hydrocarbon exploration wells	2003/1062	Not Controlled Action (Particular Manner)	Post-Approval
INDIGO Marine Cable Route Survey (INDIGO)	2017/7996	Not Controlled Action (Particular Manner)	Post-Approval
La Bella 3D Marine Seismic Survey, Otway Basin, VIC	2012/6683	Not Controlled Action (Particular	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
		Manner)	
Otway Basin Exploration Drilling Campaign, Vic	2011/6125	Not Controlled Action (Particular Manner)	Post-Approval
Santos Otway 3d Seismic VIC/P44	2007/3367	Not Controlled Action (Particular Manner)	Post-Approval
Schomberg 3D Marine Seismic survey	2007/3868	Not Controlled Action (Particular Manner)	Post-Approval
SEA Gas Project transmission pipeline	2001/513	Not Controlled Action (Particular Manner)	Post-Approval
Shaw River Power Station construct gas pipeline and associated infrastructure	2009/5089	Not Controlled Action (Particular Manner)	Post-Approval
Southern Gas Pipeline Project	2002/619	Not Controlled Action (Particular Manner)	Post-Approval
Southern Margins T/35P and T/36P 3D Seismic Surveys	2007/3817	Not Controlled Action (Particular Manner)	Post-Approval
Speculant 3D Transition Zone Seismic Survey	2010/5558	Not Controlled Action (Particular Manner)	Post-Approval
Strike Oil NL Seismic Surveys	2000/107	Not Controlled Action (Particular Manner)	Post-Approval
Surface Geochemical Exploration Program, TAS	2010/5780	Not Controlled Action (Particular Manner)	Post-Approval
The Enterprise 3D Seismic Acquisition Survey, Otway Basin, Vic	2012/6565	Not Controlled Action (Particular Manner)	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
Thylacine-A Exploration Well	2000/81	Not Controlled Action (Particular Manner)	Post-Approval
Undertake a three dimensional marine seismic survey	2010/5700	Not Controlled Action (Particular Manner)	Post-Approval
Vic/P37(v) and Vic/P44 3D marine seismic survey	2003/1102	Not Controlled Action (Particular Manner)	Post-Approval
VIC P44 Gas Exploration Wells	2002/662	Not Controlled Action (Particular Manner)	Post-Approval
Vic-P51 and Vic-P52 2D seismic survey	2002/811	Not Controlled Action (Particular Manner)	Post-Approval
Vic-P51 and Vic-P52 3D seismic survey	2002/799	Not Controlled Action (Particular Manner)	Post-Approval
Referral decision			
The Enterprise 3D Seismic Acquisition Survey, Otway Basin, VIC	2012/6545	Referral Decision	Completed
VICP61 2D Marine Seismic Survey	2008/3975	Referral Decision	Completed

Key Ecological Features [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
West Tasmania Canyons	South-east

Biologically Important Areas

Scientific Name	Behaviour	Presence
Seabirds		
Ardenna pacifica Wedge-tailed Shearwater [84292]	Breeding	Known to occur

Scientific Name	Behaviour	Presence
Ardenna pacifica Wedge-tailed Shearwater [84292]	Foraging	Likely to occur
Ardenna tenuirostris Short-tailed Shearwater [82652]	Breeding	Known to occur
Ardenna tenuirostris Short-tailed Shearwater [82652]	Foraging	Known to occur
Diomedea exulans (sensu lato) Wandering Albatross [1073]	Foraging	Known to occur
Diomedea exulans antipodensis Antipodean Albatross [82269]	Foraging	Known to occur
Eudyptula minor Little Penguin [1085]	Breeding	Known to occur
Eudyptula minor Little Penguin [1085]	Foraging	Known to occur
Morus serrator Australasian Gannet [1020]	Foraging	Known to occur
Pelagodroma marina White-faced Storm-petrel [1016]	Foraging	Known to occur
Pelecanoides urinatrix Common Diving-petrel [1018]	Foraging	Known to occur
Phalacrocorax fuscescens Black-faced Cormorant [59660]	Breeding	Known to occur
Phalacrocorax fuscescens Black-faced Cormorant [59660]	Foraging	Known to occur
Thalassarche bulleri Bullers Albatross [64460]	Foraging	Known to occur
Thalassarche cauta cauta Shy Albatross [82345]	Foraging likely	Likely to occur

Scientific Name	Behaviour	Presence
Thalassarche chlororhynchos bassi Indian Yellow-nosed Albatross [85249]	Foraging	Known to occur
Thalassarche melanophris Black-browed Albatross [66472]	Foraging	Known to occur
Thalassarche melanophris impavida Campbell Albatross [82449]	Foraging	Known to occur
Sharks		
Carcharodon carcharias White Shark [64470]	Distribution	Likely to occur
Carcharodon carcharias White Shark [64470]	Distribution	Known to occur
Carcharodon carcharias White Shark [64470]	Distribution (low density)	Likely to occur
Carcharodon carcharias White Shark [64470]	Foraging	Known to occur
Carcharodon carcharias White Shark [64470]	Known distribution	Known to occur
Whales		
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Distribution	Known to occur
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Foraging	Likely to be present
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Foraging (annual high use area)	Known to occur
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Known Foraging Area	Known to occur

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact us page.

Department of Climate Change, Energy, the Environment and Water
GPO Box 3090
Canberra ACT 2601 Australia
+61 2 6274 1111

Australian Government

Department of Climate Change, Energy, the Environment and Water

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 14-Nov-2023

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	1
Wetlands of International Importance (Ramsar	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	2
Listed Threatened Ecological Communities:	3
Listed Threatened Species:	82
Listed Migratory Species:	55

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at https://www.dcceew.gov.au/parks-heritage/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	91
Whales and Other Cetaceans:	28
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	3
Habitat Critical to the Survival of Marine Turtles:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	7
Regional Forest Agreements:	1
Nationally Important Wetlands:	1
EPBC Act Referrals:	47
Key Ecological Features (Marine):	1
Biologically Important Areas:	19
Bioregional Assessments:	None
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

National Heritage Places

[Resource Information]

Name	State	Legal Status
Historic		
Great Ocean Road and Scenic Environs	VIC	Listed place

Commonwealth Marine Area

[Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside a Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area.

Feature Name
Commonwealth Marine Areas (EPBC Act)
Commonwealth Marine Areas (EPBC Act)

Listed Threatened Ecological Communities

[Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.
Status of Vulnerable, Disallowed and Ineligible are not MNES under the EPBC Act.

Community Name	Threatened Category	Presence Text
Assemblages of species associated with open-coast salt-wedge estuaries of western and central Victoria ecological community	Endangered	Community likely to occur within area
Giant Kelp Marine Forests of South East Australia	Endangered	Community may occur within area
Subtropical and Temperate Coastal Saltmarsh	Vulnerable	Community likely to occur within area

Listed Threatened Species

[Resource Information]

Status of Conservation Dependent and Extinct are not MNES under the EPBC Act.
Number is the current name ID.

Scientific Name	Threatened Category	Presence Text
BIRD		
Anthochaera phrygia		
Regent Honeyeater [82338]	Critically Endangered	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Callocephalon fimbriatum Gang-gang Cockatoo [768]	Endangered	Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat likely to occur within area
Climacteris picumnus victoriae Brown Treecreeper (south-eastern) [67062]	Vulnerable	Species or species habitat may occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area

Scientific Name	Threatened Category	Presence Text
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat may occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat may occur within area
Halobaena caerulea Blue Petrel [1059]	Vulnerable	Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area
Limosa lapponica baueri Nunivak Bar-tailed Godwit, Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Neophema chrysogaster Orange-bellied Parrot [747]	Critically Endangered	Migration route likely to occur within area
Neophema chrysostoma Blue-winged Parrot [726]	Vulnerable	Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat likely to occur within area
Pterodroma leucoptera leucoptera Gould's Petrel, Australian Gould's Petrel [26033]	Endangered	Species or species habitat may occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Stagonopleura guttata Diamond Firetail [59398]	Vulnerable	Species or species habitat may occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Species or species habitat known to occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche bulleri platei Northern Buller's Albatross, Pacific Albatross [82273]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Foraging, feeding or related behaviour likely to occur within area

Scientific Name	Threatened Category	Presence Text
Thalassarche chrysostoma Grey-headed Albatross [66491]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Thinornis cucullatus cucullatus Eastern Hooded Plover, Eastern Hooded Plover [90381]	Vulnerable	Species or species habitat known to occur within area
FISH		
Galaxiella pusilla Eastern Dwarf Galaxias, Dwarf Galaxias [56790]	Vulnerable	Species or species habitat may occur within area
Hoplostethus atlanticus Orange Roughy, Deep-sea Perch, Red Roughy [68455]	Conservation Dependent	Species or species habitat likely to occur within area
Nannoperca obscura Yarra Pygmy Perch [26177]	Vulnerable	Species or species habitat may occur within area
Prototroctes maraena Australian Grayling [26179]	Vulnerable	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Seriolella brama Blue Warehou [69374]	Conservation Dependent	Species or species habitat known to occur within area
Thunnus maccoyii Southern Bluefin Tuna [69402]	Conservation Dependent	Species or species habitat likely to occur within area
FROG		
Litoria raniformis Growling Grass Frog, Southern Bell Frog, Green and Golden Frog, Warty Swamp Frog, Golden Bell Frog [1828]	Vulnerable	Species or species habitat known to occur within area
MAMMAL		
Antechinus minimus maritimus Swamp Antechinus (mainland) [83086]	Vulnerable	Species or species habitat known to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Dasyurus maculatus maculatus (SE mainland population) Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat likely to occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat known to occur within area
Isoodon obesulus obesulus Southern Brown Bandicoot (eastern), Southern Brown Bandicoot (south-eastern) [68050]	Endangered	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Mastacomys fuscus mordicus Broad-toothed Rat (mainland), Tooarrana [87617]	Vulnerable	Species or species habitat known to occur within area
Miniopterus orianae bassanii Southern Bent-wing Bat [87645]	Critically Endangered	Species or species habitat likely to occur within area
Neophoca cinerea Australian Sea-lion, Australian Sea Lion [22]	Endangered	Species or species habitat may occur within area
Petaurus australis australis Yellow-bellied Glider (south-eastern) [87600]	Vulnerable	Species or species habitat likely to occur within area
Potorous tridactylus trisulcatus Long-nosed Potoroo (southern mainland) [86367]	Vulnerable	Species or species habitat likely to occur within area
Pseudomys fumeus Smoky Mouse, Konoom [88]	Endangered	Species or species habitat may occur within area
Pseudomys novaehollandiae New Holland Mouse, Pookila [96]	Vulnerable	Species or species habitat may occur within area
Pteropus poliocephalus Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
PLANT		
Amphibromus fluitans River Swamp Wallaby-grass, Floating Swamp Wallaby-grass [19215]	Vulnerable	Species or species habitat may occur within area
Eucalyptus strzeleckii Strzelecki Gum [55400]	Vulnerable	Species or species habitat known to occur within area
Glycine latrobeana Clover Glycine, Purple Clover [13910]	Vulnerable	Species or species habitat likely to occur within area

Scientific Name	Threatened Category	Presence Text
Haloragis exalata subsp. exalata Wingless Raspwort, Square Raspwort [24636]	Vulnerable	Species or species habitat known to occur within area
Lepidium aschersonii Spiny Peppercress [10976]	Vulnerable	Species or species habitat may occur within area
Lepidium hyssopifolium Basalt Pepper-cress, Peppercress, Rubble Pepper-cress, Pepperweed [16542]	Endangered	Species or species habitat may occur within area
Prasophyllum spicatum Dense Leek-orchid [55146]	Vulnerable	Species or species habitat known to occur within area
Pterostylis chlorogramma Green-striped Greenhood [56510]	Vulnerable	Species or species habitat may occur within area
Pterostylis cucullata Leafy Greenhood [15459]	Vulnerable	Species or species habitat likely to occur within area
Pterostylis tenuissima Swamp Greenhood, Dainty Swamp Orchid [13139]	Vulnerable	Species or species habitat known to occur within area
Senecio psilocarpus Swamp Fireweed, Smooth-fruited Groundsel [64976]	Vulnerable	Species or species habitat known to occur within area
Thelymitra epipactoides Metallic Sun-orchid [11896]	Endangered	Species or species habitat known to occur within area
Thelymitra orientalis Hoary Sun-orchid [88011]	Critically Endangered	Species or species habitat may occur within area
Xerochrysum palustre Swamp Everlasting, Swamp Paper Daisy [76215]	Vulnerable	Species or species habitat likely to occur within area
REPTILE		

Scientific Name	Threatened Category	Presence Text
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat may occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Lissolepis coventryi Swamp Skink, Eastern Mourning Skink [84053]	Endangered	Species or species habitat known to occur within area
SHARK		
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Centrophorus uyato Little Gulper Shark [68446]	Conservation Dependent	Species or species habitat likely to occur within area
Galeorhinus galeus School Shark, Eastern School Shark, Snapper Shark, Tope, Soupfin Shark [68453]	Conservation Dependent	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

Scientific Name	Threatened Category	Presence Text
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Foraging, feeding or related behaviour likely to occur within area
Ardenna grisea Sooty Shearwater [82651]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Ardenna tenuirostris Short-tailed Shearwater [82652]		Breeding known to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat likely to occur within area
Sternula albifrons Little Tern [82849]		Species or species habitat may occur within area
Thalassarche bulleri Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area

Scientific Name	Threatened Category	Presence Text
Thalassarche carteri Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche cauta Shy Albatross [89224]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche chrysostoma Grey-headed Albatross [66491]	Endangered	Species or species habitat may occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Migratory Marine Species		
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area

Scientific Name	Threatened Category	Presence Text
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour may occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat may occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area
Eubalaena australis as Balaena glacialis australis Southern Right Whale [40]	Endangered	Species or species habitat known to occur within area
Isurus oxyrinchus Shortfin Mako, Mako Shark [79073]		Species or species habitat likely to occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat likely to occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]		Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Orcinus orca Killer Whale, Orca [46]		Species or species habitat likely to occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Migratory Terrestrial Species		
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat likely to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting likely to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat likely to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
Scientific Name	Threatened Category	Presence Text
Bird		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area
Ardenna carneipes as Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Foraging, feeding or related behaviour likely to occur within area
Ardenna grisea as Puffinus griseus Sooty Shearwater [82651]		Species or species habitat may occur within area
Ardenna tenuirostris as Puffinus tenuirostris Short-tailed Shearwater [82652]		Breeding known to occur within area
Bubulcus ibis as Ardea ibis Cattle Egret [66521]		Species or species habitat may occur within area overfly marine area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat may occur within area overfly marine area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area overfly marine area

Scientific Name	Threatened Category	Presence Text
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area overfly marine area
Chalcites osculans as Chrysococcyx osculans Black-eared Cuckoo [83425]		Species or species habitat likely to occur within area overfly marine area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Species or species habitat likely to occur within area
Diomedea antipodensis Antipodean Albatross [64458]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Eudyptula minor Little Penguin [1085]		Breeding known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat known to occur within area overfly marine area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area overfly marine area

Scientific Name	Threatened Category	Presence Text
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area overfly marine area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Halobaena caerulea Blue Petrel [1059]	Vulnerable	Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area overfly marine area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area overfly marine area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat may occur within area overfly marine area

Scientific Name	Threatened Category	Presence Text
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area overfly marine area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area overfly marine area
Neophema chrysogaster Orange-bellied Parrot [747]	Critically Endangered	Migration route likely to occur within area overfly marine area
Neophema chrysostoma Blue-winged Parrot [726]	Vulnerable	Species or species habitat known to occur within area overfly marine area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting likely to occur within area overfly marine area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat likely to occur within area
Phalacrocorax fuscescens Black-faced Cormorant [59660]		Breeding known to occur within area
Phoebetria fusca Sooty Albatross [1075]	Vulnerable	Species or species habitat likely to occur within area
Pterodroma mollis Soft-plumaged Petrel [1036]	Vulnerable	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat known to occur within area overfly marine area
Rostratula australis as Rostratula benghalensis (sensu lato)		
Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area overfly marine area
Stercorarius antarcticus as Catharacta skua		
Brown Skua [85039]		Species or species habitat may occur within area
Sterna striata		
White-fronted Tern [799]		Foraging, feeding or related behaviour likely to occur within area
Sternula albifrons as Sterna albifrons		
Little Tern [82849]		Species or species habitat may occur within area
Thalassarche bulleri		
Buller's Albatross, Pacific Albatross [64460]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche bulleri platei as Thalassarche sp. nov.		
Northern Buller's Albatross, Pacific Albatross [82273]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche carteri		
Indian Yellow-nosed Albatross [64464]	Vulnerable	Species or species habitat likely to occur within area
Thalassarche cauta		
Shy Albatross [89224]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Thalassarche chrysostoma		
Grey-headed Albatross [66491]	Endangered	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche salvini Salvin's Albatross [64463]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Thinornis cucullatus as Thinornis rubricollis Hooded Plover, Hooded Dotterel [87735]		Species or species habitat known to occur within area overfly marine area
Thinornis cucullatus cucullatus as Thinornis rubricollis rubricollis Eastern Hooded Plover, Eastern Hooded Plover [90381]	Vulnerable	Species or species habitat known to occur within area overfly marine area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area overfly marine area
Fish		
Heraldia nocturna Upside-down Pipefish, Eastern Upside-down Pipefish, Eastern Upside-down Pipefish [66227]		Species or species habitat may occur within area
Hippocampus abdominalis Big-belly Seahorse, Eastern Potbelly Seahorse, New Zealand Potbelly Seahorse [66233]		Species or species habitat may occur within area
Hippocampus breviceps Short-head Seahorse, Short-snouted Seahorse [66235]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Hippocampus minotaur Bullneck Seahorse [66705]		Species or species habitat may occur within area
Histiogamphelus briggsii Crested Pipefish, Briggs' Crested Pipefish, Briggs' Pipefish [66242]		Species or species habitat may occur within area
Histiogamphelus cristatus Rhino Pipefish, Macleay's Crested Pipefish, Ring-back Pipefish [66243]		Species or species habitat may occur within area
Hypselognathus rostratus Knifesnout Pipefish, Knife-snouted Pipefish [66245]		Species or species habitat may occur within area
Kaupus costatus Deepbody Pipefish, Deep-bodied Pipefish [66246]		Species or species habitat may occur within area
Kimblaeus bassensis Trawl Pipefish, Bass Strait Pipefish [66247]		Species or species habitat may occur within area
Leptoichthys fistularius Brushtail Pipefish [66248]		Species or species habitat may occur within area
Lissocampus caudalis Australian Smooth Pipefish, Smooth Pipefish [66249]		Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish [66251]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Mitotichthys semistriatus Halfbanded Pipefish [66261]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Mitotichthys tuckeri Tucker's Pipefish [66262]		Species or species habitat may occur within area
Notiocampus ruber Red Pipefish [66265]		Species or species habitat may occur within area
Phycodurus eques Leafy Seadragon [66267]		Species or species habitat may occur within area
Phyllopteryx taeniolatus Common Seadragon, Weedy Seadragon [66268]		Species or species habitat may occur within area
Pugnaso curtirostris Pugnose Pipefish, Pug-nosed Pipefish [66269]		Species or species habitat may occur within area
Solegnathus robustus Robust Pipehorse, Robust Spiny Pipehorse [66274]		Species or species habitat may occur within area
Solegnathus spinosissimus Spiny Pipehorse, Australian Spiny Pipehorse [66275]		Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish, Gulf Pipefish, Peacock Pipefish [66276]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Stipecampus cristatus Ringback Pipefish, Ring-backed Pipefish [66278]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Vanacampus phillipi Port Phillip Pipefish [66284]		Species or species habitat may occur within area
Vanacampus poecilolaemus Longsnout Pipefish, Australian Long-snout Pipefish, Long-snouted Pipefish [66285]		Species or species habitat may occur within area
Mammal		
Arctocephalus forsteri Long-nosed Fur-seal, New Zealand Fur-seal [20]		Species or species habitat may occur within area
Arctocephalus pusillus Australian Fur-seal, Australo-African Fur-seal [21]		Species or species habitat may occur within area
Neophoca cinerea Australian Sea-lion, Australian Sea Lion [22]	Endangered	Species or species habitat may occur within area
Reptile		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Species or species habitat may occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat known to occur within area

Whales and Other Cetaceans [Resource Information]

Current Scientific Name	Status	Type of Presence
Mammal		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area

Current Scientific Name	Status	Type of Presence
Balaenoptera bonaerensis Antarctic Minke Whale, Dark-shoulder Minke Whale [67812]		Species or species habitat likely to occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Foraging, feeding or related behaviour known to occur within area
Balaenoptera physalus Fin Whale [37]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Berardius arnuxii Arnoux's Beaked Whale [70]		Species or species habitat may occur within area
Caperea marginata Pygmy Right Whale [39]		Foraging, feeding or related behaviour may occur within area
Delphinus delphis Common Dolphin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Species or species habitat known to occur within area
Globicephala macrorhynchus Short-finned Pilot Whale [62]		Species or species habitat may occur within area
Globicephala melas Long-finned Pilot Whale [59282]		Species or species habitat may occur within area

Current Scientific Name	Status	Type of Presence
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Kogia breviceps Pygmy Sperm Whale [57]		Species or species habitat may occur within area
Kogia sima Dwarf Sperm Whale [85043]		Species or species habitat may occur within area
Lagenorhynchus obscurus Dusky Dolphin [43]		Species or species habitat likely to occur within area
Lissodelphis peronii Southern Right Whale Dolphin [44]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]		Species or species habitat known to occur within area
Mesoplodon bowdoini Andrew's Beaked Whale [73]		Species or species habitat may occur within area
Mesoplodon densirostris Blainville's Beaked Whale, Dense-beaked Whale [74]		Species or species habitat may occur within area
Mesoplodon hectori Hector's Beaked Whale [76]		Species or species habitat may occur within area
Mesoplodon layardii Strap-toothed Beaked Whale, Strap-toothed Whale, Layard's Beaked Whale [25556]		Species or species habitat may occur within area
Mesoplodon mirus True's Beaked Whale [54]		Species or species habitat may occur within area

Current Scientific Name	Status	Type of Presence
Orcinus orca Killer Whale, Orca [46]		Species or species habitat likely to occur within area
Physeter macrocephalus Sperm Whale [59]		Species or species habitat may occur within area
Pseudorca crassidens False Killer Whale [48]		Species or species habitat likely to occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area
Ziphius cavirostris Cuvier's Beaked Whale, Goose-beaked Whale [56]		Species or species habitat may occur within area

Australian Marine Parks

[Resource Information]

Park Name	Zone & IUCN Categories
Apollo	Multiple Use Zone (IUCN VI)
Zeehan	Multiple Use Zone (IUCN VI)
Zeehan	Special Purpose Zone (IUCN VI)

Extra Information

State and Territory Reserves

[Resource Information]

Protected Area Name	Reserve Type	State
Bay of Islands Coastal Park	Conservation Park	VIC
Great Otway	National Park	VIC
Latrobe B.R.	Natural Features Reserve	VIC
Port Campbell	National Park	VIC
Princetown W.R	Natural Features Reserve	VIC

Protected Area Name	Reserve Type	State
The Arches	Marine Sanctuary	VIC
Twelve Apostles	Marine National Park	VIC

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included. Please see the associated resource information for specific caveats and use limitations associated with RFA boundary information.

RFA Name	State
West Victoria RFA	Victoria

Nationally Important Wetlands [Resource Information]

Wetland Name	State
Princetown Wetlands	VIC

EPBC Act Referrals [Resource Information]

Title of referral	Reference	Referral Outcome	Assessment Status
Otway Astrolabe 3D Marine Seismic Survey, Otway Basin	2012/6421		Completed
Controlled action			
Alston-1 petroleum exploration well, permit VIC/P44	2003/1315	Controlled Action	Post-Approval
Casino Gas Field Development	2003/1295	Controlled Action	Post-Approval
Otway Development	2002/621	Controlled Action	Post-Approval
Schomberg 3D Marine Seismic Survey	2007/3754	Controlled Action	Completed
Strike Oil Gas Exploration Well, Otway Basin (VIC/P44)	2000/97	Controlled Action	Completed
Twelve Apostles Saddle Lookout	2019/8571	Controlled Action	Post-Approval
VICP61 2D Marine Seismic Survey	2008/4075	Controlled Action	Completed
Not controlled action			
Enterprise 1 Exploration Drilling Program, near Port Campbell, Vic	2019/8438	Not Controlled Action	Completed
Exploration drilling for liquid/gaseous hydrocarbons	2004/1681	Not Controlled Action	Completed
Gas Field Development	2006/2635	Not Controlled Action	Completed

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action			
Henry-1 Exploration Well, Petroleum Permit Area VIC/P44	2005/2147	Not Controlled Action	Completed
Improving rabbit biocontrol: releasing another strain of RHDV, sthrn two thirds of Australia	2015/7522	Not Controlled Action	Completed
INDIGO Central Submarine Telecommunications Cable	2017/8127	Not Controlled Action	Completed
Minerva Cut Back Project, Vic	2017/8036	Not Controlled Action	Completed
Offshore exploration drilling within permit area VIC/P 37(v)	2004/1466	Not Controlled Action	Completed
Port Campbell Headland Walking Trail Realignment	2012/6676	Not Controlled Action	Completed
Track construction - Great Ocean Walk	2002/793	Not Controlled Action	Completed
VIC-P44 Stage 2 Gas Field Development	2007/3767	Not Controlled Action	Completed
Victorian Generator Project	2005/1984	Not Controlled Action	Completed
Not controlled action (particular manner)			
'Moonlight Head' 3D seismic survey, VIC/P38(V), VIC/P43 and VIC/RL8	2005/2236	Not Controlled Action (Particular Manner)	Post-Approval
2D Marine Seismic Survey	2005/2295	Not Controlled Action (Particular Manner)	Post-Approval
2D Seismic Survey	2003/1214	Not Controlled Action (Particular Manner)	Post-Approval
3D marine seismic survey near King Island	2004/1461	Not Controlled Action (Particular Manner)	Post-Approval
3D seismic program VIC/P38(v), VIC/P43 and VIC/RL8	2003/1137	Not Controlled Action (Particular Manner)	Post-Approval
Astrolabe 3D Marine Seismic Survey	2011/6048	Not Controlled Action (Particular Manner)	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
BHPBilliton Otway 3D Seismic Survey	2007/3443	Not Controlled Action (Particular Manner)	Post-Approval
Deepwater Sorell Basin 2001 Non-Exclusive 2D Seismic Survey	2001/156	Not Controlled Action (Particular Manner)	Post-Approval
Drill and Profile Exploration Well Somerset 1, License Area T34P	2009/5037	Not Controlled Action (Particular Manner)	Post-Approval
Enterprise Three-dimensional Transition Zone Seismic Survey, Victoria	2016/7800	Not Controlled Action (Particular Manner)	Post-Approval
Geographe-A gas exploration well	2000/82	Not Controlled Action (Particular Manner)	Post-Approval
INDIGO Marine Cable Route Survey (INDIGO)	2017/7996	Not Controlled Action (Particular Manner)	Post-Approval
La Bella 3D Marine Seismic Survey, Otway Basin, VIC	2012/6683	Not Controlled Action (Particular Manner)	Post-Approval
Otway Basin Exploration Drilling Campaign, Vic	2011/6125	Not Controlled Action (Particular Manner)	Post-Approval
Santos Otway 3d Seismic VIC/P44	2007/3367	Not Controlled Action (Particular Manner)	Post-Approval
Schomberg 3D Marine Seismic survey	2007/3868	Not Controlled Action (Particular Manner)	Post-Approval
Southern Margins T/35P and T/36P 3D Seismic Surveys	2007/3817	Not Controlled Action (Particular Manner)	Post-Approval
Strike Oil NL Seismic Surveys	2000/107	Not Controlled Action (Particular	Post-Approval

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action (particular manner)			
		Manner)	
Surface Geochemical Exploration Program, TAS	2010/5780	Not Controlled Action (Particular Manner)	Post-Approval
The Enterprise 3D Seismic Acquisition Survey, Otway Basin, Vic	2012/6565	Not Controlled Action (Particular Manner)	Post-Approval
Thylacine-A Exploration Well	2000/81	Not Controlled Action (Particular Manner)	Post-Approval
Undertake a three dimensional marine seismic survey	2010/5700	Not Controlled Action (Particular Manner)	Post-Approval
Vic/P37(v) and Vic/P44 3D marine seismic survey	2003/1102	Not Controlled Action (Particular Manner)	Post-Approval
VIC P44 Gas Exploration Wells	2002/662	Not Controlled Action (Particular Manner)	Post-Approval
Vic-P51 and Vic-P52 2D seismic survey	2002/811	Not Controlled Action (Particular Manner)	Post-Approval
Referral decision			
The Enterprise 3D Seismic Acquisition Survey, Otway Basin, VIC	2012/6545	Referral Decision	Completed
VICP61 2D Marine Seismic Survey	2008/3975	Referral Decision	Completed

Key Ecological Features [Resource Information]

Key Ecological Features are the parts of the marine ecosystem that are considered to be important for the biodiversity or ecosystem functioning and integrity of the Commonwealth Marine Area.

Name	Region
West Tasmania Canyons	South-east

Biologically Important Areas

Scientific Name	Behaviour	Presence

Scientific Name	Behaviour	Presence
Seabirds		
Ardenna pacifica Wedge-tailed Shearwater [84292]	Breeding	Known to occur
Ardenna pacifica Wedge-tailed Shearwater [84292]	Foraging	Likely to occur
Ardenna tenuirostris Short-tailed Shearwater [82652]	Foraging	Known to occur
Diomedea exulans (sensu lato) Wandering Albatross [1073]	Foraging	Known to occur
Diomedea exulans antipodensis Antipodean Albatross [82269]	Foraging	Known to occur
Pelecanoides urinatrix Common Diving-petrel [1018]	Foraging	Known to occur
Thalassarche bulleri Bullers Albatross [64460]	Foraging	Known to occur
Thalassarche cauta cauta Shy Albatross [82345]	Foraging likely	Likely to occur
Thalassarche chlororhynchos bassi Indian Yellow-nosed Albatross [85249]	Foraging	Known to occur
Thalassarche melanophris Black-browed Albatross [66472]	Foraging	Known to occur
Thalassarche melanophris impavida Campbell Albatross [82449]	Foraging	Known to occur
Sharks		
Carcharodon carcharias White Shark [64470]	Distribution	Likely to occur
Carcharodon carcharias White Shark [64470]	Distribution	Known to occur
Carcharodon carcharias White Shark [64470]	Distribution (low density)	Likely to occur

Scientific Name	Behaviour	Presence
Carcharodon carcharias White Shark [64470]	Known distribution	Known to occur
Whales		
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Distribution	Known to occur
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Foraging	Likely to be present
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Foraging (annual high use area)	Known to occur
Balaenoptera musculus brevicauda Pygmy Blue Whale [81317]	Known Foraging Area	Known to occur

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact us page.

Department of Climate Change, Energy, the Environment and Water
GPO Box 3090
Canberra ACT 2601 Australia
+61 2 6274 1111

Appendix F: Sound Modelling Report – Koessler and McPherson 2021

Unit 1, 14 Hook Street
Capalaba, Queensland, 4157

Tel: +61 7 3823 2620
www.jasco.com

TECHNICAL ADDENDUM

DATE: 27 August 2021
FROM: Matthew Koessler, Craig McPherson (JASCO Applied Sciences (Australia) Pty Ltd)
TO: Phil Wemyss (Beach Energy)

SUBJECT: Beach Otway Project: Additional and Revised Modelling Study

1. Summary

JASCO Applied Sciences (JASCO) performed modelling study of underwater sound levels associated with the Beach Energy Otway Development, to supplement drilling and construction results previously presented in Koessler et al. (2020), Matthews et al. (2020) and Matthews et al. (2021).

The results have been revised due to better understanding of the propagation loss in the region gained through the validation monitoring of drilling operations at Artisan-1 McPherson et al. (2021). A significant finding of this study was lack of a thin layer of sand overlying the carbonate seabed structure near Artisan-1, which has a significant influence on propagation loss.

This monitoring project also characterised Monopole Source Levels (MSL) for project vessels (during transit and under dynamic positioning (DP)) and the *Ocean Onyx* Mobile Offshore Drilling Unit (MODU). These source levels are considered in the revised modelling.

Estimated underwater acoustic levels are presented as sound pressure levels (SPL, L_p), and as accumulated sound exposure levels (SEL, L_E) as appropriate for non-impulsive (continuous) noise sources. For the non-time dependent scenarios, the modelled maximum and 95th percentile distances to the marine mammal behavioural threshold based on the current interim NOAA (2019) criterion for marine mammals of 120 dB re 1 µPa (SPL; L_p) for non-impulsive sound sources are summarised in Table 1.

For the time-dependent scenarios, the modelled maximum distances to permanent threshold shift (PTS) and temporary threshold shift (TTS) criteria for low-frequency cetaceans (NMFS 2018), which are based on SEL accumulated over a period of time are summarised in Table 2.

Table 1. Maximum (*R_{max}*) and 95% (*R*_{95%}) horizontal distances (in km) to sound pressure level (SPL) from the most appropriate location for considered sources per scenario. MCR: Maximum Continuous Rating, MODU: Mobile Offshore Drilling Unit, OSV: Offshore Supply Vessel, ROV: Remotely Operated Vehicle.

Applicable Scenario number	Well Area	Description	R_{max} (km)	$R_{95\%}$ (km)
A1	Thylacine North-1	MODU Drilling	1.24	1.12
A2		OSV under DP	7.1	6.5
A3		OSV Standby Transit	0.38	0.35
A4	Thylacine A	Platform Operations	0.20	0.19
A5	Thylacine North-1	MODU Drilling + OSV resupply	7.89	6.56
A7		MODU Drilling + OSV Standby Transit	1.32	1.19
1, 2, 3, 4	Thylacine A	Platform Operations + OSV resupply	7.28	6.56
5, 6		Platform Operations + OSV Standby	0.45	0.43
7, 9	Thylacine North-1	Pipelay Vessel stationary (June), operating at 20% MCR	2.71	2.57
8, 10		Pipelay Vessel stationary (November), operating at 20% MCR	2.70	2.55
11, 13	Artisan-1	Pipelay Vessel stationary (June), operating at 20% MCR	2.27	2.09
12, 14		Pipelay Vessel stationary (November), operating at 20% MCR	2.26	2.02
15	Thylacine North-1 + Geographe-4	Vessel stationary, operating at 20% MCR (Thylacine North-1) + Vessel stationary, operating at 20% MCR + ROV cutting tool (Geographe-4) (June)	2.98	2.76
16		Vessel stationary, operating at 20% MCR (Thylacine North-1) + Vessel stationary, operating at 20% MCR + ROV cutting tool (Geographe-4) (November)	2.97	2.73
17	Artisan-1 + Geographe-4	Vessel stationary, operating at 20% MCR (Artsian-1) + Vessel stationary, operating at 20% MCR + ROV cutting tool (Geographe-4) (June)	2.98	2.75
18		Vessel stationary, operating at 20% MCR (Artsian-1) + Vessel stationary, operating at 20% MCR + ROV cutting tool (Geographe-4) (November)	2.97	2.72

Applicable Scenario number	Well Area	Description	R_{max} (km)	$R_{95\%}$ (km)
19, 20	Thylacine North-1 + Thylacine A	MODU Drilling + Platform + OSV resupply	7.90	6.65
21		MODU Drilling + Platform + Skid installation vessel operating at 20% MCR	4.85	4.29
23	Thylacine North-1	Pipelay Vessel stationary (June), operating at 40% MCR	4.13	3.64
24		Pipelay Vessel stationary (November), operating at 40% MCR	4.11	3.63
27	Artisan-1	Pipelay Vessel stationary (June), operating at 40% MCR	2.87	2.46
28		Pipelay Vessel stationary (November), operating at 40% MCR	2.86	2.46
31	Thylacine North-1 + Geographe-4	Vessel stationary, operating at 40% MCR (Thylacine North-1) + Vessel stationary, operating at 40% MCR + ROV cutting tool (Geographe-4) (June)	3.77	3.29
32		Vessel stationary, operating at 40% MCR (Thylacine North-1) + Vessel stationary, operating at 40% MCR + ROV cutting tool (Geographe-4) (November)	3.76	3.23
33	Artisan-1 + Geographe-4	Vessel stationary, operating at 40% MCR (Artsian-1) + Vessel stationary, operating at 40% MCR + ROV cutting tool (Geographe-4) (June)	3.76	3.24
34		Vessel stationary, operating at 40% MCR (Artsian-1) + Vessel stationary, operating at 40% MCR + ROV cutting tool (Geographe-4) (November)	3.63	3.20
35	Thylacine North-1	MODU Drilling + Platform + Skid installation vessel operating at 40% MCR	6.08	4.99

Table 2. Summary: Maximum (R_{max}) horizontal distances (in km) and ensonified area (km^2) for the frequency-weighted LF-cetacean SEL_{24h} TTS thresholds based on NMFS (2018) from the most appropriate location for considered sources per scenario. MCR: Maximum Continuous Rating, MODU: Mobile Offshore Drilling Unit, OSV: Offshore Supply Vessel, ROV: Remotely Operated Vehicle.

Scenario number	Well Area	Description	R_{max} (km)	Area (km^2)
A1	Thylacine North-1	MODU Drilling	0.39	0.33
A2		OSV under DP	0.95	2.33
A3		OSV Standby Transit	–	–
A4	Thylacine A	Platform Operations	0.04	0.004
A5	Thylacine North-1	MODU Drilling + 4h OSV resupply	1.06	2.49
A6		MODU Drilling + 8h OSV resupply	1.31	4.39
A7		MODU Drilling + OSV Standby Transit	0.39	0.33
1	Thylacine A	Platform + 2h OSV resupply	0.75	1.31
2		Platform + 4h OSV resupply	0.95	2.30
3		Platform + 6h OSV resupply	1.11	3.15
4		Platform + 8h OSV resupply	1.25	4.01
5		Platform 8h + OSV Standby	0.04	0.004
6		Platform + 24h OSV Standby	0.04	0.004
7	Thylacine North-1	Pipelay Vessel stationary (June), operating at 20% MCR	0.60	1.04
8		Pipelay Vessel stationary (November), operating at 20% MCR	0.59	1.04
9		Pipelay Vessel laying pipe (June), operating at 20% MCR	1.18	13.62
10		Pipelay Vessel laying pipe (November), operating at 20% MCR	1.17	13.53
11	Artisan-1	Pipelay Vessel stationary (June), operating at 20% MCR	0.67	1.14
12		Pipelay Vessel stationary (November), operating at 20% MCR	0.67	1.12
13		Pipelay Vessel laying pipe (June), operating at 20% MCR	0.90	10.76
14		Pipelay Vessel laying pipe (November), operating at 20% MCR	0.90	10.69
15	Thylacine North-1 + Geographe-4	Vessel stationary, operating at 20% MCR (Thylacine North-1) + Vessel stationary, operating at 20% MCR + ROV cutting tool (Geographe-4) (June)	0.66	1.35
16		Vessel stationary, operating at 20% MCR (Thylacine North-1) + Vessel stationary, operating at 20% MCR + ROV cutting tool (Geographe-4) (November)	0.66	1.34
17	Artisan-1 + Geographe-4	Vessel stationary, operating at 20% MCR (Artsian-1) + Vessel stationary, operating at 20% MCR + ROV cutting tool (Geographe-4) (June)	0.67	1.35
18		Vessel stationary, operating at 20% MCR (Artsian-1) + Vessel stationary, operating at 20% MCR + ROV cutting tool (Geographe-4) (November)	0.67	1.33
19	Thylacine North-1 + Thylacine A	MODU Drilling + Platform + 4h OSV resupply	0.95	2.31
20		MODU Drilling + Platform + 8h OSV resupply	1.23	4.03
21		MODU Drilling + Platform + Skid installation vessel operating at 20% MCR	0.65	1.10

Scenario number	Well Area	Description	R_{max} (km)	Area (km^2)
23	Thylacine North-1	Pipelay Vessel stationary (June), operating at 40% MCR	0.95	2.28
24		Pipelay Vessel stationary (November), operating at 40% MCR	0.94	2.23
25		Pipelay Vessel laying pipe (June), operating at 40% MCR	1.95	24.2
26		Pipelay Vessel laying pipe (November), operating at 40% MCR	1.95	24.1
27	Artisan-1	Pipelay Vessel stationary (June), operating at 40% MCR	0.88	2.02
28		Pipelay Vessel stationary (November), operating at 40% MCR	0.88	1.99
29		Pipelay Vessel laying pipe (June), operating at 40% MCR	1.40	17.1
30		Pipelay Vessel laying pipe (November), operating at 40% MCR	1.39	17.0
31	Thylacine North-1 + Geographe-4	Pipelay Vessel stationary, operating at 40% MCR (Thylacine North-1) + Vessel stationary, operating at 40% MCR + ROV cutting tool (Geographe-4)	0.95	2.39
32		Pipelay Vessel stationary, operating at 40% MCR (Thylacine North-1) + Vessel stationary, operating at 40% MCR + ROV cutting tool (Geographe-4)	0.94	2.38
33	Artisan-1 + Geographe-4	Pipelay Vessel stationary, operating at 40% MCR (Artsian-1) + Vessel stationary, operating at 40% MCR + ROV cutting tool (Geographe-4)	0.91	2.39
34		Vessel stationary, operating at 40% MCR (Pipelay Vessel -1) + Vessel stationary, operating at 40% MCR + ROV cutting tool (Geographe-4)	0.91	2.38
35	Thylacine North-1	MODU Drilling + Platform + Skid installation vessel operating at 40% MCR	0.85	2.10

2. Introduction

JASCO Applied Sciences (JASCO) performed modelling study of underwater sound levels associated with the Beach Energy Otway Development, to supplement drilling and construction results previously presented in Koessler et al. (2020), Matthews et al. (2020) and Matthews et al. (2021).

The results have been revised due to better understanding of the propagation loss in the region gained through the validation monitoring of drilling operations at Artisan-1 McPherson et al. (2021) as described in Section 2.1. An overview of the modelling scenarios considered is provided in Section 2.2, with results presented in Section 4, and briefly discussed in Section 5.

For noise effect criteria and explanations on methodologies applied, refer to Koessler et al. (2020), Matthews et al. (2020), Matthews et al. (2021) and McPherson et al. (2021).

2.1. Validation Monitoring Study Summary

The monitoring study (McPherson et al. 2021) was completed in relation to the exploration drilling activities at the Artisan-1 well with the aim of completing an acoustic characterisation of the drilling and associated vessel activity within the Otway Basin. Through this characterisation, validation of the modelling predictions used in Beach Energy Otway Environment Plans (EPs) for the development drilling activities was required.

The exploration well Artisan-1, drilled by the *Ocean Onyx*, was selected for the monitoring program because the predicted distances to thresholds for effects on marine mammals, including pygmy blue whales, were farthest at this location in the modelling study used for the EP (Koessler et al. 2020), as well as because it was the first well in the Otway drilling campaign.

Four JASCO Autonomous Multichannel Acoustic Recorders (AMARs) in C-lander moorings were deployed in February and retrieved in early April. Stations 1 through 4 were deployed at distances of 0.336, 1.13, 5.11, and 25 km from the *Ocean Onyx*. The AMARs recorded continuously at 24-bit resolution and 64 kHz sample rate for the entire deployment. The three stations closest to the *Ocean Onyx* were configured with a single hydrophone, whilst the station 25 km away was configured with three hydrophones to provide directional processing of received sounds.

To assist in the characterisation of *Ocean Onyx* and attendant support vessels, the vessels conducted specific activities under dynamic positioning and followed a nominated transit track between the *Ocean Onyx* and Geelong Supply Base. No specific operational requests were made of the *Ocean Onyx* and vessels during normal drilling activities due to the complexity of operationally meeting any requests. Over the course of the monitoring program, the MODU and support vessels engaged in different operational states with different uncontrollable contributors, such as variable drilling operations, resupply and support operations, weather conditions, and merchant shipping.

A summary of the findings of the monitoring study are described in the following sections.

Source Levels

The Monopole Source Levels determined through the measurement study differed from those either estimated for use in the modelling study or those determined using proxy sources. The key differences are as follows:

- The support vessels are quieter than estimated when they are under slow transit speeds, such as 7 knots.
- The support vessels are louder than estimated when they are travelling at faster transit speeds, with 9 knots used to represent these speeds and the associated MSL.
- The support vessels are louder than estimated when holding station or moving under dynamic positioning.
- The drilling operations of the *Ocean Onyx* are both louder at some frequencies and quieter at others than those for the proxy rig the *Polar Pioneer* (Austin et al. 2018), although the results presented for the *Polar Pioneer* did not examine the changes in level with increased drilling depth (over time) as completed within this study.

Comparison of Results

The results from the measurement study could not be directly compared to the modelling presented in Koessler et al. (2020) due to the differences in actual events compared to the nominal representative scenarios developed and evaluated as part of the EP assessment process. Additionally, the measurements were obtained at a receiver located 1.2 m off the seafloor, which is not the maximum-over-depth results reported in the modelling study. The ranges obtained from the measurement study were reported in relation to the Artisan-1 well location, and thus the centre of the *Ocean Onyx*. The ranges in project related modelling studies are reported from a range of locations, including the centroids of multiple sources, thus it was not possible to report the measurement results in a similar fashion using the small number of recording locations used in this study.

Geological Environment Representation

Previous modelling studies for Beach Energy, Koessler et al. (2020), Matthews et al. (2020) and Matthews et al. (2021), used MONM with the assumption of a 1 m thick layer of sand overlaying the carbonate seabed structure at the Artisan-1 well location. This assumption was made due to the lack of available information, and is similar to other inshore work in the Otway Basin, such as (Duncan et al. 2012), who represented the shelf as two zones, an in-shore zone out to a water depth of about 70 m in which the sand layer has a thickness of between 4–10 m, and an off-shore zone of effectively bare calcarenite probably due to scouring by current and swell. The transition between these two zones is ill-defined due to a lack of datapoints, and lies close to the Artisan-1 location, and a balanced approach of assuming 1 m thick layer of sand overlaying the carbonate seabed structure was judged to be appropriate given available information.

The measurement study has increased the understanding of the geological environment in the region and indicates that the sand overlay is thinner (or non-existent) at shallower water depths. The different environment required the use of an alternate configuration of numerical models to represent the propagation loss.

Propagation Loss

The accuracy of the broadband calculated propagation loss for the Otway Basin continental shelf environment depends significantly upon the frequency content of the radiating sound source together with thickness of the sand layer on carbonate seabed (calcarenite) likely to occur within the region. In general, the thinner the sand layer, the greater the overall propagation loss.

When comparing SPL data fits for Stations 1–3 in McPherson et al. (2021), the loss rate is higher than what would have been expected in this environment, considering the higher monopole source levels for the support vessel on DP derived from trial measurements. The differences are likely attributable to the potential absence of a sand veneer.

Comparisons were conducted using JASCO’s Marine Operations Noise Model (MONM), a wide-angle parabolic equation model which applies the BELLHOP Gaussian beam acoustic ray-trace model at higher frequencies, and JASCO’s wavenumber integration model (VSTACK) which can fully account for the elasto-acoustic properties of the sub-bottom. The agreement between the models was excellent when only a comparatively thin (1 m thick) layer of sand overlies the carbonate seabed structure. In an environment such as this, MONM could have been used without correction. However, the comparisons indicate a much higher rates of loss, as would be expected if no (or only a very thin) sand layer were present.

A better understanding of the propagation loss environment, and the revision of the representation and treatment of it through the measurement study, enabled the modelling scenarios for the activities at Artisan-1 presented in Koessler et al. (2020) to be recalculated (Section 6.3 in McPherson et al. (2021)).

2.2. Scenario Details

The scenarios considered within this assessment are detailed below and in Table 3, with the associated modelling sites provided in Table 4. An overview of the scenarios is as follows:

1. Otway Offshore Project Development Drilling Campaign, Thylacine North-1 Operations:
    a. Mobile Offshore Drilling Unit (MODU) conducting normal drilling operations
    b. MODU with Offshore Supply Vessel (OSV) in attendance, standing by and conducting resupply operations under Dynamic Positioning (DP)
2. Otway Offshore Project Operations scenarios:
    1. Operations of the Thylacine platform (at Thylacine-A)
    2. OSV vessel resupply at Thylacine platform for periods of 2, 4, 6 and 8 hrs.
    3. OSV vessel on standby at Thylacine platform for periods of 8 and 24 hrs
4. Otway Offshore Project Construction scenarios: A single nominated pipelay/construction vessel, the Skandi Singapore, was considered for these scenarios. Each scenario was considered with a sound speed profiles for the ‘worst case over the year’ and for the period pygmy blue whales are present in the region, between November and January:
    a. Pipelay vessel (PLV) both stationary and laying pipe at Thylacine North-1 and Artisan-1 operating at 20% of its Maximum Continuous Rating (MCR).
    b. Pipelay vessel operating a Remotely Operated Vehicle (ROV) and cutting tool at Geographe-4. The vessel at Geographe-4 was also modelled operating at 20% and 40% of its Maximum Continuous Rating (MCR).
    c. Quantitively assess the combined sound levels of drilling activities and the construction vessel(s) at the emerging SRW aggregation area at Port Campbell. This scenario considered the drilling activities at

Thylacine North-1 presented in Koessler et al. (2020) and the nominated construction vessel (Skandi Singapore) operating at Geographe-4.

5. Simultaneous assessment for drilling, operations and construction operations were considered for key scenarios:
    a. Drilling at Thylacine while doing Thylacine platform resupply
    b. Drilling at Thylacine while doing installation of Thylacine skid near Thylacine platform. The construction vessel installing the skid was modelled operating at 20% and 40% of its Maximum Continuous Rating (MCR).

Table 3. Description of modelled scenarios. MCR: Maximum Continuous Rating, MODU: Mobile Offshore Drilling Unit, OSV: Offshore Supply Vessel, ROV: Remotely Operated Vehicle.

Scenario number	Well Name	Description	SSP Month	Modelled sites
A1	Thylacine North-1	MODU Drilling	June	1
A2		OSV under DP	June	2
A3		OSV Standby Transit	June	3
A4	Thylacine A	Platform Operations	June	4
A5	Thylacine North-1	MODU Drilling + 4h OSV resupply	June	1,2,3
A6		MODU Drilling + 8h OSV resupply	June	1,2,3
A7		MODU Drilling + OSV Standby Transit	June	1,3
1	Thylacine A	Platform + 2h OSV resupply	June	4,5
2		Platform + 4h OSV resupply	June	4,5
3		Platform + 6h OSV resupply	June	4,5
4		Platform + 8h OSV resupply	June	4,5
5		Platform 8h + OSV Standby	June	3,5
6		Platform + 24h OSV Standby	June	3,5
7	Thylacine North-1	Pipelay Vessel stationary, operating at 20% MCR	June	6
8		Pipelay Vessel stationary, operating at 20% MCR	November	6
9		Pipelay Vessel laying pipe, operating at 20% MCR	June	6
10		Pipelay Vessel laying pipe, operating at 20% MCR	November	6
11	Artisan-1	Pipelay Vessel stationary, operating at 20% MCR	June	7
12		Pipelay Vessel stationary, operating at 20% MCR	November	7
13		Pipelay Vessel laying pipe, operating at 20% MCR	June	7
14		Pipelay Vessel laying pipe, operating at 20% MCR	November	7
15	Thylacine North-1 + Geographe-4	Pipelay Vessel stationary, operating at 20% MCR (Thylacine North-1) + Vessel stationary, operating at 20% MCR + ROV cutting tool (Geographe-4)	June	6,8,9
16		Pipelay Vessel stationary, operating at 20% MCR (Thylacine North-1) + Vessel stationary, operating at 20% MCR + ROV cutting tool (Geographe-4)	November	6,8,9

Scenario number	Well Name	Description	SSP Month	Modelled sites
17	Artisan-1 + Geographe-4	Pipelay Vessel stationary, operating at 20% MCR (Artsian-1) + Vessel stationary, operating at 20% MCR + ROV cutting tool (Geographe-4)	June	7,8,9
18	Artisan-1 + Geographe-4	Vessel stationary, operating at 20% MCR (Pipelay Vessel -1) + Vessel stationary, operating at 20% MCR + ROV cutting tool (Geographe-4)	November	7,8,9
19	Thylacine North-1 + Thylacine A	MODU Drilling + Platform + 4h OSV resupply	June	1,4,5
20		MODU Drilling + Platform + 8h OSV resupply	June	1,4,5
21		MODU Drilling + Platform + Skid installation vessel at 20% MCR	June	1,4,6
22	Thylacine North-1 + Geographe-4	MODU Drilling + 8h OSV resupply (Thylacine North-1) + Vessel stationary, operating at 20% MCR + ROV cutting tool (Geographe-4)	June	1,2,3,8,9
23	Thylacine North-1	Pipelay Vessel stationary, operating at 40% MCR	June	6
24		Pipelay Vessel stationary, operating at 40% MCR	November	6
25		Pipelay Vessel laying pipe, operating at 40% MCR	June	6
26		Pipelay Vessel laying pipe, operating at 40% MCR	November	6
27	Artisan-1	Pipelay Vessel stationary, operating at 40% MCR	June	7
28		Pipelay Vessel stationary, operating at 40% MCR	November	7
29		Pipelay Vessel laying pipe, operating at 40% MCR	June	7
30		Pipelay Vessel laying pipe, operating at 40% MCR	November	7
31	Thylacine North-1 + Geographe-4	Pipelay Vessel stationary, operating at 40% MCR (Thylacine North-1) + Vessel stationary, operating at 40% MCR + ROV cutting tool (Geographe-4)	June	6,8,9
32		Pipelay Vessel stationary, operating at 40% MCR (Thylacine North-1) + Vessel stationary, operating at 40% MCR + ROV cutting tool (Geographe-4)	November	6,8,9
33	Artisan-1 + Geographe-4	Pipelay Vessel stationary, operating at 40% MCR (Artsian-1) + Vessel stationary, operating at 40% MCR + ROV cutting tool (Geographe-4)	June	7,8,9
34		Vessel stationary, operating at 40% MCR (Pipelay Vessel -1) + Vessel stationary, operating at 40% MCR + ROV cutting tool (Geographe-4)	November	7,8,9

35	Thylacine North-1	MODU Drilling + Platform + Skid installation at 40% MCR	June	1,4,6
36	Thylacine North-1 + Geographe-4	MODU Drilling + 8h OSV resupply (Thylacine North-1) + Vessel stationary, operating at 40% MCR + ROV cutting tool (Geographe-4)	June	1,2,3,8,9

Table 4. Location details for the modelled sites. MODU: Mobile Offshore Drilling Unit, OSV: Offshore Supply Vessel, PLV: Pipelay Vessel, ROV: Remotely Operated Vehicle, WHP: Well Head Platform

Well	**Site**	**Source**	**Latitude (S)**	**Longitude (E)**	**MGA Zone 54 (GDA94)**		**Water depth (m)**
					X (m)	*Y* (m)	
Thylacine North-1	1	MODU	39° 12.51001'	142° 52.49601'	661882	5658411	99.1
	2	OSV	39° 12.48903'	142° 53.88508'	663882	5658408	99.1
	3	OSV standby	39° 12.50986'	142° 52.54039'	661946	5658410	99.2
Thylacine A	4	WHP	39° 14.40200'	142° 54.60100'	664838	5654848	102.4
	5	OSV	39° 14.40059'	142° 54.64574'	664902	5654849	102.3
Thylacine North-1	6	PLV	39° 12.51001'	142° 52.49601'	661882	5658411	99.1
Artisan-1	7	PLV	38° 53.45684'	142° 52.97408'	663300	5693640	71.5
Geographe-4	8	PLV	39° 6.49400'	142° 57.06700'	668700	5669400	85.0
	9	*ROV Cutting Tool*	39° 6.49400'	142° 57.06700'	668700	5669400	85.0
Thylacine North-1	10	OSV	39° 14.40200'	142° 54.60100'	664838	5654848	102.4

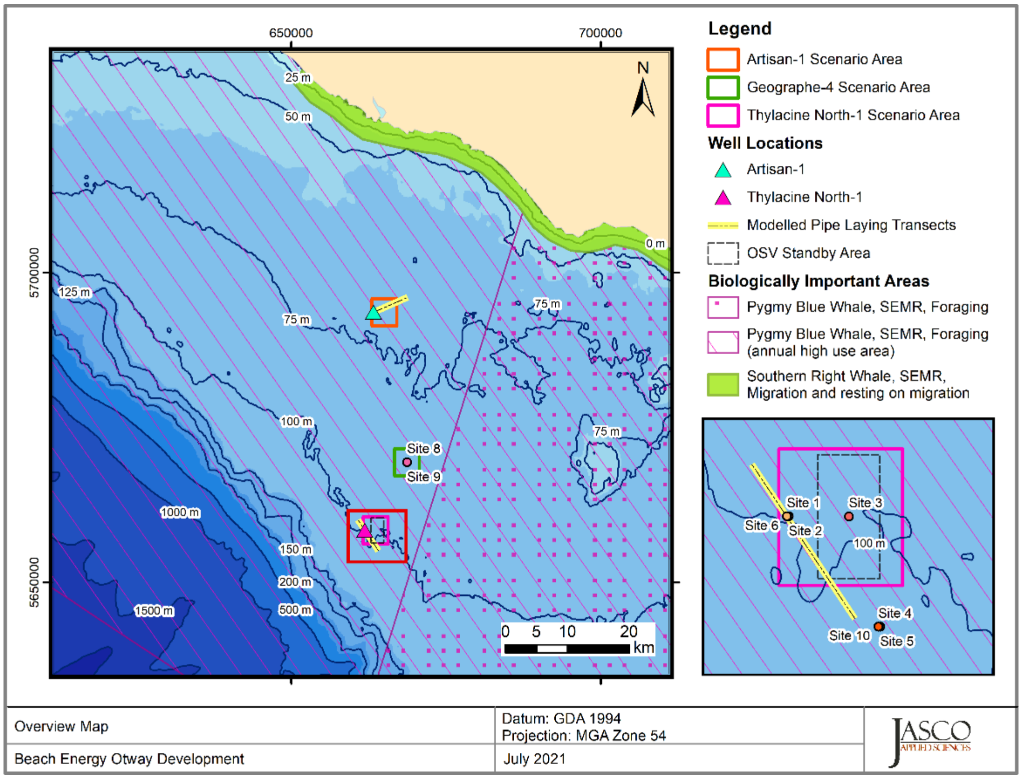


Figure 1. Overview of the modelled area (focus on Thylacine North-1 Scenario Area) and local features within the South East Marine Region (SEMR).

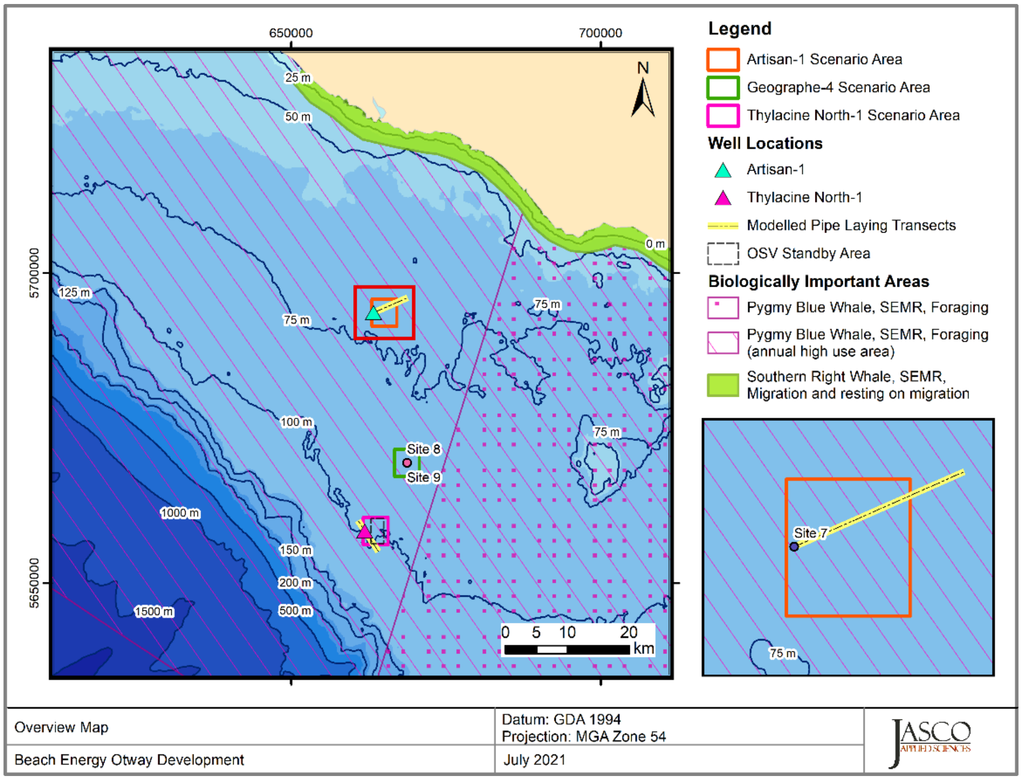


Figure 2. Overview of the modelled area (focus on Artisan-1 Scenario Area) and local features within the South East Marine Region (SEMR).

3. Methods and Parameters

A details description of the employed modelling method and input parameters can be found in refer to Koessler et al. (2020), Matthews et al. (2020), Matthews et al. (2021), Connell et al. (2021) and McPherson et al. (2021). A brief a summary of key elements used in this addendum are provided as follows.

The measured monopole source levels (MSLs) and spectra for the MODU and OSV were used here from McPherson et al. (2021):

- For the MODU drilling, mean levels from Section 5.5.1 in McPherson et al. (2021) were used.
- For scenarios where the OSV was under dynamic positioning (DP) the average spectrum from Section 5.5.2 in McPherson et al. (2021) was used.
- For scenarios where the OSV was transiting or standing by the average slow transit (7 knots) spectrum in McPherson et al. (2021) was used.

For the construction phase scenarios, estimates of the energy source levels (ESLs) for the pipelay/construction vessel were based on the specifications of the *Skandi Singapore* and an ESL derived from recordings of the TechnipFMC flexible lay and construction vessel *Deep Orient*. The specifications of proxy vessel and details on scaling can be found in Matthews et al. (2020), Matthews et al. (2021) and Connell et al. (2021).

Fixed structures such as the WHP have lower radiated sound levels than floating platforms (Spence et al. 2007). Equipment operating onboard floating platforms can contribute to marine environment sound however, airborne and structure-borne (vibration) pathways are considered more significant on these facilities, where equipment can be located below the water line. Underwater noise produced from platforms standing on metal jack-up legs is relatively low given the small surface areas available for sound transmission and also given the location of machinery above the waterline. It is therefore expected that the dominant pathway for sound generation is structure-borne (i.e., vibration from machinery passing through the legs) (Spence et al. 2007).

A study involving the Endeavour Jack-up Rig, operating in Cook Inlet, was conducted by Illingworth and Rodkin (2014) during drilling activities. The results from the sound source verification indicated that sound generated from drilling or generators were below ambient sound levels. The generators used on the Endeavour are mounted on pedestals specifically to reduce sound transfer through the infrastructure, and they are enclosed in an insulated engine room, which may have reduced further underwater sound transmission to levels below those generated by the Spartan 151. The sound source verification revealed that the submersed deep-well pumps that charge the fire-suppression system and cool the generators (in a closed water system) were the most likely dominant contributor the sound field. The measurements are reported as near-source levels recorded close to the bow leg pump system (at 10 m range) (Figure 3-5 in Illingworth and Rodkin Inc. (2014). These were backpropagated using spherical spreading to determine an energy source level (ESL) spectrum. Considering the similarities between a Jack-up Rig and a static WHP the decidecade band spectrum is shown in Figure 3 was used in modelling noise emissions from the Thylacine-A platform.

Furthermore, as discussed by (McPherson et al. 2021) and discussed above in Section 2.1, significant rates of propagation loss were found when analysing the data from the measurement study. As part of the model-measurement validation an adjustment factor was applied broadband received level predictions to account for the loss associated with a cemented limestone seabed (calcarenite) (Section 6.2 in McPherson et al. (2021)). A similar adjustment, which only differed by accounting for sources in different water depths, was applied to broadband level predictions in this addendum as a very similar type of seabed environment is expected at the Thylacine scenario area

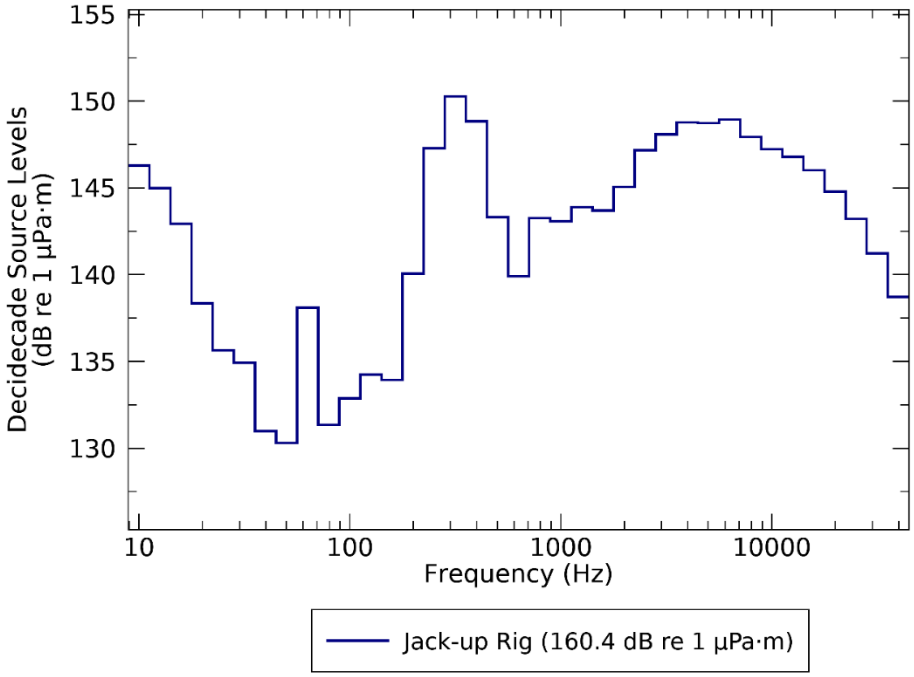


Figure 3. Energy source level (ESL) spectra (in decidecade frequency-band) for the Jack-up Rig considered as a proxy source for the Thylacine WHP.

4. Results

For the considered scenarios (described in Section 2.2), the maximum-over-depth sound fields for the modelled scenarios are presented below in two formats: as tables of distances to sound levels and, where the distances are long enough, as contour maps showing the directivity and distance to various sound levels. Distances to isopleths/thresholds were reported from either the centroid of several sources or from the most dominant single source. When an isopleth completely envelopes multiple sources the centroid was used. When several closed isopleths exist the most dominant source was used.

Tables 5–7 present the maximum and 95% distances (defined in Appendix B.1) to SPL isopleths. Since the SPL metric does not depend on the duration of the operation, these estimates are valid for both, stationary and non-stationary scenarios. Tables 11–16 present the distances to frequency-weighted SEL_{24h} threshold, as well as the total ensonified area for all scenarios.

The maximum-over-depth sound fields for nine scenarios (described in Section were extracted at the emerging SRW aggregation area at Port Campbell, and can be compared to the 120 dB re 1 µPa threshold for marine mammal behavioural response to continuous noise (NOAA 2019).

4.1. Tabulated Results

Table 5. *Scenarios A1–A7:* Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) to sound pressure level (SPL) from the most appropriate location for considered sources per scenarioA dash indicates the level was not reached within the limits of the modelling resolution (20 m). MODU: Mobile Offshore Drilling Unit, OSV: Offshore Supply Vessel, DP: Dynamic Positioning.

SPL (L_p; dB re 1 µPa)	**MODU Drilling (Scenario A1)**		**OSV under DP (Scenario A2)**		**OSV Standby Transit (Scenario A3)**		**Platform (Scenario A4)**		**MODU Drilling and OSV Resupply (Scenario A5)**		**MODU Drilling and OSV Standby (Scenario A7)**	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
180	–	–	–	–	–	–	–	–	0.05	0.05	–	–
170[A]	–	–	–	–	–	–	–	–	0.05	0.05	–	–
160	–	–	0.08	0.08	–	–	–	–	0.11	0.10	–	–
158[B]	–	–	0.13	0.12	–	–	–	–	0.15	0.15	–	–
150	–	–	0.32	0.31	–	–	–	–	0.36	0.31	–	–
140	0.09	0.09	0.87	0.81	–	–	–	–	0.88	0.82	0.09	0.09
130	0.38	0.35	2.3	2.15	0.17	0.16	–	–	2.51	2.18	0.38	0.35
120[C]	1.24	1.12	7.10	6.50	0.38	0.35	0.20	0.19	7.89	6.56	1.32	1.19

[A] 48 h threshold for recoverable injury for fish with a swim bladder involved in hearing (Popper et al. 2014).

[B] 12 h threshold for TTS for fish with a swim bladder involved in hearing (Popper et al. 2014).

[C] Threshold for marine mammal behavioural response to continuous noise (NOAA 2019).

Table 6. *Scenarios 1–11:* Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) to sound pressure level (SPL) from the most appropriate location for considered sources per scenario. A dash indicates the level was not reached within the limits of the modelling resolution (20 m). OSV: Offshore Supply Vessel, PLV: Pipelay Vessel.

SPL (L_p; dB re 1 µPa)	**Platform and OSV resupply (Scenario 1)**		**Platform and OSV standby (Scenario 5)**		**PLV stationary operating at 20% MCR, Thylacine**				**PLV stationary operating at 20% MCR, Artisan**			
					June (Scenario 7)		**November (Scenario 8)**		**June (Scenario 11)**		**November (Scenario 12)**	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
180	–	–	–	–	–	–	–	–	–	–	–	–
170[A]	–	–	–	–	–	–	–	–	–	–	–	–
160	0.08	0.08	–	–	–	–	–	–	–	–	–	–
158[B]	0.14	0.09	–	–	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
150	0.28	0.27	–	–	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
140	0.85	0.80	–	–	0.33	0.32	0.33	0.32	0.29	0.29	0.29	0.29
130	2.48	2.18	0.17	0.16	0.95	0.85	0.94	0.84	0.87	0.80	0.87	0.80
120[C]	7.31	6.56	0.45	0.43	2.71	2.57	2.70	2.55	2.27	2.09	2.26	2.02

[A] 48 h threshold for recoverable injury for fish with a swim bladder involved in hearing (Popper et al. 2014).

[B] 12 h threshold for TTS for fish with a swim bladder involved in hearing (Popper et al. 2014).

[C] Threshold for marine mammal behavioural response to continuous noise (NOAA 2019).

Table 7. *Scenarios 15–21:* Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) to sound pressure level (SPL) from the most appropriate location for considered sources per scenario. A dash indicates the level was not reached within the limits of the modelling resolution (20 m). MODU: Mobile Offshore Drilling Unit, OSV: Offshore Supply Vessel, PLV: Pipelay Vessel, ROV: Remotely Operated Vehicle.

SPL (L_p; dB re 1 µPa)	**PLV stationary operating at 20% MCR, at Thylacine and ROV Operations at Geographe-4**				**PLV stationary operating at 20% MCR, at Artisan and ROV Operations at Geographe-4**				**MODU Drilling, Platform and OSV resupply**		**MODU Drilling, Platform and Skid installation vessel at 20% MCR**	
	June (Scenario 15)		**November (Scenario 16)**		**June (Scenario 17)**		**November (Scenario 18)**		**(Scenario 19)**		**(Scenario 21)**	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
180	–	–	–	–	–	–	–	–	–	–	–	–
170[A]	–	–	–	–	–	–	–	–	–	–	–	–
160	–	–	–	–	–	–	–	–	0.08	0.08	–	–
158[B]	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.14	0.09	0.04	0.04
150	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.28	0.27	0.09	0.09
140	0.32	0.31	0.32	0.31	0.32	0.31	0.32	0.31	0.85	0.80	0.31	0.30
130	0.91	0.86	0.91	0.84	0.91	0.86	0.91	0.84	2.48	2.18	0.85	0.83
120[C]	2.98	2.76	2.97	2.73	2.98	2.75	2.97	2.72	7.90	6.65	4.85	4.29

[A] 48 h threshold for recoverable injury for fish with a swim bladder involved in hearing (Popper et al. 2014).

[B] 12 h threshold for TTS for fish with a swim bladder involved in hearing (Popper et al. 2014).

[C] Threshold for marine mammal behavioural response to continuous noise (NOAA 2019).

Table 8. *Scenarios 23–24, 27–28:* Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) to sound pressure level (SPL) from the most appropriate location for considered sources per scenario. A dash indicates the level was not reached within the limits of the modelling resolution (20 m). OSV: Offshore Supply Vessel, PLV: Pipelay Vessel.

SPL (L_p; dB re 1 µPa)	**PLV stationary operating at 40% MCR, Thylacine**				**PLV stationary operating at 40% MCR, Artisan**			
	June (Scenario 23)		**November (Scenario 24)**		**June (Scenario 27)**		**November (Scenario 28)**	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
180	–	–	–	–	–	–	–	–
170[A]	–	–	–	–	–	–	–	–
160	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
158[B]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
150	0.17	0.17	0.17	0.17	0.16	0.15	0.16	0.15
140	0.44	0.43	0.44	0.43	0.39	0.38	0.39	0.38
130	1.26	1.18	1.27	1.17	1.12	1.10	1.12	1.09
120[C]	4.13	3.64	4.11	3.63	2.87	2.46	2.86	2.46

[A] 48 h threshold for recoverable injury for fish with a swim bladder involved in hearing (Popper et al. 2014).
[B] 12 h threshold for TTS for fish with a swim bladder involved in hearing (Popper et al. 2014).
[C] Threshold for marine mammal behavioural response to continuous noise (NOAA 2019).

Table 9. *Scenarios 31–35:* Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) to sound pressure level (SPL) from the most appropriate location for considered sources per scenario. A dash indicates the level was not reached within the limits of the modelling resolution (20 m). MODU: Mobile Offshore Drilling Unit, OSV: Offshore Supply Vessel, PLV: Pipelay Vessel, ROV: Remotely Operated Vehicle.

SPL (L_p; dB re 1 µPa)	**PLV stationary operating at 40% MCR, at Thylacine and ROV Operations at Geographe-4**				**PLV stationary operating at 40% MCR, at Artisan and ROV Operations at Geographe-4**				**MODU Drilling, Platform and Skid Installation Vessel operating at 40% MCR**	
	June (Scenario 31)		**November (Scenario 32)**		**June (Scenario 33)**		**November (Scenario 34)**		**(Scenario 35)**	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
180	–	–	–	–	–	–	–	–	–	–
170[A]	–	–	–	–	–	–	–	–	–	–
160	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
158[B]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
150	0.16	0.15	0.16	0.16	0.16	0.15	0.16	0.16	0.15	0.14
140	0.46	0.41	0.46	0.4	0.46	0.41	0.46	0.40	0.42	0.38
130	1.56	1.26	1.56	1.25	1.56	1.26	1.56	1.25	1.39	1.14
120[C]	3.77	3.29	3.76	3.23	3.76	3.24	3.63	3.20	6.08	4.99

[A] 48 h threshold for recoverable injury for fish with a swim bladder involved in hearing (Popper et al. 2014).

[B] 12 h threshold for TTS for fish with a swim bladder involved in hearing (Popper et al. 2014).

[C] Threshold for marine mammal behavioural response to continuous noise (NOAA 2019).

Table 10. Received SPL at the Port Campbell SRW receiver for relevant scenarios.

Scenario	**Description**	**Location(s)**	**SPL (Lp; dB re 1 µPa) at Port Campbell SRW Receiver**
22	MODU Drilling + 8h OSV resupply (Thylacine North-1) + Vessel stationary, operating at 20% MCR + ROV cutting tool (Geographe-4)	Thylacine North-1 + Geographe-4	93.8
36	MODU Drilling + 8h OSV resupply (Thylacine North-1) + Vessel stationary, operating at 40% MCR + ROV cutting tool (Geographe-4)	Thylacine North-1 + Geographe-4	94.1

Table 11. *Scenarios A1-A7:* Maximum (R_{max}) horizontal distances (in km) to frequency-weighted SEL$_{24h}$ PTS and TTS thresholds based on NMFS (2018) and Finneran et al. (2017) from the most appropriate location for considered sources per scenario, and ensonified area (km^2). A dash indicates the level was not reached within the limits of the modelling resolution (20 m). MODU: Mobile Offshore Drilling Unit, OSV: Offshore Supply Vessel.

Hearing group	**SEL$_{24h}$ threshold** ($L_{E,24h}$; dB re 1 µPa^2·s)†	**MODU Drilling (Scenario A1)**		**OSV under DP (Scenario A2)**		**OSV Standby Transit (Scenario A3)**		**Platform (Scenario A4)**		**MODU Drilling and 4h OSV resupply (Scenario A5)**		**MODU Drilling and 8h OSV resupply (Scenario A6)**		**MODU Drilling and OSV Standby Transit (Scenario A7)**	
		R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)
PTS															
LF cetaceans	199	0.03	0.004	0.09	0.03	–	–	0.02	0.001	0.12	0.03	0.18	0.08	0.06	0.004
MF cetaceans	198	0.02	0.001	0.02	0.001	–	–	0.02	0.001	0.05	0.002	0.05	0.002	0.04	0.001
HF cetaceans	173	0.23	0.16	0.06	0.01	–	–	0.03	0.004	0.26	0.16	0.26	0.17	0.26	0.16
Phocid seals	201	0.02	0.001	0.03	0.003	–	–	0.02	0.001	0.05	0.004	0.07	0.01	0.04	0.001
Otariid seals	219	–	–	–	–	–	–	–	–	0.03	0.001	0.05	0.001	–	–
Turtles	220	–	–	0.02	0.001	–	–	–	–	0.05	0.002	0.05	0.002	–	–
TTS															
LF cetaceans	179	0.39	0.33	0.95	2.33	–	–	0.04	0.004	1.06	2.49	1.31	4.39	0.39	0.33
MF cetaceans	178	0.13	0.06	0.06	0.01	–	–	0.03	0.003	0.16	0.06	0.16	0.07	0.13	0.06
HF cetaceans	153	1.12	3.22	0.47	0.69	–	–	0.30	0.28	1.16	3.71	1.16	3.99	1.12	3.22
Phocid seals	181	0.12	0.04	0.28	0.24	–	–	0.03	0.00	0.32	0.27	0.46	0.55	0.12	0.04
Otariid seals	199	0.02	0.001	0.04	0.01	–	–	0.02	0.001	0.07	0.01	0.09	0.01	0.02	0.001
Turtles	200	0.02	0.002	0.07	0.02	–	–	0.02	0.001	0.10	0.02	0.16	0.06	0.02	0.002

Table 12. *Scenarios 1–6:* Maximum (R_{max}) horizontal distances (in km) to frequency-weighted SEL$_{24h}$ PTS and TTS thresholds based on NMFS (2018) and Finneran et al. (2017) from the most appropriate location for considered sources per scenario, and ensonified area (km^2). A dash indicates the level was not reached within the limits of the modelling resolution (20 m), OSV: Offshore Supply Vessel.

Hearing group	**SEL$_{24h}$ threshold** ($L_{E,24h}$; dB re 1 µPa^2·s)†	**Platform and OSV resupply 2 h (Scenario 1)**		**Platform and OSV resupply 4 h (Scenario 2)**		**Platform and OSV resupply 6 h (Scenario 3)**		**Platform and OSV resupply 8 h (Scenario 4)**		**Platform and OSV 8h standby (Scenario 5)**		**Platform and OSV 24h standby (Scenario 6)**	
		R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)
PTS													
LF cetaceans	199	0.10	0.02	0.12	0.03	0.14	0.04	0.18	0.07	0.02	0.001	0.02	0.001
MF cetaceans	198	0.05	0.001	0.05	0.001	0.05	0.002	0.05	0.002	0.02	0.001	0.02	0.001
HF cetaceans	173	0.08	0.01	0.09	0.02	0.10	0.02	0.11	0.02	0.03	0.004	0.03	0.004
Phocid seals	201	0.05	0.002	0.06	0.004	0.06	0.01	0.08	0.01	0.02	0.001	0.02	0.001
Otariid seals	219	–	–	–	–	–	–	–	–	–	–	–	–
Turtles	220	–	–	–	–	0.04	0.001	0.04	0.001	–	–	–	–
TTS													
LF cetaceans	179	0.75	1.31	0.95	2.30	1.11	3.15	1.25	4.01	0.04	0.004	0.04	0.004
MF cetaceans	178	0.06	0.01	0.08	0.01	0.09	0.02	0.10	0.02	0.03	0.003	0.03	0.003
HF cetaceans	153	0.45	0.60	0.52	0.79	0.60	1.05	0.63	1.17	0.30	0.28	0.30	0.28
Phocid seals	181	0.23	0.12	0.30	0.24	0.37	0.36	0.43	0.46	0.03	0.00	0.03	0.00
Otariid seals	199	0.06	0.004	0.07	0.01	0.08	0.01	0.08	0.01	0.02	0.001	0.02	0.001
Turtles	200	0.08	0.01	0.10	0.02	0.11	0.02	0.17	0.04	0.02	0.001	0.02	0.001

Table 13. *Scenarios 7–10:* Maximum (R_{max}) horizontal distances (in km) to frequency-weighted SEL$_{24h}$ PTS and TTS thresholds based on NMFS (2018) and Finneran et al. (2017) from the most appropriate location for considered sources per scenario, and ensonified area (km^2). A dash indicates the level was not reached within the limits of the modelling resolution (20 m), PLV: Pipelay Vessel.

Hearing group	**SEL$_{24h}$ threshold** ($L_{E,24h}$; dB re 1 µPa²·s)†	**PLV stationary operating at 20% MCR, at Thylacine**				**PLV laying pipe operating at 20% MCR, at Thylacine**			
		June (Scenario 7)		**November (Scenario 8)**		**June (Scenario 9)**		**November (Scenario 10)**	
		R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)
PTS									
LF cetaceans	199	0.06	0.01	0.06	0.01	0.02	0.21	0.02	0.21
MF cetaceans	198	0.02	0.001	0.02	0.001	0.01	0.02	0.01	0.02
HF cetaceans	173	0.09	0.03	0.09	0.03	0.03	0.37	0.03	0.36
Phocid seals	201	0.02	0.001	0.02	0.001	0.01	0.14	0.01	0.14
Otariid seals	219	–	–	–	–	–	–	–	–
Turtles	220	0.02	0.001	0.02	0.001	–	–	–	–
TTS									
LF cetaceans	179	0.60	1.04	0.59	1.04	1.18	13.62	1.17	13.53
MF cetaceans	178	0.07	0.02	0.07	0.02	0.02	0.22	0.02	0.22
HF cetaceans	153	0.84	2.02	0.70	1.36	1.19	15.04	1.46	16.02
Phocid seals	181	0.19	0.12	0.19	0.12	0.13	1.54	0.13	1.54
Otariid seals	199	0.02	0.001	0.02	0.001	0.01	0.15	0.01	0.15
Turtles	200	0.08	0.02	0.08	0.02	0.02	0.27	0.02	0.27

Table 14. *Scenarios 11–14:* Maximum (R_{max}) horizontal distances (in km) to frequency-weighted SEL_{24h} PTS and TTS thresholds based on NMFS (2018) and Finneran et al. (2017) from the most appropriate location for considered sources per scenario, and ensonified area (km^2). A dash indicates the level was not reached within the limits of the modelling resolution (20 m), PLV: Pipelay Vessel.

Hearing group	**SEL_{24h} threshold** ($L_{E,24h}$; dB re 1 µPa²·s)†	**PLV stationary operating at 20% MCR, at Artisan**				**PLV laying pipe operating at 20% MCR, at Artisan**			
		June (Scenario 11)		**November (Scenario 12)**		**June (Scenario 13)**		**November (Scenario 14)**	
		R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)
PTS									
LF cetaceans	199	0.06	0.01	0.06	0.01	0.02	0.25	0.02	0.25
MF cetaceans	198	0.01	0.001	0.01	0.001	–	–	–	–
HF cetaceans	173	0.09	0.03	0.09	0.03	0.03	0.37	0.03	0.37
Phocid seals	201	0.02	0.001	0.02	0.001	0.02	0.13	0.02	0.13
Otariid seals	219	–	–	–	–	–	–	–	–
Turtles	220	0.01	0.001	0.01	0.001	–	–	–	–
TTS									
LF cetaceans	179	0.67	1.14	0.67	1.12	0.90	10.76	0.90	10.69
MF cetaceans	178	0.07	0.02	0.07	0.02	0.03	0.30	0.03	0.30
HF cetaceans	153	0.77	1.60	0.62	1.18	0.95	11.92	0.91	10.68
Phocid seals	181	0.19	0.11	0.19	0.11	0.12	1.36	0.12	1.36
Otariid seals	199	0.02	0.001	0.02	0.001	0.02	0.22	0.02	0.22
Turtles	200	0.07	0.02	0.07	0.02	0.03	0.29	0.03	0.29

Table 15. *Scenarios 15–18:* Maximum (R_{max}) horizontal distances (in km) to frequency-weighted SEL_{24h} PTS and TTS thresholds based on NMFS (2018) and Finneran et al. (2017) from the most appropriate location for considered sources per scenario, and ensonified area (km^2). A dash indicates the level was not reached within the limits of the modelling resolution (20 m), PLV: Pipelay Vessel, ROV: Remotely Operated Vehicle.

Hearing group	**SEL_{24h} threshold** ($L_{E,24h}$; dB re 1 µPa²·s)†	**PLV stationary operating at 20% MCR, at Thylacine and ROV Operations at Geographe-4**				**PLV stationary operating at 20% MCR, at Artisan and ROV Operations at Geographe-4**			
		June (Scenario 15)		**November (Scenario 16)**		**June (Scenario 17)**		**November (Scenario 18)**	
		R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)
PTS									
LF cetaceans	199	0.06	0.01	0.06	0.01	0.06	0.01	0.06	0.01
MF cetaceans	198	0.02	0.001	0.02	0.001	0.02	0.001	0.02	0.001
HF cetaceans	173	0.12	0.04	0.11	0.04	0.12	0.04	0.11	0.04
Phocid seals	201	0.02	0.001	0.02	0.001	0.02	0.001	0.02	0.001
Otariid seals	219	0.01	0.001	0.01	0.001	0.01	0.001	0.01	0.001
Turtles	220	0.02	0.001	0.02	0.001	0.01	0.001	0.01	0.001
TTS									
LF cetaceans	179	0.66	1.35	0.66	1.34	0.67	1.35	0.67	1.33
MF cetaceans	178	0.09	0.03	0.09	0.03	0.09	0.03	0.09	0.03
HF cetaceans	153	0.87	2.37	0.83	1.93	0.87	2.37	0.83	1.93
Phocid seals	181	0.19	0.12	0.19	0.12	0.19	0.11	0.19	0.11
Otariid seals	199	0.02	0.001	0.02	0.001	0.02	0.001	0.02	0.001
Turtles	200	0.08	0.02	0.08	0.02	0.08	0.02	0.08	0.02

Table 16. *Scenarios 19–21:* Maximum (R_{max}) horizontal distances (in km) to frequency-weighted SEL$_{24h}$ PTS and TTS thresholds based on NMFS (2018) and Finneran et al. (2017) from the most appropriate location for considered sources per scenario, and ensonified area (km^2). A dash indicates the level was not reached within the limits of the modelling resolution (20 m). MODU: Mobile Offshore Drilling Unit, OSV: Offshore Supply Vessel.

Hearing group	**SEL$_{24h}$ threshold** ($L_{E,24h}$; dB re 1 µPa²·s)†	**MODU Drilling, Platform and 4 h OSV resupply (Scenario 19)**		**MODU Drilling, Platform and 8 h OSV resupply (Scenario 20)**		**MODU Drilling, Platform and Skid Installation Vessel operating at 20% MCR (Scenario 21)**	
		R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)
PTS							
LF cetaceans	199	0.09	0.03	0.15	0.07	0.06	0.01
MF cetaceans	198	0.04	0.001	0.04	0.001	0.04	0.001
HF cetaceans	173	0.26	0.16	0.26	0.16	0.26	0.16
Phocid seals	201	0.04	0.004	0.05	0.008	0.04	0.001
Otariid seals	219	–	–	–	–	–	–
Turtles	220	–	–	0.03	0.001	0.03	0.001
TTS							
LF cetaceans	179	0.95	2.31	1.23	4.03	0.65	1.10
MF cetaceans	178	0.16	0.06	0.16	0.06	0.16	0.06
HF cetaceans	153	1.15	3.25	1.15	3.26	1.15	3.26
Phocid seals	181	0.28	0.24	0.41	0.46	0.18	0.09
Otariid seals	199	0.04	0.005	0.06	0.011	0.04	0.001
Turtles	200	0.08	0.02	0.15	0.04	0.08	0.02

Table 17. *Scenarios 23–26:* Maximum (R_{max}) horizontal distances (in km) to frequency-weighted SEL$_{24h}$ PTS and TTS thresholds based on NMFS (2018) and Finneran et al. (2017) from the most appropriate location for considered sources per scenario, and ensonified area (km^2). A dash indicates the level was not reached within the limits of the modelling resolution (20 m), PLV: Pipelay Vessel.

Hearing group	**SEL$_{24h}$ threshold** ($L_{E,24h}$; dB re 1 µPa^2·s)†	**PLV stationary operating at 40% MCR, at Thylacine**				**PLV laying pipe operating at 40% MCR, at Thylacine**			
		June (Scenario 23)		**November (Scenario 24)**		**June (Scenario 25)**		**November (Scenario 26)**	
		R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)
PTS									
LF cetaceans	199	0.09	0.03	0.09	0.03	0.03	0.39	0.03	0.39
MF cetaceans	198	0.02	0.001	0.02	0.001	0.01	0.11	0.01	0.11
HF cetaceans	173	0.16	0.08	0.16	0.08	0.07	0.79	0.07	0.78
Phocid seals	201	0.02	0.001	0.02	0.001	0.02	0.18	0.01	0.18
Otariid seals	219	–	–	–	–	–	–	–	–
Turtles	220	0.02	0.001	0.02	0.001	–	–	–	–
TTS									
LF cetaceans	179	0.95	2.28	0.94	2.23	1.95	24.2	1.95	24.1
MF cetaceans	178	0.10	0.03	0.10	0.03	0.04	0.48	0.04	0.47
HF cetaceans	153	1.17	3.44	0.94	2.47	1.75	21.8	2.08	27.0
Phocid seals	181	0.27	0.22	0.30	0.22	0.24	2.76	0.24	2.75
Otariid seals	199	0.03	0.003	0.03	0.003	0.02	0.18	0.02	0.18
Turtles	200	0.11	0.038	0.11	0.04	0.05	0.57	0.05	0.57

Table 18. *Scenarios 27–30:* Maximum (R_{max}) horizontal distances (in km) to frequency-weighted SEL$_{24h}$ PTS and TTS thresholds based on NMFS (2018) and Finneran et al. (2017) from the most appropriate location for considered sources per scenario, and ensonified area (km^2). A dash indicates the level was not reached within the limits of the modelling resolution (20 m), PLV: Pipelay Vessel.

Hearing group	**SEL$_{24h}$ threshold** ($L_{E,24h}$; dB re 1 µPa^2·s)†	**PLV stationary operating at 40% MCR, at Artisan**				**PLV laying pipe operating at 40% MCR, at Artisan**			
		June (Scenario 27)		**November (Scenario 28)**		**June (Scenario 29)**		**November (Scenario 30)**	
		R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)
PTS									
LF cetaceans	199	0.09	0.03	0.09	0.03	0.04	0.39	0.03	0.39
MF cetaceans	198	0.01	0.001	0.01	0.001	0.01	0.02	0.01	0.01
HF cetaceans	173	0.14	0.06	0.14	0.06	0.07	0.75	0.06	0.74
Phocid seals	201	0.02	0.001	0.02	0.001	0.02	0.25	0.02	0.25
Otariid seals	219	–	–	–	–	–	–	–	–
Turtles	220	–	–	–	–	–	–	–	–
TTS									
LF cetaceans	179	0.88	2.02	0.88	1.99	1.40	17.1	1.39	17.0
MF cetaceans	178	0.10	0.03	0.11	0.04	0.04	0.49	0.04	0.48
HF cetaceans	153	0.94	2.75	0.81	1.93	1.27	16.5	1.53	18.3
Phocid seals	181	0.25	0.19	0.24	0.18	0.21	2.44	0.21	2.43
Otariid seals	199	0.03	0.002	0.03	0.002	0.02	0.25	0.02	0.25
Turtles	200	0.14	0.06	0.14	0.06	0.05	0.59	0.05	0.59

Table 19. *Scenarios 31–34:* Maximum (R_{max}) horizontal distances (in km) to frequency-weighted SEL_{24h} PTS and TTS thresholds based on NMFS (2018) and Finneran et al. (2017) from the most appropriate location for considered sources per scenario, and ensonified area (km^2). A dash indicates the level was not reached within the limits of the modelling resolution (20 m), PLV: Pipelay Vessel, ROV: Remotely Operated Vehicle.

Hearing group	**SEL_{24h} threshold** ($L_{E,24h}$; dB re 1 µPa²·s)†	**PLV stationary operating at 40% MCR, at Thylacine and ROV Operations at Geographe-4**				**PLV stationary operating at 40% MCR, at Artisan and ROV Operations at Geographe-4**				**MODU Drilling, Platform and Skid Installation Vessel operating at 40% MCR (Scenario 35)**	
		June (Scenario 31)		**November (Scenario 32)**		**June (Scenario 33)**		**November (Scenario 34)**			
		R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)
PTS											
LF cetaceans	199	0.10	0.03	0.09	0.03	0.10	0.03	0.09	0.03	0.09	0.03
MF cetaceans	198	0.02	0.001	0.02	0.001	0.02	0.001	0.02	0.001	0.04	0.001
HF cetaceans	173	0.16	0.08	0.16	0.08	0.15	0.08	0.15	0.08	0.26	0.16
Phocid seals	201	0.02	0.002	0.02	0.002	0.02	0.002	0.02	0.002	0.04	0.001
Otariid seals	219	–	–	–	–	–	–	–	–	–	–
Turtles	220	0.02	0.001	0.02	0.001	–	–	–	–	0.03	0.001
TTS											
LF cetaceans	179	0.95	2.39	0.94	2.38	0.91	2.39	0.91	2.38	0.85	2.10
MF cetaceans	178	0.13	0.05	0.13	0.05	0.13	0.05	0.13	0.05	0.16	0.06
HF cetaceans	153	1.17	3.55	0.99	3.08	1.06	3.55	0.99	3.08	1.15	3.28
Phocid seals	181	0.27	0.22	0.27	0.22	0.25	0.19	0.25	0.19	0.22	0.15
Otariid seals	199	0.03	0.003	0.03	0.003	0.03	0.003	0.03	0.003	0.04	0.003
Turtles	200	0.15	0.05	0.15	0.05	0.15	0.06	0.15	0.06	0.10	0.04

4.2. Sound Field Maps

4.2.1. SPL Maps

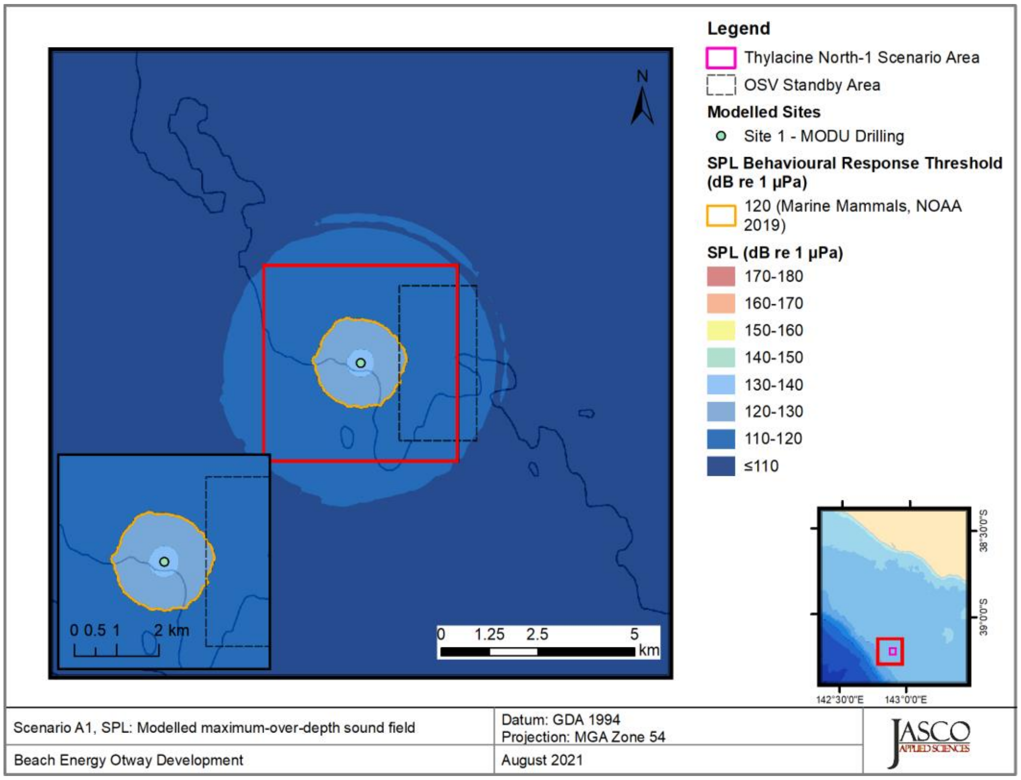


Figure 4. *Thylacine North-1, MODU Drilling (Scenario A1) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

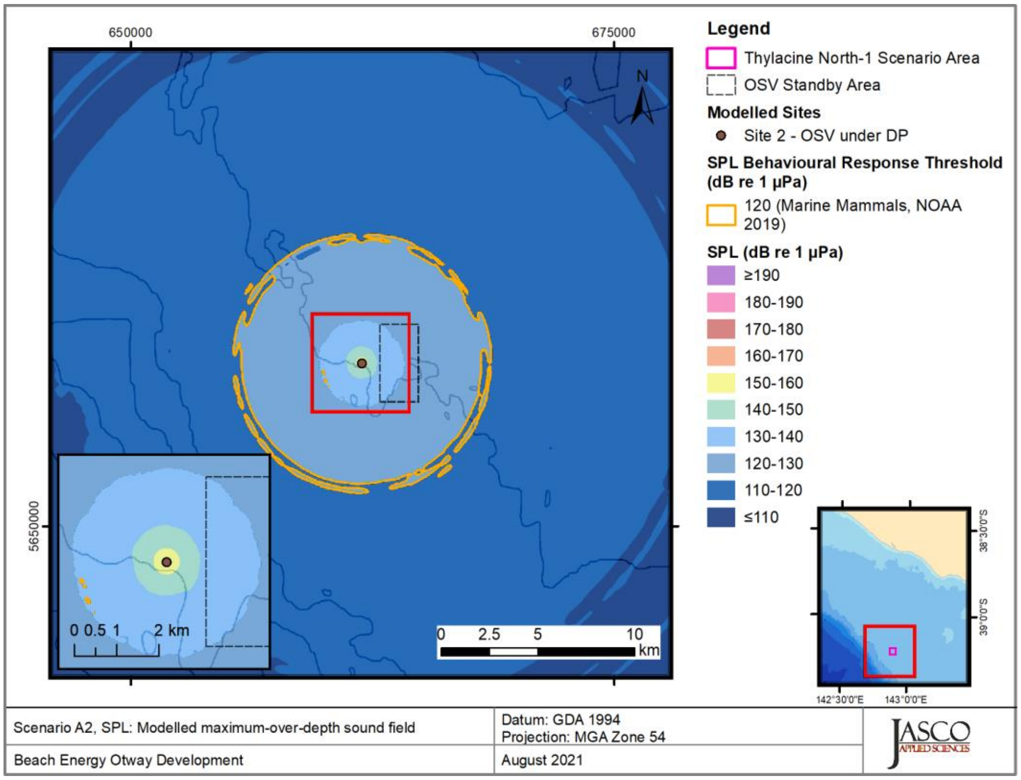


Figure 5. *Thylacine North-1, OSV on DP (Scenario A2) :* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

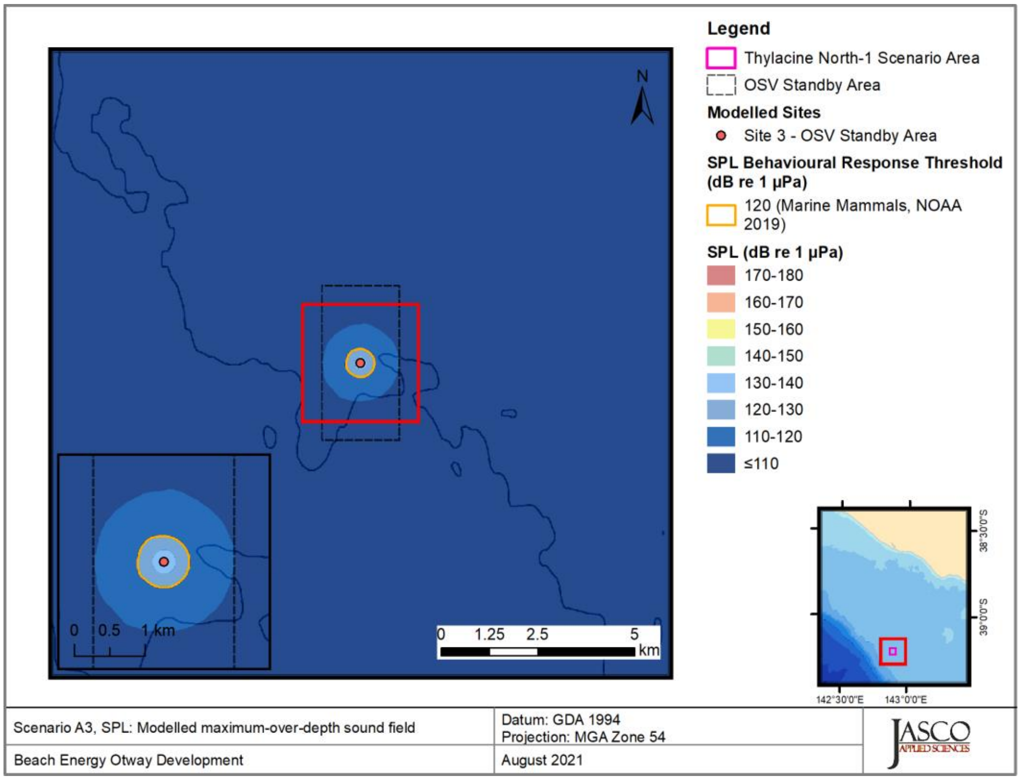


Figure 6. *Thylacine North-1, OSV Standby (Scenario A3) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

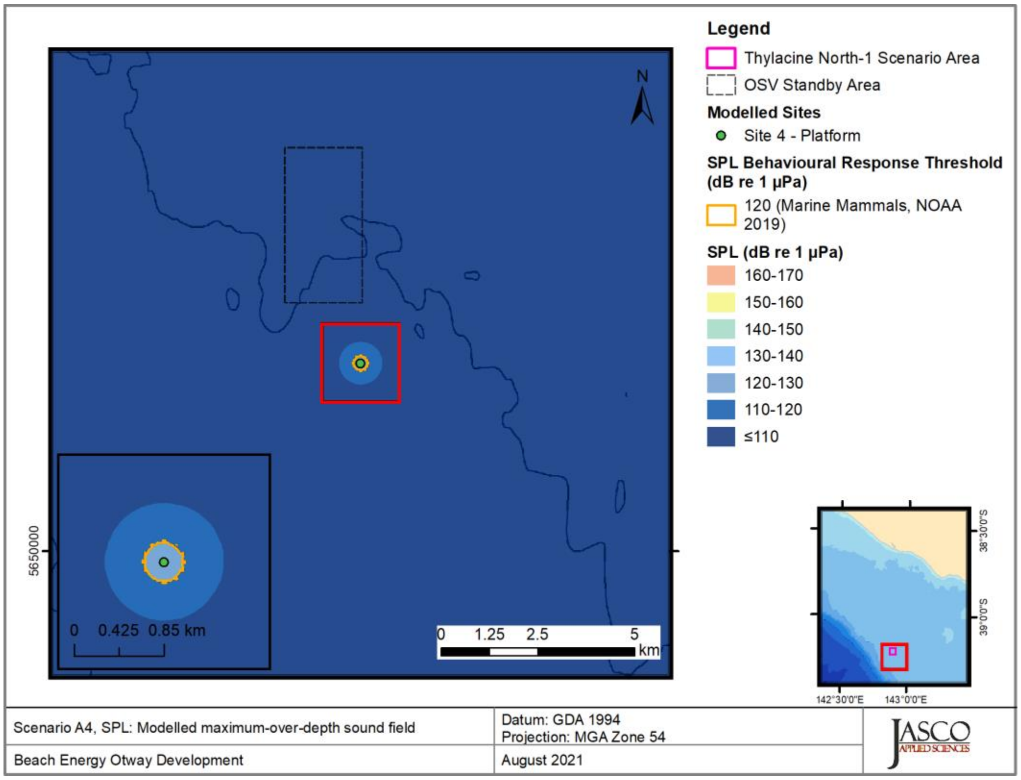


Figure 7. *Thylacine A, Platform Operations (Scenario A4) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

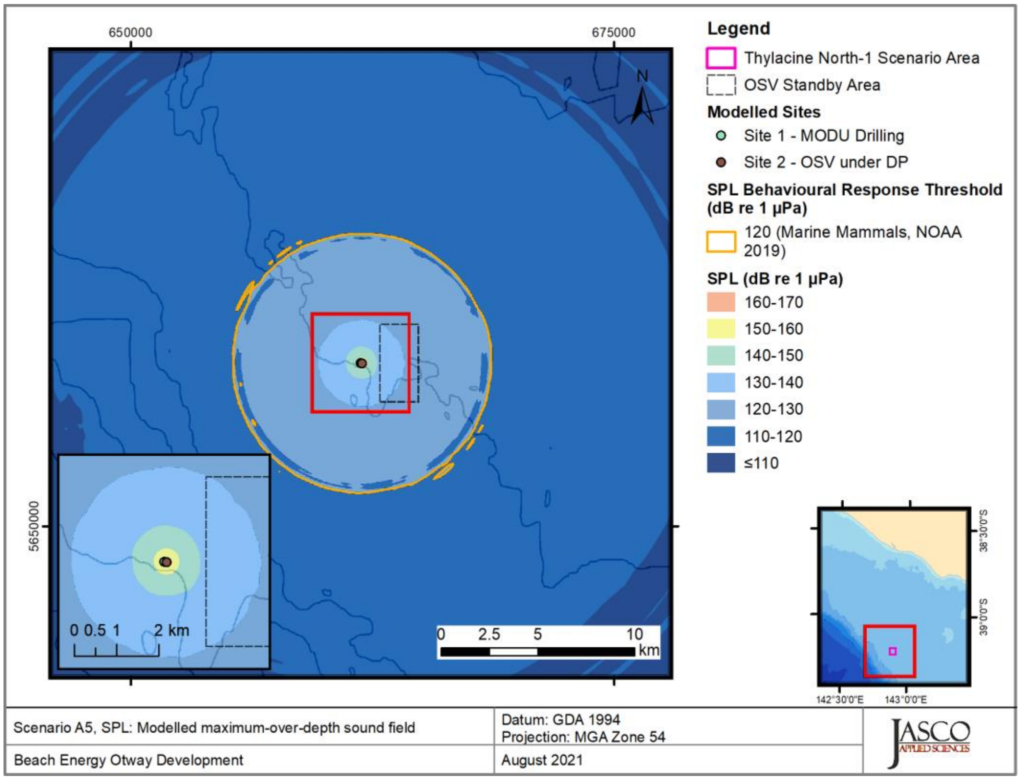


Figure 8. *Thylacine North-1, MODU Drilling and OSV Resupply (Scenario A5) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

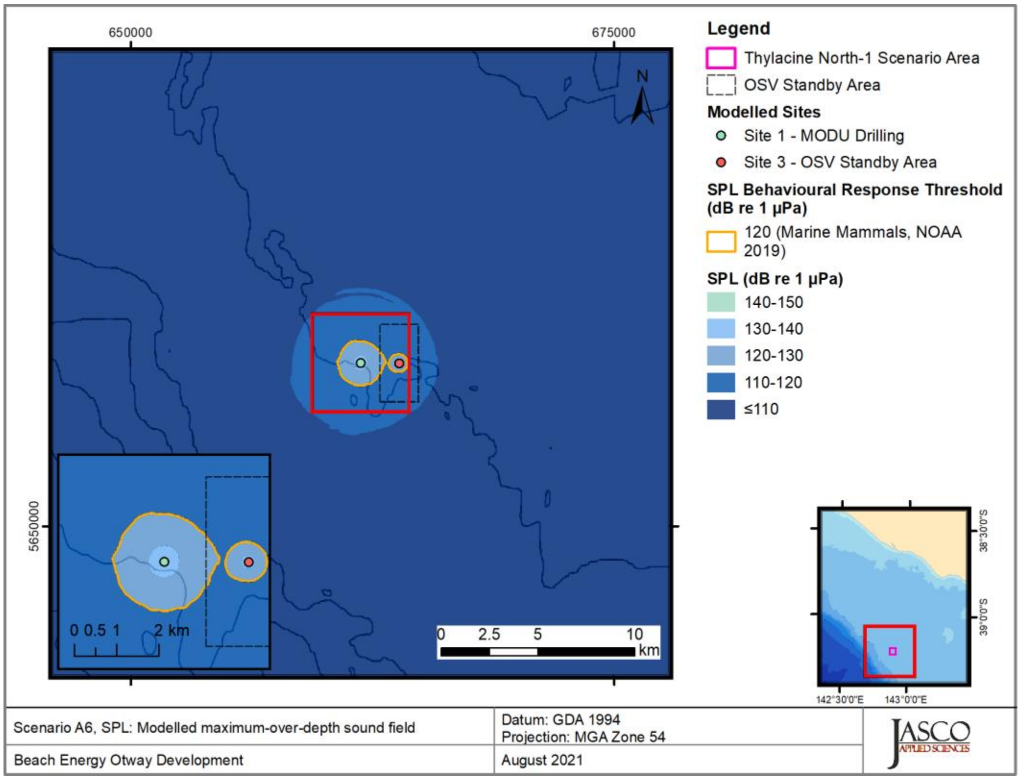


Figure 9. *Thylacine North-1, MODU Drilling and OSV Standby (Scenario A7) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

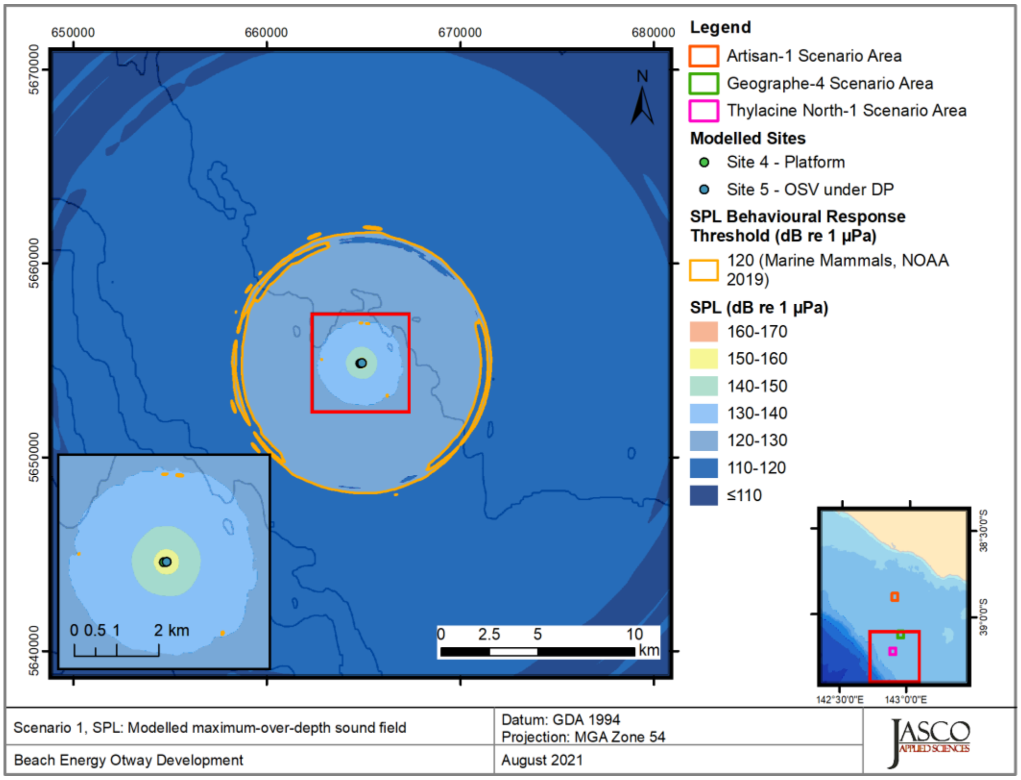


Figure 10. *Thylacine A Platform, Platform Resupply (Scenario 1) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

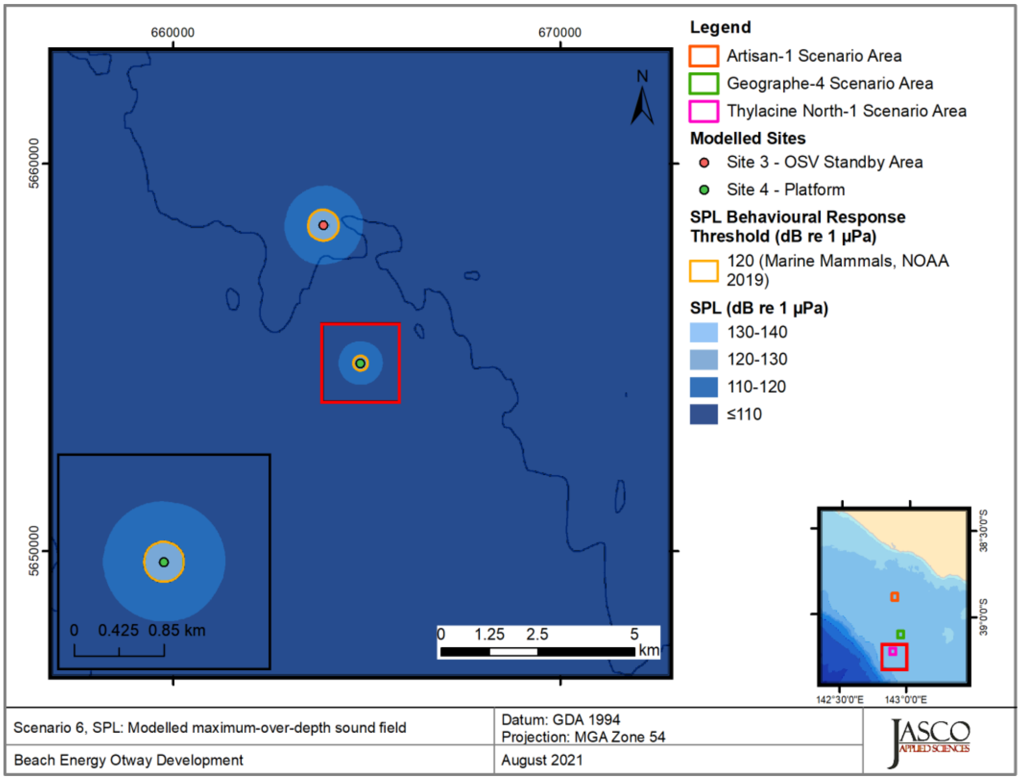


Figure 11. *Thylacine A Platform, OSV standby (Scenario 6) SPL :* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

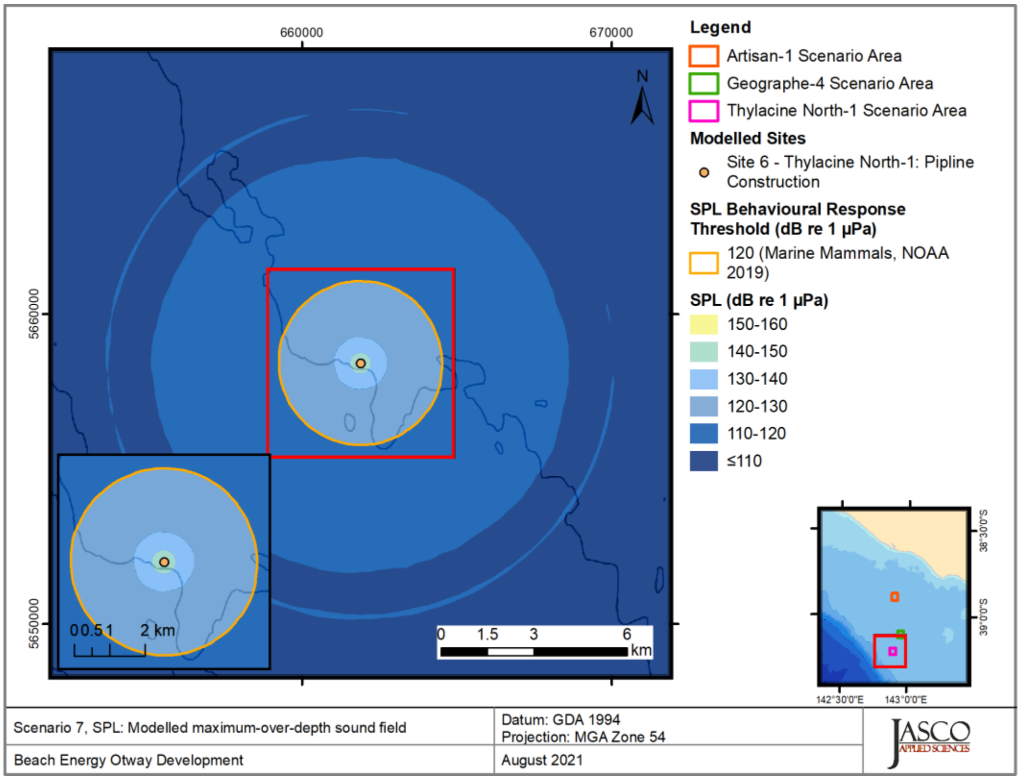


Figure 12. *Thylacine North-1, PLV stationary 20% MCR -June (Scenario 7) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

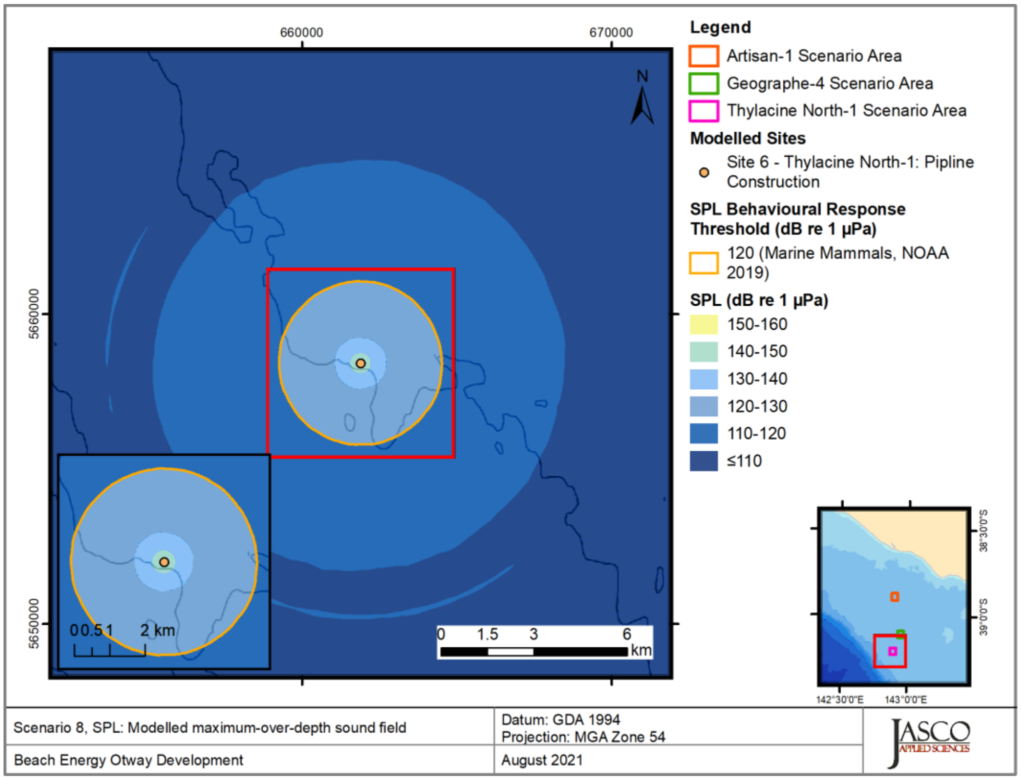


Figure 13. *Thylacine North-1, PLV stationary 20% MCR -November (Scenario 8) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

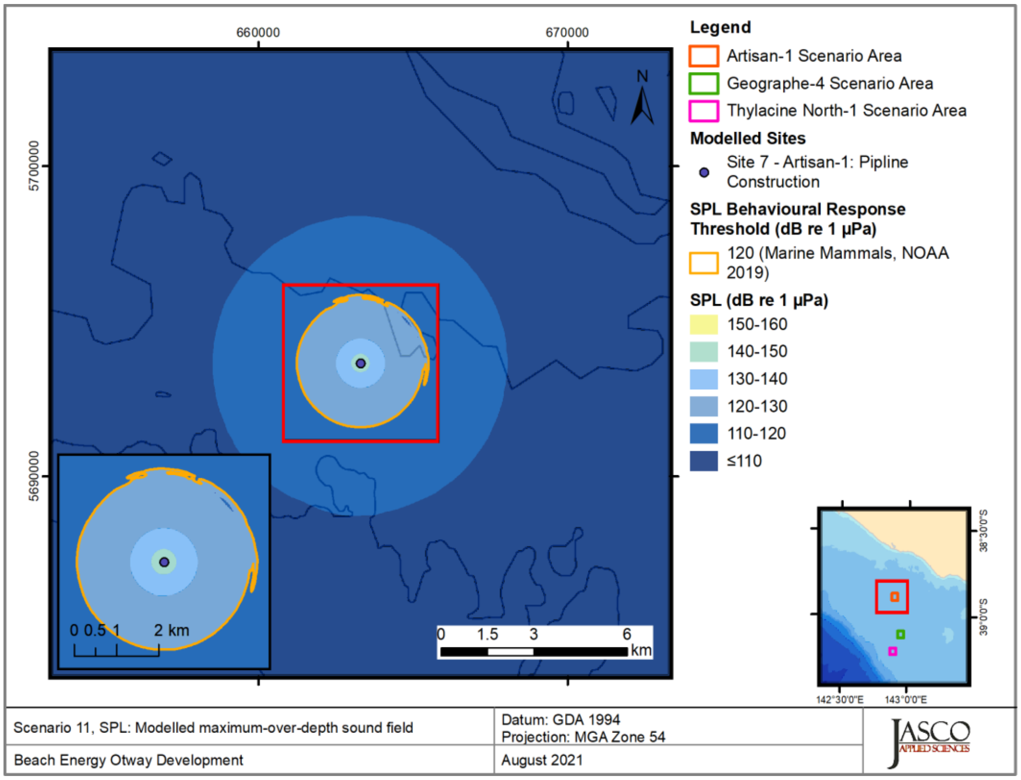


Figure 14. *Artisan-1, PLV stationary 20% MCR -June (Scenario 11) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

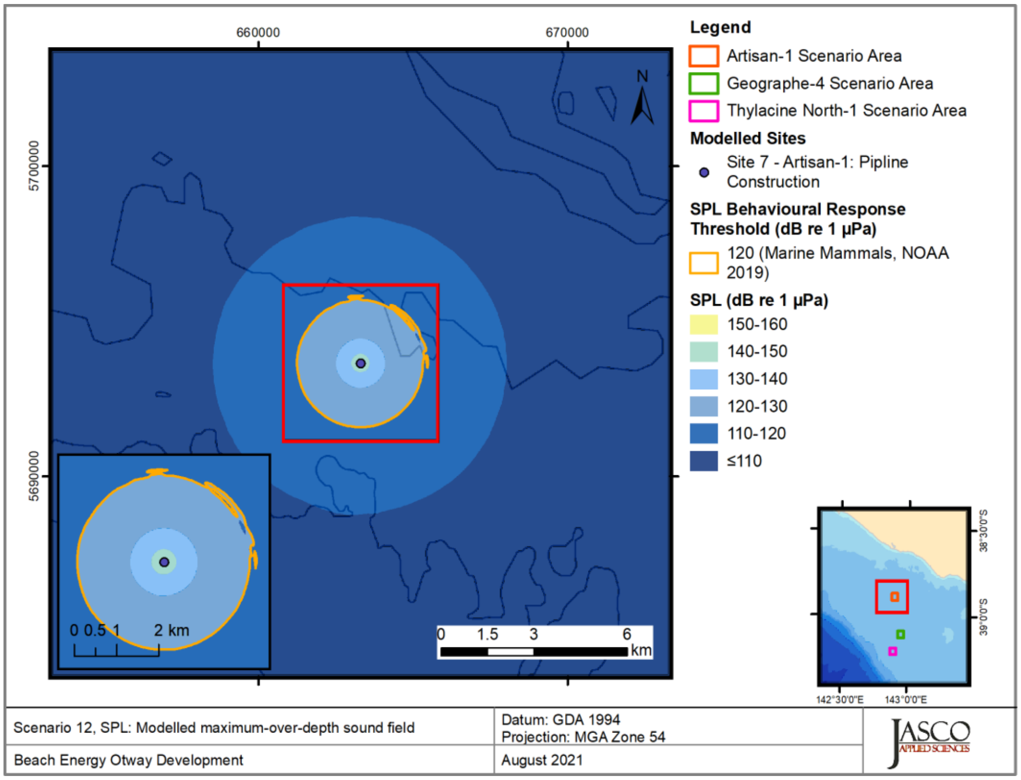


Figure 15. *Artisan-1, PLV stationary 20% MCR - November (Scenario 12) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

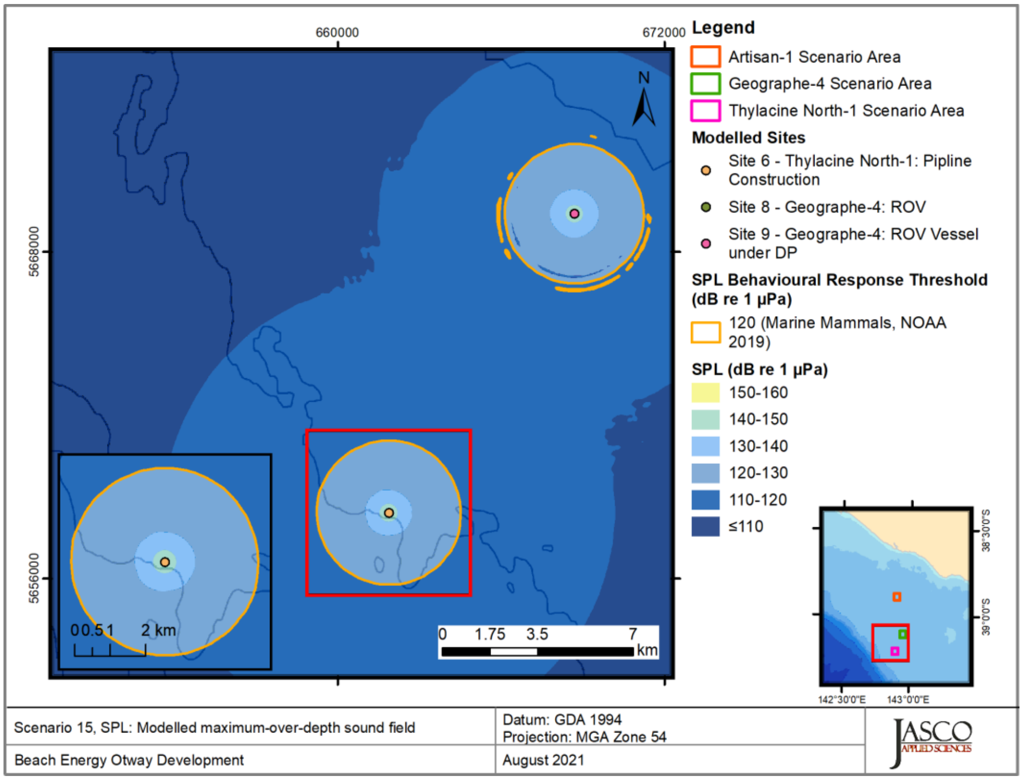


Figure 16. *Thylacine North-1, PLV stationary and ROV operations at Geographe-4 (20% MCR) - June (Scenario 15) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is s hown as an orange contour line.

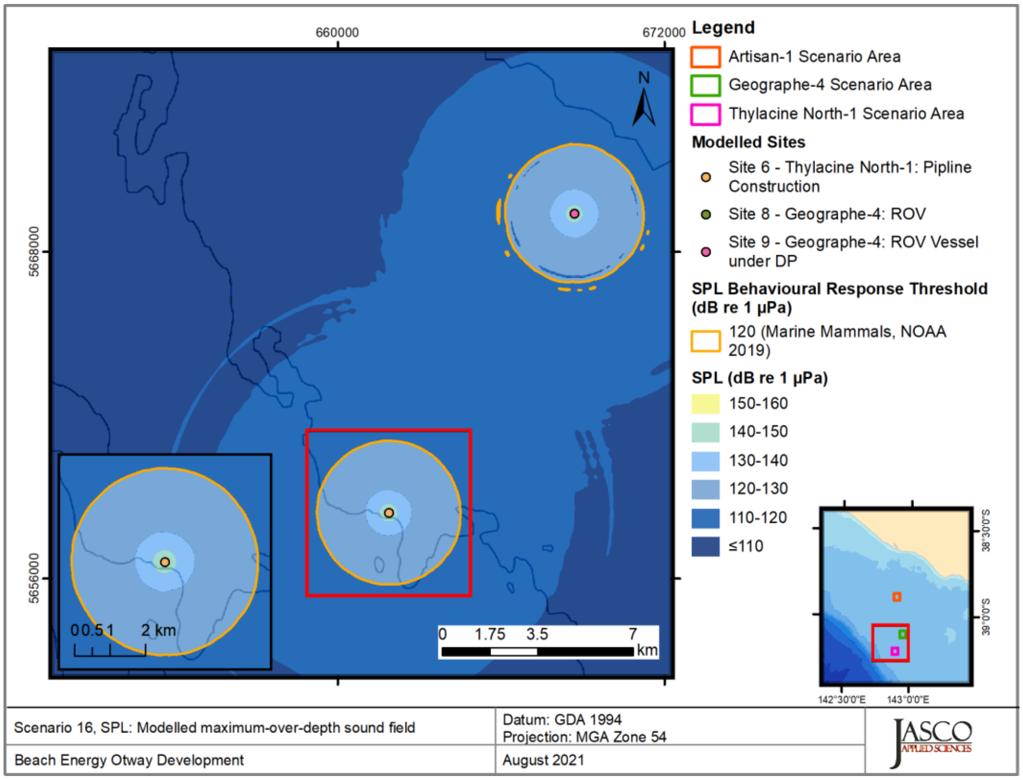


Figure 17. *Thylacine North-1, PLV stationary and ROV operations at Geographe-4 (20% MCR) – November (Scenario 16) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

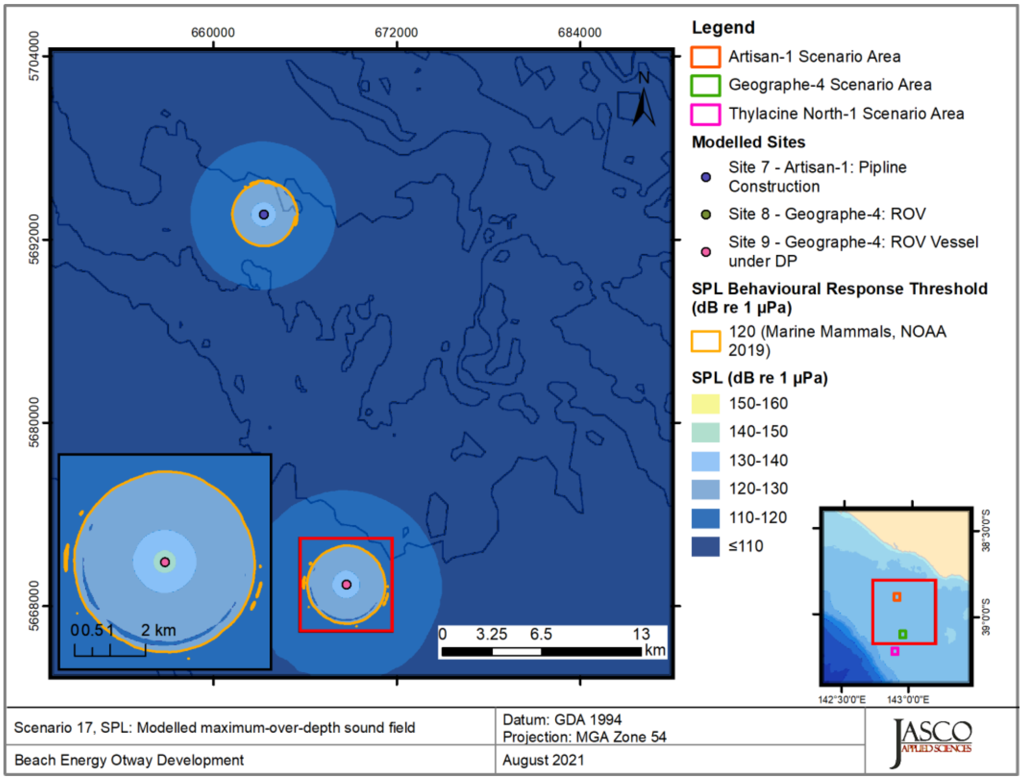


Figure 18. *Artisan-1, PLV stationary and ROV Operations at Geographe-4 (20% MCR) – June (Scenario 17) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

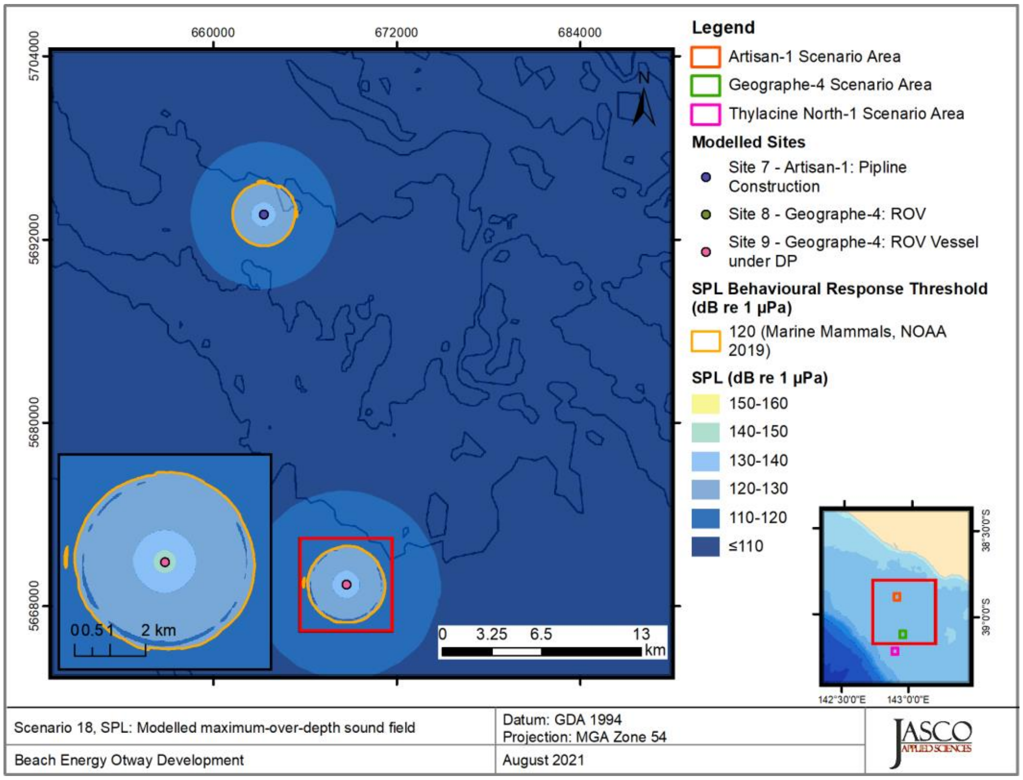


Figure 19. *Artisan-1, PLV stationary and ROV Operations at Geographe-4 (20% MCR) – November (Scenario 18) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

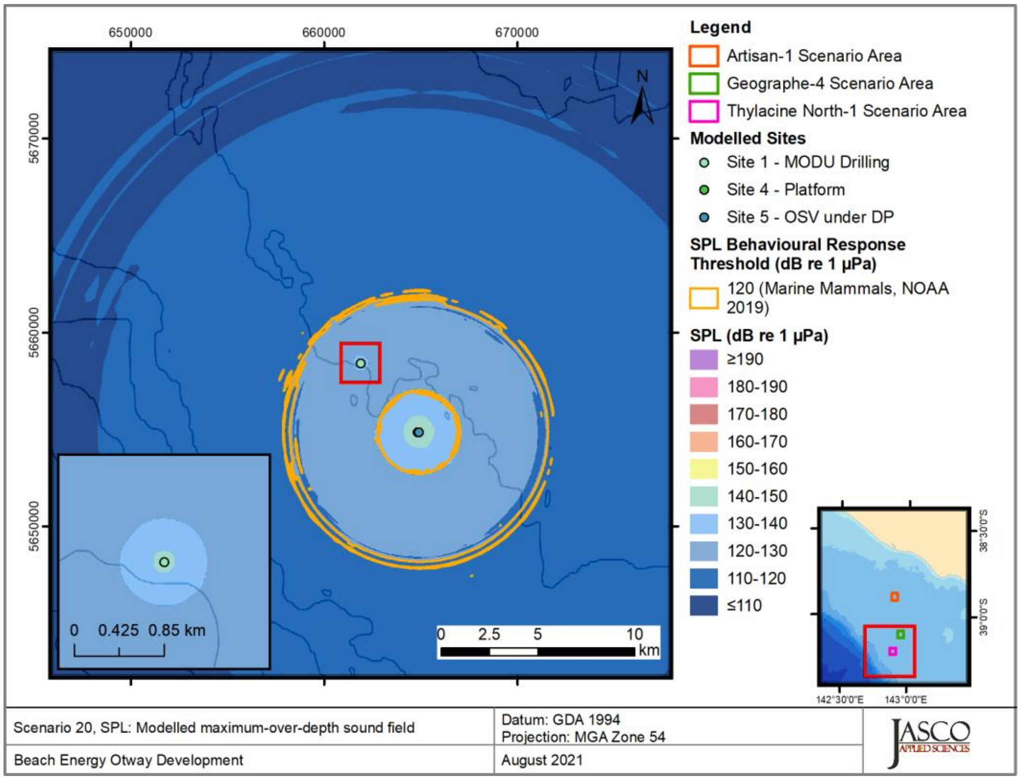


Figure 20. *Thylacine A Platform, Platform Resupply and MODU Drilling (Scenario 20) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

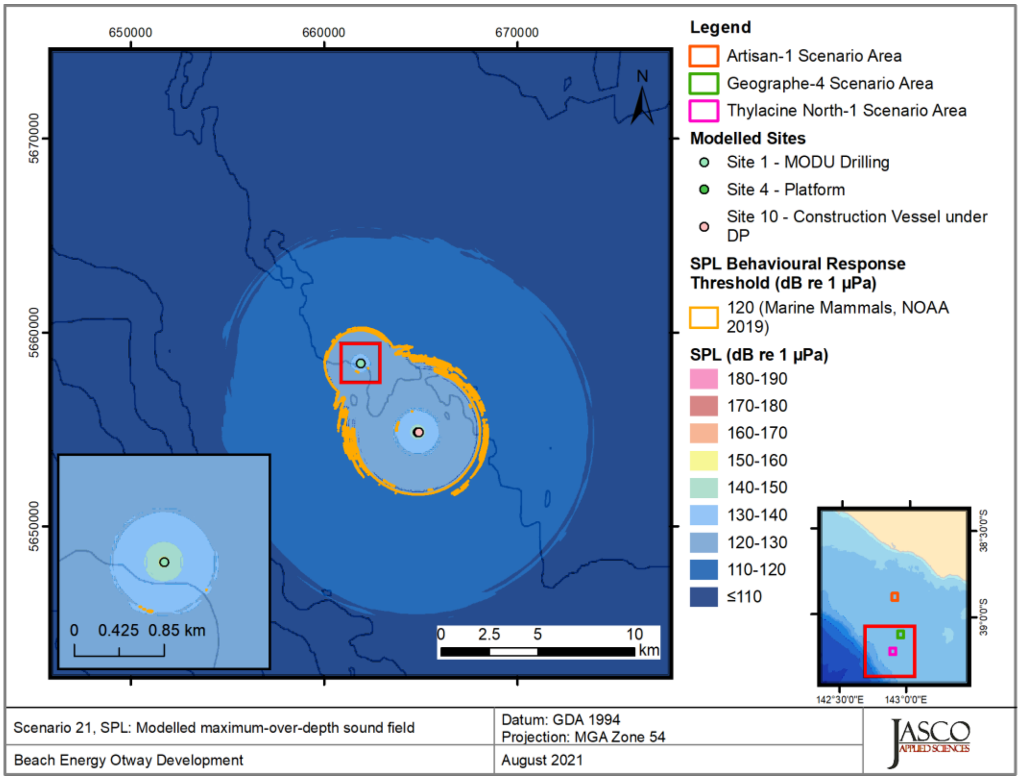


Figure 21. *Thylacine A Platform, Platform operations and skid installation* at 20% MCR *(Scenario 21) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

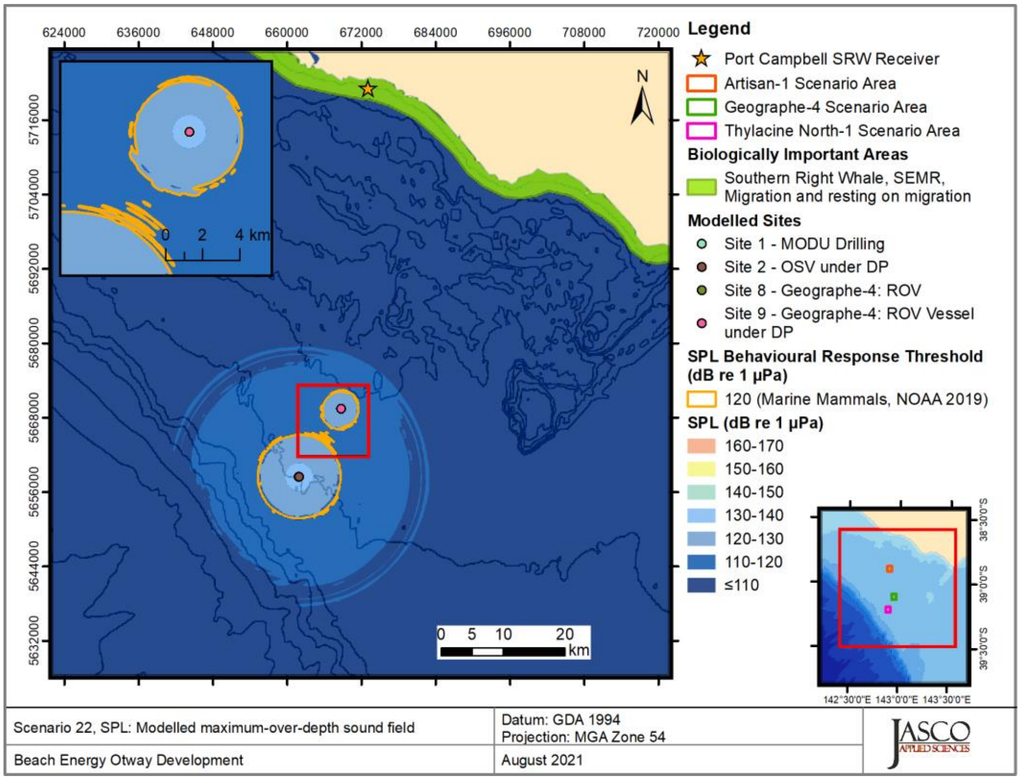


Figure 22. *Concurrent drilling operations at Thylacine North-1 and construction operations (20% MCR) at Geographe-4 (Scenario 22) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

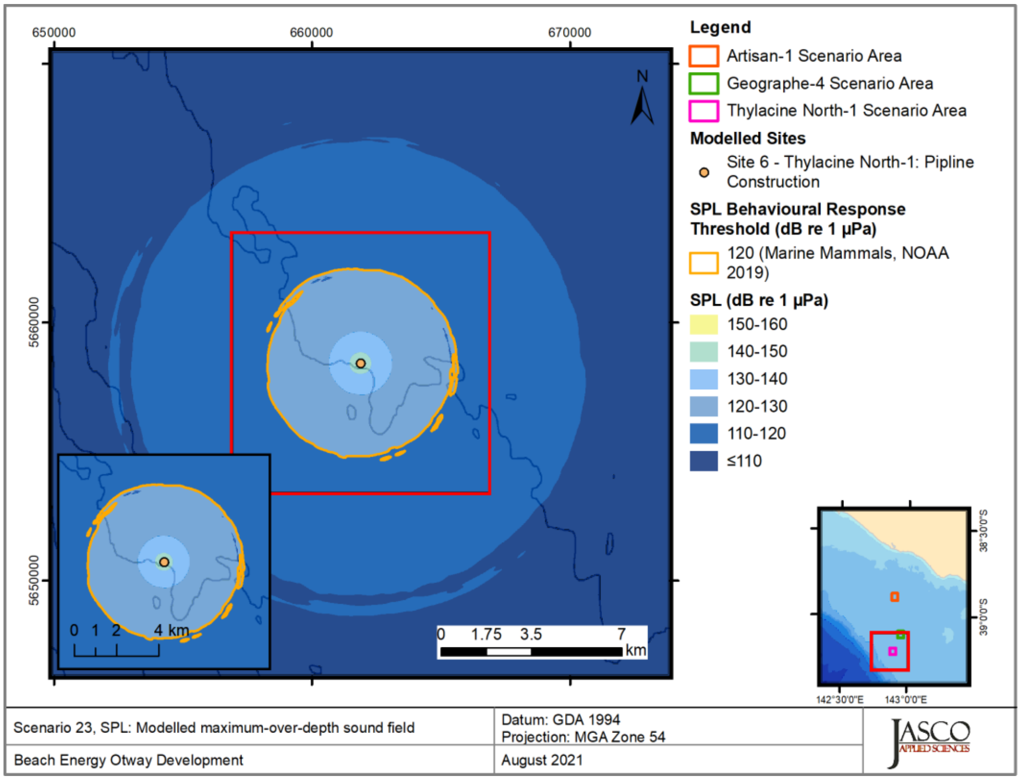


Figure 23. *Thylacine North-1, PLV stationary 40% MCR -June (Scenario 23) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

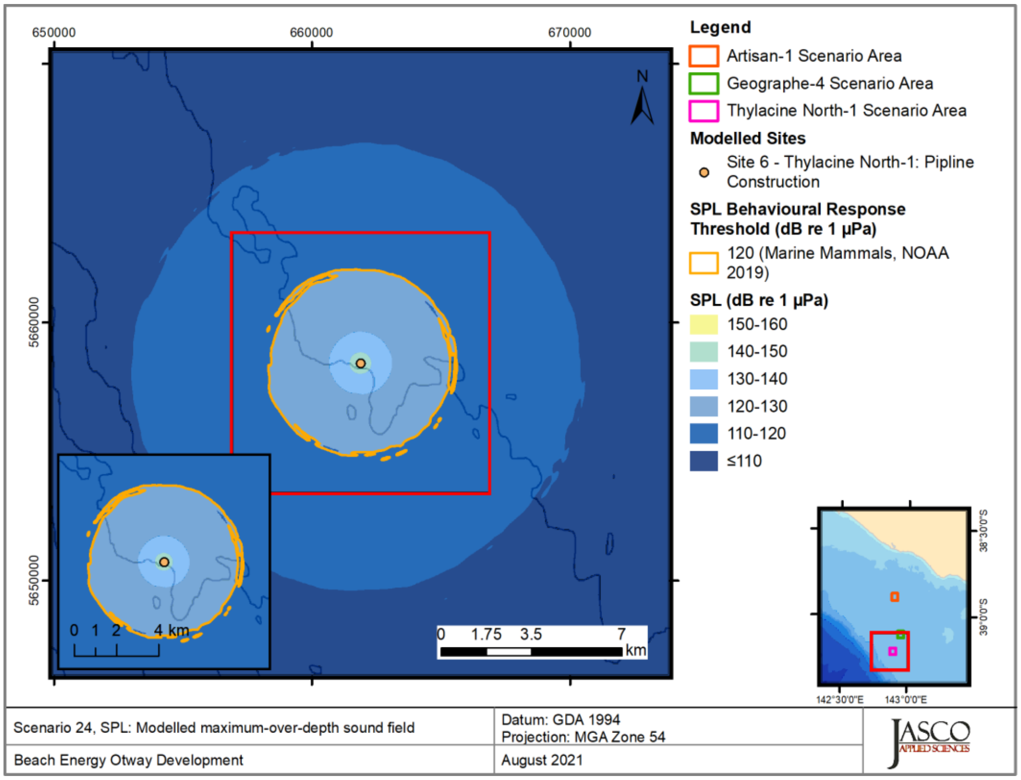


Figure 24. *Thylacine North-1, PLV stationary 40% MCR -November (Scenario 24) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

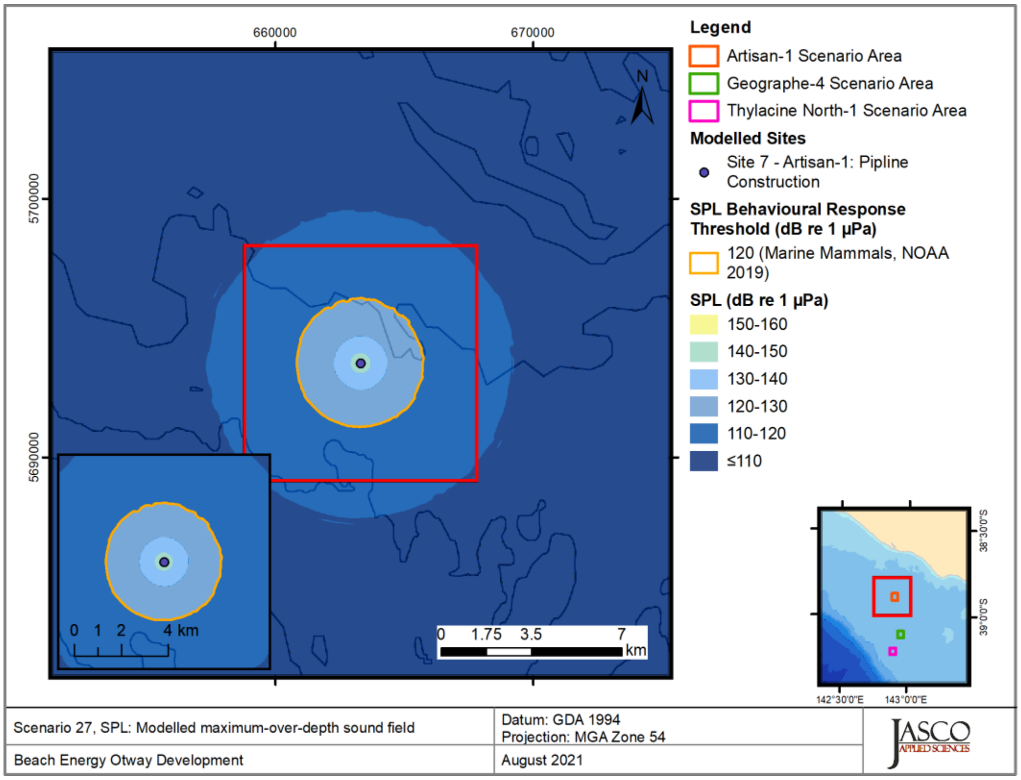


Figure 25. *Artisan-1, PLV stationary 40% MCR -June (Scenario 27) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

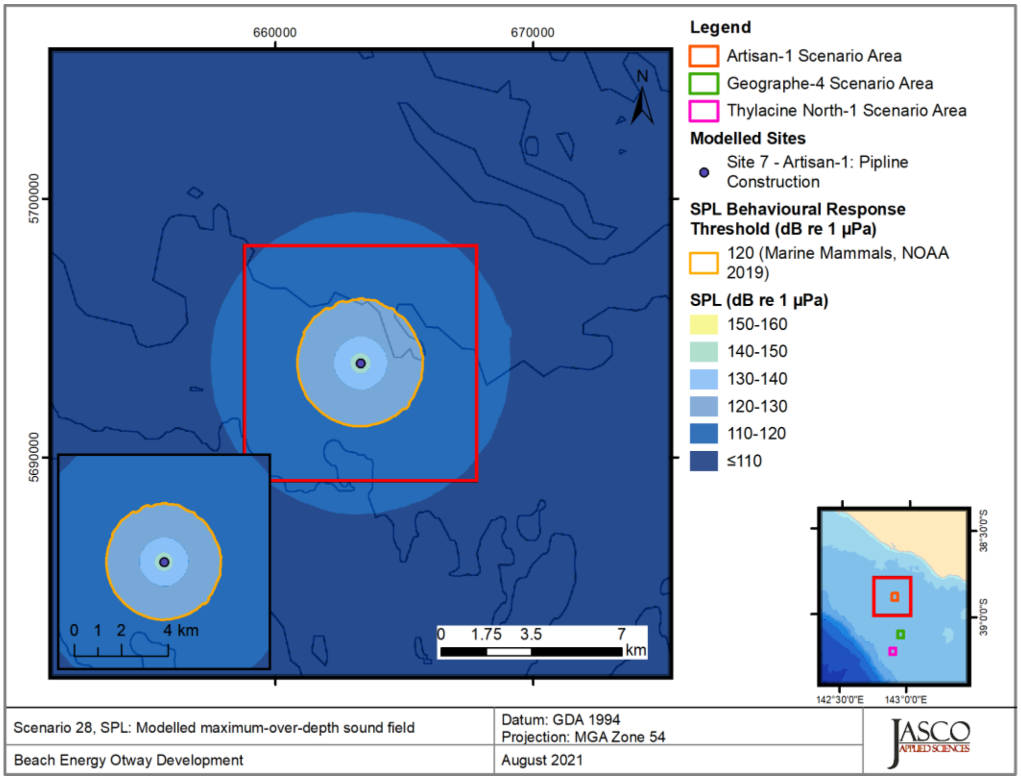


Figure 26. *Artisan-1, PLV stationary 40% MCR -November (Scenario 28) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

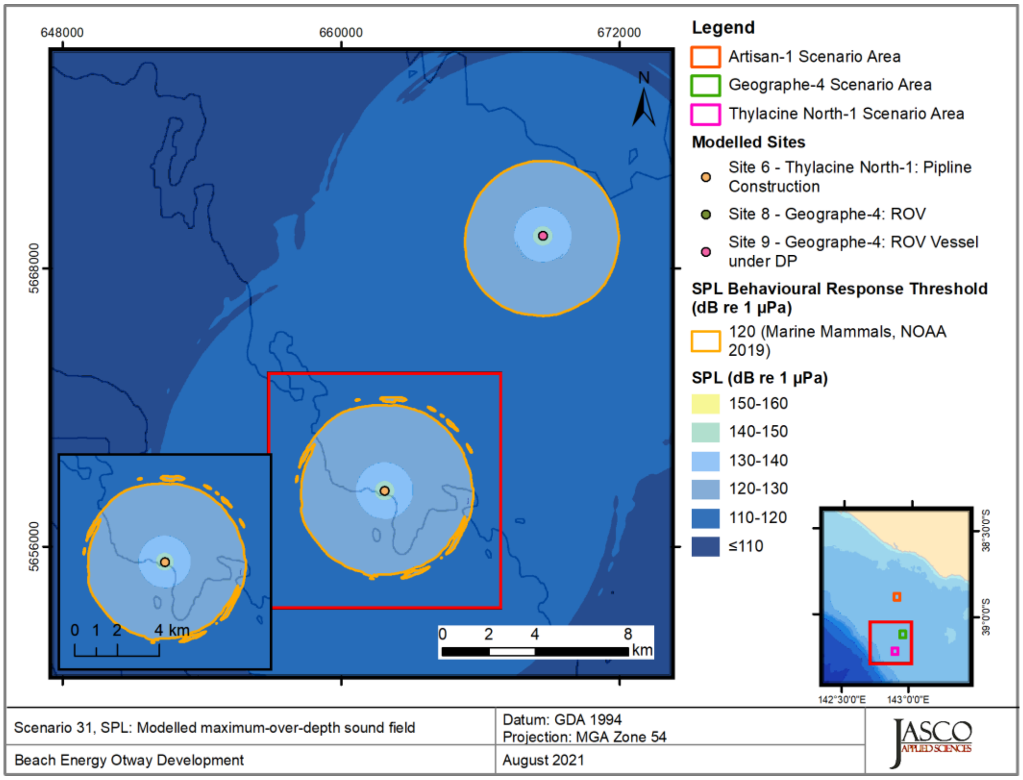


Figure 27. *Thylacine North-1, PLV stationary 40% MCR and ROV operations at Geographe-4 - June (Scenario 31) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

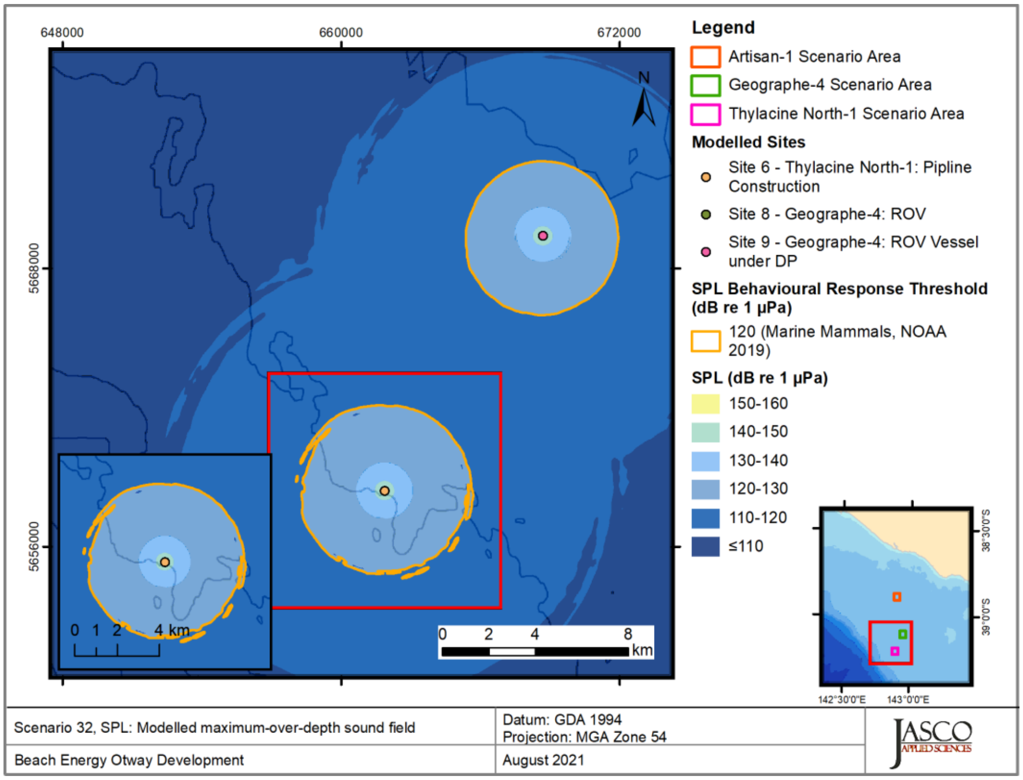


Figure 28. *Thylacine North-1, PLV stationary 40% MCR and ROV operations at Geographe-4 – November (Scenario 32) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

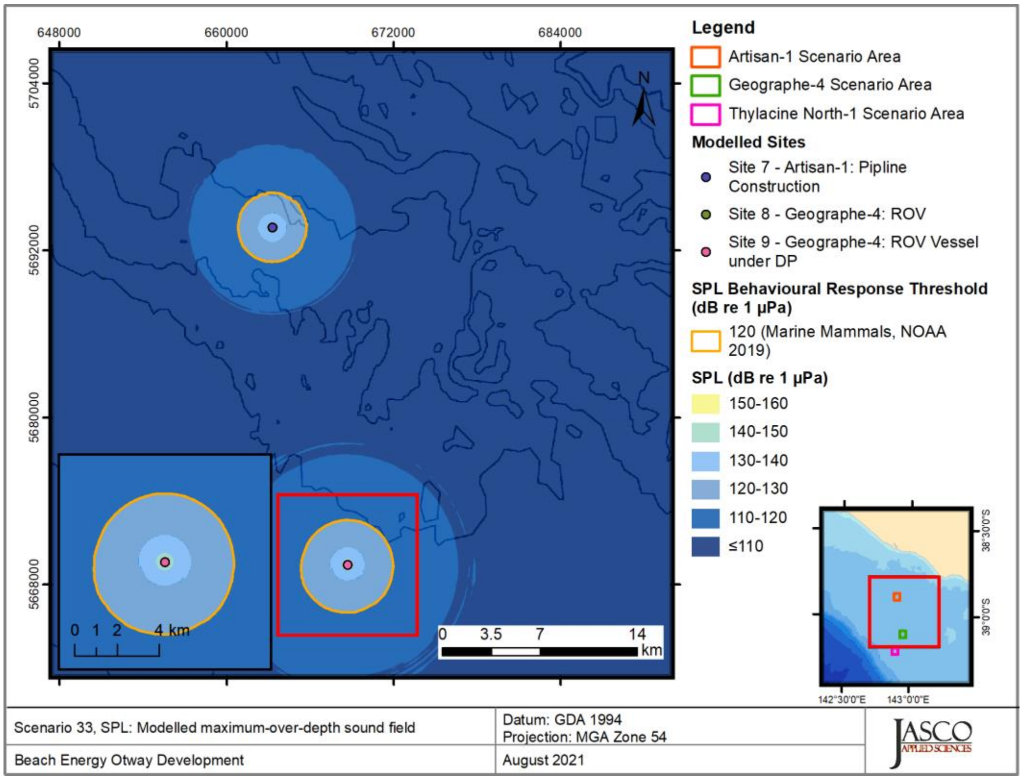


Figure 29. *Artisan-1, PLV stationary 40% MCR and ROV Operations at Geographe-4 – June (Scenario 33) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

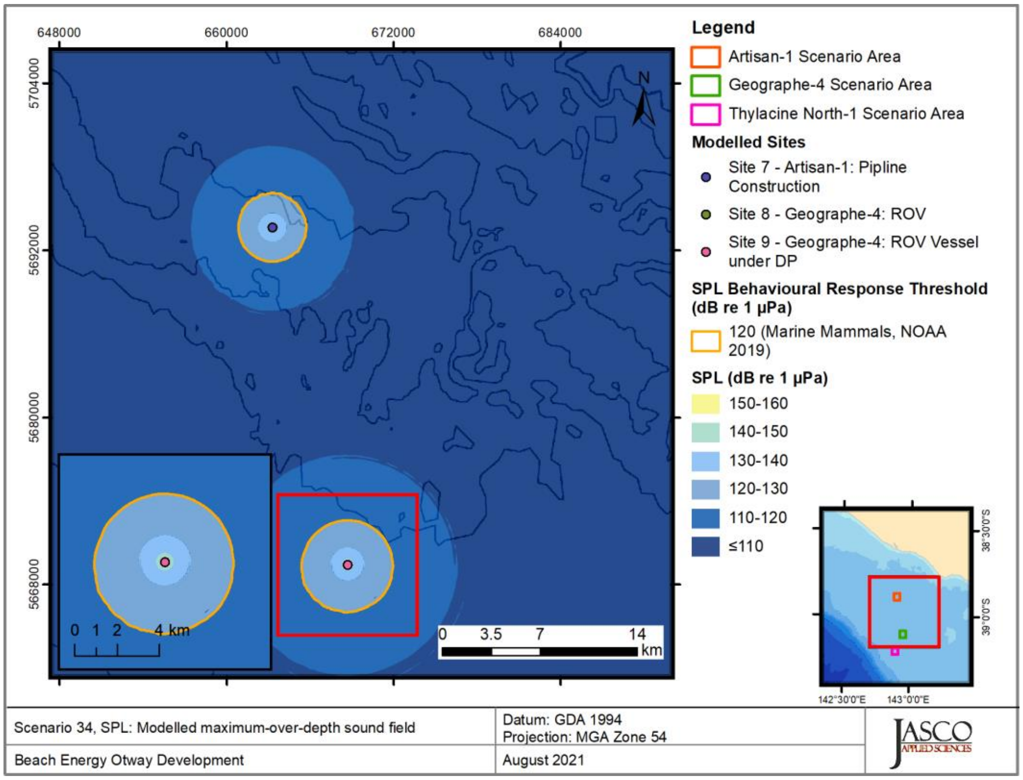


Figure 30. *Artisan-1, PLV stationary 40% MCR and ROV Operations at Geographe-4 – November (Scenario 34) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

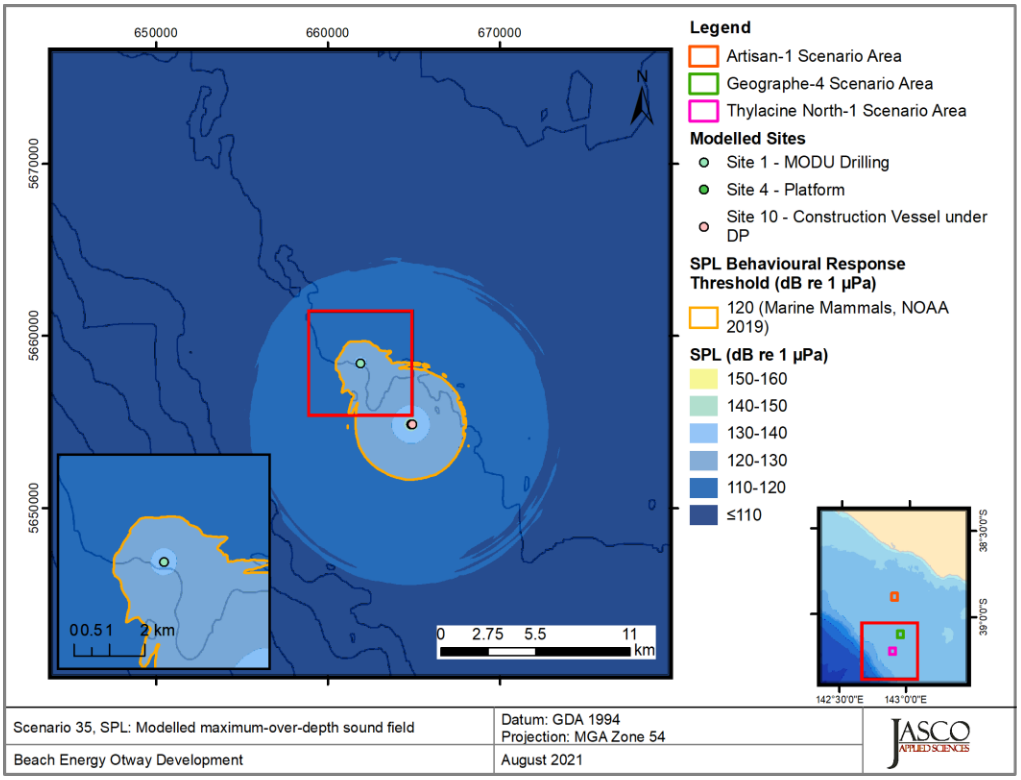


Figure 31. *Thylacine A Platform, Platform operations and skid installation at 40% MCR (Scenario 35) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

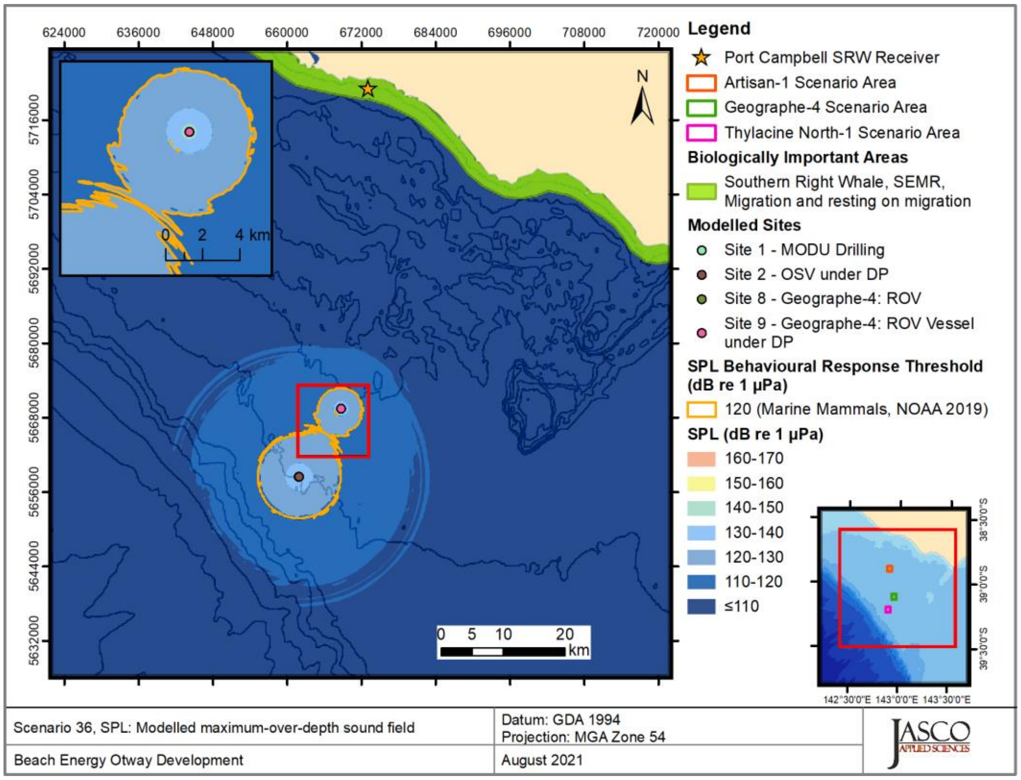


Figure 32. *Concurrent drilling operations at Thylacine North-1 and construction operations (40% MCR) at Geographe-4 (Scenario 36) SPL:* Sound level contour map, showing unweighted maximum over-depth SPL results. Isopleth for marine mammal (120 dB re 1 µPa) behavioural criteria is shown as an orange contour line.

4.2.2. Accumulated SEL_{24h} Maps

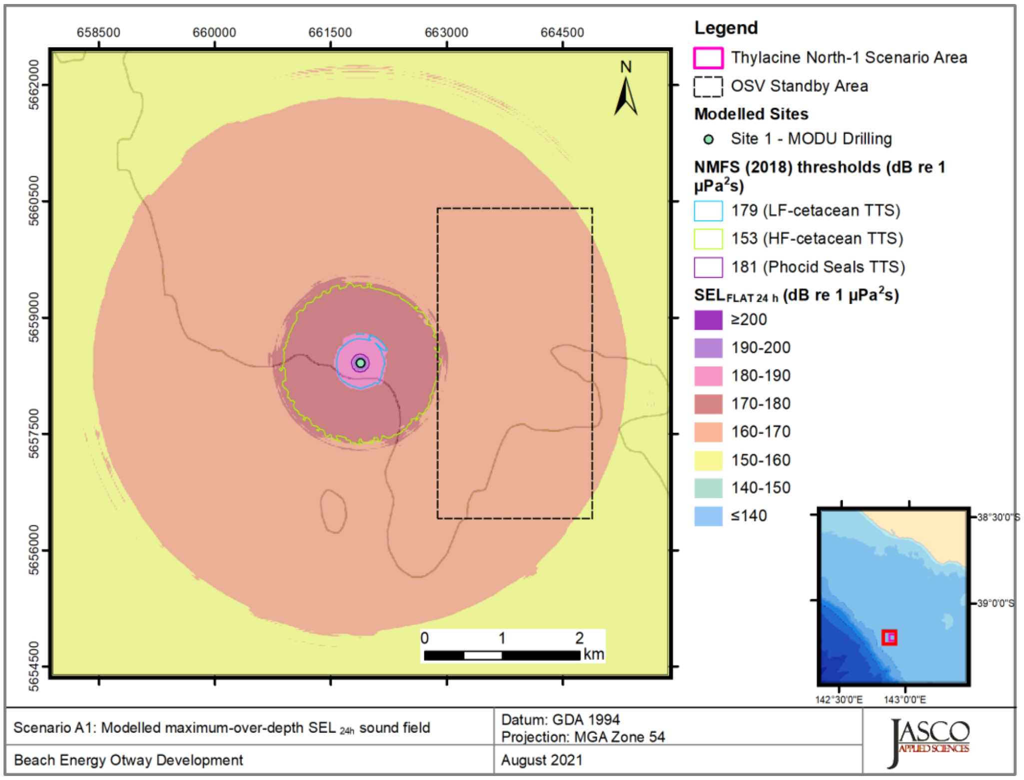


Figure 33. *Thylacine North-1, MODU Drilling (Scenario A1) SEL_{24h}:* Sound level contour map showing unweighted maximum-over-depth SEL_{24h} results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

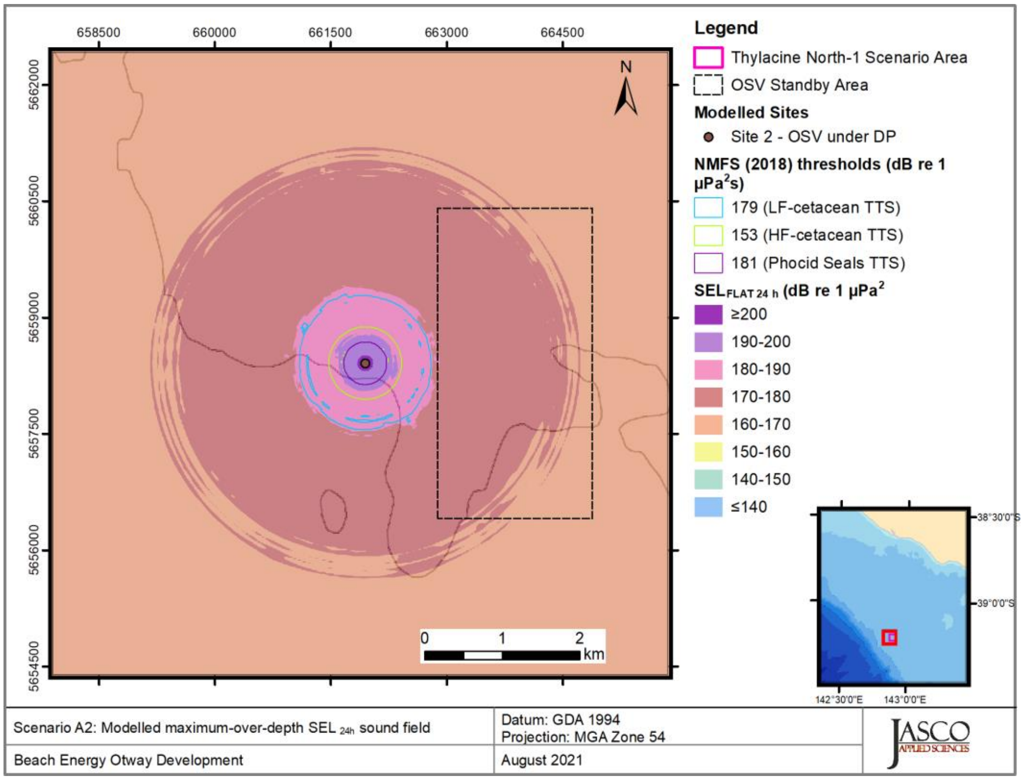


Figure 34. *Thylacine North-1, OSV on DP (4h) (Scenario A2) SEL$_{24h}$*: Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

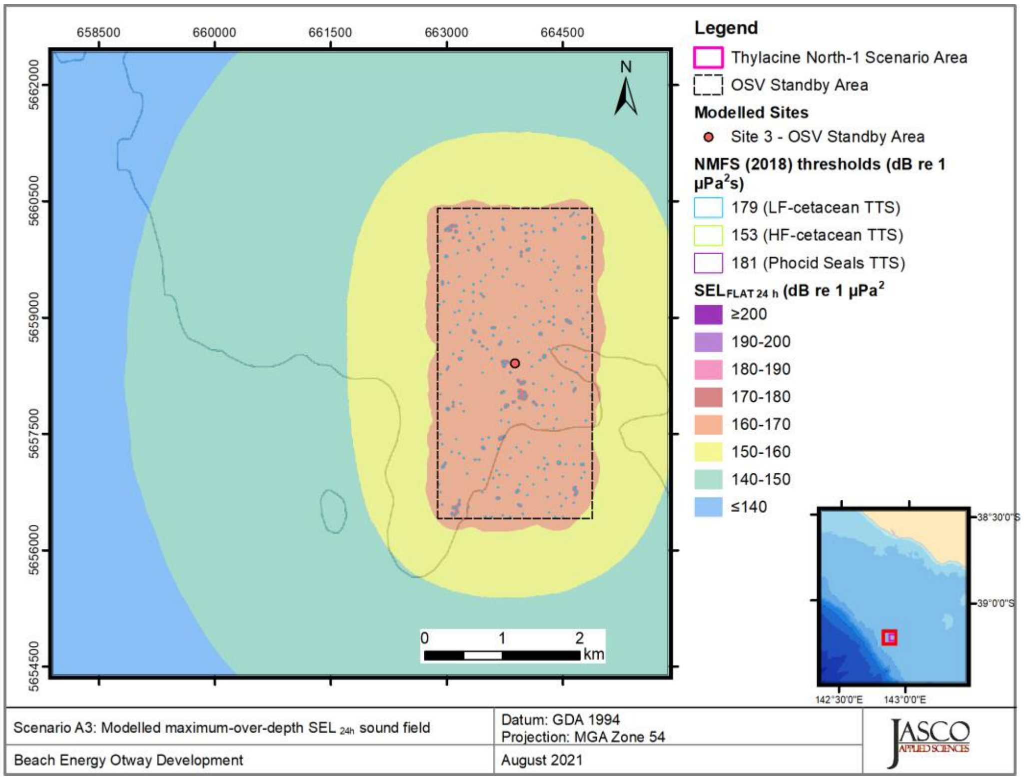


Figure 35. *Thylacine North-1, OSV Standby (Scenario A3) SEL$_{24h}$*: Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

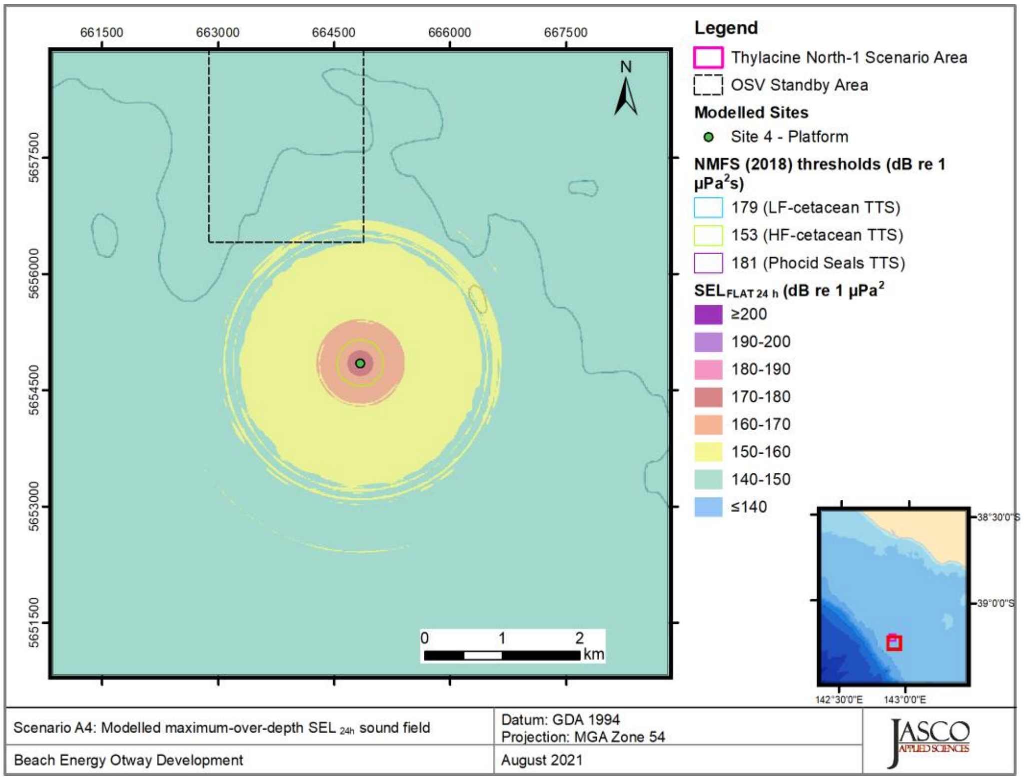


Figure 36. *Thylacine A, Platform Operations (Scenario A4) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

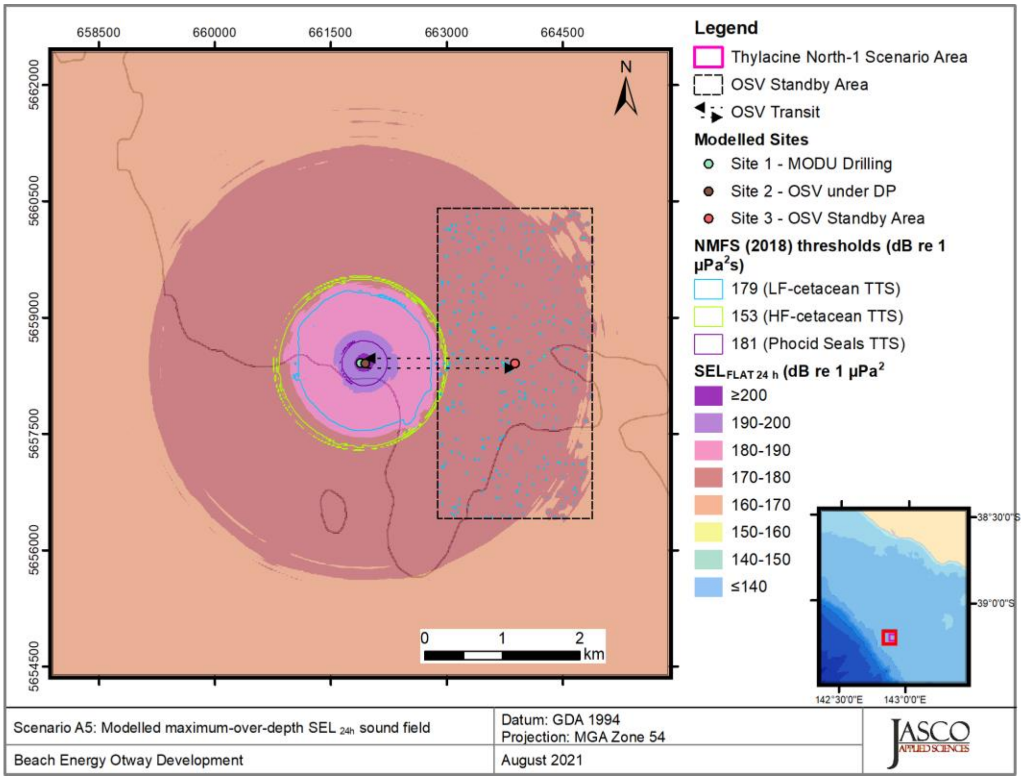


Figure 37. *Thylacine North-1, MODU 4h Resupply Operations (Scenario A5) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

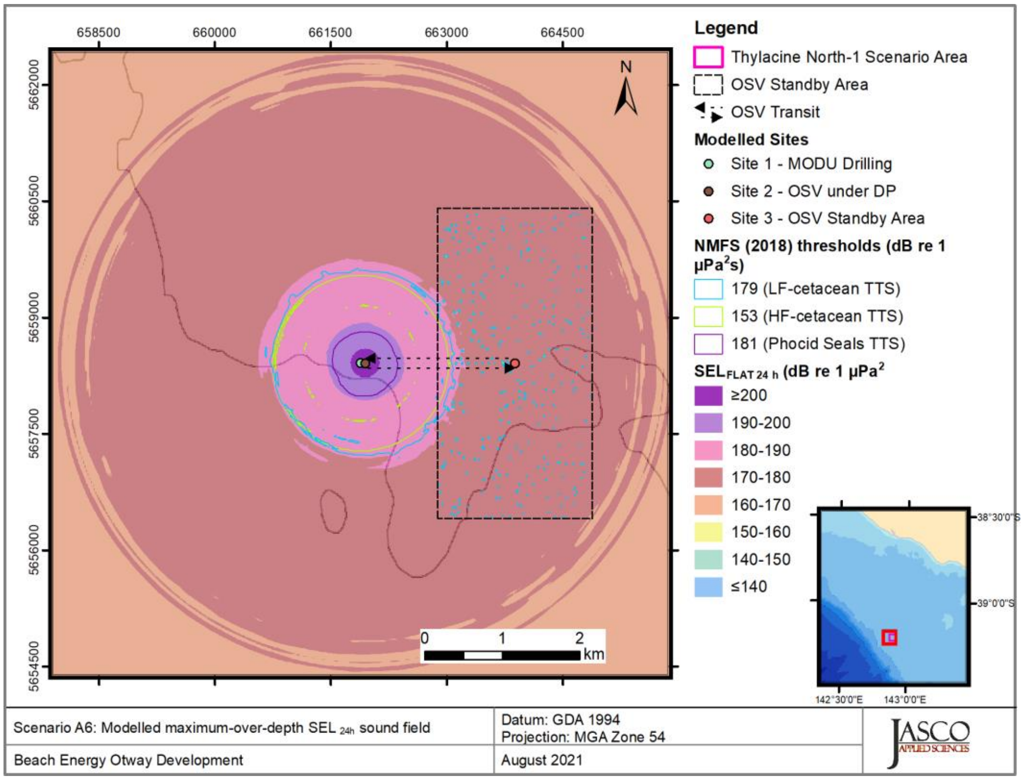


Figure 38. *Thylacine North-1, MODU 8h Resupply Operations (Scenario A6) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.*SEL24h:*

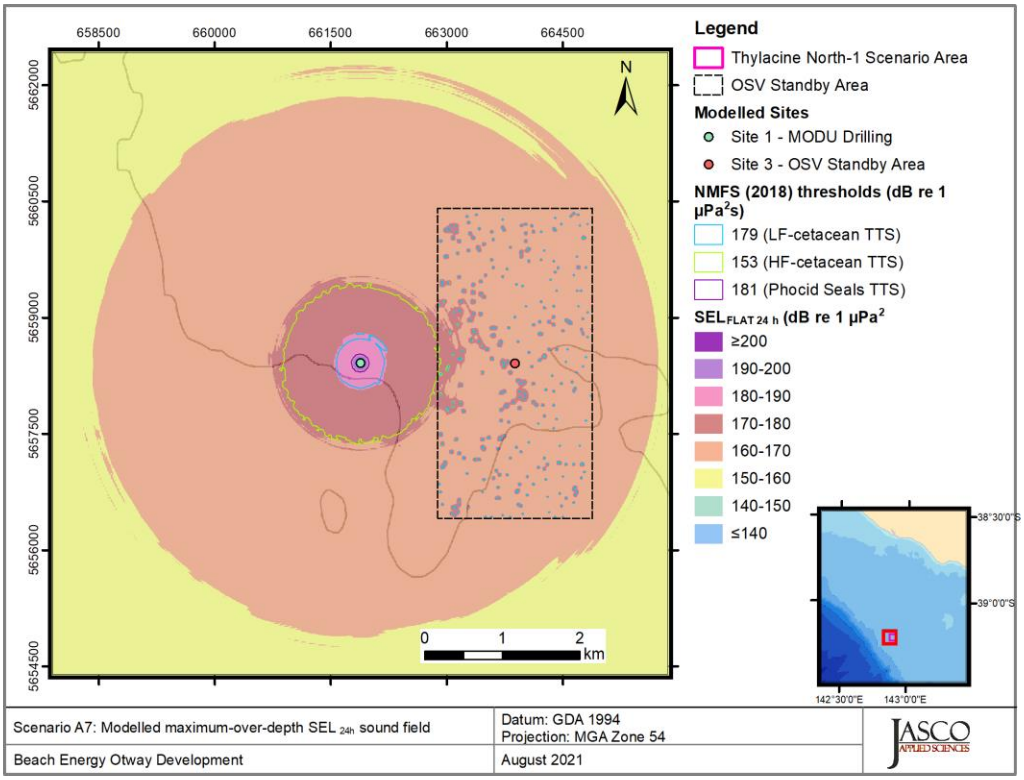


Figure 39. *Thylacine North-1, MODU Drilling and OSV standby (Scenario A7) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

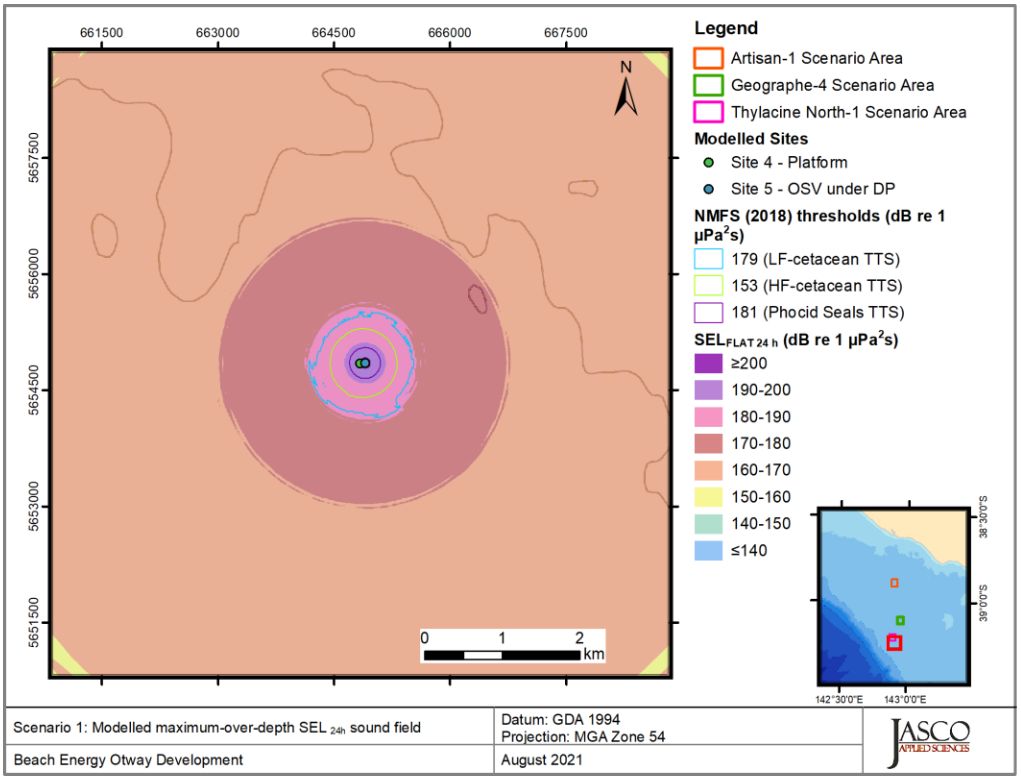


Figure 40. *Thylacine A Platform, 2 h Platform Resupply (Scenario 1) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

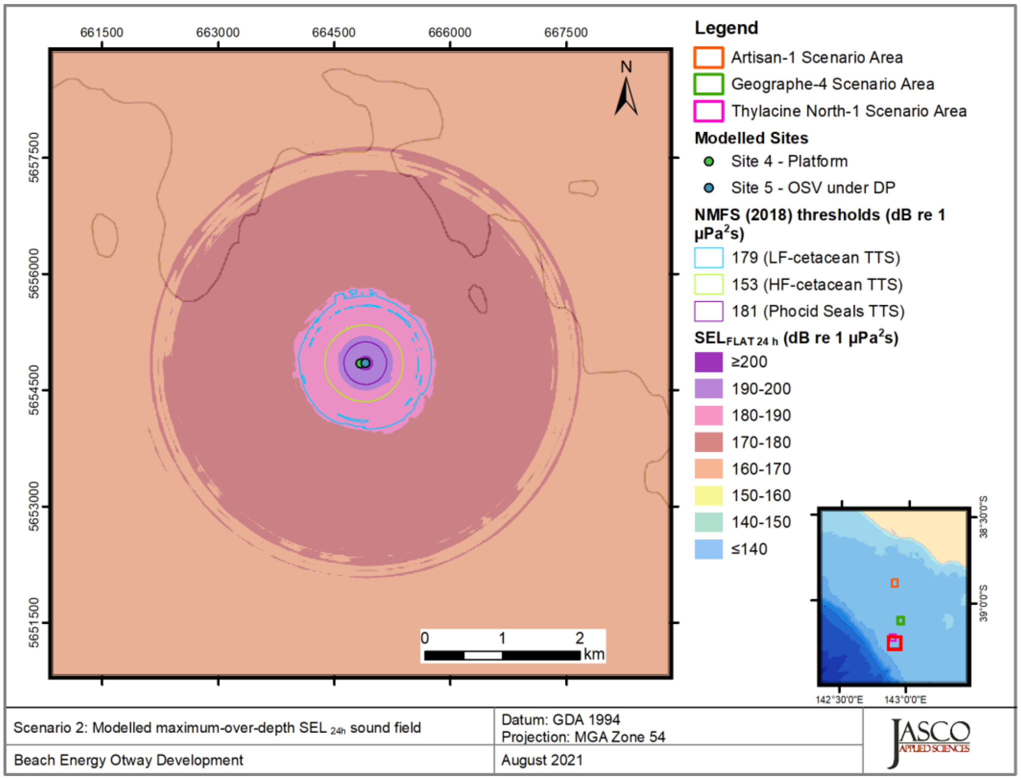


Figure 41. *Thylacine A Platform, 4 h Platform Resupply (Scenario 2) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

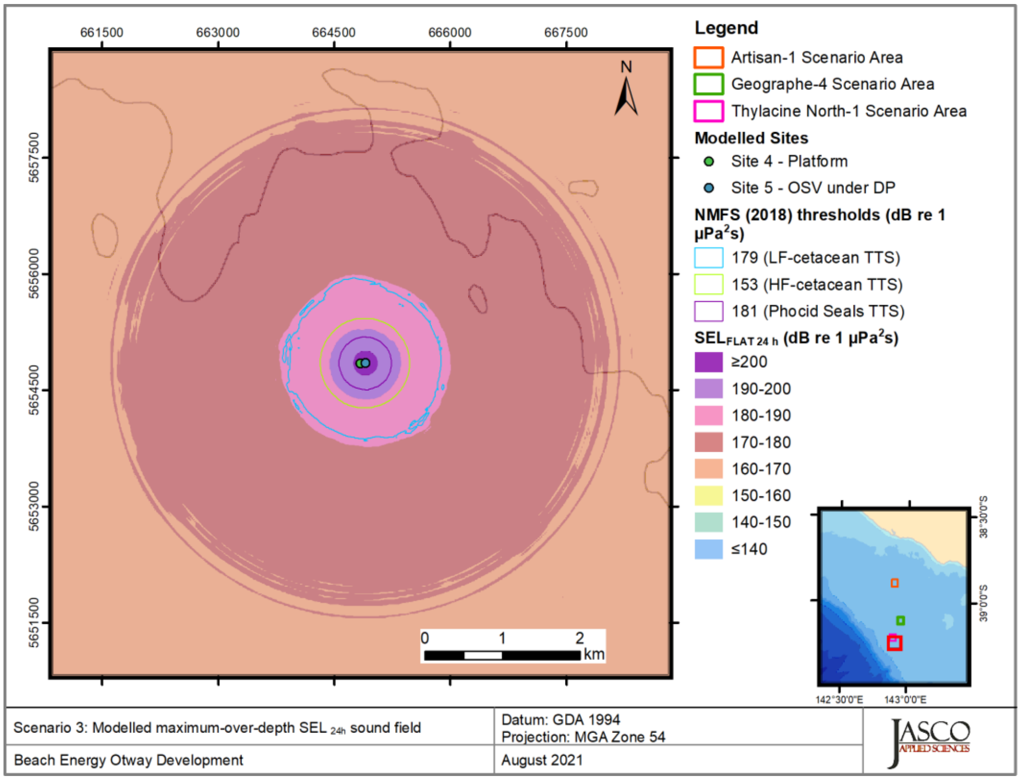


Figure 42. *Thylacine A Platform, 6 h Platform Resupply (Scenario 3) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

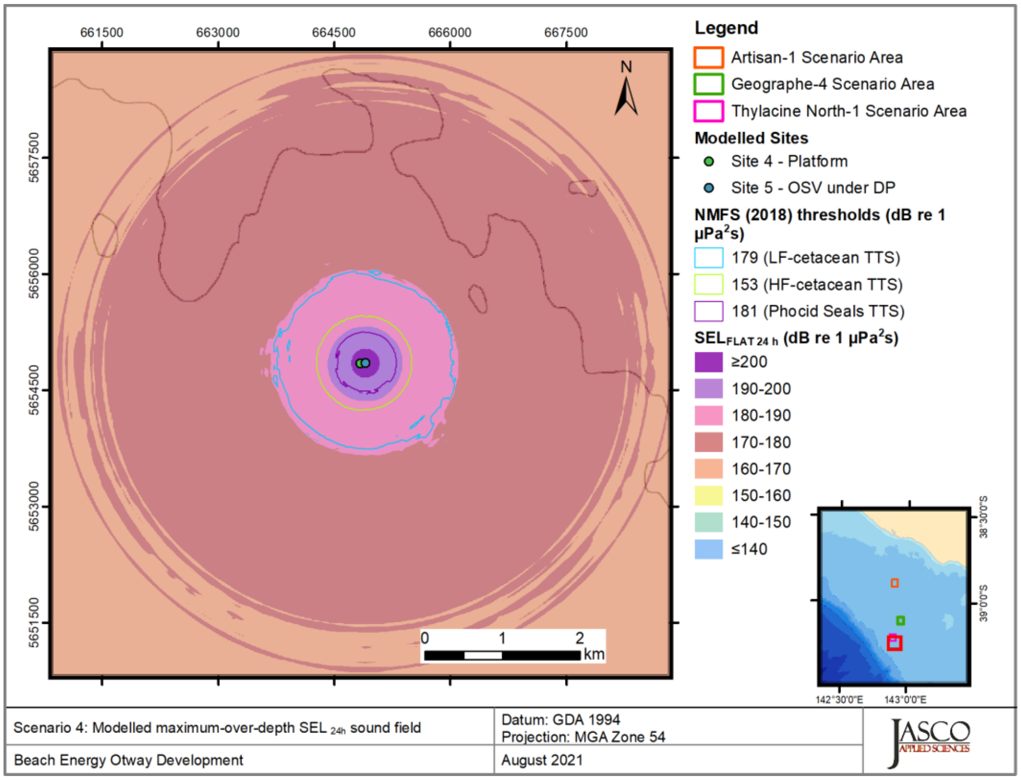


Figure 43. *Thylacine A Platform, 8 h Platform Resupply (Scenario 4) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

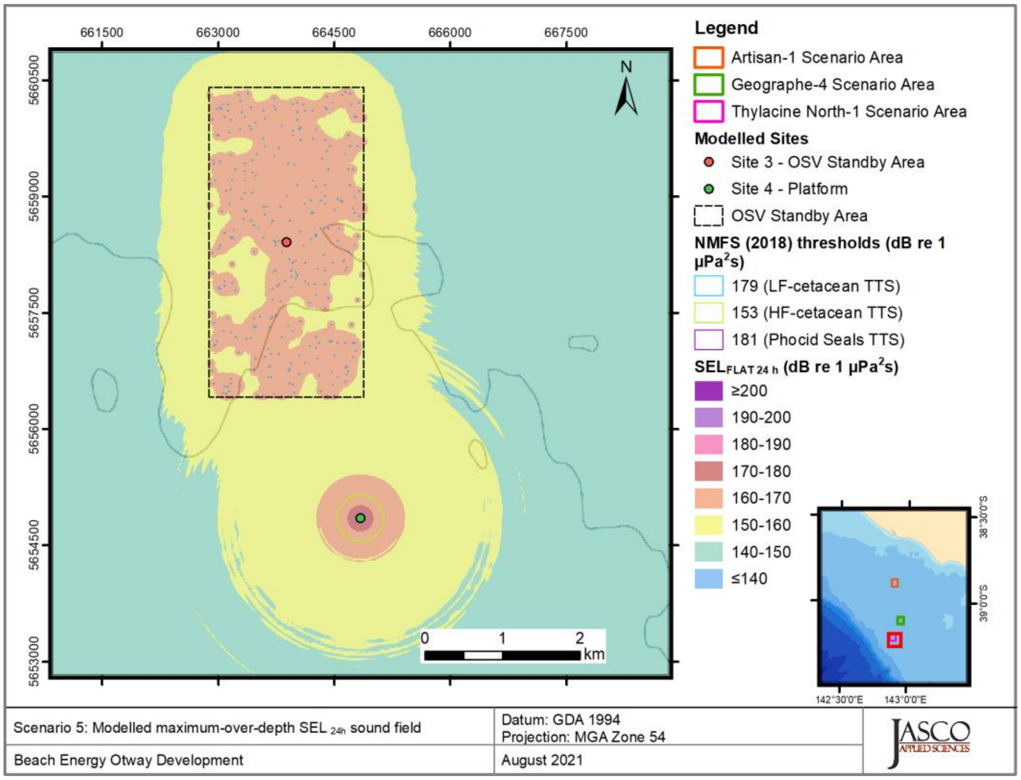


Figure 44. *Thylacine A Platform, 8h OSV standby (Scenario 5) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

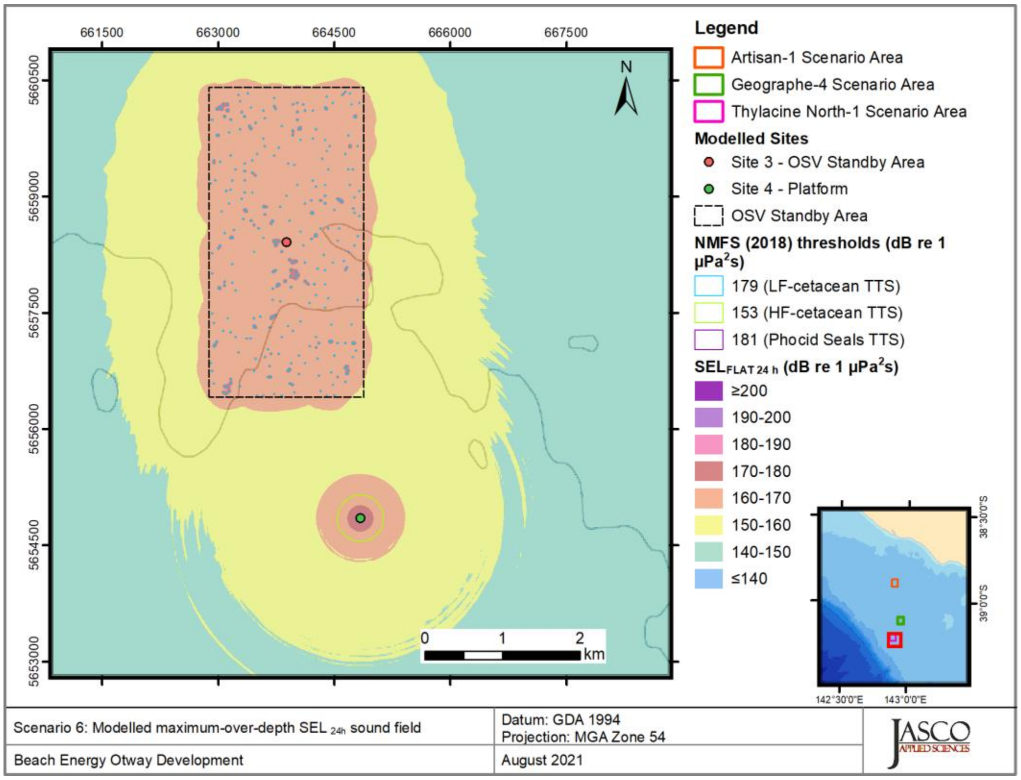


Figure 45. *Thylacine A Platform, 24h OSV standby (Scenario 6) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

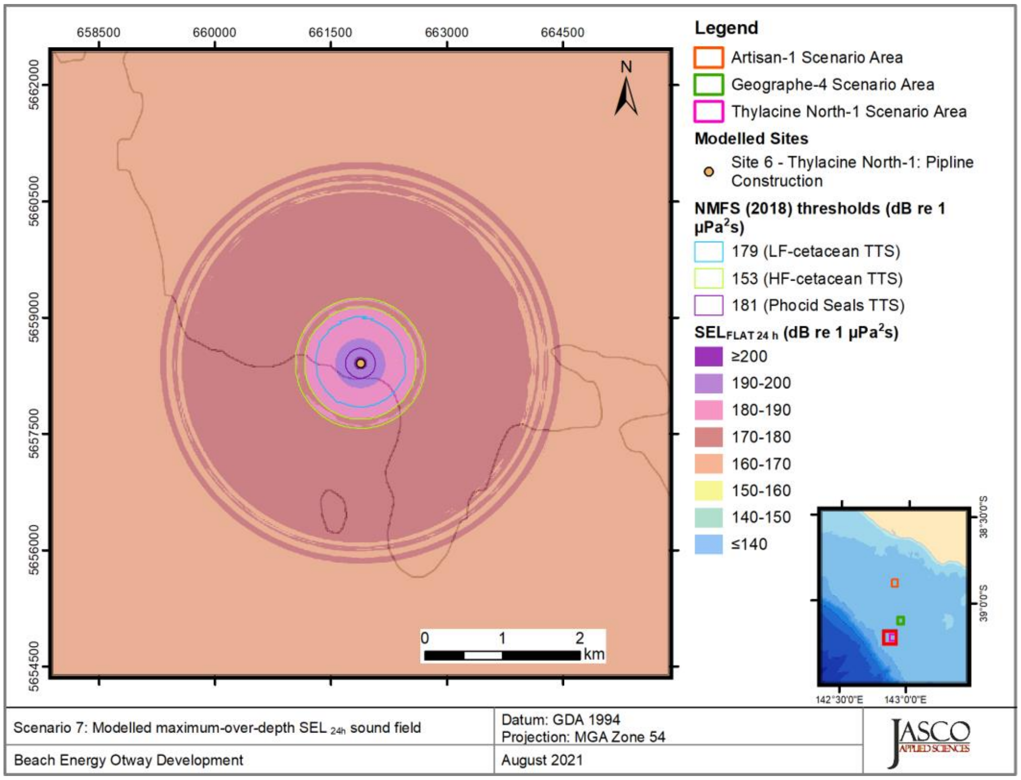


Figure 46. *Thylacine North-1, PLV stationary 20% MCR - June (Scenario 7) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL24h results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

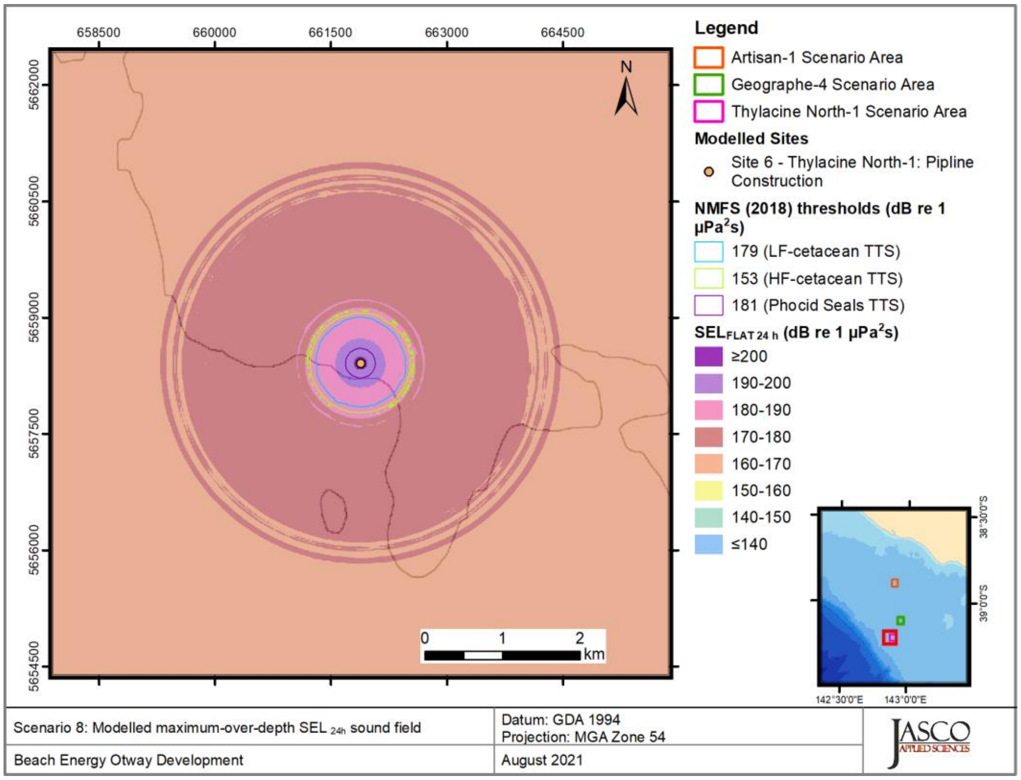


Figure 47. *Thylacine North-1, PLV stationary 20% MCR - November (Scenario 8) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

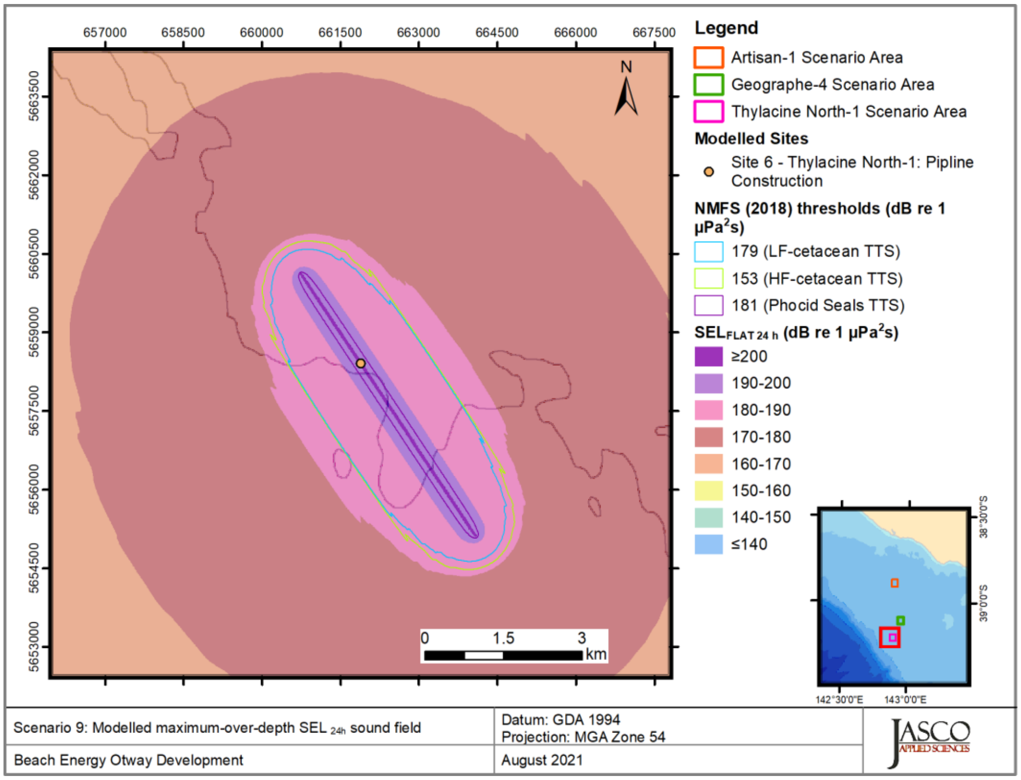


Figure 48. *Thylacine North-1, PLV pipe laying operations 20% MCR - June (Scenario 9) SEL*$_{24h}$: Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

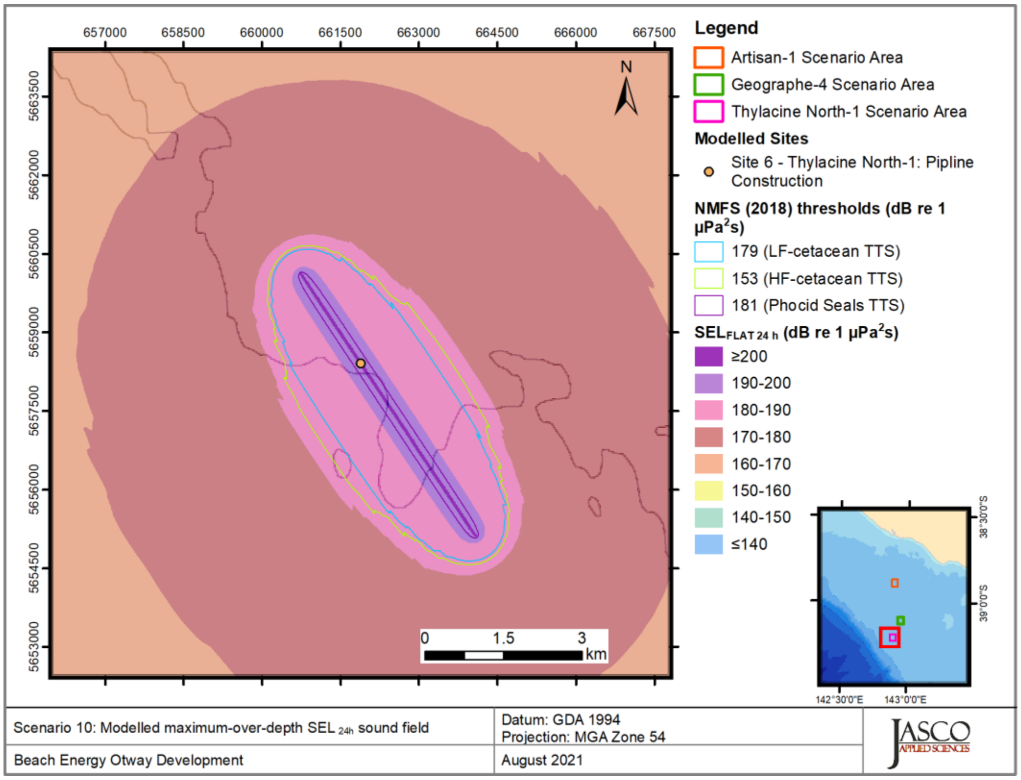


Figure 49. *Thylacine North-1, PLV pipe laying operations 20% MCR - November (Scenario 10) SEL*$_{24h}$: Sound level contour map showing unweighted maximum-over-depth SEL24h results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

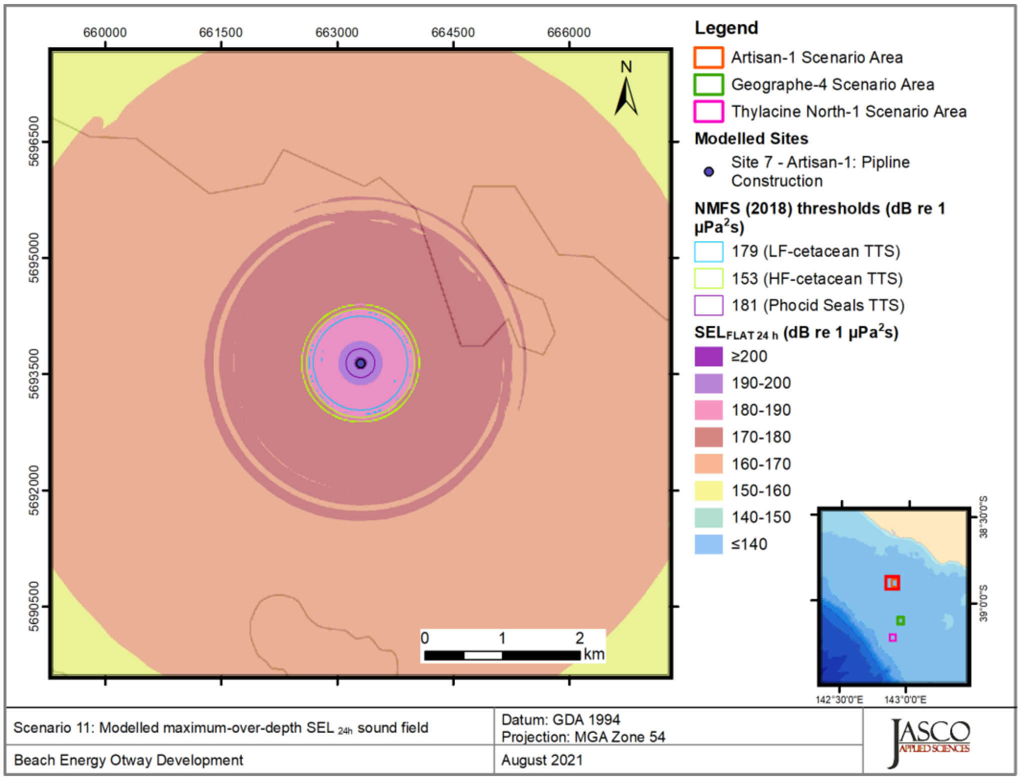


Figure 50. *Artisan-1, PLV stationary 20% MCR - June (Scenario 11) SEL$_{24h}$*: Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

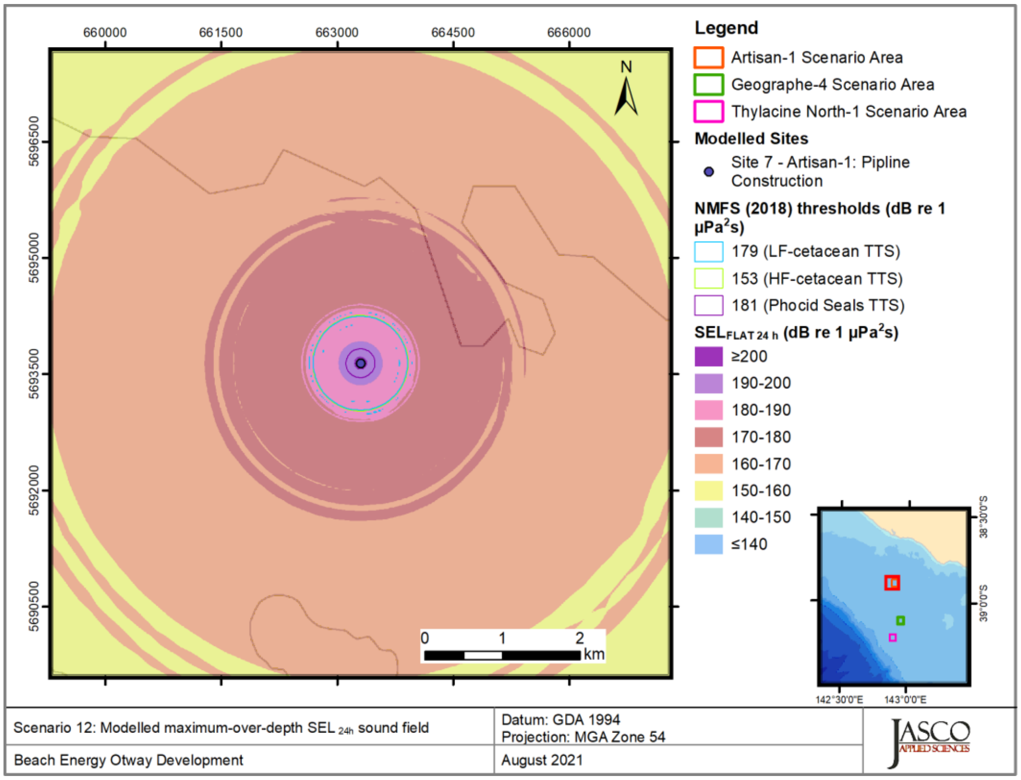


Figure 51. *Artisan-1, PLV stationary 20% MCR - November (Scenario 12) SEL$_{24h}$*: Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

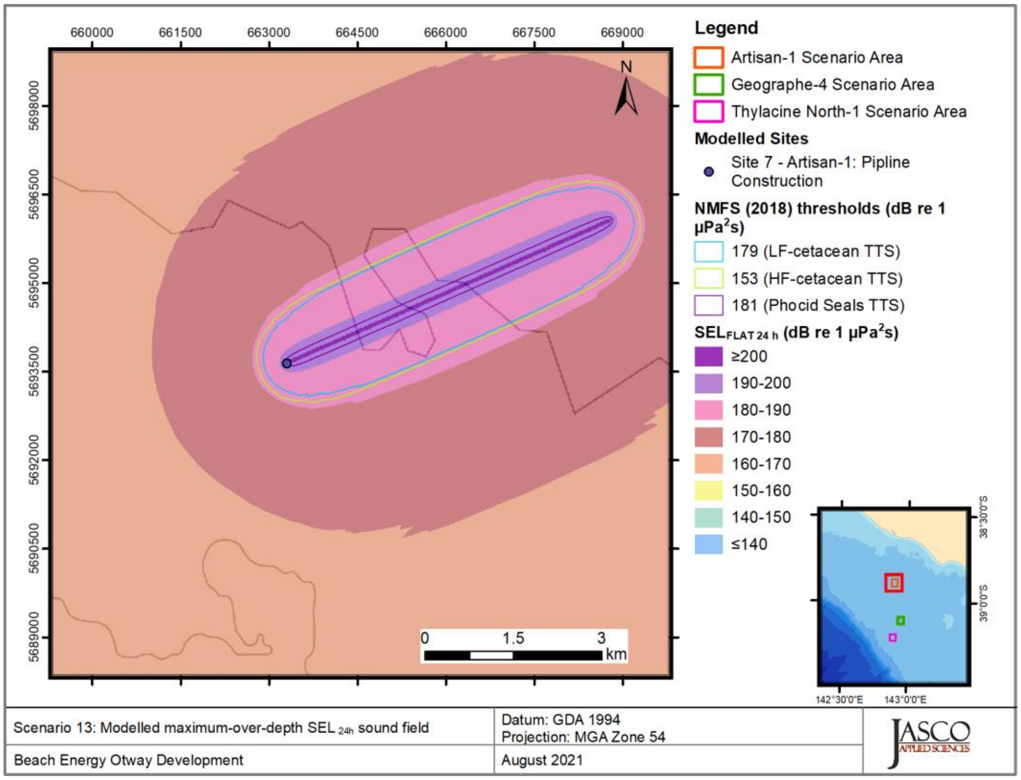


Figure 52. *Artisan-1, PLV pipe laying operations 20% MCR - June (Scenario 13) SEL*$_{24h}$: Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

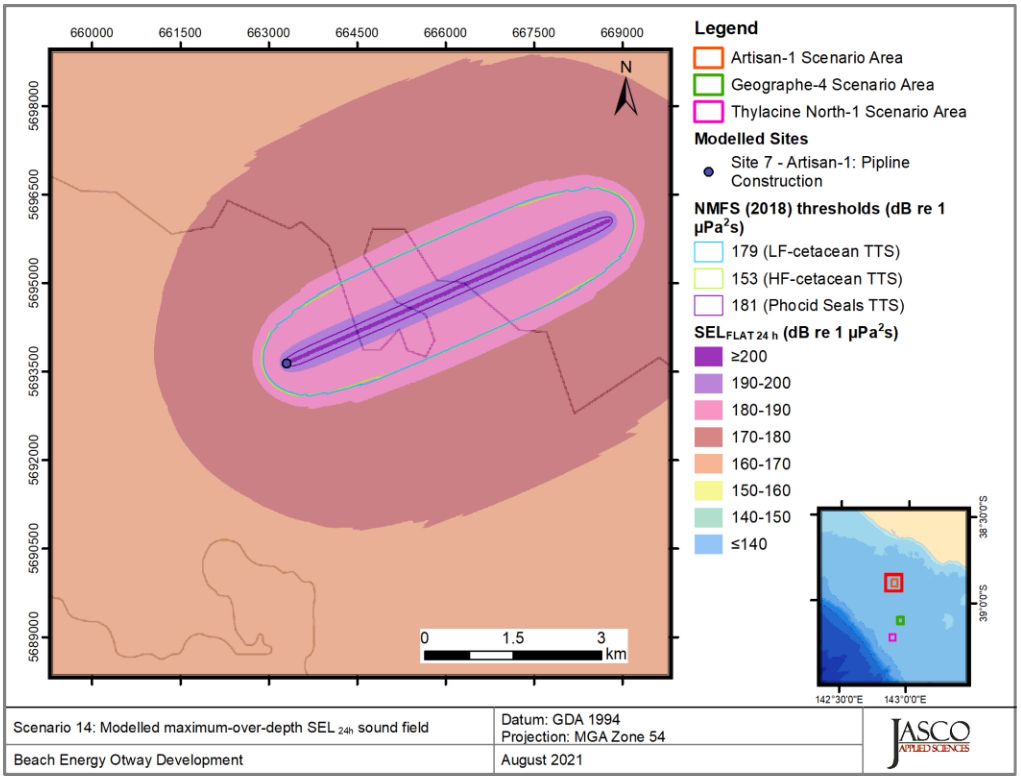


Figure 53. *Artisan-1, PLV pipe laying operations 20% MCR - November (Scenario 14) SEL*$_{24h}$: Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

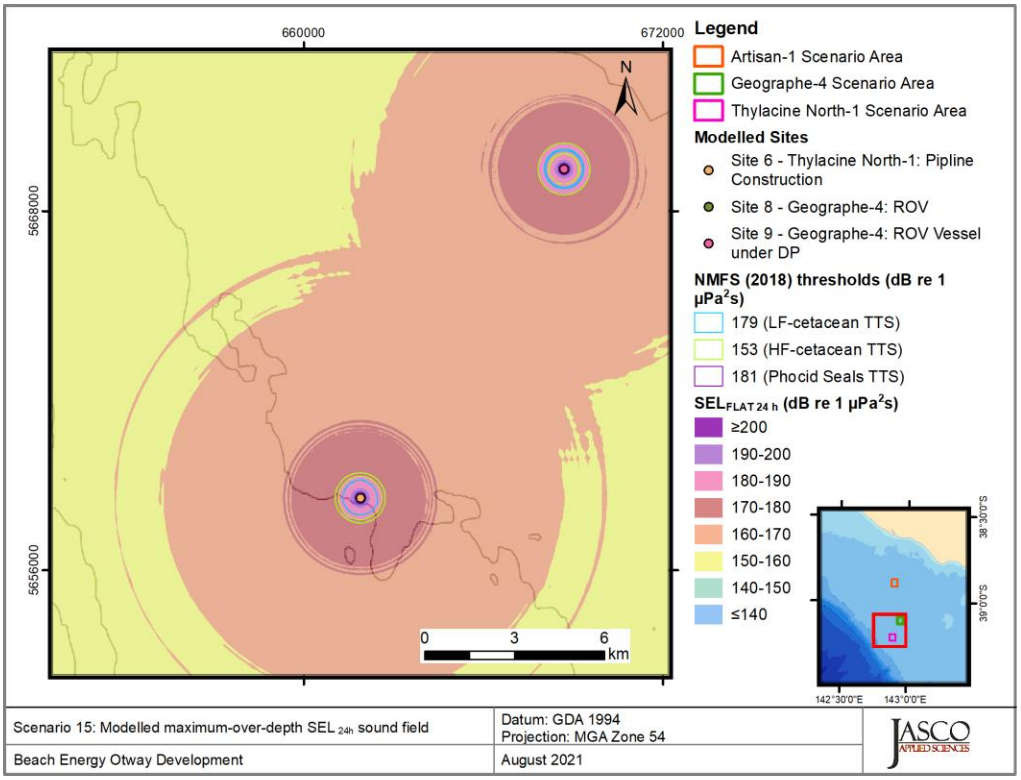


Figure 54. Thylacine North-1, PLV stationary and ROV Operations at Geographe-4 (*20% MCR*) - June (Scenario 15) SEL$_{24h}$: Sound level contour map showing unweighted maximum-over-depth SEL24h results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

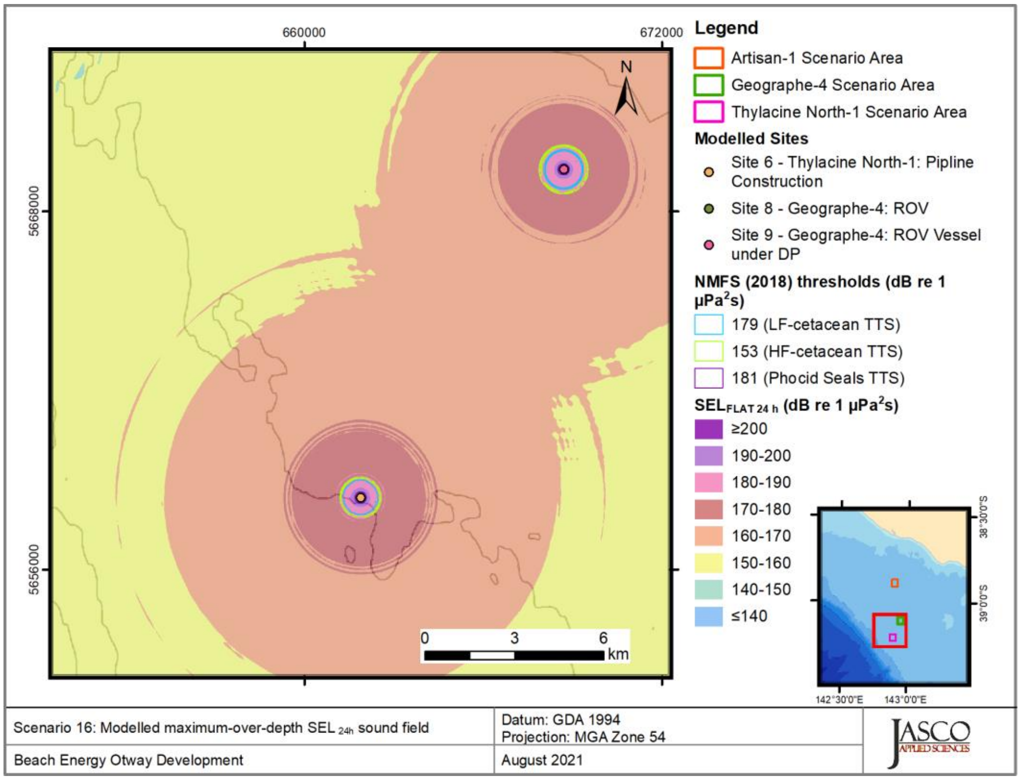


Figure 55. *Thylacine North-1, PLV stationary 20% MCR and ROV Operations at Geographe-4* (*20% MCR*) - *November (Scenario 16) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

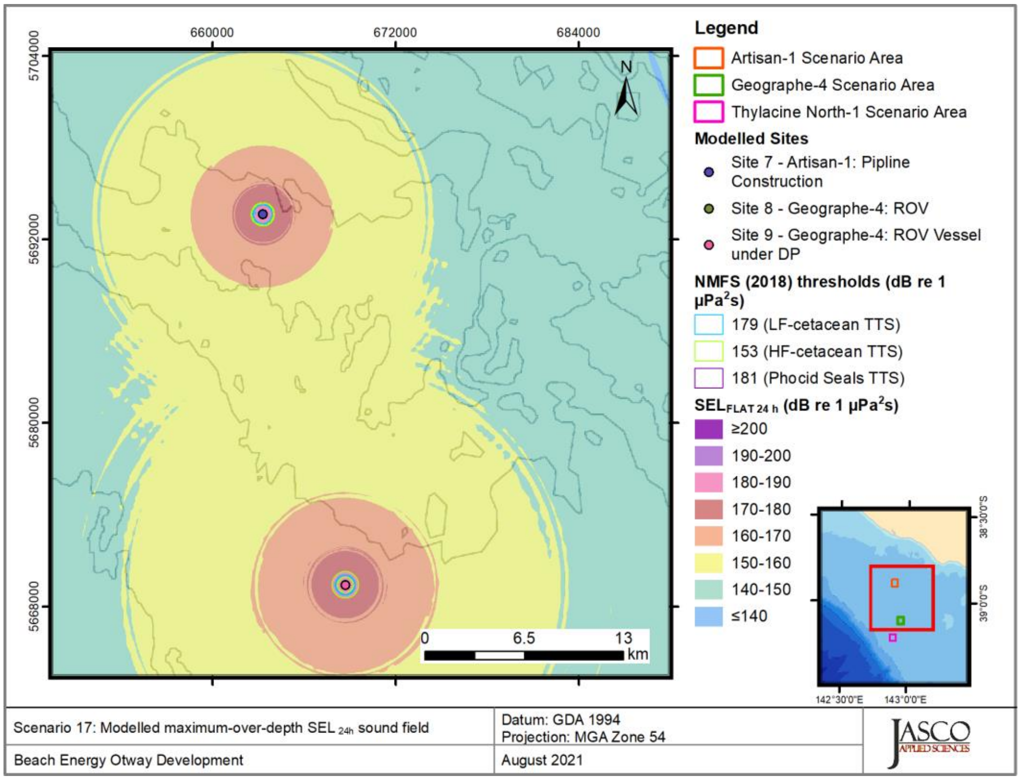


Figure 56. *Thylacine North-1, PLV stationary 20% MCR and ROV Operations at Geographe-4* (*20% MCR*) - *June (Scenario 17) SEL*$_{24h}$: Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

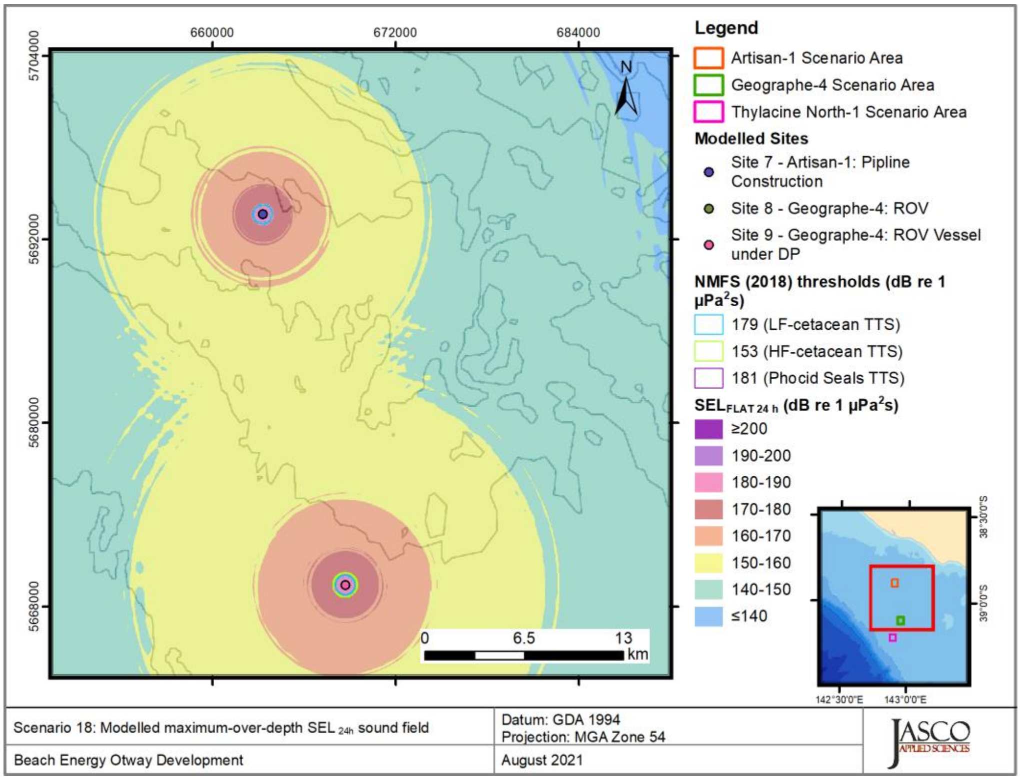


Figure 57. *Artisan-1, PLV stationary 20% MCR and ROV Operations at Geographe-4* (*20% MCR*) - *November (Scenario 18) SEL*$_{24h}$*:* Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

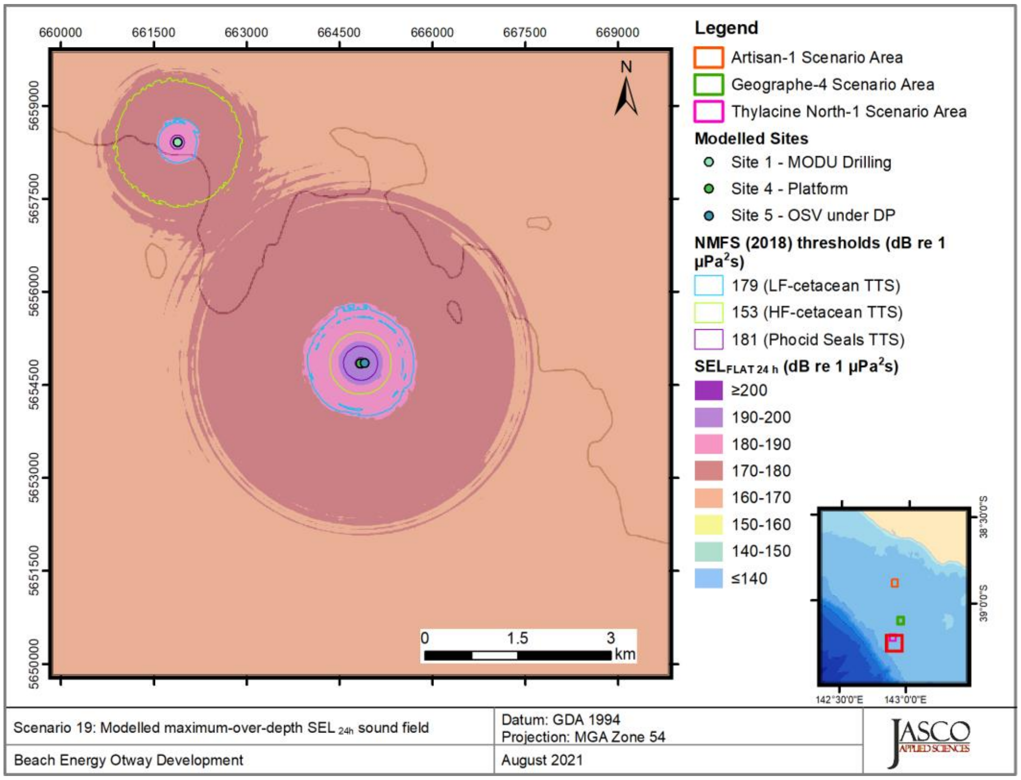


Figure 58. *Thylacine A Platform, 4h Platform Resupply and MODU Drilling (Scenario 19) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

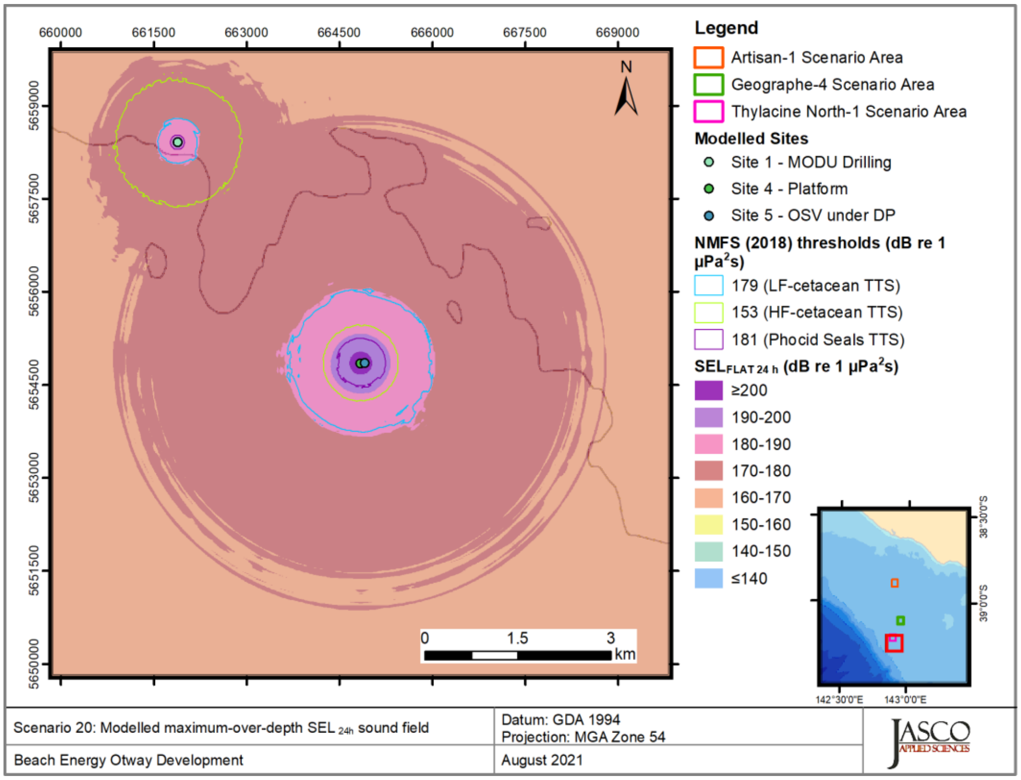


Figure 59. *Thylacine A Platform, 8h Platform Resupply and MODU Drilling (Scenario 20) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

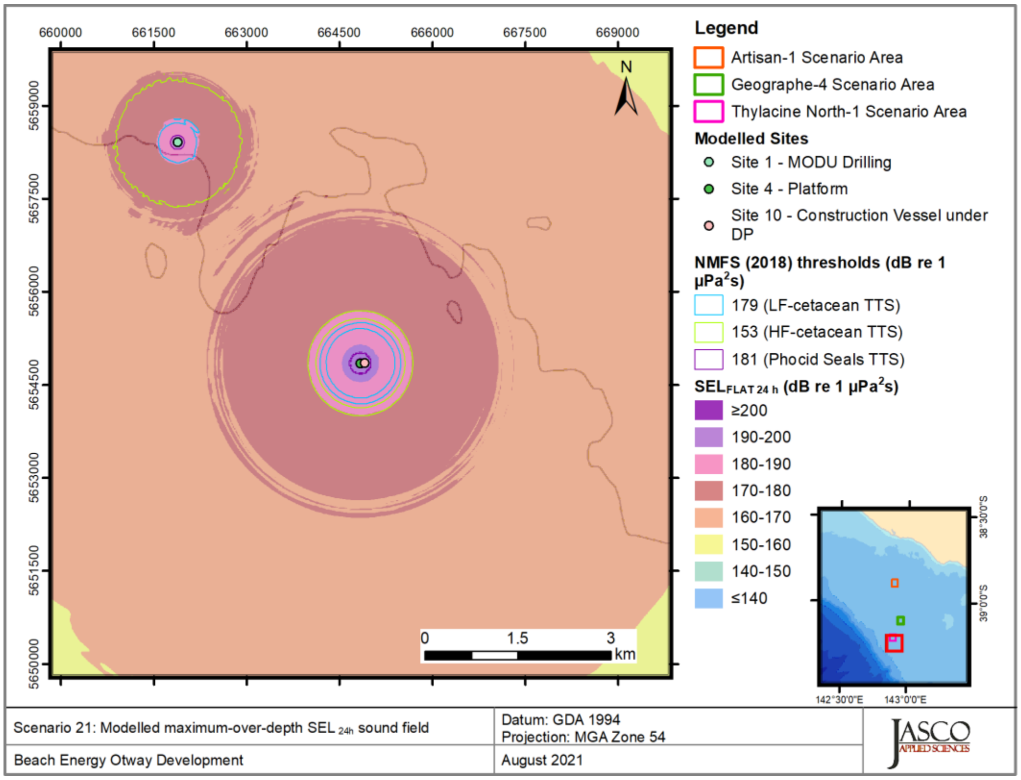


Figure 60. *Thylacine A Platform, Skid installation vessel operating at 20% MCR and MODU Drilling (Scenario 21) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

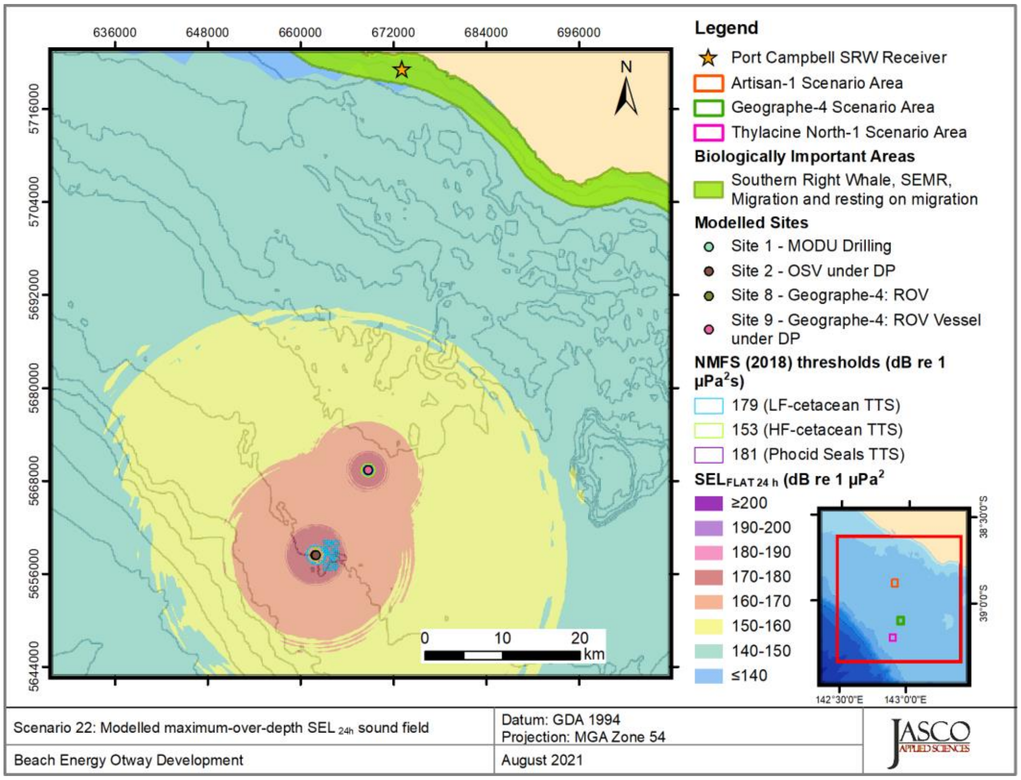


Figure 61 *Concurrent drilling operations at Thylacine North-1 and construction operations (20% MCR) at Geographe-4 (Scenario 22) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

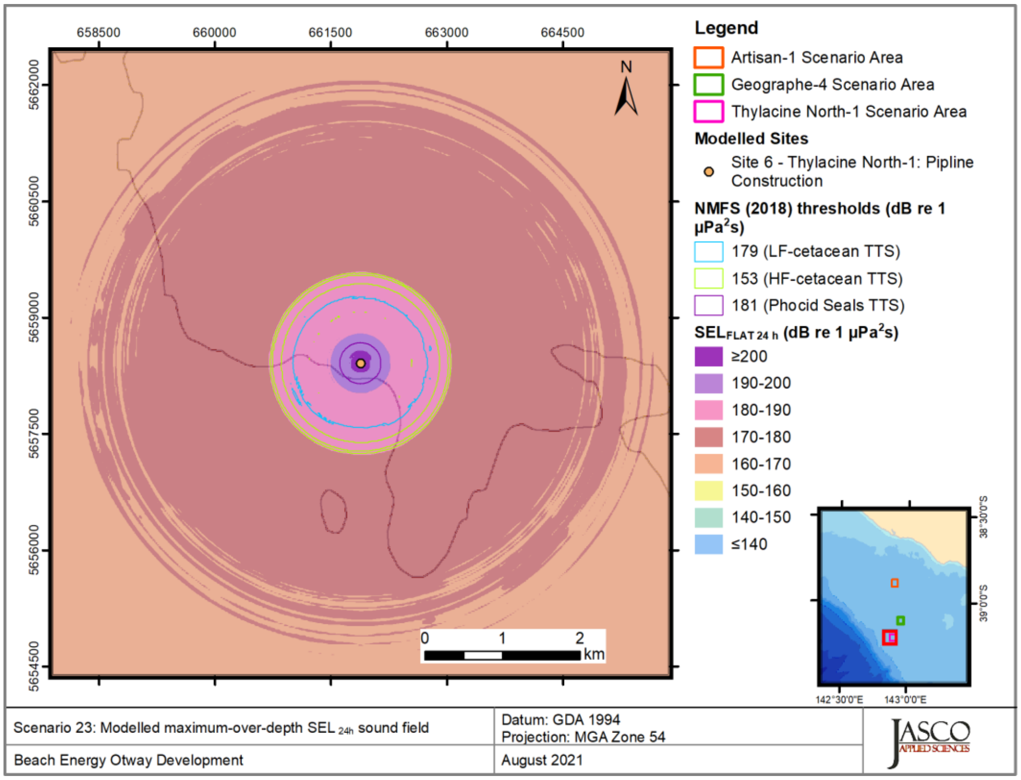


Figure 62. *Thylacine North-1, PLV stationary 40% MCR -June (Scenario 23) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL24h results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

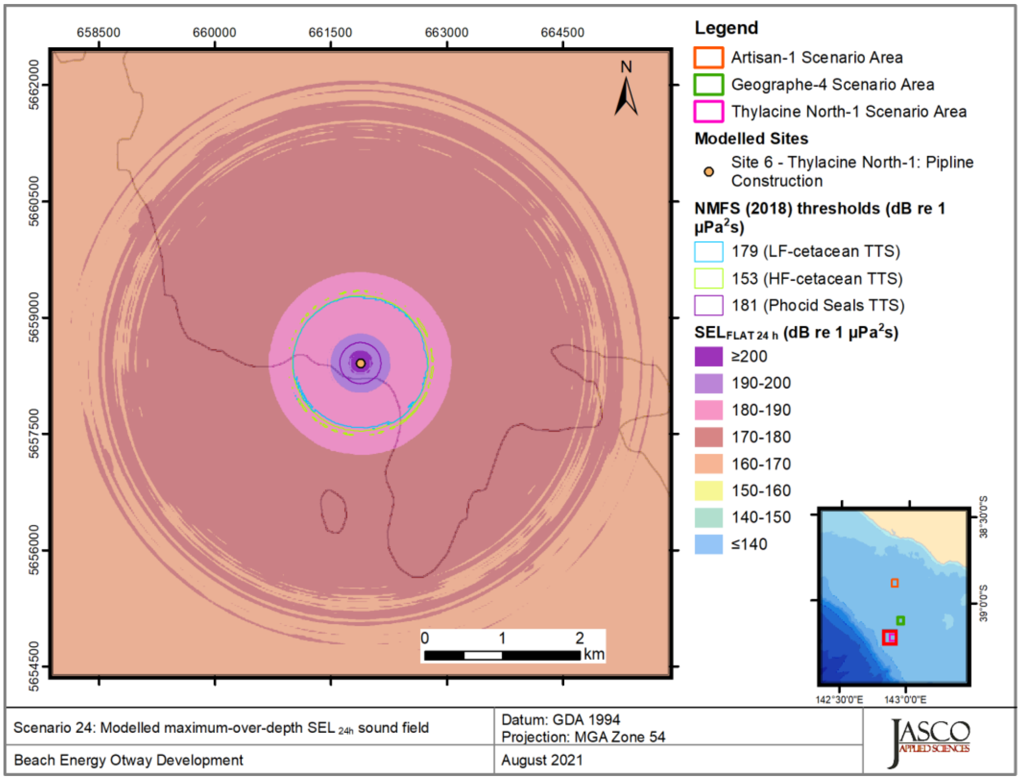


Figure 63. *Thylacine North-1, PLV stationary 40% MCR - November (Scenario 24) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

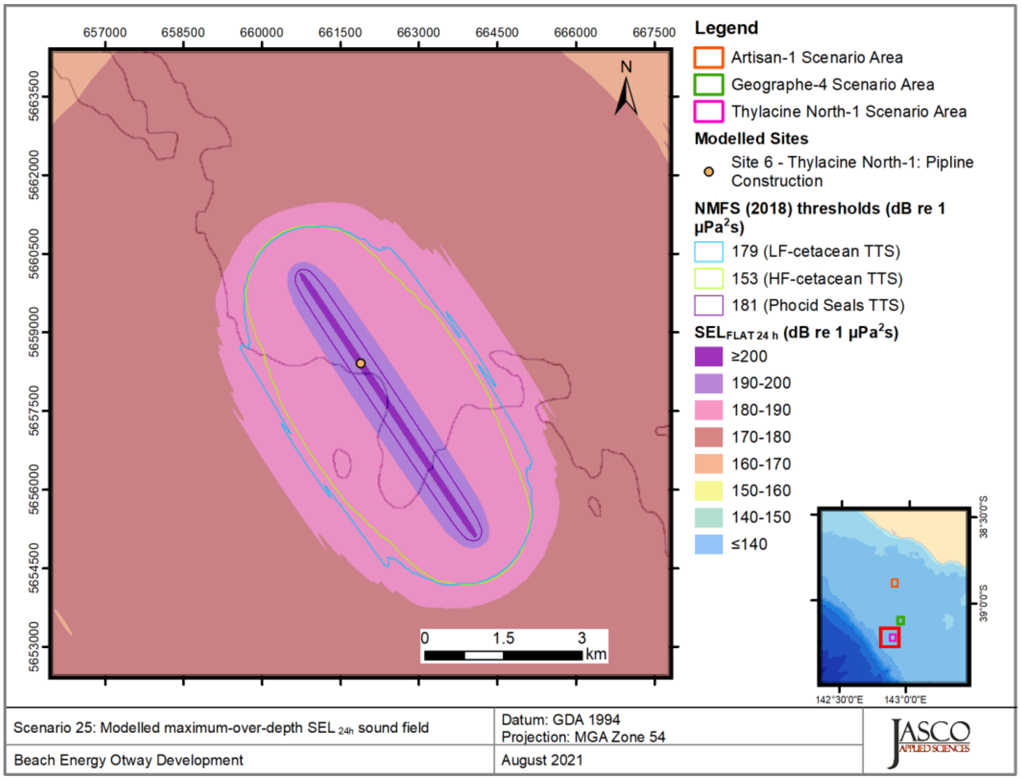


Figure 64. *Thylacine North-1, PLV pipe laying operations 40% MCR - June (Scenario 25) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

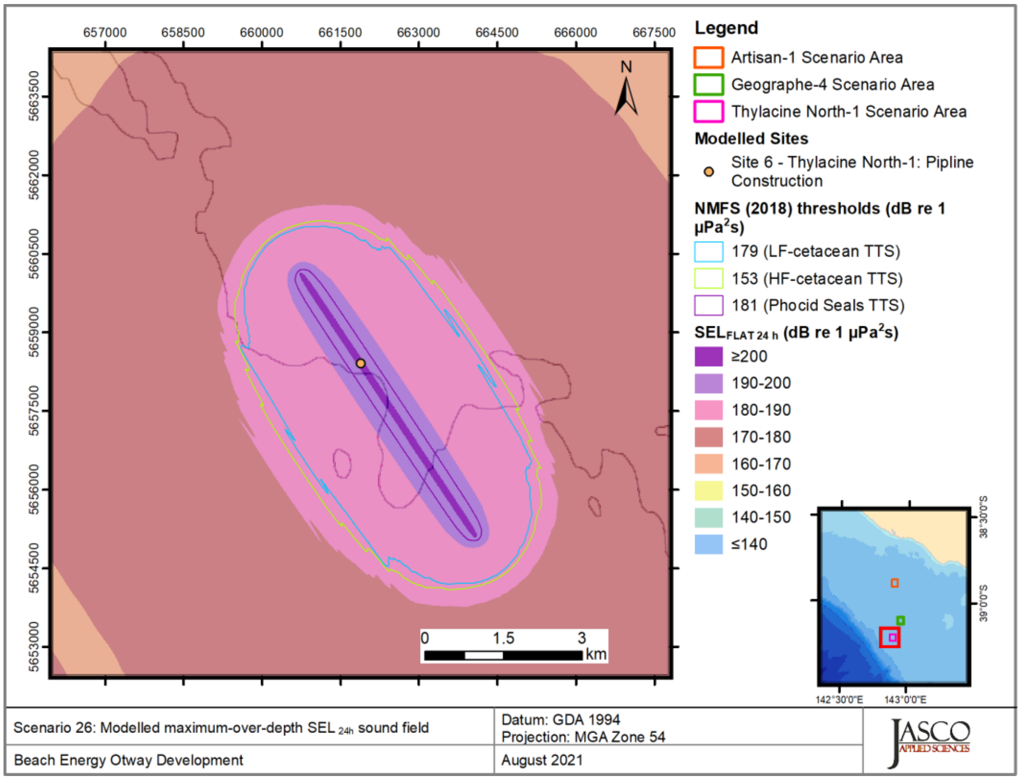


Figure 65. *Thylacine North-1, PLV pipe laying operations 40% MCR - November (Scenario 26) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL24h results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

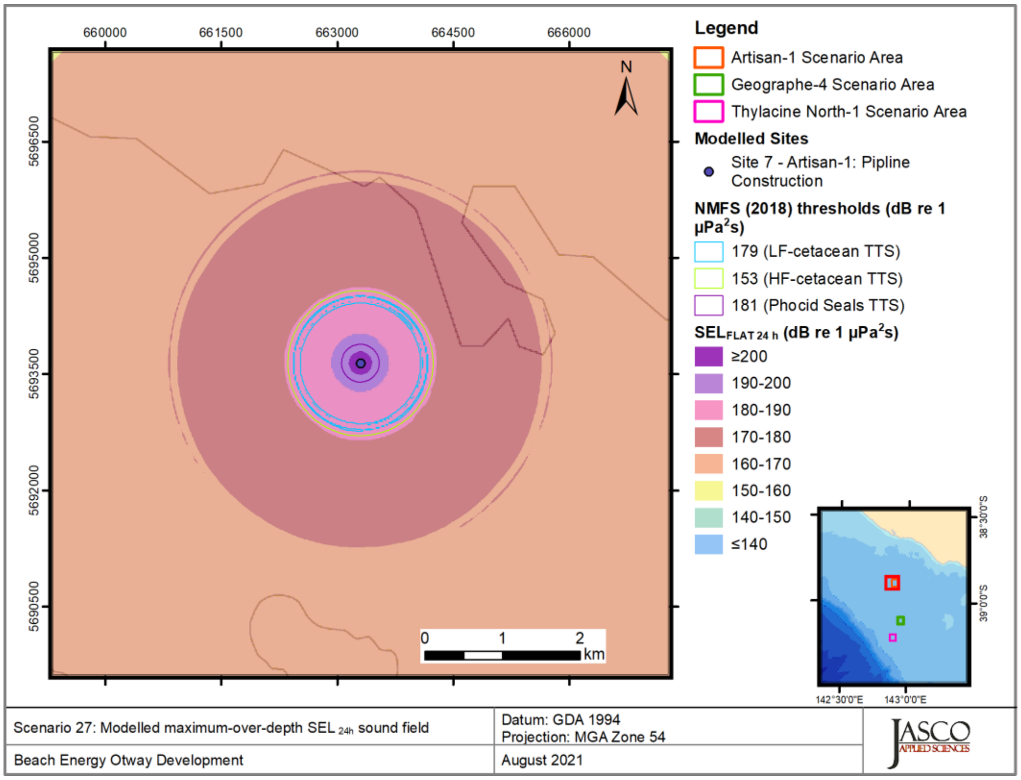


Figure 66. *Artisan-1, PLV stationary 40% MCR - June (Scenario 27) SEL$_{24h}$*: Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

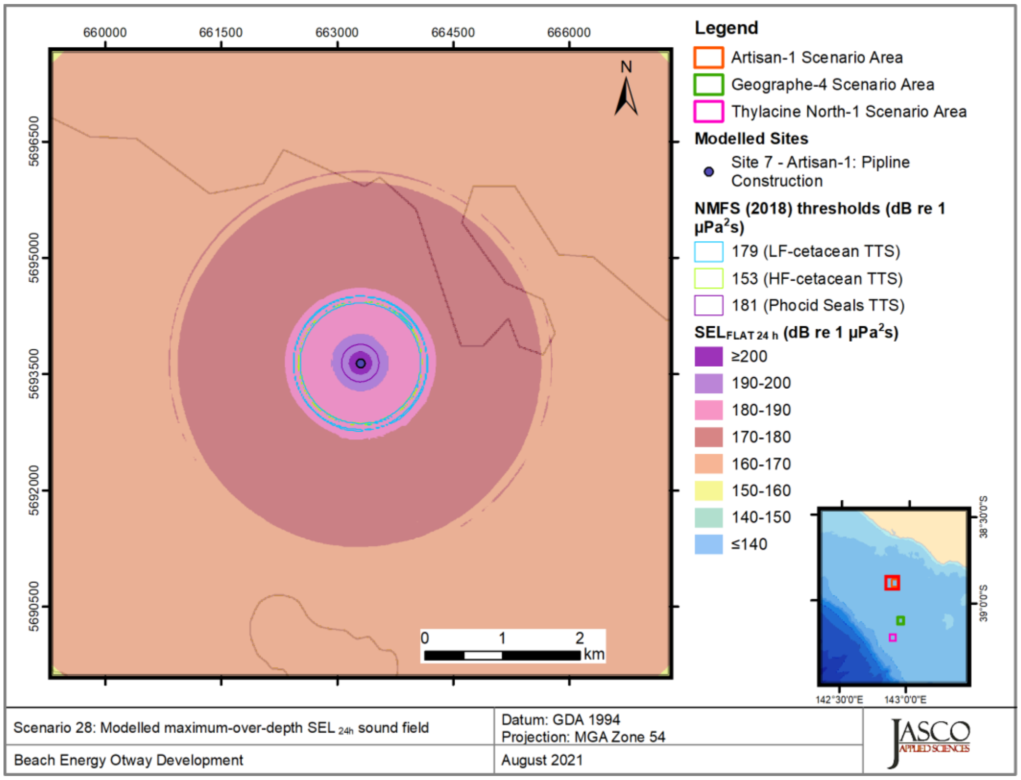


Figure 67. *Artisan-1, PLV stationary 40% MCR - November (Scenario 28) SEL$_{24h}$*: Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

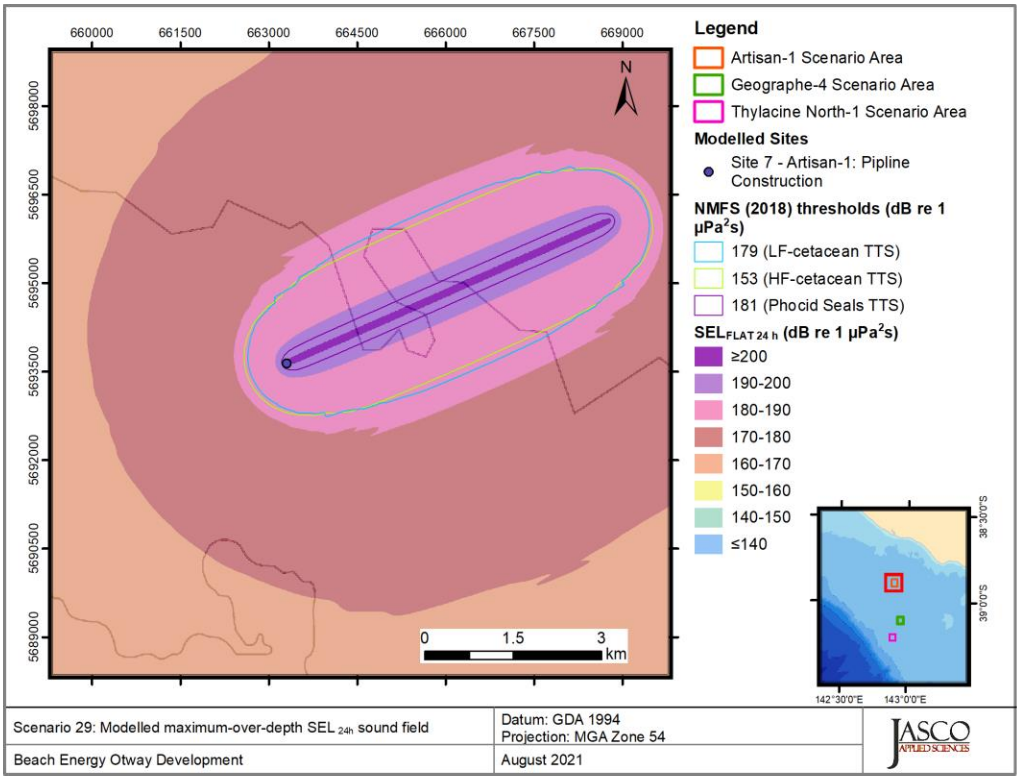


Figure 68. *Artisan-1, PLV pipe laying operations 40% MCR - June (Scenario 29) SEL$_{24h}$*: Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

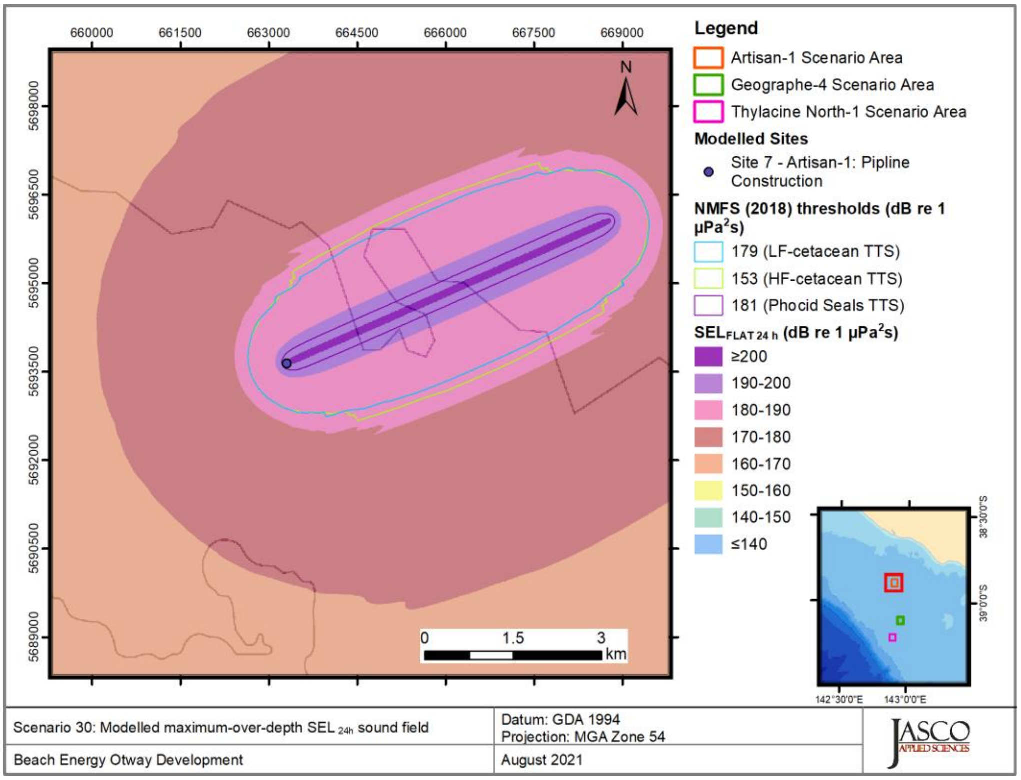


Figure 69. *Artisan-1, PLV pipe laying operations 40% MCR - November (Scenario 30) SEL$_{24h}$*: Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

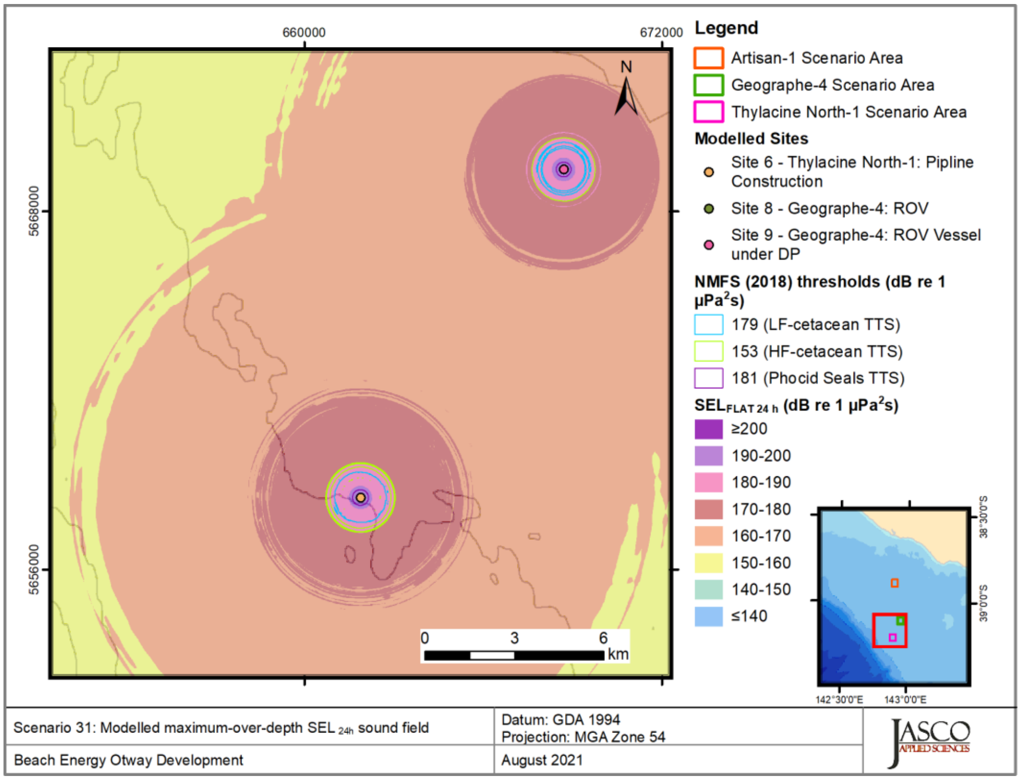


Figure 70. Thylacine North-1, PLV stationary and ROV Operations at Geographe-4 (*40% MCR*) - June (Scenario 31) SEL_{24h}: Sound level contour map showing unweighted maximum-over-depth SEL24h results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

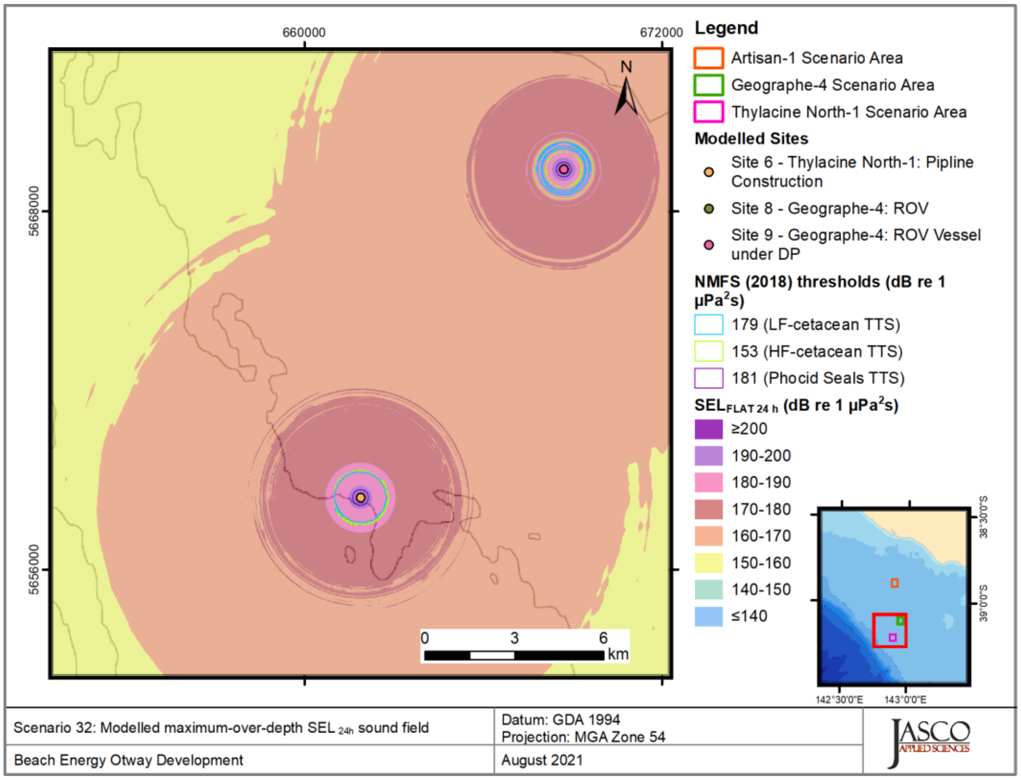


Figure 71. *Thylacine North-1, PLV stationary and ROV Operations at Geographe-4* (*40% MCR*) - *November (Scenario 32) SEL*$_{24h}$: Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

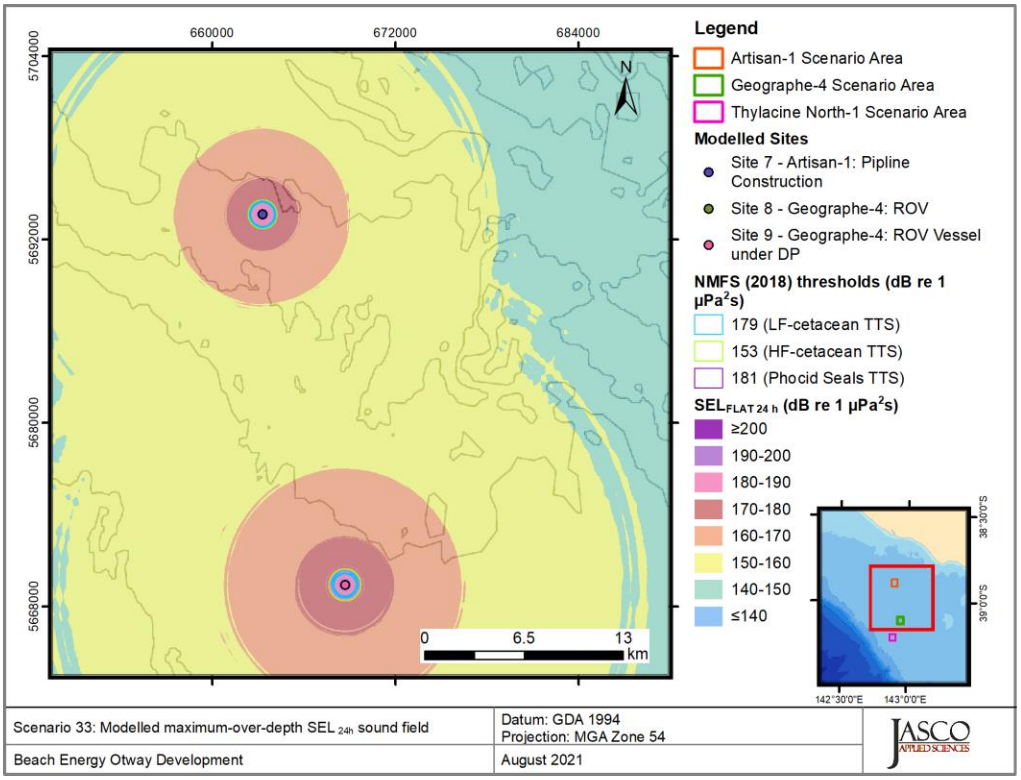


Figure 72. *Thylacine North-1, PLV stationary and ROV Operations at Geographe-4* (*40% MCR*) - *June (Scenario 33) SEL$_{24h}$*: Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

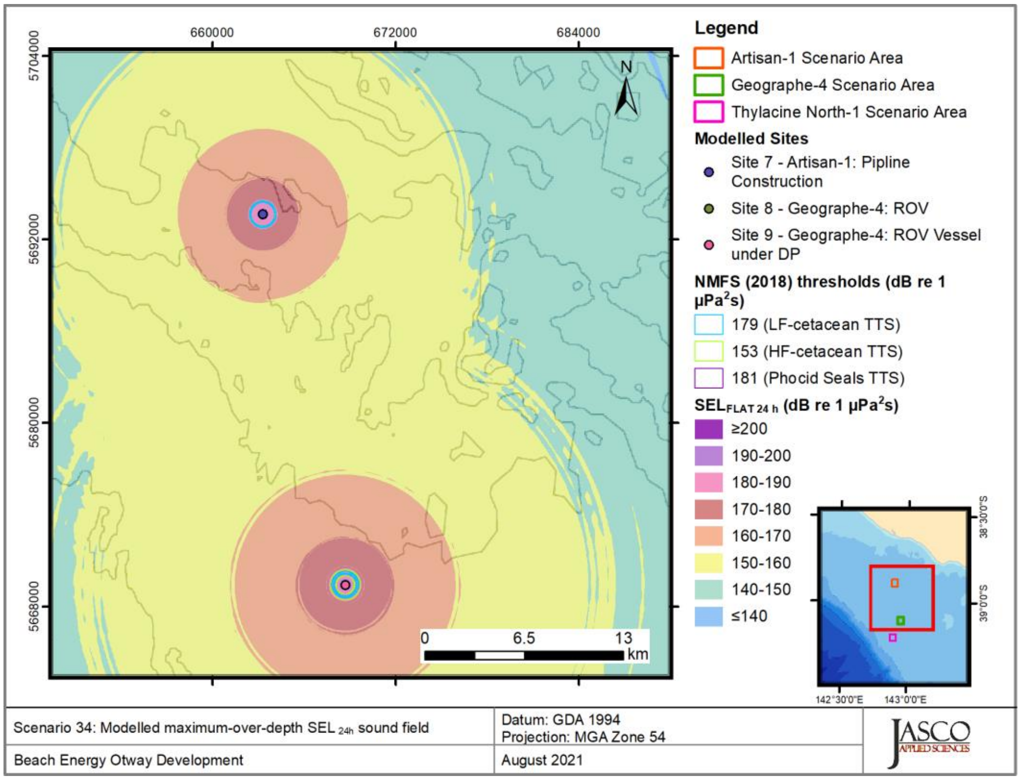


Figure 73. *Artisan-1, PLV stationary and ROV Operations at Geographe-4* (*40% MCR*) - *November (Scenario 34) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

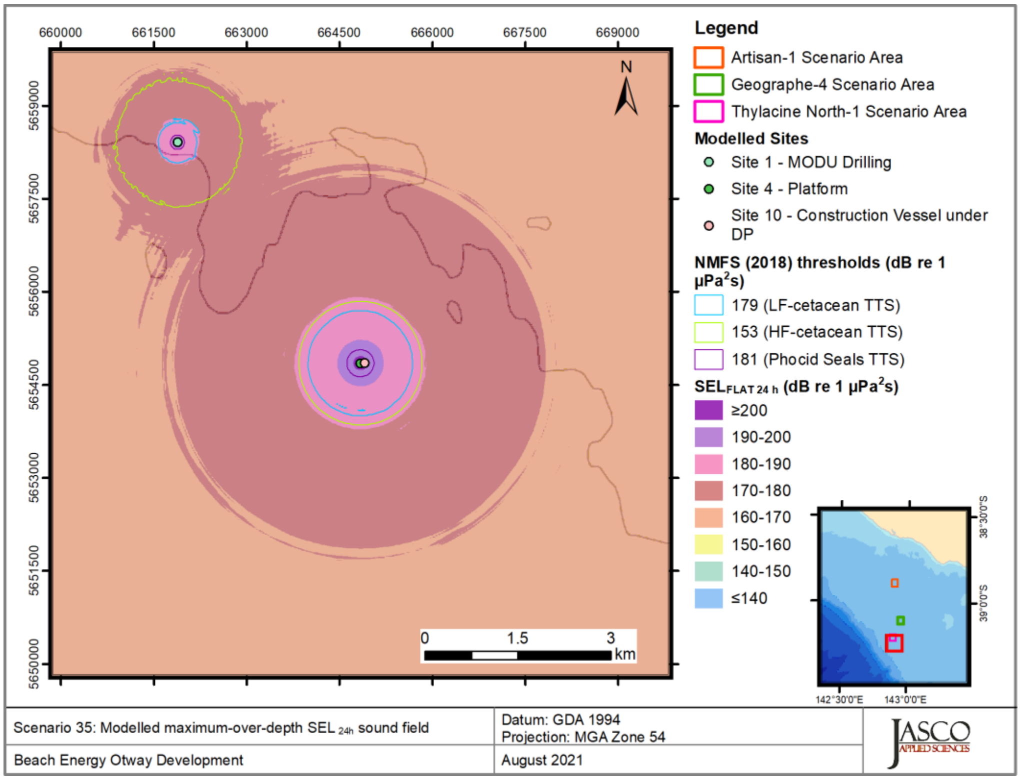


Figure 74. *Thylacine A Platform, Skid installation vessel operating at 40% MCR and MODU Drilling (Scenario 35) SEL$_{24h}$:* Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

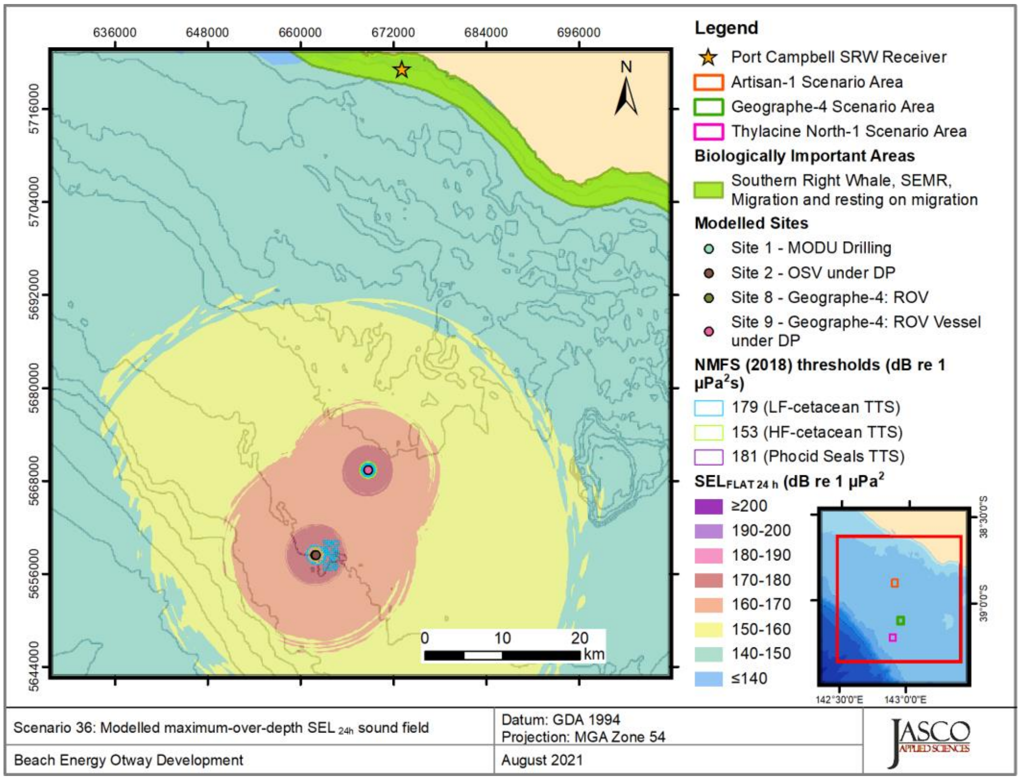


Figure 75 *Concurrent drilling operations at Thylacine North-1 and construction operations (40% MCR) at Geographe-4 (Scenario 36) SEL_{24h}:* Sound level contour map showing unweighted maximum-over-depth SEL_{24h} results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such that they could not be displayed on a map.

5. Discussion

The approach applied here to model the propagation loss was based is suitable for other locations within the continental shelf portion of the Otway Basin because it is supported by measurements of very similar operational activities (McPherson et al. 2021). However, the accuracy of the modelling propagation loss within this environment depends significantly upon the frequency content of the radiating sound source together with thickness of the sand layer on the calcarenite seabed within Otway region. In general, for these types of sources (i.e., vessels and other sources with a significant amount of energy above a few hundred Hertz) the thinner the sand layer, the greater the propagation loss. Having accurate source and site-specific information reduces the amount of uncertainty results due to model inputs uncertainty particularly when seemingly small changes in parametrisation can have reasonable significant changes in predicted results.

The distances to the effect thresholds based on modelling conducted here and supported by the results of the measurement study McPherson et al. (2021) are generally smaller when compared to those originally presented in Koessler et al. (2020). The understanding of the environment gained through the measurement study allowed for the geological environment to be represented in a site-specific fashion, and a more appropriate configuration of numerical models to represent the environmental propagation loss particularly with the layered calcarenite seabed. The application of the revised modelling approach to represent other Beach Energy activities on the continental shelf of the Otway Basin would be appropriate.

The maximum-over-depth sound field maps presented above show a few instances where threshold contours form concentric ‘rings’ around a source. These are likely the product of propagation interference patterns and the calculations method to account for the loss associated with the cemented limestone seabed (Section 6.2 in McPherson et al. (2021)). Variations in the sound field can produce local maxima and minima in loss which can results in specific levels dipping below thresholds before reaching a maximum extent. Moreover, the near constant bathymetry around most sources produces axial symmetry around a given source. Together these two factors can form the observed ‘rings’. Nevertheless, the maximum extent of these contours and associated tabulated radii are a valid prediction of the effect ranges that can be expected from the modelled operations.

The effect of different seasonality on predicted distances to the effect thresholds was minor but present. Considering the modelled Otway Offshore Project Construction scenarios, each scenario was modelled with a sound speed profiles for the ‘worst case over the year’ and for a period pygmy blue whales are present in the region, between November and January. These sound speed profiles were respectively selected as June and November. The effect thresholds applied to pygmy blue was the low-frequency cetacean SEL_{24h} thresholds based on NMFS (2018). The sound speed profile of November generally produced small distances to the low-frequency cetacean PTS and TTS threshold for the same operational activities modelled with a June SSP, see Tables 13–15. The seasonal differences were at most a few hundred metres. The receiver SPL level at the Port Campbell receiver locations presented in Table 10 are therefore expected to be lower in in November.

The SEL_{24h} is a cumulative metric that reflects the dosimetric impact of noise levels within 24 hours based on the assumption that an animal is consistently exposed to such noise levels at a fixed position. The corresponding SEL_{24h} radii represent an unlikely worst-case scenario. More realistically, marine mammals (as well as fish and turtles) are unlikely to stay in the same location for 24 hours. Therefore, a reported radius for SEL_{24h} criteria does not mean that marine fauna travelling within this radius of the source will be injured, but rather that an animal could be exposed to the sound level associated with impairment (either PTS or TTS) if it remained in that location for 24 hours.

Literature Cited

[NMFS] National Marine Fisheries Service (US). 2018. *2018 Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts*. US Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-59. 167 p. https://www.fisheries.noaa.gov/webdam/download/75962998.

[NOAA] National Oceanic and Atmospheric Administration (US). 2019. *ESA Section 7 Consultation Tools for Marine Mammals on the West Coast* (webpage), 27 Sep 2019. https://www.fisheries.noaa.gov/west-coast/endangered-species-conservation/esa-section-7-consultation-tools-marine-mammals-west. (Accessed 10 Mar 2020).

Austin, M.E., D.E. Hannay, and K.C. Bröker. 2018. Acoustic characterization of exploration drilling in the Chukchi and Beaufort seas. *Journal of the Acoustical Society of America* 144: 115-123. https://doi.org/10.1121/1.5044417

Carnes, M.R. 2009. *Description and Evaluation of GDEM-V 3.0*. US Naval Research Laboratory, Stennis Space Center, MS. NRL Memorandum Report 7330-09-9165. 21 p. https://apps.dtic.mil/dtic/tr/fulltext/u2/a494306.pdf.

Connell, S.C., M.W. Koessler, and C.R. McPherson. 2021. *Otway Offshore Project – Construction Program: Assessing Marine Fauna Sound Exposures*. Document Number 02407, Version 1.0 Technical report by JASCO Applied Sciences for Beach Energy Limited.

Coppens, A.B. 1981. Simple equations for the speed of sound in Neptunian waters. *Journal of the Acoustical Society of America* 69(3): 862-863. https://doi.org/10.1121/1.382038.

Duncan, A.J., A.L. Maggi, and T. Gourlay. 2012. *Sound exposure level and ocean wave modelling for the Enterprise 3D seismic survey (Port Campbell)*. Document Number C2012-32 v2.2 (FINAL). CMST report for Origin Energy.

Illingworth and Rodkin Inc. 2014. *Cook Inlet Exploratory Drilling Program – underwater sound source verification assessment, Cook Inlet, Alaska.* . Prepared for BlueCrest Energy, Inc. by Illingworth & Rodkin, Inc., Petaluma, California. https://www.federalregister.gov/documents/2014/09/11/2014-21662/takes-of-marine-mammals-incidental-to-specified-activities-taking-marine-mammals-incidental-to.

James, N.P. and Y. Bone. 2010. *Neritic carbonate sediments in a temperate realm: southern Australia*. Springer Science & Business Media.

Koessler, M.W., M.-N.R. Matthews, and C.R. McPherson. 2020. *Otway Offshore Project – Drilling Program: Assessing Marine Fauna Sound Exposures*. Document Number 02033, Version 1.0. Technical report by JASCO Applied Sciences for Beach Energy Limited.

Matthews, M.-N.R., M.W. Koessler, and C.R. McPherson. 2020. *Otway Offshore Project – Construction Program: Assessing Marine Fauna Sound Exposures*. Document Number 02112, Version 2.0. Technical report by JASCO Applied Sciences for Beach Energy Limited.

Matthews, M.-N.R., S. Connell, and C.R. McPherson. 2021. *Otway Offshore Project – Construction Program: Addendum – Combined Drilling and Construction Activities*. Document Number 02393, Version 1.0 DRAFT. Technical report by JASCO Applied Sciences for Beach Energy Limited. .

McPherson, C.R., Z. Li, C.C. Wilson, K.A. Kowarski, and M. Koessler. 2021. *Beach Otway Development Acoustic Monitoring: Characterisation, Validation, and Marine Mammals*. Document Number 02424, Version 2.0. Technical report by JASCO Applied Sciences for Beach Energy Limited.

Popper, A.N., A.D. Hawkins, R.R. Fay, D.A. Mann, S. Bartol, T.J. Carlson, S. Coombs, W.T. Ellison, R.L. Gentry, et al. 2014. *Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI*. ASA S3/SC1.4 TR-2014. SpringerBriefs in Oceanography. ASA Press and Springer. https://doi.org/10.1007/978-3-319-06659-2.

Spence, J.H., R. Fischer, M.A. Bahtiarian, L. Boroditsky, N. Jones, and R. Dempsey. 2007. *Review of Existing and Future Potential Treatments for Reducing Underwater Sound from Oil and Gas Industry Activities*. Report Number NCE 07-001. Report by Noise Control Engineering, Inc. for the Joint Industry Programme on E&P Sound and Marine Life. 185 p.

Teague, W.J., M.J. Carron, and P.J. Hogan. 1990. A comparison between the Generalized Digital Environmental Model and Levitus climatologies. *Journal of Geophysical Research* 95(C5): 7167-7183. https://doi.org/10.1029/JC095iC05p07167.

Whiteway, T. 2009. *Australian Bathymetry and Topography Grid, June 2009*. GeoScience Australia, Canberra. http://pid.geoscience.gov.au/dataset/ga/67703.

Wood, M.A. and C.R. McPherson. 2018. *VSP Acoustic Modelling: Enterprise 1 Drilling Program - Otway Basin*. Document Number 01670, Version 1.1. Technical report by JASCO Applied Sciences for Beach Energy Limited.

Appendix A. Acoustic Metrics

A.1. Pressure Related Acoustic Metrics

Underwater sound pressure amplitude is measured in decibels (dB) relative to a fixed reference pressure of p_0 = 1 µPa. Because the perceived loudness of sound, especially impulsive noise such as from seismic airguns, pile driving, and sonar, is not generally proportional to the instantaneous acoustic pressure, several sound level metrics are commonly used to evaluate noise and its effects on marine life. We provide specific definitions of relevant metrics used in the accompanying report. Where possible we follow the ANSI and ISO standard definitions and symbols for sound metrics, but these standards are not always consistent.

The sound pressure level (SPL; L_p; dB re 1 µPa) is the rms pressure level in a stated frequency band over a specified time window (T, s) containing the acoustic event of interest. It is important to note that SPL always refers to a rms pressure level and therefore not instantaneous pressure:

$$L_p = 10\log_{10}\left(\frac{1}{T}\int_T p^2(t)dt \Big/ p_0^2\right) \tag{A-1}$$

The SPL represents a nominal effective continuous sound over the duration of an acoustic event, such as the emission of one acoustic pulse, a marine mammal vocalization, the passage of a vessel, or over a fixed duration. Because the window length, T, is the divisor, events with similar sound exposure level (SEL) but more spread out in time have a lower SPL.

The sound exposure level (SEL; L_E; $L_{E,p}$; dB re 1 µPa^2·s) is a measure related to the acoustic energy contained in one or more acoustic events (N). The SEL for a single event is computed from the time-integral of the squared pressure over the full event duration (T):

$$L_E = 10\log_{10}\left(\int_T p^2(t)dt \Big/ T_0 p_0^2\right) \tag{A-2}$$

where T_0 is a reference time interval of 1 s. The SEL continues to increase with time when non-zero pressure signals are present. It therefore can be construed as a dose-type measurement, so the integration time used must be carefully considered in terms of relevance for impact to the exposed recipients.

SEL can be calculated over periods with multiple acoustic events or over a fixed duration. For a fixed duration, the square pressure is integrated over the duration of interest. For multiple events, SEL can be computed by summing (in linear units) SEL of the N individual events:

$$L_{E,N} = 10\log_{10}\left(\sum_{i=1}^{N} 10^{\frac{L_{E,i}}{10}}\right). \tag{A-3}$$

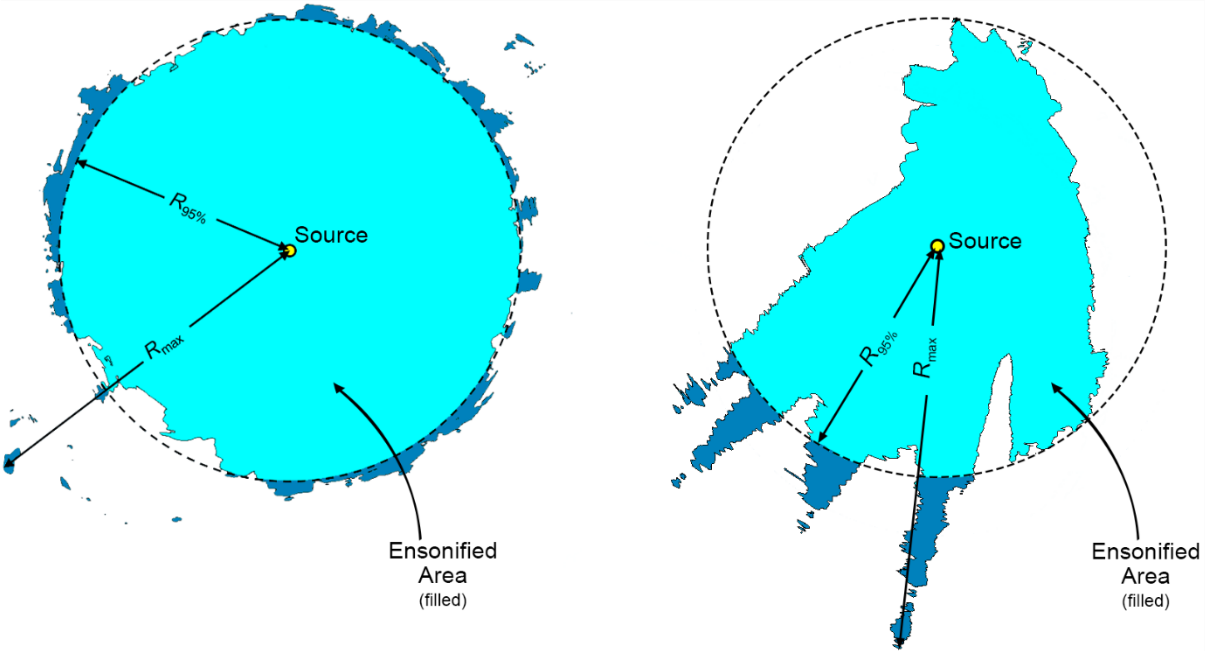
Appendix B. Methods and Parameters

This section describes the specifications of the seismic source that was used at all sites and the environmental parameters used in the propagation models.

B.1. Estimating Range to Thresholds Levels

Sound level contours were calculated based on the underwater sound fields predicted by the propagation models, sampled by taking the maximum value over all modelled depths above the sea floor for each location in the modelled region. The predicted distances to specific levels were computed from these contours. Two distances relative to the source are reported for each sound level: 1) R_{max}, the maximum range to the given sound level over all azimuths, and 2) $R_{95\%}$, the range to the given sound level after the 5% farthest points were excluded (see examples in Figure B-1).

The $R_{95\%}$ is used because sound field footprints are often irregular in shape. In some cases, a sound level contour might have small protrusions or anomalous isolated fringes. This is demonstrated in the image in Figure B-1(a). In cases such as this, where relatively few points are excluded in any given direction, R_{max} can misrepresent the area of the region exposed to such effects, and $R_{95\%}$ is considered more representative. In strongly asymmetric cases such as shown in Figure B-1(b), on the other hand, $R_{95\%}$ neglects to account for significant protrusions in the footprint. In such cases R_{max} might better represent the region of effect in specific directions. Cases such as this are usually associated with bathymetric features affecting propagation. The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the non-uniformity of the acoustic environment.



(a) (b)

Figure B-1. Sample areas ensonified to an arbitrary sound level with R_{max} and $R_{95\%}$ ranges shown for two different scenarios. (a) Largely symmetric sound level contour with small protrusions. (b) Strongly asymmetric sound level contour with long protrusions. Light blue indicates the ensonified areas bounded by $R_{95\%}$; darker blue indicates the areas outside this boundary which determine R_{max}.

B.2. Environmental Parameters

B.2.1. Bathymetry

Water depths throughout the modelled areas were extracted from the Australian Bathymetry and Topography Grid, a 9 arc-second grid rendered for Australian waters (Whiteway 2009). Bathymetry data were re-gridded onto a Map Grid of Australia (MGA) coordinate projection (Zone 54) with a regular grid spacing of 100 × 100 m.

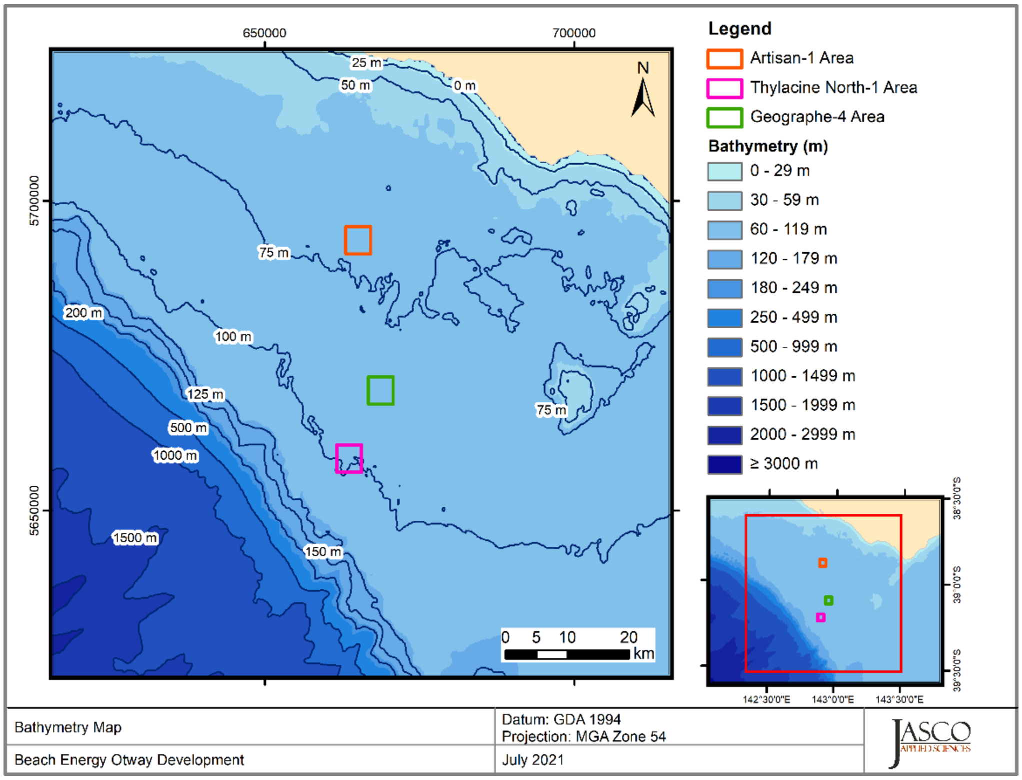


Figure B-2. Bathymetry in the modelled area.

B.2.2. Sound speed profile

The sound speed profile in the area was derived from temperature and salinity profiles from the U.S. Naval Oceanographic Office's *Generalized Digital Environmental Model V 3.0* (GDEM; Teague et al. 1990, Carnes 2009). GDEM provides an ocean climatology of temperature and salinity for the world's oceans on a latitude-longitude grid with 0.25° resolution, with a temporal resolution of one month, based on global historical observations from the U.S. Navy's Master Oceanographic Observational Data Set (MOODS). The climatology profiles include 78 fixed depth points to a maximum depth of 6800 m (where the ocean is that deep). The GDEM temperature-salinity profiles were converted to sound speed profiles according to Coppens (1981).

Mean monthly sound speed profiles were derived from the GDEM profiles at distances less than 7 km around the modelled site. The June sound speed profile is expected to be most favourable to longer-range sound propagation across the entire year. As such, June was selected for sound propagation modelling to ensure precautionary estimates of distances to received sound level thresholds. For the pygmy blue whale period between November and January November is expected to be most favourable to longer-range propagation in that period. Figure B-3 shows the resulting profiles, which were used as input to the sound propagation modelling.

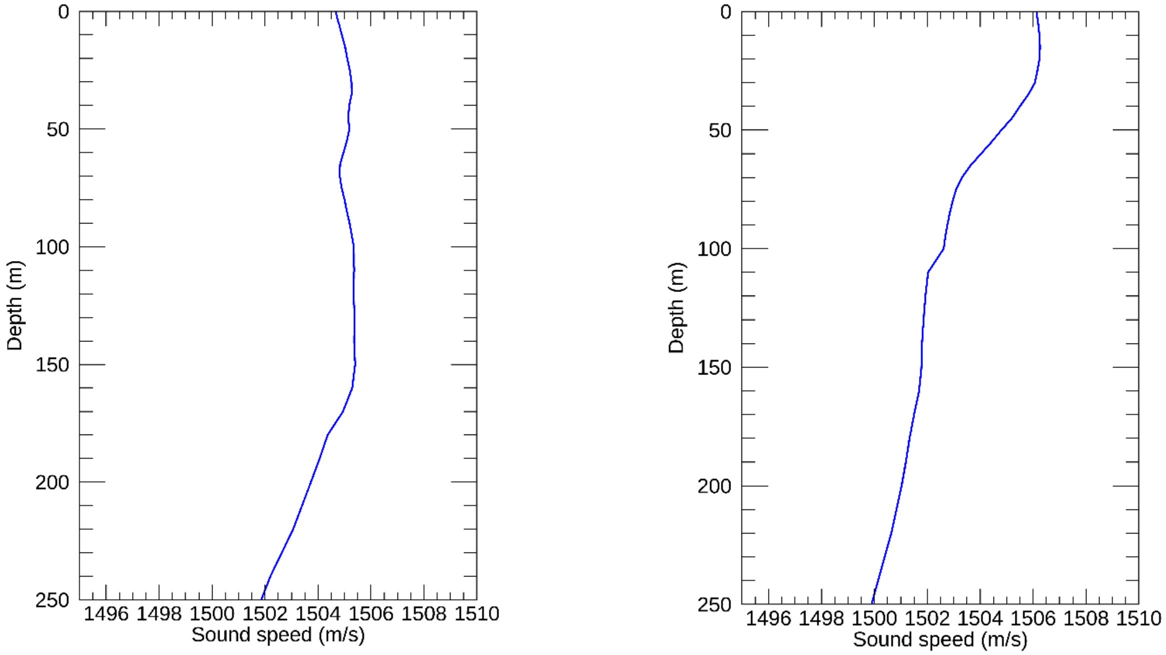


Figure B-3. The modelling sound speed profile corresponding to June (left) and November (right) Profiles are calculated from temperature and salinity profiles from *Generalized Digital Environmental Model* V 3.0 (GDEM; Teague et al. 1990, Carnes 2009).

B.2.3. Geoacoustics

The propagation model used in this study consider a single geoacoustic profile for each development area. These profiles determine how sound is reflected from the seabed, as well as how it is transmitted, reflected and absorbed into the sediment layers. As in previous acoustic studies in the area, the modelling area was divided into two seabed types (Wood and McPherson 2018). Both areas are located on the continental shelf, however the seabed in the Thylacine North-1 and were modelled as being characterised by well-cemented carbonate caprock (calcarenite), overlying semi-cemented carbonate rock (calcarenite). This contrast in seabed environment is consistent with larger scale geological data and interpretations of the Australian continental shelf environment (James and Bone 2010). Table B-1 present the geoacoustic profile used at the modelled sites in each respective development area.

Table B-1. *Thylacine North-1*: Geoacoustic profile. Each parameter varies linearly within the stated range.

Depth below seafloor (m)	**Predicted lithology**	**Density (g/cm^3)**	**Compressional wave**		**Shear wave**	
			Speed (m/s)	Attenuation (dB/λ)	Speed (m/s)	Attenuation (dB/λ)
0–0.5	Well-cemented carbonate caprock	2.7	2600	0.50	1200	0.5
0.5–20	Increasingly cemented calcarenite	2.2	2000	0.30	900	0.27
20-40		2.3	2120	0.34	960	0.32
40-60		2.4	2240	0.38	1020	0.41
60-80		2.5	2360	0.42	1080	0.45
80–100		2.6	2480	0.46	1140	0.5
>100	Well-cemented calcarenite	2.7	2600	0.5	1200	0.5

Appendix G: Sound Modelling Report – Connell and Koessler 2023

Technical Memo

DATE: 11 December 2023

DOCUMENT: 03248 Version 1.0

FROM: Steven Connell, Matthew Koessler (JASCO Applied Sciences (Australia) Pty Ltd)

TO: Glen Nicholson (Beach Energy)

Subject: Beach Otway Project, Additional Modelling at Well Location South

JASCO Applied Sciences (JASCO) performed additional modelling of underwater sound levels associated with the Beach Energy's exploration, development, and operations within the Otway basin. This study supplements work conducted to date, including drilling and construction results previously presented in Koessler and McPherson (2021), Koessler et al. (2020), Matthews et al. (2020) and Matthews et al. (2021). Additional modelling results have been added to better represent the southern part of the development area at a representative southern well location. In this report location is referred to as "Well Location South".

Estimated underwater acoustic levels are presented as sound pressure levels (SPL, L_p), and as accumulated sound exposure levels (SEL, L_E) as appropriate for non-impulsive (continuous) noise sources. For the non-time dependent scenarios, marine mammal behavioural threshold based on the current interim NOAA (2019) criterion for marine mammals of 120 dB re 1 µPa (SPL; L_p) for non-impulsive sound sources are summarised in Section 2.

For the time-dependent scenarios, the modelled maximum distances to permanent threshold shift (PTS) and temporary threshold shift (TTS) criteria for low-frequency cetaceans Southall et al. (2019)., which are based on SEL accumulated over a period of time are summarised in Section 2.

Summary tables of results are provided in Table 1 and 2 below.

Table 1. Maximum (R_{max}) horizontal distances (in km) to sound pressure level (SPL) for the NOAA (2019) behavioural response threshold from the most appropriate location for considered sources per scenario. OSV: Offshore Supply Vessel, MODU: Mobile Offshore Drilling Unit

Scenario number	Well Area	Description	R_{max} (km)
1	Well Location South	MODU Drilling	1.46
2		OSV under Transit	0.41
3		MODU Drilling + OSV under DP (4hr) + OSV under Transit (20hr) (Resupply Ops)	19.6
4		MODU Drilling + OSV under Transit	2.21

Table 2. Summary: Maximum (R_{max}) horizontal distances (in km) for the frequency-weighted LF-cetacean SEL_{24h} TTS thresholds based on Southall et al. (2019) from the most appropriate location for considered sources per scenario. OSV: Offshore Supply Vessel, MODU: Mobile Offshore Drilling Unit

Scenario number	Well Area	Description	R_{max} (km)
1	Well Location South	MODU Drilling	0.23
2		OSV under Transit	0.01
3		MODU Drilling + OSV under DP (4hr) + OSV under Transit (20hr) (Resupply Ops)	1.48
4		MODU Drilling + OSV under Transit	0.23

1. Acoustic Modelling Scenario Details

The modelled sites considered within this additional modelling are provided in Table 3, with the associated modelled scenarios detailed below and provided in Table 4. An overview of the considered scenarios is as follows:

1. MODU Drilling at Well Location South.
2. OSV vessel on standby in a 2x4 km box 2 km east of Well Location South for 24 hours.
3. MODU drilling at Well Location South with OSV under DP alongside MODU performing resupply for 4 hours and OSV vessel on standby in a 2x4 km box 2 km east of Well Location South for 20 hours.
4. MODU drilling at Well Location South with OSV vessel on standby in a 2x4 km box 2 km east of Well Location South for 24 hours.

Table 3. Location details for the modelled sites. OSV: Offshore Supply Vessel, MODU: Mobile Offshore Drilling Unit.

Well	Site	Source	Latitude (S)	Longitude (E)	MGA (GDA94), Zone 54		Water depth (m)
					X (m)	Y (m)	
Well Location South	1	MODU	39° 44' 54.61"	143° 09' 49.54"	685382	5597917	156
	2	OSV (DP)	39° 44' 54.56"	143° 09' 52.23"	685446	5597917	156
	3	OSV (transit)	39° 44' 53.04"	143° 11' 13.52"	687382	5597917	136

Table 4. Description of modelled scenarios, OSV: Offshore Supply Vessel, MODU: Mobile Offshore Drilling Unit.

Scenario	Site	Location	Operation Description
1	1	Well Location South	MODU Drilling
2	3		OSV under Transit
3	1,2,3		MODU Drilling + OSV under DP (4 hr) + OSV under Transit (20 hr) (Resupply Ops)
4	1,3		MODU Drilling + OSV under Transit

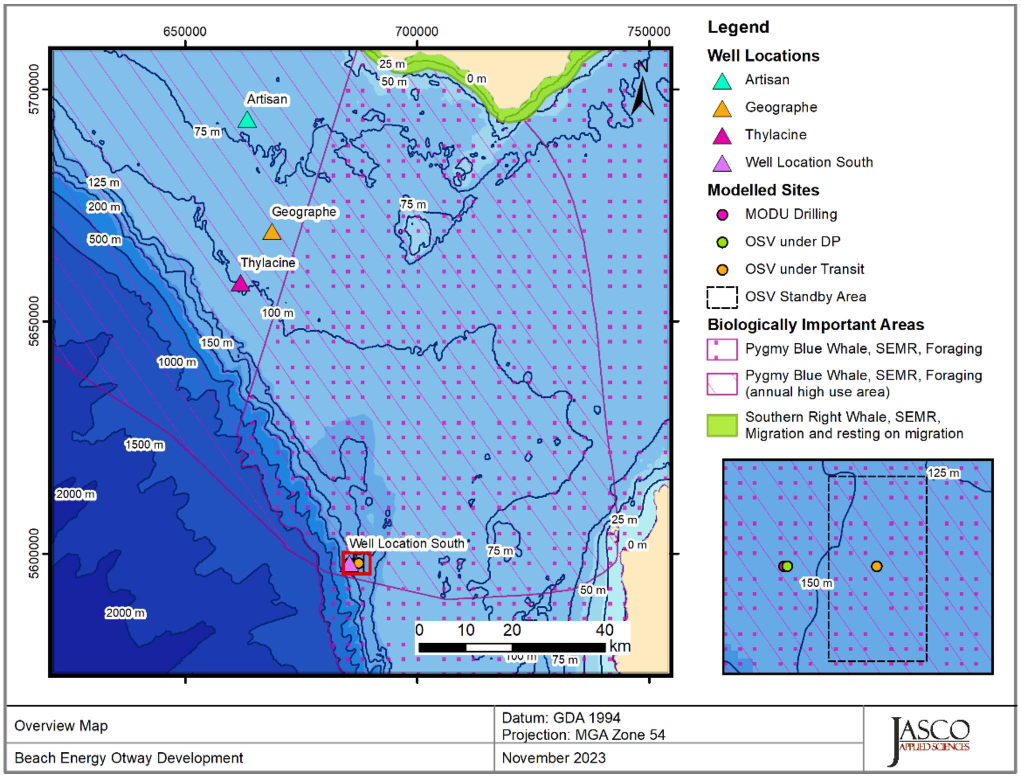


Figure 1. Overview map of the Beach Otway development area.

2. Noise Effect Criteria

To assess the potential effects of a sound-producing activity, it is necessary to establish exposure criteria (thresholds) for which sound levels may be expected to have a negative effect on animals. Whether acoustic exposure levels might injure or disturb marine fauna is an active research topic. Since 2007, several expert groups have developed SEL-based assessment approaches for evaluating auditory injury, with key works including Southall et al. (2007), Finneran and Jenkins (2012), Popper et al. (2014), United States National Marine Fisheries Service (NMFS 2018) and Southall et al. (2019). The number of studies that investigate the level of behavioural disturbance to marine fauna by anthropogenic sound has also increased substantially.

Two sound level metrics, SPL, and SEL, are commonly used to evaluate non-impulsive noise and its effects on marine life. In this report, the duration of the SEL accumulation is defined as integrated over a 24 h time period. Appropriate subscripts indicate any applied frequency weighting applied. The acoustic metrics in this report reflect the updated ANSI and ISO standards for acoustic terminology, ANSI S1.1 (2013) and ISO 18405:2017 (2017).

The following thresholds and guidelines for this study were chosen because they represent the best available science, and sound levels presented in literature for fauna with no defined thresholds:

1. Frequency-weighted accumulated sound exposure levels (SEL; $L_{\text{E,24h}}$) from Southall et al. (2019) for the onset of permanent threshold shift (PTS) and temporary threshold shift (TTS) in marine mammals for non-impulsive sources.
2. Marine mammal behavioural threshold based on the current interim U.S. National Oceanic and Atmospheric Administration (NOAA) (2019) criterion for marine mammals of 120 dB re 1 µPa (SPL; L_{p}) for non-impulsive sound sources.

3. Sound exposure guidelines for fish, fish eggs, and larvae (Popper et al. 2014).
4. Frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from Finneran et al. (2017) for the onset of PTS and TTS in turtles for non-impulsive sources.

Additional detail on thresholds, guidelines and weighting functions can be found in Koessler et al. (2020), Matthews et al. (2020) and Matthews et al. (2021).

3. Methods

For a detailed description of the employed modelling method and input parameters refer to Koessler et al. (2020), Matthews et al. (2020), Matthews et al. (2021), Connell et al. (2021) and McPherson et al. (2021). The environmental parameters used in the propagation models are described in Appendix B.2. An analysis of seasonal sound speed profiles in Koessler and McPherson (2021) indicated that June was the month most conducive to sound propagation and was chosen for modelling. Modelling also accounted for site-specific bathymetric variations (see Appendix B.2.1) and local geoacoustic properties (see Appendix B.2.3).

3.1. Vessel and MODU Noise Sources

The MODU drilling and OSV under DP and on transit was based on measurements sourced from McPherson et al. (2021). The MODU was the *Ocean Onyx* and the loudest drill measurement was chosen while the OSV was the *Siem Sapphire*. For vessel details see Koessler et al. (2020) while a brief a summary of the measured source levels and spectra for the MODU and OSV used here are provided as follows:

- For the MODU drilling, mean levels from Section 5.5.1 in McPherson et al. (2021) were used.
- For scenarios where the OSV was under dynamic positioning (DP) the average spectrum from Section 5.5.2 in McPherson et al. (2021) was used.
- For scenarios where the OSV was transiting or standing by the average slow transit (7 knots) spectrum in McPherson et al. (2021) was used.

Figure 2 presents a summary plot of considered source spectra.

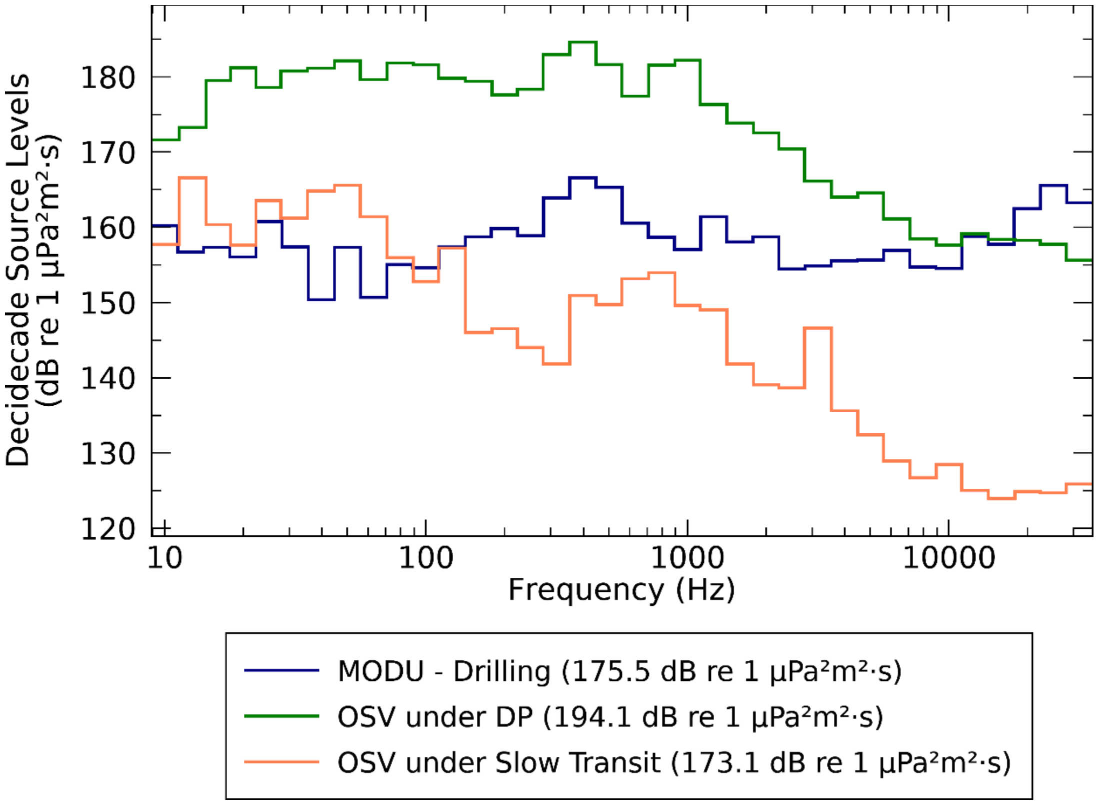


Figure 2. Energy source level (ESL) spectra (in decidecade frequency-band) for all sound sources.

4. Results

Results below are presented in two forms, tables of distances to isopleth contours (Section 4.1) and sound footprint maps (Section 4.2).

4.1. Tabulated Results

Table 5. *All Scenarios:* Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) to sound pressure level (SPL) from the most appropriate location for considered sources per scenario. A dash indicates the level was not reached within the limits of the modelling resolution (20 m). OSV: Offshore Supply Vessel, DP: Dynamic Positioning, MODU: Mobile Offshore Drilling Unit.

SPL (L_p; dB re 1 µPa)	**Scenario 1** **MODU Drilling**		**Scenario 2** **OSV under Transit**		**Scenario 3** **MODU Drilling + OSV under DP + OSV under Transit**		**Scenario 4** **MODU Drilling + OSV under Transit**	
	R_{max} **(km)**	$R_{95\%}$ **(km)**	R_{max} **(km)**	$R_{95\%}$ **(km)**	R_{max} **(km)**	$R_{95\%}$ **(km)**	R_{max} **(km)**	$R_{95\%}$ **(km)**
180	–	–	–	–	0.02	0.02	–	–
170[A]	–	–	–	–	0.02	0.02	–	–
160	–	–	–	–	0.09	0.09	–	–
158[B]	–	–	–	–	0.11	0.11	–	–
150	0.02	0.02	–	–	0.23	0.22	0.02	0.02
140	0.07	0.07	0.03	0.03	1.21	1.07	0.07	0.07
130	0.25	0.24	0.09	0.09	5.77	4.76	0.25	0.24
120[C]	1.46	1.26	0.41	0.40	19.6	15.4	2.21	2.02
110	7.24	6.36	1.69	1.54	64.3	45.8	7.84	6.40

[A] 48 h threshold for recoverable injury for fish with a swim bladder involved in hearing (Popper et al. 2014).

[B] 12 h threshold for TTS for fish with a swim bladder involved in hearing (Popper et al. 2014).

[C] Threshold for marine mammal behavioural response to continuous noise from NOAA (2019).

Table 6. *All Scenarios:* Maximum (R_{max}) horizontal distances (in km) to frequency-weighted SEL_{24h} PTS and TTS thresholds based on Southall et al. (2019) and Finneran et al. (2017) from the most appropriate location for considered sources per scenario, and ensonified area (km^2). A dash indicates the level was not reached within the limits of the modelling resolution (20 m). A slash indicates that the area is less than an area associated with the modelled resolution (0.0013 km^2). OSV: Offshore Supply Vessel, DP: Dynamic Positioning, MODU: Mobile Offshore Drilling Unit.

Hearing group	Frequency-weighted SEL_{24h} threshold ($L_{E,24h}$; dB re 1 µPa²·s)	Scenario 1 MODU Drilling		Scenario 2 OSV under Transit		Scenario 3 MODU Drilling + OSV under DP + OSV under Transit		Scenario 4 MODU Drilling + OSV under Transit	
		R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)
PTS									
Low-Frequency (LF) cetaceans	199	–	–	–	–	0.10	0.02	–	–
High-frequency (HF) cetaceans	198	–	–	–	–	0.05	/	–	–
Very High-frequency (VHF) cetaceans	173	0.13	0.06	–	–	0.17	0.07	0.13	0.06
Otariid seals	219	–	–	–	–	0.03	/	–	–
Turtles	220	–	–	–	–	0.05	/	–	–
TTS									
Low-Frequency (LF) cetaceans	179	0.23	0.16	0.01	0.11	1.48	5.10	0.23	0.28
High-frequency (HF) cetaceans	178	0.09	0.02	–	–	0.12	0.03	0.09	0.02
Very High-frequency (VHF) cetaceans	153	1.43	5.97	0.01	0.11	1.53	6.87	1.44	6.08
Otariid seals	199	–	–	–	–	0.05	/	–	–
Turtles	200	–	–	–	–	0.08	0.01	–	–

4.2. Sound Field Maps

Maps of the estimated sound fields, threshold contours, and isopleths of interest for SPL (Section 4.2.1) and SEL_{24h} (Section 4.2.2) sound fields are presented below.

4.2.1. SPL Maps

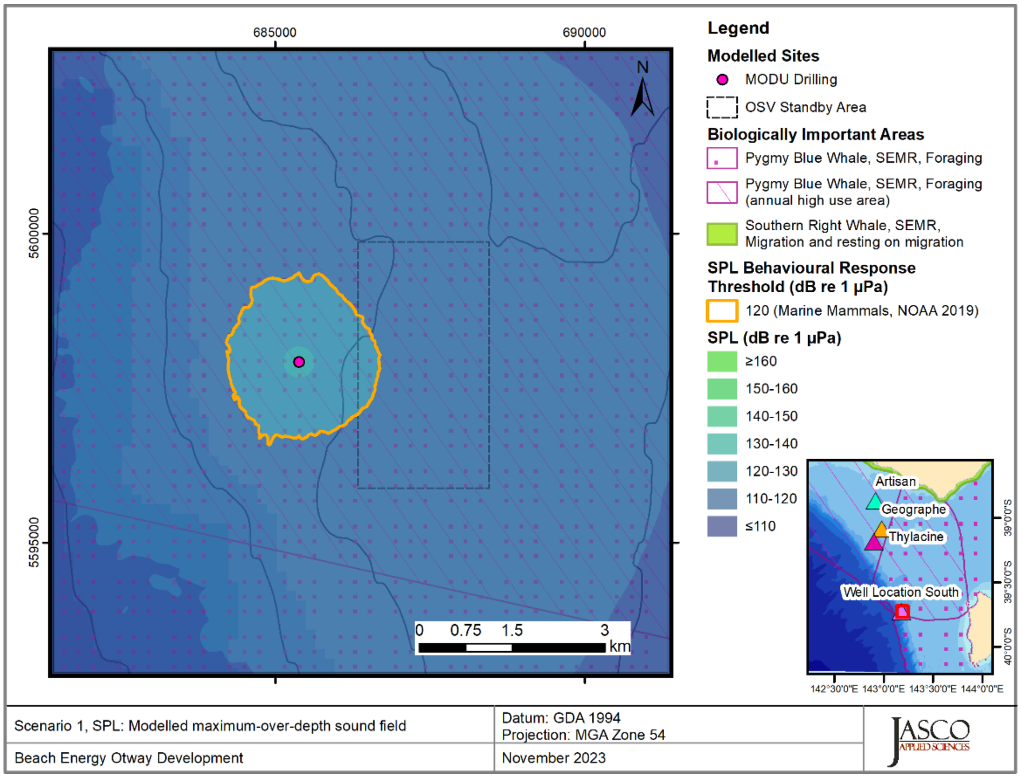


Figure 3. *Well Location South, MODU Drilling*, SPL: Sound level contour map of unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths for behavioural response thresholds for marine mammals.

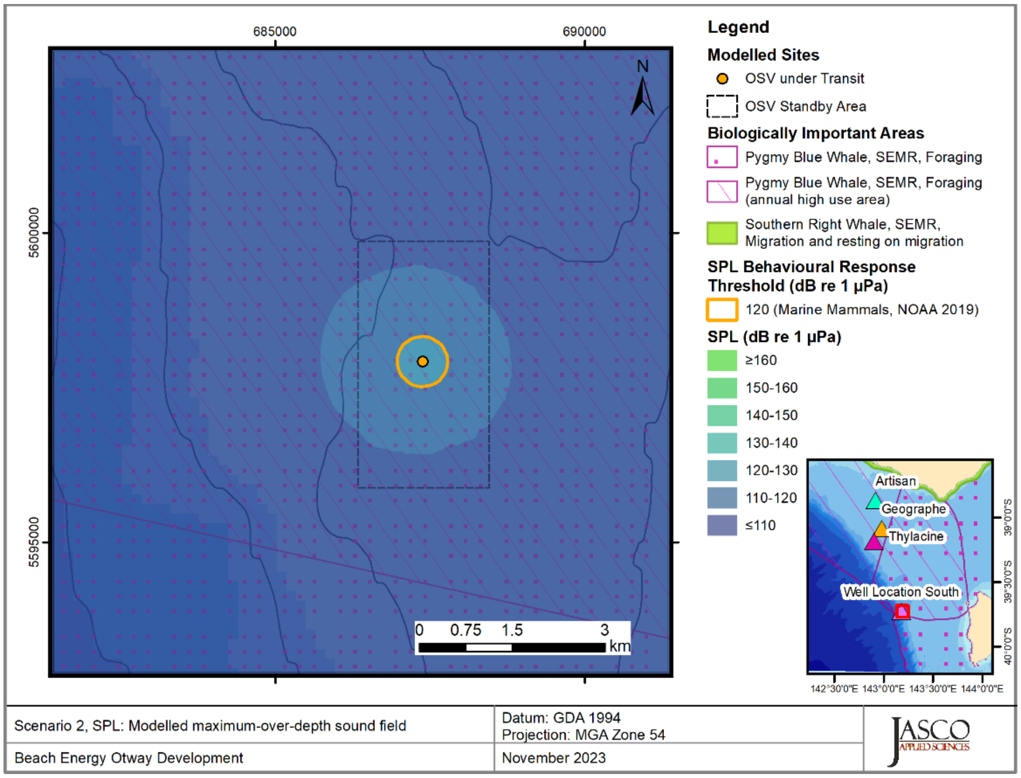


Figure 4. *Well Location South, OSV under Transit*, SPL: Sound level contour map of unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths for behavioural response thresholds for marine mammals.

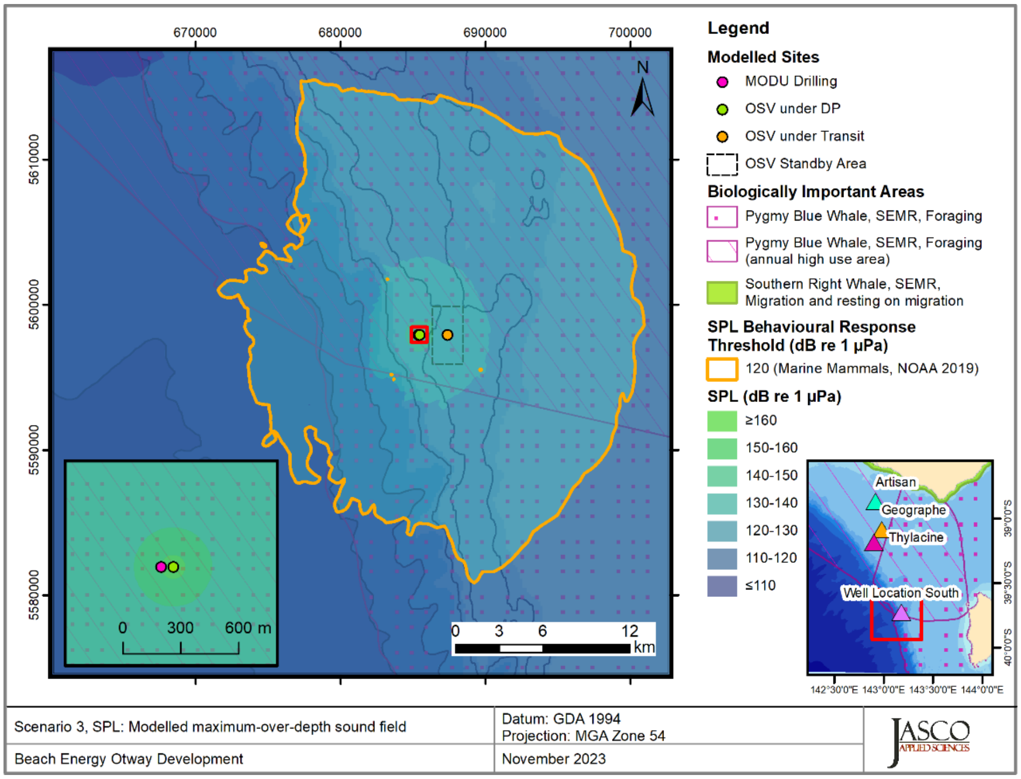


Figure 5. *Well Location South, MODU Drilling, OSV under DP, and OSV under Transit*, SPL: Sound level contour map of unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths for behavioural response thresholds for marine mammals.

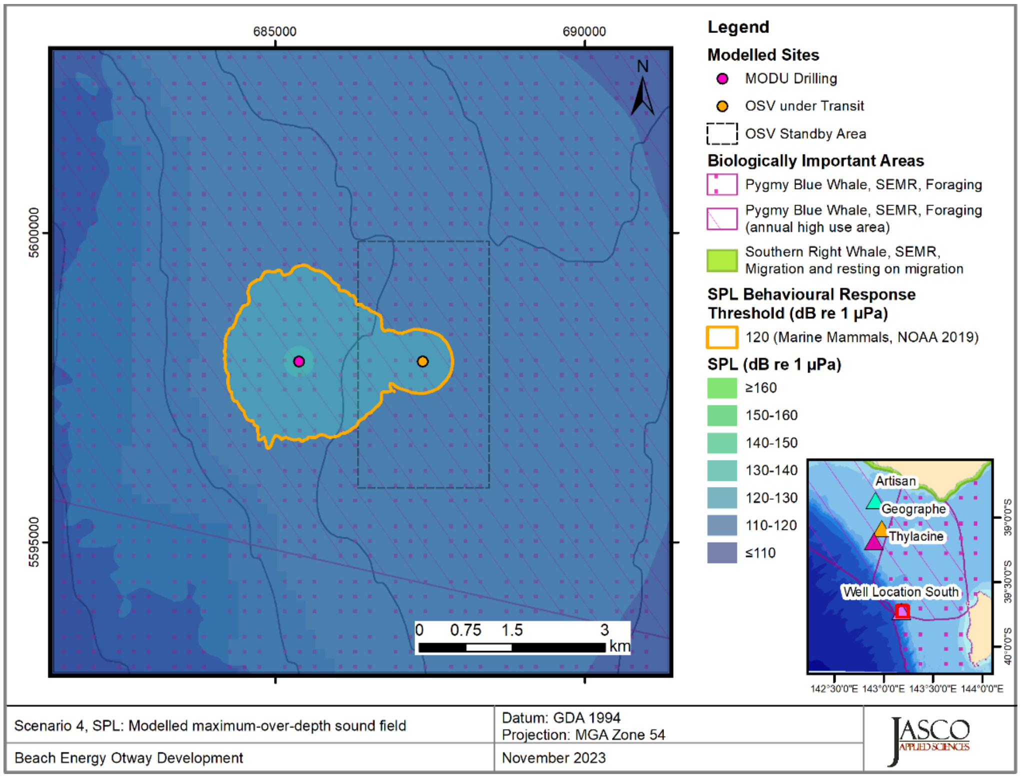


Figure 6. *Well Location South, MODU Drilling and OSV under transit*, SPL: Sound level contour map of unweighted maximum-over-depth sound field in 10 dB steps, and the isopleths for behavioural response thresholds for marine mammals.

4.2.2. Accumulated SEL_{24h} Maps

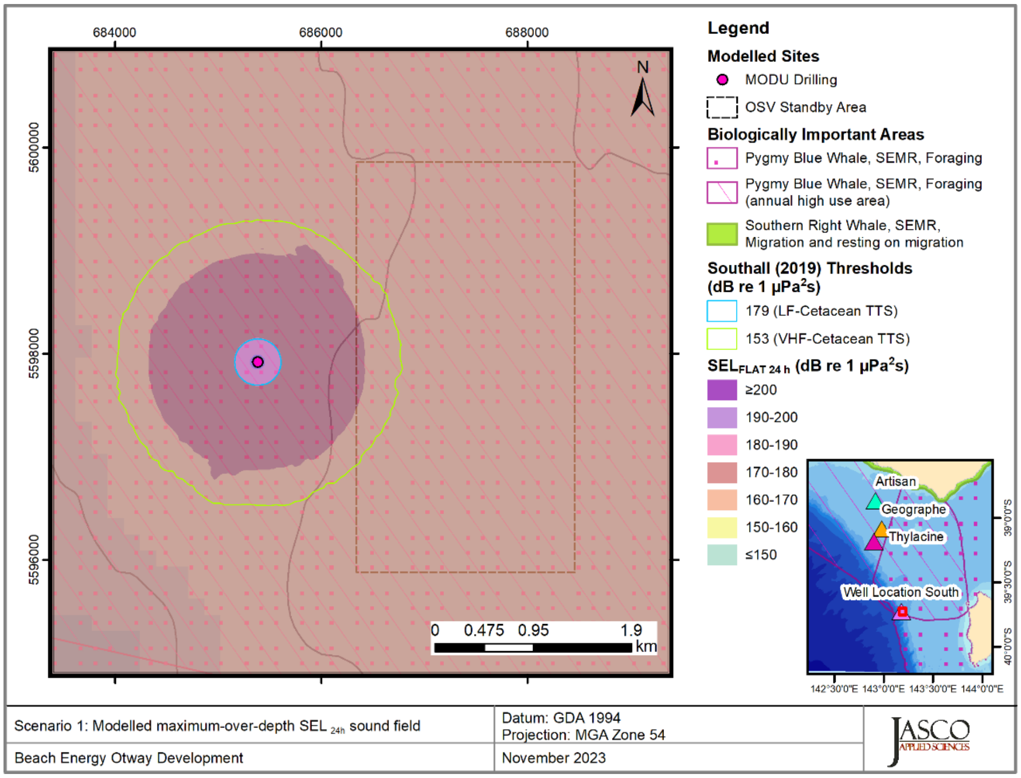


Figure 7. *Well Location South, MODU Drilling*, sound level contour map of unweighted maximum-over-depth SEL_{24h} results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such they could not be displayed on a map.

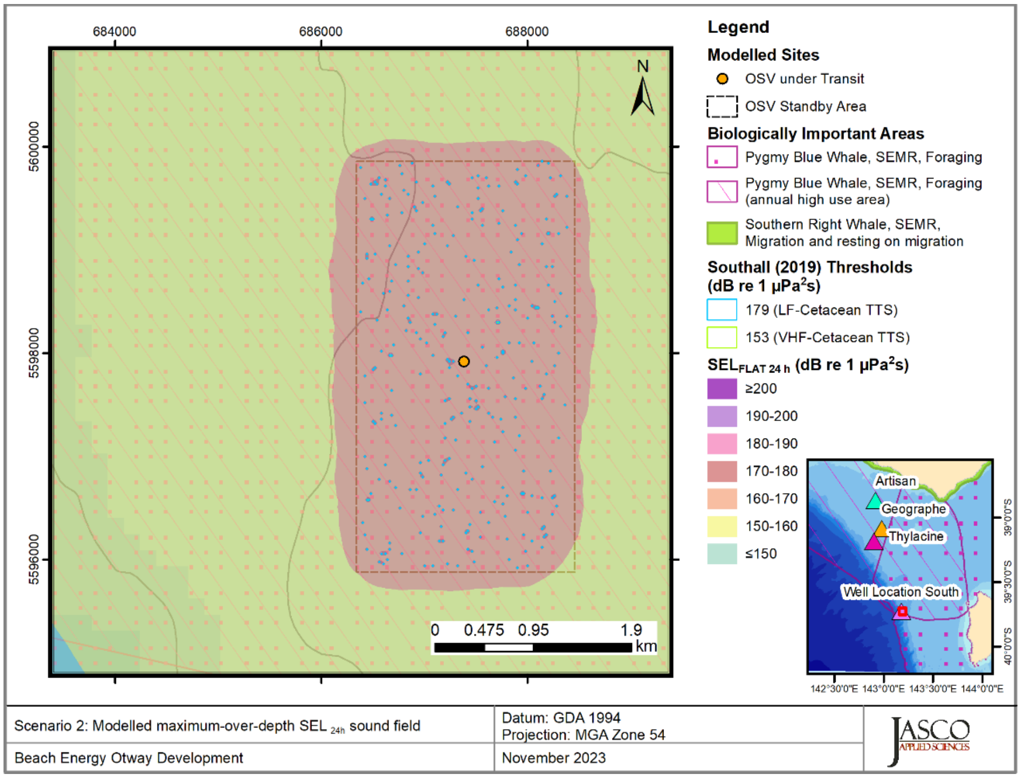


Figure 8. *Well Location South, OSV under Transit*, sound level contour map of unweighted maximum-over-depth SEL_{24h} results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such they could not be displayed on a map.

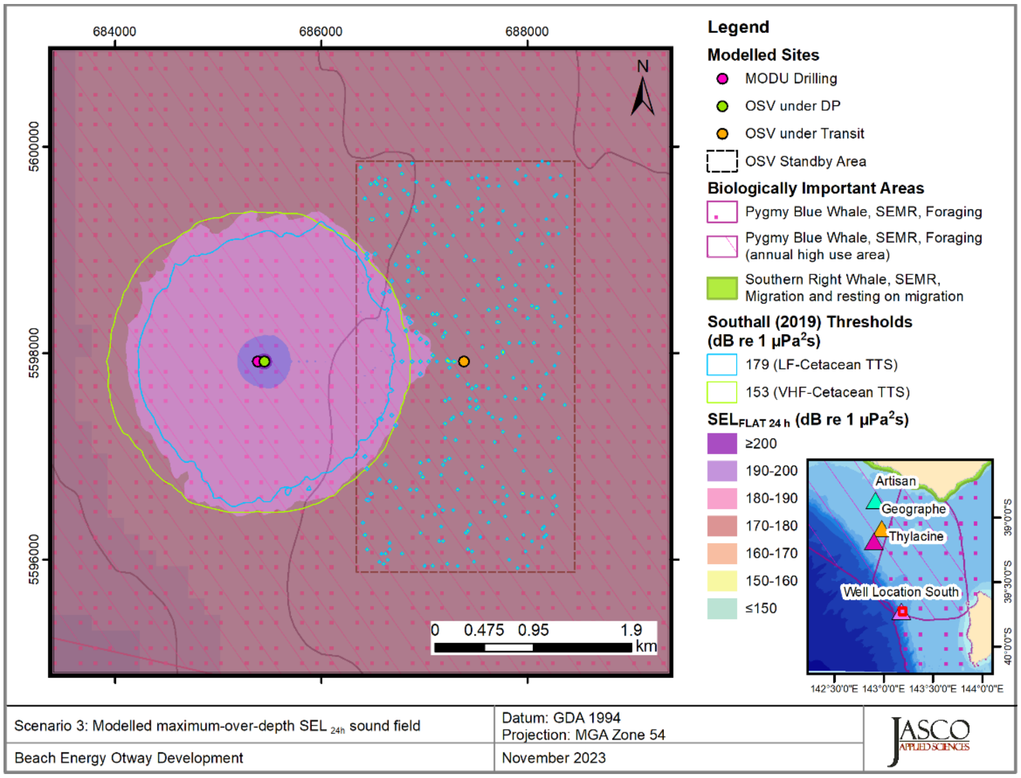


Figure 9. *Well Location South, MODU Drilling, OSV under DP (4h), and OSV under Transit (20h)*, sound level contour map of unweighted maximum-over-depth SEL_{24h} results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such they could not be displayed on a map.

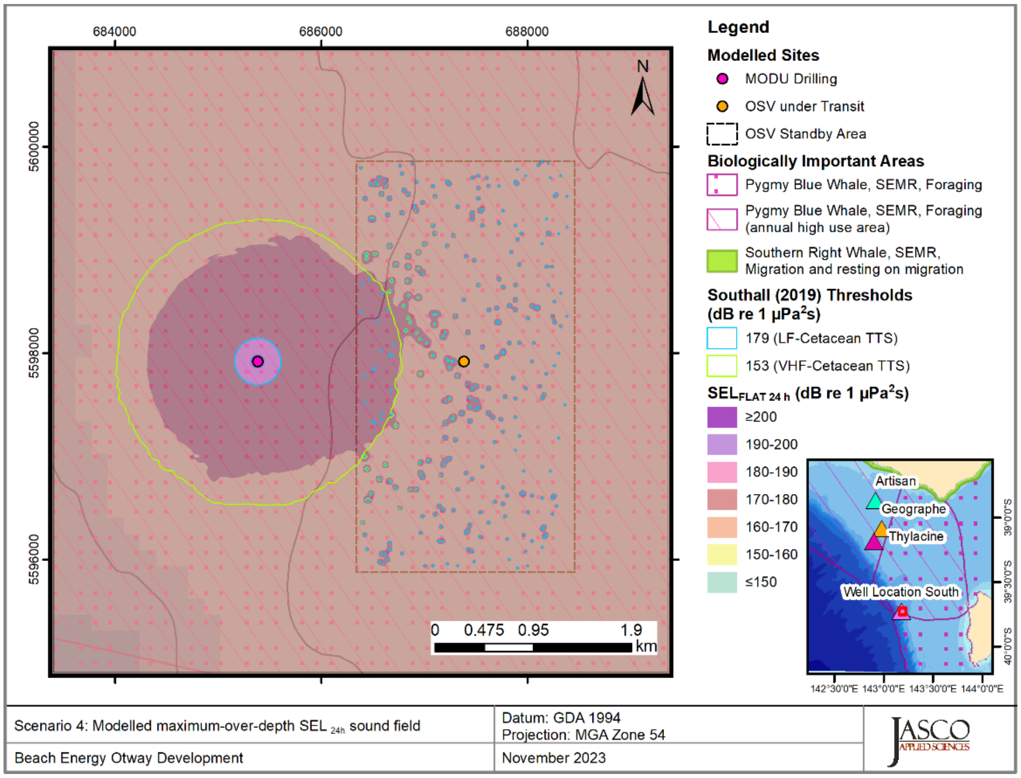


Figure 10. *Well Location South, MODU Drilling and OSV under transit*, sound level contour map of unweighted maximum-over-depth SEL_{24h} results, along with isopleths for TTS thresholds. Thresholds for PTS and some thresholds for TTS were either not reached or were small enough such they could not be displayed on a map.

Glossary

1/3-octave

One third of an octave. *Note*: A 1/3-octave is approximately equal to one decidecade (1/3 oct ≈ 1.003 ddec).

absorption

The conversion of sound energy to heat energy. Specifically, the reduction of sound pressure amplitude due to particle motion energy converting to heat in the propagation medium.

acoustic noise

Sound that interferes with an acoustic process.

acoustic self-noise

Sound at a receiver caused by the deployment, operation, or recovery of a specified receiver, and its associated platform (ISO 18405:2017).

ambient sound

Sound that would be present in the absence of a specified activity (ISO 18405:2017). It is usually a composite of sound from many sources near and far, e.g., shipping vessels, seismic activity, precipitation, sea ice movement, wave action, and biological activity.

attenuation

The gradual loss of acoustic energy from absorption and scattering as sound propagates through a medium. Attenuation depends on frequency—higher frequency sounds are attenuated faster than lower frequency sounds.

auditory frequency weighting

The process of applying an auditory frequency-weighting function. An example for marine mammals are the auditory frequency-weighting functions published by Southall et al. (2007).

auditory frequency-weighting function

Frequency-weighting function describing a compensatory approach accounting for a species' (or functional hearing group's) frequency-specific hearing sensitivity.

background noise

Combination of ambient sound, acoustic self-noise, and, where applicable, sonar reverberation (ISO 18405:2017) that is detected, measured, or recorded with a signal.

bandwidth

A range within a continuous band of frequencies. Unit: hertz (Hz).

broadband level

The total level measured over a specified frequency range. If the frequency range is unspecified, the term refers to the entire measured frequency range.

cavitation

A rapid formation and collapse of vapor cavities (i.e., bubbles or voids) in water, most often caused by a rapid change in pressure. Fast-spinning vessel propellers typically cause cavitation, which creates a lot of noise.

cetacean

Member of the order Cetacea. Cetaceans are aquatic mammals and include whales, dolphins, and porpoises.

compressional wave

A mechanical vibration wave in which the direction of particle motion is parallel to the direction of propagation. Also called a longitudinal wave. In seismology/geophysics, it's called a primary wave or P-wave. Shear waves in the seabed can be converted to compressional waves in water at the water-seabed interface.

continuous sound

A sound whose sound pressure level remains above the **background noise** during the observation period and may gradually vary in intensity with time, e.g., sound from a marine vessel.

decade

Logarithmic frequency interval whose upper bound is ten times larger than its lower bound (ISO 80000-3:2006). For example, one decade up from 1000 Hz is 10,000 Hz, and one decade down is 100 Hz.

decibel (dB)

Unit of level used to express the ratio of one value of a power quantity to another on a logarithmic scale. Especially suited to quantify variables with a large dynamic range.

decidecade

One tenth of a decade. Approximately equal to one third of an octave (1 ddec ≈ 0.3322 oct), and for this reason sometimes referred to as a 1/3-octave.

decidecade band

Frequency band whose bandwidth is one decidecade. *Note*: The bandwidth of a decidecade band increases with increasing centre frequency.

energy source level

A property of a sound source equal to the sound exposure level measured in the far field plus the propagation loss from the acoustic centre of the source to the receiver position. Unit: decibel (dB). Reference value: $1\ \mu\text{Pa}^2\ \text{m}^2\ \text{s}$.

ensonified

Exposed to sound.

far field

The zone where, to an observer, sound originating from an array of sources (or a spatially distributed source) appears to radiate from a single point.

frequency

The rate of oscillation of a periodic function measured in cycles per unit time. The reciprocal of the period. Unit: hertz (Hz). Symbol: f. 1 Hz is equal to 1 cycle per second.

frequency weighting

The process of applying a frequency-weighting function.

frequency-weighting function

The squared magnitude of the sound pressure transfer function (ISO 18405:2017). For sound of a given frequency, the frequency-weighting function is the ratio of output power to input power of a specified filter, sometimes expressed in decibels. Examples include the following:

- *Auditory frequency-weighting function*: compensatory frequency-weighting function accounting for a species' (or functional hearing group's) frequency-specific hearing sensitivity.
- *System frequency-weighting function*: frequency-weighting function describing the sensitivity of an acoustic recording system, which typically consists of a hydrophone, one or more amplifiers, and an analog-to-digital converter.

functional hearing group

Category of animal species when classified according to their hearing sensitivity, hearing anatomy, and susceptibility to sound. For marine mammals, initial groupings were proposed by Southall et al. (2007), and revised groupings are developed as new research/data becomes available. Revised groupings proposed by Southall et al. (2019) include low-frequency cetaceans, high-frequency cetaceans, very high-frequency cetaceans, phocid carnivores in water, other carnivores in water, and sirenians. See auditory frequency-weighting functions, which are often applied to these groups. Example hearing groups for fish include species for which the swim bladder is involved in hearing, species for which the swim bladder is not involved in hearing, and species without a swim bladder (Popper et al. 2014).

geoacoustic

Relating to the acoustic properties of the seabed.

hearing threshold

For a given species or functional hearing group, the sound level for a given signal that is barely audible (i.e., that would be barely audible for a given individual in the presence of specified **background noise** during a specific percentage of experimental trials).

hertz (Hz)

Unit of frequency defined as one cycle per second. Often expressed in multiples such as kilohertz (1 kHz = 1000 Hz).

high-frequency (HF) cetaceans

See functional hearing group. *Note*: The mid- and high-frequency cetaceans groups proposed by Southall et al. (2007) were renamed high- and very-high-frequency cetaceans, respectively, by Southall et al. (2019).

hydrophone

An underwater sound pressure transducer. A passive electronic device for recording or listening to underwater sound.

hydrostatic pressure

The pressure at any given depth in a static liquid that is the result of the weight of the liquid acting on a unit area at that depth, plus any pressure acting on the surface of the liquid. Unit: pascal (Pa).

impulsive sound

Qualitative term meaning sounds that are typically transient, brief (less than 1 s), broadband, with rapid rise time and rapid decay. They can occur in repetition or as a single event. Sources of impulsive sound include, among others, explosives, seismic airguns, and impact pile drivers.

isopleth

A line drawn on a map through all points having the same value of some specified quantity (e.g., sound pressure level isopleth).

knot (kn)

Unit of vessel speed equal to 1 nautical mile per hour.

level

A measure of a quantity expressed as the logarithm of the ratio of the quantity to a specified reference value of that quantity. For example, a value of sound pressure level with reference to 1 μPa^2 can be written in the form *x* dB re 1 μPa^2.

low-frequency (LF) cetaceans

See functional hearing group.

median

The 50th percentile of a statistical distribution.

mid-frequency (MF) cetaceans

See functional hearing group. *Note*: The mid-frequency cetaceans group proposed by Southall et al. (2007) was renamed high-frequency cetaceans by Southall et al. (2019).

monopole source level (MSL)

A source level that has been calculated using an acoustic model that accounts for the effect of the sea-surface and seabed on sound propagation, assuming a point source (monopole). Often used to quantify source levels of vessels or industrial operations from measurements. See also radiated noise level.

M-weighting

A set of auditory frequency-weighting functions proposed by Southall et al. (2007).

mysticete

Member of the Mysticeti, a suborder of cetaceans. Also known as baleen whales, mysticetes have baleen plates (rather than teeth) that they use to filter food from water (or from sediment as for grey whales). This group includes rorquals (Balaenopteridae, such as blue, fin, humpback, and minke whales), right and bowhead whales (Balaenidae), and grey whales (*Eschrichtius robustus*).

non-impulsive sound

Sound that is not an impulsive sound. Not necessarily a continuous sound.

octave

The interval between a sound and another sound with double or half the frequency. For example, one octave above 200 Hz is 400 Hz, and one octave below 200 Hz is 100 Hz.

odontocete

Member of Odontoceti, a suborder of cetaceans. These whales, dolphins, and porpoises have teeth (rather than baleen plates). Their skulls are mostly asymmetric, an adaptation for their echolocation. This group includes sperm whales, killer whales, belugas, narwhals, dolphins, and porpoises.

otariid

Member of the family Otariidae, one of the three groupings of pinnipeds (along with phocids and walrus). These eared seals, commonly called fur seals and sea lions, are adapted to semi-aquatic life; they use their large fore flippers for propulsion underwater and can walk on all four limbs on land.

otariid pinnipeds underwater (OW)

See functional hearing group.

other marine carnivores in water (OCW)

See functional hearing group.

parabolic equation method

A computationally efficient solution to the acoustic wave equation that is used to model propagation loss. The parabolic equation approximation omits effects of backscattered sound (which are negligible for most ocean-acoustic propagation problems), simplifying the computation of propagation loss.

permanent threshold shift (PTS)

An irreversible loss of hearing sensitivity caused by excessive noise exposure. Considered auditory injury. Compare with temporary threshold shift.

phocid

Member of the family Phocidae, one of the three groupings of pinnipeds (along with otariids and walrus). These true/earless seals are more adapted to in-water life than are otariids, which have more terrestrial adaptations. Phocids use their hind flippers to propel themselves underwater.

phocid pinnipeds underwater (PW), phocid carnivores in water (PCW)

See functional hearing group.

pinniped

Member of the superfamily Pinnipedia, which is composed of phocids (true seals or earless seals), otariids (eared seals or fur seals and sea lions), and walrus.

point source

A source that radiates sound as if from a single point.

propagation loss (PL)

Difference between a source level (SL) and the level at a specified location, $\mathrm{PL}(x) = \mathrm{SL} - L(x)$. Unit: decibel (dB). See also transmission loss.

radiated noise level (RNL)

A source level that has been calculated assuming sound pressure decays geometrically with distance from the source, with no influence of the sea-surface or seabed. Often used to quantify source levels of vessels or industrial operations from measurements. See also monopole source level.

received level

The level of a given field variable measured (or that would be measured) at a given location.

reference value

Standard value of a quantity used for calculating underwater sound level. The reference value depends on the quantity for which the level is being calculated:

Quantity	Reference value
Sound pressure	$p_0^2 = 1\ \mu\text{Pa}^2$ or $p_0 = 1\ \mu\text{Pa}$
Sound exposure	$E_0 = 1\ \mu\text{Pa}^2\,\text{s}$
Sound particle displacement	$\delta_0^2 = 1\ \text{pm}^2$
Sound particle velocity	$u_0^2 = 1\ \text{nm}^2/\text{s}^2$
Sound particle acceleration	$a_0^2 = 1\ \mu\text{m}^2/\text{s}^4$

shear wave

A mechanical vibration wave in which the direction of particle motion is perpendicular to the direction of propagation. Also called a secondary wave or S-wave. Shear waves propagate only in solid media, such as sediments or rock. Shear waves in the seabed can be converted to compressional waves in water at the water-seabed interface.

sirenians (SI)

Members of the order Sirenia, which includes several manatee species and the dugong. See also functional hearing group.

sound

A time-varying disturbance in the pressure, stress, or material displacement of a medium propagated by local compression and expansion of the medium. In common meaning, a form of energy that propagates through media (e.g., water, air, ground) as pressure waves.

sound exposure

Time integral of squared sound pressure over a stated time interval in a stated frequency band. The time interval can be a specified time duration (e.g., 24 h) or from start to end of a specified event (e.g., a pile strike, an airgun pulse, a construction operation). Unit: pascal squared second ($\text{Pa}^2\,\text{s}$). Symbol: E.

sound exposure level (SEL)

The level (L_E) of the sound exposure (E) in a stated frequency band and time window: $L_E = 10\log_{10}(E/E_0)$ (ISO 18405:2017). Unit: decibel (dB). Reference value (E_0) for sound in water: $1\ \mu\text{Pa}^2\,\text{s}$.

sound exposure spectral density

Distribution as a function of frequency of the time-integrated squared sound pressure per unit bandwidth of a sound having a continuous spectrum (ISO 18405:2017). Unit: pascal squared second per hertz ($\text{Pa}^2\,\text{s/Hz}$).

sound field

Region containing sound waves.

sound pressure

The contribution to total pressure caused by the action of sound (ISO 18405:2017). Unit: pascal (Pa). Symbol: p.

sound pressure level (SPL), rms sound pressure level

The level (L_p) of the time-mean-square sound pressure (p^2_{rms}) in a stated frequency band and time window: $L_p = 10\log_{10}(p^2_{\mathrm{rms}}/p^2_0) = 20\log_{10}(p_{rms}/p_0)$, where rms is the abbreviation for root-mean-square. Unit: decibel (dB). Reference value (p^2_0) for sound in water: 1 μPa^2. SPL can also be expressed in terms of the root-mean-square (rms) with a reference value of p_0 = 1 μPa. The two definitions are equivalent.

sound speed profile

The speed of sound in the water column as a function of depth below the water surface.

source level (SL)

A property of a sound source equal to the sound pressure level measured in the far field plus the propagation loss from the acoustic centre of the source to the receiver position. Unit: decibel (dB). Reference value: 1 μPa^2 m^2.

spectrum

Distribution of acoustic signal content over frequency, where the signal's content is represented by its power, energy, mean-square sound pressure, or sound exposure.

surface duct

The upper portion of a water column within which the gradient of the sound speed profile causes sound to refract upward and therefore reflect repeatedly off the surface resulting in relatively long-range sound propagation with little loss.

temporary threshold shift (TTS)

Reversible loss of hearing sensitivity caused by noise exposure. Compare with permanent threshold shift.

thermocline

A depth interval near the ocean surface that experiences larger temperature gradients than the layers above and below it due to warming or cooling by heat conduction from the atmosphere and by warming from the sun.

transmission loss (TL)

The difference between a specified level at one location and that at a different location: $\mathrm{TL}(x_1,x_2) = L(x_1) - L(x_2)$ (ISO 18405:2017). Unit: decibel (dB). See also propagation loss.

unweighted

Term indicating that no frequency-weighting function is applied.

very high-frequency (VHF) cetaceans

See functional hearing group.

wavelength

Distance over which a wave completes one cycle of oscillation. Unit: metre (m). Symbol: λ.

Literature Cited

[ISO] International Organization for Standardization. 2006. *ISO 80000-3:2006 Quantities and units – Part 3: Space and time*. https://www.iso.org/standard/31888.html.

[ISO] International Organization for Standardization. 2017. *ISO 18405:2017. Underwater acoustics – Terminology*. Geneva. https://www.iso.org/standard/62406.html.

[NMFS] National Marine Fisheries Service (US). 2018. *2018 Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts*. US Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-59. 167 p. https://media.fisheries.noaa.gov/dam-migration/tech_memo_acoustic_guidance_(20)_(pdf)_508.pdf.

[NOAA] National Oceanic and Atmospheric Administration (US). 2019. *ESA Section 7 Consultation Tools for Marine Mammals on the West Coast* (webpage), 27 Sep 2019. https://www.fisheries.noaa.gov/west-coast/endangered-species-conservation/esa-section-7-consultation-tools-marine-mammals-west.

ANSI S1.1-2013. 2013. *American National Standard Acoustical Terminology*. American National Standards Institute, NY, USA.

Buckingham, M.J. 2005. Compressional and shear wave properties of marine sediments: Comparisons between theory and data. *Journal of the Acoustical Society of America* 117: 137-152. https://doi.org/10.1121/1.1810231.

Carnes, M.R. 2009. *Description and Evaluation of GDEM-V 3.0*. US Naval Research Laboratory, Stennis Space Center, MS. NRL Memorandum Report 7330-09-9165. 21 p. https://apps.dtic.mil/dtic/tr/fulltext/u2/a494306.pdf.

Connell, S.C., M.W. Koessler, and C.R. McPherson. 2021. *Otway Offshore Project – Construction Program: Assessing Marine Fauna Sound Exposures*. Document Number 02407, Version 1.0 Technical report by JASCO Applied Sciences for Beach Energy Limited.

Coppens, A.B. 1981. Simple equations for the speed of sound in Neptunian waters. *Journal of the Acoustical Society of America* 69(3): 862-863. https://doi.org/10.1121/1.382038.

Duncan, A.J., A.N. Gavrilov, N. Alexander, R.D. McCauley, I.M. Parnum, and J.M. Collis. 2013. Characteristics of sound propagation in shallow water over an elastic seabed with a thin cap-rock layer. *Journal of the Acoustical Society of America* 134(1): 207-215. https://doi.org/10.1121/1.4809723.

Finneran, J.J. and A.K. Jenkins. 2012. *Criteria and thresholds for U.S. Navy acoustic and explosive effects analysis*. SPAWAR Systems Center Pacific, San Diego, CA, USA. 64 p.

Finneran, J.J., E. Henderson, D.S. Houser, K. Jenkins, S. Kotecki, and J. Mulsow. 2017. *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)*. Technical report by Space and Naval Warfare Systems Center Pacific (SSC Pacific). 183 p.

Heap, A.D. 2009. *Marine Sediments (MARS) Database* (webpage). Commonwealth of Australia (Geoscience Australia), Creative Commons Attribution 4.0 International Licence. http://www.ga.gov.au/metadata-gateway/metadata/record/gcat_69869.

Koessler, M.W., M.-N.R. Matthews, and C.R. McPherson. 2020. *Otway Offshore Project – Drilling Program: Assessing Marine Fauna Sound Exposures*. Document Number 02033, Version 1.0. Technical report by JASCO Applied Sciences for Beach Energy Limited.

Koessler, M.W. and C. McPherson. 2021. *Beach Otway Project: Additional and Revised Modelling Study*. Document Number 02502, Version 1.0. Technical Memo by JASCO Applied Sciences for Beach Energy Limited.

Matthews, M.-N.R., M.W. Koessler, and C.R. McPherson. 2020. *Otway Offshore Project – Construction Program: Assessing Marine Fauna Sound Exposures*. Document Number 02112, Version 2.0. Technical report by JASCO Applied Sciences for Beach Energy Limited.

Matthews, M.-N.R., S. Connell, and C.R. McPherson. 2021. *Otway Offshore Project – Construction Program: Addendum – Combined Drilling and Construction Activities*. Document Number 02393, Version 1.0 DRAFT. Technical report by JASCO Applied Sciences for Beach Energy Limited. .

McPherson, C.R., Z. Li, C.C. Wilson, K.A. Kowarski, and M. Koessler. 2021. *Beach Otway Development Acoustic Monitoring: Characterisation, Validation, and Marine Mammals*. Document Number 02424, Version 2.0. Technical report by JASCO Applied Sciences for Beach Energy Limited.

Popper, A.N., A.D. Hawkins, R.R. Fay, D.A. Mann, S. Bartol, T.J. Carlson, S. Coombs, W.T. Ellison, R.L. Gentry, et al. 2014. *Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI*. ASA S3/SC1.4 TR-2014. SpringerBriefs in Oceanography. ASA Press and Springer. https://doi.org/10.1007/978-3-319-06659-2.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene, Jr., D. Kastak, D.R. Ketten, J.H. Miller, et al. 2007. Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. *Aquatic Mammals* 33(4): 411-521. https://doi.org/10.1080/09524622.2008.9753846.

Southall, B.L., J.J. Finneran, C.J. Reichmuth, P.E. Nachtigall, D.R. Ketten, A.E. Bowles, W.T. Ellison, D.P. Nowacek, and P.L. Tyack. 2019. Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. *Aquatic Mammals* 45(2): 125-232. https://doi.org/10.1578/AM.45.2.2019.125.

Teague, W.J., M.J. Carron, and P.J. Hogan. 1990. A comparison between the Generalized Digital Environmental Model and Levitus climatologies. *Journal of Geophysical Research* 95(C5): 7167-7183. https://doi.org/10.1029/JC095iC05p07167.

Whiteway, T. 2009. *Australian Bathymetry and Topography Grid, June 2009*. GeoScience Australia, Canberra. http://pid.geoscience.gov.au/dataset/ga/67703.

Appendix A. Acoustic Metrics

A.1. Pressure Related Acoustic Metrics

Underwater sound pressure amplitude is measured in decibels (dB) relative to a fixed reference pressure of p_0 = 1 μPa. Because the perceived loudness of sound, especially impulsive noise such as from seismic airguns, pile driving, and sonar, is not generally proportional to the instantaneous acoustic pressure, several sound level metrics are commonly used to evaluate noise and its effects on marine life. We provide specific definitions of relevant metrics used in the accompanying report. Where possible we follow the ANSI and ISO standard definitions and symbols for sound metrics, but these standards are not always consistent.

The sound pressure level (SPL; L_p; dB re 1 μPa) is the rms pressure level in a stated frequency band over a specified time window (T, s) containing the acoustic event of interest. It is important to note that SPL always refers to a rms pressure level and therefore not instantaneous pressure:

$$L_p = 10\log_{10}\left(\frac{1}{T}\int_T p^2(t)dt \Big/ p_0^2\right) \tag{A-1}$$

The SPL represents a nominal effective continuous sound over the duration of an acoustic event, such as the emission of one acoustic pulse, a marine mammal vocalization, the passage of a vessel, or over a fixed duration. Because the window length, T, is the divisor, events with similar sound exposure level (SEL) but more spread out in time have a lower SPL.

The sound exposure level (SEL; L_E; $L_\mathrm{E,p}$; dB re 1 μPa^2·s) is a measure related to the acoustic energy contained in one or more acoustic events (N). The SEL for a single event is computed from the time-integral of the squared pressure over the full event duration (T):

$$L_E = 10\log_{10}\left(\int_T p^2(t)dt \Big/ T_0 p_0^2\right) \tag{A-2}$$

where T_0 is a reference time interval of 1 s. The SEL continues to increase with time when non-zero pressure signals are present. It therefore can be construed as a dose-type measurement, so the integration time used must be carefully considered in terms of relevance for impact to the exposed recipients.

SEL can be calculated over periods with multiple acoustic events or over a fixed duration. For a fixed duration, the square pressure is integrated over the duration of interest. For multiple events, SEL can be computed by summing (in linear units) SEL of the N individual events:

$$L_{E,N} = 10\log_{10}\left(\sum_{i=1}^{N} 10^{\frac{\mathrm{L}_{E,i}}{10}}\right). \tag{A-3}$$

Appendix B. Methods and Parameters

This section describes the specifications of the seismic source that was used at all sites and the environmental parameters used in the propagation models.

B.1. Estimating Range to Thresholds Levels

Sound level contours were calculated based on the underwater sound fields predicted by the propagation models, sampled by taking the maximum value over all modelled depths above the sea floor for each location in the modelled region. The predicted distances to specific levels were computed from these contours. Two distances relative to the source are reported for each sound level: 1) R_{max}, the maximum range to the given sound level over all azimuths, and 2) $R_{95\%}$, the range to the given sound level after the 5% farthest points were excluded (see examples in Figure B-1).

The $R_{95\%}$ is used because sound field footprints are often irregular in shape. In some cases, a sound level contour might have small protrusions or anomalous isolated fringes. This is demonstrated in the image in Figure B-1(a). In cases such as this, where relatively few points are excluded in any given direction, R_{max} can misrepresent the area of the region exposed to such effects, and $R_{95\%}$ is considered more representative. In strongly asymmetric cases such as shown in Figure B-1(b), on the other hand, $R_{95\%}$ neglects to account for significant protrusions in the footprint. In such cases R_{max} might better represent the region of effect in specific directions. Cases such as this are usually associated with bathymetric features affecting propagation. The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the non-uniformity of the acoustic environment.

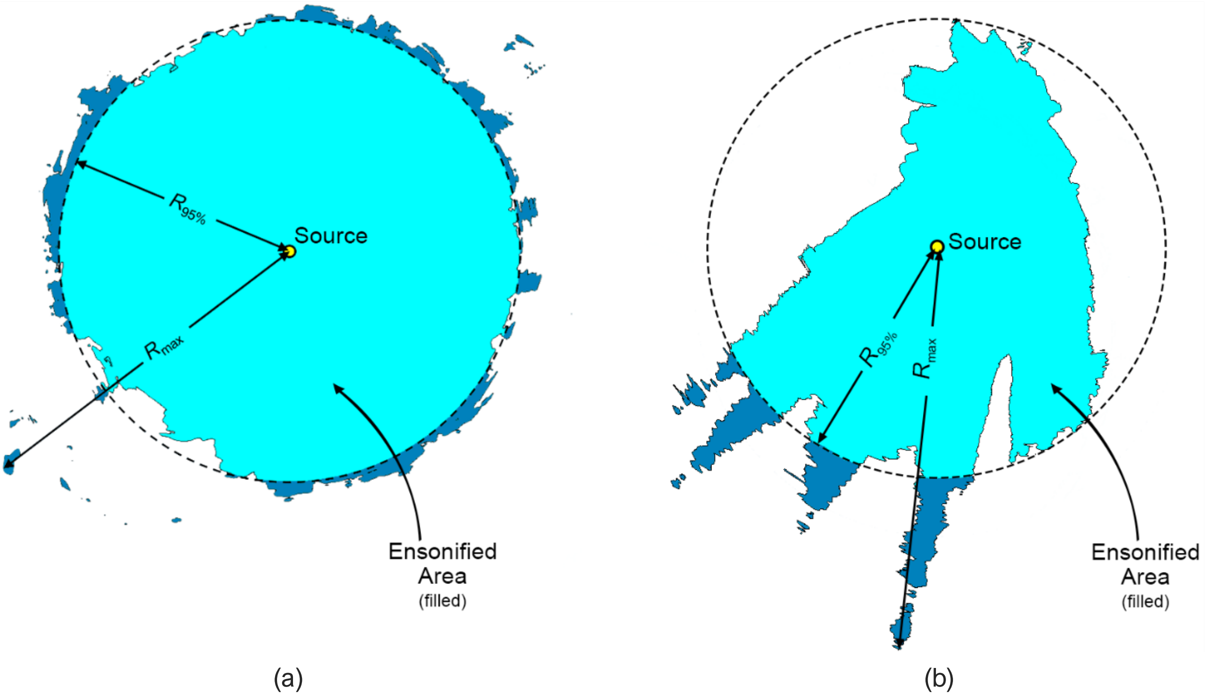


Figure B-1. Sample areas ensonified to an arbitrary sound level with R_{max} and $R_{95\%}$ ranges shown for two different scenarios. (a) Largely symmetric sound level contour with small protrusions. (b) Strongly asymmetric sound level contour with long protrusions. Light blue indicates the ensonified areas bounded by $R_{95\%}$; darker blue indicates the areas outside this boundary which determine R_{max}.

B.2. Environmental Parameters

B.2.1. Bathymetry

Water depths throughout the modelled areas were extracted from the Australian Bathymetry and Topography Grid, a 9 arc-second grid rendered for Australian waters (Whiteway 2009). Bathymetry data were re-gridded onto a Map Grid of Australia (MGA) coordinate projection (Zone 54) with a regular grid spacing of 250 × 250 m.

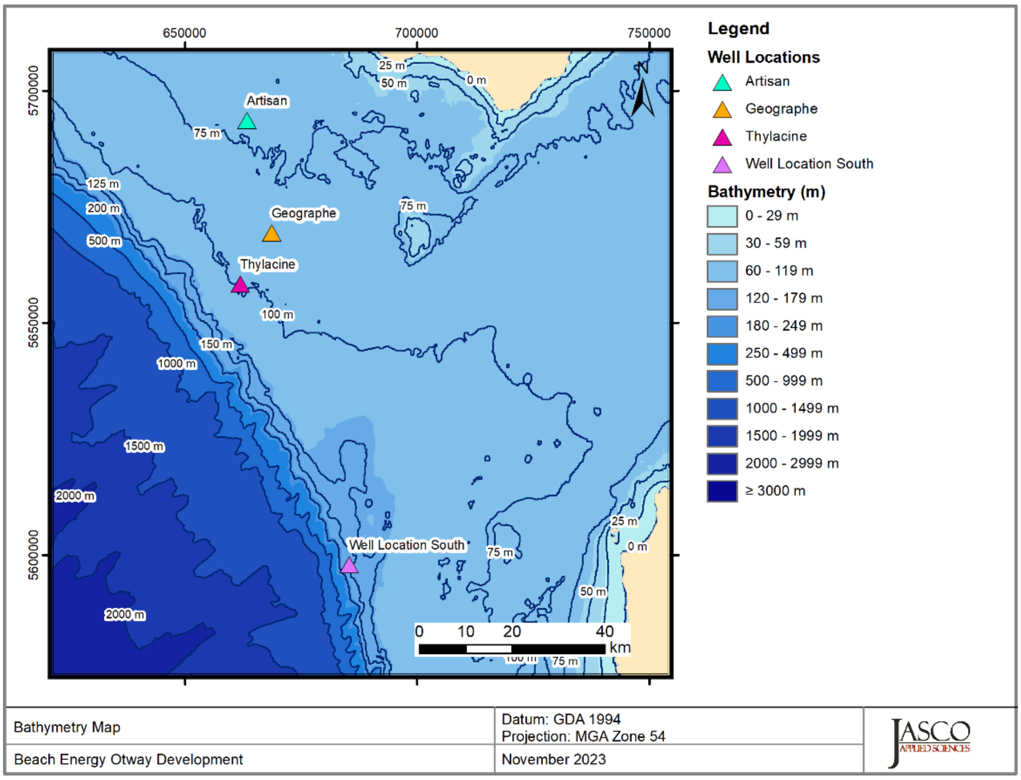


Figure B-2. Bathymetry map of the Beach Otway development area.

B.2.2. Sound speed profile

The sound speed profile in the area was derived from temperature and salinity profiles from the U.S. Naval Oceanographic Office’s *Generalized Digital Environmental Model V 3.0* (GDEM; Teague et al. 1990, Carnes 2009). GDEM provides an ocean climatology of temperature and salinity for the world’s oceans on a latitude-longitude grid with 0.25° resolution, with a temporal resolution of one month, based on global historical observations from the U.S. Navy’s Master Oceanographic Observational Data Set (MOODS). The climatology profiles include 78 fixed depth points to a maximum depth of 6800 m (where the ocean is that deep). The GDEM temperature-salinity profiles were converted to sound speed profiles according to Coppens (1981).

Mean monthly sound speed profiles were derived from the GDEM profiles at distances less than 7 km around the modelled site. The June sound speed profile is expected to be most favourable to longer-range sound propagation across the entire year. As such, June was selected for sound propagation modelling to ensure precautionary estimates of distances to received sound level thresholds. For the pygmy blue whale period between November and January November is expected to be most favourable to longer-range propagation in that period. Figure B-3 shows the resulting profiles, which were used as input to the sound propagation modelling.

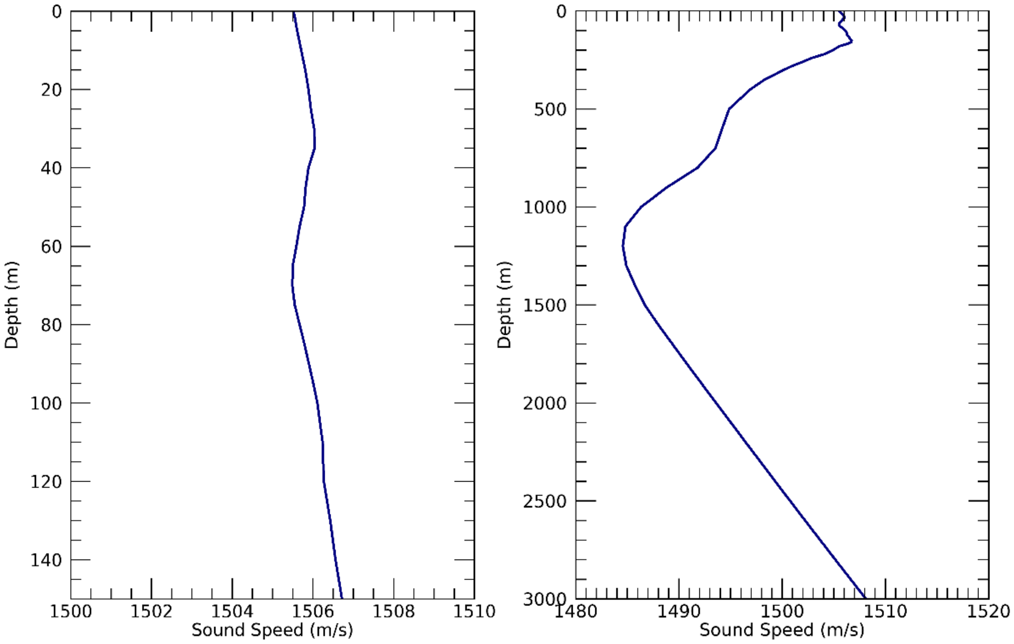


Figure B-3. The modelling sound speed profile corresponding to June for the top 150 m (left) and 3000 m (right) Profiles are calculated from temperature and salinity profiles from *Generalized Digital Environmental Model* V 3.0 (GDEM; Teague et al. 1990, Carnes 2009).

B.2.3. Geoacoustics

A single geoacoustic profile was used for modelling. Geoacoustic parameters used for all modelled sites were derived from sedimentary grain size measurements from the Australian Government's Marine Sediments (MARS) database (Heap 2009). On average, the surficial grain size indicates silty sand is present throughout the modelled area. Representative grain sizes were used in the grain-shearing model proposed by Buckingham (2005) to estimate the geoacoustic parameters required by the sound propagation models. Table B-1 lists the geoacoustic parameters used for modelling. This profile is expected to better represent the slope environment and may yield less accurate towards the continental shelf. On the shelf it is possible that a less reflective seabed type consisting of limestone may be present (Duncan et al. 2013). It is expected that towards the shelf the estimate to threshold ranges may be overestimated.

Table B-1. Geoacoustic profile for all modelled sites.

Depth below seafloor (m)	Predicted lithology	Density (g/cm^3)	Compressional wave		Shear wave	
			Speed(m/s)	Attenuation(dB/λ)	Speed(m/s)	Attenuation(dB/λ)
0–10	Silty carbonate sand to semi-cemented limestone	1.88	1605–1700	0.35–0.70	255	3.65
10–20		1.88–1.89	1700–1755	0.70–0.85		
20–50		1.89–1.90	1755–1850	0.85–1.15		
50–100		1.90–1.92	1850–1950	1.15–1.35		
100–200		1.92–1.96	1950–2100	1.35–1.60		
200–500		1.96–2.05	2100–2355	1.60–1.95		
>500		2.05	2355	1.95		

Appendix H: Sound Modelling Report – McPherson et al 2021

Beach Otway Development Acoustic Monitoring

Characterisation, Validation, and Marine Mammals

JASCO Applied Sciences (Australia) Pty Ltd

Submitted to:

Phil Wemyss
Beach Energy Limited
Contract: BE00032123

Authors:

Craig R. McPherson
Zizheng Li
Collen C. Wilson
Katie A. Kowarski
Matthew W. Koessler

20 June 2021

P001359-006
Document 02424
Version 2.0

Suggested citation:

McPherson, C.R., Z. Li, C.C. Wilson, K.A. Kowarski, and M.W. Koessler. 2021. Beach Otway Development Acoustic Monitoring: Characterisation, Validation, and Marine Mammals. Document 02424, Version 2.0. Technical report by JASCO Applied Sciences for Beach Energy Limited.

Contents

Figures

Tables

Executive Summary

Overview

JASCO Applied Sciences (Australia), JASCO, completed a monitoring study for Beach Energy (Operations) Ltd (Beach Energy) in relation to the exploration drilling activities at the Artisan-1 well with the aim of completing an acoustic characterisation of the drilling and associated vessel activity within the Otway Basin. Through this characterisation, validation of the modelling predictions used in Beach Energy Otway Environment Plans (EPs) for the development drilling activities was required.

The exploration well Artisan-1, drilled by the *Ocean Onyx*, was selected for the monitoring program because the predicted distances to thresholds for effects on marine mammals, including pygmy blue whales, were farthest at this location in the modelling study used for the EP (Koessler et al. 2020), as well as because it was the first well in the Otway drilling campaign.

Four JASCO Autonomous Multichannel Acoustic Recorders (AMARs) in C-lander moorings were deployed in February and retrieved in early April. Stations 1 through 4 were deployed at distances of 0.336, 1.13, 5.11, and 25 km from the *Ocean Onyx*. The AMARs recorded continuously at 24-bit resolution and 64 kHz sample rate for the entire deployment. The three stations closest to the *Ocean Onyx* were configured with a single hydrophone, whilst the station 25 km away was configured with three hydrophones to provide directional processing of received sounds.

To assist in the characterisation of *Ocean Onyx* and attendant support vessels, the vessels conducted specific activities under dynamic positioning and followed a nominated transit track between the *Ocean Onyx* and Geelong Supply Base. No specific operational requests were made of the *Ocean Onyx* and vessels during normal drilling activities due to the complexity of operationally meeting any requests. Over the course of the monitoring program, the MODU and support vessels engaged in different operational states with different uncontrollable contributors, such as variable drilling operations, resupply and support operations, weather conditions, and merchant shipping.

Data Analysis

The data was analysed to determine total ocean sound levels, which presented the expansive data in a manner that documented the underwater sound conditions near Artisan-1 and allowed a comparison over time, and with external factors that affect sound levels, such as weather and human activities. The data was presented using a range of graphical and statistical representations. JASCO's ShipSound software was used to determine the source levels for the Ocean Onyx during drilling activities and the support vessels whilst under dynamic positioning and transit.

ShipSound calculates two kinds of vessel source levels from the data window: Radiated Noise Level (RNL) and Monopole Source Level (MSL). RNL is equal to the measured sound pressure level, back-propagated according to the distance between a source and the hydrophone using an empirical propagation loss approach. MSL is equal to the measured sound pressure level scaled according to a numerical acoustic propagation loss (PL) model that accounts for the effect of the local environment on sound propagation (i.e., sea-surface reflection, water column refraction and absorption, and bottom loss).

The presence of sounds produced by marine mammals were searched for using a combination of automated detector-classifiers (referred to as automated detectors) and manual review by experienced analysts. The manual review was limited to only a subset (0.5%) of acoustic data, as this was not the primary aim of the project.

Results

The analysis of data at the two stations furthest from the Ocean Onyx, 3 and 4 (5 and 25 km), found a positive correlation between wind speeds and wave heights and sound levels for frequencies over 100 Hz, with the relationship with wind speed being stronger than that for wave height. For both of these stations shipping is a strong contributor. Most days recorded a significant number of vessel detections, with the contributions at Station 4 typically between 40 and approximately 100 Hz. The station most representative of a typical ambient soundscape within the region, Station 4, had a median broadband ambient noise of 104.5 dB re 1 μPa. Dolphins and pygmy blue whales were identified in the data. The data for pygmy blue whales indicates an apparent trend in the animals early in the recording being more to the east and later in the recording being more to the west, through the directional analysis of data from Station 4, but the data were too sparse (and the analysis too limited) to confirm anything about animal movements. Extended analysis may provide more details about their presence and movements during the drilling activities.

The provided drill logs for the Artisan-1 well were reviewed to identify periods of activity defined as drilling, as this was the activity considered in the modelling study Koessler et al. (2020). Seventy ten-minute time periods were deemed suitable for use, which resulted in the MSL being calculated over three different drilling depth ranges and presented as mean and maximum levels. MSL's were calculated for support vessels during dynamic positioning trials and transit, with results summarised in Table 1.

Table 1. Project drill rig and support vessel monopole source levels (MSLs).

Vessel	Measurement	Monopole source level (dB re 1 µPa m)	
		Mean	Maximum
Ocean Onyx	Drilling 26”x42” hole from 95-172 m	175.2	180.0
	Drilling 17.5” hole from 365-621 m	169.3	171.0
	Drilling 12.25” hole up to 1851 m	162.7	170.6
Siem *Sapphire*	Dynamic Positioning Trial	193.9	194.2
	Transit at 7 kn	171.6	173.6
	Transit at 9 kn	185.0	—*
Siem *Aquamarine*	Transit at 9 kn	182.8	—*
Siem *Topaz*	Transit at 9 kn	185.2	—*

* Not reported.

Validation

The Monopole Source Levels determined through the measurement study differed from those either estimated for use in the modelling study or those determined using proxy sources. The key differences are as follows:

- The support vessels are quieter than estimated when they are under slow transit speeds, such as 7 kn.
- The support vessels are louder than estimated when they are travelling at faster transit speeds, with 9 kn used to represent these speeds and the associated MSL.
- The support vessels are louder than estimated when holding station or moving under dynamic positioning.
- The drilling operations of the *Ocean Onyx* are both louder at some frequencies and quieter at others than those for the proxy rig the *Polar Pioneer* (Austin et al. 2018), although the results presented for the *Polar Pioneer* did not examine the changes in level with increased drilling depth (over time) as completed within this study.

The results from the measurement study could not be directly compared to the modelling presented in Koessler et al. (2020) due to the differences in actual events compared to the nominal representative scenarios developed and evaluated as part of the EP assessment process. Additionally, the measurements were obtained at a receiver located 1.2 m off the seafloor, which is not the maximum-over-depth results reported in the modelling study. The ranges obtained from the measurement study are reported in relation to the Artisan-1 well location, and thus the centre of the *Ocean Onyx*. The ranges in the modelling study are reported from a range of locations, including the centroids of multiple sources, thus it is not possible to report the measurement results in a similar fashion using the small number of recording locations used in this study.

The accuracy of the broadband calculated propagation loss for the Otway Basin continental shelf environment depends significantly upon the frequency content of the radiating sound source together with thickness of the sand layer on carbonate seabed (calcarenite) likely to occur within the region. In general, the thinner the sand layer, the greater the overall propagation loss.

When comparing SPL data fits for Stations 1–3, the loss rate is higher than what would have been expected in this environment, considering the higher monopole source levels for the support vessel on DP derived from trial measurements. The differences are likely attributable to the potential absence of a sand veneer.

Comparisons were conducted using JASCO's Marine Operations Noise Model (MONM), a wide-angle parabolic equation model which applies the BELLHOP Gaussian beam acoustic ray-trace model at higher frequencies, and JASCO's wavenumber integration model (VSTACK) which can fully account for the elasto-acoustic properties of the sub-bottom. The agreement between the models was excellent when only a comparatively thin (1 m thick) layer of sand overlies the carbonate seabed structure. In an environment such as this, MONM could have been used without correction. However, the comparisons indicate a much higher rates of loss, as would be expected if no (or only a very thin) sand layer were present.

A better understanding of the propagation loss environment, and the revision of the representation and treatment of it through the measurement study, enabled the modelling scenarios for the activities at Artisan-1 presented in Koessler et al. (2020) to be recalculated. The revised results for distances to maximum-over-depth SPL isopleths are presented in Table 2, and the revised results for distances to maximum-over-depth SEL thresholds presented in Table 3.

The understanding of the environment gained through the measurement study allowed for both the geological environment to be represented in a site-specific fashion and the use of a more appropriate configuration of numerical models to represent the propagation loss. The application of the revised modelling approach to represent other Beach Energy activities on the continental shelf of the Otway Basin would be appropriate.

Table 2. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) to the marine mammal behavioural response threshold of 120 dB re 1 µPa sound pressure level (SPL) from the most appropriate location for considered sources per scenario (see table footnotes).

SPL (L_p; dB re 1 µPa)	MODU (Scenario 5)		OSV standby (Scenario 6)		MODU and OSV resupply (Scenario 7)[A]		MODU and OSV standby (Scenario 8)[B]	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
120[C]	1.17	1.09	0.37	0.35	7.02	6.41	2.09	1.9

[A] Radial distance reported from the mid-point between the Mobile Offshore Drilling Unit (MODU) and the Offshore Support Vessel (OSV) on dynamic positioning (DP) in resupply operations

[B] Radial distances for isopleths/thresholds that envelope the MODU and OSV were reported from the mid-point between the MODU and the centre of the OSV standby area. Otherwise radial distances reported from the OSV in the standby area.

[C] Threshold for marine mammal behavioural response to continuous noise (NOAA 2019).

A dash indicates the level was not reached within the limits of the modelling resolution (25 m).

Table 3. Maximum (R_{max}) horizontal distances (in km) to frequency-weighted 24 hour sound exposure level (SEL_{24h}) thresholds for permanent threshold shift (PTS) and temporary threshold shift (TTS) thresholds based on NMFS (2018) and Finneran et al. (2017) from the most appropriate location for considered sources per scenario, and ensonified area (km^2).

Hearing group	SEL_{24h} threshold ($L_{E,24h}$; dB re 1 µPa² s)[B]	MODU (Scenario 5)		OSV standby (Scenario 6)		MODU and OSV resupply (Scenario 7)[A]		MODU and OSV standby (Scenario 8)[A]	
		R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)	R_{max} (km)	Area (km^2)
PTS									
LF cetaceans	199	–	–	–	–	–	–	–	–
MF cetaceans	198	–	–	–	-–	–	–	–	–
HF cetaceans	173	0.19	0.11	–	–	0.2	0.12	0.19	0.11
Phocid seals	201	–	–	–	–	–	–	–	–
Otariid seals	219	–	–	–	–	–	–	–	–
Turtles	220	–	–	–	–	–	–	–	–
TTS									
LF cetaceans	179	0.31	0.31	1.01	0.35	0.95	2.78	0.31	0.66
MF cetaceans	178	0.13	0.05	–	–	0.16	0.06	0.13	0.05
HF cetaceans	153	1.07	3.44	1.01	0.18	1.09	3.86	1.06	3.64
Phocid seals	181	0.12	0.05			0.35	0.28	0.12	0.05
Otariid seals	199	–	–	–	–	–	–	–	–
Turtles	200	–	–	–	–	–	–	–	–

[A] Radial distance reported from the centre of the MODU, unless indicated otherwise.

[B] Frequency weighted.

A dash indicates the level was not reached within the limits of the modelling resolution (25 m).

1. Introduction

JASCO Applied Sciences (Australia), JASCO, completed a monitoring study for Beach Energy (Operations) Ltd (Beach Energy) in relation to the exploration drilling activities at the Artisan-1 well with the aim of completing an acoustic characterisation of the drilling and associated vessel activity within the Otway Basin. Through this characterisation, it was then required to validate the modelling predictions used in Beach Energy Otway Environment Plans (EPs) for the development drilling activities. These validation results are applicable for drilling, construction, and operational activities within the Otway Basin.

The exploration well Artisan-1 was selected for the monitoring program, because the predicted distances to thresholds for effects on marine mammals, including pygmy blue whales, were farthest at this location in the modelling study used for the EP (Koessler et al. 2020), as well as because it was the first well in the Otway drilling campaign.

This report presents an overview of the operations, environment, and measurement approaches (Section 2); general information about the marine acoustic environment (Section 3); the methods used for the data analysis, presentation, and modelling validation (Section 4); results of the monitoring program (Section 5); the validation analysis (Section 6); and a discussion of the program results and findings (Section 7).

The location of the four acoustic recording stations and the Artisan-1 well are provided in Table 4 and shown in Figure 1. One JASCO Autonomous Multichannel Acoustic Recorders (AMAR) was deployed at each recording station.

Table 4. Artisan-1 well and acoustic recording stations, including distance to Artisan-1.

Item	Latitude (S)	Longitude (E)	MGA Zone 54 (GDA94)		Water depth (m)	Distance to Artisan-1 (km)
			X (m)	*Y* (m)		
Artisan-1 (well)	38° 53.49077'	142° 52.94869'	663262.0	5693578.0	71.6	–
Station 1	38° 53.39316'	142° 53.14475'	663549.2	5693753.0	71.7	0.336
Station 2	38° 53.16585'	142° 53.61184'	664233.1	5694159.0	70.5	1.13
Station 3	38° 52.04100'	142° 55.95360'	667662.6	5696169.0	68.9	5.11
Station 4	38° 56.93456'	143° 9.71333'	687345.7	5686671.0	73.6	25.05

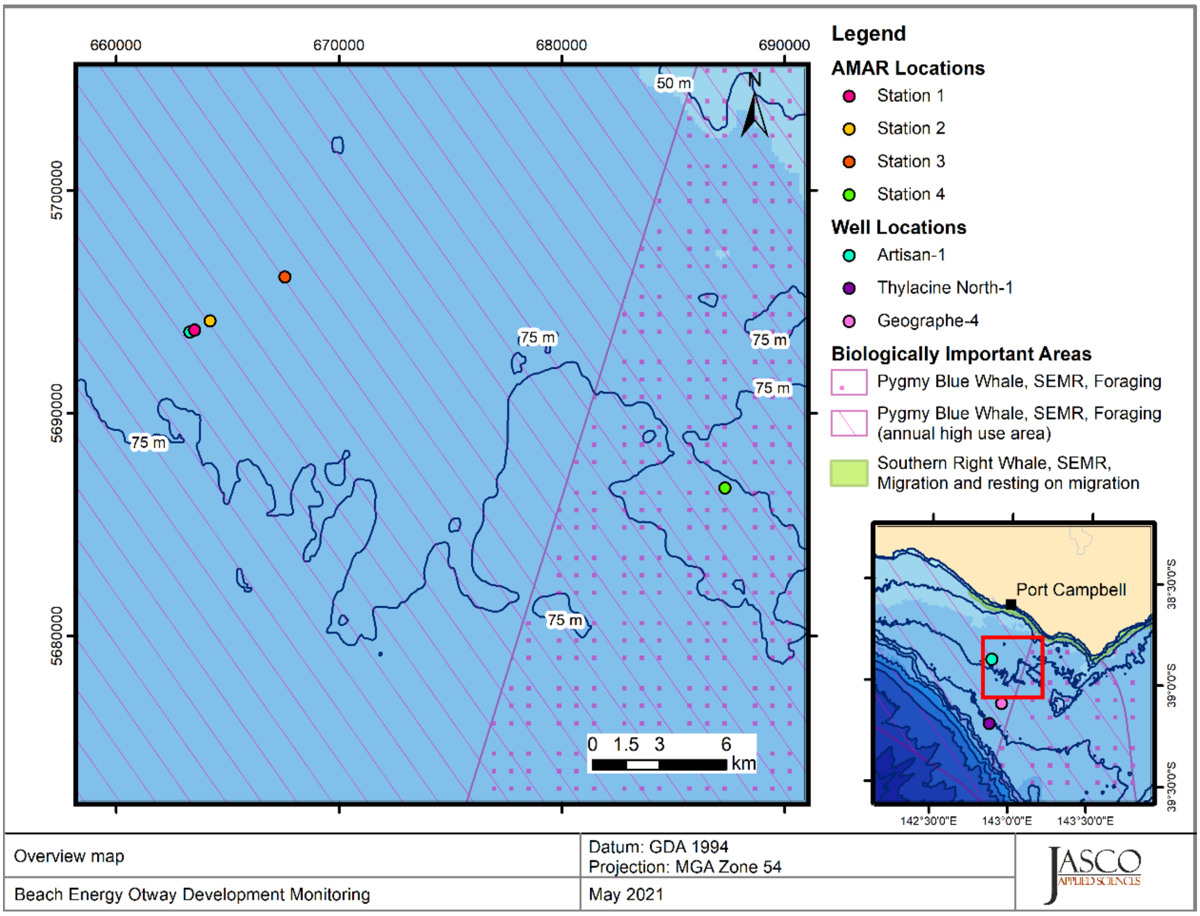


Figure 1. Otway Development Area showing location of the JASCO recorder stations.

2. Background Information

2.1. Operational Overview and Logs

The Otway Development Drilling Campaign being undertaken by Beach Energy utilises the *Ocean Onyx* Mobile Offshore Drilling Unit (MODU) (Figure 2). It is held in position via anchors and chains, as opposed to using thrusters, and has dimensions of approximately 100 m in length and width, and a draft of 22.7 m.

Figure 2. *Ocean Onyx* semi-submersible platform.

The following information was provided by Beach Energy:

- Drilling activity logs for the *Ocean Onyx,*
- Daily operational logs for the Development Drilling program,
- Daily vessel activity logs, and
- Vessel locations in ~15-minute increments from the Siem navigation systems.

The operational and activity logs used local time, which was Australian Eastern Daylight Time (AEDT), UTC+11 until 4 Apr 2021 at 3:00 am, when they changed over to Australian Eastern Standard Time (AEST), UTC+10. Therefore, AEDT is considered local time for the monitoring program. Vessel location data, including and Automated Identification System (AIS) data, as well as other ancillary environmental data and JASCO's recorders use UTC as the time zone. Thus, to avoid potential confusion, all timestamps were converted to UTC.

The *Ocean Onyx* anchoring operation commenced on 11 Feb 2021 and completed on 12 Feb 2021 local time; therefore, 01:00 12 Feb 2021 UTC was considered the start of data with the *Ocean Onyx* moored and in location after all anchor handling was complete. The *Ocean Onyx* departed Artisan-1 on 28 Mar 2021, after commencing disconnect operations on 26 Mar 2021 local time; therefore, 00:00 25 Mar 2021 UTC was considered the end of drilling or rig operations for analysis purposes.

2.2. Vessel Traffic

Regional vessel movement information, including for the project vessels, was obtained from MarineTraffic (www.marinetraffic.com), with data supplied for the time range between 1 Feb 2021 and 5 Apr 2021 in the region. The requested area was 11,003 km^2, with the vertices shown in Table 5.

The supplied data used a one-hour timestamp for vessel locations and all data were derived from satellites, with no terrestrial reporting stations in the vicinity. Figure 3 shows the marine traffic in the project area, derived from vessels broadcasting on the Automated Identification System (AIS), with a map focused on Artisan-1 shown in Figure 4.

Table 5. MarineTraffic data request bounds.

Vertex	Latitude (S)	Longitude (E)	MGA Zone 54 (GDA94)	
			X (m)	*Y* (m)
1	38° 38.71418'	142° 15.17165'	609029.0	5721846.24
2	38° 36.92154'	143° 55.51902'	754698.76	5721846.24
3	39° 17.70699'	143° 57.20532'	754698.76	5646313.77
4	39° 19.54340'	142° 15.89490'	609029.0	5646313.77

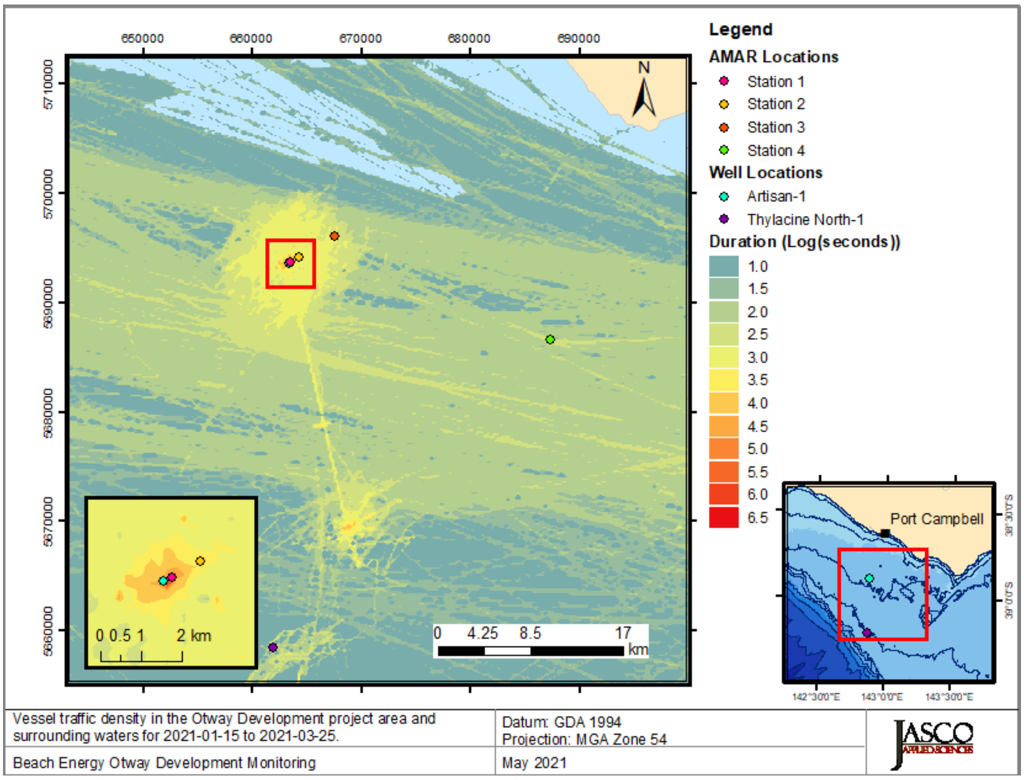


Figure 3. Vessel traffic density within the Development Drilling project area and surrounding waters for 15 Jan to 25 Mar 2021.

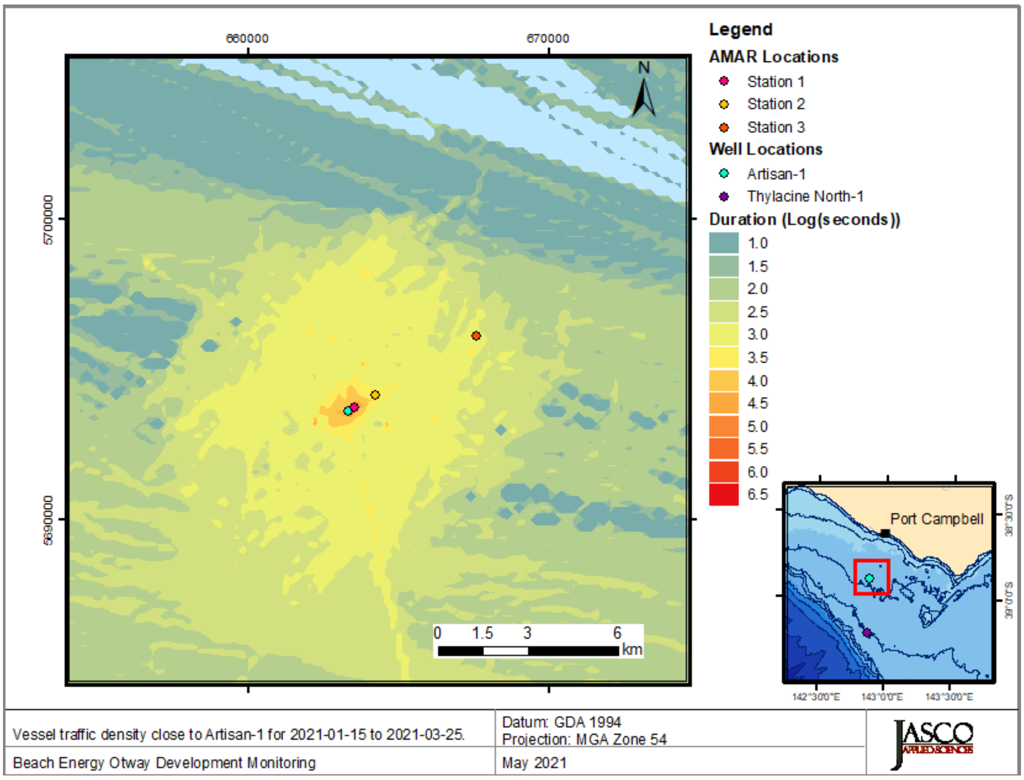


Figure 4. Vessel traffic density near Artisan-1 for 15 Jan to 25 Mar 2021.

2.3. Weather Conditions

Weather conditions at Artisan-1 were quantified through nowcast data provided by MetraWeather (Australia) for the period 00:00 on 1 Feb through until 24:00 6 Apr 2021 (UTC). The data included the following parameters:

- Significant wave height,
- Peak wave period,
- Peak wave direction,
- Significant wave height of swell >8 second period,
- Average wind speed,
- Wind direction, and
- Maximum wind gust speed.

Figure 5 shows the wave and swell weight, and Figure 6 shows the wind and gust speeds.

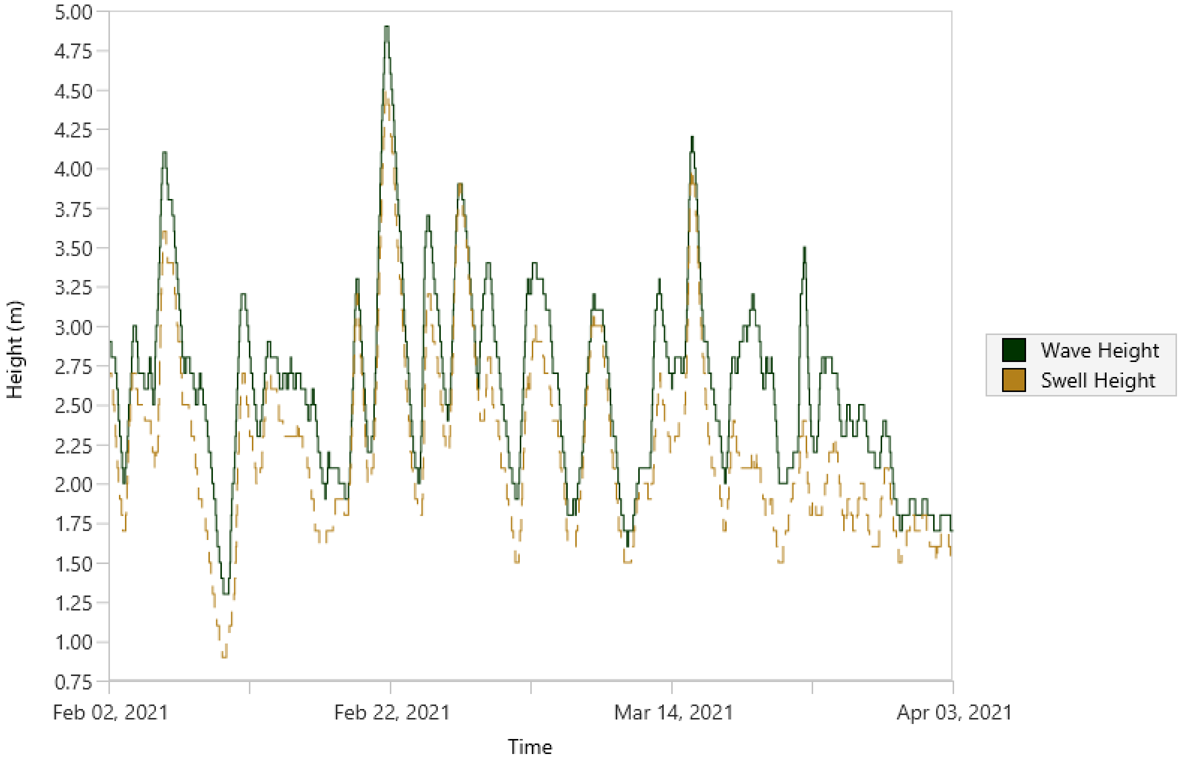


Figure 5. Hourly significant wave height (m) and significant swell height (m), with a period of greater than 8 seconds.

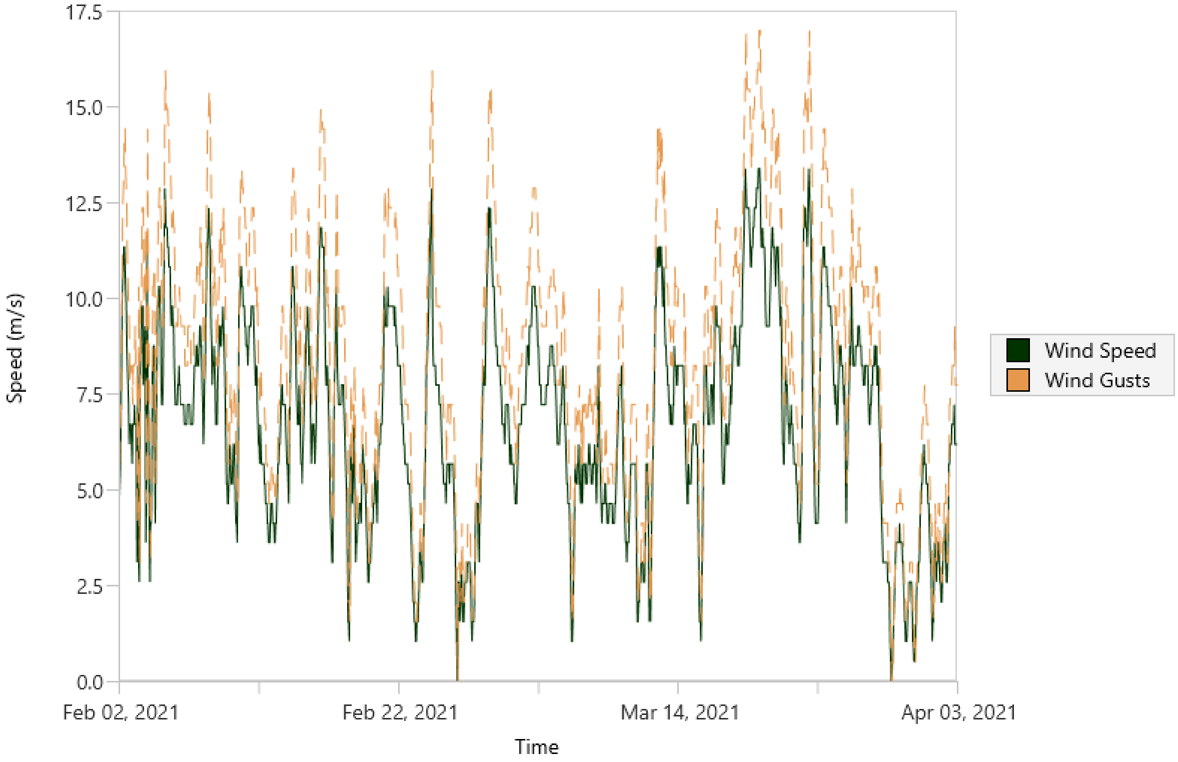


Figure 6. Hourly average wind speed (m/s) and maximum gust speed (m/s).

2.4. Geology

The propagation model used in this study considers a single geologic seabed profile for the Artisan area. The previous work by Koessler et al. (2020) considered two geologic and associated geoacoustic profiles. For deeper areas closer to the continental shelf edge, a profile characterised by well-cemented carbonate caprock (calcarenite) overlying semi-cemented calcarenite was used. Closer to the Artisan area the seabed, located in shallower waters, was characterised by a thin veneer of coarse sand/gravel overlying cemented and semi-cemented carbonate rock. This profile was selected based on a mixture of previous modelling studies (Wood and McPherson 2018) and client supplied geologic reports.

All these sources support a generalised geologic structure within the first 100 m seabed consisting of cemented or semi-cemented calcareous rock (‘calcarenite’) on the continental shelf within Artisan area. Collated information also indicated that there was the potential for a thin layer of coarse sand that could overlay the more cemented calcarenite. This was also indicated by seafloor sediment grab samples from the MARS sediment database (Heap 2009). The seabed environment was considered to be consistent with larger scale geological data and interpretations of the Australian continental shelf environment as summarised by James and Bone (2010), who indicated that the sediments along the continental shelf may be subject to transport and erosion yielding non-uniform distributions of seafloor sediment thickness.

2.5. Specific Source Measurement Operations

2.5.1. MODU Measurements

No operational requirements were requested of the *Ocean Onyx* or attendant support vessels while conducting resupply or standby operations during the drilling program due to the complexity of operationally meeting any requests. Over the course of the monitoring program, the MODU and support vessels engaged in different operational states, with different uncontrollable contributors, such as variable drilling operations, resupply and support operations, weather conditions, and merchant shipping. Operational details were obtained from the provided logs (Section 2.1).

2.5.2. Support Vessel Measurements

Specific operations were defined for the characterisation of the support vessels prior to the *Ocean Onyx* being moored, and while in transit to and from Geelong. For transit measurements, vessels were requested to pass along a defined track line according to ANSI S12.64 (R2014), with the vessel maintaining the straightest track possible and a requested separation from the AMAR of 150 m at the closest point of approach (CPA), with a water depth of 70 m. In deep water vessel noise measurements, it is a requirement for the vessels to be a minimum of either 100 m or one vessel length away from the recorder; in this case the typical vessel length is 91 m. Whilst there are standards for deep water source level measurements, there are none for shallow water environments. Methods to make accurate shallow water measurements of vessel source levels are currently being investigated by JASCO and DW Ship Consult for Transport Canada, with the findings to contribute to standard development (Ainslie et al. 2020); these methods were considered during the design of this study where possible.

The transit measurement track defined at Station 4 is shown in Figure 7, and in increased detail in Figure 8.

For measurements of dynamic positioning (DP), three exercises were defined, with *Exercise Two* completed twice. The three exercises all commenced at a horizontal separation of 150 m from the AMAR:

- *Exercise One*: Vessel to hold station, broadside to AMAR and operate at weather determined power levels for a minimum of 5 minutes.
- *Exercise Two*: Vessel to hold station, broadside to AMAR, then induce maximum reasonable thrust level and move in a perpendicular direction away from the AMAR in the up current direction for two minutes, reset and repeat exercise.
- *Exercise Three*: Vessel to hold station, broadside to AMAR, then using DP, step the vessel to the corners of a 10 × 10 m box using weather determined thruster levels.

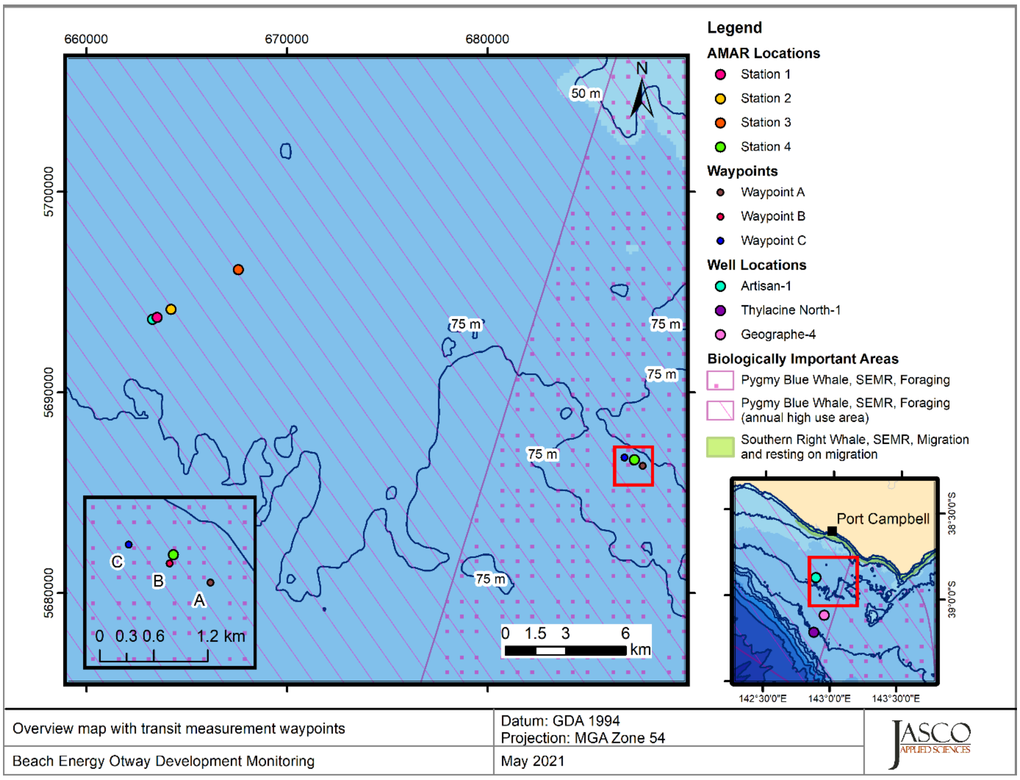


Figure 7. Map showing AMAR locations along with the three waypoints for the measurement track at Station 4 for transit vessels, Waypoints A, B, and C.

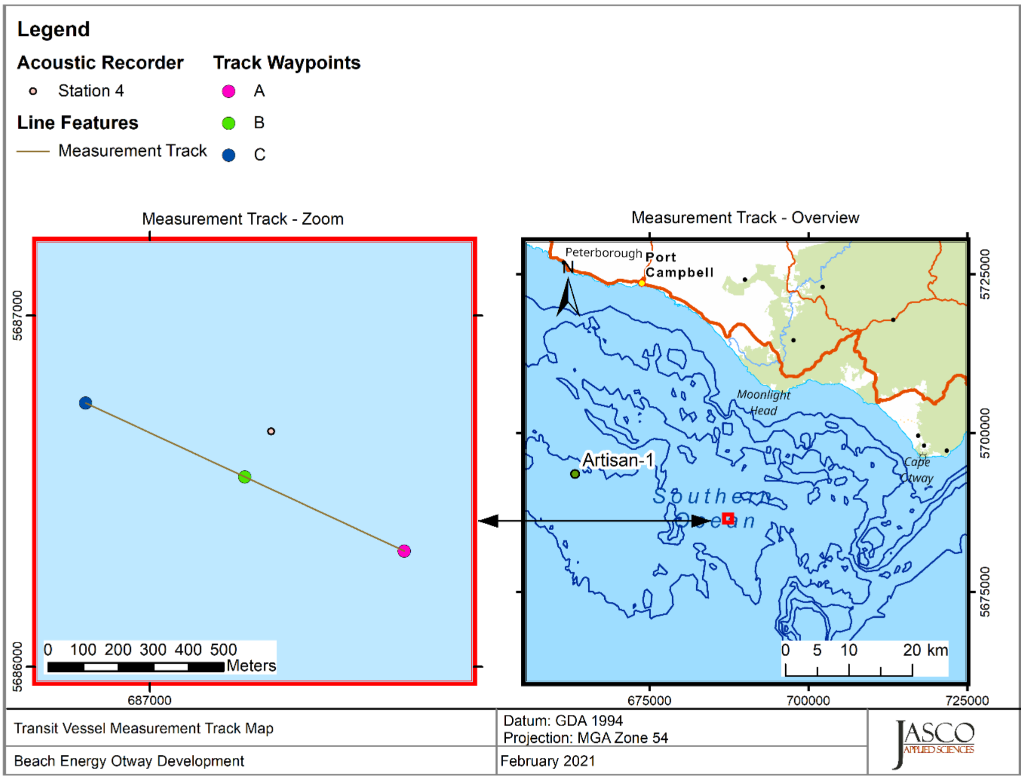


Figure 8. Zoom in of measurement track at Station 4 for transit vessels, as shown in Figure 7.

2.6. Noise Effect Criteria

To assess the potential effects of a sound-producing activity, it is first necessary to establish exposure criteria (thresholds) for which sound levels may be expected to have a negative effect on animals. Whether acoustic exposure levels might injure or disturb marine fauna is an active research topic. Since 2007, several expert groups have developed sound exposure level (SEL) based assessment approaches for evaluating auditory injury, with key works including Southall et al. (2007), Finneran and Jenkins (2012), Popper et al. (2014), United States National Marine Fisheries Service (NMFS 2018) and Southall et al. (2019). The number of studies that investigate the level of behavioural disturbance to marine fauna by anthropogenic sound has also increased substantially.

Two sound level metrics, sound pressure level (SPL), and SEL (Appendix A), are commonly used to evaluate non-impulsive noise and its effects on marine life. In this report, the duration of the SEL accumulation is defined as integrated over a 24 h time period. Appropriate subscripts indicate any applied frequency weighting applied. The acoustic metrics in this report reflect the amended ANSI and ISO standards for acoustic terminology, ANSI S1.1 (S1.1-2013), and ISO 18405:2017 (2017a).

The following thresholds and guidelines for this study were chosen because they represent the best available science, and sound levels presented in literature for fauna with no defined thresholds:

1. Frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from the US National Oceanic and Atmospheric Administration (NOAA) Technical Guidance (NMFS 2018) for the onset of permanent threshold shift (PTS) and temporary threshold shift (TTS) in marine mammals for non-impulsive sources.
2. Marine mammal behavioural threshold based on the current interim U.S. National Oceanic and Atmospheric Administration (NOAA) (2019) criterion for marine mammals of 120 dB re 1 µPa (SPL; L_p) for non-impulsive sound sources.

The criteria applied in this study to assess possible effects of vessel noise on marine mammals are summarised in Table 6, with frequency weighting explained in Appendix E.

Table 6. Criteria for effects of continuous noise exposure, including vessel noise, for marine mammals: Unweighted sound pressure level (SPL) and 24 h sound exposure level (SEL_{24h}) thresholds.

Hearing group	NOAA (2019)	NMFS (2018)	
	Behaviour	**PTS onset thresholds (received level)**	**TTS onset thresholds (received level)**
	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2 s)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2 s)
Low-frequency (LF) cetaceans	120	199	179
High-frequency (HF) cetaceans		198	178
Very high-frequency (VHF) cetaceans		173	153
Phocid seals		201	181
Otariid seals		219	199

L_p denotes sound pressure level period and has a reference value of 1 µPa.
L_E denotes cumulative sound exposure over a 24 h period and has a reference value of 1 µPa^{2}s.

3. Marine Acoustic Environment

3.1. Ambient Ocean Soundscape

The ambient acoustic environment, or soundscape, consists of cumulative contributions from abiotic (geophonic), biotic (biophonic), and man-made (anthrophonic) sound sources (Krause 2008). Variation in soundscape characteristics over time and space can act as proxies for geographical, biological, and anthropogenic events occurring within an environment.

In the marine environment, geophonic elements of the soundscape commonly correlate with oceanographic conditions. Increased sea state and wind speed lead to higher sound intensities across frequencies ranging from 500 Hz to 30 kHz, via sound produced by breaking waves, cavitation, surface flow noise, and pressure changes (Knudsen et al. 1948, Wenz 1962) (Figure 9). Rainfall elevates sound levels in the 1–15 kHz frequency range, via surface impacts and bubble entrainment (Heindsmann et al. 1955, Bom 1969, Scrimger et al. 1987). The specific frequency band affected by rainfall depends on rain strength and droplet size. Abiotic acoustic contributions are often unpredictable or irregular (Urick 1983). For example, significant low frequency acoustic energy can be contributed to marine soundscapes by earthquakes and sea ice movement (Urick 1974, Matsumoto et al. 2014). On the other hand, biophonic contributions often feature seasonal and diel activity patterns (Hannay et al. 2013, Erbe et al. 2017). Water movement, or flow noise, is considered to be a pseudo-noise that results from eddies and vortices forming as water flows past an acoustic receiver, and is not considered to be part of a marine soundscape (Strasberg 1979).

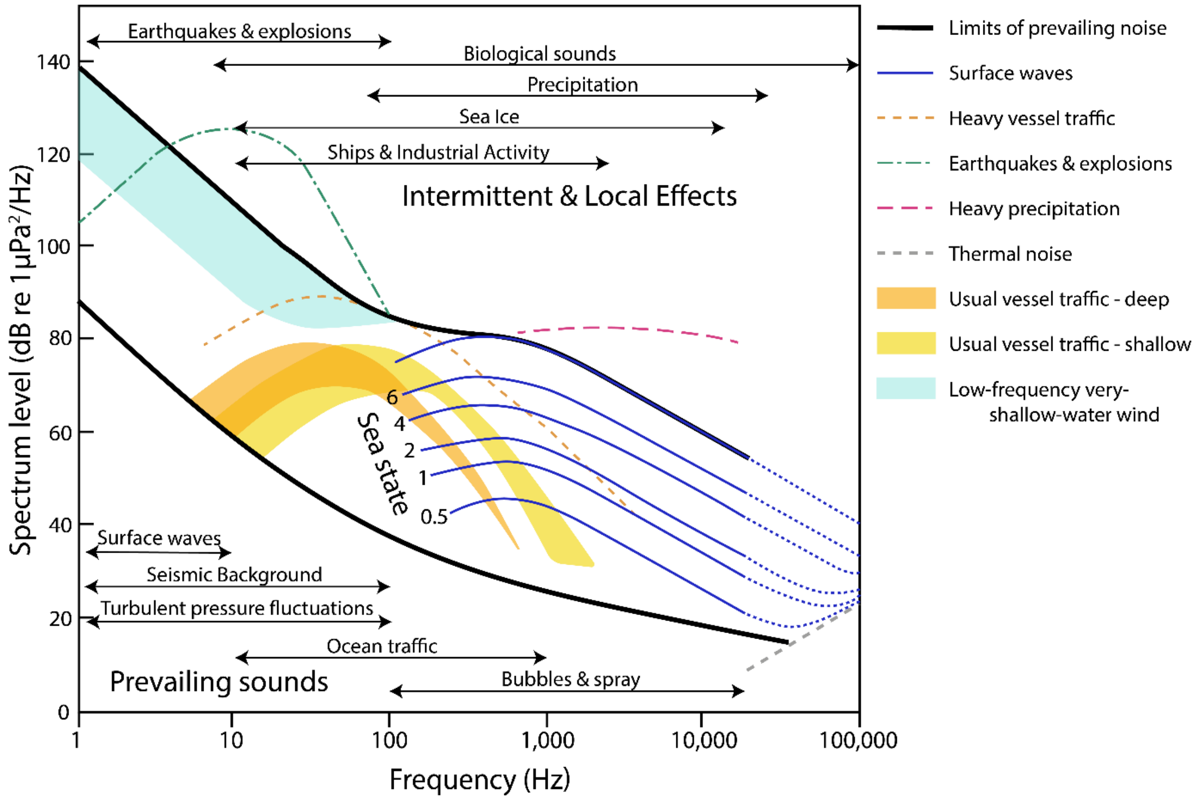


Figure 9. Wenz curves describing pressure spectral density levels of marine ambient sound from weather, wind, geologic activity, and commercial shipping (adapted from NRC 2003, based on Wenz 1962). Thick lines indicate limits of prevailing ambient sound.

3.2. Anthropogenic Contributors to the Soundscape

Anthropogenic (human-generated) sounds are relatively recent additions to soundscapes and, unlike biophonic contributors, often overlap in frequency, space, or time (Cato 1997, van Opzeeland and Boebel 2018). Anthrophonic contributors to global ocean noise include vessel traffic (commercial and recreational) at frequencies mainly in the frequency band 50–500 Hz. This sound can be a by-product of vessel operations, such as engine sound radiating through vessel hulls and cavitating propulsion systems, or it can be a product of active acoustic data collection with seismic surveys, military sonar, and depth sounding as the main contributors.

Marine construction projects involve vessel operations and project specific noise sources that can produce a range of both impulsive and non-impulsive noise. The contribution of anthropogenic sources to the ocean soundscape has increased from the 1950s to 2010, largely due to greater maritime shipping traffic (Ross 1976, Andrew et al. 2011). Oil and gas exploration with seismic airguns, marine pile driving, and oil and gas production platforms elevate sound levels over significant ranges when present (Bailey et al. 2010, Miksis-Olds and Nichols 2016, Delarue et al. 2018).The extent of seismic survey sounds has increased substantially following the expansion of oil and gas exploration into deep water, and seismic sounds have been detected across ocean basins (Nieukirk et al. 2004). Recent trends suggest that global sound levels are leveling off or potentially decreasing in some areas (Andrew et al. 2011, Miksis-Olds and Nichols 2016).

A recent paper examining seasonal fluctuations of ambient sound level in the Pacific Ocean (Ainslie et al. 2021) determined that a 5 dB increase in ambient sound level in the frequency range 63–125 Hz was caused by increases in vessel traffic and vessel size in the second half of the 20th century. A larger (approximate 10 dB) increase at lower frequencies (~16–32 Hz), often attributed incorrectly to shipping, occurs in bands dominated by baleen whale vocalisations. This paper also found that the seasonal dependence in ambient sound level is explained by seasonal changes in average sea surface temperature. This work provides a holistic and valuable examination of long-term trends.

3.3. Soniferous Marine Life

Biophonic contributors to marine soundscapes include tonal and pulsive vocalisations produced by marine mammals, fish, and invertebrates to communicate, orientate, and feed. Seasonal trends in biophonic sounds can act as proxies for behaviours, such as the migration of whales (e.g., Leroy et al. 2016, Gavrilov et al. 2018, Jolliffe et al. 2019). Other sounds of animal origin that contribute to marine soundscapes include by-products of behaviour, such as the snaps produced by snapping shrimp (*Alpheus heterochaelis*) during agonistic or foraging behaviours (Versluis et al. 2000). Snapping shrimp can increase background sound levels by a factor of 10 (20 dB) in the 500 Hz to 20 kHz frequency band (Hildebrand 2009). When a large number of sound-producing animals are present, both voluntary and involuntary sounds can combine to generate choruses where individual sounds cannot be distinguished. Chorusing fish can temporarily elevate the background sound levels by greater than tenfold in the 100 and 2000 Hz frequency band (Cato 1992, Zelick et al. 1999).

Diel trends in choruses can be indicative of time-specific behaviours, such as crepuscular or nocturnal fish activity (McCauley and Cato 2000, D'Spain and Batchelor 2006, McCauley and Cato 2016), with a variety of different species contributing the to the soundscape (Parsons et al. 2016, Parsons et al. 2017).

Many fish species produce sound during the breeding season or when engaged in agonistic behaviours (Amorim 2006). Several species of gadids (cod family), such as Northern cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*), form spawning aggregations that have been detected acoustically (Nordeide and Kjellsby 1999, Hawkins et al. 2002). The acoustic monitoring of fish is hindered by a limited understanding of their acoustic repertoire and behaviour. Nevertheless, the stereotypical nature of acoustic signals produced by some species have led to the development of dedicated acoustic detectors (e.g., cod; see Urazghildiiev and Van Parijs 2016). These detectors allow for a more systematic analysis of acoustic data for fish occurrence. Irrespective of species identity, fish choruses can raise ambient noise levels and therefore influence local soundscapes (Erbe et al. 2015).

The main, best documented, biological contributors to the ocean soundscape are marine mammals. All studied cetacean and pinniped species produce sounds ranging in frequency from ~8 Hz for blue whale (*Balaenoptera musculus*) and fin whale (*B. physalus*) vocalisations to 150 kHz for some porpoise and dolphin vocalisations (Richardson et al. 1995).

Baleen whale sounds can double background sound levels within their frequency bands and persist for extended periods of time (McDonald et al. 2008), such as species off southern Australia, including pygmy blue and southern right whales, that are all notable contributors when present (Cato 1991, McCauley et al. 2001, Gavrilov and McCauley 2013, Erbe et al. 2016, McPherson et al. 2017). For instance, fin whale songs can raise noise levels in the 18–25 Hz band by 15 dB for extended durations (Simon et al. 2010).

Marine mammals, cetaceans in particular, rely almost exclusively on sound for navigating, foraging, breeding, and communicating (Clark 1990, Edds-Walton 1997, Tyack and Clark 2000). Although species differ widely in their vocal behaviour, most can be reasonably expected to produce sounds on a regular basis. Passive acoustic monitoring is therefore increasingly preferred as a cost-effective and efficient survey method. Seasonal and sex- or age-biased differences in sound production, as well as signal frequency, source level, and directionality, all influence the applicability and success rate of acoustic monitoring, thus its effectiveness must be considered separately for each species.

In most cases, baleen whale signals can be reliably identified to the species level, although, seasonal variation in the types of vocalisations produces results in seasonal differences in our ability to detect these species acoustically. For example, the tonal signals produced by blue, fin, and sei (*B. borealis*) whales tend to show lots of similarities in late spring and summer, but they are markedly different from September to April. These issues are considered and discussed on a case-by-case basis.

Knowledge of the acoustic signals of the marine mammals expected in the study area varies across species. These sounds can be split into two broad categories: Tonal signals, including baleen whale moans and delphinid whistles, and echolocation clicks produced by all odontocetes mainly for foraging and navigating. Although the signals of most species have been described to some extent, these descriptions are not always sufficient for reliable, systematic identification, let alone to design automated detectors to process large data sets.

3.4. Changes to Sound as it Travels in the Ocean

A key question in the study of underwater sound is how a sound changes in nature as it propagates from its source to a receiver some distance away. Understanding and modelling sound propagation in the ocean is a complex topic that is the subject of numerous studies. This section provides a descriptive overview of key sound propagation concepts to assist with the results presented in this report. These concepts are integral to interpreting how sounds emitted by a source are transformed into those received some distance away. The sounds are transformed by 1) geometric spreading losses; 2) reflection, scattering, and absorption at the seabed and sea surface; 3) refraction due to changes in sound speed with depth; and 4) absorption by sea water. This section does not address point 3), as sound refraction plays only a minor role in shallow water, such as the Otway Development area.

At one extreme, the echolocation clicks of porpoises at 130 kHz travel only 500 m before becoming inaudible (Au et al. 1999). At the other extreme, sounds from fin whales (20 Hz) and low frequency energy from seismic airguns (5–100 Hz) can be detected thousands of km away under the right conditions (Nieukirk et al. 2012).

Geometric spreading losses: Sound levels from an omnidirectional point source in the water column are reduced with range, a process known as *geometric spreading loss*. As sound leaves the source, each spherical sound wave propagates outward and the sound energy is spread out over this ever-expanding sphere. The farther you are from the source, the lower the sound level you will receive. The received sound pressure levels at a recorder located a distance R (in m) from the source are $20\log_{10}R$ dB lower than the source level (SL) referenced to a standard range of 1 m. However, the sound cannot spread uniformly in all directions forever. Once the waves interact with the sea surface and seabed, the spreading becomes cylindrical rather than spherical and is limited to the cylinder formed by the surface and seabed with a lower range-dependent decay of $10\log_{10}R$ dB. Thus, the water depth is a key factor in predicting spreading losses and thus received sound levels. These spherical and cylindrical spreading factors provide limits for quick approximations of expected levels from a given source. In very shallow waters, sound rapidly attenuates if the water depth is less than a quarter of a wavelength (Urick 1983).

Reflection, scattering, absorption at the sea surface and seabed: If geometric spreading were the only factor governing sound attenuation in water, then at a given distance from a source, sound levels in shallow waters would almost always be higher than those in deep waters. In shallow water, however, the sound interacts with the seabed and sea surface more often than sound travelling in deep waters does, and these interactions reflect, absorb, and scatter the sounds. The sea surface behaves approximately as a pressure release boundary, where incident sound is almost completely reflected with opposite phase. As a result, the sum of the incident and reflected sounds at the sea-surface is zero. At the seabed, many types of interactions can occur depending on the composition of the bottom. Soft silt and clay bottoms absorb sound, sand and gravel bottoms tend to reflect sound like a partially reflective mirror, and some hard yet elastic bottoms, such as limestone, reflect some of the sound while absorbing some of the energy by converting the compressional waves to elastic shear waves.

Absorption by sea water: As sound travels through the ocean, some of the energy is absorbed by molecular relaxation in the seawater, which turn the acoustic energy into heat. The amount of absorption that occurs is quantified by an attenuation coefficient, expressed in units of decibels per kilometre (dB/km). This absorption coefficient depends on the temperature, salinity, pH, and pressure of the water, as well as the sound frequency. In general, the absorption coefficient increases with the square of the frequency, so low frequencies are less affected. The absorption of acoustic wave energy has a noticeable effect (>0.05 dB/km) at frequencies above 1 kHz. For example, at 10 kHz the absorption loss over 10 km distance can exceed 10 dB, as computed according to the formulae of François and Garrison (1982a, b).

4. Methods

4.1. Acoustic Data Acquisition

Underwater sound was recorded with four Autonomous Multichannel Acoustic Recorders (AMARs, JASCO; Figure 10). The AMARs were each fitted with M36 omnidirectional hydrophones (GeoSpectrum Technologies Inc., −164 re 1 V/µPa at 1 kHz sensitivity) and recorded continuously at 24-bit resolution at 64 kHz. Three AMARs stored acoustic data with three SD cards with 512 GB memory each (1.5 TB total), and one AMAR (Station 4) used seven SD-cards with 512 GB memory each (3.5 TB total). Appendix C provides details about the calibration procedure.

The deployment of the AMARs coincided with an inspection trip of the pre-laid anchors at the Artisan 1 drilling location by the Siem *Sapphire*. They were deployed on 3 Feb 2021, for an intended deployment duration of approximately 60 days. The deployment of one of the moorings is shown in Figure 11. The mooring at Station 3 released upon contact with the seafloor, potentially due to the lander striking a rock on the seafloor. It was immediately retrieved, and after sourcing a new weight plate and being re-configured, it was re-deployed on 24 Feb 2021. The retrieval of the moorings was conducted by Beach under guidance from JASCO on 3 Apr 2021.

The AMARs were deployed as part of a JASCO C-lander, with tandem acoustic releases (Figure 10). Each mooring consisted of:

- An AMAR G4 and battery packs,
- A Xeos Apollo Locator Beacon,
- Custom syntactic foam,
- A tandem acoustic release system (EdgeTech), and
- An anchor weight.

The AMAR hydrophones were protected by a hydrophone cage, which was covered with a nylon shroud to minimise noise artifacts from water flow (described in Section 3.1). The AMAR at Station 4 was configured with three hydrophones to allow for directional analysis (Thode et al. 2019).

Figure 10. The four C-Lander bottom moorings with Autonomous Multichannel Acoustic Recorders (AMAR G4s; JASCO) used for the project prior to loading onto the Siem *Sapphire*.

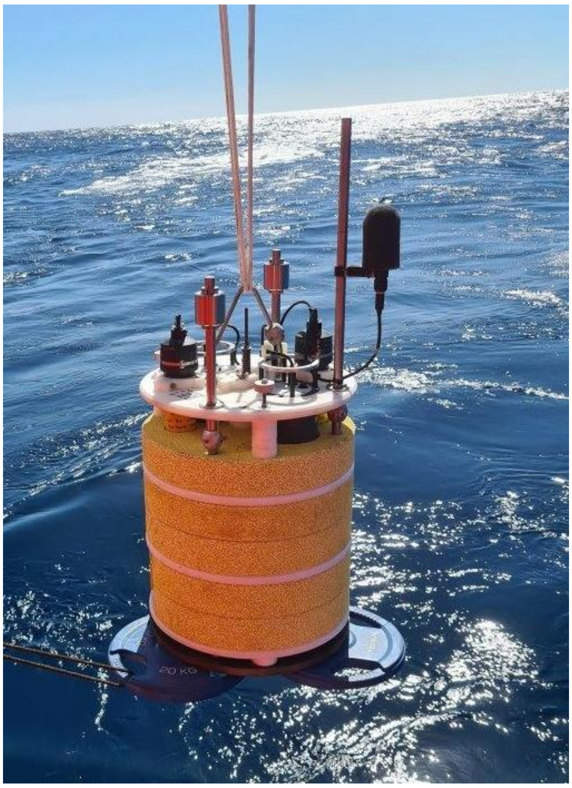


Figure 11. A single hydrophone C-Lander bottom mooring during deployment.

Table 7. Operation period, location, and depth of the Autonomous Multichannel Acoustic Recorders (AMARs) deployed at the Otway Project Area

Station	AMAR	Deployment	Recording duration (days)	Retrieval	Deployment duration (days)	Hydrophone details
1	628	3 Feb 2021	63	3 Apr 2021	58	One M36-V35-900
2	626	3 Feb 2021	63	3 Apr 2021	58	
3	627	24 Feb 2021	42	3 Apr 2021	37	
4	629	3 Feb 2021	63	3 Apr 2021	58	Three M36-V35-900

4.2. Data Analysis

The AMARs collected approximately 10.46 TB of acoustic data during this study, the equivalent of 1 year and 85 days JASCO used a specialised computing platform (PAMlab; JASCO) capable of processing acoustic data hundreds of times faster than real time. The system performed automated analysis of total ocean noise and sounds from vessels, other anthropogenic sources, and marine mammal vocalisations to provide context for the ambient ocean soundscape, anthropogenic contributors, and soniferous marine life (Section 3). Appendix D outlines the stages of the automated analysis.

4.2.1. Total Ocean Sound Levels

The data collected for the project spanned a frequency band between 10 Hz and 32 kHz. The goal of the total ocean sound analysis was to present the expansive data in a manner that documented the underwater sound conditions near Artisan-1 and allowed a comparison over time, along with external factors that change sound levels, such as weather and human activities.

The first stage of the total sound level analysis involves computing the peak sound pressure level and root-mean-square sound pressure level (SPL) for each minute of data collected. This reduced the data to a manageable size without compromising the value for characterising the soundscape (ISO 2017b, Ainslie et al. 2018, Martin et al. 2019). The SPL analysis was performed by averaging 120 fast-Fourier transforms (FFTs) that each include 1 s of data with a 50% overlap and that use the Hann window to reduce spectral leakage. The 1-minute average data were stored as power spectral densities (1 Hz resolution up to 455 Hz and millidecades frequency bands above 455 Hz) and summed over frequency to calculate decidecade band SPL levels. The millidecade band analysis approach is described in Martin et al. (2021). Millidecades are logarithmically spaced frequency bands but have a bandwidth equal to 1/1000th of a decade. The use of millidecades instead of 1 Hz frequency bands reduces the size of the spectral data by a large factor without compromising the use of the data.

Decidecade band levels are very similar to 1/3-octave-band levels. Table B-1 lists the decidecade band frequencies, and Table B-2 lists the decade-band frequencies. The decidecade analysis sums the frequency range from the millidecade bands (representing the frequency range 10 Hz to 32 kHz) in the power spectral density data to a manageable set of 45 bands. The decade bands further summarise the sound levels into four frequency bands for manageability. Detailed descriptions of the acoustic metrics and decidecade analysis can be found in Appendices B.1 and B.2.

In Section 5, the total sound levels are presented as:

- **Band-level plots**: These strip charts show the averaged received sound pressure levels as a function of time within a given frequency band. We show the total sound levels (across the entire recorded bandwidth from 10–32,000 Hz) and the levels in the decade bands of 10–100 (Decade A), 100–1000 (Decade B), 1000–10,000 (Decade C). The 10–100 Hz band is associated with pygmy blue whales, large shipping vessels, flow (or pseudo-noise) and mooring noise, and seismic survey impulses. Sounds within the 100–1000 Hz band are generally associated with the physical environment such as wind and wave conditions but can also include both biological and anthropogenic sources such as minke and humpback whales, fish, nearby vessels, seismic surveys, and pile driving. Sounds above 1000 Hz include high-frequency components of humpback whale sounds, odontocete whistles and echolocation signals, wind- and wave-generated sounds, and sounds from human sources at close range including pile driving, vessels, seismic surveys, and sonars.

- **Long-term Spectral Averages (LTSAs)**: These colour plots show power spectral density levels as a function of time (*x*-axis) and frequency (*y*-axis). The frequency axis uses a logarithmic scale, which provides equal vertical space for each decade increase in frequency and allows the reader to equally see the contributions of low and high-frequency sound sources. The LTSAs are excellent summaries of the temporal and frequency variability in the data.
- **Decidecade box-and-whisker plots**: In these figures, the ‘boxes’ represent the middle 50% of the range of sound pressure levels measured, so that the bottom of the box is the sound level 25th percentile (L_{25}) of the recorded levels, the bar in the middle of the box is the median (L_{50}), and the top of the box is the level that exceeded 75% of the data (L_{75}). The whiskers indicate the maximum and minimum range of the data.
- **Spectral density level percentiles**: The decidecade box-and-whisker plots are representations of the histogram of each band’s sound pressure levels. The power spectral density data has too many frequency bins for a similar presentation. Instead, coloured lines are drawn to represent the L_{eq}, L_5, L_{25}, L_{50}, L_{75}, and L_{95} percentiles of the histograms. Shading is provided underneath these lines to provide an indication of the relative probability distribution. It is common to compare the power spectral densities to the results from Wenz (1962), which documented the variability of ambient spectral levels off the US Pacific coast as a function of frequency of measurements for a range of weather, vessel traffic, and geologic conditions. The Wenz levels are appropriate for approximate comparisons only because the data were collected in deep water, largely before an increase in low-frequency sound levels due to human activities (Andrew et al. 2011).
- **Daily sound exposure levels (SEL; $L_{E,\mathrm{24h}}$)**: The SEL represents the total sound energy received over a 24 h period, computed as the linear sum of all 1-minute values for each day. It has become the standard metric for evaluating the probability of temporary or permanent hearing threshold shift in marine mammals. Long-term exposure to sound impacts an animal more severely if the sounds are within its most sensitive hearing frequency range. Therefore, during SEL analysis, recorded sounds are typically filtered by the animal’s auditory frequency weighting function (Appendix E) before integrating to obtain SEL. For this analysis, the 10 Hz and above SEL were computed as well as the SEL weighted by the marine mammal auditory filters (NMFS 2018).

4.2.2. Directional Processing: Maximum Likelihood Beamforming

A maximum likelihood beamformer was applied to direction finding of the Station 4 acoustic data. For random continuous and impulsive signals, such as ship noise, anthropogenic noise, and marine animal vocalisations, the beamforming technique is reduced to Distance of Arrival (DOA) estimation. The sufficient statistic for random signals is the sampled covariance matrix,

$$\boldsymbol{C}(f,t) = \sum_{t}^{t+T_C} \boldsymbol{x}(f,t)\boldsymbol{x}^{+}(f,t)\,, \tag{1}$$

computed using N-dimensional DFT spectrums of array outputs, $\boldsymbol{x}(f,t) = [x_1(f,t),\dots,x_N(f,t)]^T$; where $x_n(f,t) = DFT\{x_n(t)\}$ is the short-time discrete Fourier Transform of the output of the *n*th hydrophone, $x_n(t)$. The output of the beamformer can be represented as:

$$P(f,t,\theta,\varepsilon) = \boldsymbol{w}^{+}(f,\theta,\varepsilon)\boldsymbol{C}(f,t)\boldsymbol{w}(f,\theta,\varepsilon)\,, \tag{2}$$

where $\boldsymbol{w}(f,\theta,\varepsilon) = [w_1(f,\theta,\varepsilon),\dots,w_N(f,\theta,\varepsilon)]^T$ is the N-dimensional vector of weighting coefficients of the array; and symbol “+” denotes transpose and complex conjugation, θ is the azimuth angle and ε is the estimation error. Figure 12 shows an example of the beamformer output in azimuth domain, $P(f,t,\theta,\varepsilon=0)$. In this figure, colour represents the azimuth. The azimuth and elevation estimates of random signals can be computed for each frequency f and time slice t as:

$$\{\hat{\theta}(f,t),\hat{\varepsilon}(f,t)\} = arg\max_{\theta,\varepsilon} P(f,t,\theta,\varepsilon)\,. \tag{3}$$

An example of the directional information we obtain from this approach is shown in Figure 12. The performance of the beamformer is presented in Urazghildiiev and Hannay (2017). This method is most effective between 50 and 3000 Hz. The direction of true North was obtained using AIS data compared to vessel movements observed in the acoustic data.

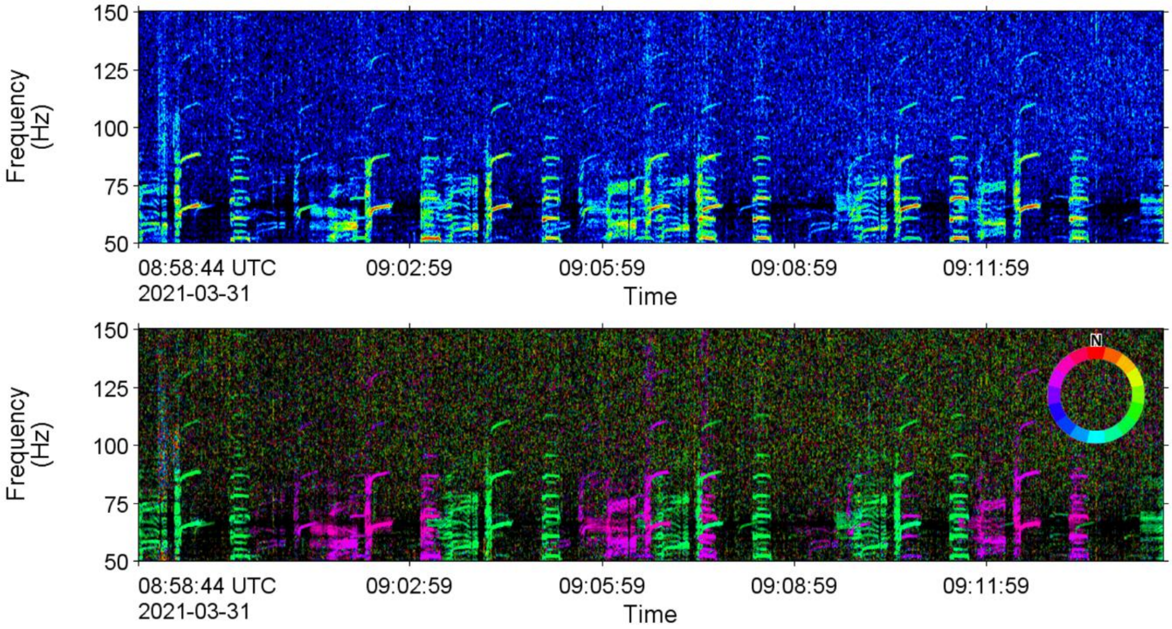


Figure 12. Spectrogram (top) versus directogram (bottom) of same data. In the directogram, colour represents the direction of arrival, with the colour legend shown in the top right corner. In the spectrogram, we cannot tell how many pygmy blue whales are vocalising; however, the directional information allows us to see that there were two animals singing.

4.2.3. Source Level Measurements with ShipSound

4.2.3.1. Overview

JASCO's ShipSound software monitors sound level measurements and AIS broadcasts from passing vessels. For vessel transiting scenarios, it identifies vessels that traverse a predefined transit area and then automatically extracts the corresponding acoustic data for analysis. It uses a vessel's broadcast speed together with a cepstral analysis of the Lloyd mirror pattern to determine the timing and location of closest point of approach (CPA) of the vessel's acoustic centre. For stationary sources, such as MODU or vessels in DP, it processes acoustic data within the specified period for the activity. ShipSound can analyse streaming data from a hydrophone in real time or, as in the case of the Beach Otway recorders, analyse archival hydrophone data downloaded from autonomous recorders. The vessel AIS data were based on Marine Traffic AIS data, vessel measurement logs, as well as client-provided data. AIS data were fed into the ShipSound system for vessel source level analysis. Environmental conditions, such as wind speed, were also recorded for each measurement. Ocean current data can be used to calculate speed through water (STW) from speed over ground (SOG) information received via AIS for each vessel measurement. However, current speed was not available in this project area, so STW was not calculated.

For transiting vessel measurements, the ANSI/ASA S12.64 data window is defined by the period over which the acoustic centre is within ±30° of the CPA. ShipSound can automatically determine the data window. For stationary sources, ShipSound determines the data window based on input specified time. ShipSound processes a single acoustic channel in 1-second periods stepped in 0.5-second intervals (Figure 13). Spectrum measurements are calculated using 1-second fast Fourier transforms, shaded using a Hanning window.

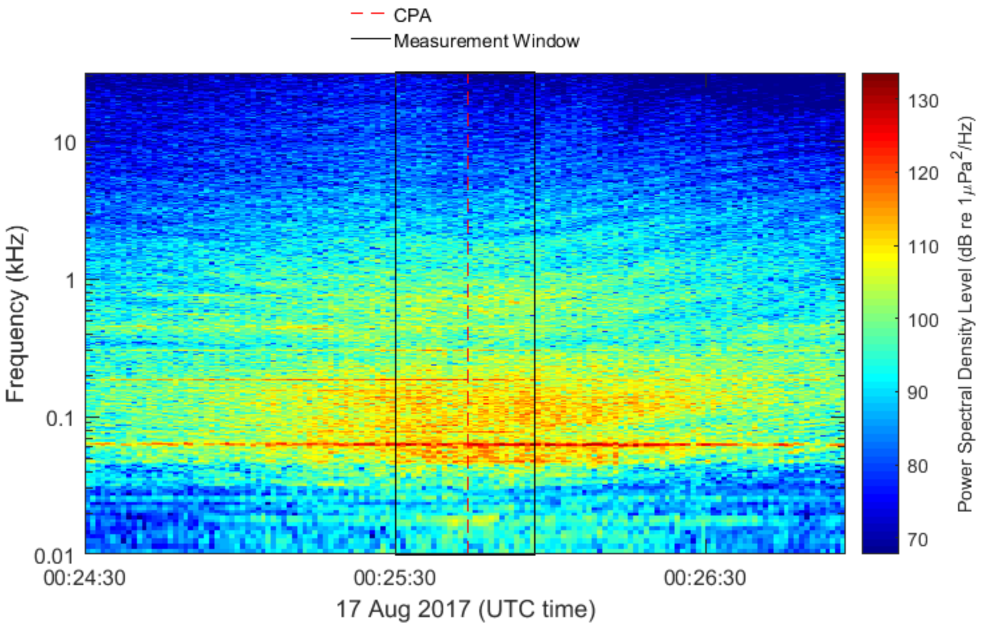


Figure 13. Spectrogram of a single transiting vessel measurement from ShipSound, showing the closest point of approach (CPA) time (dashed red line) and the measurement window (black box) used for calculating vessel source levels. The spectrogram shows the spectrum of the underwater sound pressure recorded on the hydrophone versus time and frequency.

ShipSound calculates two kinds of vessel source levels from the data window: Radiated Noise Level (RNL) and Monopole Source Level (MSL). RNL is equal to the measured sound pressure level, back-propagated according to the distance between a source and the hydrophone. The software applies the ANSI/ASA S12.64 Grade-A method for back-propagation distance: it determines instantaneous vessel range (R) in metres from the measurement hydrophone for each 1-second step within the data window. The RNL back propagation method of 20 x $\mathrm{Log}_{10}(R)$ is applied to the spectra of each step separately. MSL is equal to the measured sound pressure level scaled according to a numerical acoustic propagation loss (PL) model that accounts for the effect of the local environment on sound propagation (i.e., sea-surface reflection, water column refraction and absorption, and bottom loss). Since no single acoustic model is applicable at all sampled ranges and frequencies, a hybrid TL model was used to calculate MSL as follows:

1. At frequencies less than 4 kHz and ranges less than 120 m, PL was calculated using a wavenumber integration model (Hannay et al. 2010, Jensen et al. 2011), which computes reflection coefficients for layered elastic media (Brekhovskikh 1980).
1. At frequencies less than 4 kHz and ranges greater than 240 m, PL was calculated using a wide-angle parabolic equation model (Collins 1993), modified to treat reflection losses for an elastic seabed using a complex-density equivalent fluid approximation (Zhang and Tindle 1995).
2. At frequencies less than 4 kHz and ranges between 120 m and 240 m, PL was calculated from the average of the parabolic equation and wavenumber integration models.
3. At frequencies greater than 4 kHz, PL was calculated using an image-method model (Brekhovskikh and Lysanov 2003), which accounts for surface and seabed reflection coefficients and frequency-dependent absorption (François and Garrison 1982b).

Average TL in each decidecade band was based on the mean propagation factor calculated at 50 frequencies, which were spaced logarithmically between the minimum and maximum band limits. Mean source depth for the MSL calculation was taken to be:

1. For vessel transit, source depth is defined as shaft depth minus 0.7 of the propeller radius. The stern propeller diameter of 4.2 m was used for the calculation.
2. For vessel in DP, since all the thrusters were operating and each are at different depths, the source depth is defined as 0.7 times vessel static draft reported on AIS.
3. For the MODU, the source depth is defined as half the static draft reported on AIS, which gives 11 m of the source depth.

The TL was smoothed by assuming the source depth had a Gaussian distribution, in a manner similar to Wales and Heitmeyer (2002), where the standard deviation was taken to be 30% of the source depth. Additional details regarding the automated source level measurement system are given in Hannay et al. (2016b). ShipSound also calculates background noise in each frequency band. For vessel measurements, ShipSound only accepts measured source band levels if they exceed the background levels by 3 dB or more. ShipSound corrects the band levels if they exceed background levels by 3–10 dB but rejects them if they are less than 3 dB above background. Adjusted and rejected levels are flagged in the database. Figure 14 summarises this approach.

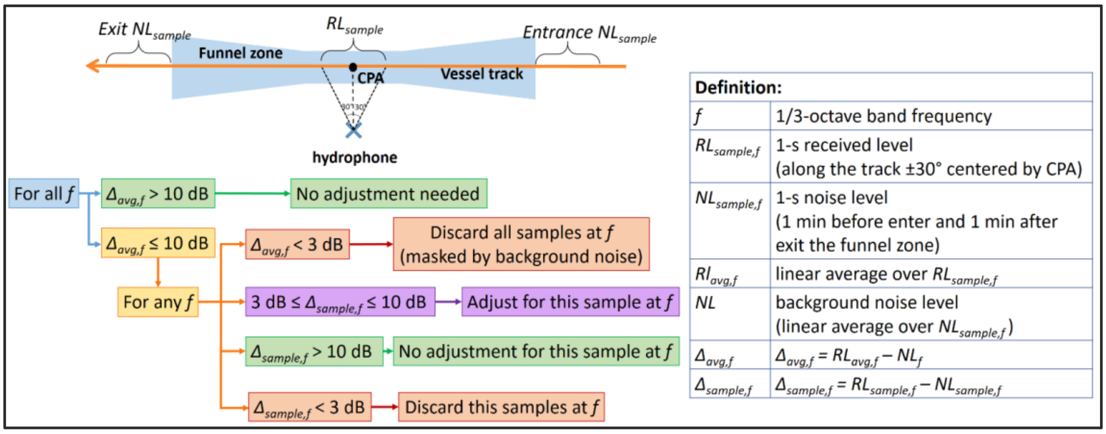


Figure 14. Background noise comparison and adjustment process.

PortListen includes a web-based user interface to access vessel and measurement information. A table view screen lets the user select and view multiple measurements by vessel criteria. This information, including broadband MSL and RNL source levels, can be exported as a spreadsheet. Vessel measurements are summarised in PDFs, presenting vessel and environment information, and the 1/3-octave-band MSL and RNL source levels. A manual quality review of every measurement was performed by an experienced analyst using the web-based interface. An analyst may reject a measurement because it contains interference from other vessels, has high levels of background noise, or if a vessel does not have constant speed and a straight track inside the data window.

MSL was the preferred metric for noise modelling because MSL back-propagation better accounts for the effect of the environment on vessel source levels (e.g., from absorption, surface, and seabed reflections) than RNL back-propagation. Measurements for vessel transits were obtained at different speeds, Ross's classical power law model (Ross 1976) was used to adjust the source levels to a reference speed. The change in source level (SL) to relative changes in speed:

$$\mathrm{SL} - \mathrm{SL}_{\mathrm{ref}} = C_v \times 10 \log_{10}\left(\frac{v}{v_{\mathrm{ref}}}\right). \tag{4}$$

In this equation, SL is the source level at speed v, $\mathrm{SL}_{\mathrm{ref}}$ is the source level at some reference speed v_{ref}, and $\mathrm{C_v}$ = 6, which is a coefficient corresponding to the slope of the curve.

4.2.3.2. MODU

The provided drill logs for the Artisan-1 well were reviewed to identify periods of activity defined as drilling, as this was the activity considered in the modelling study Koessler et al. (2020). Activities associated with mooring operations, cementing, installation of the Blow Out Preventer (BOP), or running casing were not considered. Twenty time periods for drilling were identified, and Long-term Spectral Averages (LSTAs) were created to review the data. From these data, 115 ten-minute time periods were identified as suitable or of interest for processing with ShipSound, listed in Table 8. Of these measurements, 70 were accepted (i.e., passed a manual quality review). Some measurements were rejected by the contamination of nearby vessels in DP (by checking both AIS data and noise spectrum). Source level measurements were matched with drill logs and the source levels were grouped by the drilling activities. The MSL was calculated over three different drilling depth ranges and presented as mean and maximum levels.

Table 8. Details of selected measurement periods for the *Ocean Onyx* mobile offshore drilling unit (MODU) and corresponding drill activities.

Drill activity	Date	Start	End	QC status
Spudded Artisan 1 at 2100 h. Drilled from 94.7 m (seabed) to 115 mMDRT. Pumped 100 bbl PHG sweep and took MWD survey at connection. Survey at 95.62 mMDRT: 0.82 deg inc, 13.97 deg azimuth. *Parameters*: 10–40 rpm, 3–5 kft-lbs torq, 8–10 klbs WOB, 600 gpm, 170 psi SPP	2021 Feb 23	10:05:00	10:15:00	Rejected
		10:25:00	10:35:00	Rejected
		10:55:00	11:05:00	Rejected
		11:00:00	11:10:00	Accepted
		11:25:00	11:35:00	Accepted
		11:45:00	11:55:00	Accepted
Continued drilling 26 × 42" hole from 115 to 171 m (SectionTD). Several small stringers encountered at 140 and 157 m. Pumped 100 bbl PHG sweep and took MWD survey at connection. Survey at 135 mMDRT: 0.5 deg inc. *Parameters*: 60 rpm, 3–5 kft-lb tq, 10 klbs WOB, 800–1,100 gpm, 400–550 psi SPP	2021 Feb 23	13:05:00	13:15:00	Accepted
		13:25:00	13:35:00	Accepted
		13:55:00	14:05:00	Accepted
		14:25:00	14:35:00	Rejected
		14:55:00	15:05:00	Accepted
		15:25:00	15:35:00	Accepted
		15:55:00	16:05:00	Rejected
		16:25:00	16:35:00	Rejected
		16:55:00	17:05:00	Accepted
		17:25:00	17:35:00	Accepted
		17:55:00	18:05:00	Rejected
		18:15:00	18:25:00	Accepted
Drilled 26 × 42” hole from 171 to 171.7 m with seawater at 60 rpm, 2 kft-lbs tq and 8 klbs WOB, 945 gpm with 400 psi.	2021 Feb 23	19:05:00	19:15:00	Accepted
		19:25:00	19:35:00	Rejected
		19:55:00	20:05:00	Rejected
Continued to drill 17.5” hole from 365 to 621 m with S/W and PHG sweeps. Pumped 50 bbls mid stand and spotted 100 bbls on around BHA at connections. Bubble watch in place on surface and ROV in TMS at LPWHH monitoring for shallow gas on sonar. *Parameters*: Flow: 1,100 gpm; Press: 2,240 psi; RPM: 80 surface. Total 201 Torque: 2–5 kft/lbs; WOB: 15–20 kft/lbs; Average ROP: 31 m/h P/U wt: 252 k, S/O 265 k, Rot 260 k.	2021 Feb 26	19:05:00	19:15:00	Rejected
		19:25:00	19:35:00	Accepted
		19:55:00	20:05:00	Accepted
		20:25:00	20:35:00	Accepted
		20:55:00	21:05:00	Accepted
		21:25:00	21:35:00	Accepted
		21:55:00	22:05:00	Accepted
		22:25:00	22:35:00	Accepted
		22:55:00	23:05:00	Rejected

		23:25:00	23:35:00	Accepted
	2021 Feb 27	23:55:00	00:05:00	Accepted
		00:25:00	00:35:00	Accepted
		00:55:00	01:05:00	Accepted
		01:25:00	01:35:00	Accepted
		01:55:00	02:05:00	Accepted
		02:25:00	02:35:00	Accepted
		02:55:00	03:05:00	Accepted
Held JHA for P/U and RIH with the 12 1/4"" BHA. Picked up and RIH with the 12 1/4"" BHA from surface to 50 m. Picked up the SLB motor and RIH from surface to 8.5 m. DSV confirmed that the motor configured with a 0.78 deg bend. Installed a non-ported, plunger type float valve into the motor-DSV on the drill floor and witnessed. Made up the SLB ARC-9 tool onto the motor and picked up the assembly above the RT and installed the 12 1/4"" PDC bit. Continued RIH with the BHA to 50 m.	2021 Mar 4	07:05:00	07:15:00	Rejected
		07:25:00	07:35:00	Rejected
		07:55:00	08:05:00	Rejected
		08:25:00	08:35:00	Rejected
		08:55:00	09:05:00	Rejected
		09:15:00	09:25:00	Accepted
Continued RIH with the 12 1/4"" BHA on 8 1/4"" DC. Picked up and made up 3x singles of 8 1/4"" DC, RIH from 50 to 80 m. Picked up and made up the 8"" Drilling Jar (with 2x 8 1/4"" DC) and continued RIH from 80-107 m. Picked up and made up the Jar Intensifier (with 2 x 8 1/4"" DC) and continued RIH from 107 to 135 m. Weight below the jars (40 klbs). Continued RIH with the 12 1/4"" BHA on 5 7/8"" Spiral HWDP. Made up 3x stand of 5 7/8"" spiral HWDP, RIH from 135 m to 220 mRT. Total string weight 65 klbs.	2021 Mar 4	09:35:00	09:45:00	Accepted
		09:55:00	10:05:00	Accepted
		10:25:00	10:35:00	Accepted
		10:55:00	11:05:00	Accepted
		11:25:00	11:35:00	Accepted
Continued RIH with the 12 1/4"" BHA on 5 7/8"" drill pipe from 220–278 m. Filled string on first stand of drill pipe.	2021 Mar 4	12:20:00	12:30:00	Accepted
		12:40:00	12:50:00	Accepted
PU off bottom 5 m. Staged up pump rate to drill out cement. Drilled out cement from 558 to 563 m. *Parameters*: ROP: 6.7 m/h; Flow: 750 gpm; Rotary: 30 rpm; SPP: 821 psi; WOB: 2–5 klbs; Off Bottom Tq: 1–2 kft-lbs; On Bottom Tq: 2–5 kft-lbs; ECD: 8.77 ppg	2021 Mar 4	16:35:00	16:45:00	Accepted
		16:50:00	17:00:00	Accepted
		17:05:00	17:15:00	Accepted
Continued drilling out cement with the 12 1/4"" BHA from 563 to 565 m. *Parameters*: ROP: 2.7 m/h; Flow 750 gpm; Rotary 30 rpm; SPP 821 psi; WOB-2–5 klbs; Off Bottom Tq 1–2 kft-lbs; On Bottom Tq 2–5 kft-lbs; ECD 8.77ppg	2021 Mar 4	18:15:00	18:25:00	Accepted
		18:30:00	18:40:00	Accepted
		18:45:00	18:55:00	Accepted
Continued to drill hard cement, float Collar and shoe track cement from 565 to 612 m (3 m from shoe) with seawater and 50 bbl PHG sweeps as required. *Parameters*: *ROP*: 13.4 m/h; Flow 800 gpm; Rotary 60 rpm; SPP 1000 psi; WOB 10–12 klbs; Off Bottom Tq 1–2 kft-lbs; On Bottom Tq 2–5 kft-lbs ECD 8.87 ppg; P/U weight 232 klbs; S/O weight 250 klbs; Rot weight 246 klbs	2021 Mar 4	19:05:00	19:15:00	Accepted
		19:25:00	19:35:00	Accepted
		19:55:00	20:05:00	Accepted
		20:25:00	20:35:00	Accepted
		20:55:00	21:05:00	Rejected
		21:25:00	21:35:00	Rejected
		21:55:00	22:05:00	Rejected
		22:25:00	22:35:00	Rejected
Drilled 12 1/4"" hole from 647 to 711 m. *Parameters*: Flow: 800 gpm; Press: 1,640 psi; RPM: 51 surface. 137 bit Torque: 1–3 kft/lbs; WOB: 4–5 kft/lbs; Average ROP: 21.3 m/h; P/U wt: 240 k, S/O 255 k, Rot 250 k. ESD: 10.1 ppg; ECD: 10.57 ppg	2021 Mar 5	10:05:00	10:15:00	Rejected
		10:25:00	10:35:00	Rejected
		10:55:00	11:05:00	Rejected
		11:25:00	11:35:00	Rejected
		11:55:00	12:05:00	Rejected
		12:25:00	12:35:00	Rejected

Drilled 12 1/4"" hole from 711 to 804 m. Parameters: Flow: 1002 gpm; Press: 2365 psi; RPM: 98 surface. 205 bit; Torque: 1–10 kft/lbs; WOB: 2–5 klbs; Average ROP: 46.5 m/h; P/U wt: 244 klbs, S/O 260 klbs, Rot 253 klbs. ESD: 10.18 ppg, ECD: 10.63 ppg	2021 Mar 5	13:05:00	13:15:00	Rejected
		13:25:00	13:35:00	Rejected
		13:55:00	14:05:00	Rejected
		14:25:00	14:35:00	Rejected
		14:45:00	14:55:00	Rejected
Drilled 12 1/4"" hole from 804 to 869 m. *Parameters*: *Flow*: 991 gpm; Press: 2390 psi; RPM: 99 surface. 206 bit; Torque: 2–5 kft/lbs; WOB: 2–5 kft/lbs; Average ROP: 18.57 m/h; P/U wt: 250 klbs, S/O 270 klbs, Rot 265 klbs. ESD: 10.2 ppg, ECD: 10.47 ppg	2021 Mar 5	15:35:00	15:45:00	Rejected
		15:55:00	16:05:00	Rejected
		16:25:00	16:35:00	Rejected
		16:55:00	17:05:00	Rejected
		17:25:00	17:35:00	Rejected
		17:55:00	18:05:00	Rejected
		18:25:00	18:35:00	Rejected
		18:45:00	18:55:00	Rejected
Drilled 12–1/4"" hole from 1,000 to 1,001 m. *Parameters*: Flow: 800 gpm; SPP: 2,650–2,800 psi; RPM: 79 surface/176 bit; Tq: Off 2 kft-lbs/On 5–15 kft-lbs. WOB: 5–20 klbs; Average ROP: 1 m/h; ESD: 10.11 ppg, ECD: 10.4 ppg; Slow drilling due to hard stringer. Boosted riser with 325 gpm at 75 psi.	2021 Mar 6	12:05:00	12:15:00	Accepted
		12:25:00	12:35:00	Accepted
		12:45:00	12:55:00	Accepted
Drilled ahead 12–1/4"" hole from 1,006 to 1014 m. *Parameters*: Flow: 900 gpm; SPP: 2,210 psi; RPM: 60 surface/170 bit; Tq: Off 1–2 kft-lbs/On 1–10 kft-lbs; WOB: 1–5 klbs P/U wt: 260 klbs, S/O wt: 280 klbs, Rot: 275 klbs; Average ROP: 8 m/h; ESD: 10.14 ppg, ECD: 10.52 ppg	2021 Mar 7	12:05:00	12:15:00	Accepted
		12:25:00	12:35:00	Accepted
		12:45:00	12:55:00	Accepted
Drilled ahead 12–1/4"" hole from 1,146 to 1,164 m. *Parameters*: Flow: 920 gpm; SPP: 2,330 psi; RPM: 100–120 surface/197–217 bit; Tq: Off 1–2 kft-lbs/On 1–10 kft-lbs; WOB: 1–5 klbs P/U wt: 266 klbs, S/O wt: 288 klbs, Rot: 285 klbs. Average ROP: 24 m/h. ESD: 10.39 ppg, ECD: 10.68 ppg	2021 Mar 7	18:20:00	18:30:00	Accepted
		18:40:00	18:50:00	Accepted
Drilled ahead 12–1/4"" hole from 1,433 to 1,545 m. *Parameters*: Flow: 1,000 gpm; Boost Pump: 250 gpm; SPP: 3,000 psi; RPM: 120 surface/217 bit; Tq: Off 1–2 kft-lbs/On 5–10 kft-lbs; WOB: 5–15 klbs P/U wt: 300 klbs, S/O wt: 325 klbs, Rot: 315 klbs; Average ROP: 18.6 m/h; ESD: 11.18 ppg, ECD: 11.37 ppg; Offline: Displaced the Boost line and flushed the MGS utilising the boost pump-total of 20 strokes pumped (10 bbls). At 1,510 m MW over the shakers recorded at 10.7 ppg (ESD-10.88 ppg). Ceased centrifuging and weighted up the mud with additions of barite. MW at 1543 m recorded at 11.1 ppg.	2021 Mar 8	13:05:00	13:15:00	Accepted
		13:25:00	13:35:00	Accepted
		14:25:00	14:35:00	Accepted
		14:55:00	15:05:00	Accepted
		15:25:00	15:35:00	Accepted
		15:55:00	16:05:00	Accepted
		16:25:00	16:35:00	Accepted
		16:55:00	17:05:00	Accepted
		17:25:00	17:35:00	Accepted
		17:55:00	18:05:00	Accepted
		18:25:00	18:35:00	Accepted
		18:45:00	18:55:00	Accepted
Continued to drill 12–1/4” hole from 1,623 to 1,655 m. *Parameters*: Flow: 805 gpm; SPP: 2,135 psi; RPM: 120 surface/206 bit; Tq: Off 1–2 kft-lbs/On 4–15 kft-lbs; WOB: 5–15 klbs; P/U wt: 310 klbs, S/O wt: 330 klbs, Rot: 325 klbs; Average ROP: 11m/h including connections; ESD: 11.13 ppg; ECD: 11.39 ppg	2021 Mar 9	08:45:00	08:55:00	Rejected
		09:10:00	09:20:00	Rejected
		09:40:00	09:50:00	Accepted
		10:10:00	10:20:00	Accepted
		10:40:00	10:50:00	Accepted

		11:10:00	11:20:00	Accepted
		11:35:00	11:45:00	Accepted
Continued to drill 12–1/4” hole from 1,830 to 1,851 m. *Parameters*: Flow: 920 gpm; SPP: 2,750 psi; RPM: 100 surface/198 bit; Tq: Off 1–2 kft-lbs/On 3–10 kft-lbs.; WOB: 10–20 klbs; P/U wt: 320 klbs, S/O wt: 345 klbs, Rot: 325 klbs; Average ROP: 19.3 m/h including connections. ECD: 11.40 ppg; ROP controlled to max 30 m/h for flow rate, mud rheology and surface equipment.	2021 Mar 10	01:35:00	01:45:00	Accepted
		01:55:00	02:05:00	Accepted
		02:25:00	02:35:00	Accepted
		02:45:00	02:55:00	Accepted

4.2.3.3. Vessels

ShipSound was used to process a total of 4 vessel DP measurements collected from Station 2, five vessel transit measurements collected from Station 2, and 16 vessel transit measurements collected from Station 4. All these measurements were accepted measurements. Details of the measurements were shown in Table 9. The classical power law model of Ross (1976) was used to calculate source levels to a referenced speed (Section 4.2.3.1), with the speed scaling coefficients C_v = 6 proposed by Ross (1976).

Table 9. Vessel measurements collected from Stations 2 and 4.

MMSI	Vessel	Activity	Speed (kn)	CPA time	CPA distance (m)	QC status
Station 2						
257544000	SIEM *SAPPHIRE*	DP	0.6	2021 Feb 4 01:23:00	162.3	Accepted
257544000	SIEM *SAPPHIRE*	DP	0.6	2021 Feb 4 01:38:30	183.9	Accepted
257544000	SIEM *SAPPHIRE*	DP	0.6	2021 Feb 4 01:47:30	182.6	Accepted
257544000	SIEM *SAPPHIRE*	DP	0.8	2021 Feb 4 02:00:00	185.6	Accepted
257544000	SIEM *SAPPHIRE*	Transit	8	2021 Feb 4 02:32:48	189.4	Accepted
257544000	SIEM *SAPPHIRE*	Transit	6.9	2021 Feb 4 08:10:52	165.6	Accepted
257544000	SIEM *SAPPHIRE*	Transit	7.7	2021 Feb 4 08:29:14	165.5	Accepted
257544000	SIEM *SAPPHIRE*	Transit	6.5	2021 Feb 4 08:45:40	184.6	Accepted
257544000	SIEM *SAPPHIRE*	Transit	7.9	2021 Feb 4 09:01:22	160.7	Accepted
Station 4						
257544000	SIEM *SAPPHIRE*	Transit	9.3	2021 Feb 5 15:02:57	187.6	Accepted
257662000	SIEM *AQUAMARINE*	Transit	9.3	2021 Feb 15 02:33:00	147.7	Accepted
257544000	SIEM *SAPPHIRE*	Transit	6.3	2021 Feb 15 04:19:19	128.9	Accepted
257709000	SIEM *TOPAZ*	Transit	8.8	2021 Feb 17 06:50:05	121.5	Accepted
257709000	SIEM *TOPAZ*	Transit	10.4	2021 Feb 20 08:38:36	118.2	Accepted
257709000	SIEM *TOPAZ*	Transit	10	2021 Feb 23 17:11:01	113.8	Accepted
257662000	SIEM *AQUAMARINE*	Transit	14.7	2021 Feb 25 10:35:02	133.4	Accepted
257662000	SIEM *AQUAMARINE*	Transit	10.1	2021 Feb 27 18:45:40	118.9	Accepted
257544000	SIEM *SAPPHIRE*	Transit	9.9	2021 Mar 1 05:41:49	108.7	Accepted
257544000	SIEM *SAPPHIRE*	Transit	8.6	2021 Mar 3 21:48:03	120.6	Accepted
257662000	SIEM *AQUAMARINE*	Transit	8.2	2021 Mar 8 05:01:58	120.1	Accepted
257662000	SIEM *AQUAMARINE*	Transit	9.4	2021 Mar 10 21:56:02	35.3	Accepted
257709000	SIEM *TOPAZ*	Transit	6.6	2021 Mar 13 00:22:58	118.7	Accepted
257544000	SIEM *SAPPHIRE*	Transit	8.7	2021 Mar17 12:14:59	124.8	Accepted
257662000	SIEM *AQUAMARINE*	Transit	10.1	2021 Mar 21 06:29:56	144.5	Accepted
257662000	SIEM *AQUAMARINE*	Transit	11.1	2021 Mar 23 09:51:01	131.0	Accepted

4.2.4. Fit Equations

For each minute of data at each station, the analysis provided the range and received sound levels, with the metric of interest being SPL. To be able to understand the trends of the change in sound levels with range, and to interpolate the sound levels in between the measurement locations, it is required to obtain equations which represent the measurement data. The data were fit using linear models from ‘R’ (R Core Team 2020) of the form:

$$\text{model} = lm(\text{SPL}\sim \log(range) + range)\,. \tag{5}$$

The tilde (~) is used to separate the left- and right-hand sides in a model formula. The models provide the following values that fit the data:

- An intercept,
- Coefficients multiplied by log10(range), and
- Range.

The coefficient of log10(range) may be interpreted as the average geometric spreading for the environment. The coefficient of range may be interpreted as an additional loss term that models the effects of reflection and scattering when the sound interacts with the surface and seabed. This simple model formulation is valid when:

- There are no systematic changes to the geometric spreading–i.e., it is not valid very close to the Ocean Onyx and associated vessel movements within the 500 m zone where DP is required,
- The seabed geoacoustic properties are approximately constant, and
- The water depth does not significantly vary.

The models were used to predict the most likely data values for ranges of 20 to 6000 m, as well as the 90% prediction interval. The top of the prediction interval corresponds to the value that is greater than 95% of the measured data. The distance to 95% of the measured data is not the same as the $R_{95\%}$ range determined through modelling.

The coefficient of determination (r2) was used to assess the validity of the fit, with fits where r2 was less than 0.85 being flagged as suspect.

The per-minute SPL at each station was influenced by both the operations centred on the Ocean Onyx and sound sources close to each station. To create a model which focuses on understanding the trends of the change in sound level with range in relation to activities closes to Station 1, the data was split into three different sets. The data was therefore presented in the following ways:

- All per-minute SPL data from Station 1–3 while the Ocean Onyx was operational (01:00 12 Feb through until 00:00 25 Mar)
- Per-minute SPL data for per-minute SPL at Station 1 between 130 and 150 dB re 1µPa, thereby excluding periods when high noise levels, likely due to a close support vessel, or support vessels operating at high thrust levels which might skew the fit.
- Per-minute SPL data for per-minute SPL at Station 1 over 150 dB re 1µPa, to examine the trends in change in sound level with range for notably loud period at Station 1.
- The low-frequency weighted per-minute SPL can be adjusted by $10*\log_{10}(T)$, where T is 1440 (the number of minutes in 24 h) to determine the daily SEL for each of the three data sets.

4.2.5. Vessel Noise Detection

Outside of the specific individual vessel analysis requirements, vessels are detected in two steps (Martin 2013):

1. Detect constant, narrowband tones produced by a vessel's propulsion system and other rotating machinery (Arveson and Vendittis 2000). These sounds are also referred to as tonals. We detect the tonals as lines in a 0.125 Hz resolution spectrogram of the data (8 s of data, Hann window, 2 s advance).
2. Assess the SPL for each minute in the 40–315 Hz shipping frequency band, which commonly contains most sound energy produced by mid-sized to large vessels. Background estimates of the shipping band SPL and system-weighted SPL are then compared to their mean values over a 12 h window, centred on the current time.

Vessel detections are defined by the following criterion (Figure 15):

1. SPL in the shipping band (40–315 Hz) is at least 3 dB above the 12 h mean for the shipping band for at least 5 min.
2. AND at least three shipping tonals (0.125 Hz bandwidth) are present for at least 1 min per 5 min window. Tonals are difficult to detect during turns and near the closest points of approach (CPA) due to Lloyds' mirror and Doppler effects.
3. AND SPL in the shipping band is within 12 dB of the system weighted SPL.

The duration where these constraints are valid is identified as a period with shipping present. A 10 min shoulder period before and after the detection period is also included in the shipping period. The shipping period is searched for the highest 1 min SPL in the vessel detection band, which is then identified as the CPA time. This algorithm is designed to find detectable shipping, meaning situations where the vessel noise can be distinguished from the background. It does not identify cases of two vessels moving together or cases of continuous noise from stationary platforms, such as oil and gas drilling and dynamic positioning operations. Those situations are easily identified from tools such as the daily SEL and long-term spectral average figures.

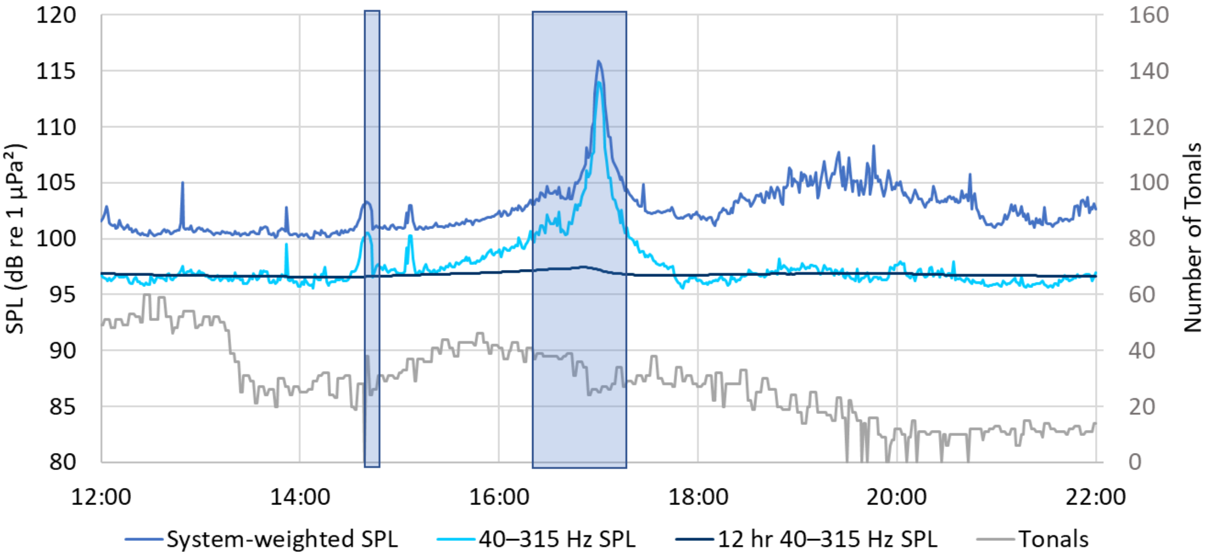


Figure 15. Example of broadband and 40–315 Hz band sound pressure level (SPL), as well as the number of tonals detected per minute as a vessel approached a recorder, stopped, and then departed. The shaded area is the period of shipping detection. Fewer tonals are detected at the vessel's closest point of approach (CPA) at 17:00 because of masking by broadband cavitation noise and due to Doppler shift, that affects the tone frequencies.

4.2.6. Seismic Survey Event Detection

Seismic pulse sequences were looked for using correlated spectrogram contours. The processing calculated spectrograms using a 300 s long window with 4 Hz frequency resolution and a 0.05 s time resolution (Reisz window). All frequency bins were normalised by their medians over window the 300 s window. The detection threshold was set to three times the median value at each frequency. If pulses were found, contours were created by joining the time-frequency bins above threshold in the 7–1000 Hz band using a 5 × 5 bin kernel. Contours 0.2–6 s in duration with a bandwidth of at least 60 Hz are then further analysed.

The process is used to create an "event" time series by summing the normalised value of the frequency bins in each time step that contained detected contours. The event time series is auto correlated to look for repeated events. The correlated data space was normalised by its median, and a detection threshold of 3 was applied. Peaks larger than their two nearest neighbours can be identified, and the list of peaks searched for entries with a set repetition interval. The allowed spacing between the minimum and maximum time peaks was 4.8–65 s, which captures the normal range of seismic pulse periods. If at least six regularly spaced peaks occur, the original event time series is searched for all peaks that match the repetition period within a tolerance of 0.25 s. The duration of the 90% SPL window of each peak can be determined from the originally sampled time series, and pulses more than three second long were rejected.

Despite the flexibility of the detection process, no impulses were detected, and thus no results are presented for seismic survey impulses.

4.2.7. Marine Mammal Detection Overview

We used a combination of automated detector-classifiers (referred to as automated detectors) and manual review by experienced analysts to determine the presence of sounds produced by marine mammals in the acoustic data. First, a suite of automated detectors was applied to the full data set (Appendices D.1 and D.2). Second, a subset (0.5%) of acoustic data was selected for manual analysis of marine mammal acoustic occurrence. The subset was selected based on automated detector results via our Automatic Data Selection for Validation (ADSV) algorithm (Kowarski et al. 2021) (Appendix D.3). Third, manual analysis results were compared to automated detector results to determine automated detector performance (Appendix D.4). Finally, hourly marine mammal occurrence plots were created that incorporated both manual and automated detections as well as automated detector performance metrics to provide a reliable representation of marine mammal presence in the acoustic data (Section 5.7). These marine mammal analysis steps are summarised here and described in detail in Appendix D.

4.2.7.1. Automated Click Detection

Odontocete clicks are high-frequency impulses ranging from 5 to over 150 kHz (Au et al. 1999, Møhl et al. 2000). We applied an automated click detector to the acoustic data to identify clicks from sperm whales and delphinids. This automated detector is based on zero-crossings in the acoustic time series. Zero-crossings are the rapid oscillations of a click's pressure waveform above and below the signal's normal level (e.g., Figure D-1). Zero-crossing-based features of automatically detected events are then compared to templates of known clicks for classification (see Appendix D.1 for details).

4.2.7.2. Automated Tonal Signal Detection

Tonal signals are narrowband, often frequency-modulated, signals produced by many species across a range of taxa (e.g., baleen whale moans and delphinids whistles). They range predominantly between 15 Hz and 20 kHz (Steiner 1981, Berchok et al. 2006, Risch et al. 2007). The automated tonal signal detector identified continuous contours of elevated energy and classified them against a library of marine mammal signals (see Appendix D.2 for details).

4.2.7.3. Evaluating Automated Detector Performance

JASCO's suite of automated detectors are developed, trained, and tested to be as reliable and broadly applicable as possible. However, the performance of marine mammal automated detectors varies across acoustic environments (e.g., Hodge et al. 2015, Širović et al. 2015, Erbs et al. 2017, Delarue et al. 2018). Therefore, automated detector results must always be supplemented by some level of manual review to evaluate automated detector performance. Here, we manually analysed a subset of 5 min acoustic files for the presence/absence of marine mammal acoustic signals via spectrogram review in JASCO's PAMlab software. A subset (0.5%) of acoustic data from each station was selected via ADSV for manual review (Appendix D.3).

To determine the performance of the automated detectors at each station per 5 min acoustic file, the automated and manual results (excluding files where an analyst indicated uncertainty in species occurrence) were fed into an algorithm that calculates precision (*P*), recall (*R*), and Matthew's Correlation Coefficient (*MCC*) (see Appendix D.4 for formulas). *P* represents the proportion of files with detections that are true positives. A *P* value of 0.90 means that 90% of the files with automated detections truly contain the targeted signal, but it does not indicate whether all files containing acoustic signals from the species were identified. *R* represents the proportion of files containing the signal of interest that were identified by the automated detector. An *R* value of 0.90 means that 90% of files known to contain a target signal had automated detections, but it says nothing about how many files with automated detections were incorrect. An MCC is a combined measure of *P* and *R*, where an MCC of 1.00 indicates perfect performance–all events were correctly detected. The algorithm determines a per file automated detector threshold (the number of automated detections per file at and above which automated detections were considered valid) that maximizes the MCC.

The acoustic occurrence of each species (both automated and manual results) was plotted using JASCO's Ark software as time series showing presence/absence by hour over each day of the recording period. Automated detector performance metrics are provided alongside these figures and should be considered wen interpreting results.

4.3. Modelling Validation

In order to validate the modelled predictions presented in Koessler et al. (2020), the calculated Monopole Source Levels (MSLs), which were computed from measured data using the method outlined in Section 4.2.3, were used to update the acoustic model inputs for the scenarios from Koessler et al. (2020). This process yielded new ranges to thresholds based on in-situ measured data. Only the scenarios for Artisan (i.e., Scenario 5 – 8 in Koessler et al. (2020)) were consider for a validation exercise.

The following process was implemented for updating the inputs to the acoustic model.

1. Update the sound speed profile to use predictions from the Global Ice Ocean Prediction System (GIOPS) forecasting system for the period when the data was acquired. Determine and median profile to best represent potential propagation conditions over the February 2021 – March 2021 periods.
2. Update the decidecade MSLs and MSL source depth based on the results of the ShipSound analysis presented in Section 5.5.
3. Re-run all propagation modelling, gridding and radii calculations as detailed in Koessler et al. (2020) with these updated input parameters for all scenarios.

During this process, the data fit plots discussed in Section 4.2.4 and presented Section 5.3 were reviewed in the context of results from previous modelled scenarios and newly acquired MSLs to infer the appropriateness of the seabed selection for the Artisan development area and its effect on the distances to thresholds. Further detail can be found in Section 6.2.

5. Results

5.1. Soundscape Characterisation

Long-term spectra averages, power spectral density, and decidecade band box plots are shown in Figure 16 for all stations during the period the *Ocean Onyx* was moored (01:00 12 Feb through 00:00 25 Mar 2021), with the decade band percentile levels presented in Table 10.

The same plots are presented for two examples of operational activity at the *Ocean Onyx* (Table 8), Figure 17, from 5 Mar 2021, which included resupply and drilling operations, and Figure 18, from 26 Feb 2021, for a drilling operations with support vessels further from the *Ocean Onyx*.

5.1.1. Spectrograms and Statistical Analysis

The spectrogram and band-level plots for all stations (Figure 16) provide an overview of the sound variability in time and frequency presenting an overview of presence and level of contribution from different sources. Short-term events appear as vertical stripes on the spectrograms and spikes on the band level plots. Long-term events affect (increasing or decreasing accordingly) the band level over the event period and appear in the spectrograms as horizontal bands of colour.

The most prominent feature to note is the decrease in sound level with distance from the drill rig. Stations 1 and 2, located 336 m and 1132 m from the platform respectively, demonstrate elevated sound levels across all frequencies, but particularly at frequencies under approximately 2000 Hz. This is consistent with the bands most typically impacted by seismic and pressure fluctuations, as well as vessel noise, as can be seen in the Wenz curves of Figure 9. At these two stations, the L_{50} and above, as well as the L_{mean} percentiles exceed the upper limit of the Wenz curve across all frequencies. At Stations 3 and 4, located 5 km and 25 km from the platform respectively, the sound levels are much reduced. Station 3 still receives some sound energy emitted from the platform and associated operations, whereas these contributions are not notable within Station 4’s soundscape, as can be seen in the two right side panels of Figure 16. The soundscape of these two stations is more influenced by vessel traffic, apparent by the ‘ripples’ in the L_{mean} percentiles between 40 and approximately 100 Hz, which are due to narrowband tones produced by vessel propulsion systems.

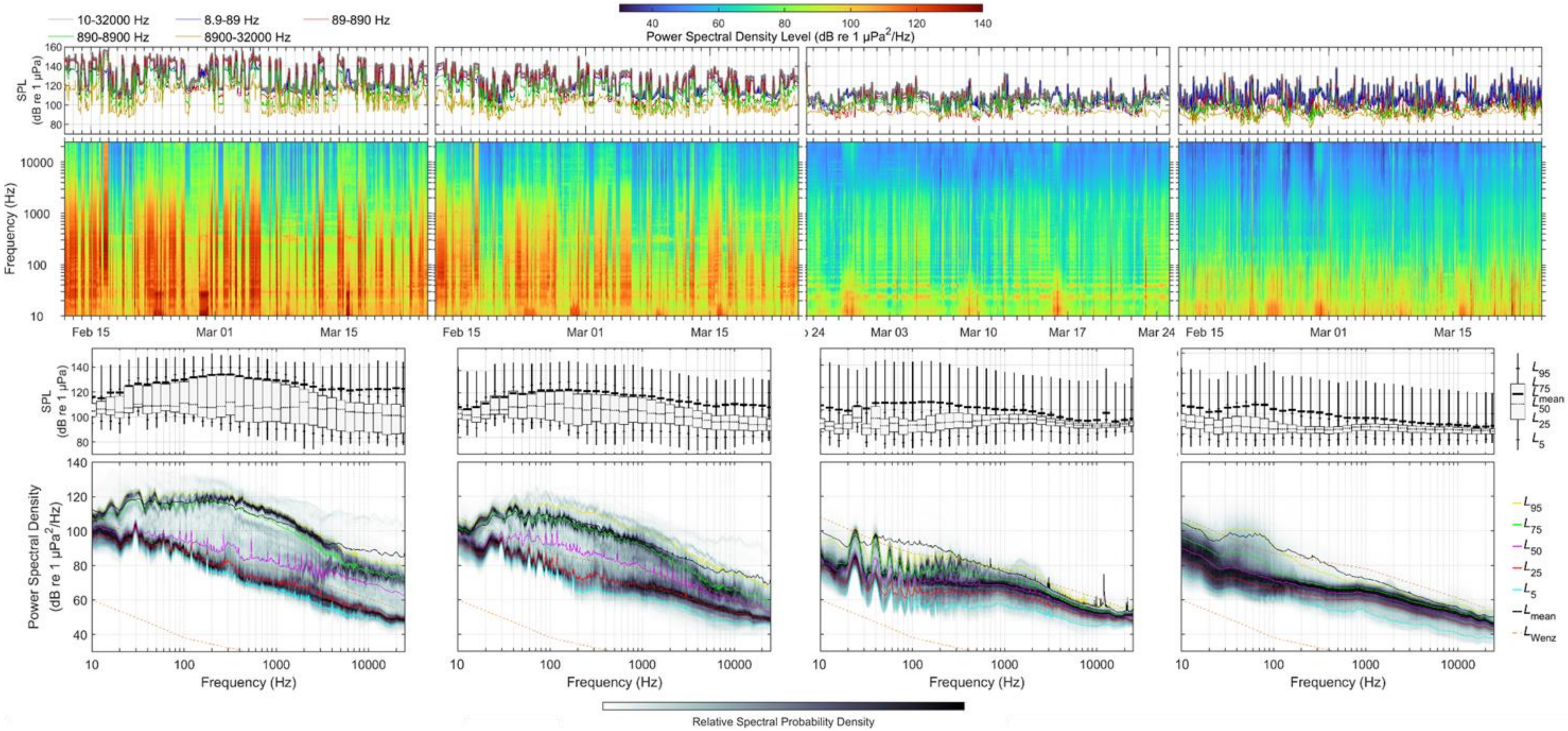


Figure 16. *Entire Ocean Onyx moored period*: (Top row) In-band sound pressure level (SPL) and spectrogram (or long-term spectral average; LTSA) of underwater sound, (bottom row) percentiles and mean of decidecade sound pressure level (SPL) and percentiles and probability density (grayscale) of 1-min power spectral density levels, by station compared to the Wenz curve limits (coloured lines) of prevailing noise (Wenz 1962), for 01:00 12 Feb through until 00:00 25 Mar, for Stations 1, 2 and 4, or from 12:00 24 Feb for Station 3.

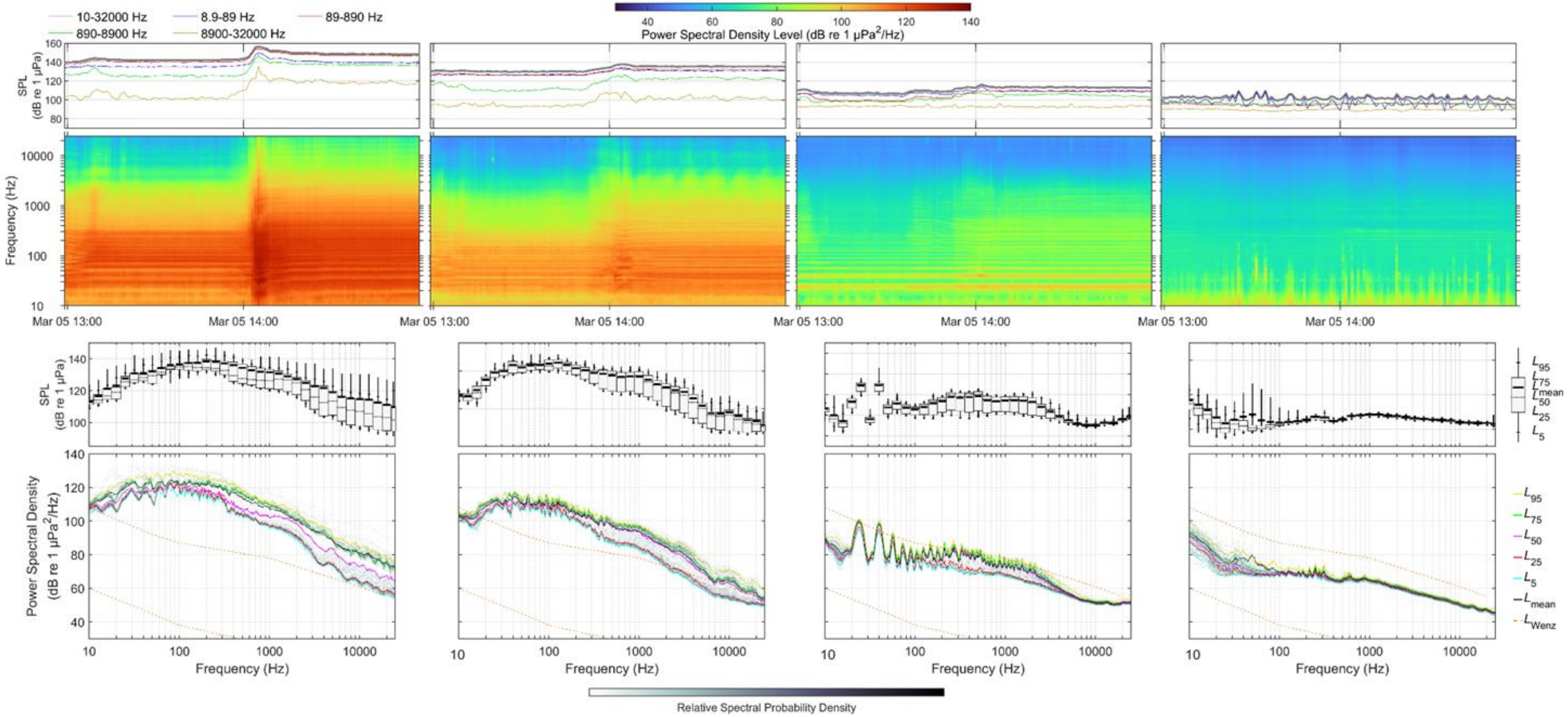


Figure 17. *Drilling and vessel operation 5 Mar 2021*: (Top row) In-band sound pressure level (SPL) and spectrogram (or long-term spectral average; LTSA) of underwater sound, (bottom row) percentiles and mean of decidecade sound pressure level (SPL) and percentiles and probability density (grayscale) of 1-min power spectral density levels, by station for a drilling period on 5 Mar 2021 (Table 8) which included resupply and support vessels, compared to the Wenz curve limits (coloured lines) of prevailing noise (Wenz 1962).

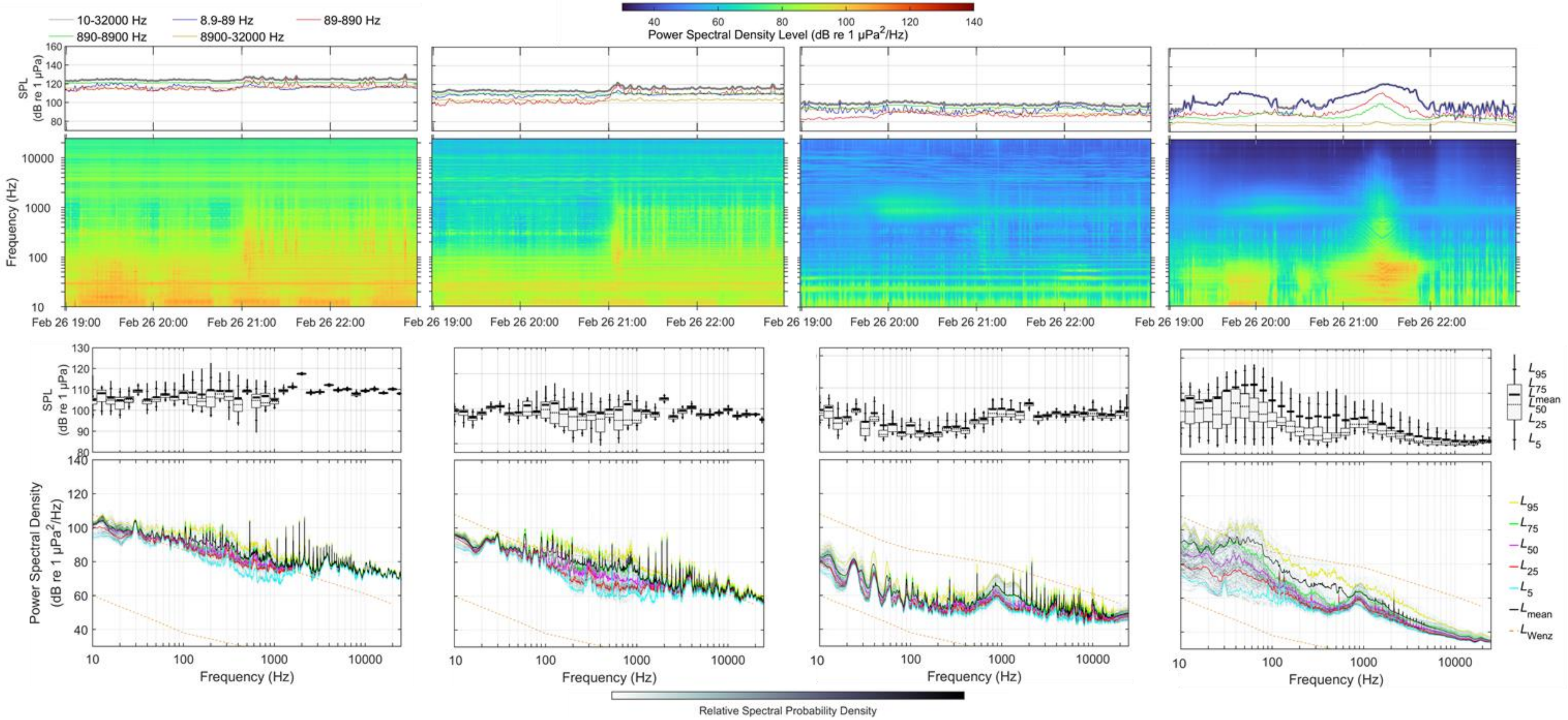


Figure 18. *Drilling operations 26 Feb 2021*: (Top row) In-band sound pressure level (SPL) and spectrogram (or long-term spectral average; LTSA) of underwater sound, (bottom row) percentiles and mean of decidecade sound pressure level (SPL) and percentiles and probability density (grayscale) of 1-min power spectral density levels, by station for a drilling period on 5 Mar 2021 compared to the Wenz curve limits (coloured lines) of prevailing noise (Wenz 1962).

Table 10. Statistical a0nalysis of sound levels while *Ocean Onyx* was moored, 01:00 12 Feb through until 00:00 25 Mar 2021, for Stations 1, 2, and 4, or from 12:00 24 Feb 2021 for Station 3. SPL units: dB re 1 µPa.

Sound level statistic	Station	Sound level				
		10–32000 Hz	8.9–89 Hz	89–890 Hz	890–8900 Hz	8900–32000 Hz
Minimum	1	107.6	105.1	102.2	92.5	85.5
	2	101.1	98.5	92.6	83.1	82.2
	3	91.9	83.5	80.1	82.6	84.4
	4	86.6	79.3	80.2	80.9	77.2
L_{5}	1	112.9	110.7	106.7	98.1	90.7
	2	107	105.1	98.4	94.5	89.5
	3	97.5	89.4	87.6	91.5	89
	4	96.3	88.4	87.3	86.4	82
L_{25}	1	117.1	114.2	110.6	103.7	94.3
	2	112	109.1	104.1	101.9	93.5
	3	102.1	94.4	94.1	96.8	92
	4	101.1	95.5	92.6	92.6	87.7
L_{50}	1	124.6	118.3	119.7	119.3	109.6
	2	121.3	116.2	117.4	110.7	99.5
	3	106.4	101.3	99.2	100.2	93.7
	4	104.5	101.8	95.9	96.2	90.9
L_{75}	1	143.8	135.4	142.4	132.6	117.2
	2	132.1	127.8	129.5	119.9	105.8
	3	111.3	107.8	105.7	103.5	95
	4	110.1	109.2	99.1	98.7	93.1
L_{95}	1	149	139.4	147.8	139.8	124.3
	2	141.3	133.6	138.9	130.2	114.1
	3	115.8	111.8	111.3	110.2	98.8
	4	120.7	120	109.8	102	98.2
Maximum	1	159	155	156.5	152.6	151.3
	2	158.6	154.2	156.2	147.9	139.3
	3	153.4	150	150.4	139.8	137.4
	4	153.6	153.1	145.1	138.6	128.6
Mean	1	144	135.5	142.3	135.7	129.6
	2	133.4	127.5	131.3	123.6	116
	3	117.8	114	114.8	106.8	99.9
	4	118.3	117	111.7	103.2	95.1

5.1.2. Frequency Weighted Sound Exposure Levels

The perception of underwater sound depends on the hearing sensitivity of the receiving animal in the frequency bands of the sound. Hearing sensitivity in animals, however, varies over the frequency band of their hearing (the hearing curve (audiogram) usually resembling a U-shaped form). The frequency range of hearing and hearing sensitivity differ between species, resulting in the fact that different species will perceive underwater sound differently. Auditory (frequency) weighting functions (Appendix E) are applied to account for this difference as they reflect an animal's ability to hear a sound, emphasising the frequency band of best sensitivity over frequencies animals do not hear well. Figure 19 shows the difference between perceived ambient noise by low-, mid- and high frequency cetaceans. Similar to the figures in Section 5.1.1, Figure 19 demonstrates the decrease in sound levels with distance from the drilling platform. Station 4 is more exposed to general shipping traffic within the shipping lanes when compared to Station 3 (Figure 3), and thus its daily SEL were more variable, being less influenced or driven by activity close to the *Ocean Onyx* more by the frequency of shipping traffic. The low-frequency cetacean weighted daily SEL for all stations, along with the thresholds for PTS and TTS (Section 2.6) are shown in Figure 20.

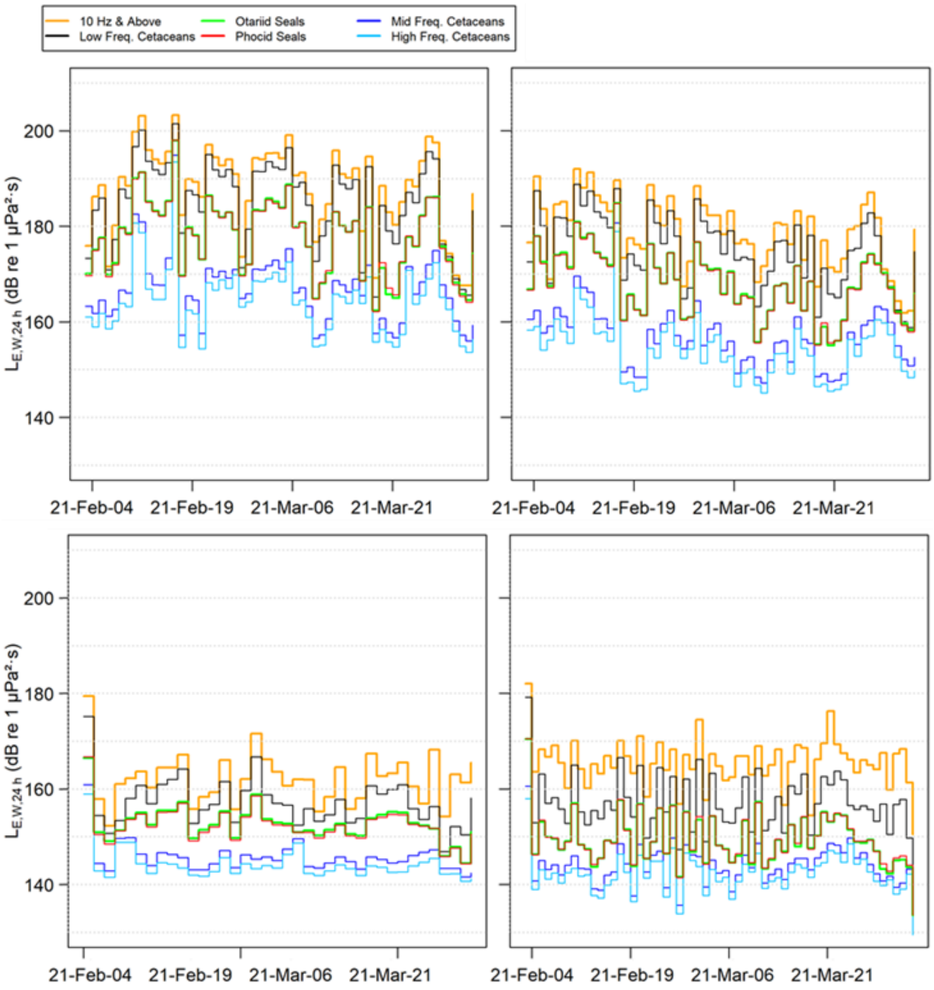


Figure 19. Auditory frequency weighted ambient noise (10 Hz and above) over the measurement period shown as daily sound exposure levels (SEL) (NMFS 2018). (Top left to right) Stations 1 and 2 and (bottom left to right) Stations 3 and 4. Locations are provided in Table 4.

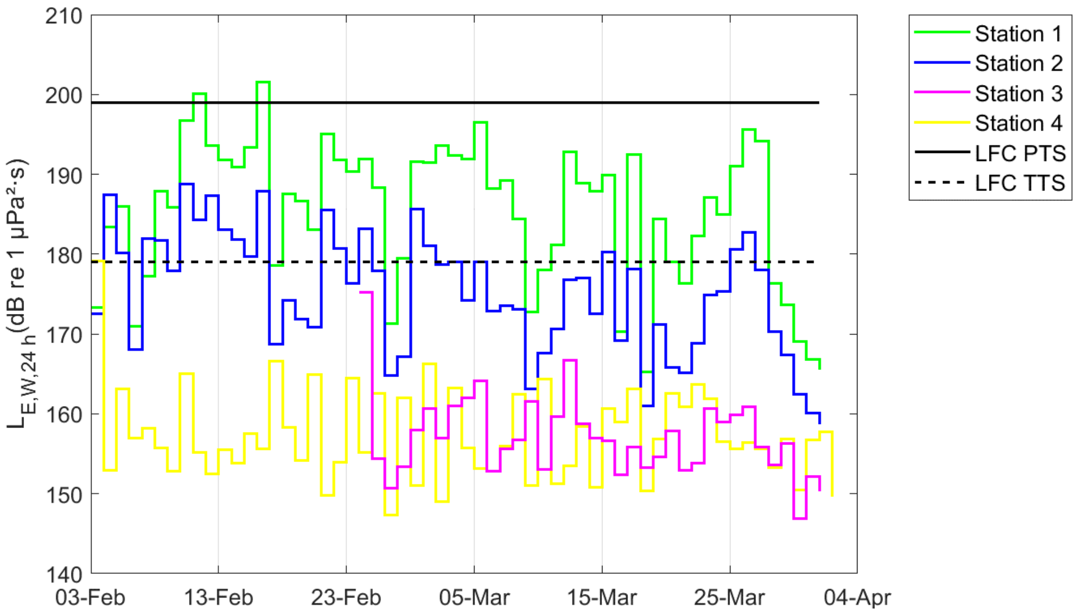


Figure 20. Daily low-frequency cetacean (LFC) weighted sound exposure levels (SEL) (NMFS 2018) at each station (composite created from Figure 19, station locations provided in Table 4), including thresholds for permanent threshold shift (PTS) and temporary threshold shift (TTS) (Table 6).

5.2. Environmental Correlations

The environmental conditions during the drilling period, specifically the wave height and wind speed, were compared to sound pressure levels during the drilling period in the 20 Hz, 80 Hz, 630 Hz, 3150 Hz, and 125000 Hz decidecade bands in the correlograms in Figure 21. Correlograms offer two ways to visualise correlations between two variables: the upper right panels show the scatter plot between each variable pair, and the bottom left show the strength of the correlation both by amount of the circle filled and depth of the colour. Blue represents a positive correlation, and red a negative. The four panels show Stations 1 to 4, respectively. The impact of wind and wave conditions on underwater soundscape is generally above 100 Hz, as shown in Figure 9 (Wenz 1962).

Stations 1 and 2, at 336 and 1132 m from the drill rig respectively, show very little correlation of sound level at any band with wind or wave conditions. At these stations, the soundscape was dominated by drilling operations. As the distance to the station increases, i.e., for Stations 3 and 4 at 5 and 25 km, the wind speeds and wave heights have a positive correlation with sound levels, although the relationship with wind speed is much stronger than that for wave height.

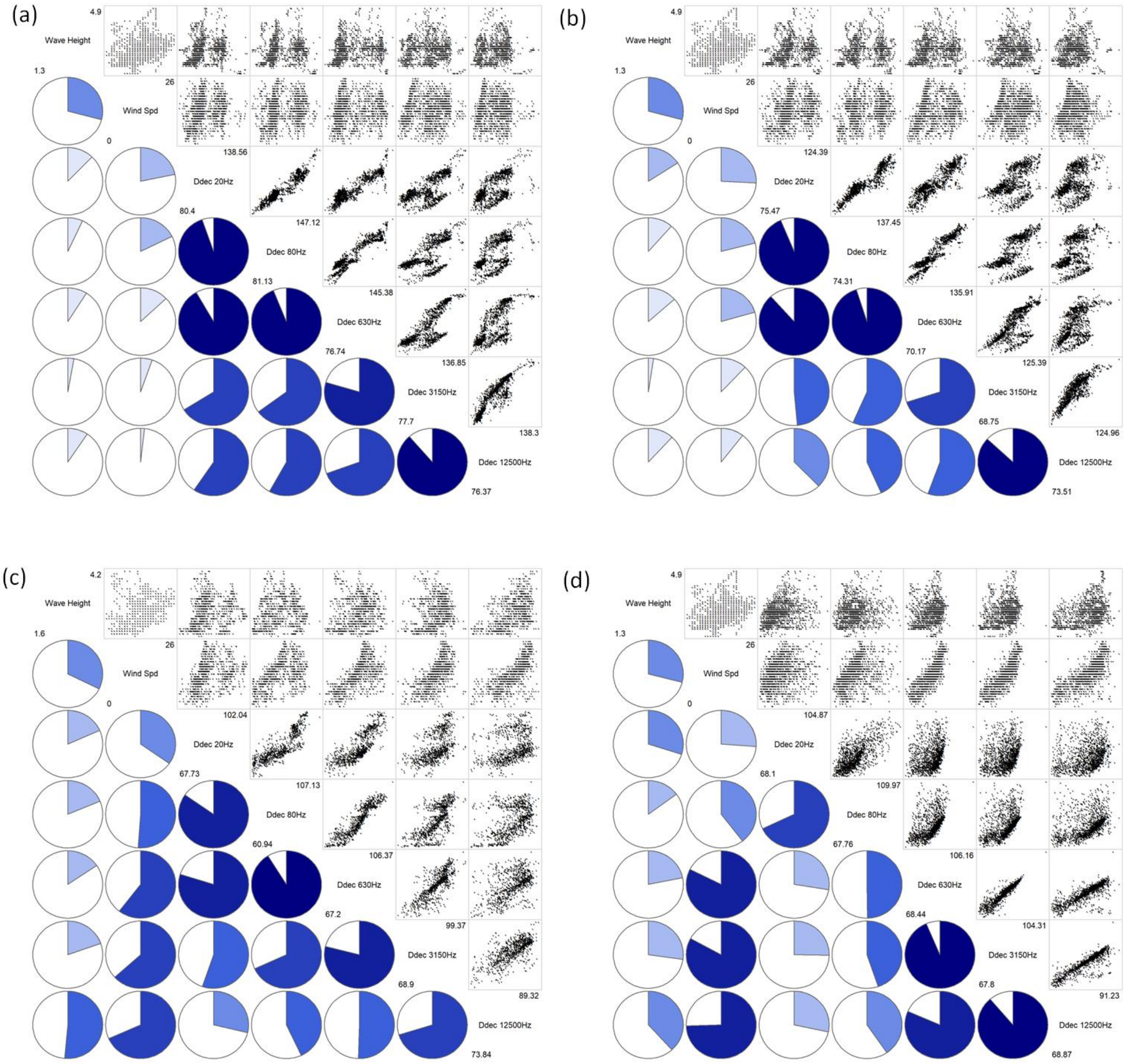


Figure 21. Correlogram comparing weather conditions to sound levels in five specified decidecade bands for (a) Station 1 at 300 m; (b) Station 2 at 1 km; (c) Station 3 at 5 km; and (d) Station 4 channel 1 at 25 km.

5.3. Data Fits

The per-minute SPL data from Station 1–3 while the Ocean Onyx was moored (01:00 12 Feb through until 00:00 25 Mar 2021) was analysed according to the methods detailed in Section 4.2.4, with the results presented in Figures 22 and 23. These fits were used to gain an understanding of the propagation loss environment, and to complete the validation analysis (Section 4.3), as discussed in Section 6.2.

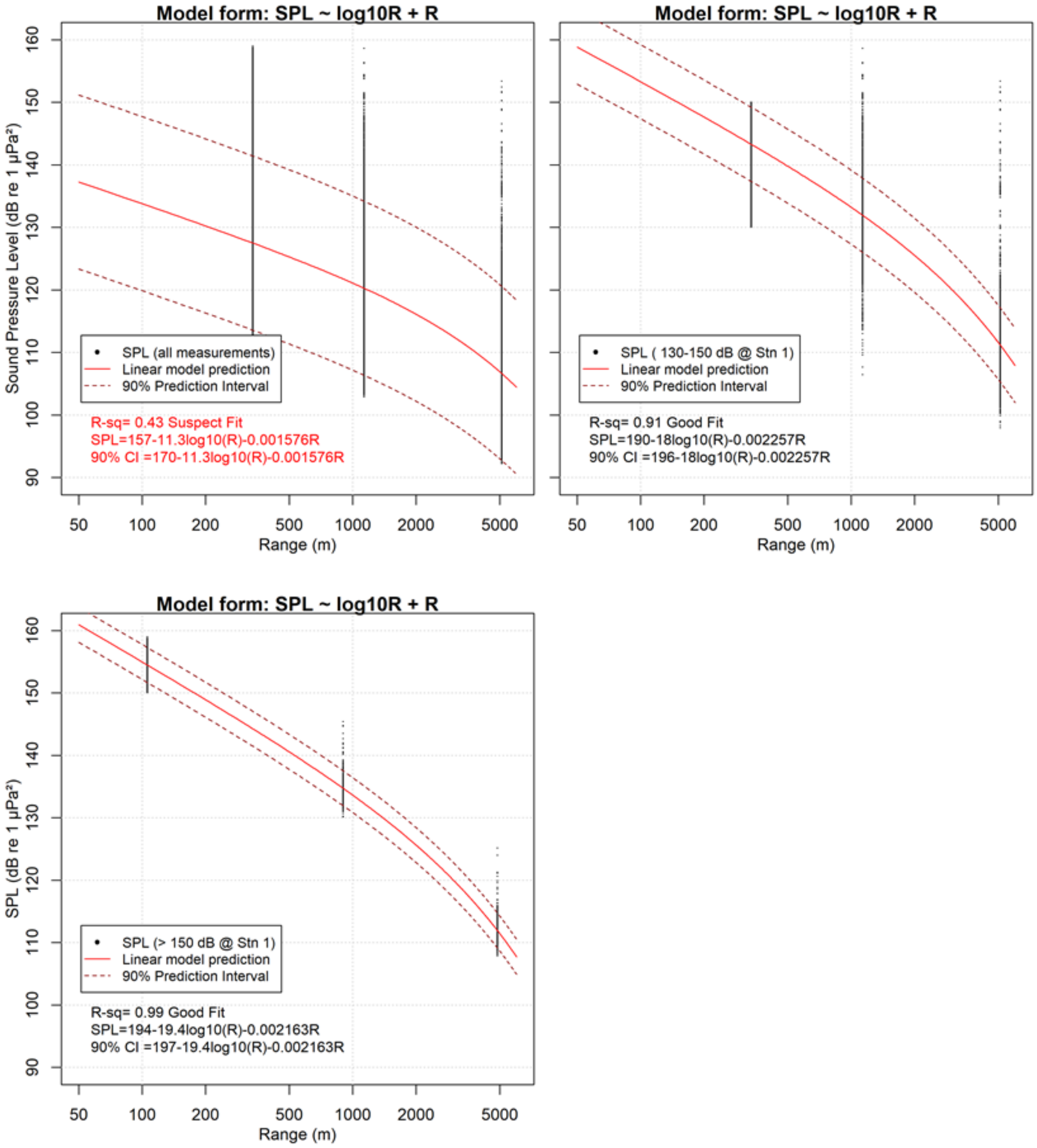


Figure 22. Per-minute sound pressure level (SPL) plotted against range for Stations 1–3, for the entire period the *Ocean Onyx* is present (top-left), levels at Station 1 between 130 and 150 dB re 1µPa (top-right), and levels at Station 1 above 150 dB re 1µPa (bottom-left).

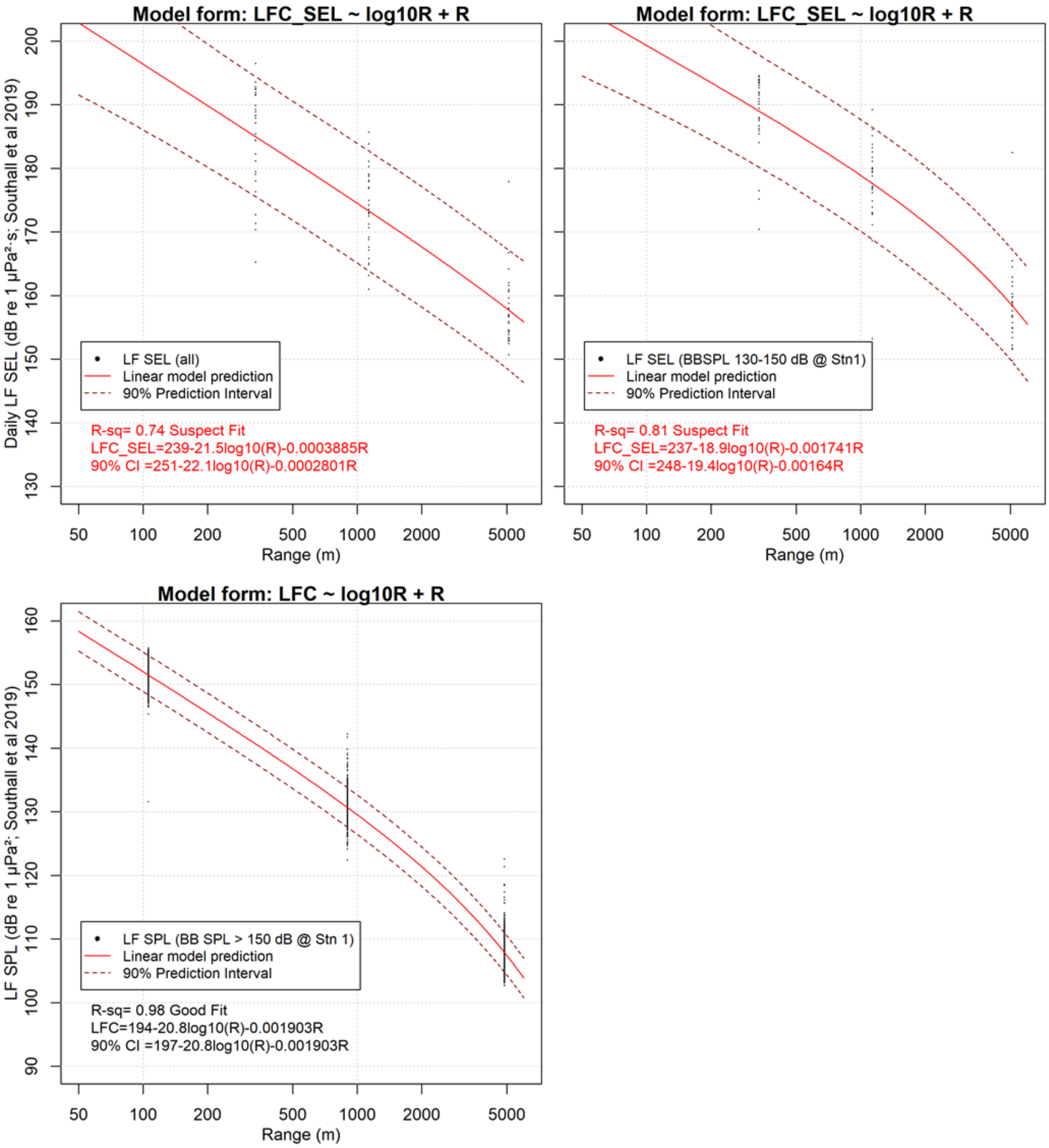


Figure 23. Daily low-frequency cetacean weighted sound exposure level (SEL) (calculated from frequency weighted per-minute sound pressure level (SPL)) plotted against range for Stations 1–3, for the entire period the *Ocean Onyx* is present (top-left), levels at Station 1 between 130 and 150 dB re 1µPa (top-right), and levels at Station 1 above 150 dB re 1µPa (bottom-left).

5.4. Drilling Operations

A detailed analysis was undertaken on two file snippets from Station 1, focused on correlating the acoustic signals to the drilling logs, and providing details on some of the signals observed in the acoustic data.

5.4.1. Snippet 1

A snippet of data from Station 1 for 22 Feb 2021 from 14:14:37 was examined to look for alignment between the acoustic data and the drilling logs to provide a detailed insight into the noise producing sources. The drilling log for this period stated:

> Continued drilling 26" x 42" hole from 115m to 171m (SectionTD). Several small stringers encountered at 140m and 157m. Pumped 100bbl PHG sweep and took MWD survey at connection. Survey @ 135mMDRT: 0.5deg inc.
>
> Parameters: 60rpm, 3-5kft-lb tq, 10klbs WOB, 800-1,100gpm, 400-550psi SPP

The spectrogram of the entire wav file is shown in Figure 24, with a shorter timescale and more focused frequency range shown in Figure 25, both showing components above 10 Hz only. In this data, drilling tonals with a spacing of 155 Hz were identified (Figure 26), and the analysis of the very low frequency tonals (Figure 27) clearly shows a 1 Hz tonal, which aligns with the 60 rpm drilling speed in the logs. A steady state pump operating at centre frequencies of 2992 Hz and 3062 Hz, with a strong correlation to high frequency harmonics (Figure 28). In this snippet there were three unstable narrowband noise sources present which are likely due to the drilling operations. This is considered likely due to their harmonic spacing under varying loads of operations. Tonals indicate that something, potentially the drill bit or the main aperture rod, is rotating between 52 and 74 RPM. This appears unrelated to the steady state pumps, which are likely high pressure pumps that fluctuate very little over time or load. During this recording, a vessel was also present although it did not appear to be operating under DP.

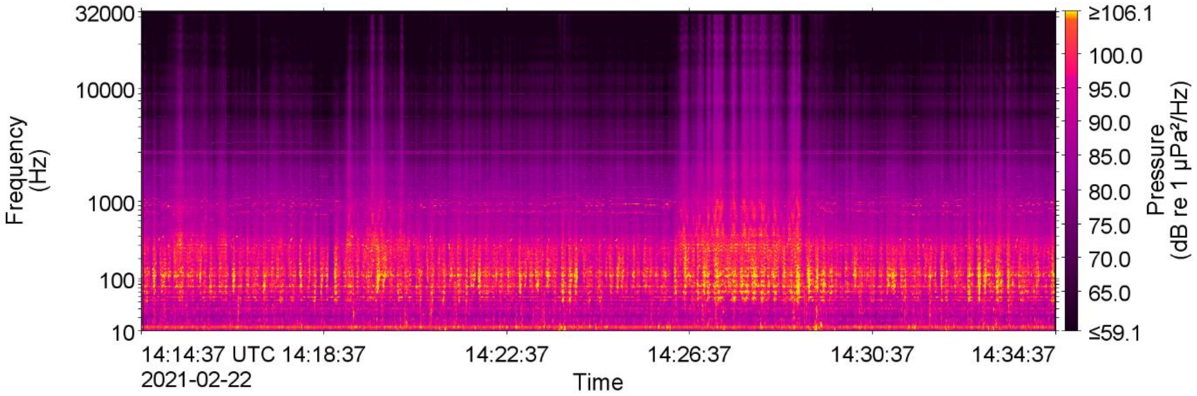


Figure 24. Spectrogram of 20 minutes of drilling operations on 22 Feb 2021 from 14:14:37 at Station 1(0.2 Hz frequency resolution, 1 s time window, 0.5 s time step, Hamming window).

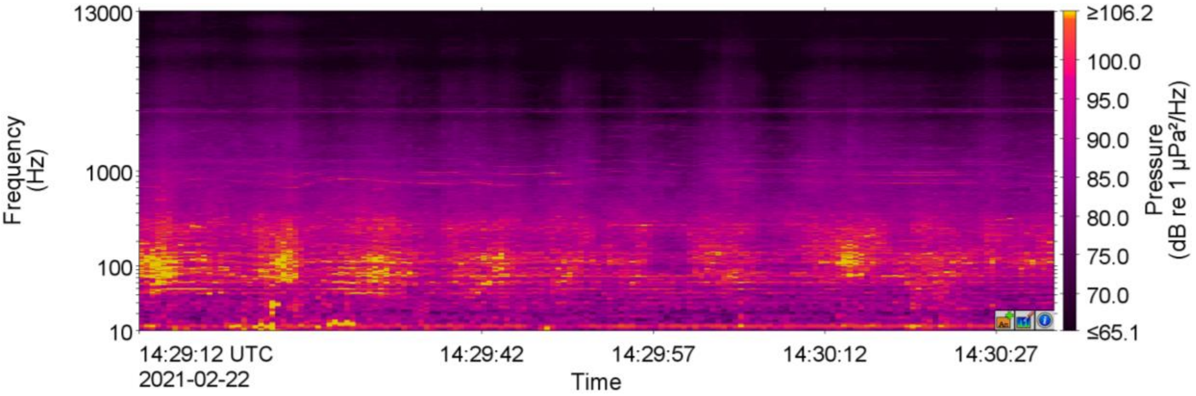
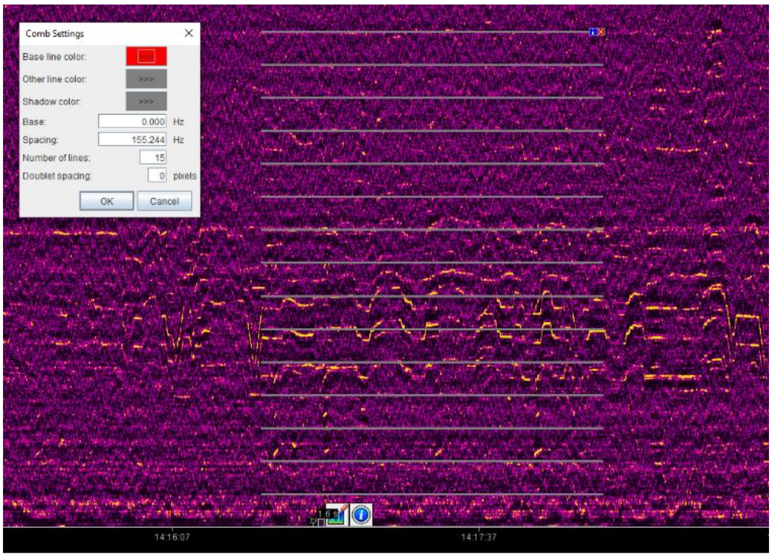
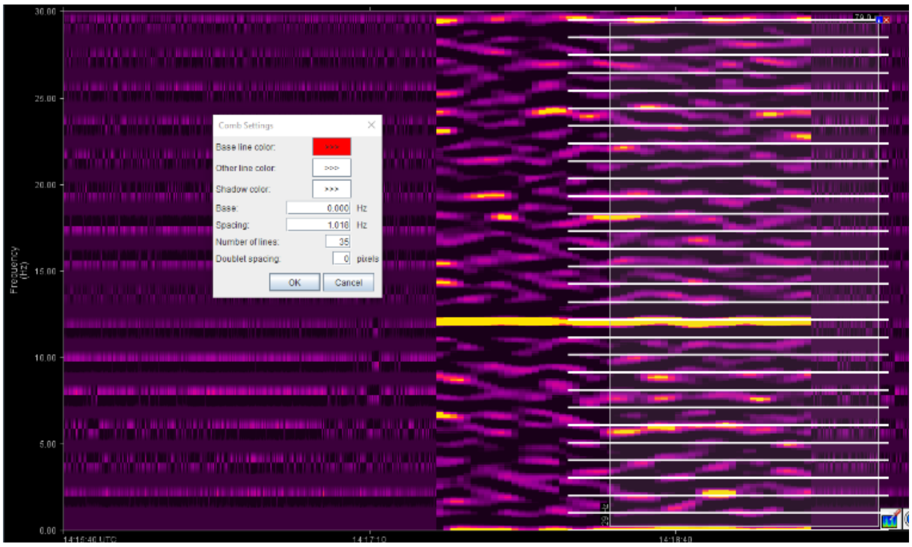


Figure 25. Spectrogram of 80 s minutes of drilling operations on 22 Feb 2021 from 14:29:12 at Station 1(0.2 Hz frequency resolution, 1 s time window, 0.5 s time step, Hamming window).


Comb Settings

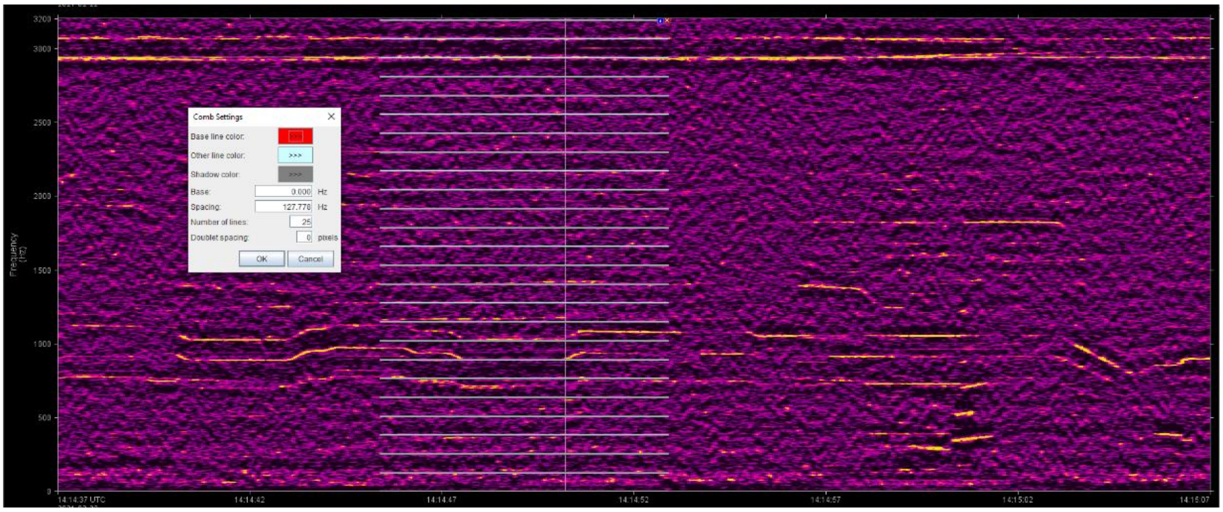
Base line color: >>>
Other line color: >>>
Shadow color: >>>
Base: 0.000 Hz
Spacing: 155.244 Hz
Number of lines: 15
Doublet spacing: 0 pixels

Figure 26. Drilling tonals, spaced at 155 Hz


Comb Settings

Base line color: >>>
Other line color: >>>
Shadow color: >>>
Base: 0.000 Hz
Spacing: 1.016 Hz
Number of lines: 35
Doublet spacing: 0 pixels

Figure 27. Very low frequency tonal analysis correlates with 60 rpm drilling speed


Comb Settings

Base: 0.000 Hz

Spacing: 127.778 Hz

Number of lines: 25

Doublet spacing: 0 pixels

Figure 28. Example of correlation between harmonics and load on main pump with centre frequencies of 2992 and 3062 Hz. The example also shows the diesel generators with engine firings rates fluctuating between 149 and 152 Hz while under hotel load from *Ocean Onyx*.

5.4.2. Snippet 2

A snippet of data from Station 1 for 08 Mar 2021 from 18:14:40 was examined to look for alignment between the acoustic data and the drilling logs to provide a detailed insight into the noise producing sources. The drilling log for this period stated:

> Drilled ahead 12-1/4" hole from 1,433m to 1,545m.
> Parameters:
> Flow: 1,000gpm, Boost Pump-250gpm, SPP: 3,000psi, RPM: 120 surface/217 bit
> Tq: Off 1-2kft-lbs/On 5-10kft-lbs. WOB: 5-15klbs P/U wt: 300klbs, S/O wt: 325klbs, Rot: 315klbs. Average ROP: 18.6m/hr
> ESD: 11.18ppg, ECD: 11.37ppg
> Offline: Displaced the Boost line and flushed the MGS utilising the boost pump - total of 20 strokes pumped (10bbls).
> At 1,510m MW over the shakers recorded at 10.7ppg (ESD-10.88ppg).
> Ceased centrifuging and weighted up the mud with additions of barite. MW at 1543m recorded at 11.1ppg.

The spectrogram of the entire wav file is shown in Figure 29, with a shorter timescale and more focused frequency range shown in Figure 30, both showing components above 10 Hz only. In this snippet there is no secondary source, such as a support vessel, present, just the *Ocean Onyx*. The narrowband tonals below 200 Hz indicate that the revolutions-per-minute fluctuate between 178 and 220 rpm, this aligns with data pins 9, 13 and 16 in Figure 31, along with various higher frequency harmonics. A second low-frequency rotating source, with a speed of 120.6 rpm was detected, Figure 32, and it demonstrates no apparent relationship between the 1.63:1 reduction ratio present in the low frequency spectrum to the other source. These frequencies align with information provided in the drill logs.

The data indicates various generator (diesel gensets and pumps) running in multiple configurations. All appear to be running in a steady-state fashion with varying loads, apparent through the fluctuations in frequency. Two distinct gensets are noted in particular as running hotel load, as they are more stable than the others which are likely being used for the *Ocean Onyx* drilling operations, and thus having changing requirements which changes their load. The tone at 3 kHz which is consistent without fluctuation, shown clearly in Figure 34, is probably a high-pressure pump which does not fluctuate with power draw, as no banding (harmonics) are observed, the motor is not a pole motor.

Figure 35 shows three distinct gensets (one tonal each) with accompanying cylinder firing rates throughout the spectrogram. These appear related to *Ocean Onyx* drilling operations as there are no secondary contacts on spectrogram (such as vessels) and the tonals fluctuate with power draw over time.

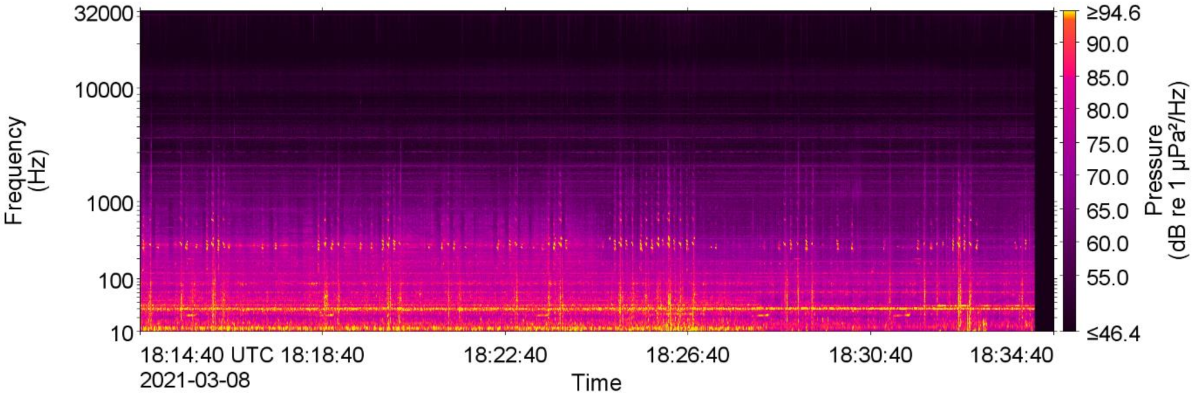


Figure 29. Spectrogram of 20 minutes of drilling operations on 08 Mar 2021 from 18:14:40 at Station 1(0.2 Hz frequency resolution, 1 s time window, 0.5 s time step, Hamming window).

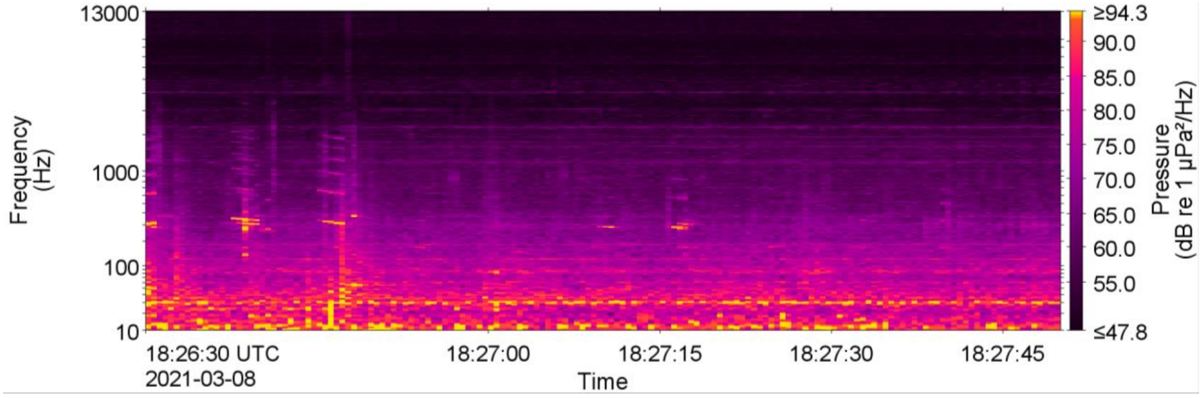
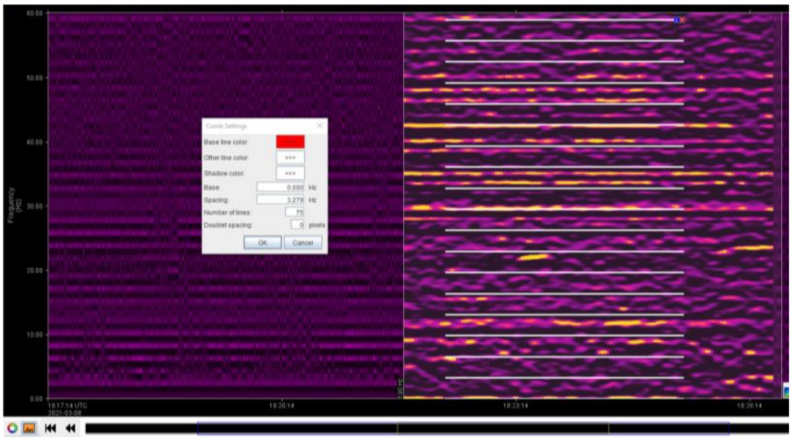
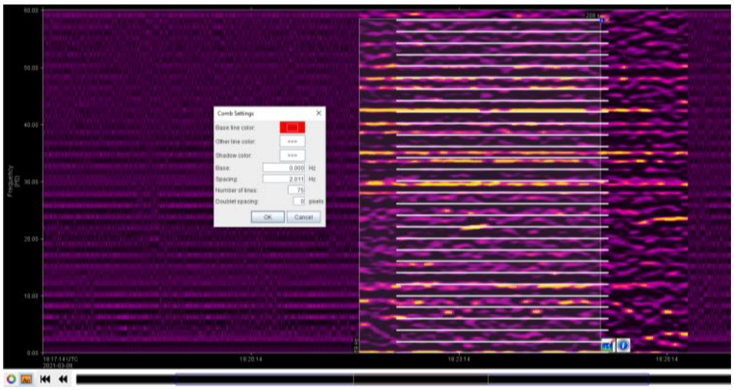


Figure 30. Spectrogram of 80 s of drilling operations on 08 Mar 2021 from 18:26:30 at Station 1(0.2 Hz frequency resolution, 1 s time window, 0.5 s time step, Hamming window).



Base line color:
Other line color: ...
Shadow color: ...
Base: 0.000 Hz
Spacing: 3.279 Hz
Number of lines: 75
Doublet spacing: 0 pixels

Figure 31. Low frequency analysis – rotating source contribution from first source.



Comb Settings
Base line color:
Other line color: >>>
Shadow color: >>>
Base: 0.000 Hz
Spacing: 2.011 Hz
Number of lines: 75
Doublet spacing: 0 pixels
OK Cancel

Figure 32. Low frequency analysis – rotating source contribution from second source rotating at 120.6 rpm.

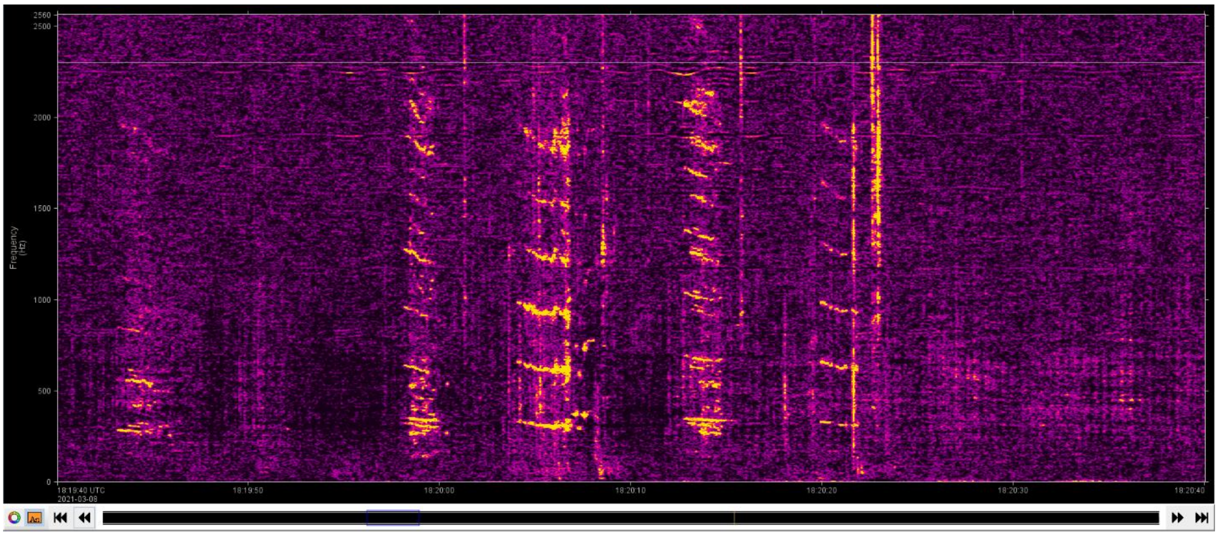
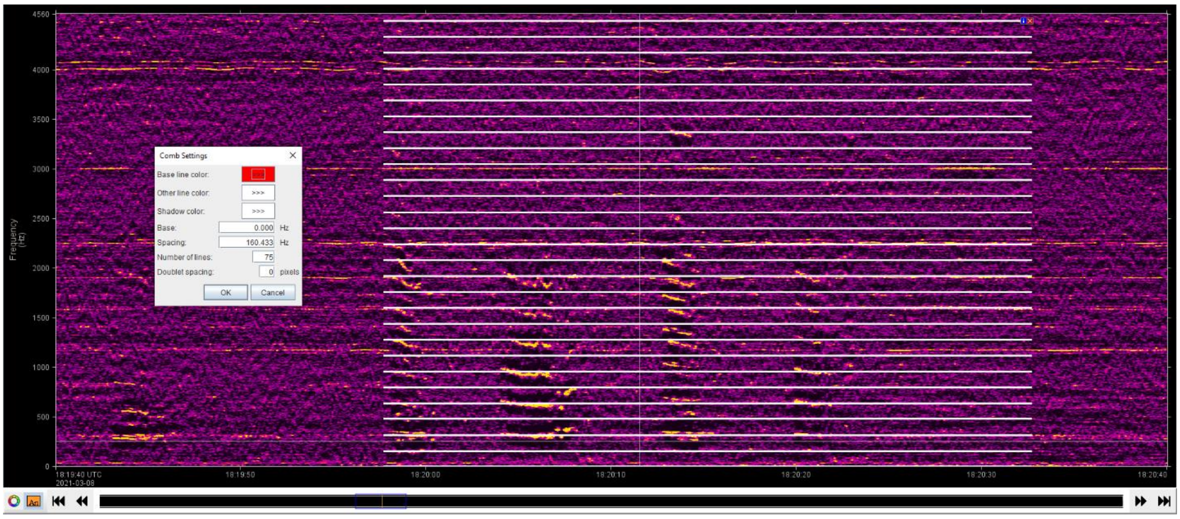


Figure 33. Transient noise from Mobile Offshore Drilling Unit (MODU) due to sea state or other movement on the anchored position (spectrogram normalised across transients).



Comb Settings
Base line color:
Other line color: >>>
Shadow color: >>>
Base: 0.000 Hz
Spacing: 160.433 Hz
Number of lines: 75
Doublet spacing: 0 pixels
OK Cancel

Figure 34. Generator analysis showing hotel load tonals.

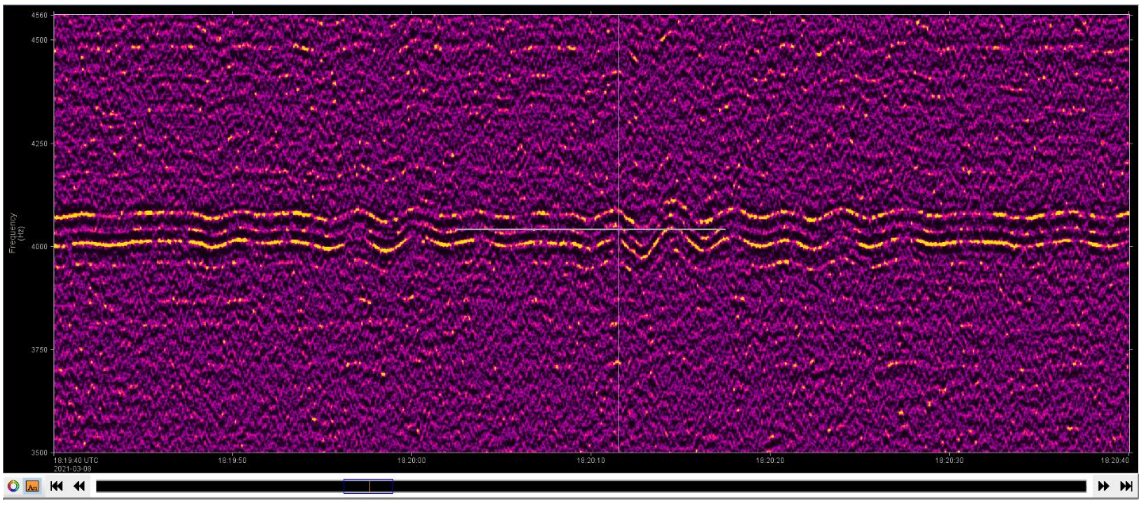


Figure 35. Three distinct gensets with accompanying cylinder firing rates throughout the spectrogram. These appear related to MODU operations as there are no secondary contacts on spectrogram and the tonals fluctuate with power draw.

5.5. Source Levels

ShipSound was used to determine the source levels for the *Ocean Onyx* and support vessels under dynamic positioning and during transits using the methods detailed in Section 4.2.3 and the operations described in Section 2.5. The following sections detail the Monopole Source Levels for each of these sources.

5.5.1. MODU

Following the method detailed in Section 4.2.3.2 and the periods specified in Table 8, the mean and maximum MSL for the *Ocean Onyx* was determined for three drilling depth ranges (Figure 36). The mean MSL is more representative of typical levels for each drilling depth and therefore suitable for comparison to the levels used in Koessler et al. (2020). Three example ShipSound reports are provided in Appendix G.1, and a spectrogram of drilling activities extracted from the ShipSound report included in Appendix G.1.2 is shown in Figure 37.

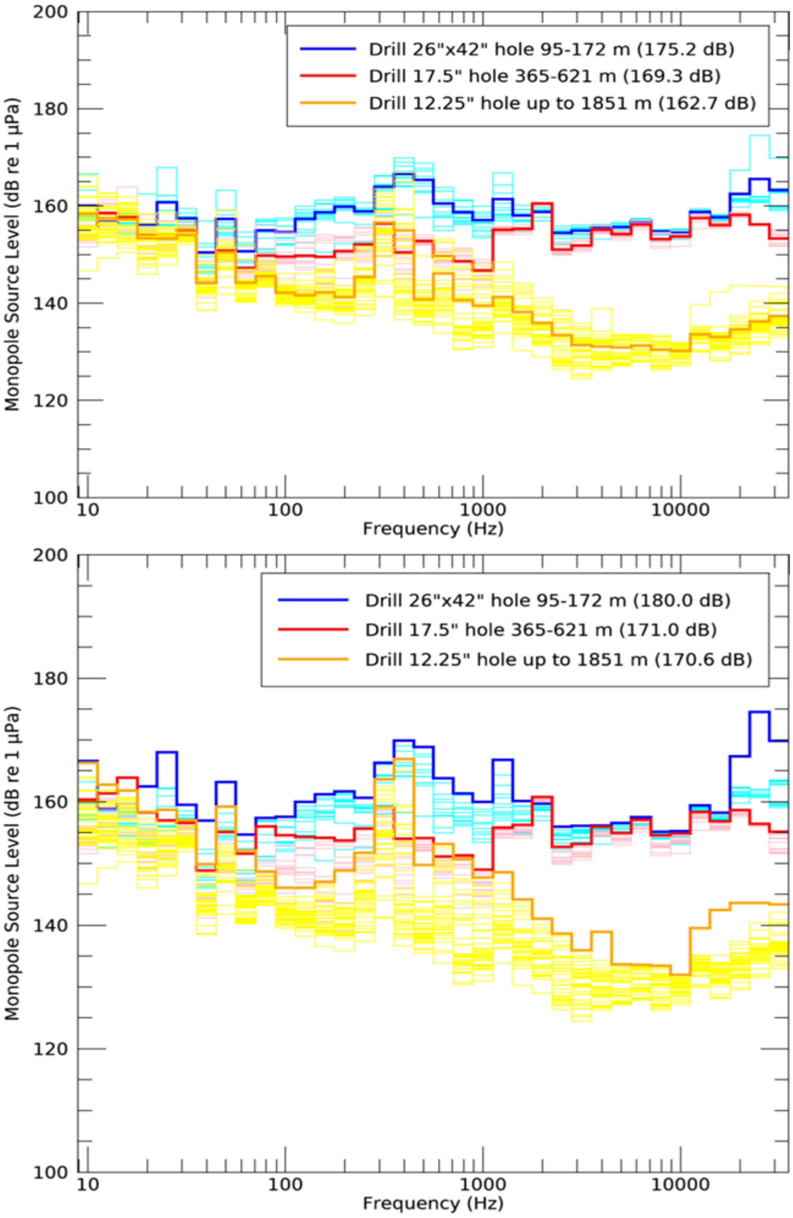


Figure 36. Monopole Source Level (MSL) and spectra for *Ocean Onyx* Mobile Offshore Drilling Unit (MODU) from Station 1 ShipSound processing, averaged over a ShipSound measurements over three different drilling depths, mean (top) and maximum (bottom).

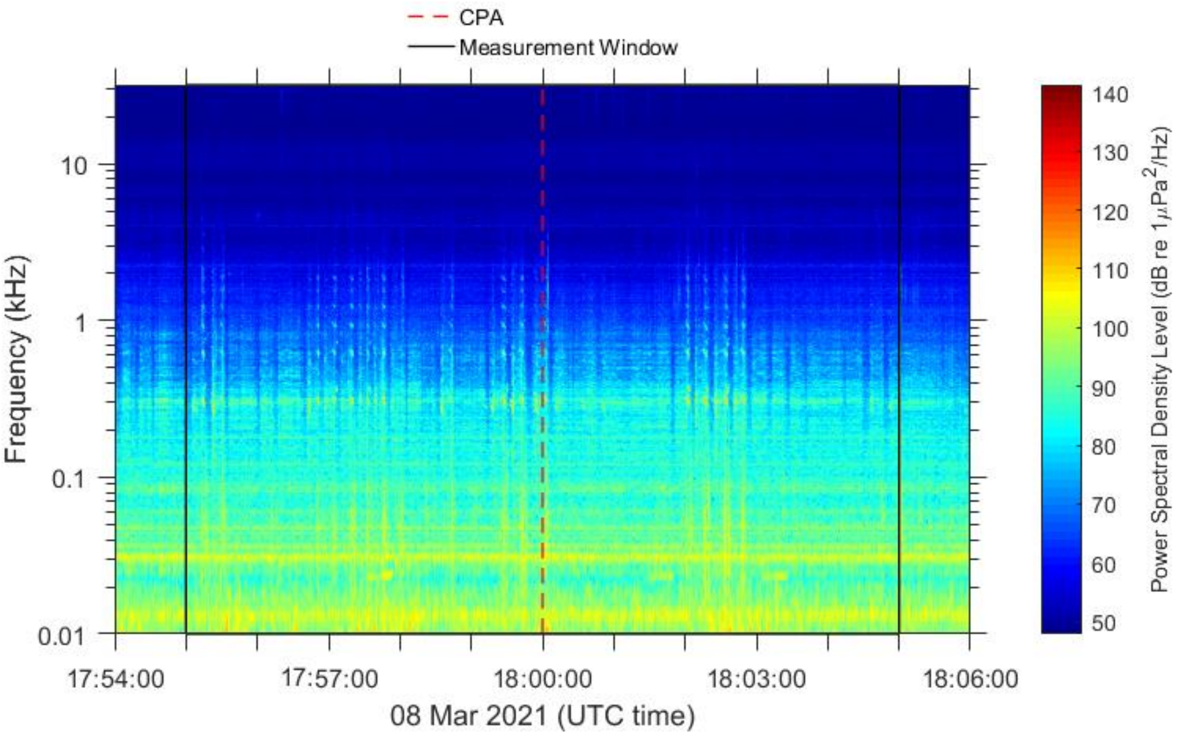


Figure 37. Spectrogram from ShipSound report included in Appendix G.1.2, with a calculated Monopole Source Level (MSL) of 159.6 dB re 1µPa m.

Table 11. *Ocean Onyx* monopole source levels (MSLs) from Figure 36.

Measurement	Monopole source level (dB re 1 µPa m)	
	Mean	Maximum
Drilling 26”x42” hole from 95–172 m	175.2	180.0
Drilling 17.5” hole from 365–621 m	169.3	171.0
Drilling 12.25” hole up to 1851 m	162.7	170.6

5.5.2. Vessels under Dynamic Positioning

Following the method detailed in Section 4.2.3 for vessels under dynamic positioning, the mean MSL was determined to be 193.9 dB re 1 µPa (Figure 38). The mean representative of typical levels from the trials of dynamic positioning is therefore suitable for comparison to the levels used in Koessler et al. (2020). One example ShipSound report is provided in Appendix G.2.

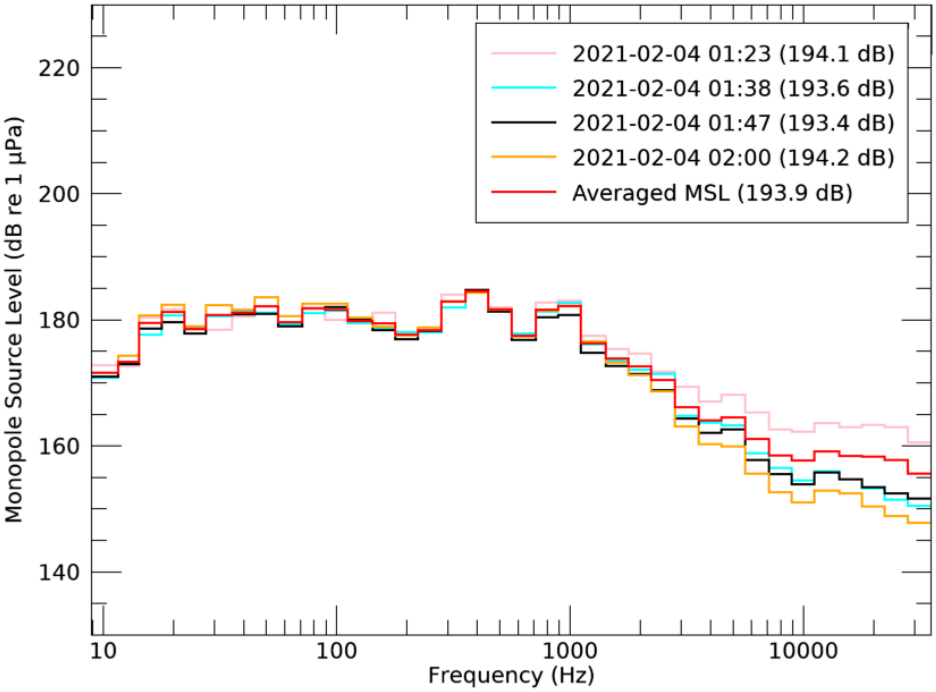


Figure 38. Monopole Source Level (MSL) and spectra for Siem *Sapphire* in dynamic positioning (DP) from Station 2 ShipSound processing. The MSL was averaged over all ShipSound measurements.

5.5.3. Vessels during Transit

Following the method detailed in Section 4.2.3 for vessels under transit, the mean MSL was determined for each vessel, the Siem *Sapphire* under transit at both 7 and 9 kn (Figures 39 and 40), and the Siem *Aquamarine* and *Topaz* at 9 kn (Figures 41 and 42). The two transit speeds are therefore suitable for comparison to the levels used in Koessler et al. (2020). One example ShipSound report is provided in Appendix G.3.

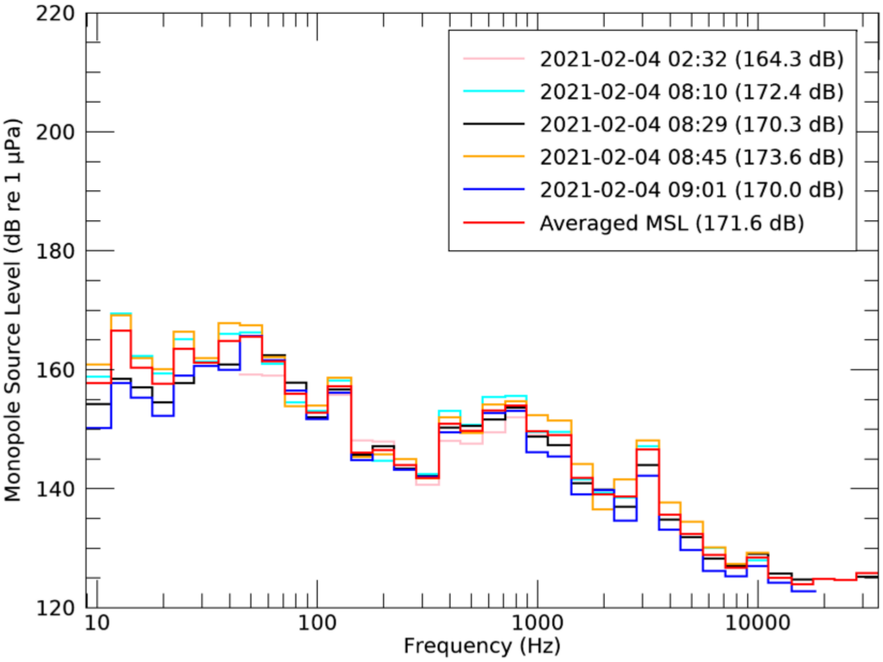


Figure 39. Monopole Source Level (MSL) and spectra for Siem *Sapphire* from Station 2 ShipSound processing. The MSL was converted to 7 kn and averaged over a few ShipSound measurements.

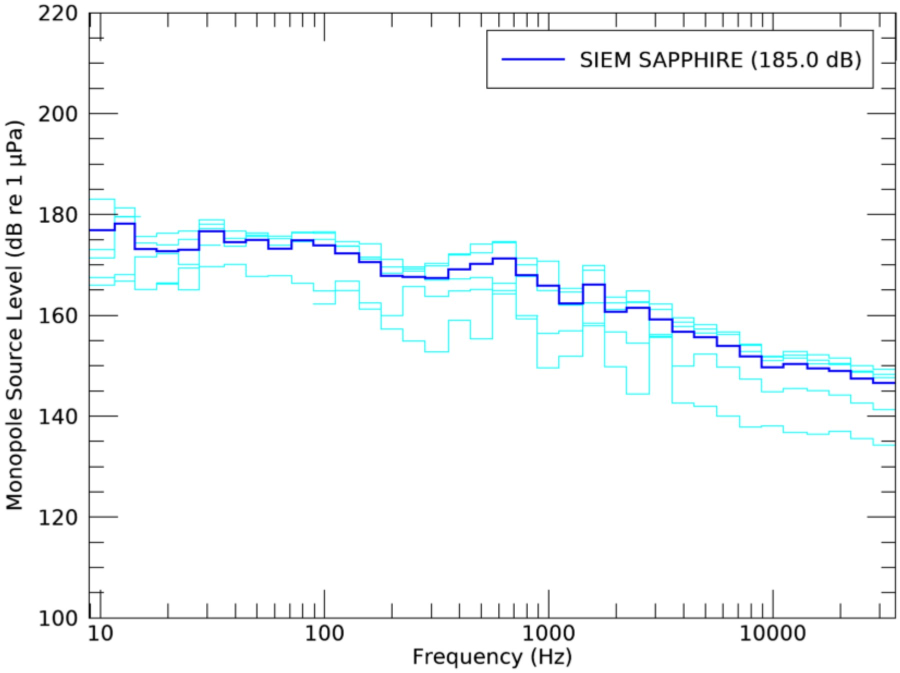


Figure 40. Monopole Source Level (MSL) and spectra for Siem *Sapphire* from Station 4 ShipSound processing. The MSL was converted to 9 kn and averaged over a few ShipSound measurements.

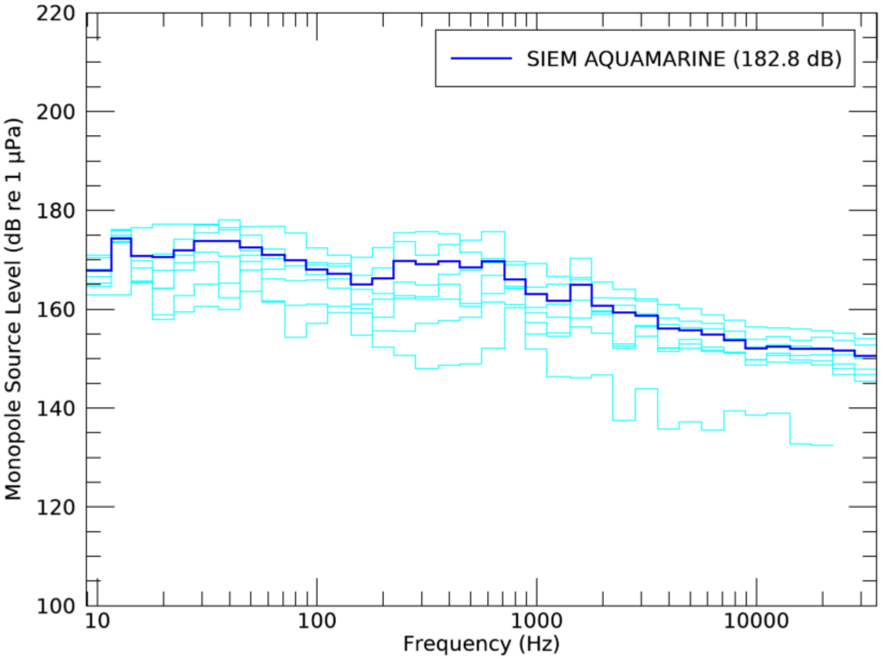


Figure 41. Monopole Source Level (MSL) and spectra for Siem *Aquamarine* from Station 4 ShipSound processing. The MSL was converted to 9 kn and averaged over a few ShipSound measurements.

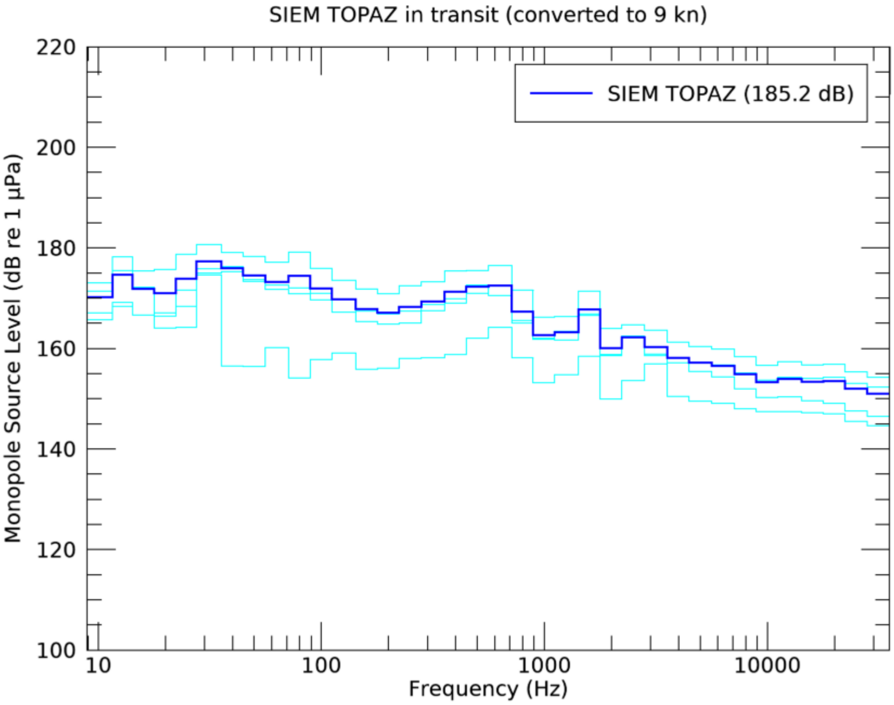


Figure 42. Monopole Source Level (MSL) for Siem *Topaz* from Station 4 ShipSound processing. The MSL was converted to 9 kn and averaged over a few ShipSound measurements.

5.6. Vessel Detections

Vessels were detected throughout the entire recording period using the automated detection algorithm described in Section 4.2.2. Results are shown for the two stations farthest from the *Ocean Onyx*, Stations 3 and 4 (Figure 43). Figure 44 shows an example of a large container vessel passing with a Lloyd's mirror pattern, and the map of the pass is shown in Figure 45, along with less defined contributions from vessel operations at the *Ocean Onyx* to the north-west (purple) between 100 and 1000 Hz. A spectrogram of a closer vessel pass and associated map are shown in Figures 46 and 47.

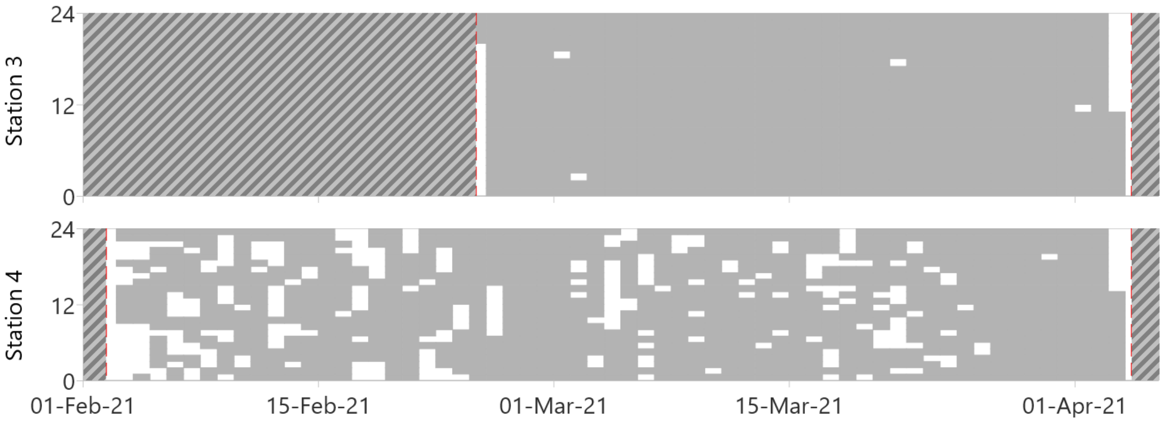


Figure 43. Vessel detections each hour (vertical axis) compared to date (horizontal axis) over the entire recording period at Stations 3 and 4. Vertical dashed lines (red) indicate AMAR deployment and retrieval dates.

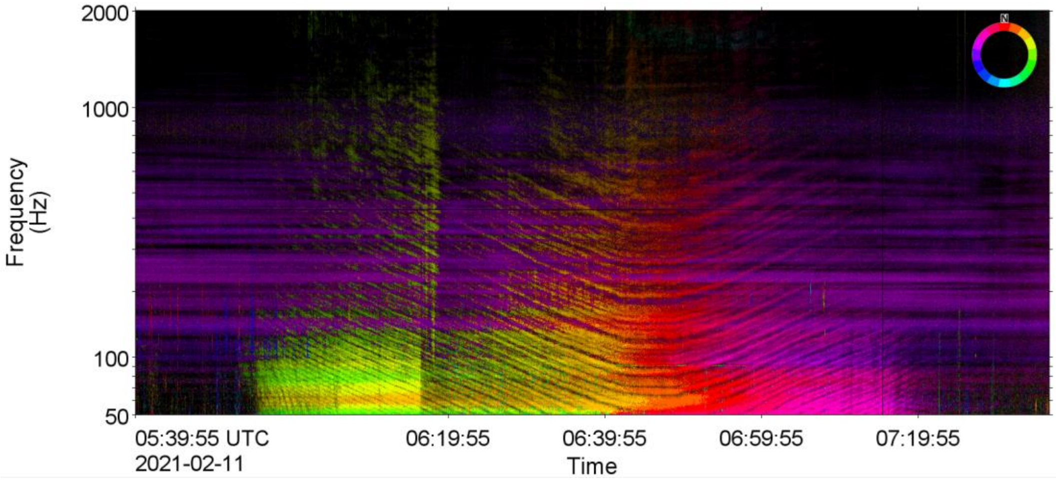


Figure 44. Example of a 334 m long container ship (*E.R. Tokyo*) travelling at 16 kn passing within 5.9 km north of Station 4 from east to west (green/yellow through to purple) that illustrates the Lloyd's mirror, or bathtub pattern over 2 h, with less defined contributions from vessel operations at the *Ocean Onyx* to the north-west (purple) between 100 and 1000 Hz. This pattern is caused by constructive and destructive interference between direct and reflected paths of sound (0.4 Hz frequency resolution, 2 s time window, 0.5 s time step, Hamming window, normalised across time).

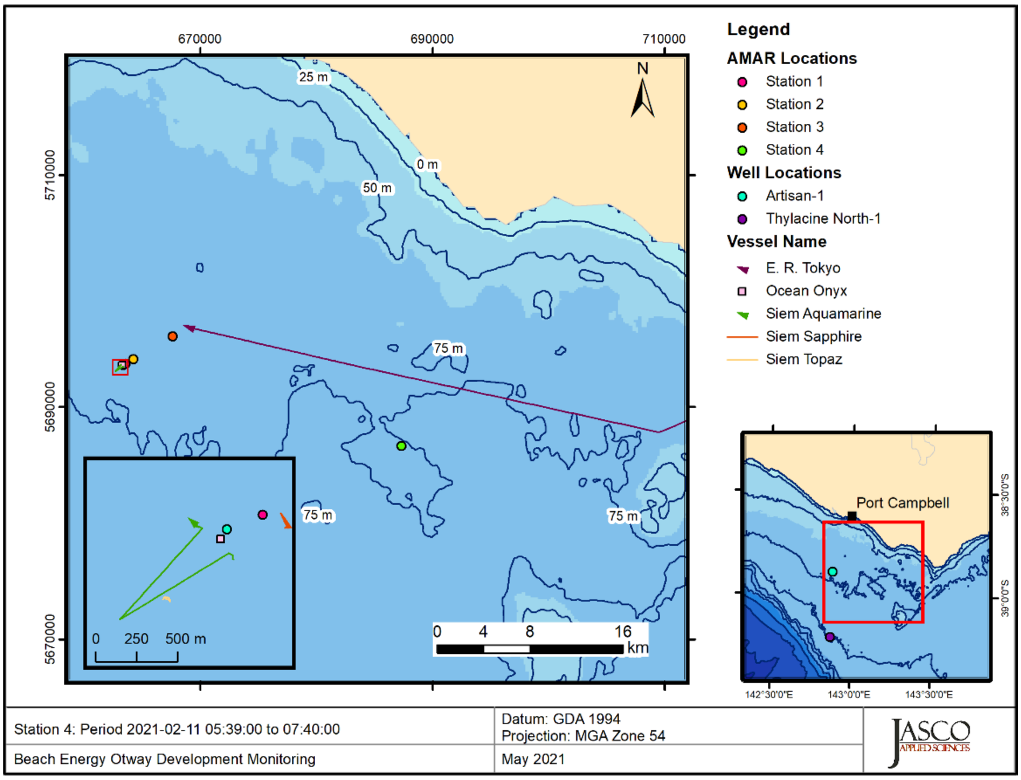


Figure 45. Map of automatic identification system (AIS) reported vessel locations for the spectrogram shown in Figure 44.

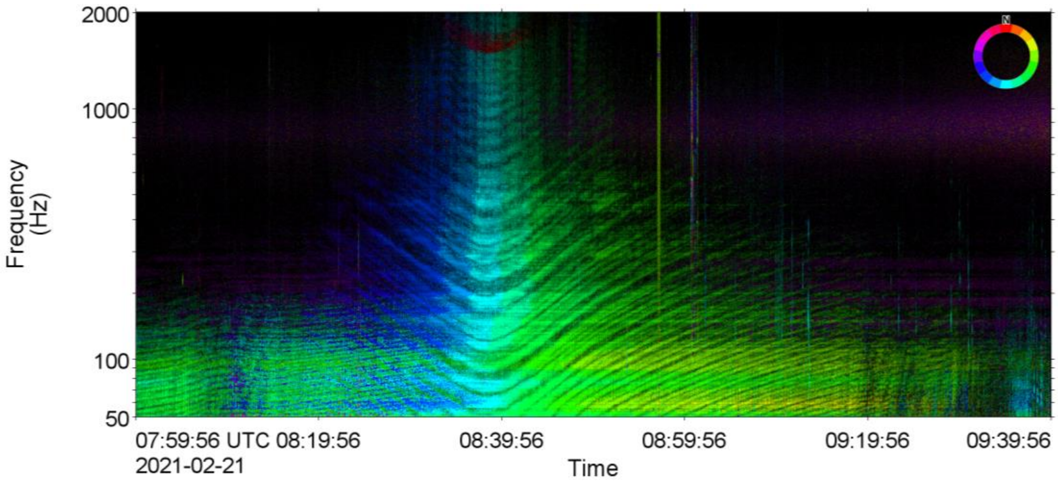


Figure 46. Example of a 200 m long vehicle carrier (*Tombarra*) travelling at 13 kn passing within 2.6 km south of Station 4 from east to west (green/yellow through to purple) that illustrates the Lloyd's mirror, or bathtub pattern over 2 h, with less defined contributions from vessel operations at the *Ocean Onyx* to the north-west (purple) between 100 and 1000 Hz. This pattern is caused by constructive and destructive interference between direct and reflected paths of sound (0.4 Hz frequency resolution, 2 s time window, 0.5 s time step, Hamming window, normalised across time).

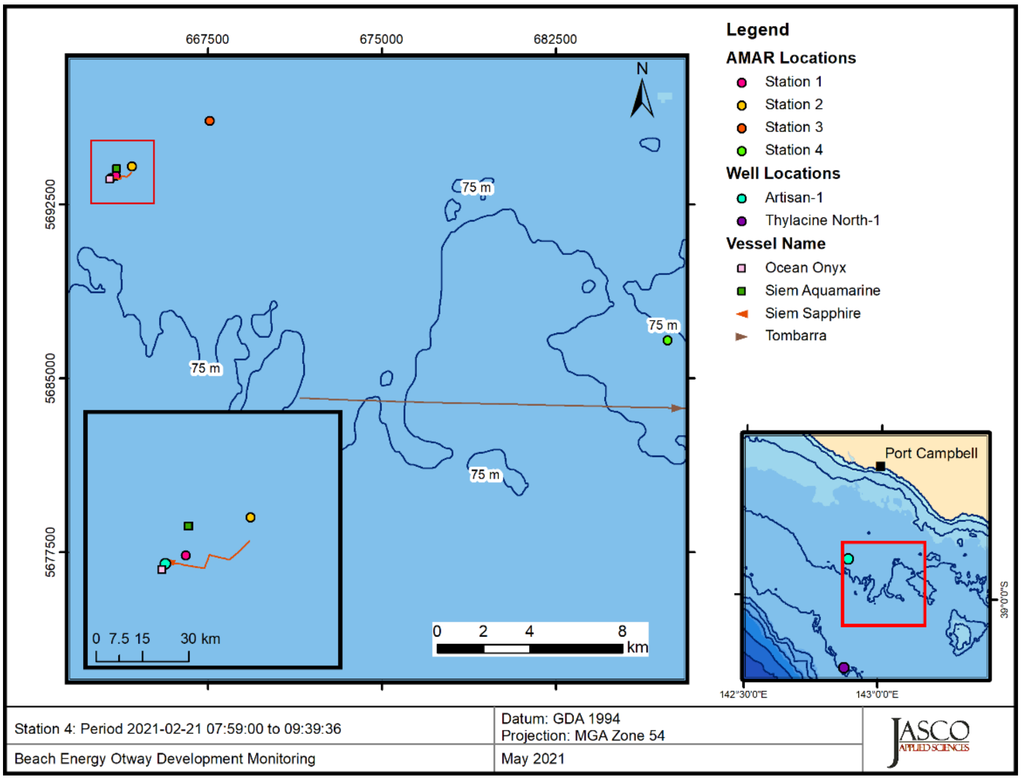


Figure 47. Map of automatic identification system (AIS) reported vessel locations for the spectrogram shown in Figure 46.

5.7. Marine Mammals

The acoustic presence of marine mammals was identified automatically by JASCO's detectors (Section 4.2.7.3) and validated via the manual review of 0.5% of the data, which represents 312 of the 5 min sound files, or 26 h worth of data. Acoustic signals of pygmy blue whales and dolphins were identified and vocalisations of other mysticetes, such as humpback and southern right whales, were not detected by the detectors (D.2), or observed during the 0.5% manual review.

5.7.1. Dolphins

Dolphins produce both impulsive (click) and tonal (whistle) sounds that show less species-level specificity than other marine mammal signals and are therefore more difficult to distinguish acoustically. Due to the directionality of impulsive clicks and the associated degradation of their spectral features when recorded at increasing angles away from the longitudinal axis of the vocalising animal, delphinid clicks cannot be confidently assigned to individual species. Furthermore, because the audible frequency of the acoustic data only reached 32 kHz, much of the energy from dolphin clicks (which can reach over 150 kHz) was not captured. Because of the overlap in spectral features of tonal signals from different dolphin species (Steiner 1981) and the expected but unquantified variability of these signals around the few described vocalisation types, we were unable to distinguish dolphin whistles by species.

The dolphin clicks and whistles observed in the data (Figure 48) were likely produced by short-beaked common dolphins (*Delphinus delphis*), and/or bottlenose dolphins (*Tursiops sp.*) (Bilgmann et al. 2007, Bilgmann et al. 2014, Charlton-Robb et al. 2015). These signals were observed at all stations throughout the recording period with detections highest at Station 4 and through the month of March at Stations 1, 2, and 3 (Figures 49 and 50). It was apparent that dolphin clicks occurred more at night than during the day, particularly at Stations 1–3 (Figure 49).

A third vocalisation type believed to be produced by dolphin calves was also observed in March at Station 3 alongside whistles (Figure 51). These lower frequency patterns of ‘chirps’ and ‘quacks’ have previously been attributed by JASCO analysts to young bottlenose dolphins.

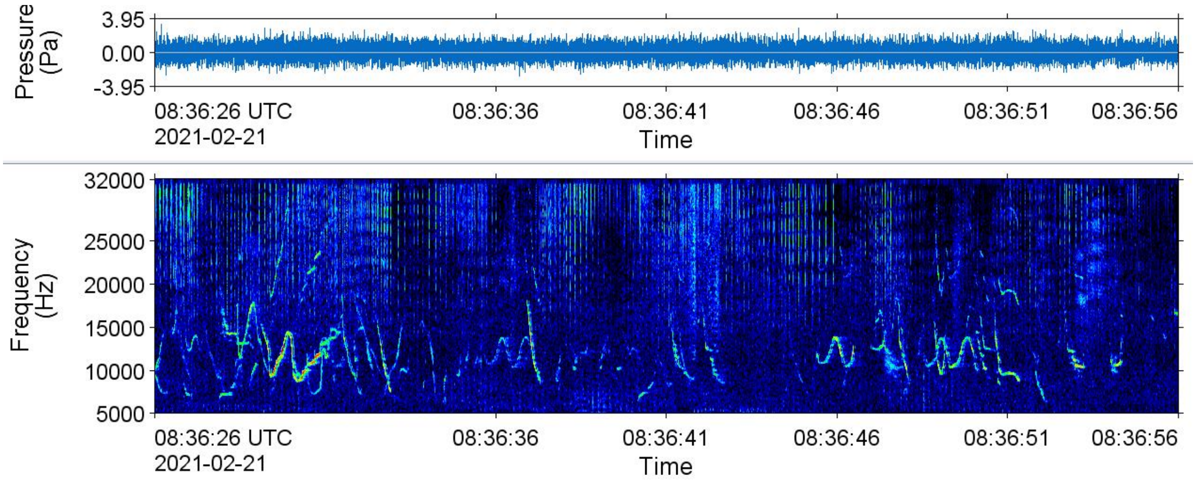


Figure 48. Spectrogram of dolphin clicks and whistles recorded on 21 Feb 2021 at Station 4 (64 Hz frequency resolution, 0.01 s time window, 0.005 s time step, Hamming window, normalised across time). The window length is 30 s.

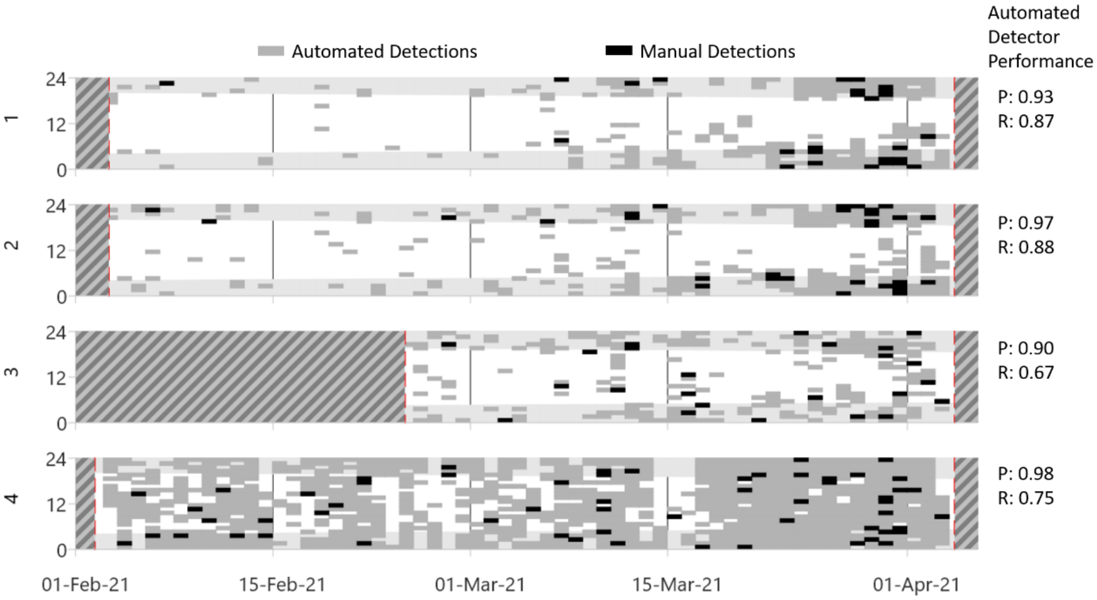


Figure 49. Daily and hourly occurrence of dolphin click detections recorded at Stations 1–4 (top – bottom) with automated detector performance metrics included along right side. The grey areas indicate hours of darkness from sunset to sunrise (Ocean Time Series Group 2009). Hashed areas indicate when there was no acoustic data and red dashed lines indicate the start and end of recordings. Automated detector results are for the dolphin click train detector.

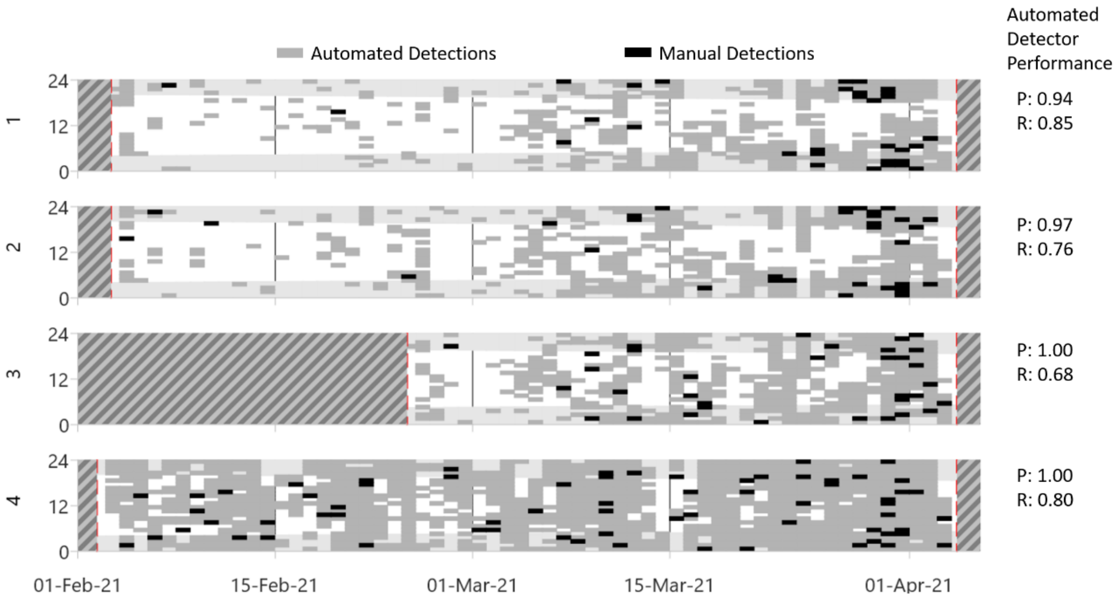


Figure 50. Daily and hourly occurrence of dolphin whistle detections recorded at Stations 1–4 (top – bottom) with automated detector performance metrics included along right side. The grey areas indicate hours of darkness from sunset to sunrise (Ocean Time Series Group 2009). Hashed areas indicate when there was no acoustic data and red dashed lines indicate the start and end of recordings. Automated detector results are for the WhistleHigh detector.

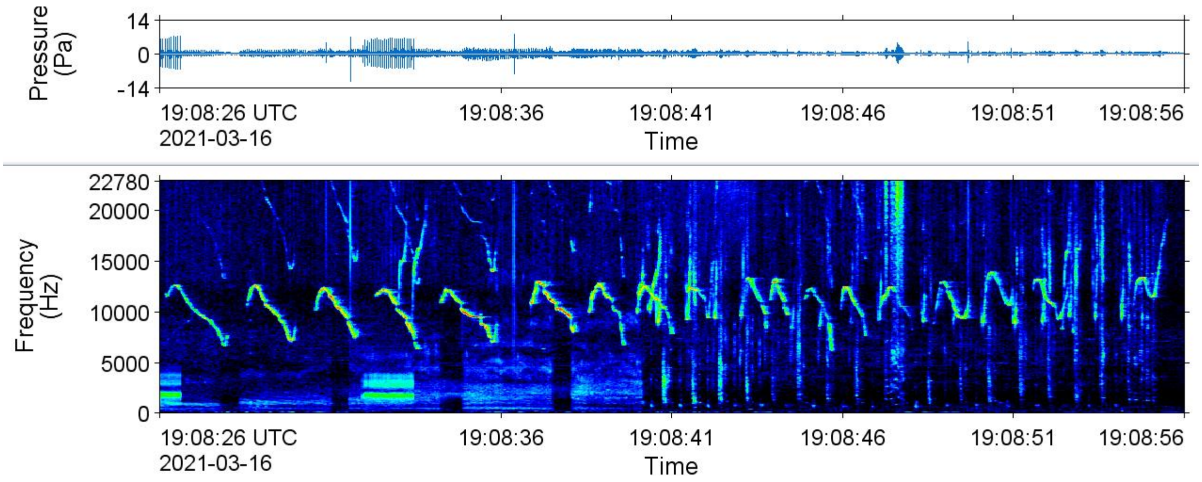


Figure 51. Spectrogram of dolphin whistles (above 5000 Hz) and sounds from young dolphins (majority present under 5000 Hz) recorded on 16 Mar 2021 at Station 3 (2 Hz frequency resolution, 0.125 s time window, 0.03125 s time step, Hamming window, normalised across time). The window length is 30 s.

5.7.2. Pygmy Blue Whales

Songs of pygmy blue whales (*Balaenoptera musculus brevicauda*; Figures 52 and 53) were detected sporadically through February and the first half of March. By the end of March, the signals were present in almost every hour of recording (Figure 54). This pattern of occurrence was reflected across all recording stations (Figure 54). In addition to the songs containing A, B, and C notes (Figures 52 and 53) (McDonald et al. 2006, Gavrilov and McCauley 2013, McCauley et al. 2018) that were the most common blue whale vocalisation in the data, blue whale D calls (Figure 55) (Recalde-Salas et al. 2014) were also present at the end of March and into April.

At Station 4, the direction of the blue whale acoustic signals relative to the recorder position was observed. An example of this is provided in Figure 52, where one blue whale is singing to the northwest, and one is singing to the southeast. Similarly, in Figure 55, the blue whale is calling from south of the recorder. When manually analysing blue whales at Station 4, an annotation was created for every direction of calling animals and the direction saved with the annotation. Figure 56 summarises these blue whale directional results from manual analysis. Blue whales occurred in all directions relative to Station 4, and there were 1–3 individuals confirmed vocalising at a time (Figure 56). Early in the recording, there is an apparent trend in the animals being more to the east and, later in the recording, being more to the west. However, the data were too sparse to confirm anything about animal movements.

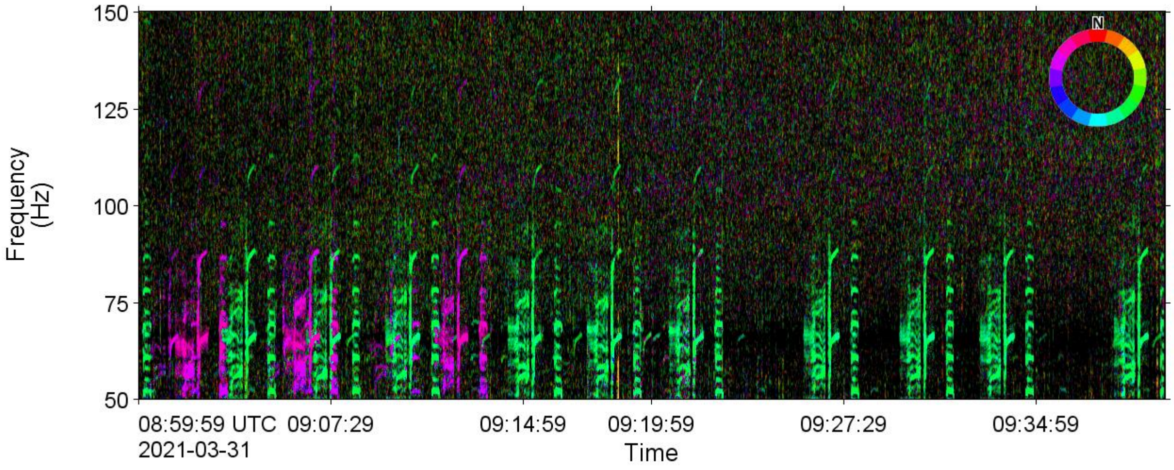


Figure 52. Directogram of pygmy blue whale songs recorded on 31 Mar 2021 at Station 4 (UTC) (0.4 Hz frequency resolution, 2 s time window, 0.5 s time step, Hamming window, normalised across time). Displaying ~40 min of data. One blue whale is singing to the northwest of Station 4 (pink) and one is singing to the southeast of Station 4 (green).

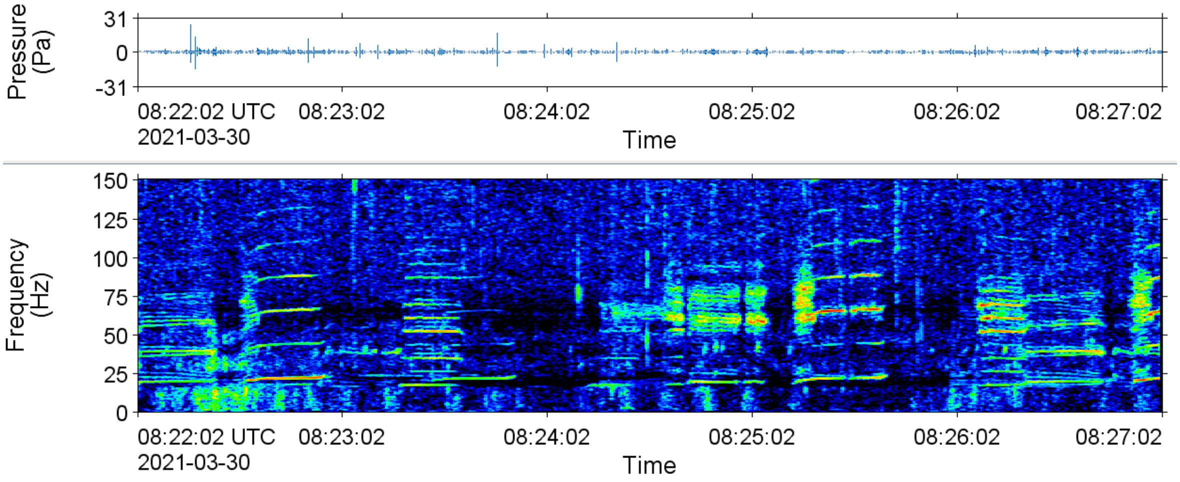


Figure 53. Spectrogram of pygmy blue whale songs recorded on 30 Mar 2021 at Station 3 (UTC) (0.4 Hz frequency resolution, 2 s time window, 0.5 s time step, Hamming window, normalised across time). Displaying 5 min of data.

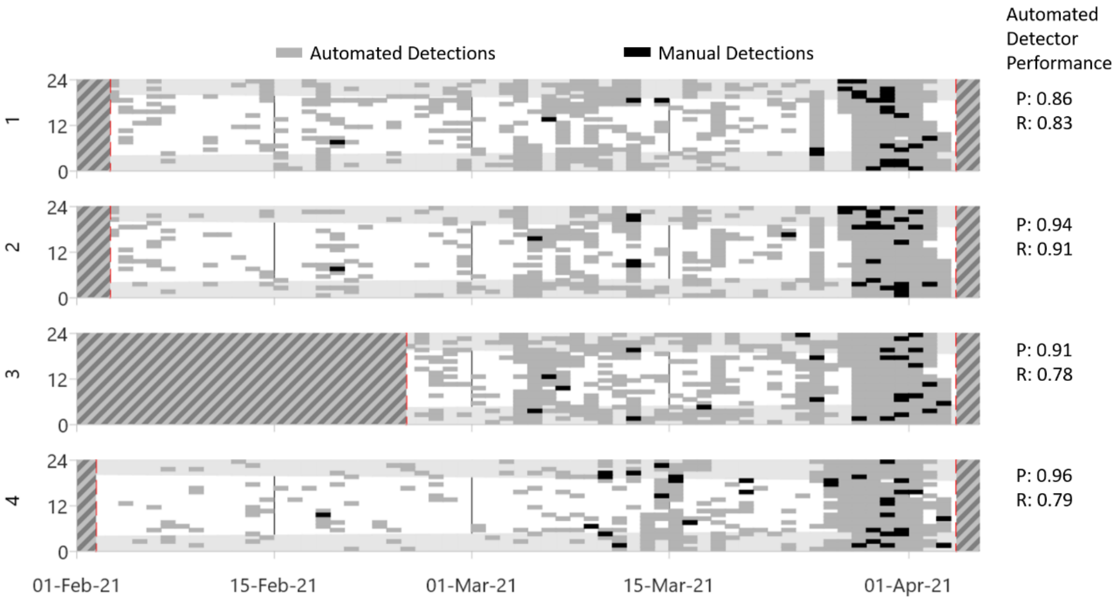


Figure 54. Daily and hourly occurrence of pygmy blue whale vocalisations recorded at Stations 1–4 (top – bottom) with automated detector performance metrics included along right side. The grey areas indicate hours of darkness from sunset to sunrise (Ocean Time Series Group 2009). Hashed areas indicate when there was no acoustic data and red dashed lines indicate the start and end of recordings. Automated detector results are for the AUS_BW_BH20 detector.

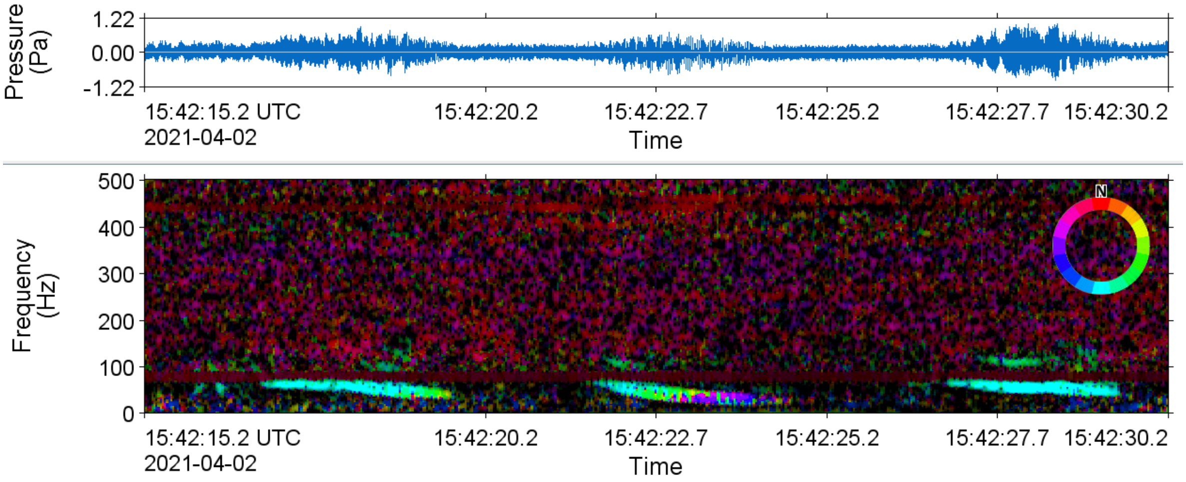


Figure 55. Directogram of pygmy blue D calls recorded on 2 Apr 2021 at Station 4 (UTC) (2 Hz frequency resolution, 0.125 s time window, 0.03125 s time step, Hamming window, normalised across time). Displaying 16 s of data. The blue whale is vocalising to the south of Station 4 (teal). In the second call, the frequencies fall below those which can be accurately determined with the hydrophone spacing using, with the colour of the signal changing from teal to purple and navy blue.

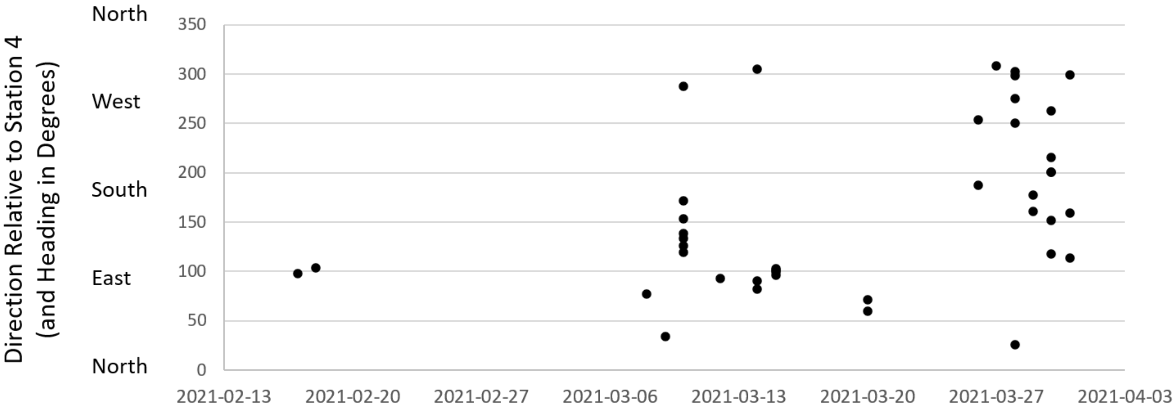


Figure 56. Plot of direction of blue whale vocalisations relative to Station 4 over the recording period where each point is a calculated from a manual annotation created during the 0.5% manual validation analysis (one annotation per direction per 5 min file analysed).

5.7.3. Other Potential Biological Sounds

Occasionally during manual analysis, pulses ranging from ~750 to 1250 Hz (Figure 57) were observed that may have been produced by fish. Alternatively, these signals could be a result of some anthropogenic activity, noises from which were noted through much of the data during manual review, particularly at Stations 1 and 2. Fish chorusing activity was apparent in the LTSAs, in particular at Station 4, with examples provided in Figures 58–60.

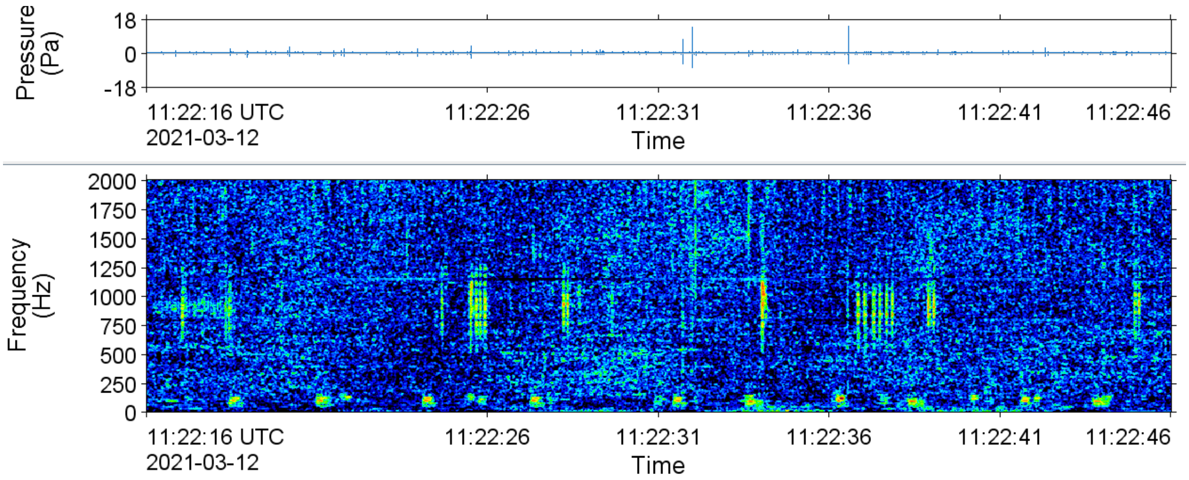


Figure 57. Spectrogram of unknown signals potentially produced by fish (pulses at 500–1250 Hz) recorded on 12 Mar 2021 at Station 3 (UTC) (2 Hz frequency resolution, 0.125 s time window, 0.03125 s time step, Hamming window, normalised across time). Displaying 30 s of data.

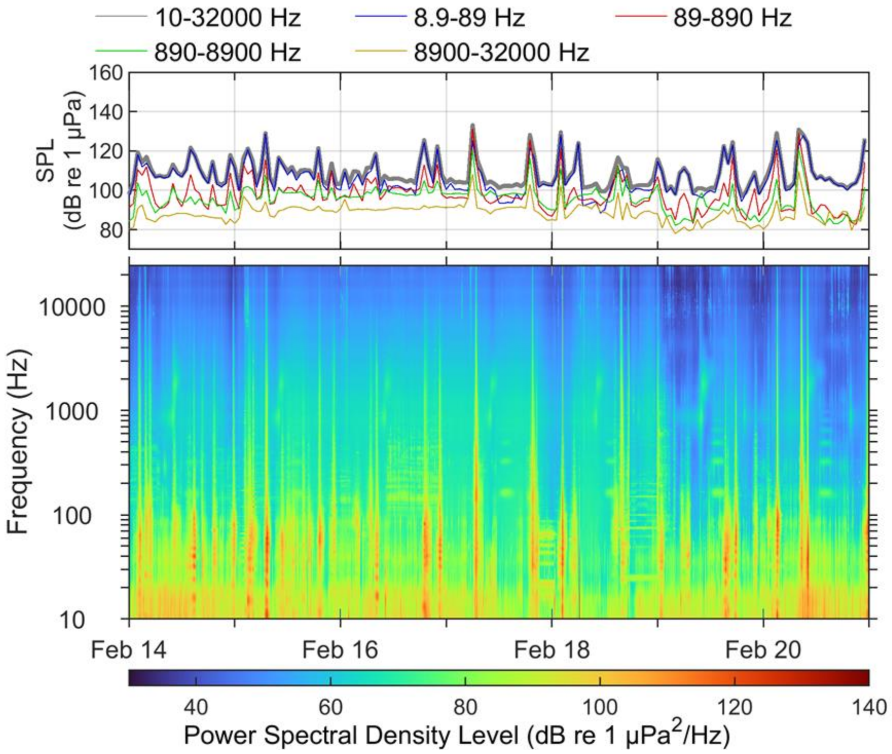


Figure 58. In-band sound pressure level (SPL) and spectrogram (or long-term spectral average; LTSA) of underwater sound for one week of data at Station 4, showing daily fish chorus's between 700 and 2000 kHz, and between 150 and 450 Hz, more obvious after 17 Feb 2021.

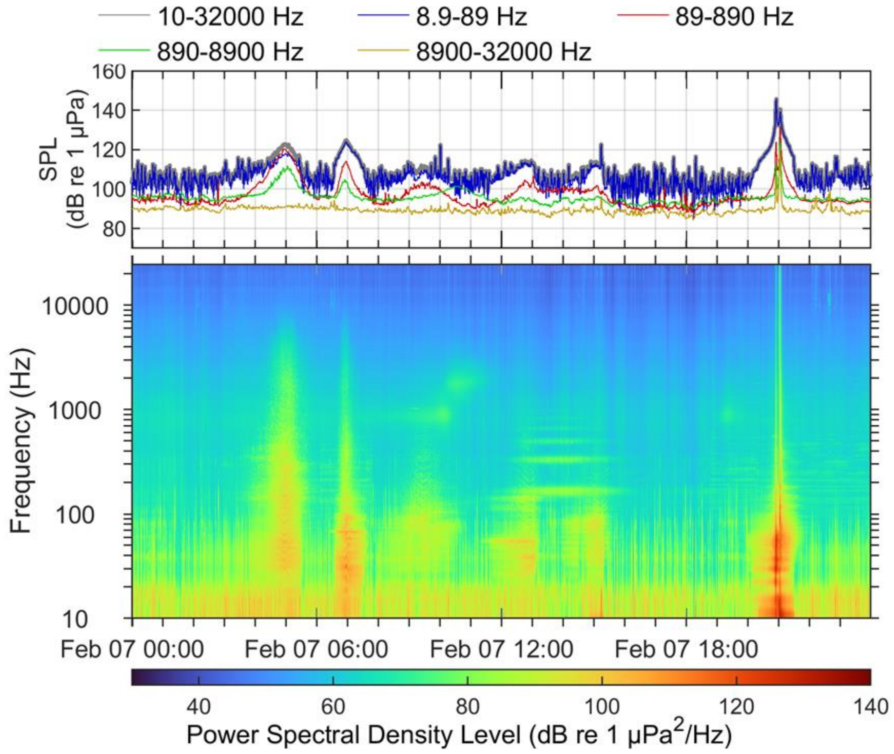


Figure 59. In-band sound pressure level (SPL) and spectrogram (or long-term spectral average; LTSA) of underwater sound for one day of data at Station 4, showing the daily fish chorus between 700 and 2000 kHz, and between 150 and 450 Hz, apparent in Figure 58, and six vessel transits.

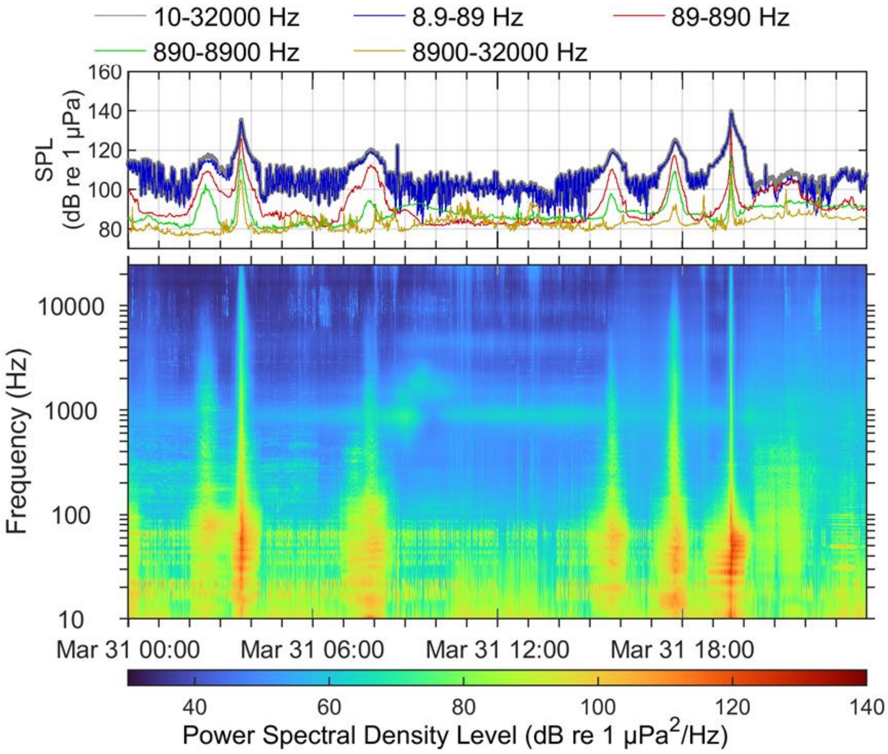


Figure 60. In-band sound pressure level (SPL) and spectrogram (or long-term spectral average; LTSA) of underwater sound for one day of data at Station 4, showing the daily fish chorus between 700 and 2000 kHz, lasting almost the entire day, along with six vessel transits.

6. Validation Analysis

Table 12 presents the four scenarios that need to be considered to validate the pre-measurement modelling presented in Koessler et al. (2020) for the Artisan-1. The scenarios are described in Table 12, with the modelling site locations and descriptions provided in Table 13.

Table 12. Description of modelling scenarios for the Artisan-1 development area from Koessler et al. (2020)

Well	Scenario number	Description	Associated modelled sites
Artisan-1	5	MODU, normal drilling operations	4
	6	OSV standby, independent of MODU, for 24 h	6
	7	MODU with OSV during resupply operations (including 4 hours alongside the MODU)	4, 5 and 6
	8	MODU with OSV standby (combination of Scenarios 5 and 6)	4 and 6

Table 13. Location details for the validation modelled sites.

Well	Site	Source	Latitude (S)	Longitude (E)	MGA Zone 54 (GDA94)		Water depth (m)
					X (m)	*Y* (m)	
Artisan-1	4	MODU	38° 53' 27.4106"	142° 52' 58.4450"	663300	5693640	71.5
	5	OSV	38° 53' 27.4021"	142° 53' 01.0962"	663364	5693639	71.6
	6	OSV standby	38° 53' 26.1553"	142° 54'21.4165"	665300	5693637	70.2

6.1. Source Level Comparison

The modelled source levels used in Koessler et al. (2020) are shown in Figures 61–63 alongside MSLs from the measurement program.

The mean estimated source levels for the vessels under transit used in the modelling study, which were derived based on the scaling of the power level, were similar to the MSL determined through the measurement study, which varied significantly with vessel speed (between 171.6 and 185.2 dB re µPa m). The trend of decreased MSL with speed follow those from studies on commercial shipping and ferries (MacGillivray et al. 2019). The measured MSL under dynamic positioning was different to that used in Koessler et al. (2020), in part due to the vessel power levels applied, but also because the approach used to estimate sound levels under dynamic positioning is based upon vessels under transit and is an approximation based on the Maximum Continuous Rating (MCR). Limited measurements of vessels under dynamic positioning using standardised measurement approaches are reported in literature, and there are significant differences between the thruster models and specifications, depths, and vessel dynamic positioning systems which control thruster operations. Therefore, this characterisation is a valuable contribution to understanding the MSLs for systems installed in anchor handling vessels.

The mean MSLs for the *Ocean Onyx* Figure 63 decrease as the drilling depth increases. The estimate of the *Ocean Onyx* source level spectrum was based on the Transocean *Polar Pioneer*, a similarly sized MODU. The *Polar Pioneer* was measured by JASCO while anchored and drilling, and had a broadband (10 Hz to 35 kHz) source level of 170.1 dB re 1 µPa m (Austin et al. 2018), although the source level used in the modelling was 178.7 dB re 1 µPa m. The mean maximum MSL from the measurement program was 175.2 re 1 µPa m, associated with shallowest drilling depths.

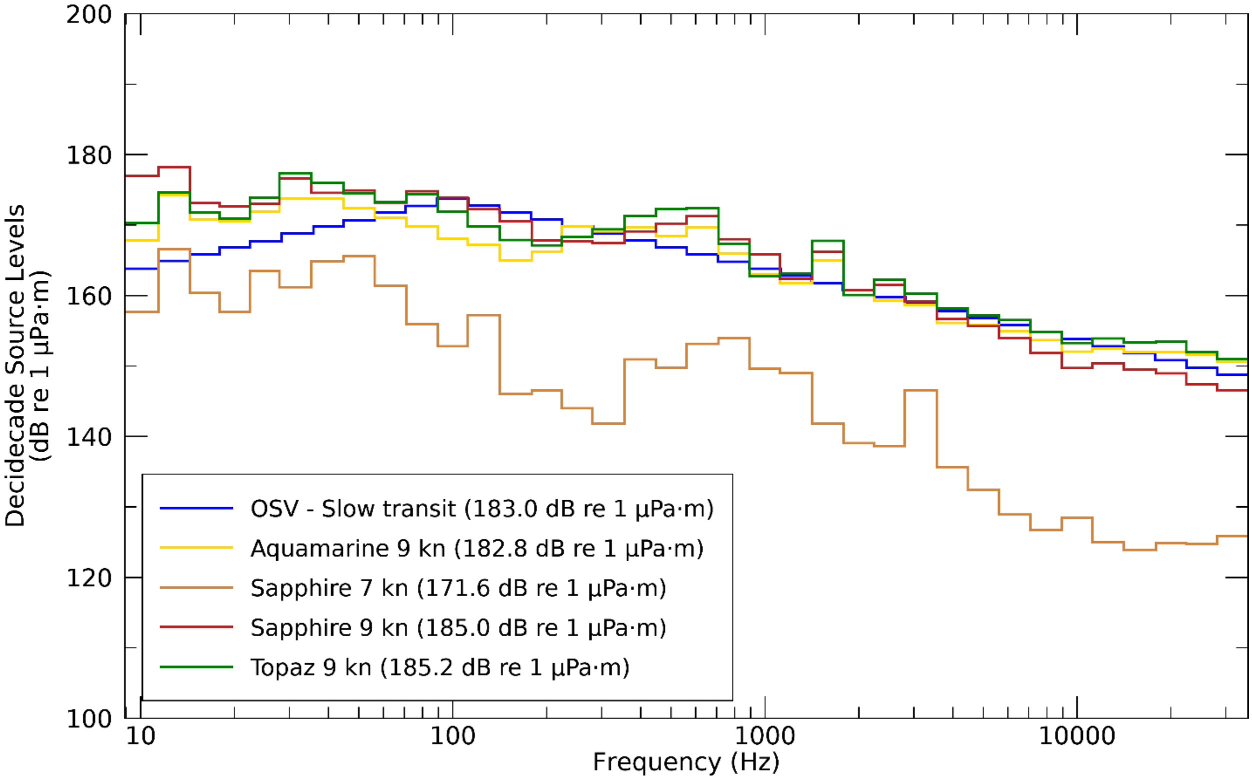


Figure 61. *Offshore Support Vessel (OSV)*: Decidecade source level spectra of the modelled OSV, slow transit (15% MCR) and Monopole source levels (MSLs) determined through the measurement program.

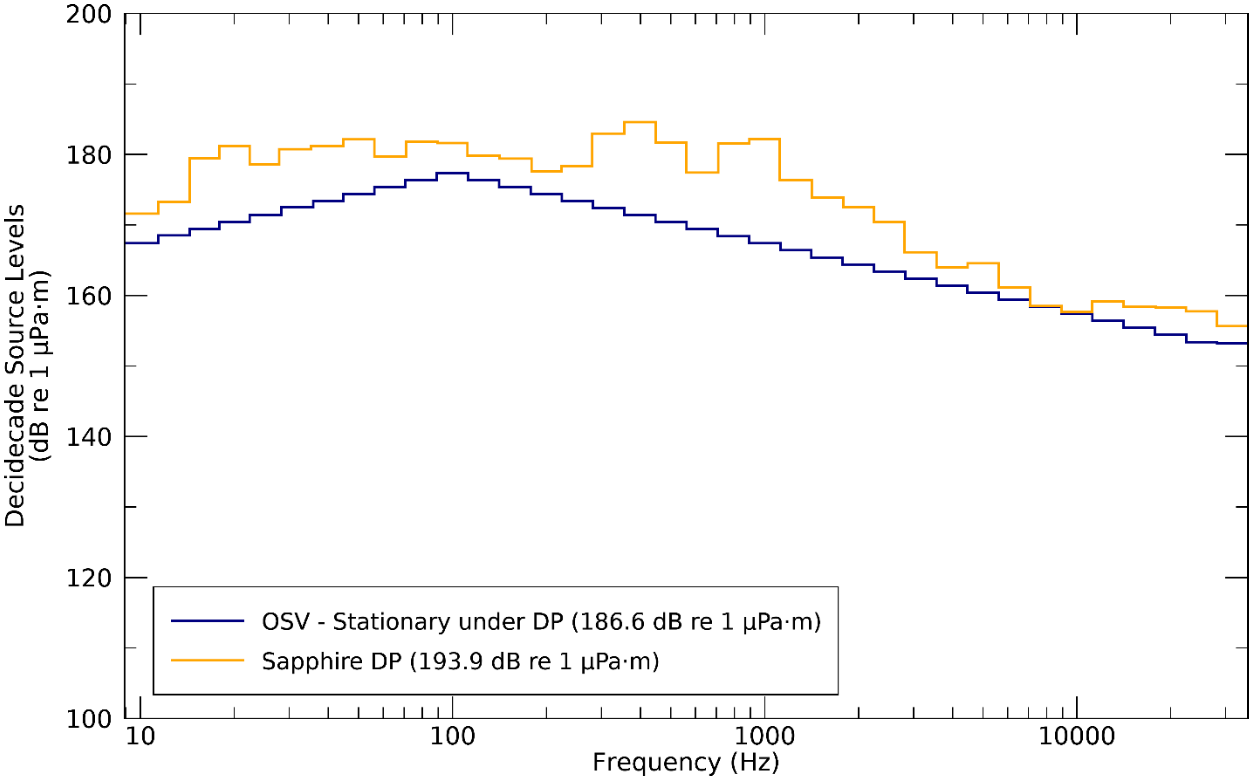


Figure 62. *Offshore Support Vessel (OSV)*: Decidecade source level spectra of the modelled DP (20% MCR) and MSLs determined through the measurement program.

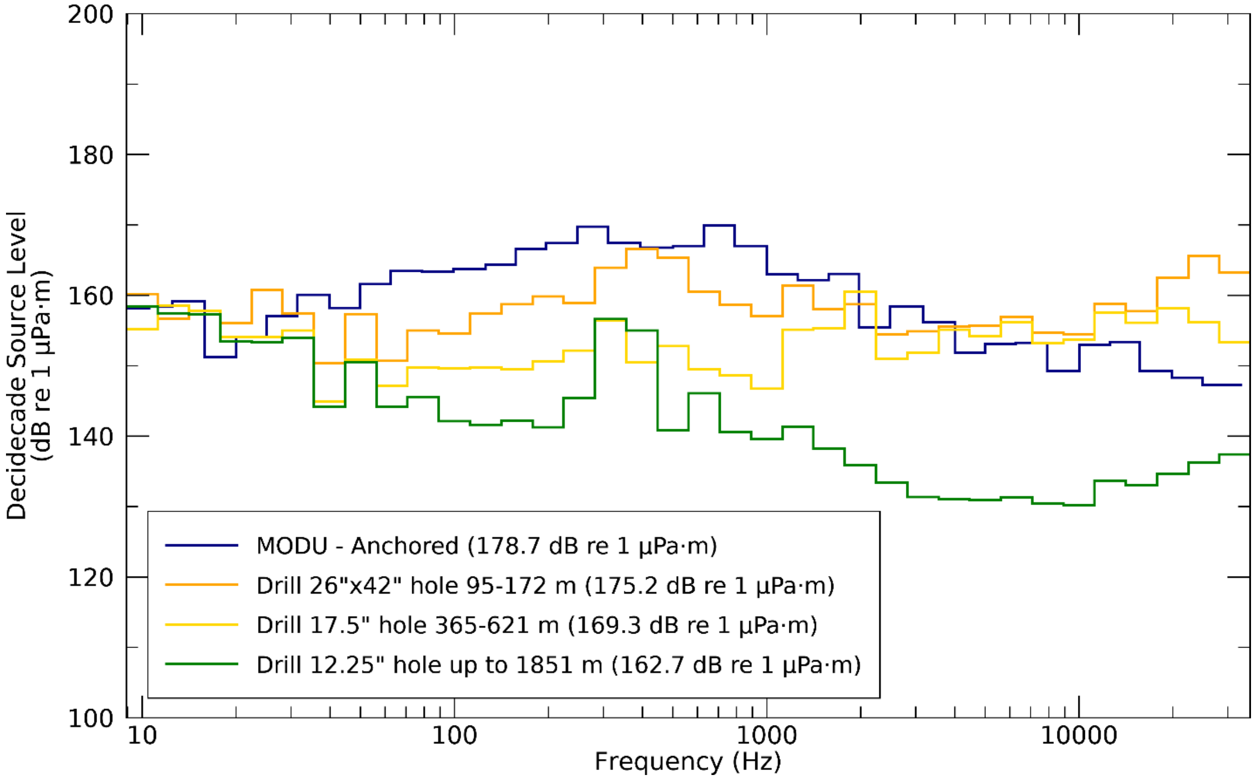


Figure 63. *Mobile Offshore Drilling Unit (MODU)*: Decidecade source level spectra of the modelled MODU, and the mean MSLs determined through the measurement program of the *Ocean Onyx* for three stages of drilling.

6.2. Understanding Propagation Loss

The plotted data and curve fits, as discussed in Section 4.2.4 and presented in Section 5.3, provide substantial detail on the environmental effects on the propagation of acoustic energy in the water column. In comparing SPL data fits for Stations 1–3, the loss rate is higher than what would have been expected in this environment, considering the higher MSLs for the support vessel on DP derived from measurements. In consideration of the potential variations in the seabed geologic compositions as indicated in Section 2.4, any difference may be attributed to the existence or absence of a thin veneer of sand.

A comparison exercise was conducted using JASCO’s Marine Operations Noise Model (MONM) and JASCO’s wavenumber integration model (VSTACK; Hannay et al. 2010, Jensen et al. 2011). VSTACK computes propagation loss versus depth and range for arbitrarily layered, range-independent acoustic environments using the wavenumber integration approach to solve the exact (range-independent) acoustic wave equation. Seabed reflectivity in the model is dependent on the seabed layer properties: compressional and shear wave speeds, attenuation coefficients, and layer densities. It is valid over the full angular range of the wave equation and can fully account for the elasto-acoustic properties of the sub-bottom.

A simple range-independent isovelocity water column (1500 m/s) was modelled considering a calcarenite seabed with and without a thin layer of sand as detailed in the Appendix of Koessler et al. (2020). The decidecade spectra of the measured MODU in Section 6.1 were combined with the modelled propagation loss from MONM and VSTACK to produce received level (SPL; L_p) scatter plots with range. Receivers were chosen to span the water column and the MSL source depth was located at 11 m. The results are shown below in Figures 64 and 65 when considering the mean maximum decidecade MSL presented above in Section 6.1 .

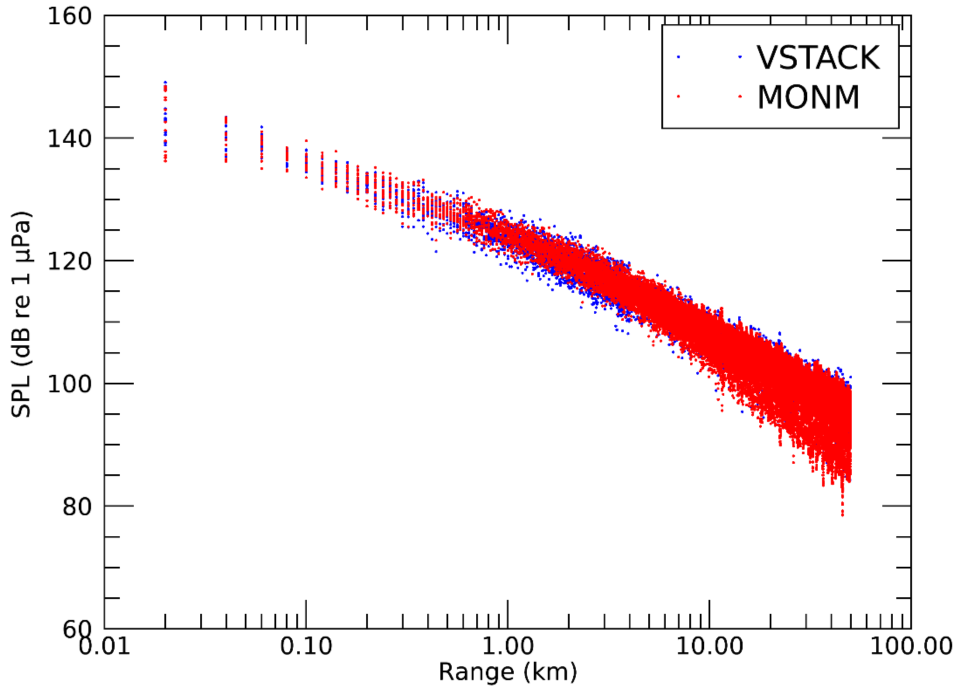


Figure 64 *Mobile Offshore Drilling Unit (MODU)*: Predicted received levels (SPL) for a simplified range independent environment with a calcarenite seabed with a thin overlying veneer of sand.

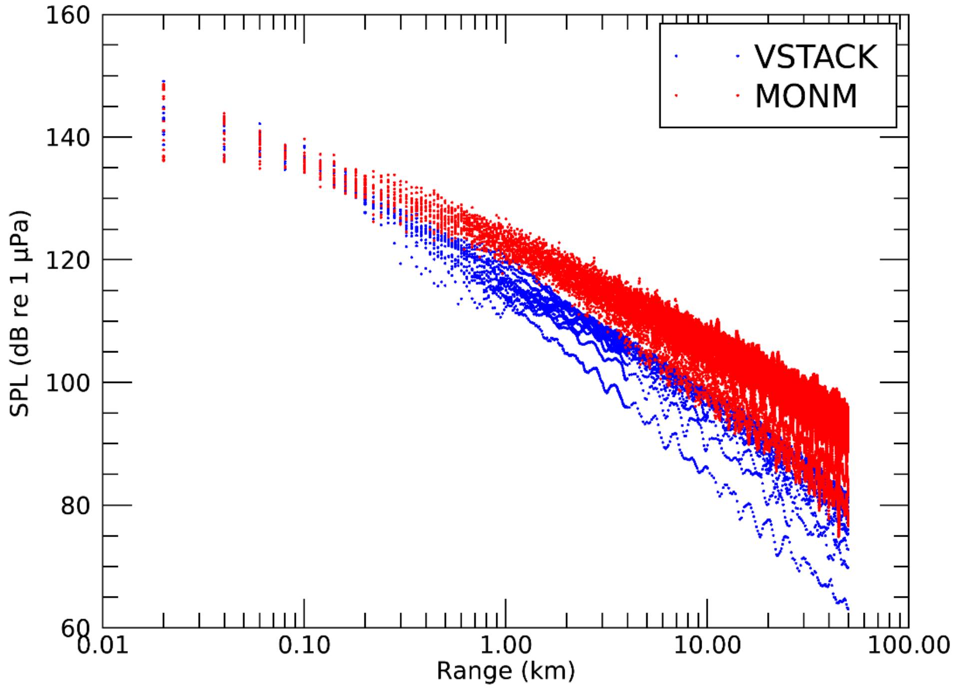


Figure 65 *Mobile Offshore Drilling Unit (MODU)*: Predicted received levels (SPL) for a simplified range independent environment with a calcarenite seabed with no sand layer.

When considering the results from VSTACK, the indication is that much higher rates of loss would be expected if no sand layer were present. Considering the variably of the distribution of seafloor sediments within the wider region, the higher rates of loss indicate that that the any overlaying sand is much thinner than or completely absent at the seafloor. In consideration of these modelled results and the SPL curve fits in in Section 5.3, the validation exercise was therefore carried out with the geoacoustic model consisting of well-cemented carbonate caprock, overlying semi-cemented carbonate rock.

An additional broadband correction was applied to the propagation loss results from MONM to account for the higher rates of loss when the full for the elasto-acoustic properties of the sub-bottom are consider. The differences between the broadband SPL from MONM and VSTACK were extracted at the same modelled ranges and depths that corresponded range independent predictions. The 90th percentile of the resultant dB differences was selected at each range to generate a generalised conversion function for each individual site to be modelled. The conversion functions were applied after the propagation loss calculation from MONM but before summing decidecade band levels, gridding, and radii calculations for each modelled site in each modelled scenario considered. Figure 66 shows an example comparison of the re-modelled results for Scenario 7 (MODU with OSV during resupply operations), at a receiver depth of 70.5 m (the median depth of measurement Stations 1–3) and an azimuth of 60°, against the data and 90th percentile data fit bounds for when the levels at Station 1 are above 150 dB re 1µPa (Figure 22). It is inferred that the data plotted here is associated with operational activity in the vicinity of the MODU and therefore may be similar to the modelled resupply operations scenario, at least for comparative purposes. The similar decay rates between the modelling and measured data indicate that re-modelled results presented here are broadly within measured range of levels for similar operations.

However, these data contain many different operations that will not exactly align with nominal representative scenarios for modelling, due to the time varying nature of the operations and associated produced sound levels. The modelled scenario produces levels that intersect the upper bound of the measured data, and therefore it is likely conservative through using the static MSL and operational representations – whilst a more detailed scenario is possible to be created (Quijano et al. 2019), that was beyond the scope of this study.

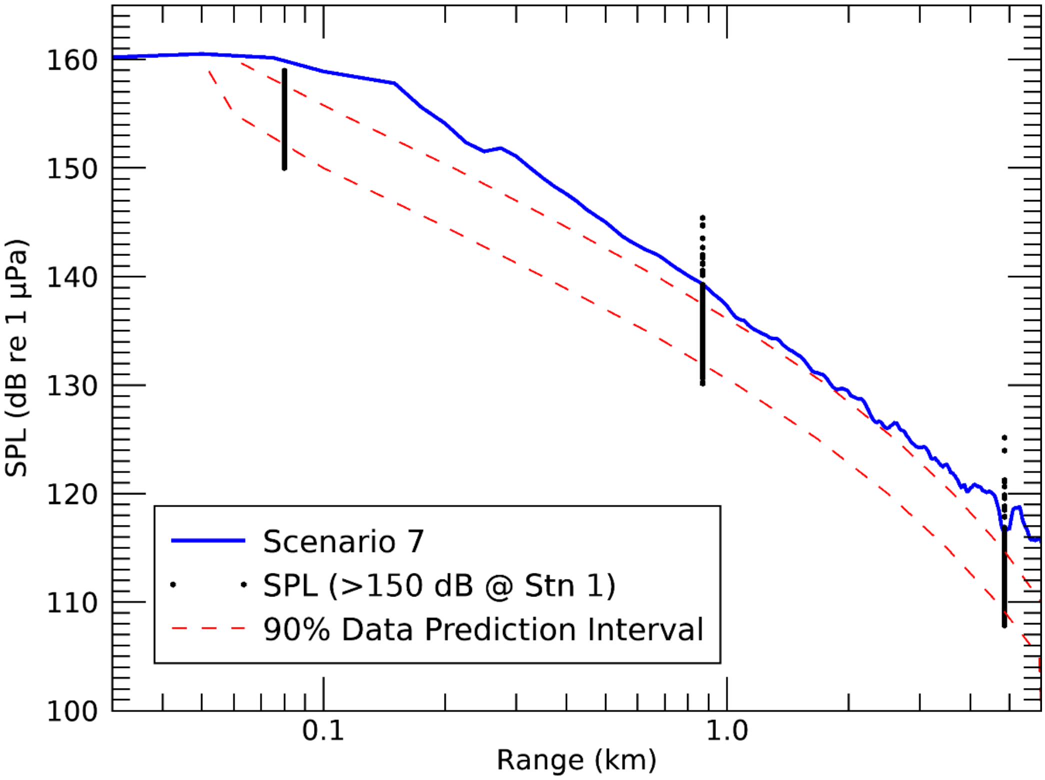


Figure 66. Generalised model validation plot.

6.3. Revised Threshold Distances

The results from the measurement study cannot be directly compared to the modelling presented in Koessler et al. (2020) due to the differences in actual events compared to the nominal representative scenarios developed and evaluated as part of the EP assessment process. Additionally, the measurements were obtained at a receiver 1.2 m off the seafloor, not at the maximum-over-depth results reported in the modelling study. The ranges obtained from the measurement study are reported in relation to the Artisan-1 well location, and thus the centre of the *Ocean Onyx*. The ranges in the modelling study are reported from a range of locations, including the centroids of multiple sources, thus it is not possible to report the measurement results in a similar fashion using the small number of recording locations used in this study.

However, the understanding of the propagation loss environment, and the revision of the representation and treatment of it as detailed in Section 6.2, enabled the modelling scenarios for activities at Artisan-1 presented in Koessler et al. (2020) to be recalculated. The revised results for distances to maximum-over-depth SPL isopleths are presented in Table 14 and compared in Table 15 to the original modelling. The revised results for distances to maximum-over-depth SEL thresholds are presented in Table 16 and compared in Table 17 to the original modelling.

Table 14. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) to sound pressure level (SPL) from the most appropriate location for considered sources per scenario (see table footnotes).

SPL (L_p; dB re 1 µPa)	MODU (Scenario 5)		OSV standby (Scenario 6)		MODU and OSV resupply (Scenario 7)[A]		MODU and OSV standby (Scenario 8)[B]	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
180	–	–	–	–	0.03	0.03	–	–
170[C]	–	–	–	–	0.06	0.06	–	–
160	–	–	–	–	0.13	0.12	–	–
158[D]	–	–	–	–	0.16	0.15	–	–
150	0.04	0.04	–	–	0.32	0.31	–	–
140	0.12	0.11	0.03	0.03	0.83	0.78	0.03	0.03
130	0.36	0.35	0.14	0.14	2.3	2.16	0.14	0.14
120[E]	1.17	1.09	0.37	0.35	7.02	6.41	2.09	1.9
110	4.74	3.87	0.91	0.88	18.03	15.85	5.21	4.54

[A] Radial distance reported from the mid-point between the MODU and the OSV on DP in resupply operations.

[B] Radial distances for isopleths/thresholds that envelope the MODU and OSV were reported from the mid-point between the MODU and the centre of the OSV standby area. Otherwise radial distances reported from the OSV in the standby area.

[C] 48 h threshold for recoverable injury for fish with a swim bladder involved in hearing (Popper et al. 2014).

[D] 12 h threshold for TTS for fish with a swim bladder involved in hearing (Popper et al. 2014).

[E] Threshold for marine mammal behavioural response to continuous noise (NOAA 2019).

A dash indicates the level was not reached within the limits of the modelling resolution (25 m).

Table 15. Difference in maximum ($R_{\max}$) and 95% ($R_{95\%}$) horizontal distances (in km) to sound pressure level (SPL) between Koessler et al. (2020) and modelling completed using data from measurement study. Positive values indicate and increase in distance as compared to Koessler et al. (2020), negative values indicate a decrease.

SPL (L_p; dB re 1 µPa)	MODU (Scenario 5)		OSV standby (Scenario 6)		MODU and OSV resupply (Scenario 3)		MODU and OSV standby (Scenario 4)	
	Difference $R_{\max}$ (km)	Difference $R_{95\%}$ (km)	Difference $R_{\max}$ (km)	Difference $R_{95\%}$ (km)	Difference $R_{\max}$ (km)	Difference $R_{95\%}$ (km)	Difference $R_{\max}$ (km)	Difference $R_{95\%}$ (km)
180	*	*	*	*	*	*	*	*
170	*	*	*	*	0.03	0.03	*	*
160	*	*	*	*	0.07	0.06	*	*
158	*	*	*	*	0.07	0.06	*	*
150	-0.04	-0.04	-0.05	-0.05	-0.01	0.0	-0.05	-0.05
140	-0.09	-0.09	-0.34	-0.33	-0.77	-0.75	-0.34	-0.33
130	-0.83	-0.74	-1.75	-1.67	-3.59	-3.25	-3.08	-2.68
120	-4.74	-4.3	-5.86	-5.34	-10.4	-8.99	-6.85	-5.99
110	-30.13	-18.76	-18.06	-14.43	-42.03	-32.65	-31.54	-23.44

An asterisk indicates that the difference in radial distance could not be computed due to distances less than the modelled resolution .

Table 16. Maximum ($R_{\max}$) horizontal distances (in km) to frequency-weighted SEL_{24h} PTS and TTS thresholds based on NMFS (2018) and Finneran et al. (2017) from the most appropriate location for considered sources per scenario, and ensonified area (km^2).

Hearing group	SEL_{24h} threshold ($L_{E,24h}$; dB re 1 µPa$^2\cdot$s)[B]	MODU (Scenario 5)		OSV standby (Scenario 6)		MODU and OSV resupply (Scenario 7)[A]		MODU and OSV standby (Scenario 8)[A]	
		$R_{\max}$ (km)	Area (km^2)	$R_{\max}$ (km)	Area (km^2)	$R_{\max}$ (km)	Area (km^2)	$R_{\max}$ (km)	Area (km^2)
PTS									
LF cetaceans	199	–	–	–	–	–	–	–	–
MF cetaceans	198	–	–	–	–	–	–	–	–
HF cetaceans	173	0.19	0.11	–	–	0.2	0.12	0.19	0.11
Phocid seals	201	–	–	–	–	–	–	–	–
Otariid seals	219	–	–	–	–	–	–	–	–
Turtles	220	–	–	–	–	–	–	–	–
TTS									
LF cetaceans	179	0.31	0.31	1.01	0.35	0.95	2.78	0.31	0.66
MF cetaceans	178	0.13	0.05	–	–	0.16	0.06	0.13	0.05
HF cetaceans	153	1.07	3.44	1.01	0.18	1.09	3.86	1.06	3.64
Phocid seals	181	0.12	0.05			0.35	0.28	0.12	0.05
Otariid seals	199	–	–	–	–	–	–	–	–
Turtles	200	–	–	–	–	–	–	–	–

[A] Radial distance reported from the centre of the MODU, unless indicated otherwise.

[B] Frequency weighted.

A dash indicates the level was not reached within the limits of the modelling resolution (25 m).

Table 17. Difference in maximum (R_{max}) horizontal distances (in km) to frequency-weighted SEL_{24h} PTS and TTS thresholds based on NMFS (2018) and Finneran et al. (2017) between Koessler et al. (2020) and modelling completed using data from measurement study. Positive values indicate and increase in distance as compared to Koessler et al. (2020), negative values indicate a decrease.

Hearing group	SEL_{24h} threshold ($L_{E,24h}$; dB re 1 µPa²·s)†	MODU (Scenario 5)	OSV standby (Scenario 6)	MODU and OSV resupply (Scenario 7)	MODU and OSV standby (Scenario 8)
		R_{max} (km)	R_{max} (km)	R_{max} (km)	R_{max} (km)
PTS					
LF cetaceans	199	*	*	*	*
MF cetaceans	198	*	*	*	*
HF cetaceans	173	0.15	*	0.16	0.15
Phocid seals	201	*	*	*	*
Otariid seals	219	*	*	*	*
Turtles	220	*	*	*	*
TTS					
LF cetaceans	179	-0.61	-0.11	-1.78	-2.45
MF cetaceans	178	*	*		
HF cetaceans	153	0.47	-0.03	-1.59	0.02
Phocid seals	181	-0.09	*	0.14	-0.09
Otariid seals	199	*	*	*	*
Turtles	200	*	*	*	*

† Frequency weighted.

An asterisk indicates that the difference in radial distance could not be computed due to distances less than the modelled resolution.

7. Discussion and Conclusion

7.1. Ambient Soundscape

The insights into ambient soundscape within the Otway Basin and in the vicinity of the Development Drilling program can be obtained through the data recorded at Station 4, and in part, Station 3. Stations 1 and 2 are too close to the location of the Artisan-1 well and associated activity to provide any information about ambient noise while the *Ocean Onyx* is present. Whilst data exists outside the period in which the *Ocean Onyx* is present, this data includes noise from the moored rig anchor chains, which are not a typical soundscape contributor.

The correlograms (Section 5.2) show a positive correlation between wind speeds and wave heights and sound levels for frequencies over 100 Hz, with the relationship with wind speed being stronger than that for wave height. For both stations shipping is a strong contributor: most days recorded a significant number of vessel detections (Section 5.6), with the contributions at Station 4 apparent in the power spectral density and percentile plot (Figure 16), between 40 and approximately 100 Hz. If the support vessels for the Development Drilling program did not pass near Station 3 as often while under station keeping, the number of close vessel passes would have been less, and thus it is likely that the statistics presented in Table 10 would have reflected a soundscape with quieter sound levels on average.

In terms of monitoring work with the Otway and Bass Strait regions, between 2009 and 2016 the Integrated Marine Observing System (IMOS) has been recording underwater sound south of Portland, Victoria (38°32.5' S, 115°0.1'E). Prominent sound sources identified in recordings include blue and fin whales at frequencies below 100 Hz, ship noise at 20 to 200 Hz, and fish at 1 to 2 kHz (Erbe et al. 2016). In the broader region, primary contributors to background sound levels were wind, rain and currents-and waves-associated sound at low frequencies under 2 kHz (Przeslawski et al. 2016), and biological sound sources including dolphin vocalisations were also recorded.

To gain an understanding of the existing marine acoustic environment to inform the impact assessment for the Otway Gas Development, acoustic monitoring was undertaken by Woodside (2003). During April-May 2001, two underwater noise loggers were placed (5.1 km and 2.9 km) south-west of an exploration petroleum drilling vessel at the Thylacine site to measure underwater noise before, during, and after drilling activity. Only one of the loggers (5.9 km) was able to be recovered. A further logger was placed in the shipping lane approximately 60 kms due south of Port Fairy to measure ambient noise produced by physical, man-made and biological sources between late November 2001 and early March 2002.

A summary of the report states that the following features were noted with respect to underwater noise environment at the Thylacine location:

- Relatively quiet with only the passage of several boats (about ten) evident.
- The rig tender and drill rig noise show clearly from 13:00 on the 3 May 2001.
- Drill rig noise was evident as sharp tones.
- Rig tender noise was evident either at a low but persistent level for days or in short bursts of high level noise for several hours associated with manoeuvring, use of thrusters or as a close passage by the receiver.
- The horizontal banding characteristic of persistent calling by pygmy blue whales was not evident, rather these call types occurred infrequently and at low levels indicating the respective sources were at long range.
- Evidence of low-level, distant evening fish choruses only.

However, at the shipping lane location, it was noted:

- Regular passages of boats evident.
- Regular evening fish choruses, there were also dawn choruses and persistent low level calling by these sources over daytime.
- Blue whale calling persisted over many hours, an example is the first close passage for the season just before midday on 4 January 2002 followed by several more animals a day later.
- Evidence of calling from at least three other whale species.
- Baseline broadband underwater noise for the period was in the order of 93 to 97 dB re 1 µPa with shipping raising the averaged noise level above 105 dB re 1 µPa for 6% of the deployment time.

An acoustic monitoring program was also undertaken during exploratory drilling of the Casino-3 well. A sound logger located 28.03 km from the drill site did not detect drilling noise and recorded ambient noise that ranged between 90 and 110 dB re 1 µPa (McCauley 2004). Passive acoustic monitoring commissioned by Origin from April 2012 to January 2013, 5 km offshore from the coastline east of Warrnambool, identified that ambient underwater noise in coastal areas is generally higher than further offshore, with a mean of 110 dB re 1 µPa and maximum of 161 dB re 1 µPa.

JASCO has not reviewed these historical reports and the associated activity descriptions within them, or information on the vessels and MODU used, therefore direct comparison between the data collected during exploratory drilling of the Casino-3 well and the Artisan-1 well should be conducted with caution.

Comparing the results from a recorder 28.3 km from drilling operations at Casino 3 with Station 4, the results for Station 4 were a median broadband ambient noise of 104.5 dB re 1 µPa, a mean of 118.3 dB re 1 µPa, a minimum of 86.6 dB re 1 µPa, and a maximum of 153.6 dB re 1 µPa, which is both quieter and louder than those for Casino 3. The mean levels at Station 4 are 8.3 dB higher than those recorded 5 km offshore of Warrnambool, while the maximum recorded at Station 4 is lower by 7.4 dB. The use of percentiles, as provided in Section 5.1.1, Figure 16 and Table 10, in the context of contributors such as weather (Section 5.2), shipping (Section 5.6), and marine mammals (Section 5.7), provides a more nuanced understanding of sound levels received at a recording station. Local variations in ambient noise and received levels can depend upon water depth and the proximity to contributors In this case, the shipping lanes (Section 2.2) and the frequency and proximity of vessel passes are strong drivers of the ambient noise at Station 4. The use of Station 4 as a dedicated measurement location for the support vessels (Section 2.5.2) does not change the relevance of the results from this measurement location, as those vessels would still have been transiting at similar speeds and along similar tracks on trips between Geelong and Artisan-1. The quieter levels reported at Thylacine in Lattice Energy (2017) are likely due to the placement of the monitoring station at a distance from the shipping lanes (Figure 3), which limited their contributions to the data set and thus resulted in a lower reported range of received sound levels.

7.2. Modelling Validation

The Monopole Source Levels determined through the measurement study differed from those either estimated for use in the modelling study or those determined using proxy sources. The key differences are as follows:

- The support vessels are quieter than estimated when they are under slow transit speeds, such as 7 kn.
- The support vessels are louder than estimated when they are travelling at faster transit speeds, with 9 kn used to represent these speeds and the associated MSL.
- The support vessels are louder than estimated when holding station or moving under dynamic positioning.
- The drilling operations of the *Ocean Onyx* are both louder at some frequencies and quieter at others than those for the proxy rig the *Polar Pioneer* (Austin et al. 2018), although the results presented for the *Polar Pioneer* did not examine the changes in level with increased drilling depth (over time) as completed within this study.

The relationship between vessel speed and MSL is well known, with recent detailed examinations on shipping traffic associated with the Port of Vancouver (Joy et al. 2019, Trounce et al. 2019, JASCO Applied Sciences and SMRU Consulting 2020). Conducting the measurement campaign in deeper water, along with higher time resolution location reporting systems for the vessels, automated high time resolution engine information reporting, and a greater number of vessel passes at a range of speeds would further develop this dataset to allow for more accurate predictions of sound level in relation to vessel speed or operations. Predictions of sound levels using speed and operational state is preferred to estimates determined using scaling of power levels, particularly when considering the range of propulsion systems on the vessels.

The measurement of sound levels for vessels under DP is complex and time consuming. It requires dedicated operations in the absence of other activities, which is a challenge considering the task requirements of typical support and anchor handling vessels. Few studies have reported the MSL of support vessels under DP, with the majority estimating the RNL rather than MSL. The large range of thrusters and operational control systems and the variable source depths of each individual thruster contribute to the complexity of estimating source levels. Measurement studies are complicated by environmental conditions and the specifics of each vessel. The MSLs calculated from each of the three DP exercises defined (Section 2.5.2) were very similar. However, the ability to replicate these across different weather conditions and position holding constraints would likely provide valuable information which could help contextualise future modelling studies.

The MSLs reported within this study can be used as inputs to modelling studies for other operations for the same or similar vessels or MODU's. However, the reported ranges to thresholds are specific to the Artisan-1 well location, and not transferrable to other locations, particularly in different water depths, geologic environments, and sound speed profiles. The approach developed to represent the propagation loss based upon the measurement results is suitable for other locations within the continental shelf portion of the Otway Basin. However, the accuracy of the representation of the propagation loss within this environment depends significantly upon the frequency content of the radiating sound source together with thickness of the sand layer on the calcarenite seabed within the region. In general, the thinner the sand layer, the greater the propagation loss.

The agreement between VSTACK and MONM would be expected depend on the level and frequency content of the modelled source and the thickness of any unconsolidated sediments at the seafloor as low frequency energy will be less sensitive to thin layers. For the comparison conducted here in Section 6.2, the comparison between VSTACK and MONM is excellent when only a comparatively thin 1 m thick layer of sand overlies the carbonate seabed structure. If the data decay rates were more indicative of propagation over a layer of sediment, then MONM could have been used without correction.

The distances to the effect thresholds based on the measurement study results (Section 6.3) are reduced compared to those presented in Koessler et al. (2020). The understanding of the environment gained through the measurement study allowed for the geological environment to be represented in a site specific fashion, and a more appropriate configuration of numerical models to represent the propagation loss. The application of the revised modelling approach to represent other Beach Energy activities on the continental shelf of the Otway Basin would be appropriate.

7.3. Development Drilling Program Contributions

Soundscape contributions of the Development Drilling operations were activity-dependent and depended upon proximity to both the *Ocean Onyx* and associated support vessels. At the three closest stations, the relative contributions are demonstrated through the LTSAs and percentiles for the entire period the *Ocean Onyx* was operational at Artisan-1, and two presented example periods. One of the presented example periods involved significant contributions to the sound fields at the three stations close to the rig presented in Section 5.1.1, as well as considering the per station daily SELs (Section 5.1.2).

A better understanding of the contributions from the Development Drilling operations on a regional scale is provided through the data recorded at Station 4, 25 km from the *Ocean Onyx* (whilst drilling operations were being conducted at Artisan-1), and they did not appear to be a significant contributor to the overall soundscape. While the operational contributions were not significant at Station 4, they were apparent throughout different stages of the activity. At long ranges, the contribution from the drilling itself is hard to distinguish from associated vessel operations, complicated by support vessels manoeuvring over an area greater than 100 km^2. The support vessels operating under dynamic position while completing tasks at Artisan-1 which required high thrust levels, such as anchor handling and accurate station keeping in high sea states, were apparent at Station 4 (for example Figure 44). The configuration of Station 4 to be able to present received signals with the context of direction allowed for the attribution of signals to specific sources. Whilst the recording station 28 km from the Casino 3 drilling operation reported in Lattice Energy (2017) was not able to detect drilling noise, the analysis would not have been able to attribute detected vessel noise to the support vessels for the rig. Therefore, it is likely that the Casino 3 monitoring program recorded noise associated with the drilling program but was unable to attribute it due to the lack of context provided by single omni-directional hydrophone recorder configurations (similar to Stations 1–3).

Periods with less dynamic positioning utilisation, such as between 17:00 and 18:39 on 8 Mar 2021, ShipSound report in Appendix G.1.2, with the spectrogram shown in Figure 37, had only faint potential contributions noticeable at Station 4 (Figure 67). In this figure, long tonals which originate in a north-west direction (the direction of Artisan-1) are apparent between 100 and 250 Hz. However, these are not apparent in data at Station 1 (Figure 37), and thus potentially do not originate close to the rig. In addition to these tonals, the spectrogram shown in Figure 67 shows periods of rain, the approach of the 17 m long sailing boat *Zatara* (Figure 68), which passes within 686 m of Station 4 at a speed of 8 kn, and a likely fish chorus between 800 and 1000 Hz from the north-west.

The rig move operations were apparent, similarly to other periods of high thrust levels, with contributions from the support vessels throughout the tow period matching the relative direction received at Station 4 (Figures 69 and 70). The frequency range, which was still typically detectable at long ranges, 100 to up to 1000 Hz, is above the frequency range for the fundamentals and primary harmonics for pygmy blue whale vocalisations (Section 5.7.2), as shown in Figure 69. Therefore, the potential effect on the communication and listening space (Hannay et al. 2016a), and thus masking, at longer ranges is less apparent than it is for seismic survey activity, or regions in which low frequency signals experience less loss then they do in locations with highly absorptive seabeds.

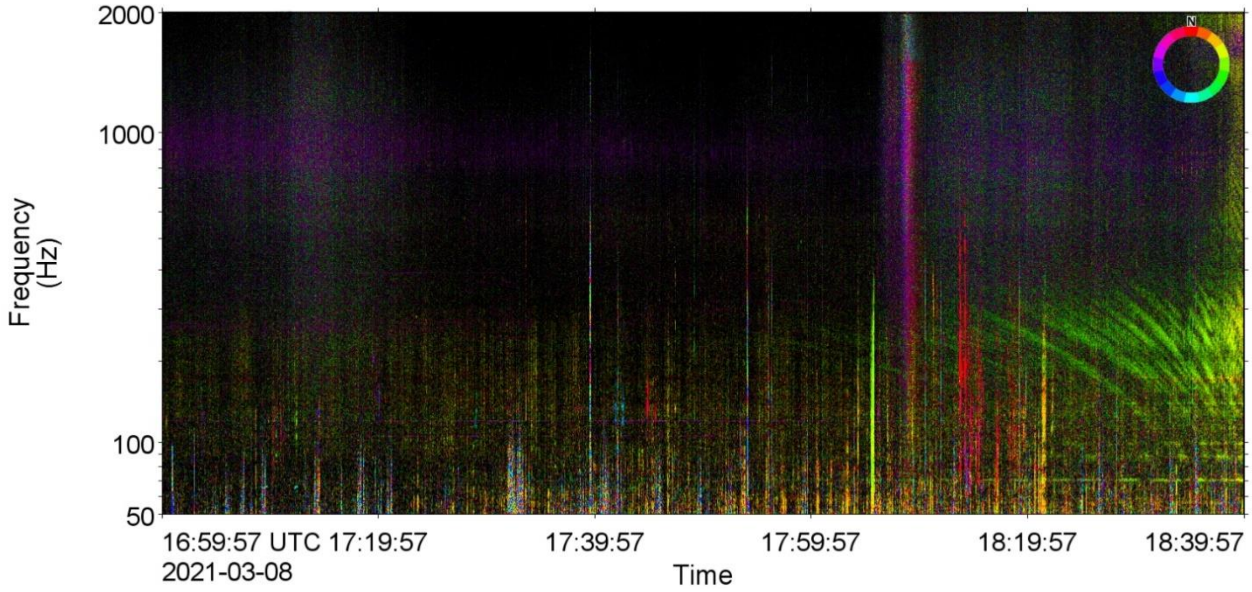


Figure 67. Data recorded on Station 4 including *Ocean Onyx* ShipSound analysis reports between 17:00 and 18:39 on 8 Mar 2021, ShipSound report in Appendix G.1.2, with the spectrogram shown in Figure 37 (0.4 Hz frequency resolution, 2 s time window, 0.5 s time step, Hamming window, normalised across time).

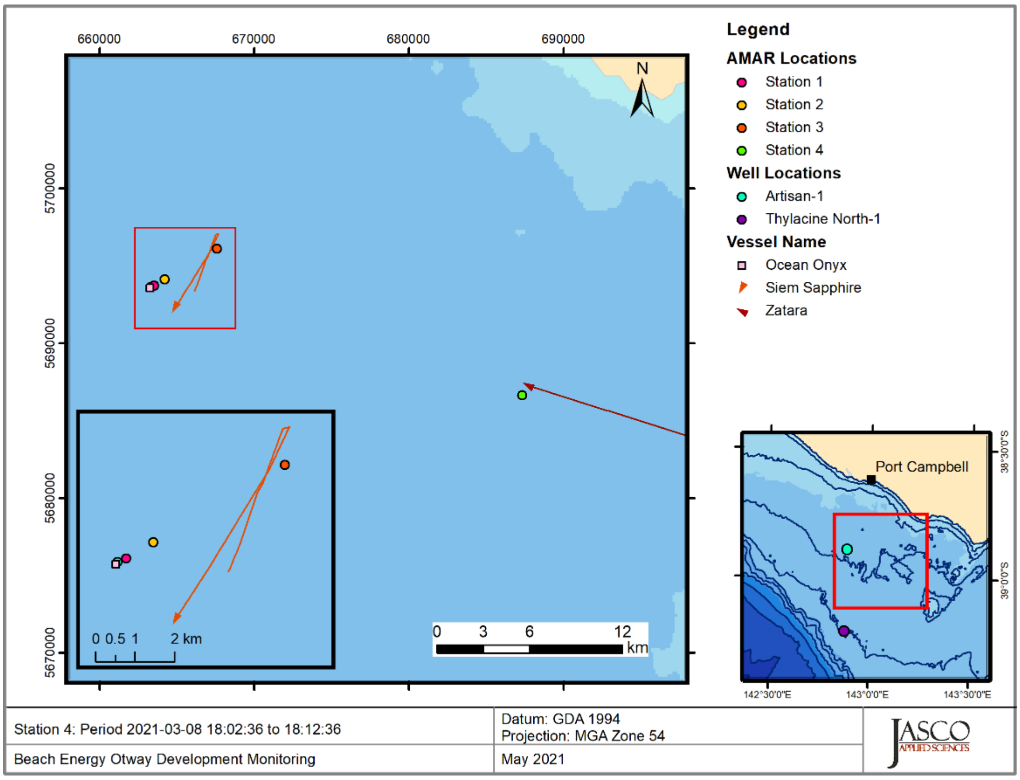


Figure 68. Map of AIS reported vessel locations for the spectrogram shown in Figure 67.

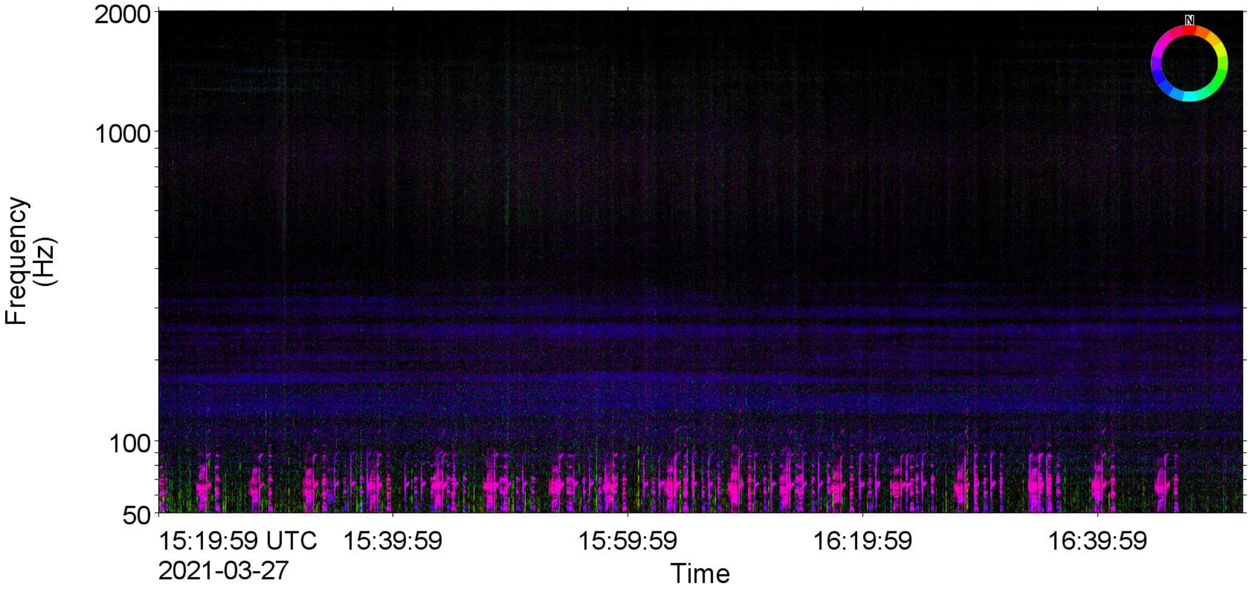


Figure 69. Example of the contribution of the three support vessels and the *Ocean Onyx* while ~23 km away in a south-west direction under tow from Artisan-1 to Geographe, apparent via the blue horizontal striations between 100 and 500 Hz, along with multiple pygmy blue whales in a west to north-west direction of Station 4 (0.4 Hz frequency resolution, 2 s time window, 0.5 s time step, Hamming window, normalised across time).

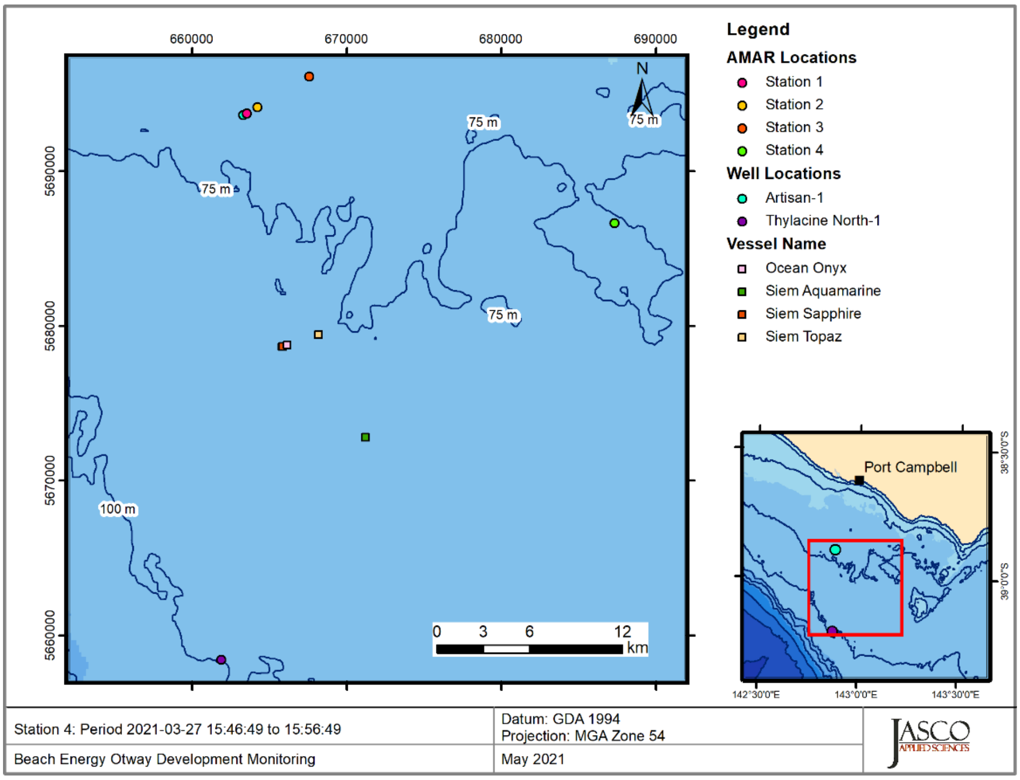


Figure 70. Map of automatic identification system (AIS) reported vessel locations for the spectrogram shown in Figure 69.

7.4. Marine Mammals

The marine mammal acoustic detection results presented in this report provide an index of acoustic occurrence for each species. Although they can be used to describe the relative occurrence of a species, several factors influence the detectability of the targeted signals. Although acoustic detection does indicate presence, an absence of detections (automated or manual) does not necessarily indicate an absence of animals. An animal may be present but not detected if no individuals were vocalising near the recorder, their signals were masked by environmental and/or anthropogenic noise sources, or a combination of these factors. Different sound propagation environments and different seasonal effects will impact the detection range of a given signal over time and, therefore, influence the number of detectable signals. The acoustic signals of both dolphins and pygmy blue whales were present in the acoustic data. vVcalisations of other mysticetes, such as humpback and southern right whales, were not detected by the detectors (D.2), or observed during the 0.5% manual review.

7.4.1. Dolphins

Dolphin species reported in offshore Victorian waters include the short-beaked common and bottlenose dolphins (Bilgmann et al. 2007, Bilgmann et al. 2014). Burrunan dolphins (*Tursiops australis*) can also occur in the region (Charlton-Robb et al. 2015), although they are likely more coastal. While it would be ideal to discriminate between species, success has been limited using automated detectors, and the detailed manual analysis required to attempt to identify individual species is beyond the scope of this report (Steiner 1981, Rendell et al. 1999, Oswald et al. 2003, Baron et al. 2008).

Based on the occurrence of echolocation clicks and whistles, dolphins occurred in the area throughout the recording period at all stations. Dolphin acoustic occurrence was low in February and increased through March at Stations 1, 2, and 3. In contrast, dolphins were consistently present at an almost hourly basis at Station 4. It is impossible to say whether the sparsity of dolphins at Stations 2 and 3 in February is a result of the animals not being common or of their signals being masked by the high noise environment (Figure 16).

The predominance of delphinid clicks during hours of darkness could correspond to foraging on prey species that follow the diel vertical migrations of zooplankton. Similar patterns have been observed in studies of a number of whale species (Víkingsson 1997, Au et al. 2000, Wiggins et al. 2005, Baumgartner and Fratantoni 2008, Sayigh et al. 2013) and by JASCO in studies conducted in northern Australian waters (McPherson et al. 2012, McPherson et al. 2014, McPherson et al. 2016). However, recent research suggests that though such patterns are common, they may not be as closely linked to prey as previously thought (Osiecka et al. 2020).

The presence of sounds believed to be produced by young bottlenose dolphins suggests that not only were dolphins using this region to socialize (indicated by presence of whistles) and forage (indicated by presence of clicks), but they also care for their young.

7.4.2. Pygmy Blue Whales

The acoustic occurrence of pygmy blue whale vocalisations in the acoustic data was unsurprising as they have previously been reported in the region and the Bonney Upwelling is a known foraging area for this species (Garcia-Rojas et al. 2018, McCauley et al. 2018, Möller et al. 2020). Tag data indicates that blue whales are most common in the recording area between January and July, coinciding with the upwelling season of the region (Möller et al. 2020). The lack of clear directional movement during the recording period is unsurprising given both the small sample size and that this area is believed to be a location where blue whales aggregate, as opposed to a migratory corridor where a more consistent pattern in direction over time would be expected. The data does indicate an apparent trend in the animals early in the recording being more to the east and later in the recording being more to the west, but the data were too sparse to confirm anything about animal movements. A monitoring program with directional stations distributed across the Otway Basin would be able to provide this information.

The presence of songs indicates the presence of male pygmy blue whales and the increased regularity of songs at the end of March at all stations corresponds with the onset of the winter singing season for this species (McCauley et al. 2018). Indeed, we cannot say whether the increased vocal activity in March is a result of increased animals in the region or a shift in acoustic behaviour. The blue whale occurrence results were extremely similar across recording stations which is unsurprising given the close vicinity of the recorders that were likely simultaneously recording the same blue whale vocalisations which can propagate great distances, as demonstrated for both pygmy and Antarctic blue whales (Gavrilov and McCauley 2013, Miller et al. 2013, Warren et al. 2021). It is believed that non-song D calls can be produced by male or female blue whales, and it may be a social call (Recalde-Salas et al. 2014).

Acknowledgements

The authors would like to thank the captain and crew of the Siem vessels *Sapphire*, *Aquamarine* and *Topaz*, as well as Klaus Lucke from JASCO for performing the fieldwork.

Glossary

1/3-octave

One third of an octave. Note: A one-third octave is approximately equal to one decidecade (1/3 oct ≈ 1.003 ddec; ISO 2017a).

1/3-octave-band

Frequency band whose bandwidth is one one-third octave. Note: The bandwidth of a one-third octave-band increases with increasing centre frequency.

90%-energy time window

The time interval over which the cumulative energy rises from 5 to 95% of the total pulse energy. This interval contains 90% of the total pulse energy. Symbol: T_{90}.

90% sound pressure level (90% SPL)

The root-mean-square sound pressure levels calculated over the 90%-energy time window of a pulse. Used only for pulsed sounds.

absorption

The reduction of acoustic pressure amplitude due to acoustic particle motion energy converting to heat in the propagation medium.

ambient noise

All-encompassing sound at a given place, usually a composite of sound from many sources near and far (ANSI S1.1-1994 (R2004)), e.g., shipping vessels, seismic activity, precipitation, sea ice movement, wave action, and biological activity.

annotation

A labelled selection of a period of time and frequency within a spectrogram as created by a human analyst during **manual analysis**.

attenuation

The gradual loss of acoustic energy from absorption and scattering as sound propagates through a medium.

audiogram

A graph of hearing threshold level (sound pressure levels) as a function of frequency, which describes the hearing sensitivity of an animal over its hearing range.

audiogram weighting

The process of applying an animal’s audiogram to sound pressure levels to determine the sound level relative to the animal’s hearing threshold (HT). Unit: dB re HT.

Auditory frequency weighting (auditory weighting function, frequency-weighting function)

The process of band-pass filtering sounds to reduce the importance of inaudible or less-audible frequencies for individual species or groups of species of aquatic mammals (ISO 2017a). One example is M-weighting introduced by Southall et al. (2007) to describe “Generalised frequency weightings for various functional hearing groups of marine mammals, allowing for their functional bandwidths and appropriate in characterizing auditory effects of strong sounds”.

automated detection

The output of an **automated detector**.

automated detector

An algorithm that includes both the **automated detection** of a sound of interest based on how it stands out from the background and its automated classification based on similarities to templates in a library of reference signals.

background noise

Total of all sources of interference in a system used for the production, detection, measurement, or recording of a signal, independent of the presence of the signal (ANSI S1.1-1994 (R2004)). Ambient noise detected, measured, or recorded with a signal is part of the background noise.

bandwidth

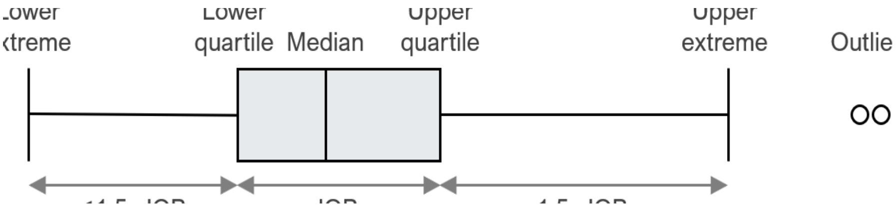
The range of frequencies over which a sound occurs. Broadband refers to a source that produces sound over a broad range of frequencies (e.g., seismic airguns, vessels) whereas narrowband sources produce sounds over a narrow frequency range (e.g., sonar) (ANSI and ASA S1.13-2005 (R2010)).

bar

Unit of pressure equal to 100 kPa, which is approximately equal to the atmospheric pressure on Earth at sea level. 1 bar is equal to 10^5 Pa or 10^{11} µPa.

box-and-whisker plot

A plot that illustrates the centre, spread, and overall range of data from a visual 5-number summary. The box is the interquartile range (IQR), which shows the middle 50% of the data—from the lower quartile (25th percentile) to the upper quartile (75th percentiles). The line inside the box is the median (50th percentile). The whiskers show the lower and upper extremes excluding outliers, which are data points that fall more than 1.5 × IQR beyond the upper and lower quartiles.



broadband sound level

The total sound pressure level measured over a specified frequency range. If the frequency range is unspecified, it refers to the entire measured frequency range.

cavitation

A rapid formation and collapse of vapor cavities (i.e., bubbles or voids) in water, most often caused by a rapid change in pressure. Fast-spinning vessel propellers typically cause cavitation, which creates a lot of noise.

cetacean

Any animal in the order Cetacea. These are aquatic, mostly marine mammals and include whales, dolphins, and porpoises.

continuous sound

A sound whose sound pressure level remains above ambient sound during the observation period (ANSI and ASA S1.13-2005 (R2010)). A sound that gradually varies in intensity with time, for example, sound from a marine vessel.

decade

Logarithmic frequency interval whose upper bound is ten times larger than its lower bound (ISO 2006).

decidecade

One tenth of a decade (ISO 2017a). Note: An alternative name for decidecade (symbol ddec) is "one-tenth decade". A decidecade is approximately equal to one third of an octave (1 ddec ≈ 0.3322 oct) and for this reason is sometimes referred to as a "one-third octave".

decidecade band

Frequency band whose bandwidth is one decidecade. Note: The bandwidth of a decidecade band increases with increasing centre frequency.

decibel (dB)

One-tenth of a bel. Unit of level when the base of the logarithm is the tenth root of ten, and the quantities concerned are proportional to power ([ANSI] American National Standards Institute S1.1-1994 (R2004)).

delphinid

Family of oceanic dolphins, or Delphinidae, composed of approximately thirty extant species, including dolphins, porpoises, and killer whales.

duty cycle

The time when sound is periodically recorded by an acoustic recording system.

far-field

The zone where, to an observer, sound originating from an array of sources (or a spatially distributed source) appears to radiate from a single point. The distance to the acoustic far-field increases with frequency.

fast-average sound pressure level

The time-averaged sound pressure levels calculated over the duration of a pulse (e.g., 90%-energy time window), using the leaky time integrator from Plomp and Bouman (1959) and a time constant of 125 ms. Typically used only for pulsed sounds.

fast Fourier transform (FFT)

A computationally efficiently algorithm for computing the discrete Fourier transform.

frequency

The rate of oscillation of a periodic function measured in cycles-per-unit-time. The reciprocal of the period. Unit: hertz (Hz). Symbol: *f*. 1 Hz is equal to 1 cycle per second.

hearing group

Groups of marine mammal species with similar hearing ranges. Commonly defined functional hearing groups include low-, mid-, and high-frequency cetaceans, pinnipeds in water, and pinnipeds in air.

harmonic

A sinusoidal sound component that has a frequency that is an integer multiple of the frequency of a sound to which it is related. For example, the second harmonic of a sound has a frequency that is double the fundamental frequency of the sound.

hearing threshold

The sound pressure level for any frequency of the hearing group that is barely audible for a given individual in the absence of significant background noise during a specific percentage of experimental trials.

hertz (Hz)

A unit of frequency defined as one cycle per second.

high-frequency (HF) cetacean

The functional cetacean hearing group that represents those odontocetes (toothed whales) specialised for hearing high frequencies.

hydrophone

An underwater sound pressure transducer. A passive electronic device for recording or listening to underwater sound.

intermittent sound

A level of sound that abruptly drops to the background noise level several times during the observation period.

impulsive sound

Sound that is typically brief and intermittent with rapid (within a few seconds) rise time and decay back to ambient levels (NOAA 2013, ANSI S12.7-1986 (R2006)). For example, seismic airguns and impact pile driving.

low-frequency (LF) cetacean

The functional cetacean hearing group that represents mysticetes (baleen whales) specialised for hearing low frequencies.

manual analysis

Human examination of acoustic data via visual review of spectrograms and/or aural inspection of data.

manual detection

The output of **manual analysis** as recorded in an **annotation**.

masking

Obscuring of sounds of interest by sounds at similar frequencies.

mean-square sound pressure spectral density

Distribution as a function of frequency of the mean-square sound pressure per unit bandwidth (usually 1 Hz) of a sound having a continuous spectrum (ANSI S1.1-1994 (R2004)). Unit: $\mu Pa^2/Hz$.

median

The 50th percentile of a statistical distribution.

mid-frequency (MF) cetacean

The functional cetacean hearing group that represents those odontocetes (toothed whales) specialised for mid-frequency hearing.

mysticete

Mysticeti, a suborder of cetaceans, use their baleen plates, rather than teeth, to filter food from water. They are not known to echolocate, but they use sound for communication. Members of this group include rorquals (Balaenopteridae), right whales (Balaenidae), and grey whales (*Eschrichtius robustus*).

non-impulsive sound

Sound that is broadband, narrowband or tonal, brief or prolonged, continuous or intermittent, and typically does not have a high peak pressure with rapid rise time (typically only small fluctuations in decibel level) that impulsive signals have (ANSI S3.20-1995 (R2008)). For example, marine vessels, aircraft, machinery, construction, and vibratory pile driving (NIOSH 1998, NOAA 2015).

octave

The interval between a sound and another sound with double or half the frequency. For example, one octave above 200 Hz is 400 Hz, and one octave below 200 Hz is 100 Hz.

odontocete

The presence of teeth, rather than baleen, characterizes these whales. Members of the Odontoceti are a suborder of cetaceans, a group comprised of whales, dolphins, and porpoises. The skulls of toothed whales are mostly asymmetric, an adaptation for their echolocation. This group includes sperm whales, killer whales, belugas, narwhals, dolphins, and porpoises.

peak pressure level (PK)

The maximum instantaneous sound pressure level, in a stated frequency band, within a stated period. Also called zero-to-peak pressure level. Unit: decibel (dB).

percentile level, exceedance

The sound level exceeded *n* % of the time during a measurement.

permanent threshold shift (PTS)

A permanent loss of hearing sensitivity caused by excessive noise exposure. PTS is considered auditory injury.

pinniped

A common term used to describe all three groups that form the superfamily Pinnipedia: phocids (true seals or earless seals), otariids (eared seals or fur seals and sea lions), and walrus.

power spectrum density

Generic term, formally defined as power in W/Hz, but sometimes loosely used to refer to the spectral density of other parameters such as square pressure or time-integrated square pressure.

pressure, acoustic

The deviation from the ambient hydrostatic pressure caused by a sound wave. Also called overpressure. Unit: pascal (Pa). Symbol: p.

received level (RL)

The sound level measured (or that would be measured) at a defined location.

rms

root-mean-square.

signature

Pressure signal generated by a source.

sound

A time-varying pressure disturbance generated by mechanical vibration waves travelling through a fluid medium such as air or water.

sound exposure

Time integral of squared, instantaneous frequency-weighted sound pressure over a stated time interval or event. Unit: pascal-squared second ($\text{Pa}^2\cdot\text{s}$) (ANSI S1.1-1994 (R2004)).

sound exposure level (SEL)

A cumulative measure related to the sound energy in one or more pulses. Unit: dB re 1 $\mu\text{Pa}^2\cdot\text{s}$. SEL is expressed over the summation period (e.g., per-pulse SEL [for airguns], single-strike SEL [for pile drivers], 24-hour SEL).

sound exposure spectral density

Distribution as a function of frequency of the time-integrated squared sound pressure per unit bandwidth of a sound having a continuous spectrum (ANSI S1.1-1994 (R2004)). Unit: $\mu\text{Pa}^2\cdot\text{s/Hz}$.

sound pressure level (SPL)

The decibel ratio of the time-mean-square sound pressure, in a stated frequency band, to the square of the reference sound pressure (ANSI S1.1-1994 (R2004)).

For sound in water, the reference sound pressure is one micropascal (p_0 = 1 µPa) and the unit for SPL is dB re 1 μPa^2:

$$L_p = 10\log_{10}(p^2/p_0^2) = 20\log_{10}(p/p_0)$$

Unless otherwise stated, SPL refers to the root-mean-square (rms) pressure level. See also 90% sound pressure level and fast-average sound pressure level. Non-rectangular time window functions may be applied during calculation of the rms value, in which case the SPL unit should identify the window type.

source level (SL)

The sound level measured in the far-field and scaled back to a standard reference distance of 1 metre from the acoustic centre of the source. Unit: dB re 1 µPa·m (pressure level) or dB re 1 $\mu\text{Pa}^2\cdot\text{s}\cdot\text{m}$ (exposure level).

spectral density level

The decibel level ($10\cdot\log_{10}$) of the spectral density of a given parameter such as SPL or SEL, for which the units are dB re 1 $\mu\text{Pa}^2\text{/Hz}$ and dB re 1 $\mu\text{Pa}^2\cdot\text{s/Hz}$, respectively.

spectrogram

A visual representation of acoustic amplitude compared with time and frequency.

spectrum

An acoustic signal represented in terms of its power, energy, mean-square sound pressure, or sound exposure distribution with frequency.

validated detection

The output of an **automated detector** that has been subsequently validated by a human analyst.

Literature Cited

[ANSI] American National Standards Institute. 12.64-2009 (R2014). *Grade C – Survey Method - Quantities and Procedures for Description and Measurement of Underwater Sound from Ships – Part 1: General Requirements*.

[ANSI] American National Standards Institute. S1.1-1994 (R2004). *American National Standard: Acoustical Terminology*. NY, USA. https://webstore.ansi.org/Standards/ASA/ANSIS11994R2004.

[ANSI] American National Standards Institute and [ASA] Acoustical Society of America. S1.1-2013. *American National Standard: Acoustical Terminology*. NY, USA. https://webstore.ansi.org/Standards/ASA/ANSIASAS12013.

[ANSI] American National Standards Institute and [ASA] Acoustical Society of America. S1.13-2005 (R2010). *American National Standard: Measurement of Sound Pressure Levels in Air*. NY, USA. https://webstore.ansi.org/Standards/ASA/ANSIASAS1132005R2010.

[ANSI] American National Standards Institute and [ASA] Acoustical Society of America. S3.20-1995 (R2008). *American National Standard: Bioacoustical Terminology*. NY, USA. https://webstore.ansi.org/Standards/ASA/ANSIASAS3201995R2008.

[ANSI] American National Standards Institute. S12.7-1986 (R2006). *American National Standard: Methods for Measurements of Impulsive Noise*. NY, USA. https://webstore.ansi.org/Standards/ASA/ANSIS121986R2006.

[ISO] International Organization for Standardization. 2006. *ISO 80000-3:2006 Quantities and units – Part 3: Space and time*. https://www.iso.org/standard/31888.html.

[ISO] International Organization for Standardization. 2017a. *ISO 18405:2017. Underwater acoustics – Terminology*. Geneva. https://www.iso.org/standard/62406.html.

[ISO] International Organization for Standardization. 2017b. *ISO 18406:2017(E). Underwater acoustics – Measurement of radiated underwater sound from percussive pile driving*. Geneva. https://www.iso.org/obp/ui/#iso:std:iso:18406:ed-1:v1:en.

[NIOSH] National Institute for Occupational Safety and Health. 1998. *Criteria for a recommended standard: Occupational noise exposure. Revised Criteria*. Document Number 98-126. US Department of Health and Human Services, NIOSH, Cincinnati, OH, USA. 122 p. https://www.cdc.gov/niosh/docs/98-126/pdfs/98-126.pdf.

[NMFS] National Marine Fisheries Service (US). 2016. *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts*. US Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-55. 178 p.

[NMFS] National Marine Fisheries Service (US). 2018. *2018 Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts*. US Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-59. 167 p. https://www.fisheries.noaa.gov/webdam/download/75962998.

[NOAA] National Oceanic and Atmospheric Administration (US). 2013. *Draft guidance for assessing the effects of anthropogenic sound on marine mammals: Acoustic threshold levels for onset of permanent and temporary threshold shifts*. National Oceanic and Atmospheric Administration, US Department of Commerce, and NMFS Office of Protected Resources, Silver Spring, MD, USA. 76 p.

[NOAA] National Oceanic and Atmospheric Administration (US). 2015. *Draft guidance for assessing the effects of anthropogenic sound on marine mammal hearing: Underwater acoustic threshold levels for onset of permanent and temporary threshold shifts*. NMFS Office of Protected Resources, Silver Spring, MD, USA. 180 p.

[NOAA] National Oceanic and Atmospheric Administration (US). 2019. *ESA Section 7 Consultation Tools for Marine Mammals on the West Coast* (webpage), 27 Sep 2019. https://www.fisheries.noaa.gov/west-coast/endangered-species-conservation/esa-section-7-consultation-tools-marine-mammals-west. (Accessed 10 Mar 2020).

[NRC] National Research Council (US). 2003. *Ocean Noise and Marine Mammals*. National Research Council (US), Ocean Studies Board, Committee on Potential Impacts of Ambient Noise in the Ocean on Marine Mammals. The National Academies Press, Washington, DC, USA. https://doi.org/10.17226/10564.

Ainslie, M.A., J.L. Miksis-Olds, S.B. Martin, K.D. Heaney, C.A.F. de Jong, A.M. von Benda-Beckmann, and A.P. Lyons. 2018. *ADEON Underwater Soundscape and Modeling Metadata Standard*. Version 1.0. Technical report by JASCO Applied Sciences for ADEON Prime Contract No. M16PC00003. https://doi.org/10.6084/m9.figshare.6792359.v2.

Ainslie, M.A., S.B. Martin, T.J. Deveau, A.O. MacGillivray, C. Bae, and D. Wittekind. 2020. *Towards a Standard for Vessel URN Measurement in Shallow Water: Applying Acoustical Propagation Modelling to Inform the Design of a Measurement Program that Determines if Shallow Water URN Measurements can be Comparable to those from Deep Water*. Document Number 02167, Version 1.0. White paper by JASCO Applied Sciences for Transport Canada Innovation Center.

Ainslie, M.A., R.K. Andrew, B.M. Howe, and J.A. Mercer. 2021. Temperature-driven seasonal and longer term changes in spatially averaged deep ocean ambient sound at frequencies 63–125 Hz. *Journal of the Acoustical Society of America* 149(4): 2531-2545. https://doi.org/10.1121/10.0003960.

Amorim, M.C.P. 2006. Diversity of sound production in fish. *In* Ladich, F., S.P. Collin, P. Moller, and B.G. Kapoor (eds.). *Communication in fishes*. Volume 1. Science Publishers. pp. 71-104.

Andrew, R.K., B.M. Howe, and J.A. Mercer. 2011. Long-time trends in ship traffic noise for four sites off the North American West Coast. *Journal of the Acoustical Society of America* 129(2): 642-651. https://doi.org/10.1121/1.3518770.

Au, W.W.L., R.A. Kastelein, T. Rippe, and N.M. Schooneman. 1999. Transmission beam pattern and echolocation signals of a harbor porpoise (*Phocoena phocoena*). *Journal of the Acoustical Society of America* 106(6): 3699-3705. https://doi.org/10.1121/1.428221.

Au, W.W.L., J. Mobley, W.C. Burgess, M.O. Lammers, and P.E. Nachtigall. 2000. Seasonal and diurnal trends of chorusing humpback whales wintering in waters off Western Maui. *Marine Mammal Science* 16(3): 530-544. https://doi.org/10.1111/j.1748-7692.2000.tb00949.x.

Austin, M.E., D.E. Hannay, and K.C. Bröker. 2018. Acoustic characterization of exploration drilling in the Chukchi and Beaufort seas. *Journal of the Acoustical Society of America* 144: 115-123. https://doi.org/10.1121/1.5044417

Bailey, H., G. Clay, E.A. Coates, D. Lusseau, B. Senior, and P.M. Thompson. 2010. Using T-PODs to assess variations in the occurrence of coastal bottlenose dolphins and harbour porpoises. *Aquatic Conservation: Marine and Freshwater Ecosystems* 20(2): 150-158. https://doi.org/10.1002/aqc.1060.

Baron, S.C., A. Martinez, L.P. Garrison, and E.O. Keith. 2008. Differences in acoustic signals from Delphinids in the western North Atlantic and northern Gulf of Mexico. *Marine Mammal Science* 24(1): 42-56. https://doi.org/10.1111/j.1748-7692.2007.00168.x.

Baumgartner, M.F. and D.M. Fratantoni. 2008. Diel periodicity in both sei whale vocalization rates and the vertical migration of their copepod prey observed from ocean gliders. *Limnology and Oceanography* 53(5): 2197-2209. https://doi.org/10.4319/lo.2008.53.5_part_2.2197.

Berchok, C.L., D.L. Bradley, and T.B. Gabrielson. 2006. St. Lawrence blue whale vocalizations revisited: Characterization of calls detected from 1998 to 2001. *Journal of the Acoustical Society of America* 120(4): 2340-2354. https://doi.org/10.1121/1.2335676.

Bilgmann, K., L.M. Möller, R.G. Harcourt, S.E. Gibbs, and L.B. Beheregaray. 2007. Genetic differentiation in bottlenose dolphins from South Australia: association with local oceanography and coastal geography. *Marine Ecology Progress Series* 341: 265-276.

Bilgmann, K., G.J. Parra, N. Zanardo, L.B. Beheregaray, and L.M. Möller. 2014. Multiple management units of short-beaked common dolphins subject to fisheries bycatch off southern and southeastern Australia. *Marine Ecology Progress Series* 500: 265-279.

Bom, N. 1969. Effect of rain on underwater noise level. *Journal of the Acoustical Society of America* 45(1): 150-156. https://doi.org/10.1121/1.1911351.

Brekhovskikh, L.M. 1980. *Waves in Layered Media*. 2nd edition. Applied mathematics and mechanics, Volume 16. Academic Press, New York. 503 p.

Brekhovskikh, L.M. and Y.P. Lysanov. 2003. *Fundamentals of Ocean Acoustics*, New York.

Carnes, M.R. 2009. *Description and Evaluation of GDEM-V 3.0*. US Naval Research Laboratory, Stennis Space Center, MS. NRL Memorandum Report 7330-09-9165. 21 p. https://apps.dtic.mil/dtic/tr/fulltext/u2/a494306.pdf.

Cato, D.H. 1991. *Songs of humpback whales: The Australian perspective*. Defence Science and Technology Organisation, Canberra, Australia.

Cato, D.H. 1992. The biological contribution to the ambient noise in waters near Australia. *Acoustics Australia* 20(3): 76-80. http://www.acoustics.asn.au/journal/Vol20No3.pdf#page=10.

Cato, D.H. 1997. Ambient sea noise in Australian waters. *5th International Congress on Sound and Vibration*. Volume 5, 15-18 Dec 1997, Adelaide, Australia. pp. 2813-2818.

Charlton-Robb, K., A. Taylor, and S. McKechnie. 2015. Population genetic structure of the Burrunan dolphin (*Tursiops australis*) in coastal waters of south-eastern Australia: conservation implications. *Conservation Genetics* 16(1): 195-207.

Clark, C.W. 1990. Acoustic behaviour of mysticete whales. *In* Thomas, J.A. and R.A. Kastelein (eds.). *Sensory Abilities of Cetaceans*. Springer, Boston, MA. pp. 571-583. https://doi.org/10.1007/978-1-4899-0858-2_40.

Collins, M.D. 1993. A split-step Padé solution for the parabolic equation method. *Journal of the Acoustical Society of America* 93(4): 1736-1742. https://doi.org/10.1121/1.406739.

Coppens, A.B. 1981. Simple equations for the speed of sound in Neptunian waters. *Journal of the Acoustical Society of America* 69(3): 862-863. https://doi.org/10.1121/1.382038.

D'Spain, G.L. and H.H. Batchelor. 2006. Observations of biological choruses in the Southern California Bight: A chorus at midfrequencies. *Journal of the Acoustical Society of America* 120(4): 1942-1955.

Delarue, J.J.-Y., K.A. Kowarski, E.E. Maxner, J.T. MacDonnell, and S.B. Martin. 2018. *Acoustic Monitoring Along Canada's East Coast: August 2015 to July 2017*. Document Number 01279, Environmental Studies Research Funds Report Number 215, Version 1.0. Technical report by JASCO Applied Sciences for Environmental Studies Research Fund, Dartmouth, NS, Canada. 120 pp + appendices.

Edds-Walton, P.L. 1997. Acoustic communication signals of mysticetes whales. *Bioacoustics* 8(1-2): 47-60. https://doi.org/10.1080/09524622.1997.9753353.

Erbe, C., A. Verma, R.D. McCauley, A. Gavrilov, and I. Parnum. 2015. The marine soundscape of the Perth Canyon. *Progress in Oceanography* 137: 38-51. https://doi.org/10.1016/j.pocean.2015.05.015.

Erbe, C., R.D. McCauley, A. Gavrilov, S. Madhusudhana, and A. Verma. 2016. The underwater soundscape around Australia. *ACOUSTICS 2016*. 9-11 Nov 2016, Brisbane, Australia.

Erbe, C., R. Dunlop, K.C.S. Jenner, M.-N.M. Jenner, R.D. McCauley, I. Parnum, M. Parsons, T. Rogers, and C. Salgado-Kent. 2017. Review of underwater and in-air sounds emitted by Australian and Antarctic marine mammals. *Acoustics Australia*. https://doi.org/10.1007/s40857-017-0101-z.

Erbs, F., S.H. Elwen, and T. Gridley. 2017. Automatic classification of whistles from coastal dolphins of the southern African subregion. *Journal of the Acoustical Society of America* 141(4): 2489-2500. https://doi.org/10.1121/1.4978000.

Finneran, J.J. and A.K. Jenkins. 2012. *Criteria and thresholds for U.S. Navy acoustic and explosive effects analysis*. SPAWAR Systems Center Pacific, San Diego, CA, USA. 64 p.

Finneran, J.J. 2015. *Auditory weighting functions and TTS/PTS exposure functions for cetaceans and marine carnivores*. Technical report by SSC Pacific, San Diego, CA, USA.

Finneran, J.J. 2016. *Auditory weighting functions and TTS/PTS exposure functions for marine mammals exposed to underwater noise*. Technical Report for Space and Naval Warfare Systems Center Pacific, San Diego, CA, USA. 49 p. https://apps.dtic.mil/dtic/tr/fulltext/u2/1026445.pdf.

François, R.E. and G.R. Garrison. 1982a. Sound absorption based on ocean measurements: Part I: Pure water and magnesium sulfate contributions. *Journal of the Acoustical Society of America* 72(3): 896-907. https://doi.org/10.1121/1.388170.

François, R.E. and G.R. Garrison. 1982b. Sound absorption based on ocean measurements: Part II: Boric acid contribution and equation for total absorption. *Journal of the Acoustical Society of America* 72(6): 1879-1890. https://doi.org/10.1121/1.388673.

Garcia-Rojas, M.I., K.C.S. Jenner, P.C. Gill, M.N.M. Jenner, A.L. Sutton, and R.D. McCauley. 2018. Environmental evidence for a pygmy blue whale aggregation area in the Subtropical Convergence Zone south of Australia. *Marine Mammal Science* 34(4): 901-923.

Gavrilov, A.N. and R.D. McCauley. 2013. Acoustic detection and long-term monitoring of pygmy blue whales over the continental slope in southwest Australia. *Journal of the Acoustical Society of America* 134(3): 2505-2513. https://doi.org/10.1121/1.4816576.

Gavrilov, A.N., R.D. McCauley, G. Paskos, and A. Goncharov. 2018. Southbound migration corridor of pygmy blue whales off the northwest coast of Australia based on data from ocean bottom seismographs. *Journal of the Acoustical Society of America* 144(4): EL281-EL285. https://doi.org/10.1121/1.5063452.

Hannay, D., R. Racca, S. Carr, M. Jenkerson, R. Melton, D. Hedgeland, and S.L. Tsoflias. 2010. A model based assessment of underwater sound levels during a seismic source soft-start operation. *SPE International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production* 12–14 April 2010. Society of Petroleum Engineers, Rio de Janeiro, Brazi. p. 7.

Hannay, D.E., J.J.-Y. Delarue, X. Mouy, S.B. Martin, D. Leary, J.N. Oswald, and J. Vallarta. 2013. Marine mammal acoustic detections in the northeastern Chukchi Sea, September 2007–July 2011. *Continental Shelf Research* 67: 127-146. https://doi.org/10.1016/j.csr.2013.07.009.

Hannay, D.E., M.-N.R. Matthews, A. Schlesinger, L. Hatch, and J. Harrison. 2016a. Lost listening area assessment of anthropogenic sounds in the Chukchi Sea [abstact]. *Journal of the Acoustical Society of America* 140(4): 3072-3073. https://doi.org/10.1121/1.4969572.

Hannay, D.E., X. Mouy, and Z. Li. 2016b. An automated real-time vessel sound measurement system for calculating monopole source levels using a modified version of ANSI/ASA S12.64-2009. *Canadian Acoustics* 44(3). https://jcaa.caa-aca.ca/index.php/jcaa/article/view/3002.

Hawkins, A.D., L. Casaretto, M. Picciulin, and K. Olsen. 2002. Locating Spawning Haddock by Means of Sound. *Bioacoustics* 12(2-3): 284-286. https://doi.org/10.1080/09524622.2002.9753723.

Heap, A.D. 2009. *Marine Sediments (MARS) Database* (webpage). Commonwealth of Australia (Geoscience Australia), Creative Commons Attribution 4.0 International Licence. http://www.ga.gov.au/metadata-gateway/metadata/record/gcat_69869.

Heindsmann, T.E., R.H. Smith, and A.D. Arneson. 1955. Effect of rain upon underwater noise levels [Letter to the editor]. *Journal of the Acoustical Society of America* 27(2): 378-379. https://doi.org/10.1121/1.1907897.

Hildebrand, J.A. 2009. Anthropogenic and natural sources of ambient noise in the ocean. *Marine Ecology Progress Series* 395: 5-20. https://doi.org/10.3354/meps08353.

Hodge, K.B., C.A. Muirhead, J.L. Morano, C.W. Clark, and A.N. Rice. 2015. North Atlantic right whale occurrence near wind energy areas along the mid-Atlantic US coast: Implications for management. *Endangered Species Research* 28(3): 225-234. https://doi.org/10.3354/esr00683.

Houser, D.S., W. Yost, R. Burkard, J.J. Finneran, C. Reichmuth, and J. Mulsow. 2017. A review of the history, development and application of auditory weighting functions in humans and marine mammals. *Journal of the Acoustical Society of America* 141(3): 1371-1413. https://doi.org/10.1121/1.4976086.

James, N.P. and Y. Bone. 2010. *Neritic carbonate sediments in a temperate realm: southern Australia*. Springer Science & Business Media.

JASCO Applied Sciences and SMRU Consulting. 2020. *ECHO Program 2019 Voluntary Vessel Slowdown Hydroacoustic Studies: Final Report*. Document Number 01994, Version 1.0. Technical report by JASCO Applied Sciences and SMRU Consulting for Vancouver Fraser Port Authority.

Jensen, F.B., W.A. Kuperman, M.B. Porter, and H. Schmidt. 2011. *Computational Ocean Acoustics*. 2nd edition. AIP Series in Modern Acourics and Signal Processing. AIP Press - Springer, New York. 794 p. https://doi.org/10.1007/978-1-4419-8678-8.

Jolliffe, C.D., R.D. McCauley, A.N. Gavrilov, K.C.S. Jenner, M.-N.M. Jenner, and A.J. Duncan. 2019. Song variation of the South Eastern Indian Ocean pygmy blue whale population in the Perth Canyon, Western Australia. *PLOS ONE* 14(1): e0208619. https://doi.org/10.1371/journal.pone.0208619.

Joy, R., D.J. Tollit, J.D. Wood, A.O. MacGillivray, Z. Li, K. Trounce, and O. Robinson. 2019. Potential Benefits of Vessel Slowdowns on Endangered Southern Resident Killer Whales. *Frontiers in Marine Science* 6: 344. https://doi.org/10.3389/fmars.2019.00344.

Knudsen, V.O., R.S. Alford, and J.W. Emling. 1948. Underwater ambient noise. *Journal of Marine Research* 7: 410-429.

Koessler, M.W., M.-N.R. Matthews, and C.R. McPherson. 2020. *Otway Offshore Project – Drilling Program: Assessing Marine Fauna Sound Exposures*. Document Number 02033, Version 1.0. Technical report by JASCO Applied Sciences for Beach Energy Limited.

Kowarski, K.A., J.J.-Y. Delarue, B.J. Gaudet, and S.B. Martin. 2021. Automatic data selection for validation: A method to determine cetacean occurrence in large acoustic data sets. *JASA Express Letters* 1: 051201. https://doi.org/10.1121/10.0004851.

Krause, B. 2008. Anatomy of the Soundscape: Evolving Perspectives. *Journal of the Audio Engineering Society* 56(1/2): 73-80. http://www.aes.org/e-lib/browse.cfm?elib=14377.

Lattice Energy. 2017. *OFFSHORE ENVIRONMENT PLAN SUMMARY: Otway*. VIC 9000 ENV PLN CDN/ID 17275058. https://earthresources.vic.gov.au/__data/assets/word_doc/0006/459510/Lattice-Energy-Otway-Offshore-Continued-Operations-Envionment-Plan-Summary.docx.

Leroy, E.C., F. Samaran, J. Bonnel, and J.-Y. Royer. 2016. Seasonal and Diel Vocalization Patterns of Antarctic Blue Whale (*Balaenoptera musculus intermedia*) in the Southern Indian Ocean: A Multi-Year and Multi-Site Study. *PLOS ONE* 11(11): e0163587. https://doi.org/10.1371/journal.pone.0163587.

MacGillivray, A.O., Z. Li, D.E. Hannay, K.B. Trounce, and O. Robinson. 2019. Slowing deep-sea commercial vessels reduces underwater radiated noise. *Journal of the Acoustical Society of America* 146: 340-351. https://doi.org/10.1121/1.5116140.

Martin, B. 2013. Computing cumulative sound exposure levels from anthropogenic sources in large data sets. *Proceedings of Meetings on Acoustics* 19(1): 9. https://doi.org/10.1121/1.4800967.

Martin, S.B., C. Morris, K. Bröker, and C. O'Neill. 2019. Sound exposure level as a metric for analyzing and managing underwater soundscapes. *Journal of the Acoustical Society of America* 146(1): 135-149. https://doi.org/10.1121/1.5113578.

Martin, S.B., B.J. Gaudet, H. Klinck, P.J. Dugan, J.L. Miksis-Olds, D.K. Mellinger, D.A. Mann, O. Boebel, C.C. Wilson, et al. 2021. Hybrid millidecade spectra: A practical format for exchange of long-term ambient sound data. *JASA Express Letters* 1(1). https://doi.org/10.1121/10.0003324.

Matsumoto, H., D.R. Bohnenstiehl, J. Tournadre, R.P. Dziak, J.H. Haxel, T.K.A. Lau, M. Fowler, and S.A. Salo. 2014. Antarctic icebergs: A significant natural ocean sound source in the Southern Hemisphere. *Geochemistry, Geophysics, Geosystems* 15(8): 3448-3458. https://doi.org/10.1002/2014GC005454.

McCauley, R.D. and D.H. Cato. 2000. Patterns of fish calling in a nearshore environment in the Great Barrier Reef. *Philosophical Transactions of the Royal Society B* 355(1401): 1289-1293. https://doi.org/10.1098/rstb.2000.0686.

McCauley, R.D., C. Jenner, J.L. Bannister, C.K.L. Burton, D.H. Cato, and A. Duncan. 2001. *Blue Whale Calling In The Rottnest Trench - 2000, Western Australia*. Document Number R2001-6 Report Number R2001-6. Report by Centre for Marine Science and Technology (CMST), Curtin University of Technology, Perth, Western Australia. 55 p.

McCauley, R.D. 2004. *Underwater sea noise in the Otway Basin – drilling, seismic and blue whales.* Report prepared by Centre for Marine Science and Technology, Curtin University, for Santos Ltd.

McCauley, R.D. and D.H. Cato. 2016. Evening choruses in the Perth Canyon and their potential link with Myctophidae fishes. *Journal of the Acoustical Society of America* 140(4): 2384-2398.

McCauley, R.D., A.N. Gavrilov, C.D. Jolliffe, R. Ward, and P.C. Gill. 2018. Pygmy blue and Antarctic blue whale presence, distribution and population parameters in southern Australia based on passive acoustics. *Deep Sea Research Part II* 157–158: 154-168. https://doi.org/10.1016/j.dsr2.2018.09.006.

McDonald, M.A., S.L. Mesnick, and J.A. Hildebrand. 2006. Biogeographic characterization of blue whale song worldwide: Using song to identify populations. *Journal of Cetacean Research and Management* 8(1): 55-65.

McDonald, M.A., J.A. Hildebrand, S.M. Wiggins, and D. Ross. 2008. A 50 year comparison of ambient ocean noise near San Clemente Island: A bathymetrically complex coastal region off southern California. *Journal of the Acoustical Society of America* 124(4): 1985-1992. https://doi.org/10.1121/1.2967889.

McPherson, C.R., B. Martin, and C. Erbe. 2012. *Ambient Noise Monitoring in the Timor Sea: December 2010–December 2011*. Document Number 00329, Version 1.0. Technical report by JASCO Applied Sciences for Environmental Resources Management.

McPherson, C.R., H. Frouin-Mouy, J.T. MacDonnell, and B. Martin. 2014. *Poseidon Field–Baseline Underwater Acoustic Monitoring: October 2012–February 2014*. Document Number 00737, Version 1.0 DRAFT. Technical report by JASCO Applied Sciences for Sinclair Knight Merz.

McPherson, C.R., K.A. Kowarski, J.J.-Y. Delarue, C.J. Whitt, J.T. MacDonnell, and B. Martin. 2016. *Passive Acoustic Monitoring of Ambient Noise and Marine Mammals—Barossa Field: July 2014 to July 2015*. Document Number 00997, Version 1.0. Technical report by JASCO Applied Sciences for ANZ Infrastructure & Environment, Jacobs. Appendix M of Barossa Area Development Offshore Project Proposal. http://static.conocophillips.com/files/resources/appendix-e.pdf.

McPherson, C.R., J.J.-Y. Delarue, and E.E. Maxner. 2017. Investigating the presence of Omura's whale in Northwest Australian waters using passive acoustic data. *The Society for Marine Mammalogy Conference*. Halifax, NS, Canada.

Miksis-Olds, J.L. and S.M. Nichols. 2016. Is low frequency ocean sound increasing globally? *Journal of the Acoustical Society of America* 139(1): 501-511. https://doi.org/10.1121/1.4938237.

Miller, B.S., K. Natalie, P. David, B. Jay, C. Susannah, C. Kym, L. Russell, O. Paula, E. Paul, et al. 2013. Real-time acoustic tracking of Antarctic blue whales in the Southern Ocean: Towards a precise abundance estimate. *20th Biennial Conference on the Biology of Marine Mammals*. 9-13 Dec 2013, Dunedin, New Zealand.

Møhl, B., M. Wahlberg, P.T. Madsen, L.A. Miller, and A. Surlykke. 2000. Sperm whale clicks: Directionality and source level revisited. *Journal of the Acoustical Society of America* 107(1): 638-648. https://doi.org/10.1121/1.428329.

Möller, L.M., C.R.M. Attard, K. Bilgmann, V. Andrews-Goff, I. Jonsen, D. Paton, and M.C. Double. 2020. Movements and behaviour of blue whales satellite tagged in an Australian upwelling system. *Scientific Reports* 10(1): 21165. https://doi.org/10.1038/s41598-020-78143-2.

Nedwell, J.R. and A.W. Turnpenny. 1998. The use of a generic frequency weighting scale in estimating environmental effect. *Workshop on Seismics and Marine Mammals*. 23–25 Jun 1998, London, UK.

Nedwell, J.R., A.W. Turnpenny, J. Lovell, S.J. Parvin, R. Workman, J.A.L. Spinks, and D. Howell. 2007. *A validation of the dB$_{ht}$ as a measure of the behavioural and auditory effects of underwater noise*. Document Number 534R1231 Report prepared by Subacoustech Ltd. for Chevron Ltd, TotalFinaElf Exploration UK PLC, Department of Business, Enterprise and Regulatory Reform, Shell UK Exploration and Production Ltd, The Industry Technology Facilitator, Joint Nature Conservation Committee, and The UK Ministry of Defence. 74 p. https://tethys.pnnl.gov/sites/default/files/publications/Nedwell-et-al-2007.pdf.

Nieukirk, S.L., K.M. Stafford, D.K. Mellinger, R.P. Dziak, and C.G. Fox. 2004. Low-frequency whale and seismic airgun sounds recorded in the mid-Atlantic Ocean. *Journal of the Acoustical Society of America* 115(4): 1832-1843. https://doi.org/10.1121/1.1675816.

Nieukirk, S.L., D.K. Mellinger, S.E. Moore, K. Klinck, R.P. Dziak, and J. Goslin. 2012. Sounds from airguns and fin whales recorded in the mid-Atlantic Ocean, 1999–2009. *Journal of the Acoustical Society of America* 131(2): 1102-1112. https://doi.org/10.1121/1.3672648.

Nordeide, J.T. and E. Kjellsby. 1999. Sound from spawning cod at their spawning grounds. *ICES Journal of Marine Science* 56(3): 326-332. https://doi.org/10.1006/jmsc.1999.0473.

Ocean Time Series Group. 2009. *MATLAB Numerical Scientific and Technical Computing*. Scripps Institution of Oceanography, University of California San Diego. http://mooring.ucsd.edu/software.

Osiecka, A.N., O. Jones, and M. Wahlberg. 2020. The diel pattern in harbour porpoise clicking behaviour is not a response to prey activity. *Scientific Reports* 10(1): 1-7.

Oswald, J.N., J.P. Barlow, and T.F. Norris. 2003. Acoustic identification of nine delphinid species in the eastern tropical Pacific Ocean. *Marine Mammal Science* 19(1): 20-37. https://doi.org/10.1111/j.1748-7692.2003.tb01090.x.

Parsons, M.J.G., C.P. Salgado-Kent, S.A. Marley, A.N. Gavrilov, and R.D. McCauley. 2016. Characterizing diversity and variation in fish choruses in Darwin Harbour. *ICES Journal of Marine Science* 73(8): 2058–2074. https://doi.org/10.1093/icesjms/fsw037.

Parsons, M.J.G., C.P. Salgado Kent, A. Recalde-Salas, and R.D. McCauley. 2017. Fish choruses off Port Hedland, Western Australia. *Bioacoustics* 26(2): 135-152. https://doi.org/10.1080/09524622.2016.1227940.

Plomp, R. and M.A. Bouman. 1959. Relation between Hearing Threshold and Duration for Tone Pulses. *Journal of the Acoustical Society of America* 31(6): 749-758. https://doi.org/10.1121/1.1907781.

Popper, A.N., A.D. Hawkins, R.R. Fay, D.A. Mann, S. Bartol, T.J. Carlson, S. Coombs, W.T. Ellison, R.L. Gentry, et al. 2014. *Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI*. ASA S3/SC1.4 TR-2014. SpringerBriefs in Oceanography. ASA Press and Springer. https://doi.org/10.1007/978-3-319-06659-2.

Przeslawski, R., D. Bruce, J. Anderson, S. Foster, M. Edmunds, A. Durrant, R. Bradford, A.G. Carroll, S. Williams, et al. 2016. *Marine Seismic Survey Impacts on Fish and Invertebrates*. Final report by Geoscience Australia for the Gippsland Marine Environmental Monitoring Project, Canberra, Australia.

Quijano, J.E., D.E. Hannay, and M.E. Austin. 2019. Composite Underwater Noise Footprint of a Shallow Arctic Exploration Drilling Project. *IEEE Journal of Oceanic Engineering* 44(4): 1228-1239. https://doi.org/10.1109/JOE.2018.2858606.

R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/.

Recalde-Salas, A., C.P. Salgado Kent, M.J.G. Parsons, S.A. Marley, and R.D. McCauley. 2014. Non-song vocalizations of pygmy blue whales in Geographe Bay, Western Australia. *Journal of the Acoustical Society of America* 135(5): EL213-EL218. https://doi.org/10.1121/1.4871581.

Rendell, L.E., J.N. Matthews, A. Gill, J.C.D. Gordon, and D.W. MacDonald. 1999. Quantitative analysis of tonal calls from five odontocete species, examining interspecific and intraspecific variation. *Journal of Zoology* 249(4): 403-410. https://doi.org/10.1111/j.1469-7998.1999.tb01209.x.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. 1995. *Marine Mammals and Noise*. Academic Press, San Diego, CA, USA. 576 p. https://doi.org/10.1016/C2009-0-02253-3.

Risch, D., C.W. Clark, P.J. Corkeron, A. Elepfandt, K.M. Kovacs, C. Lydersen, I. Stirling, and S.M. Van Parijs. 2007. Vocalizations of male bearded seals, *Erignathus barbatus*: Classification and geographical variation. *Animal Behaviour* 73(5): 747-762. https://doi.org/10.1016/j.anbehav.2006.06.012.

Ross, D. 1976. *Mechanics of Underwater Noise*. Pergamon Press, NY, USA.

Sayigh, L., N. Quick, G. Hastie, and P.L. Tyack. 2013. Repeated call types in short-finned pilot whales, *Globicephala macrorhynchus*. *Marine Mammal Science* 29(2): 312-324.

Scrimger, J.A., D.J. Evans, G.A. McBean, D.M. Farmer, and B.R. Kerman. 1987. Underwater noise due to rain, hail, and snow. *Journal of the Acoustical Society of America* 81(1): 79-86. https://doi.org/10.1121/1.394936.

Simon, M., K.M. Stafford, K. Beedholm, C.M. Lee, and P.T. Madsen. 2010. Singing behavior of fin whales in the Davis Strait with implications for mating, migration and foraging. *Journal of the Acoustical Society of America* 128(5): 3200-3210. https://doi.org/10.1121/1.3495946.

Širović, A., A. Rice, E. Chou, J.A. Hildebrand, S.M. Wiggins, and M.A. Roch. 2015. Seven years of blue and fin whale call abundance in the Southern California Bight. *Endangered Species Research* 28(1): 61-76. https://doi.org/10.3354/esr00676.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene, Jr., D. Kastak, D.R. Ketten, J.H. Miller, et al. 2007. Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. *Aquatic Mammals* 33(4): 411-521. https://doi.org/10.1578/AM.33.4.2007.411.

Southall, B.L., J.J. Finneran, C.J. Reichmuth, P.E. Nachtigall, D.R. Ketten, A.E. Bowles, W.T. Ellison, D.P. Nowacek, and P.L. Tyack. 2019. Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. *Aquatic Mammals* 45(2): 125-232. https://doi.org/10.1578/AM.45.2.2019.125.

Steiner, W.W. 1981. Species-specific differences in pure tonal whistle vocalizations of five western North Atlantic dolphin species. *Behavioral Ecology and Sociobiology* 9(4): 241-246. https://doi.org/10.1007/BF00299878.

Strasberg, M. 1979. Nonacoustic noise interference in measurements of infrasonic ambient noise. *Journal of the Acoustical Society of America* 66(5): 1487-1493. https://doi.org/10.1121/1.383543.

Teague, W.J., M.J. Carron, and P.J. Hogan. 1990. A comparison between the Generalized Digital Environmental Model and Levitus climatologies. *Journal of Geophysical Research* 95(C5): 7167-7183. https://doi.org/10.1029/JC095iC05p07167.

Thode, A.M., T. Sakai, J. Michalec, S. Rankin, M.S. Soldevilla, B. Martin, and K.H. Kim. 2019. Displaying bioacoustic directional information from sonobuoys using “azigrams”. *Journal of the Acoustical Society of America* 146(1): 95-102. https://doi.org/10.1121/1.5114810.

Trounce, K.B., O. Robinson, A.O. MacGillivray, D.E. Hannay, J.D. Wood, D.J. Tollit, and R. Joy. 2019. The effects of vessel slowdowns on foraging habitat of the southern resident killer whales. *Proceedings of Meetings on Acoustics* 37(1). https://doi.org/10.1121/2.0001230.

Tyack, P.L. and C.W. Clark. 2000. Communication and acoustic behavior of dolphins and whales. (Chapter 4) *In* Au, W.W.L., A.N. Popper, and R.R. Fay (eds.). *Hearing by Whales and Dolphins*. Springer, New York. pp. 156-224.

Urazghildiiev, I.R. and S.M. Van Parijs. 2016. Automatic grunt detector and recognizer for Atlantic cod (*Gadus morhua*). *Journal of the Acoustical Society of America* 139(5): 2532-2540. https://doi.org/10.1121/1.4948569.

Urazghildiiev, I.R. and D.E. Hannay. 2017. Maximum likelihood estimators and Cramér–Rao bound for estimating azimuth and elevation angles using compact arrays. *Journal of the Acoustical Society of America* 141(4): 2548-2555. https://doi.org/10.1121/1.4979792.

Urick, R.J. 1974. Sea-bed motion as a source of the ambient noise background of the sea. *Journal of the Acoustical Society of America* 56(3): 1010-1011.

Urick, R.J. 1983. *Principles of Underwater Sound*. 3rd edition. McGraw-Hill, New York, London. 423 p.

van Opzeeland, I. and O. Boebel. 2018. Marine soundscape planning: Seeking acoustic niches for anthropogenic sound. *Journal of Ecoacoustics* 2(5GSNT). https://doi.org/10.22261/JEA.5GSNT8.

Versluis, M., B. Schmitz, A. von der Heydt, and D. Lohse. 2000. How Snapping Shrimp Snap: Through Cavitating Bubbles. *Science* 289(5487): 2114-2117. https://doi.org/10.1126/science.289.5487.2114.

Víkingsson, G.A. 1997. Feeding of fin whales (*Balaenoptera physalus*) off Iceland–diurnal and seasonal variation and possible rates. *Journal of Northwest Atlantic Fishery Science* 22: 77-89.

Wales, S.C. and R.M. Heitmeyer. 2002. An ensemble source spectra model for merchant ship-radiated noise. *Journal of the Acoustical Society of America* 111(3): 1211-1231. https://doi.org/10.1121/1.1427355.

Warren, V.E., A. Širović, C.R. McPherson, K.T. Goetz, C.A. Radford, and R. Constantine. 2021. Passive Acoustic Monitoring Reveals Spatio-Temporal Distributions of Antarctic and Pygmy Blue Whales Around Central New Zealand. *Frontiers in Marine Science* 7(1162). https://doi.org/10.3389/fmars.2020.575257.

Wenz, G.M. 1962. Acoustic Ambient Noise in the Ocean: Spectra and Sources. *Journal of the Acoustical Society of America* 34(12): 1936-1956. https://doi.org/10.1121/1.1909155.

Whiteway, T. 2009. *Australian Bathymetry and Topography Grid, June 2009*. GeoScience Australia, Canberra. http://pid.geoscience.gov.au/dataset/ga/67703.

Wiggins, S.M., E.M. Oleson, M.A. McDonald, and J.A. Hildebrand. 2005. Blue whale (*Balaenoptera musculus*) diel call patterns offshore of Southern California. *Aquatic Mammals* 31(2): 161-168. https://doi.org/10.1578/AM.31.2.2005.161.

Wood, M.A. and C.R. McPherson. 2018. *VSP Acoustic Modelling: Coastal Sound Levels: Enterprise 1 Drilling Program - Otway Basin*. Document Number 01794, Version 1.0. Technical report by JASCO Applied Sciences for Beach Energy Limited.

Woodside. 2003. *Environmental Impact Statement/Environmental Effects Statement: Otway Gas Project*. Woodside Energy Ltd, Perth.

Zelick, R., D. Mann, and A.N. Popper. 1999. Acoustic communication in fishes and frogs. *In* Fay, R.R. and A.N. Popper (eds.). *Comparative Hearing: Fish and Amphibians* Springer-Verlag, New York. pp. 363-411. https://doi.org/10.1007/978-1-4612-0533-3_9.

Zhang, Z.Y. and C.T. Tindle. 1995. Improved equivalent fluid approximations for a low shear speed ocean bottom. *Journal of the Acoustical Society of America* 98(6): 3391-3396. https://doi.org/10.1121/1.413789.

Appendix A. Underwater Acoustics

A.1. Acoustic Metrics

Sound levels with individual metrics defined below, are presented as:

- Broadband and approximate-decade-band SPL over time for these frequency bands for the low sample rate: 10 Hz–32 kHz (Nyquist), 10–100 Hz, 100 Hz to 1 kHz, 1–10 kHz, and 10–32 kHz. For the high sample rate, the Nyquist is 256 kHz.
- Spectrograms: Ambient noise at each station was analysed by Hamming-windowed fast Fourier transforms (FFTs), with 1 Hz resolution and 50% window overlap. The 120 FFTs performed with these settings are averaged to yield 1 min average spectra.
- Statistical distribution of SPL in each decidecade. The boxes of the statistical distributions indicate the first (L_5), second (L_{50}), and third (L_{75}) quartiles. The whiskers indicate the maximum and minimum range of the data. The solid line indicates the sound pressure level (SPL) or L_{eq} in each decidecade.
- Spectral level percentiles: Histograms of each frequency bin per 1 min of data. The L_{eq}, L_5, L_{25}, L_{50}, L_{75}, and L_{95} percentiles are plotted. The L_5 percentile curve is the frequency-dependent level exceeded by 95% of the 1 min averages. Equivalently, 5% of the 1 min spectral levels are above the 95th percentile curve.
- Daily cumulative sound exposure levels (SEL (24 h)): computed for the total received sound energy. The SEL (24 h) is the linear sum of the 1 min sound exposure levels (SEL). These SEL values were weighted to mimic different functional hearing groups according to the marine mammal frequency-weighted curves described in Appendix E.

Sound is most commonly described using the sound pressure level (SPL) metric. Underwater sound amplitude levels are commonly measured in decibels (dB) relative to a fixed reference pressure of p_0 = 1 µPa.

SPL (dB re 1 µPa) is the decibel level of the rms pressure in a stated frequency band over a time window (*T; s*) containing the acoustic event:

$$\mathrm{SPL} = 10\log_{10}\left(\frac{1}{T}\int_T p^2(t)\,dt \Big/ p_0^2\right) \tag{A-1}$$

The SPL is a measure of the effective pressure level over the duration of an acoustic event, such as the emission of one acoustic pulse or sweep. Because the window length, T, is the divisor, events more spread out in time have a lower SPL even though they may have similar total acoustic energy density.

Power spectral density (PSD) level is a description of how the acoustic power is distributed over different frequencies within a spectrum. It is expressed in dB re 1 µPa^2/Hz.

The sound exposure level (SEL, dB re 1 µPa^2·s) is a measure of the total acoustic energy contained in one or more acoustic events. The SEL for a single event is computed from the time-integral of the squared pressure over the full event duration (T_{100}):

$$\mathrm{SEL} = 10\log_{10}\left(\int_{T_{100}} p^2(t)\,dt \Big/ T_0 p_0^2\right) \tag{A-2}$$

where T_0 is a reference time interval of 1 s. The SEL represents the total acoustic energy received at a location during an acoustic event; it measures the total sound energy an organism at that location would be exposed to.

Because the SPL and SEL are both computed from the integral of square pressure, these metrics are related by the following expression, which depends only on the duration of the energy time window T:

$$\mathrm{SPL} = \mathrm{SEL} - 10\log_{10}(T) \tag{A-3}$$

Sound level statistics, namely percentiles, were used to quantify the distribution of recorded sound levels. The *n*th percentile level (L_n) is the level (i.e., PSD level, SPL, or SEL) *n*% of the data are below this level. L_{eq} is the linear arithmetic mean of the sound power, which can be substantially different from the median sound level L_{50}. SPL can also be referred to as L_{eq}, which stands for ‘equivalent level’. The two terms are used interchangeably throughout. L_{95}, the level exceeded by only 5% of the data, represents the highest typical sound levels measured. Sound levels between L_5 and L_{99} are generally from very close passes of vessels, very intense weather events, and other infrequent conditions. L_5 represents the quietest typical conditions.

Appendix B. Acoustic Data Analysis Methods

The data sampled at 64 kHz and 512 kHz was processed for ambient sound analysis, vessel noise detection, and detection of all marine mammal vocalisations. This section describes the ambient, vessel, and marine mammal detection algorithms employed (Figure B-1).

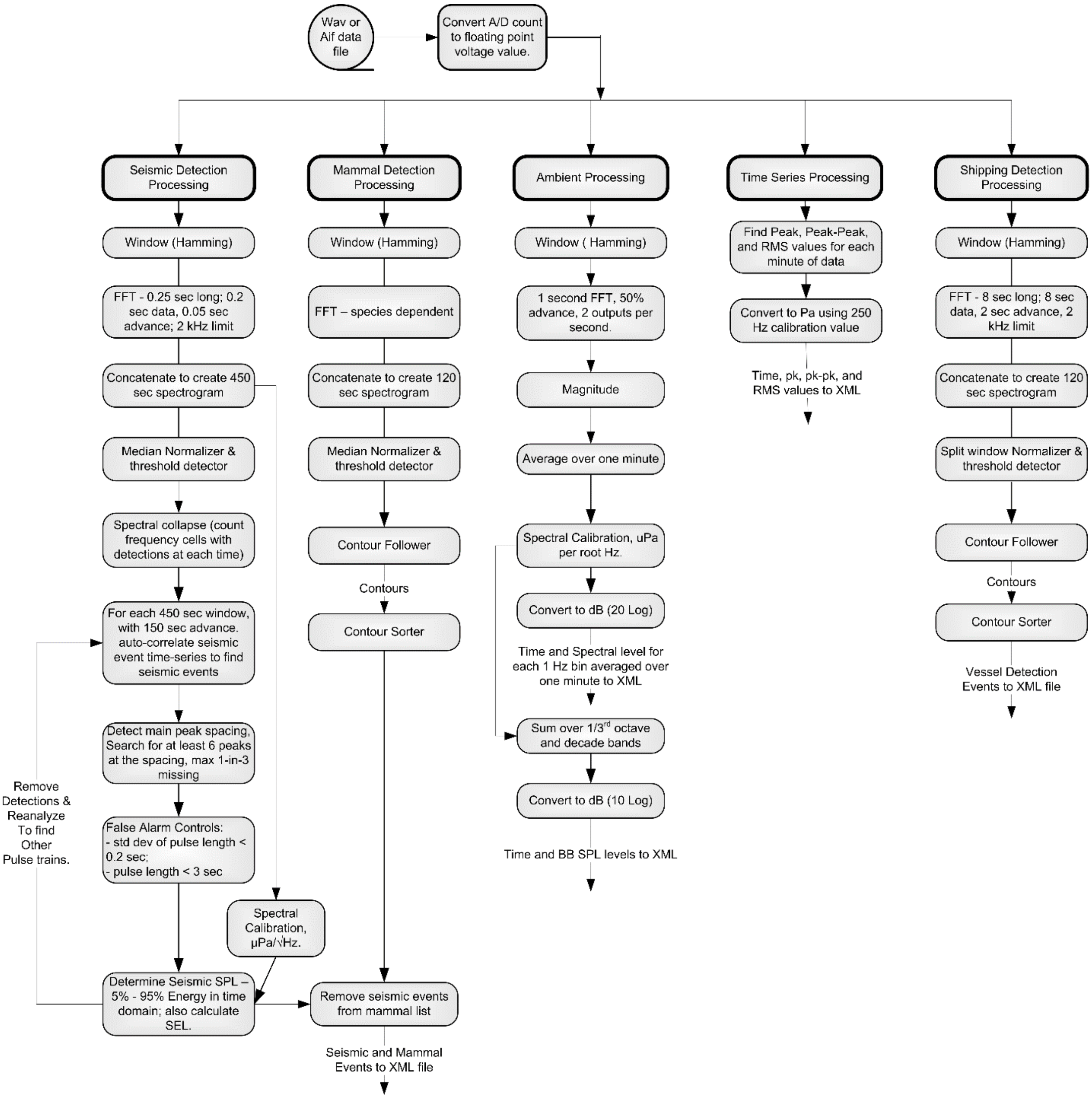


Figure B-1. Major stages of the automated acoustic analysis process performed with JASCO's custom software suite.

B.1. Total Ambient Sound Levels

Underwater sound pressure amplitude is measured in decibels (dB) relative to a fixed reference pressure of p_0 = 1 μPa. Because the perceived loudness of sound, especially impulsive noise such as from seismic airguns, pile driving, and sonar, is not generally proportional to the instantaneous acoustic pressure, several sound level metrics are commonly used to evaluate noise and its effects on marine life. We provide specific definitions of relevant metrics used in this report. Where possible we follow the ANSI and ISO standard definitions and symbols for sound metrics, but these standards are not always consistent.

The zero-to-peak pressure level, or peak pressure level (PK or $L_{p,pk}$; dB re 1 μPa), is the decibel level of the maximum instantaneous sound pressure level in a stated frequency band attained by an acoustic pressure signal, $p(t)$:

$$\mathrm{PK} = L_{p,\mathrm{pk}} = 10\log_{10}\frac{\max|p^2(t)|}{p_0^2} \tag{B-6}$$

PK is often included as criterion for assessing whether a sound is potentially injurious; however, because it does not account for the duration of a noise event, it is generally a poor indicator of perceived loudness.

The sound pressure level (SPL or L_p; dB re 1 μPa) is the decibel level of the root-mean-square (rms) pressure in a stated frequency band over a specified time window (T; s) containing the acoustic event of interest. It is important to note that SPL always refers to an rms pressure level and therefore not instantaneous pressure:

$$\mathrm{SPL} = L_p = 10\log_{10}\left[\frac{1}{T}\int_T p^2(t)\,dt \Big/ p_0^2\right] \tag{B-7}$$

The SPL represents a nominal effective continuous sound over the duration of an acoustic event, such as the emission of one acoustic pulse, a marine mammal vocalisation, the passage of a vessel, or over a fixed duration. Because the window length, *T*, is the divisor, events with similar sound exposure level (SEL), but more spread out in time have a lower SPL.

The sound exposure level (SEL or L_E, dB re 1 μPa^2·s) is a measure related to the acoustic energy contained in one or more acoustic events (N). The SEL for a single event is computed from the time-integral of the squared pressure over the full event duration (T):

$$\mathrm{SEL} = L_E = 10\log_{10}\left[\int_T p^2(t)\,dt \Big/ T_0 p_0^2\right] \tag{B-8}$$

where T_0 is a reference time interval of 1 s. The SEL continues to increase with time when non-zero pressure signals are present. It therefore can be construed as a dose-type measurement, so the integration time used must be carefully considered in terms of relevance for impact to the exposed recipients.

SEL can be calculated over periods with multiple events or over a fixed duration. For a fixed duration, the square pressure is integrated over the duration of interest. For multiple events, the SEL can be computed by summing (in linear units) the SEL of the N individual events:

$$L_{E,N} = 10\log_{10}\sum_{i=1}^{N} 10^{\frac{L_{E,i}}{10}} \tag{B-9}$$

To compute the SPL(T_{90}) and SEL of acoustic events in the presence of high levels of background noise, equations B-6 and B-7 are modified to subtract the background noise contribution:

$$\mathrm{SPL}(T_{90}) = L_{p90} = 10\log_{10}\left[\frac{1}{T_{90}}\int_{T_{90}}\left(p^2(t) - \overline{n^2}\right)dt \Big/ p_0^2\right] \tag{B-10}$$

$$L_E = 10\log_{10}\left[\int_{T}\left(p^2(t) - \overline{n^2}\right)dt \Big/ T_0 p_0^2\right] \tag{B-11}$$

where $\overline{n^2}$ is the mean square pressure of the background noise, generally computed by averaging the squared pressure of a temporally-proximal segment of the acoustic recording during which acoustic events are absent (e.g., between pulses).

Because the SPL(T_{90}) and SEL are both computed from the integral of square pressure, these metrics are related numerically by the following expression, which depends only on the duration of the time window T:

$$L_p = L_E - 10\log_{10}(T) \tag{B-12}$$

$$L_{p90} = L_E - 10\log_{10}(T_{90}) - 0.458 \tag{B-13}$$

where the 0.458 dB factor accounts for the 10% of SEL missing from the SPL(T_{90}) integration time window.

Energy equivalent SPL (dB re 1 µPa) denotes the SPL of a stationary (constant amplitude) sound that generates the same SEL as the signal being examined, $p(t)$, over the same period of time, T:

$$L_{\mathrm{eq}} = 10\log_{10}\left[\frac{1}{T}\int_{T} p^2(t)\,dt \Big/ p_0^2\right] \tag{B–14}$$

The equations for SPL and the energy-equivalent SPL are numerically identical; conceptually, the difference between the two metrics is that the former is typically computed over short periods (typically of 1 s or less) and tracks the fluctuations of a non-steady acoustic signal, whereas the latter reflects the average SPL of an acoustic signal over times typically of one minute to several hours.

B.2. Decidecade Band Analysis

The distribution of a sound's power with frequency is described by the sound's spectrum. The sound spectrum can be split into a series of adjacent frequency bands. Splitting a spectrum into 1 Hz wide bands, called passbands, yields the power spectral density of the sound. These values directly compare to the Wenz curves, which represent typical deep ocean sound levels (Figure 9) (Wenz 1962). This splitting of the spectrum into passbands of a constant width of 1 Hz, however, does not represent how animals perceive sound.

Because animals perceive exponential increases in frequency rather than linear increases, analysing a sound spectrum with passbands that increase exponentially in size better approximates real-world scenarios. In underwater acoustics, a spectrum is commonly split into decidecade bands, which are one tenth of a decade wide. A decidecade is sometimes referred to as a "1/3-octave" because one tenth of a decade is approximately equal to one third of an octave. Each decade represents a factor 10 in sound frequency. Each octave represents a factor 2 in sound frequency. The centre frequency of the ith band, $f_\mathrm{c}(i)$, is defined as:

$$f_\mathrm{c}(i) = 10^{\frac{i}{10}}\ \mathrm{kHz} \tag{B-1}$$

and the low (f_{lo}) and high (f_{hi}) frequency limits of the ith decade band are defined as:

$$f_{\text{lo},i} = 10^{\frac{-1}{20}} f_{\text{c}}(i) \quad \text{and} \quad f_{\text{hi},i} = 10^{\frac{1}{20}} f_{\text{c}}(i) \tag{B-2}$$

The decidecade bands become wider with increasing frequency, and on a logarithmic scale the bands appear equally spaced (Figure B-2).

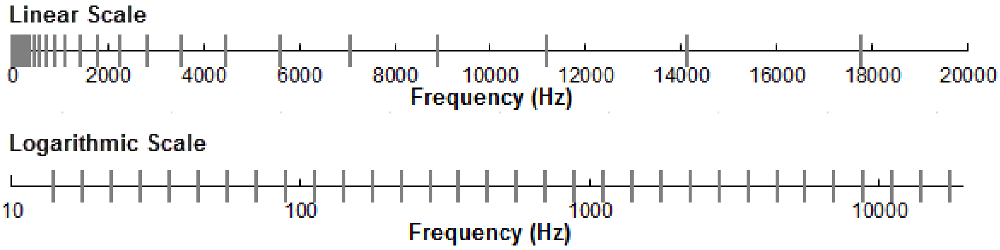


Figure B-2. Decidecade frequency bands (vertical lines) shown on a linear frequency scale and a logarithmic scale.

The sound pressure level in the ith band ($L_{p,i}$) is computed from the spectrum $S(f)$ between $f_{\text{lo},i}$ and $f_{\text{hi},i}$:

$$L_{p,i} = 10 \log_{10} \int_{f_{\text{lo},i}}^{f_{\text{hi},i}} S(f)\, df \tag{B-3}$$

Summing the sound pressure level of all the bands yields the broadband sound pressure level:

$$\text{Broadband SPL} = 10 \log_{10} \sum_{i} 10^{\frac{L_{p,i}}{10}} \tag{B-4}$$

Figure B-3 shows an example of how the decidecade band sound pressure levels compare to the sound pressure spectral density levels of an ambient noise signal. Because the decidecade bands are wider with increasing frequency, the decidecade band SPL is higher than the spectral levels at higher frequencies. Decidecade band analysis is applied to continuous and impulsive noise sources. For impulsive sources, the decidecade band SEL is typically reported.

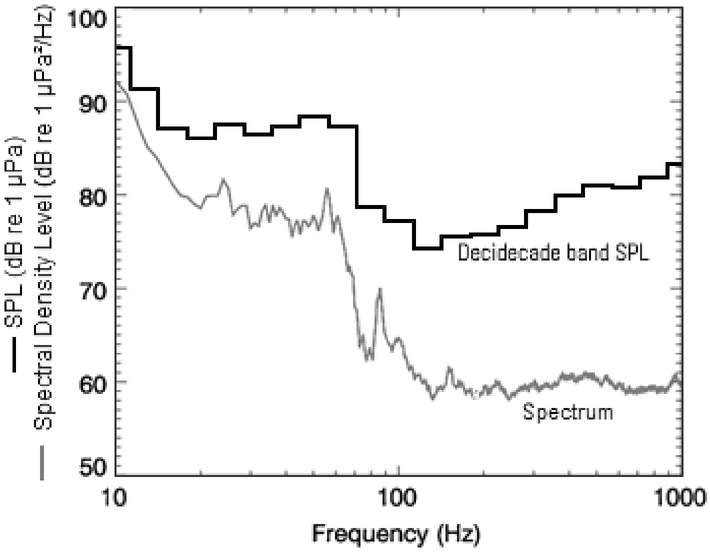


Figure B-3. Sound pressure spectral density levels and the corresponding decidecade band sound pressure levels of example ambient noise shown on a logarithmic frequency scale.

Table B-1. Decidecade band frequencies (Hz)

Band	Lower frequency	Nominal centre frequency	Upper frequency
10	8.9	10.0	11.2
11	11.2	12.6	14.1
12	14.1	15.8	17.8
13	17.8	20.0	22.4
14	22.4	25.1	28.2
15	28.2	31.6	35.5
16	35.5	39.8	44.7
17	44.7	50.1	56.2
18	56.2	63.1	70.8
19	70.8	79.4	89.1
20	89.1	100.0	112.2
21	112	126	141
22	141	158	178
23	178	200	224
24	224	251	282
25	282	316	355
26	355	398	447
27	447	501	562
28	562	631	708
29	708	794	891
30	891	1000	1122
31	1122	1259	1413
32	1413	1585	1778
33	1778	1995	2239
34	2239	2512	2818
35	2818	3162	3548
36	3548	3981	4467
37	4467	5012	5623
38	5623	6310	7079
39	7079	7943	8913
40	8913	10000	11220
41	11220	12589	14125
42	14260	16000	17952
43	17825	20000	22440
44	22281	25000	28050
45	28074	31500	35344

Table B-2. Decade-band frequencies (Hz)

Decade band	Lower frequency	Nominal centre frequency	Upper frequency
A	10	50	100
B	100	500	1,000
C	1,000	5,000	10,000

B.3. Millidecade Band Analysis

JASCO Applied Sciences has adopted a hybrid millidecade spectrum system to store and exchange passive acoustic spectral data to optimize data resolution while minimising data size, described in Martin et al. (2021).

Millidecades are logarithmically spaced frequency bands but have a bandwidth equal to 1/1000th of a decade. This frequency resolution is high enough to support many types of analysis, including analysing different types of soundscapes, computing weighted sound exposure levels, and summing the millidecades to find decidecades, 1/3-octave, and other desired frequency bands. The size of the millidecade files greatly compresses the acoustic data compared to 1 Hz resolution, such that data from long-term, multiple-station, high-sampling frequency projects can easily be stored at a single location. For example, there are 1,000 millidecades in each frequency decade, where a decade is an increase in the frequency by a factor of 10. A pure millidecade presentation of a spectrum from 1–100,000 Hz has 5,000 bands rather than 100,000 1 Hz bands, which results in a 20:1 decrease in the amount of data required for storage or exchange. For a 256 kHz spectrum, which is becoming a common size for recorders sampling at 512 kHz, there are 3,206 hybrid millidecades resulting in a compression ratio of 80:1.

The format uses 1-Hz resolution up to 455 Hz and millidecades frequency bands above 455 Hz. The lowest millidecades over-resolve (bin sizes <1 Hz) the space between 1–435 Hz for nearly all soundscape applications. To address this, a hybrid solution was applied that uses 1 Hz bands up to 455 Hz, where the millidecades are 1 Hz wide.

Similar to decidecades, the centre frequency for the ith millidecade (f_{c_i}) is defined as

$$f_{c\_i} = 10^{i/1{,}000}\ (\mathrm{Hz}) \tag{15}$$

and the lower (f_{lo_i}) and upper (f_{hi_i}) bounds for each millidecade are

$$f_{lo\_i} = f_{c\_i} \cdot 10^{-1/2{,}000}\ (\mathrm{Hz}) \tag{16}$$

$$f_{hi\_i} = f_{c\_i} \cdot 10^{1/2{,}000}\ (\mathrm{Hz})\,. \tag{17}$$

Appendix C. Recorder Calibration

The AMAR was calibrated before deployment with a pistonphone type 42AC precision sound source (G.R.A.S. Sound & Vibration A/S; Figure C-1). Due to the unforeseen delay of the retrieval the battery life was exhausted which prevented a calibration after retrieval. The pistonphone calibrator produces a constant tone at 250 Hz at a fixed distance from the hydrophone sensor in an airtight space with known volume. The recorded level of the reference tone on the AMAR yields the system gain for the AMAR and hydrophone. To determine absolute sound pressure levels, this gain was applied during data analysis. Typical calibration variance using this method is less than 0.7 dB absolute pressure.

Figure C-1. Split view of a G.R.A.S. 42AC pistonphone calibrator with an M36 hydrophone.

Appendix D. Marine Mammal Detection Methodology

D.1. Automated Click Detector for Odontocetes

We applied an automated click detector/classifier to the data to detect clicks from odontocetes (Figure D-1.). This detector/classifier is based on the zero-crossings in the acoustic time series. Zero-crossings are the rapid oscillations of a click's pressure waveform above and below the signal's normal level (e.g., Figure D-1.). Clicks are detected by the following steps (Figure D-1.):

1. The raw data is high-pass filtered to remove all energy below 5 kHz. This removes most energy from other sources such as shrimp, vessels, wind, and cetacean tonal calls, yet allows the energy from all marine mammal click types to pass.
2. The filtered samples are summed to create a 0.334 ms rms time series. Most marine mammal clicks have a 0.1–1 ms duration.
3. Possible click events are identified with a split-window normaliser that divides the 'test' bin of the time series by the mean of the 6 'window' bins on either side of the test bin, leaving a 1-bin wide 'notch'.
4. A Teager-Kaiser energy detector identifies possible click events.
5. The high-pass filtered data is searched to find the maximum peak signal within 1 ms of the detected peak.
6. The high-pass filtered data is searched backwards and forwards to find the time span where the local data maxima are within 9 dB of the maximum peak. The algorithm allows for two zero-crossings to occur where the local peak is not within 9 dB of the maximum before stopping the search. This defines the time window of the detected click.
7. The classification parameters are extracted. The number of zero crossings within the click, the median time separation between zero crossings, and the slope of the change in time separation between zero crossings are computed. The slope parameter helps to identify beaked whale clicks, as beaked whales can be identified by the increase in frequency (upsweep) of their clicks.
8. The Mahalanobis distance between the extracted classification parameters and the templates of known click types is computed. The covariance matrices for the known click types, computed from thousands of manually identified clicks for each species, are stored in an external file. Each click is classified as a type with the minimum Mahalanobis distance unless none of them are less than the specified distance threshold.

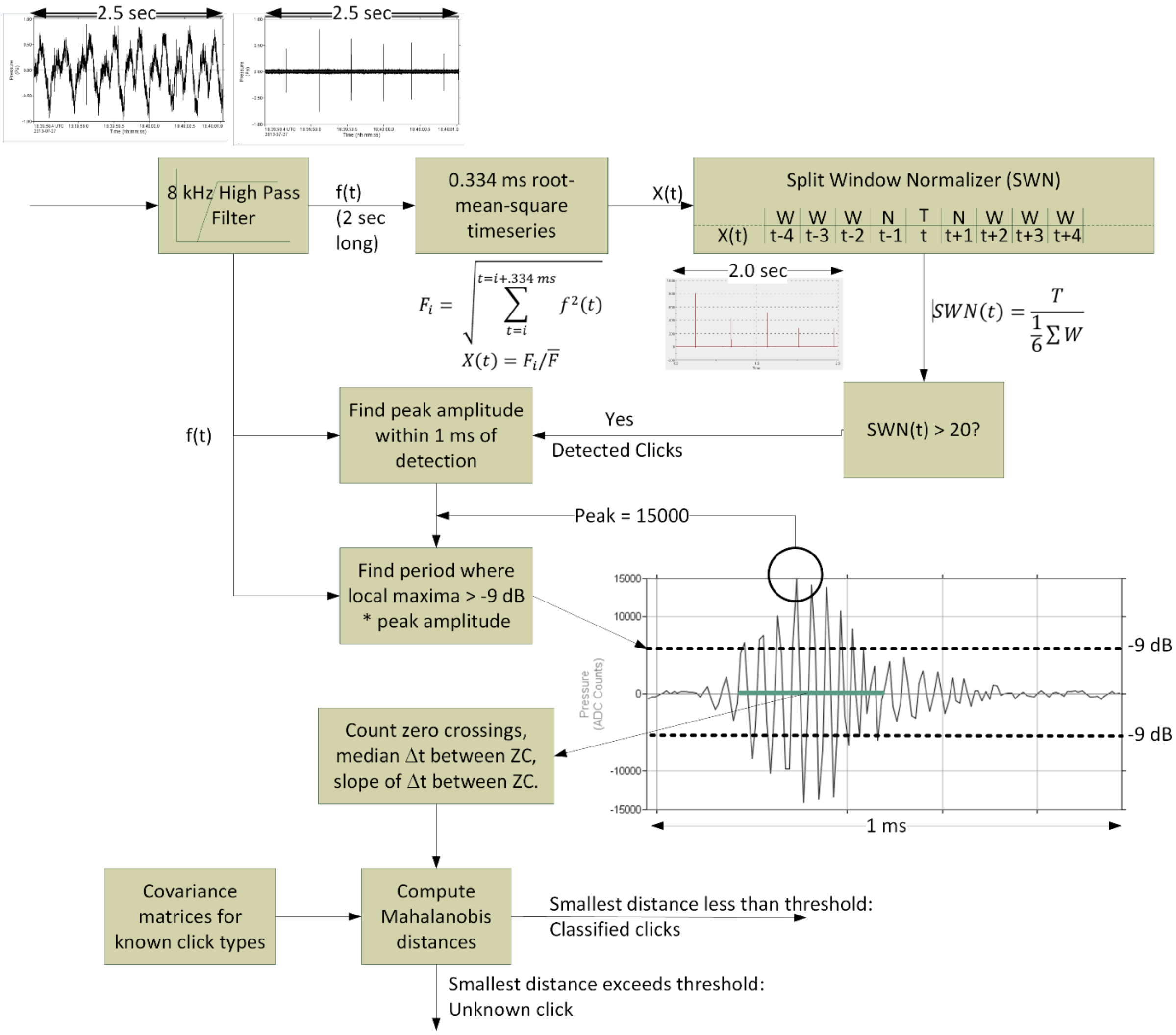


Figure D-1. The automated click detector/classifier block diagram.

Odontocete clicks occur in groups called click trains. Each species has a characteristic inter-click-interval (ICI) and number of clicks per train. The automated click detector includes a second stage that associates individual clicks into trains (Figure D-2). The steps of the click train associator algorithm are:

1. Queue clicks for N seconds, where N is twice the maximum number of clicks per train times the maximum ICI.
2. Search for all clicks within the window that have Mahalanobis distances less than 11 for the species of interest (this gets 99% of all clicks for the species as defined by the template).
3. Create a candidate click train if:
   a. The number of clicks is greater or equal to the minimum number of clicks in a train;
   b. The maximum time between any two clicks is less than twice the maximum ICI, and
   c. The smallest Mahalanobis distance for all clicks in the candidate train is less than 4.1.
4. Create a new ‘time-series’ that has a value of 1 at the time of arrival of each clicks and zeroes everywhere else.
5. Apply a Hann window to the timeseries then compute the cepstrum.
4. A click train is classified if a peak in the cepstrum with amplitude > 5 times the standard deviation of the cepstrum occurs at a quefrency between the minimum maximum ICI.
5. Queue clicks for N seconds

6. Search for all clicks within the window that have Mahalanobis distances less than 10 (equal to the extent of the variance in the training data set).
7. If the number of clicks is greater than or equal to 3 and dT is less than 2 * max ICI, make a new time-series at the 0.333 ms rate; where the value is 1 when the clicks occurred and 0 for all other time bins. Perform the following processing on this time series:
    a. Compute cepstrum
    b. ICI is the peak of the cepstrum with amplitude > 5 * stdev and searching for quefrency between minICI and maxICI.
    c. For each click related to the previous Ncepstrum, create a new time series and compute ICI; if we get a good match, extend the click train; find a mean ICI and variance.
8. If the click features, total clicks and mean ICI match the species, output a species_click_train detection.

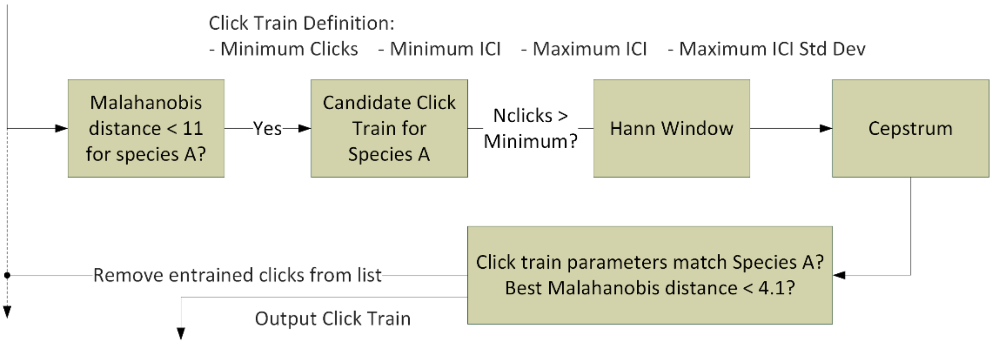


Figure D-2. The click train automated detector/classifier block diagram.

D.2. Automated Tonal Signal Detection

Marine mammal tonal acoustic signals are automatically detected by the following steps:

1. Spectrograms of the appropriate resolution for each mammal vocalisation type that were normalised by the median value in each frequency bin for each detection window Table D-1 were created.
2. Adjacent bins were joined, and contours were created via a contour-following algorithm (Figure D-3).
3. A sorting algorithm determined if the contours match the definition of a marine mammal vocalisation (Table D-2).

Due to the available time, a limited validation of the detections was performed by opening files with detections to check if actual calls were present.

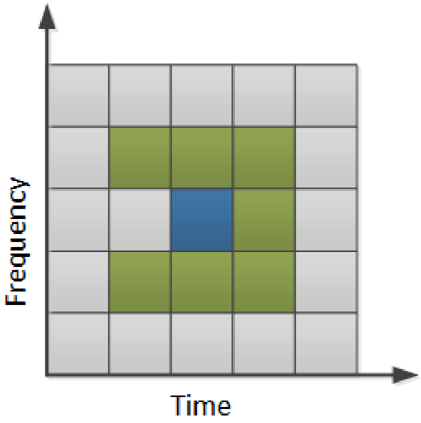


Figure D-3. Illustration of the search area used to connect spectrogram bins. The blue square represents a bin of the binary spectrogram equalling 1 and the green squares represent the potential bins it could be connected to. The algorithm advances from left to right so grey cells left of the test cell need not be checked.

Table D-1. Fast Fourier Transform (FFT) and detection window settings for all automated contour-based detectors used to detect tonal vocalisations of marine mammal species expected in the data. Values are based on JASCO's experience and empirical evaluation on a variety of data sets.

Automated detector	FFT			Detection window (s)	Detection threshold
	Resolution (Hz)	Frame length (s)	Timestep (s)		
AUS_BW_AH17	0.5	2	0.125	50	2
AUS_BW_AH60	0.5	2	0.125	50	2
AUS_BW_BH20	0.5	2	0.125	40	2
AUS_BW_BH43	0.5	2	0.125	40	2
AUS_BW_BH65	0.5	2	0.125	40	2
BW_H67	0.5	2	0.125	1200	3
BW_DS	0.05	2	0.2	5	3
NPac_BW_D	0.05	2	0.25	10	2
Brydes_DS	0.125	2	0.25	120	3
Brydes_IM_W	0.5	2	0.125	5	4
VLFMoan	2	0.2	0.05	15	4
LFMoan	2	0.25	0.05	10	3
ShortLow	7	0.17	0.025	10	3
MFMoanLow	4	0.2	0.05	5	3
MFMoanHigh	8	0.125	0.05	5	3
Omura_S1	0.25	2	0.25	120	6
Omura_S2	0.25	0.5	0.5	60	4
Omura_W	0.25	2	0.25	120	4
WhistleLow	16	0.03	0.015	5	3
WhistleHigh	64	0.015	0.005	5	3
MF Moan-LowDS-H:M	0.05	4	0.2	5	7
MF Moan-MidT-L	0.05	4	0.2	5	1.5
MF Moan-LowT-L	0.05	4	0.2	5	1.5
MF Moan-LowDS-L	0.05	4	0.2	5	3

Table D-2. A sample of vocalisation sorter definitions for the tonal vocalisations of cetacean species expected in the area.

Automated detector	Target species	Frequency (Hz)	Duration (s)	Bandwidth (B; Hz)	Other detection parameters
AUS_BW_AH17	Blue whale	10–100	6–60	1–50	Peak frequency 17–18.5
AUS_BW_AH60	Blue whale	10–100	6–60	1–50	Peak frequency 59–60.5
AUS_BW_BH20	Blue whale	10–100	6–30	1–3	Peak frequency 21–22.5
AUS_BW_BH43	Blue whale	10–100	6–30	1–3	Peak frequency 43–44.5
AUS_BW_BH65	Blue whale	10–100	6–30	1–3	Peak frequency 64–66.5
BW_H67	Blue whale	60–70	10–30	1–10	n/a
BW_DS	Blue whale	30–100	0.45–1	30–60	n/a
NPac_BW_D	Blue whale	20–100	2–10	15–50	Sweep rate −15 to −5
Brydes_DS	Bryde’s whale	30–200	0.5–3	10–80	n/a
Brydes_IM_W	Bryde’s whale	24–30	2–6	0.5–4	n/a
VLFMoan	Blue/fin/sei whale	10–100	0.30–10.00	>10	minF<40 Hz
LFMoan	Blue/right/sei whale	40–250	0.50–10.00	>15	InstantaneousBandwidth<50 Hz
ShortLow	Fin/baleen whale	30–400	0.08–0.60	>25	n/a
MFMoanLow	Humpback whale	100–700	0.50–5.00	>50	minF<450 Hz InstantaneousBandwidth<200 Hz
MFMoanHigh	Humpback whale	500–2500	0.50–5.00	>150	minF<1500 Hz InstantaneousBandwidth<300 Hz
Omura_S1	Omura’s whale	15–60	5–12	8–40	n/a
Omura_S2	Omura’s whale	10–60	3–15	8–40	n/a
Omura_W	Omura’s whale	24–30	2–6	0.5–4	n/a
WhistleLow	Pilot/killer whale	1000–10000	0.50–5.00	>300	Max Instantaneous Bandwidth = 1000 Hz minF<5000 Hz
WhistleHigh	Other delphinid	4000–20000	0.30–3.00	>700	Max Instantaneous Bandwidth = 5000 Hz
MF Moan-LowDS-H:M	Humpback whale	100–1000	0.35–1.5	200–900	n/a
MF Moan-MidT-L	Humpback whale	500–1500	0.9–2.9	125–500	n/a
MF Moan-LowT-L	Humpback whale	50–950	0.9–2.9	50–500	n/a
MF Moan-LowDS-L	Humpback whale	100–1000	0.35–1.5	200–900	n/a

D.3. Automatic Data Selection for Validation (ADSV)

To standardise the file selection process for the selection of data for manual analysis, we applied our Automated Data Selection for Validation (ADSV) algorithm. Details of the ADSV algorithm are described in Kowarski et al. (2021) and a schematic of the process is provided in Figure D-4. ADSV computes the distribution of three descriptors that describe the automated detections in the full data set: the Diversity (number of automated detectors triggered per file), the Counts (number of automated detections per file for each automated detector), and the Temporal Distribution (spread of detections for each automated detector across the recording period). The algorithm removes files from the temporary data set that have the least impact on the distribution of the three descriptors in the full data set. Files are removed until a pre-determined data set size (*N*) is reached, at which point the temporary data set becomes the subset to be manually reviewed.

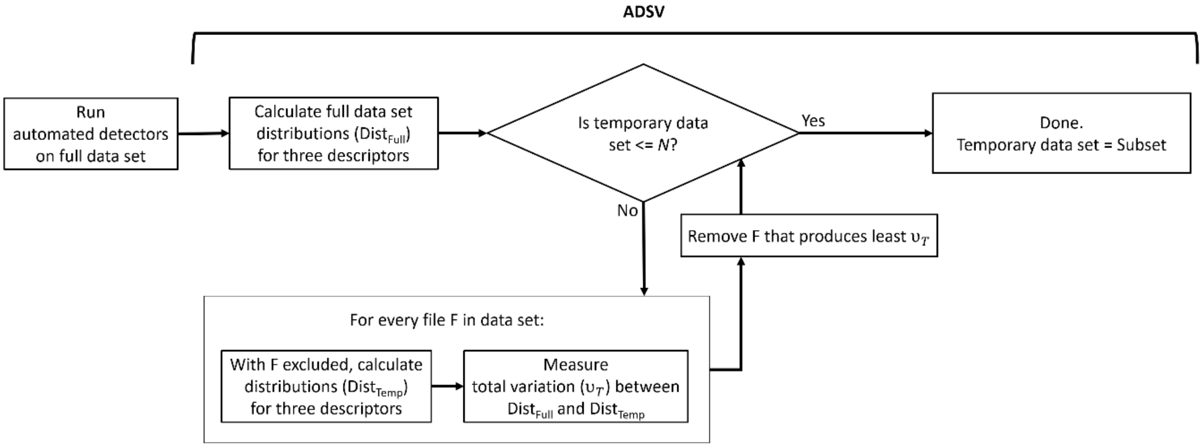


Figure D-4. Automated Data Selection for Validation (ADSV) process Figure 1 from Kowarski et al. (2021).

For the present work, an *N* of 0.5% was selected, largely due to limited scope for this project and marine mammal analysis. Even with limited manual review, the results presented here can be considered reliable, but some caveats should be considered. It is important to note that with such limited data manually reviewed, very rare species may have been missed or their occurrence underestimated. If the 0.5% subset of data manually analysed was not sufficiently large to capture the full range of acoustic environments in the full data set, the resulting automated detector performance metrics may be inaccurate and therefore should be taken as an estimate.

D.4. Automated Detector Performance Calculation and Optimization

All files selected for manual validation were reviewed by one of two experienced analysts using JASCO's PAMlab software to determine the presence or absence of every species, regardless of whether a species was automatically detected in the 5 min file. Although the automated detectors classify specific signals, we validated the presence/absence of species at the file level, not the detection level. Acoustic signals were only assigned to a species if the analyst was confident in their assessment. When unsure, analysts would consult one another, peer reviewed literature, and other experts in the field. If certainty could not be reached, the file of concern would be classified as possibly containing the species in question or containing an unknown acoustic signal. Next, the validated results were compared to the automated detector results in three phases to refine the results and ensure they accurately represent the occurrence of each species in the study area.

In phase 1, the human validated versus automated detector results were plotted as time series and critically reviewed to determine when and where automated detections should be excluded. Questionable detections that overlap with the detection period of other species were scrutinized. By restricting detections spatially and/or temporally where appropriate, we can maximize the reliability of the results. No temporal restrictions were necessary for our automated detector results.

In phase 2, the performance of the automated detectors was calculated and optimized for each species using a threshold, defined as the number of automated detections per file at and above which detections of species were considered valid.

To determine the performance of each automated detector and any necessary thresholds, the automated and validated results (excluding files where an analyst indicated uncertainty in species occurrence) were fed to a maximum likelihood estimation algorithm that maximizes the probability of detection and minimizes the number of false alarms using the Matthews Correlation Coefficient (MCC):

$$MCC = \frac{TPxTN - FPxFN}{\sqrt{(\mathrm{TP}+\mathrm{FP})(\mathrm{TP}+\mathrm{FN})(\mathrm{TN}+\mathrm{FP})(\mathrm{TN}+\mathrm{FN})}}$$

$$P = \frac{TP}{TP+FP}; R = \frac{TP}{TP+FN}$$

where *TP* (true positive) is the number of correctly detected files, *FP* (false positive) is the number of files that are false detections, and *FN* (false negatives) is the number of files with missed detections. No thresholds were necessary for our automated detector results.

In phase 3, detections were further restricted to include only those where *P* was greater than or equal to 0.75. When *P* was less than 0.75, only validated results were used to describe the acoustic occurrence of a species. All species in the present data set had automated detectors that performed sufficiently well. The occurrence of each species was plotted using JASCO's Ark software as time series showing presence/absence by hour over each day.

Appendix E. Auditory Frequency Weighting Functions

The potential for anthropogenic sounds to impact marine mammals is largely dependent on whether the sound occurs at frequencies that an animal can hear well, unless the sound pressure level is so high that it can cause physical tissue damage regardless of frequency. Auditory (frequency) weighting functions reflect an animal's ability to hear a sound (Nedwell and Turnpenny 1998, Nedwell et al. 2007). Houser et al (2017) provide an example illustrating the effect of applying a weighting function to a (hypothetical) sound (Figure E-1).

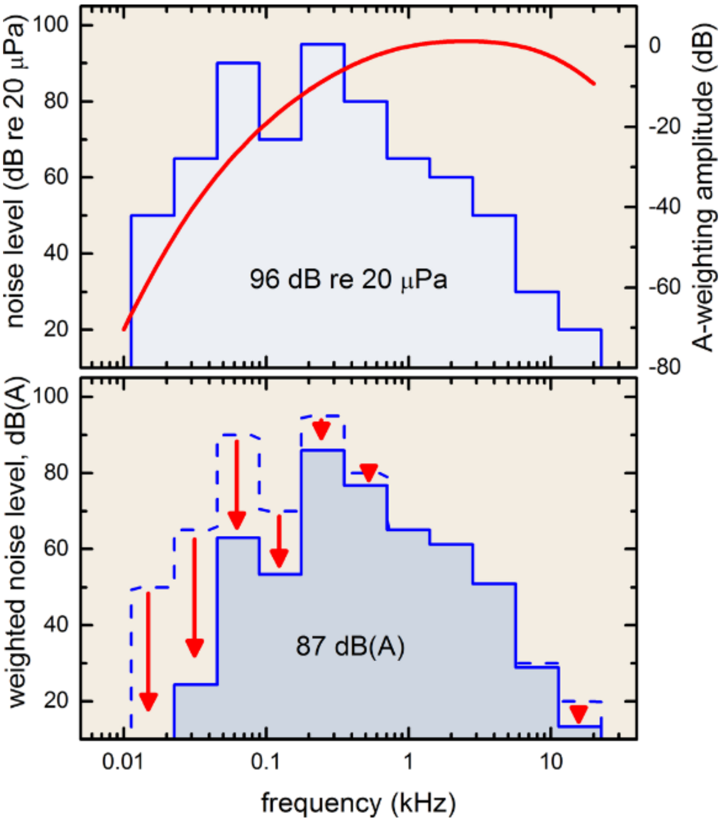


Figure E-1. Application of an auditory weighting function. Blue line shows a hypothetical, octave-band sound pressure spectrum in air, with a total sound pressure level (integrated over all octave-bands) of 96 dB re 20 µPa (This example uses in air-noise levels; therefore, a different reference pressure (20 µPa) applies. The principle is identical to underwater sound where a reference pressure of 1 µPa applies). (Top) Red line shows the human A-weighting function amplitude (A-weighting applies only to human hearing). (Bottom) To determine the weighted exposure level, the A-weighting amplitude at each frequency is added to the sound pressure level at each frequency (red arrows). The weighted spectrum has lower amplitude at the frequencies where the A-weighting function amplitudes are negative. The values from 1–4 kHz do not change substantially, because the weighting function is flat (i.e., the weights are near zero). The weighted SPL is calculated by integrating the weighted spectrum across all octave-bands; the result is 87 dBA, meaning a sound pressure level of 87 dB re 20 µPa after applying the human A-weighting function (Source: Houser et al. 2017).

To better reflect the auditory similarities between phylogenetically closely related species, but also significant differences between species groups among the marine mammals, the extant marine mammal species are assigned to functional hearing groups based on their hearing capabilities and sound production (NMFS 2018) (Table E-1). This division into broad categories is intended to provide a realistic number of categories for which individual noise exposure criteria were developed and the categorisation as such has proven to be a scientifically justified and useful approach in developing auditory frequency weighting functions and deriving noise exposure criteria for marine mammals.

Table E-1. Marine mammal hearing groups (NMFS 2018).

Hearing group	Generalised hearing range*
Low-frequency (LF) cetaceans (mysticetes or baleen whales)	7 Hz to 35 kHz
Mid-frequency (MF) cetaceans (odontocetes: delphinids, beaked whales)	150 Hz to 160 kHz
High-frequency (HF) cetaceans (other odontocetes)	275 Hz to 160 kHz
Phocid pinnipeds (PW) (underwater)	50 Hz to 86 kHz
Otariid pinnipeds (OW) (underwater)	60 Hz to 39 kHz

* The generalised hearing range for all species within a group. Individual hearing will vary.

The potential for noise to affect animals depends on how well the animals can hear it. Noises are less likely to disturb or injure an animal if they are at frequencies that the animal cannot hear well. An exception occurs when the sound pressure is so high that it can physically injure an animal by non-auditory means (i.e., barotrauma). For sound levels below such extremes, the importance of sound components at particular frequencies can be scaled by frequency weighting relevant to an animal's sensitivity to those frequencies (Nedwell and Turnpenny 1998, Nedwell et al. 2007).

In 2015, a U.S. Navy technical report by Finneran (2015) recommended new auditory weighting functions. The overall shape of the auditory weighting functions is similar to human A-weighting functions, which follows the sensitivity of the human ear at low sound levels. The new frequency-weighting function is expressed as:

$$G(f) = K + 10\log_{10}\left[\left(\frac{(f/f_{lo})^{2a}}{\left[1+(f/f_{lo})^2\right]^a \left[1+(f/f_{hi})^2\right]^b}\right)\right] \qquad \text{(E-1)}$$

Finneran (2015) proposed five functional hearing groups for marine mammals in water: low-, mid-, and high-frequency cetaceans, phocid pinnipeds, and otariid pinnipeds. The parameters for these frequency-weighting functions were further modified the following year (Finneran 2016) and were adopted in NOAA's technical guidance that assesses noise impacts on marine mammals (NMFS 2016, NMFS 2018). Table E-2 lists the frequency-weighting parameters for each hearing group; Figure E-2 shows the resulting frequency-weighting curves.

Table E-2. Parameters for the auditory weighting functions used in this project as recommended by NMFS (2018).

Hearing group	a	b	f_{lo} (Hz)	f_{hi} (kHz)	K (dB)
Low-frequency cetaceans (baleen whales)	1.0	2	200	19,000	0.13
Mid-frequency cetaceans (dolphins, plus toothed, beaked, and bottlenose whales)	1.6	2	8,800	110,000	1.20
High-frequency cetaceans (true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* and *L. australis*)	1.8	2	12,000	140,000	1.36
Phocid seals in water	1.0	2	1,900	30,000	0.75
Otariid seals in water	2.0	2	940	25,000	0.64

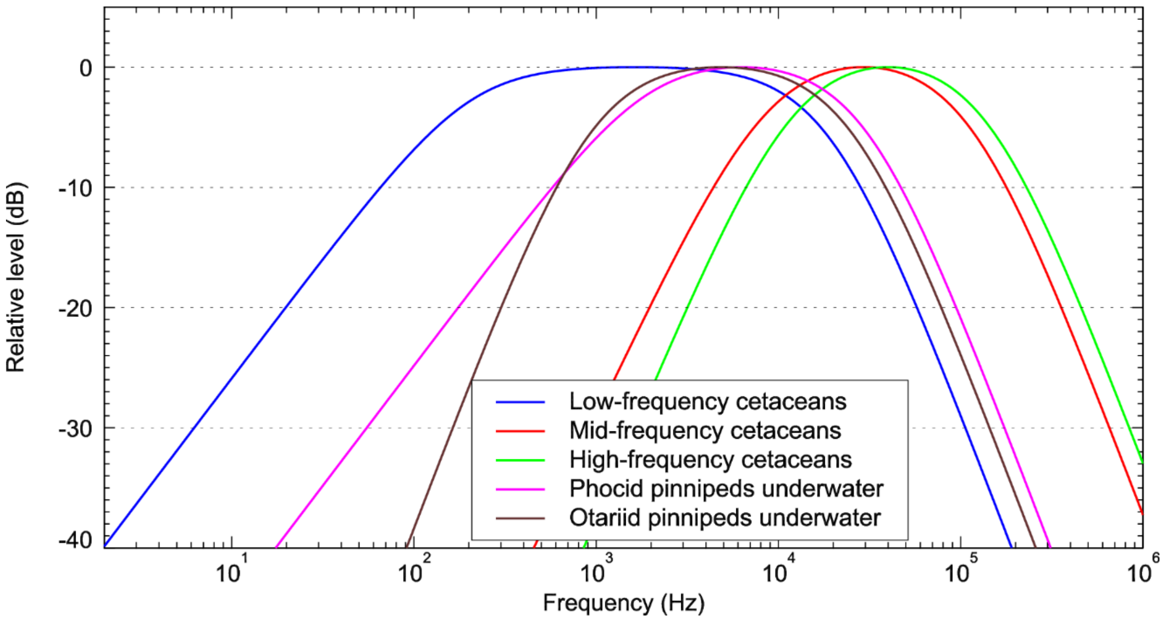


Figure E-2. Auditory weighting functions for functional marine mammal hearing groups as recommended by NMFS (2018).

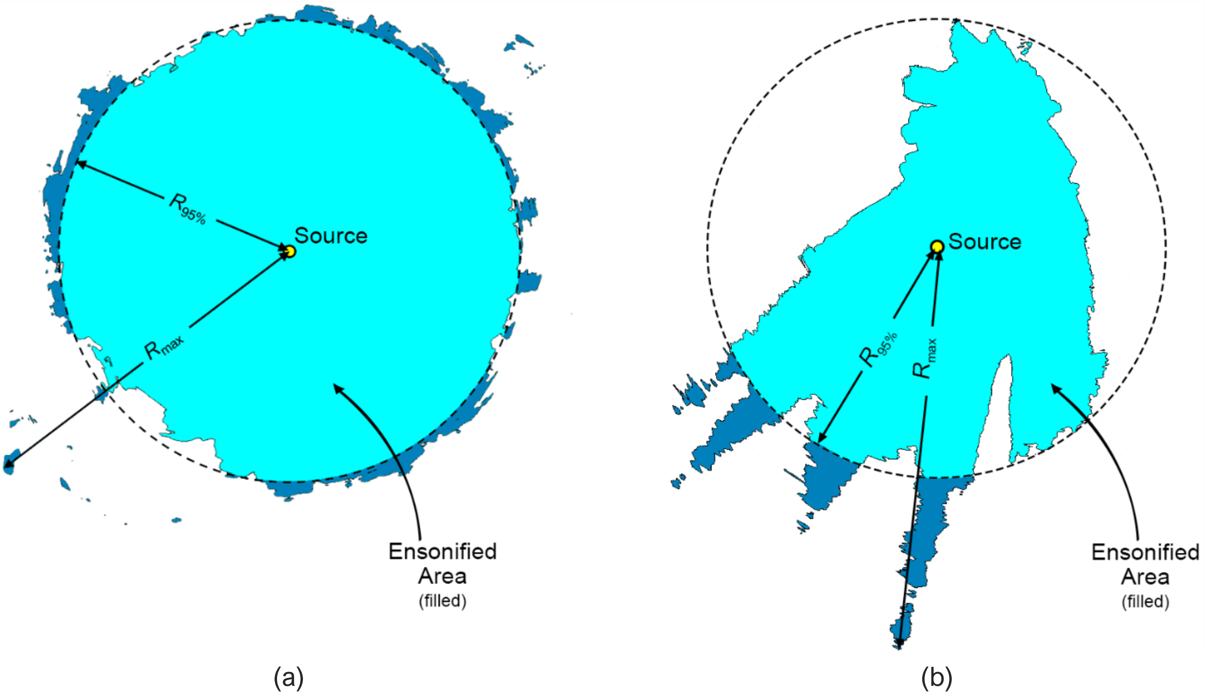
Appendix F. Methods and Parameters

This section describes the specifications of the seismic source that was used at all sites and the environmental parameters used in the propagation models.

F.1. Estimating Range to Thresholds Levels

Sound level contours were calculated based on the underwater sound fields predicted by the propagation models, sampled by taking the maximum value over all modelled depths above the sea floor for each location in the modelled region. The predicted distances to specific levels were computed from these contours. Two distances relative to the source are reported for each sound level: 1) R_{max}, the maximum range to the given sound level over all azimuths, and 2) $R_{95\%}$, the range to the given sound level after the 5% farthest points were excluded (see examples in Figure F-1).

The $R_{95\%}$ is used because sound field footprints are often irregular in shape. In some cases, a sound level contour might have small protrusions or anomalous isolated fringes. This is demonstrated in the image in Figure F-1(a). In cases such as this, where relatively few points are excluded in any given direction, R_{max} can misrepresent the area of the region exposed to such effects, and $R_{95\%}$ is considered more representative. In strongly asymmetric cases such as shown in Figure F-1(b), on the other hand, $R_{95\%}$ neglects to account for significant protrusions in the footprint. In such cases R_{max} might better represent the region of effect in specific directions. Cases such as this are usually associated with bathymetric features affecting propagation. The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the non-uniformity of the acoustic environment.



(a) (b)

Figure F-1. Sample areas ensonified to an arbitrary sound level with R_{max} and $R_{95\%}$ ranges shown for two scenarios. (a) Largely symmetric sound level contour with small protrusions. (b) Strongly asymmetric sound level contour with long protrusions. Light blue indicates the ensonified areas bounded by $R_{95\%}$; darker blue indicates the areas outside this boundary which determine R_{max}.

F.2. Environmental Parameters

F.2.1. Bathymetry

Water depths throughout the modelled areas were extracted from the Australian Bathymetry and Topography Grid, a 9 arc-second grid rendered for Australian waters (Whiteway 2009). Bathymetry data were re-gridded onto a Map Grid of Australia (MGA) coordinate projection (Zone 54) with a regular grid spacing of 100 × 100 m.

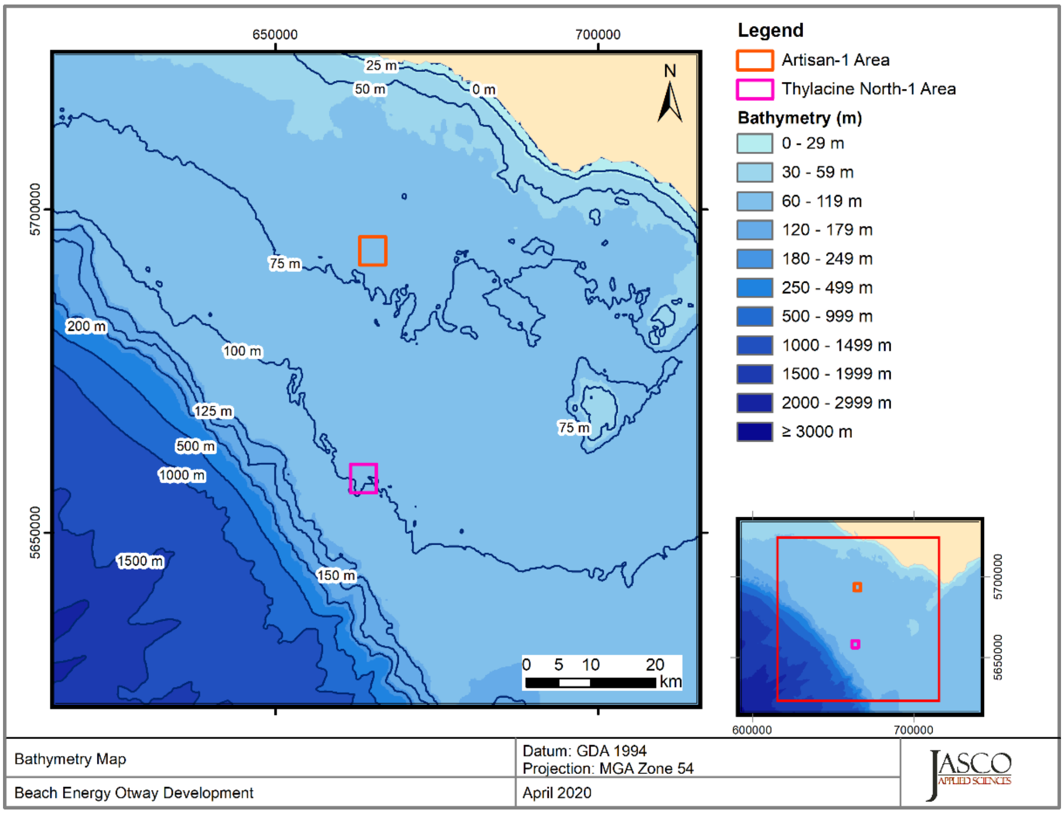


Figure F-2. Bathymetry in the modelled area.

F.2.2. Sound speed profile

Between 0–77 m water depth, mean daily sound speed profiles were derived from the Global Ice Ocean Prediction System (GIOPS) forecasting system for the period when the measurement data was acquired (February 2021 to March 2021 inclusive). A median profile determined to best represent potential propagation conditions over the periods. For deeper water depths below 77 m the sounds speed profile was combined with the sound speed profiles from GDEM (GDEM; Teague et al. 1990, Carnes 2009).

The GIOPS is a data assimilation system that combines satellite and in-situ measurements for ice and ocean analyses and forecasts. Available sea ice analysis products are generated from sea ice concentration data and other satellite measurements from the Canadian Ice Service. For oceanographic variables, GIOPS assimilates a variety of satellite and in-situ observations (Argos profiling floats, ice buoys, moorings, ship observations, and others) to provide a 3-d representation of ocean temperature and salinity, water velocity, sea surface height and mixed layer depth. Meant primarily as a forecasting tool, the daily reported results are not archived long term for general use, but JASCO started caching GIOPS output in 2017 to support Arctic programs.

GDEM provides an ocean climatology of temperature and salinity for the world's oceans on a latitude-longitude grid with 0.25° resolution, with a temporal resolution of one month, based on global historical observations from the U.S. Navy's Master Oceanographic Observational Data Set (MOODS). The climatology profiles include 78 fixed depth points to a maximum depth of 6800 m (where the ocean is that deep). The GDEM temperature-salinity profiles were converted to sound speed profiles according to Coppens (1981).

The February and March were selected for sound propagation modelling to ensure to align with the measurement period. Figure F-3 shows the resulting profile, which was used as input for the sound propagation modelling.

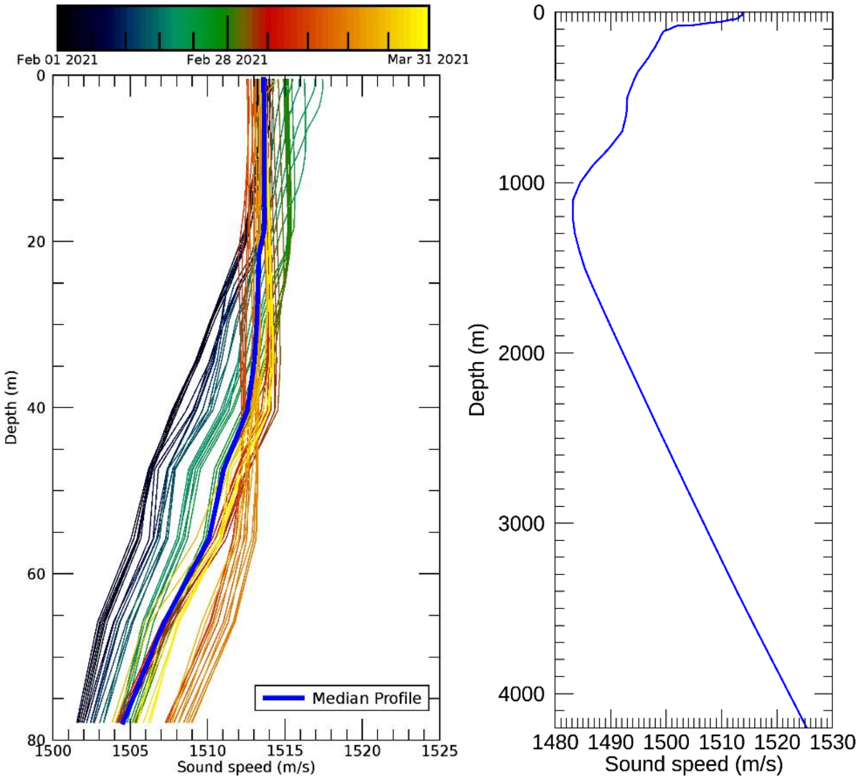


Figure F-3. The sound speed profile used for modelling: The daily and median profiles for the first 77 m from Global Ice Ocean Prediction System (GIOPS) (left) and full depth (right).

F.2.3. Geoacoustics

The propagation model used in this study consider a single geoacoustic profile for the modelled area. These profiles determine how sound is reflected from the seabed, as well as how it is transmitted, reflected, and absorbed into the sediment layers. The seabed in the Artisan-1, located in shallower waters, was characterised by cemented and semi-cemented carbonate rock (calcarenite). semi-cemented carbonate rock with the potential for a thin overlying veneer of coarse sand. This geologic model of the seabed environment is consistent with larger scale geological data and interpretations of the Australian continental shelf environment (James and Bone 2010). Tables F-1 and F-2 present the geoacoustic profiles used modelled sites for each seabed type considered.

Table F-1. *Artisan-1*: Carbonate rock geoacoustic profile. Each parameter varies linearly within the stated range.

Depth below seafloor (m)	Predicted lithology	Density (g/cm^3)	Compressional wave		Shear wave	
			Speed (m/s)	Attenuation (dB/λ)	Speed (m/s)	Attenuation (dB/λ)
0–0.5	Well-cemented carbonate caprock	2.7	2600	0.50	500	0.4
0.5–20	Increasingly cemented calcarenite	2.2	2000	0.30		
20–40		2.3	2120	0.34		
40–60		2.4	2240	0.38		
60–80		2.5	2360	0.42		
80–100		2.6	2480	0.46		
>100	Well-cemented calcarenite	2.7	2600	0.5		

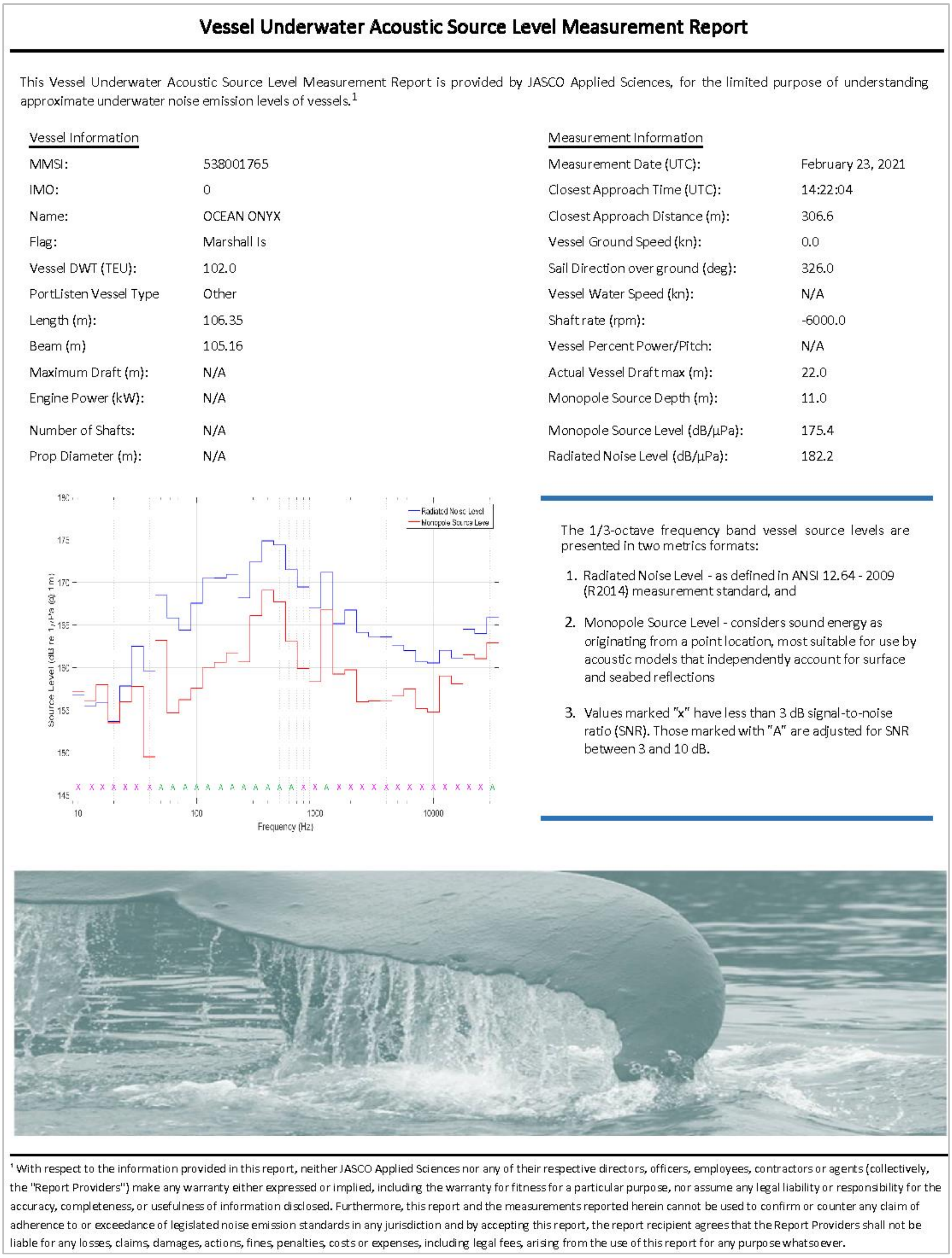
Table F-2. *Artisan-1*: Carbonate rock geoacoustic profile with overlying sand veneer. Each parameter varies linearly within the stated range.

Depth below seafloor (m)	Predicted lithology	Density (g/cm^3)	Compressional wave		Shear wave	
			Speed (m/s)	Attenuation (dB/λ)	Speed (m/s)	Attenuation (dB/λ)
0–1	Coarse carbonate sand	2.03	1800	0.85	300	3.68
1–20	Increasingly cemented calcarenite	2.2	2000	0.30		
20–40		2.3	2120	0.34		
40–60		2.4	2240	0.38		
60–80		2.5	2360	0.42		
80–100		2.6	2480	0.46		
>100	Well-cemented calcarenite	2.7	2600	0.5		

Appendix G. ShipSound Reports

G.1. *Ocean Onyx* Reports

G.1.1. Report 1: 14:22 on 23 Feb 2021



Vessel Underwater Acoustic Source Level Measurement Report

This Vessel Underwater Acoustic Source Level Measurement Report is provided by JASCO Applied Sciences, for the limited purpose of understanding approximate underwater noise emission levels of vessels.[1]

Vessel Information	
MMSI:	538001765
IMO:	0
Name:	OCEAN ONYX
Flag:	Marshall Is
Vessel DWT (TEU):	102.0
PortListen Vessel Type	Other
Length (m):	106.35
Beam (m)	105.16
Maximum Draft (m):	N/A
Engine Power (kW):	N/A
Number of Shafts:	N/A
Prop Diameter (m):	N/A

Measurement Information	
Measurement Date (UTC):	February 23, 2021
Closest Approach Time (UTC):	14:22:04
Closest Approach Distance (m):	306.6
Vessel Ground Speed (kn):	0.0
Sail Direction over ground (deg):	326.0
Vessel Water Speed (kn):	N/A
Shaft rate (rpm):	-6000.0
Vessel Percent Power/Pitch:	N/A
Actual Vessel Draft max (m):	22.0
Monopole Source Depth (m):	11.0
Monopole Source Level (dB/µPa):	175.4
Radiated Noise Level (dB/µPa):	182.2

The 1/3-octave frequency band vessel source levels are presented in two metrics formats:

1. Radiated Noise Level - as defined in ANSI 12.64 - 2009 (R2014) measurement standard, and
2. Monopole Source Level - considers sound energy as originating from a point location, most suitable for use by acoustic models that independently account for surface and seabed reflections
3. Values marked "x" have less than 3 dB signal-to-noise ratio (SNR). Those marked with "A" are adjusted for SNR between 3 and 10 dB.

---

[1] With respect to the information provided in this report, neither JASCO Applied Sciences nor any of their respective directors, officers, employees, contractors or agents (collectively, the "Report Providers") make any warranty either expressed or implied, including the warranty for fitness for a particular purpose, nor assume any legal liability or responsibility for the accuracy, completeness, or usefulness of information disclosed. Furthermore, this report and the measurements reported herein cannot be used to confirm or counter any claim of adherence to or exceedance of legislated noise emission standards in any jurisdiction and by accepting this report, the report recipient agrees that the Report Providers shall not be liable for any losses, claims, damages, actions, fines, penalties, costs or expenses, including legal fees, arising from the use of this report for any purpose whatsoever.

Vessel Underwater Noise Rating - Additional Information

Underwater Noise from vessels has the potential to disturb marine mammals, fish and other marine fauna. JASCO wishes to assist the shipping industry reduce its noise footprint in the marine environment. With this goal in mind, we have developed a vessel noise measurement system and a comparative noise ranking method that allows vessel noise emissions to be characterized relative to those of other vessels of the same class and similar size. The acoustic measurement approach conforms approximately with the protocol defined in ANSI standard 12.64-2009 Grade C, with exceptions as outlined below.

Vessel underwater noise emissions vary with vessel class, size, tonnage, speed, loading and other parameters. The system implements frequency weighting that considers that different marine species have different hearing acuities. For example, humpback whales are believed to be more sensitive to low-frequency sounds than killer whales. To account for these differences, the system calculates frequency-weighted noise metrics based on functions adopted by U.S. National Oceanic and Atmospheric Administration (NOAA) and published in their Marine Mammal Acoustic Technical Guidance[2]. The listening station calculates frequency-weighted noise levels for: Low Frequency Cetaceans (LFC), Mid-Frequency Cetaceans (MFC), and High-Frequency Cetaceans (HFC), Phocid Pinnipeds (PPW) and Otariid Pinnipeds (OPW). The actual rating value is the percentile of the vessel's adjusted and frequency-weighted noise level relative to all vessels of the same class.

RNL with Marine Mammal Weightings (NOAA 2016):

Low Frequency Cetaceans (LFC):	180.4	LFC Rank:	N/A
Mid-Frequency Cetaceans (MFC):	165.9	MFC Rank:	N/A
High-Frequency Cetaceans (HFC):	165.8	HFC Rank:	N/A

Additional Information for this Vessel Measurement:

Name of Vessel:	OCEAN ONYX
Measurement ID:	BEACHOTWAY-stn1-2021-02-538001765202102231422
Date of Measurement:	February 23, 2021

Environmental Information:

Closest Point of Approach location (WGS 84):	-38°53'029"S, 142°52'056"E		
Hydrophone location (WGS-84):	-38°53'024"S, 142°53'008"E		
Water Depth (m):	70.0		
Hydrophone Depth (m):	68.5	Wind Speed (kn):	9.0
Speed of Current (kn):	N/A	Wind Direction (deg):	184.0
Current Direction (deg):	N/A	Sea State Code (WMO):	N/A

Conformance with Standard

The vessel source measurements reported here were acquired using procedures conforming approximately with Grade C - Survey Method - ANSI 12.64-2009 (R2014) Quantities and Procedures for Description and Measurement of Underwater Sound from Ships - Part 1: General Requirements. Notable conformance exceptions are:

1. The standard requires 4 vessel passes, while this measurement is of a single pass.
2. The standard requires vessel Closest Point of Approach (CPA) of the greater of 100 m or one vessel length. This system may admit measurements at other distances.
3. The standard requires the hydrophone subtend depression angles relative to the ship of 20° ± 5° below horizontal, while this system permits angles from 10° to 60°.

Vessel name and dimension information is obtained from Automatic Identification System (AIS) records sent from the vessel at time of measurement and from MarineTraffic.com. Fields not transmitted by these services are marked as N/A in the report. Frequency bands marked with "X" or "A" in the source level graphs are respectively invalid or adjusted, due to being insufficiently above background noise levels as described in the standard.

---

[2] Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0), NOAA Technical Memorandum NMFS-OPR-59 April 2018. https://www.fisheries.noaa.gov/webdam/download/75962998

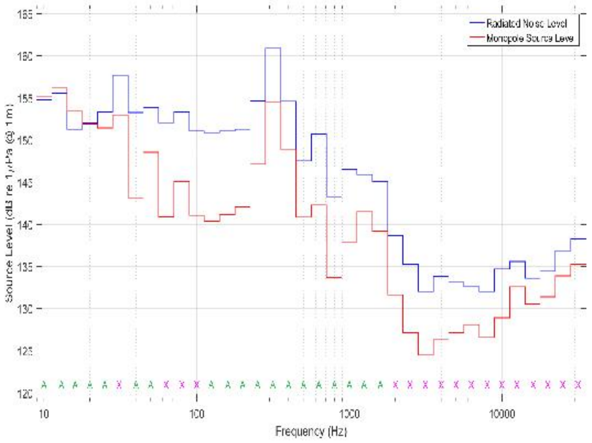
G.1.2. Report 2: 17:52 on 8 Mar 2021

Vessel Underwater Acoustic Source Level Measurement Report

This Vessel Underwater Acoustic Source Level Measurement Report is provided by JASCO Applied Sciences, for the limited purpose of understanding approximate underwater noise emission levels of vessels.[1]

Vessel Information	
MMSI:	538001765
IMO:	0
Name:	OCEAN ONYX
Flag:	Marshall Is
Vessel DWT (TEU):	102.0
PortListen Vessel Type	Other
Length (m):	106.35
Beam (m)	105.16
Maximum Draft (m):	N/A
Engine Power (kW):	N/A
Number of Shafts:	N/A
Prop Diameter (m):	N/A

Measurement Information	
Measurement Date (UTC):	March 08, 2021
Closest Approach Time (UTC):	17:52:04
Closest Approach Distance (m):	306.6
Vessel Ground Speed (kn):	0.0
Sail Direction over ground (deg):	326.0
Vessel Water Speed (kn):	N/A
Shaft rate (rpm):	-6000.0
Vessel Percent Power/Pitch:	N/A
Actual Vessel Draft max (m):	22.0
Monopole Source Depth (m):	11.0
Monopole Source Level (dB/µPa):	159.6
Radiated Noise Level (dB/µPa):	165.3



The 1/3-octave frequency band vessel source levels are presented in two metrics formats:

1. Radiated Noise Level - as defined in ANSI 12.64 - 2009 (R2014) measurement standard, and
2. Monopole Source Level - considers sound energy as originating from a point location, most suitable for use by acoustic models that independently account for surface and seabed reflections
3. Values marked "x" have less than 3 dB signal-to-noise ratio (SNR). Those marked with "A" are adjusted for SNR between 3 and 10 dB.

---

[1] With respect to the information provided in this report, neither JASCO Applied Sciences nor any of their respective directors, officers, employees, contractors or agents (collectively, the "Report Providers") make any warranty either expressed or implied, including the warranty for fitness for a particular purpose, nor assume any legal liability or responsibility for the accuracy, completeness, or usefulness of information disclosed. Furthermore, this report and the measurements reported herein cannot be used to confirm or counter any claim of adherence to or exceedance of legislated noise emission standards in any jurisdiction and by accepting this report, the report recipient agrees that the Report Providers shall not be liable for any losses, claims, damages, actions, fines, penalties, costs or expenses, including legal fees, arising from the use of this report for any purpose whatsoever.

Vessel Underwater Noise Rating - Additional Information

Underwater Noise from vessels has the potential to disturb marine mammals, fish and other marine fauna. JASCO wishes to assist the shipping industry reduce its noise footprint in the marine environment. With this goal in mind, we have developed a vessel noise measurement system and a comparative noise ranking method that allows vessel noise emissions to be characterized relative to those of other vessels of the same class and similar size. The acoustic measurement approach conforms approximately with the protocol defined in ANSI standard 12.64-2009 Grade C, with exceptions as outlined below.

Vessel underwater noise emissions vary with vessel class, size, tonnage, speed, loading and other parameters. The system implements frequency weighting that considers that different marine species have different hearing acuities. For example, humpback whales are believed to be more sensitive to low-frequency sounds than killer whales. To account for these differences, the system calculates frequency-weighted noise metrics based on functions adopted by U.S. National Oceanic and Atmospheric Administration (NOAA) and published in their Marine Mammal Acoustic Technical Guidance[2]. The listening station calculates frequency-weighted noise levels for: Low Frequency Cetaceans (LFC), Mid-Frequency Cetaceans (MFC), and High-Frequency Cetaceans (HFC), Phocid Pinnipeds (PPW) and Otariid Pinnipeds (OPW). The actual rating value is the percentile of the vessel's adjusted and frequency-weighted noise level relative to all vessels of the same class.

RNL with Marine Mammal Weightings (NOAA 2016):

Low Frequency Cetaceans (LFC):	162.6	LFC Rank:	N/A
Mid-Frequency Cetaceans (MFC):	126.5	MFC Rank:	N/A
High-Frequency Cetaceans (HFC):	118.2	HFC Rank:	N/A

Additional Information for this Vessel Measurement:

Name of Vessel:	OCEAN ONYX
Measurement ID:	BEACHOTWAY-stn1-2021-02-538001765202103081752
Date of Measurement:	March 08, 2021

Environmental Information:

Closest Point of Approach location (WGS 84):	-38°53'029"S, 142°52'056"E		
Hydrophone location (WGS-84):	-38°53'024"S, 142°53'008"E		
Water Depth (m):	70.0		
Hydrophone Depth (m):	68.5	Wind Speed (kn):	9.0
Speed of Current (kn):	N/A	Wind Direction (deg):	231.0
Current Direction (deg):	N/A	Sea State Code (WMO):	N/A

Conformance with Standard

The vessel source measurements reported here were acquired using procedures conforming approximately with Grade C - Survey Method - ANSI 12.64-2009 (R2014) Quantities and Procedures for Description and Measurement of Underwater Sound from Ships - Part 1: General Requirements. Notable conformance exceptions are:

1. The standard requires 4 vessel passes, while this measurement is of a single pass.
2. The standard requires vessel Closest Point of Approach (CPA) of the greater of 100 m or one vessel length. This system may admit measurements at other distances.
3. The standard requires the hydrophone subtend depression angles relative to the ship of 20° ± 5° below horizontal, while this system permits angles from 10° to 60°.

Vessel name and dimension information is obtained from Automatic Identification System (AIS) records sent from the vessel at time of measurement and from MarineTraffic.com. Fields not transmitted by these services are marked as N/A in the report. Frequency bands marked with "X" or "A" in the source level graphs are respectively invalid or adjusted, due to being insufficiently above background noise levels as described in the standard.

---

[2] Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0), NOAA Technical Memorandum NMFS-OPR-59 April 2018. https://www.fisheries.noaa.gov/webdam/download/75962998

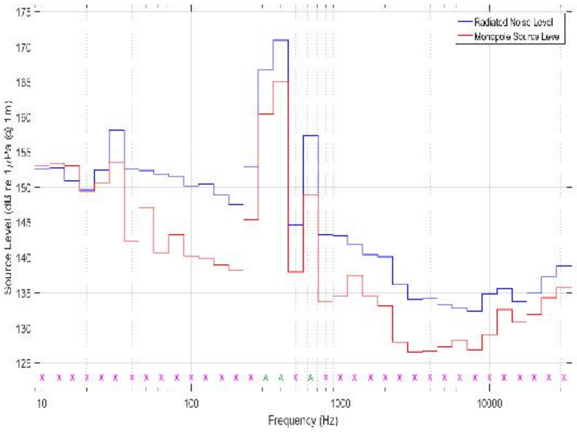
G.1.3. Report 3: 18:22 on 8 Mar 2021

Vessel Underwater Acoustic Source Level Measurement Report

This Vessel Underwater Acoustic Source Level Measurement Report is provided by JASCO Applied Sciences, for the limited purpose of understanding approximate underwater noise emission levels of vessels.[1]

Vessel Information	
MMSI:	538001765
IMO:	0
Name:	OCEAN ONYX
Flag:	Marshall Is
Vessel DWT (TEU):	102.0
PortListen Vessel Type	Other
Length (m):	106.35
Beam (m)	105.16
Maximum Draft (m):	N/A
Engine Power (kW):	N/A
Number of Shafts:	N/A
Prop Diameter (m):	N/A

Measurement Information	
Measurement Date (UTC):	March 08, 2021
Closest Approach Time (UTC):	18:22:05
Closest Approach Distance (m):	306.6
Vessel Ground Speed (kn):	0.0
Sail Direction over ground (deg):	326.0
Vessel Water Speed (kn):	N/A
Shaft rate (rpm):	-6000.0
Vessel Percent Power/Pitch:	N/A
Actual Vessel Draft max (m):	22.0
Monopole Source Depth (m):	11.0
Monopole Source Level (dB/µPa):	166.5
Radiated Noise Level (dB/µPa):	172.5



The 1/3-octave frequency band vessel source levels are presented in two metrics formats:

1. Radiated Noise Level - as defined in ANSI 12.64 - 2009 (R2014) measurement standard, and
2. Monopole Source Level - considers sound energy as originating from a point location, most suitable for use by acoustic models that independently account for surface and seabed reflections
3. Values marked "x" have less than 3 dB signal-to-noise ratio (SNR). Those marked with "A" are adjusted for SNR between 3 and 10 dB.

---

[1] With respect to the information provided in this report, neither JASCO Applied Sciences nor any of their respective directors, officers, employees, contractors or agents (collectively, the "Report Providers") make any warranty either expressed or implied, including the warranty for fitness for a particular purpose, nor assume any legal liability or responsibility for the accuracy, completeness, or usefulness of information disclosed. Furthermore, this report and the measurements reported herein cannot be used to confirm or counter any claim of adherence to or exceedance of legislated noise emission standards in any jurisdiction and by accepting this report, the report recipient agrees that the Report Providers shall not be liable for any losses, claims, damages, actions, fines, penalties, costs or expenses, including legal fees, arising from the use of this report for any purpose whatsoever.

Vessel Underwater Noise Rating - Additional Information

Underwater Noise from vessels has the potential to disturb marine mammals, fish and other marine fauna. JASCO wishes to assist the shipping industry reduce its noise footprint in the marine environment. With this goal in mind, we have developed a vessel noise measurement system and a comparative noise ranking method that allows vessel noise emissions to be characterized relative to those of other vessels of the same class and similar size. The acoustic measurement approach conforms approximately with the protocol defined in ANSI standard 12.64-2009 Grade C, with exceptions as outlined below.

Vessel underwater noise emissions vary with vessel class, size, tonnage, speed, loading and other parameters. The system implements frequency weighting that considers that different marine species have different hearing acuities. For example, humpback whales are believed to be more sensitive to low-frequency sounds than killer whales. To account for these differences, the system calculates frequency-weighted noise metrics based on functions adopted by U.S. National Oceanic and Atmospheric Administration (NOAA) and published in their Marine Mammal Acoustic Technical Guidance[2]. The listening station calculates frequency-weighted noise levels for: Low Frequency Cetaceans (LFC), Mid-Frequency Cetaceans (MFC), and High-Frequency Cetaceans (HFC), Phocid Pinnipeds (PPW) and Otariid Pinnipeds (OPW). The actual rating value is the percentile of the vessel's adjusted and frequency-weighted noise level relative to all vessels of the same class.

RNL with Marine Mammal Weightings (NOAA 2016):

Low Frequency Cetaceans (LFC):	171.5	LFC Rank:	N/A
Mid-Frequency Cetaceans (MFC):	130.5	MFC Rank:	N/A
High-Frequency Cetaceans (HFC):	120.5	HFC Rank:	N/A

Additional Information for this Vessel Measurement:

Name of Vessel:	OCEAN ONYX
Measurement ID:	BEACHOTWAY-stn1-2021-02-538001765202103081822
Date of Measurement:	March 08, 2021

Environmental Information:

Closest Point of Approach location (WGS 84):	-38°53'029"S, 142°52'056"E		
Hydrophone location (WGS-84):	-38°53'024"S, 142°53'008"E		
Water Depth (m):	70.0		
Hydrophone Depth (m):	68.5	Wind Speed (kn):	9.0
Speed of Current (kn):	N/A	Wind Direction (deg):	231.0
Current Direction (deg):	N/A	Sea State Code (WMO):	N/A

Conformance with Standard

The vessel source measurements reported here were acquired using procedures conforming approximately with Grade C - Survey Method - ANSI 12.64-2009 (R2014) Quantities and Procedures for Description and Measurement of Underwater Sound from Ships - Part 1: General Requirements. Notable conformance exceptions are:

1. The standard requires 4 vessel passes, while this measurement is of a single pass.
2. The standard requires vessel Closest Point of Approach (CPA) of the greater of 100 m or one vessel length. This system may admit measurements at other distances.
3. The standard requires the hydrophone subtend depression angles relative to the ship of 20° ± 5° below horizontal, while this system permits angles from 10° to 60°.

Vessel name and dimension information is obtained from Automatic Identification System (AIS) records sent from the vessel at time of measurement and from MarineTraffic.com. Fields not transmitted by these services are marked as N/A in the report. Frequency bands marked with "X" or "A" in the source level graphs are respectively invalid or adjusted, due to being insufficiently above background noise levels as described in the standard.

---

[2] Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0), NOAA Technical Memorandum NMFS-OPR-59 April 2018. https://www.fisheries.noaa.gov/webdam/download/75962998

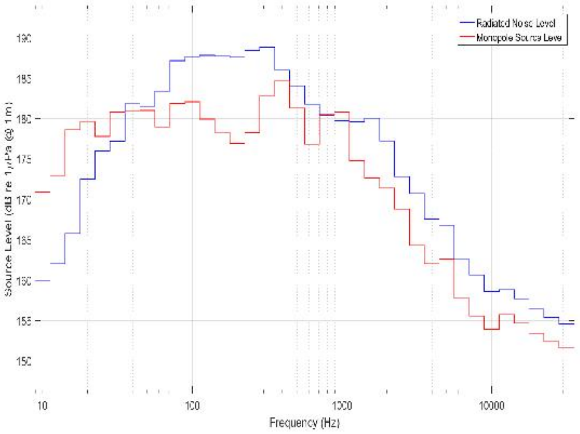
G.2. Vessel DP Trial Report: 01:48 on 4 Feb 2021

Vessel Underwater Acoustic Source Level Measurement Report

This Vessel Underwater Acoustic Source Level Measurement Report is provided by JASCO Applied Sciences, for the limited purpose of understanding approximate underwater noise emission levels of vessels.[1]

Vessel Information	
MMSI:	257544000
IMO:	0
Name:	SIEM SAPPHIRE
Flag:	Norway
Vessel DWT (TEU):	4250.0
PortListen Vessel Type	Other
Length (m):	91.0
Beam (m)	22.04
Maximum Draft (m):	N/A
Engine Power (kW):	N/A
Number of Shafts:	N/A
Prop Diameter (m):	N/A

Measurement Information	
Measurement Date (UTC):	February 04, 2021
Closest Approach Time (UTC):	1:48:00
Closest Approach Distance (m):	182.6
Vessel Ground Speed (kn):	0.6
Sail Direction over ground (deg):	152.4
Vessel Water Speed (kn):	N/A
Shaft rate (rpm):	-6000.0
Vessel Percent Power/Pitch:	N/A
Actual Vessel Draft max (m):	7.0
Monopole Source Depth (m):	4.9
Monopole Source Level (dB/μPa):	193.4
Radiated Noise Level (dB/μPa):	198.0



The 1/3-octave frequency band vessel source levels are presented in two metrics formats:

1. Radiated Noise Level - as defined in ANSI 12.64 - 2009 (R2014) measurement standard, and
2. Monopole Source Level - considers sound energy as originating from a point location, most suitable for use by acoustic models that independently account for surface and seabed reflections
3. Values marked "x" have less than 3 dB signal-to-noise ratio (SNR). Those marked with "A" are adjusted for SNR between 3 and 10 dB.

---

[1] With respect to the information provided in this report, neither JASCO Applied Sciences nor any of their respective directors, officers, employees, contractors or agents (collectively, the "Report Providers") make any warranty either expressed or implied, including the warranty for fitness for a particular purpose, nor assume any legal liability or responsibility for the accuracy, completeness, or usefulness of information disclosed. Furthermore, this report and the measurements reported herein cannot be used to confirm or counter any claim of adherence to or exceedance of legislated noise emission standards in any jurisdiction and by accepting this report, the report recipient agrees that the Report Providers shall not be liable for any losses, claims, damages, actions, fines, penalties, costs or expenses, including legal fees, arising from the use of this report for any purpose whatsoever.

Vessel Underwater Noise Rating - Additional Information

Underwater Noise from vessels has the potential to disturb marine mammals, fish and other marine fauna. JASCO wishes to assist the shipping industry reduce its noise footprint in the marine environment. With this goal in mind, we have developed a vessel noise measurement system and a comparative noise ranking method that allows vessel noise emissions to be characterized relative to those of other vessels of the same class and similar size. The acoustic measurement approach conforms approximately with the protocol defined in ANSI standard 12.64-2009 Grade C, with exceptions as outlined below.

Vessel underwater noise emissions vary with vessel class, size, tonnage, speed, loading and other parameters. The system implements frequency weighting that considers that different marine species have different hearing acuities. For example, humpback whales are believed to be more sensitive to low-frequency sounds than killer whales. To account for these differences, the system calculates frequency-weighted noise metrics based on functions adopted by U.S. National Oceanic and Atmospheric Administration (NOAA) and published in their Marine Mammal Acoustic Technical Guidance[2]. The listening station calculates frequency-weighted noise levels for: Low Frequency Cetaceans (LFC), Mid-Frequency Cetaceans (MFC), and High-Frequency Cetaceans (HFC), Phocid Pinnipeds (PPW) and Otariid Pinnipeds (OPW). The actual rating value is the percentile of the vessel's adjusted and frequency-weighted noise level relative to all vessels of the same class.

RNL with Marine Mammal Weightings (NOAA 2016):

Low Frequency Cetaceans (LFC):	195.0	LFC Rank:	N/A
Mid-Frequency Cetaceans (MFC):	168.4	MFC Rank:	N/A
High-Frequency Cetaceans (HFC):	164.7	HFC Rank:	N/A

Additional Information for this Vessel Measurement:

Name of Vessel:	SIEM SAPPHIRE
Measurement ID:	BEACHOTWAY-stn2-2021-02-257544000202102040148
Date of Measurement:	February 04, 2021

Environmental Information:

Closest Point of Approach location (WGS 84):	-38°53'010"S, 142°53'044"E		
Hydrophone location (WGS-84):	-38°53'011"S, 142°53'036"E		
Water Depth (m):	70.0		
Hydrophone Depth (m):	68.5	Wind Speed (kn):	13.0
Speed of Current (kn):	N/A	Wind Direction (deg):	89.0
Current Direction (deg):	N/A	Sea State Code (WMO):	N/A

Conformance with Standard

The vessel source measurements reported here were acquired using procedures conforming approximately with Grade C - Survey Method - ANSI 12.64-2009 (R2014) Quantities and Procedures for Description and Measurement of Underwater Sound from Ships - Part 1: General Requirements. Notable conformance exceptions are:

1. The standard requires 4 vessel passes, while this measurement is of a single pass.
2. The standard requires vessel Closest Point of Approach (CPA) of the greater of 100 m or one vessel length. This system may admit measurements at other distances.
3. The standard requires the hydrophone subtend depression angles relative to the ship of 20° ± 5° below horizontal, while this system permits angles from 10° to 60°.

Vessel name and dimension information is obtained from Automatic Identification System (AIS) records sent from the vessel at time of measurement and from MarineTraffic.com. Fields not transmitted by these services are marked as N/A in the report. Frequency bands marked with "X" or "A" in the source level graphs are respectively invalid or adjusted, due to being insufficiently above background noise levels as described in the standard.

---

[2] Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0), NOAA Technical Memorandum NMFS-OPR-59 April 2018. https://www.fisheries.noaa.gov/webdam/download/75962998

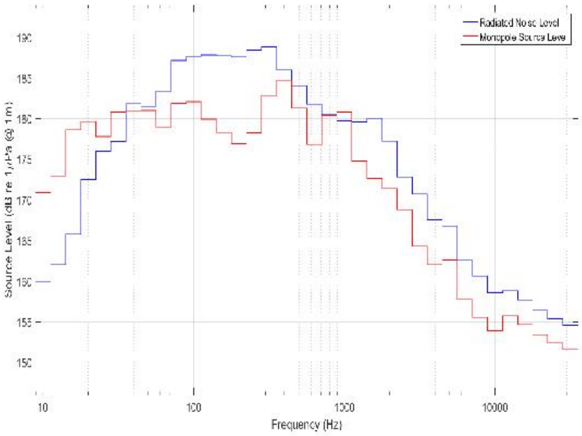
G.3. Vessel Transit Report: 21:56 on 10 Mar 2021

Vessel Underwater Acoustic Source Level Measurement Report

This Vessel Underwater Acoustic Source Level Measurement Report is provided by JASCO Applied Sciences, for the limited purpose of understanding approximate underwater noise emission levels of vessels.[1]

Vessel Information	
MMSI:	257544000
IMO:	0
Name:	SIEM SAPPHIRE
Flag:	Norway
Vessel DWT (TEU):	4250.0
PortListen Vessel Type	Other
Length (m):	91.0
Beam (m)	22.04
Maximum Draft (m):	N/A
Engine Power (kW):	N/A
Number of Shafts:	N/A
Prop Diameter (m):	N/A

Measurement Information	
Measurement Date (UTC):	February 04, 2021
Closest Approach Time (UTC):	1:48:00
Closest Approach Distance (m):	182.6
Vessel Ground Speed (kn):	0.6
Sail Direction over ground (deg):	152.4
Vessel Water Speed (kn):	N/A
Shaft rate (rpm):	-6000.0
Vessel Percent Power/Pitch:	N/A
Actual Vessel Draft max (m):	7.0
Monopole Source Depth (m):	4.9
Monopole Source Level (dB/µPa):	193.4
Radiated Noise Level (dB/µPa):	198.0



The 1/3-octave frequency band vessel source levels are presented in two metrics formats:

1. Radiated Noise Level - as defined in ANSI 12.64 - 2009 (R2014) measurement standard, and
2. Monopole Source Level - considers sound energy as originating from a point location, most suitable for use by acoustic models that independently account for surface and seabed reflections
3. Values marked "x" have less than 3 dB signal-to-noise ratio (SNR). Those marked with "A" are adjusted for SNR between 3 and 10 dB.

---

[1] With respect to the information provided in this report, neither JASCO Applied Sciences nor any of their respective directors, officers, employees, contractors or agents (collectively, the "Report Providers") make any warranty either expressed or implied, including the warranty for fitness for a particular purpose, nor assume any legal liability or responsibility for the accuracy, completeness, or usefulness of information disclosed. Furthermore, this report and the measurements reported herein cannot be used to confirm or counter any claim of adherence to or exceedance of legislated noise emission standards in any jurisdiction and by accepting this report, the report recipient agrees that the Report Providers shall not be liable for any losses, claims, damages, actions, fines, penalties, costs or expenses, including legal fees, arising from the use of this report for any purpose whatsoever.

Vessel Underwater Noise Rating - Additional Information

Underwater Noise from vessels has the potential to disturb marine mammals, fish and other marine fauna. JASCO wishes to assist the shipping industry reduce its noise footprint in the marine environment. With this goal in mind, we have developed a vessel noise measurement system and a comparative noise ranking method that allows vessel noise emissions to be characterized relative to those of other vessels of the same class and similar size. The acoustic measurement approach conforms approximately with the protocol defined in ANSI standard 12.64-2009 Grade C, with exceptions as outlined below.

Vessel underwater noise emissions vary with vessel class, size, tonnage, speed, loading and other parameters. The system implements frequency weighting that considers that different marine species have different hearing acuities. For example, humpback whales are believed to be more sensitive to low-frequency sounds than killer whales. To account for these differences, the system calculates frequency-weighted noise metrics based on functions adopted by U.S. National Oceanic and Atmospheric Administration (NOAA) and published in their Marine Mammal Acoustic Technical Guidance[2]. The listening station calculates frequency-weighted noise levels for: Low Frequency Cetaceans (LFC), Mid-Frequency Cetaceans (MFC), and High-Frequency Cetaceans (HFC), Phocid Pinnipeds (PPW) and Otariid Pinnipeds (OPW). The actual rating value is the percentile of the vessel's adjusted and frequency-weighted noise level relative to all vessels of the same class.

RNL with Marine Mammal Weightings (NOAA 2016):

Low Frequency Cetaceans (LFC):	195.0	LFC Rank:	N/A
Mid-Frequency Cetaceans (MFC):	168.4	MFC Rank:	N/A
High-Frequency Cetaceans (HFC):	164.7	HFC Rank:	N/A

Additional Information for this Vessel Measurement:

Name of Vessel:	SIEM SAPPHIRE
Measurement ID:	BEACHOTWAY-stn2-2021-02-257544000202102040148
Date of Measurement:	February 04, 2021

Environmental Information:

Closest Point of Approach location (WGS 84):	-38°53'010"S, 142°53'044"E		
Hydrophone location (WGS-84):	-38°53'011"S, 142°53'036"E		
Water Depth (m):	70.0		
Hydrophone Depth (m):	68.5	Wind Speed (kn):	13.0
Speed of Current (kn):	N/A	Wind Direction (deg):	89.0
Current Direction (deg):	N/A	Sea State Code (WMO):	N/A

Conformance with Standard

The vessel source measurements reported here were acquired using procedures conforming approximately with Grade C - Survey Method - ANSI 12.64-2009 (R2014) Quantities and Procedures for Description and Measurement of Underwater Sound from Ships - Part 1: General Requirements. Notable conformance exceptions are:

1. The standard requires 4 vessel passes, while this measurement is of a single pass.
2. The standard requires vessel Closest Point of Approach (CPA) of the greater of 100 m or one vessel length. This system may admit measurements at other distances.
3. The standard requires the hydrophone subtend depression angles relative to the ship of 20° ± 5° below horizontal, while this system permits angles from 10° to 60°.

Vessel name and dimension information is obtained from Automatic Identification System (AIS) records sent from the vessel at time of measurement and from MarineTraffic.com. Fields not transmitted by these services are marked as N/A in the report. Frequency bands marked with "X" or "A" in the source level graphs are respectively invalid or adjusted, due to being insufficiently above background noise levels as described in the standard.

---

[2] Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0), NOAA Technical Memorandum NMFS-OPR-59 April 2018. https://www.fisheries.noaa.gov/webdam/download/75962998

Appendix I: Sound Modelling Report – McPherson and Wood 2017

Otway Basin Geophysical Operations Acoustic Modelling

Acoustic Modelling for Assessing Marine Fauna Sound Exposures

Submitted to:

Zoe Brooking
Lattice Energy

Authors:

Craig McPherson
Michael Wood

2 November 2017

P001359-001
Document 01473
Version 1.0

JASCO Applied Sciences (Australia) Pty Ltd
Unit 1, 14 Hook Street
Capalaba, Queensland, 4157
Tel: +61 7 3823 2620
Mob: +61 4 3812 8179
www.jasco.com

Document Version Control

Version	Date	Name	Change
2.0	2017 November 02	C. McPherson	Final submitted to client

Suggested citation:

McPherson, C., M. Wood. 2017. *Otway Basin Geophysical Operations Acoustic Modelling: Acoustic Modelling for Assessing Marine Fauna Sound Exposures*. Document 01473, Version 1.0. Technical report by JASCO Applied Sciences for Lattice Energy.

Disclaimer:

The results presented herein are relevant within the specific context described in this report. They could be misinterpreted if not considered in the light of all the information contained in this report. Accordingly, if information from this report is used in documents released to the public or to regulatory bodies, such documents must clearly cite the original report, which shall be made readily available to the recipients in integral and unedited form.

Contents

Figures

Tables

Executive Summary

Sound models were used to assess underwater noise levels during the proposed Otway Basin Geophysical Survey by Lattice Energy. The modelling approach accounted for the acoustic emission characteristics of a representative boomer and sub-bottom profiler (SBP) both towed at 3 m depth, along with a 450 in^3 vertical seismic profiler (VSP) array operated at a centroid depth of 6 m. The boomer and SBP geophysical survey sources planned for use had not been decided at the time of the modelling study, therefore JASCO chose commonly-used representative systems for each source, with levels derived from previous JASCO field measurement campaigns of such sources. The modelled per-pulse in-beam SEL and SPL source levels of the boomer were 180.0 dB re 1 µPa^2·s @ 1 m and 200.5 dB re 1 µPa @ 1 m respectively, and for the sub-bottom profiler they were 171.4 dB re 1 µPa^2·s @ 1 m and 191.7 dB re 1 µPa @ 1 m. The modelling considered source directivity and the area's range-dependent environmental properties.

The modelling study assessed six sites for the representative boomer and sub-bottom profiler, and one site for the VSP operations, focusing on the metrics relevant to benthic invertebrates. Accumulated SEL was modelled for four full surveys of the boomer and SBP operating in tandem. The scenarios considered operational periods of either 51 or 40.2 hours, including turn times.

The analysis considered the maximum distances away from the seismic source or survey lines at which several effects criteria were reached. The results are summarised below for representative single pulse sites and for accumulated sound exposure level (SEL) scenarios.

Benthic Invertebrates and Fish

- Sound fields from the representative boomer and SBP do not reach any of the assessed thresholds for benthic crustaceans or fish at the seafloor for either single pulse or accumulated SEL scenarios. The sound level drops below the lowest relevant peak-to-peak pressure level (PK-PK) isopleth of 202 dB re 1 µPa at a vertical distance of 11 m below the source, and below the lowest relevant peak pressure level (PK) of 207 dB re 1 µPa within 1.6 m, while the maximum per-pulse SEL isopleth predicted to occur at the seafloor is 155 dB re 1 µPa^2·s at a maximum horizontal distance of 1 m from the source.
- The SBP is a higher-frequency, more directional, and lower energy source than the boomer; consequently, the ranges are consistently lower. The PK-PK isopleth of 202 dB re 1 µPa is predicted to occur at 1.4 m vertically below the source, while the maximum per-pulse SEL isopleth predicted to occur at the seafloor is 130 dB re 1 µPa^2·s at a maximum horizontal distance of 6 m.
- The maximum accumulated SEL from the combined operations of the boomer and SBP at the seafloor is not predicted to exceed 170 dB re 1 µPa^2·s for any single survey. This is below any of the relevant isopleths for benthic invertebrates, including the 183 dB re 1 µPa^2·s 'no effect' accumulated SEL (McCauley and Duncan 2016). It is also below the threshold for temporary hearing impairment (TTS) in fish. The predicted ranges for the four surveys modelled at similar, due to the identical sources, sound speed profiles, similar depths and geoacoustics.
- The VSP source was modelled with models capable of accounting for all environmental parameters and high propagation angles. The results show that the lowest PK-PK isopleths of interest derived from Day et al. (2016b), 209 dB re 1 µPa, is not reached at the seafloor; and the horizontal range along the seafloor to the 202 dB re 1 µPa PK-PK level from Payne et al. (2007) is 185 m. PK metrics relevant to the Popper et al. (2014) criteria for fish and turtles are also not reached at the seafloor. The maximum per-pulse SEL on the seafloor below the array is 181 dB re 1 µPa^2·s, below the lowest level from Day et al. (2016b) of 186 dB re 1 µPa^2·s.

Marine Mammals and Turtle Behaviour

- Considering the United States (US) National Marine Fisheries Service (NMFS; 2013) acoustic threshold for behavioural effects in marine mammals of 160 dB re 1 µPa (SPL), the boomer could potentially disturb marine mammals at horizontal distances of up to 145 m, and the SBP at 2 m.
- Considering the US NMFS criterion for behavioural effects in turtles of 166 dB re 1 µPa (SPL), the boomer could potentially disturb turtles are horizontal distances of up to 36 m, while this level is not reached for the SBP.

- For the VSP array, sounds exceeded the unweighted per-pulse SEL criterion for the 1 km low-power zone of 160 dB re 1 µPa^2·s (DEWHA 2008) within 1.03 km of the 450 in^3 array ($R_{95\%}$ distance). The maximum ranges to the marine mammal and turtle behavioural thresholds of 160 and 166 dB re 1 µPa SPL are 2.56 and 1.55 km respectively.

1. Introduction

JASCO Applied Sciences (JASCO) performed a numerical estimation study of underwater sound levels associated with the Otway Basin Geotechnical Operations proposed by Lattice Energy in the Otway Basin. The acoustic modelling evaluated the effects of sounds produced by three sources on marine fauna, with a specific focus on benthic invertebrates. The three sources considered in the modelling were a representative boomer and sub-bottom profiler (SBP) both towed at 3 m, along with a 450 in^3 vertical seismic profiler (VSP) array operated at a centroid depth of 6 m. The boomer and SBP geophysical survey sources planned for use had not been decided at the time of the modelling study, therefore JASCO proposed a commonly used representative for each source, with levels derived from a previous JASCO measurement campaign of such sources. The results are presented as sound pressure levels (SPL), zero-to-peak pressure levels (PK), peak-to-peak pressure levels (PK-PK) and either per-pulse (i.e., per-pulse) or accumulated sound exposure levels (SEL), as appropriate to each scenario.

Single pulse sound fields for each source were modelled at six representative locations (Table 1, Figure 1), although it is likely that the boomer and SBP will not operate at Site 5. The VSP will only be operated at Site 5. Accumulated SEL was modelled for four full surveys of the boomer and SBP operating in tandem, using the single pulse modelling results from Sites 1, 3, 4 and 6.

Table 1. Location details for modelled sites (UTM zone 54S).

Site #	Site Name	Site Name Acronym	Water depth (m)	Latitude	Longitude	Easting	Northing
1	Thylacine Midpoint	THY MID	100.5	-39.2168	142.8665	661137	5657503
2	Murchinson Downdip	MURCH DDIP	129.5	-39.2249	142.7614	652042	5656787
3	Geographe 3	G3	85	-39.1082	142.9517	668752	5669398
4	Artisan	ARTISAN	71.6	-38.8909	142.8829	663300	5693640
5	Block VICP69, North	VICP69 NTH	72.8	-38.8829	143.1359	685264	5694052
6	Block VICP69, Meeki	VICP69 MEEKI	79.1	-38.9881	143.051	677633	5682538

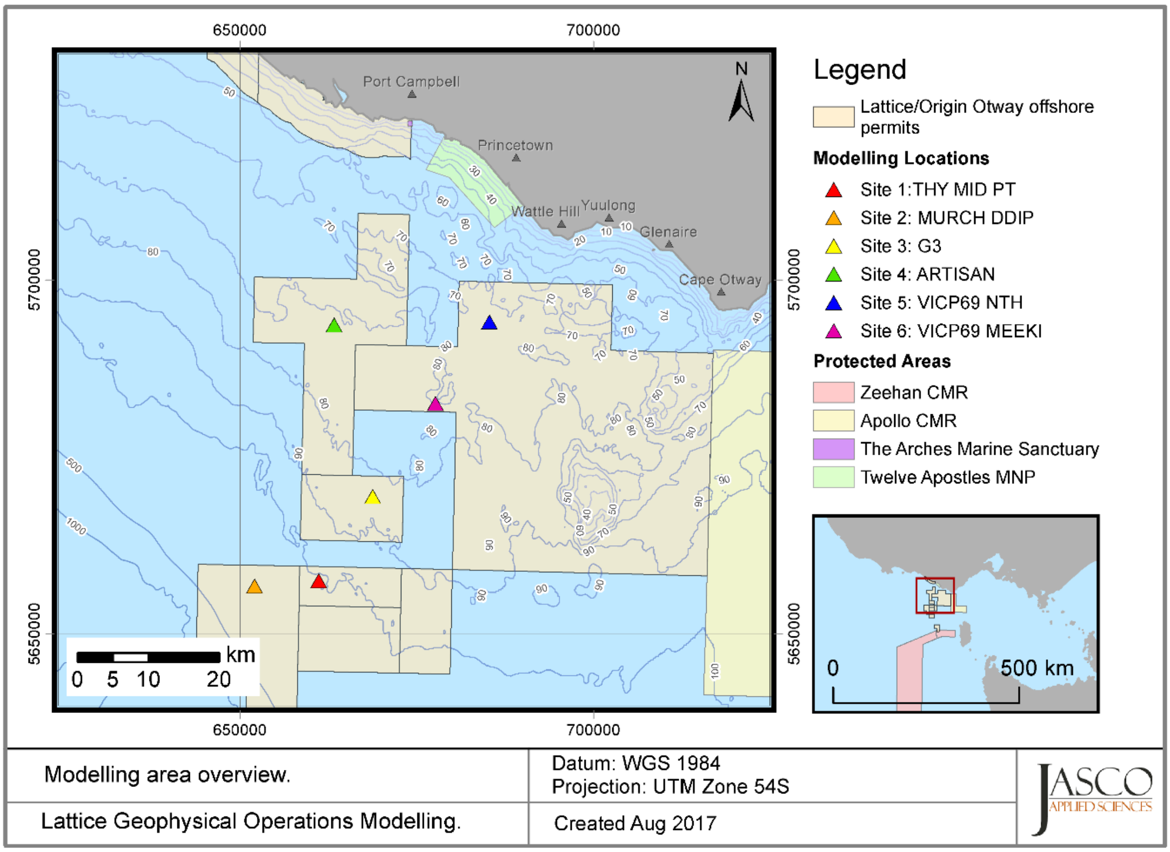


Figure 1. Single pulse modelling site locations and relevant features, including Commonwealth Marine Reserves (CMR), and Marine National Parks (MNP)

2. Noise Effects Criteria

The perceived loudness of sound, especially impulsive noise such as from seismic airguns, is not generally proportional to the instantaneous acoustic pressure. Rather, perceived loudness depends on the time over which the pulse rises, how long this occurs for, and its frequency content. Thus, several sound level metrics are commonly used to evaluate noise and its effects on marine life. The metrics applied in this report, including peak pressure level (PK), peak-peak pressure (PK-PK), sound pressure level (SPL), and sound exposure level (SEL), are defined in Appendix A. Appropriate subscripts indicate any applied frequency weighting; unweighted SEL is defined as required. The acoustic metrics in this report reflect the updated ANSI and ISO standards for acoustic terminology, ANSI-ASA S1.1 (R2013) and ISO/DIS 18405.2:2017 (2016).

Whether acoustic exposure levels might injure or disturb marine fauna is an active research topic. Since 2007, several expert groups have investigated an SEL-based assessment approach for injury in marine mammals, with a handful of key papers published on the topic. The number of studies that investigated the level of disturbance to marine animals by underwater noise has also increased substantially.

We chose the following noise criteria for this study because they include requested thresholds, standard thresholds, thresholds suggested by the best available science (Sections 2.1, 2.2 and 2.3):

1. For comparison to results in Payne et al. (2008), and Day et al. (2016a), the following metrics are reported for benthic crustaceans:
    - Seafloor per-pulse SEL: 186–190 dB re 1 µPa^2.s
    - Seafloor SEL$_{24h}$: 192–199 dB re 1 µPa^2.s
    - Peak-peak pressure: 202, 209–212 dB re 1 µPa
2. ‘No effect on lobster’ accumulated SEL for the Crowes Foot MSS of 183 dB re 1 µPa^2.s (McCauley and Duncan 2016).
3. Per-pulse threshold for cetaceans (unweighted per-pulse SEL of 160 dB re 1 µPa^2·s) outlined in the Australian Environment Protection and Biodiversity Conservation (EPBC) Act Policy Statement 2.1, Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008).
4. Marine mammal behavioural threshold based on the current interim U.S. National Marine Fisheries Service (NMFS) criterion (NMFS 2013) for marine mammals of 160 dB re 1 µPa SPL for impulsive sound sources.
5. Sound exposure guidelines for fish, fish eggs and larvae, and turtles (Popper et al. 2014).
6. Threshold for turtle behavioural response 166 dB re 1 µPa (SPL) (NSF 2011), applied by the US NMFS.

2.1. Benthic Invertebrates (Crustaceans)

Research is ongoing into the relationship between sound and its effects on crustaceans, including the relevant metrics for both effect and impact. Available literature suggests particle motion, rather than sound pressure, is a more important factor for crustacean and bivalve hearing. Water depth and airgun array size are related to the particle motion levels at the seafloor, with larger arrays and shallower water being related to higher particle motion levels, more likely relevant to effects on bivalves. Although some impact assessments have estimated areas of potential impacts from seismic surveys based on the results in Day et al. (2016b), current literature does not clearly define an appropriate metric or identify relevant sound levels for an assessment. This includes the consideration of what particle motion levels lead to a behavioural response, or mortality.

At the seafloor interface bivalves are subject to particle motion stimuli from several acoustic or acoustically-induced waves. These include the particle motion associated with an impinging sound pressure wave in the water column (the incident, reflected, and transmitted portions), substrate acoustic waves, and interface waves of the Scholte type. However, it is unclear which aspect(s) of these waves is/are most relevant to the animals, either when they normally sense the environment or their physiological responses to loud sounds so there is not enough information to establish similar criteria and thresholds as done for marine mammals and fish. Therefore, at this stage, JASCO is not able to define thresholds to inform the impact assessment. Additionally, prediction of particle motion from sources such as low-energy geophysical sources including boomers and sub-bottom profilers is not possible currently due to the lack of source models.

Despite this, the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) has publicly stated that the seafloor levels, sound levels at the seafloor derived from Day et al. (2016b) should be used to assist in the assessment of impacts on scallops and lobster. Therefore, JASCO has used the following metrics in its evaluation:

- Per-pulse SEL: 186–190 dB re 1 μPa^2.s
- Accumulated SEL: 192–199 dB re 1 μPa^2.s
- Peak-peak pressure: 209–212 dB re 1 μPa

Additionally a PK-PK of 202 dB re 1 μPa from Payne et al. (2007) has been included along with an accumulated SEL of 183 dB re 1 μPa^2.s as specified by Lattice Energy based on McCauley and Duncan (2016).

2.2. Marine Mammals

The criteria applied in this study to assess possible effects of impulsive noise on marine mammals are summarised in Table 2 and detailed in Sections 2.2.1 and 2.2.2.

Table 2. The SPL and per-pulse SEL thresholds for acoustic effects on marine mammals.

Hearing group	DEWHA (2008)	NMFS (2013)
	Unweighted per-pulse SEL (dB re 1 μPa^2·s)	Behaviour
		SPL (dB re 1 μPa)
Low-frequency cetaceans	160	160
Mid-frequency cetaceans		
High-frequency cetaceans		
Phocid pinnipeds in water	Not Applicable	
Otariid pinnipeds in water	Not Applicable	

2.2.1. Injury and Hearing Sensitivity Changes

There are two categories of auditory threshold shifts representing reduced hearing ability: permanent threshold shift (PTS), considered a physical injury to an animal’s hearing organs, and temporary threshold shift (TTS), a temporary reduction in an animal’s hearing sensitivity, understood to be partly a result of receptor hair cells in the cochlea becoming fatigued.

For seismic surveys in Australian waters, the EPBC Act Policy Statement 2.1 determines suitable exclusion zones with an unweighted per-pulse SEL threshold of 160 dB re 1 μPa^2·s (DEWHA 2008). This threshold minimises the likelihood of TTS in mysticetes and large odontocetes. The Policy Statement does not apply to smaller dolphins and porpoises as DEWHA assessed these cetaceans as having relatively low hearing sensitivity to the low frequencies produced by seismic airgun arrays.

2.2.2. Behavioural Response

Southall et al. (2007) extensively reviewed marine mammal behavioural responses to sounds. Their review found that most marine mammals exhibited varying responses between 140 and

180 dB re 1 µPa SPL, but inconsistent results between studies makes choosing a single behavioural threshold difficult. Studies varied in their lack of control groups, imprecise measurements, inconsistent metrics, and that animal responses depended on study context, which included the animal's activity state. To create meaningful quantitative data from the collected information, Southall et al. (2007) proposed a severity scale that increased with increasing sound levels.

NMFS has historically used a relatively simple sound level criterion for potentially disturbing a marine mammal. For impulsive sounds, this threshold is 160 dB re 1 µPa SPL for pinnipeds and cetaceans (NMFS 2013).

2.3. Fish, Turtles, Fish Eggs, and Fish Larvae

In 2006, the Working Group on the Effects of Sound on Fish and Turtles was formed to continue developing noise exposure criteria for fish and turtles, work begun by a NOAA panel two years earlier. The resulting guidelines included specific thresholds for different levels of effects and for different groups of species (Popper et al. 2014). These guidelines defined quantitative thresholds for three types of immediate effects:

- Mortality, including injury leading to death.
- Recoverable injury, including injuries unlikely to result in mortality, such as hair cell damage and minor haematoma.
- TTS

Masking and behavioural effects can be assessed qualitatively, by assessing relative risk rather than by specific sound level thresholds. These effects are not assessed in this report. Because the presence or absence of a swim bladder has a role in hearing, fish's susceptibility to injury from noise exposure varies depending on the species and the presence and possible role of a swim bladder in hearing. Thus, different thresholds were proposed for fish without a swim bladder (also appropriate for sharks and applied to whale sharks in the absence of other information), fish with a swim bladder not used for hearing, and fish that use their swim bladders for hearing. Turtles, fish eggs, and fish larvae are considered separately.

Table 3 lists relevant effects thresholds from Popper et al. (2014). In general, any adverse effects of seismic sound on fish behaviour depends on the species, the state of the individuals exposed, and other factors. We note that, despite mortality being a possibility for fish exposed to airgun sounds, Popper et al. (2014) do not reference an actual occurrence of this effect. Since the publication of that work, newer studies have further examined the question of possible mortality. Popper et al. (2016) adds further information to the possible levels of impulsive seismic airgun sound to which adult fish can be exposed without immediate mortality. They found that the two fish species in their study, with body masses in the range 200–400 g, exposed to a per-pulse of a maximum received level of either 231 dB re 1 µPa (PK) or 205 dB re 1 $\mu Pa^2 \cdot s$ (SEL), remained alive for 7 days after exposure and that the probability of mortal injury did not differ between exposed and control fish.

The SEL metric integrates noise intensity over some period of exposure. Because the period of integration for regulatory assessments is not well defined for sounds that do not have a clear start or end time, or for very long-lasting exposures, it is required to define a time period. This is done for marine mammals in the Southall et al. (2007) criteria, where it is 24 h or the duration of the activity, whichever longer. Popper et al. (2014) recommend a standard period of time should be applied, where this is either defined as a justified fixed period or the duration of the activity, however also include caveats about how long the fish will be exposed because they can move (or remain in location) and so can the source. In the discussion of the criteria, Popper et al. (2014) discuss the complications in determining a relevant period of mobile seismic surveys, as the received levels at the fish change between impulses due to the mobile source, and that in reality a revised guideline based on the closest PK or the per-pulse SEL might be more useful than one based on accumulated SEL. This is because exposures at the closest point of approach are the primary exposures contributing to a receiver's accumulated level (Gedamke et al. 2011). Additionally, several important factors determine the likelihood and duration a receiver is expected to be in close proximity to a sound source (i.e., overlap in space and time between the source and receiver). For example, accumulation time for fast moving (relative to the receiver) mobile sources is driven primarily by the characteristics of source (i.e., speed, duty cycle) (NMFS 2016).

Popper et al. (2014) summaries that in all TTS studies considered, fish that showed TTS recovered to normal hearing levels within 18–24 hours. However in this study the full period of operations has been considered as the accumulation period for SEL.

Table 3. Criteria for seismic noise exposure for fish and turtles, adapted from Popper et al. (2014).

Type of animal	**Mortality and potential mortal injury**	**Impairment**			**Behaviour**
		Recoverable injury	**TTS**	**Masking**	
Fish: No swim bladder (particle motion detection)	> 219 dB SEL_{24h} or > 213 dB PK	> 216 dB SEL_{24h} or > 213 dB PK	>> 186 dB SEL_{24h}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder not involved in hearing (particle motion detection)	210 dB SEL_{24h} or > 207 dB PK	203 dB SEL_{24h} or > 207 dB PK	>> 186 dB SEL_{24h}	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: Swim bladder involved in hearing (primarily pressure detection)	207 dB SEL_{24h} or > 207 dB PK	203 dB SEL_{24h} or > 207 dB PK	186 dB SEL_{24h}	(N) Low (I) Low (F) Moderate	(N) High (I) High (F) Moderate
Turtles	210 dB SEL_{24h} or > 207 dB PK	(N) High (I) Low (F) Low	(N) High (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish eggs and fish larvae	> 210 dB SEL_{24h} or > 207 dB PK	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low

Notes: Peak sound pressure level dB re 1 µPa; SEL_{24h} dB re 1µPa^2·s. All criteria are presented as sound pressure even for fish without swim bladders since no data for particle motion exist. Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms as near (N), intermediate (I), and far (F).

2.3.1. Turtle Behavioural Response

There is a paucity of data regarding responses of turtles to acoustic exposure, and no studies of hearing loss due to exposure to loud sounds. McCauley et al. (2000) observed the behavioural response of caged turtles—green (*Chelonia mydas*) and loggerhead (*Caretta caretta*)—to an approaching seismic airgun. For received levels above 166 dB re 1 µPa (SPL), the turtles increased their swimming activity and above 175 dB re 1 µPa they began to behave erratically, which was interpreted as an agitated state. The 166 dB re 1 µPa level has been used as the threshold level for a behavioural disturbance response by NMFS and applied in the Arctic Programmatic Environment Impact Statement (PEIS) (NSF 2011). At that time, and in the absence of any data from which to determine the sound levels that could injure an animal, TTS or PTS onset were considered possible at an SPL of 180 dB re 1 µPa (NSF 2011). Some additional data suggest that behavioural responses occur closer to an SPL of 175 dB re 1 µPa, and TTS or PTS at even higher levels (Moein et al. 1995), but the received levels were unknown and the NSF (2011) PEIS maintained the earlier NMFS criteria levels of 166 and 180 dB re 1 µPa (SPL) for behavioural response and injury, respectively. Popper et al. (2014) suggested injury to turtles could occur for sound exposures above 207 dB re 1 µPa (PK) or above 210 dB re 1 µPa^2·s (SEL_{24h}) (Table 3). Sound levels defined by Popper et al. (2014) show that animals are very likely to exhibit a behavioural response when they are near an airgun (tens of metres), a moderate response if they encounter the source at intermediate ranges (hundreds of metres), and a low response if they are far (thousands of meters) from the airgun. Both the NMFS criteria for behavioural disturbance (SPL of 166 dB re 1 µPa) and the Popper et al. (2014) injury criteria were included in this analysis, although the analysis did not consider the ranges at which an animal could suffer impairment, as defined by Popper et al. (2014).

3. Methods

This section details the methodology for predicting source levels, modelling sound propagation, and assessing distances to the selected impact criteria.

The environmental parameters used in the propagation models are described in detail in Appendix D. A single sound speed profile that provided the greatest propagation across the year was applied, which occurs during the month of September.

3.1. Acoustic Sources

3.1.1. Boomer: AP3000 Dual-Plate Boomer

The representative boomer system for geophysical survey operations is the AP3000 triple-plate boomer (manufactured by Subsea Systems, Inc.). To estimate the sound field for the boomer source, the specifications of the Applied Acoustics AA202 boomer plate (Applied Acoustics Engineering 2013), a suitable approximation, were taken to represent a single plate, three of which comprise the full system. The boomer plate is 38 cm wide by 38 cm long with a circular baffle. Because the boomer source is a circular piston surrounded by a rigid baffle, it cannot be considered a point-like source (Verbeek and McGee 1995). The beam pattern of a boomer plate shows some directivity for frequencies above 1 kHz. Above this frequency, the acoustic wave's emitted length becomes comparable (of the same order of magnitude) with the baffle size (< 150 cm vs. 35 cm).

The input energy for the AP3000 system is up to 600 J per pulse per plate, or up to 1800 J per pulse from all three plates. The width of the pulse calculated based on the 90% SPL (T_{90})is 8.1 ms.

JASCO performed a source verification study on an AP3000 system (Martin et al. 2012) with a double-plate configuration operating at maximum input energy of 1000 J. During the study, the acoustic data were collected as close as 8 m to the source and directly below it (Figure 2). By assuming a reduction in pressure in line with spherical spreading laws the data showed that the broadband source level for the system was 197.9 dB 1 µPa @ 1 m SPL and 177.4 dB re 1 µPa^2·s @ 1 m SEL.

The increase in the source level of an AP3000 boomer when in triple-plate configuration, instead of double-plate configuration, was estimated at 2.6 dB because a triple-plate configuration could be used with a higher energy input per pulse (up to 1800 J vs. up to 1000 J for double plate configuration). For modelling, the source level of the AP3000 triple-plated boomer operating at 1800 J per pulse energy was calculated to be 200.5 dB 1 µPa @ 1 m SPL and 180.0 dB re 1 µPa^2·s @ 1 m SEL (Table 4). The power spectrum of the boomer signal was determined directly from the measurement of the boomer signal having compensated the signal for geometric spreading and the change in energy (Figure 3). The 1/3-octave frequency boomer source spectra are shown in Figure 4.

The beamwidth of a boomer plate at each 1/3-octave frequency was calculated based on the standard formula for the beam pattern of a circular transducer (Equation 1). Figure 5 shows a vertical slice for the calculated beam pattern at (a) 1.25 and (b) 16.0 kHz. In order to simplify the acoustic propagation calculations, the beam pattern from the triple-plate system was considered to be equal to the beam pattern from a single plate.

Table 4. Specifications of the AP3000 triple-plate boomer system towed at a depth of 2 m used for the modelling

Specification	Specification	Source
Operating frequency (broad band):	200 Hz–16 kHz;	Estimated from field measurements; Martin et al. (2012)
Beam width	omnidirectional –8°	
Beams	1	

Specification	Specification	Source
Tilt angle (below horizontal plane)	90°	System specification document
Maximum energy input (per pulse):	1800 J	
Peak pressure source level	210.8 dB re 1 µPa @ 1 m	Estimated from field measurements; Martin et al. (2012).
Peak-Peak pressure source level	222.7 dB re 1 µPa @ 1 m	
SPL source level	200.5 dB re 1 µPa @ 1 m	
Pulse length (T_{90})	8.1 ms	
Per-pulse SEL source level	180.0 dB re 1 µPa²•s @ 1 m	

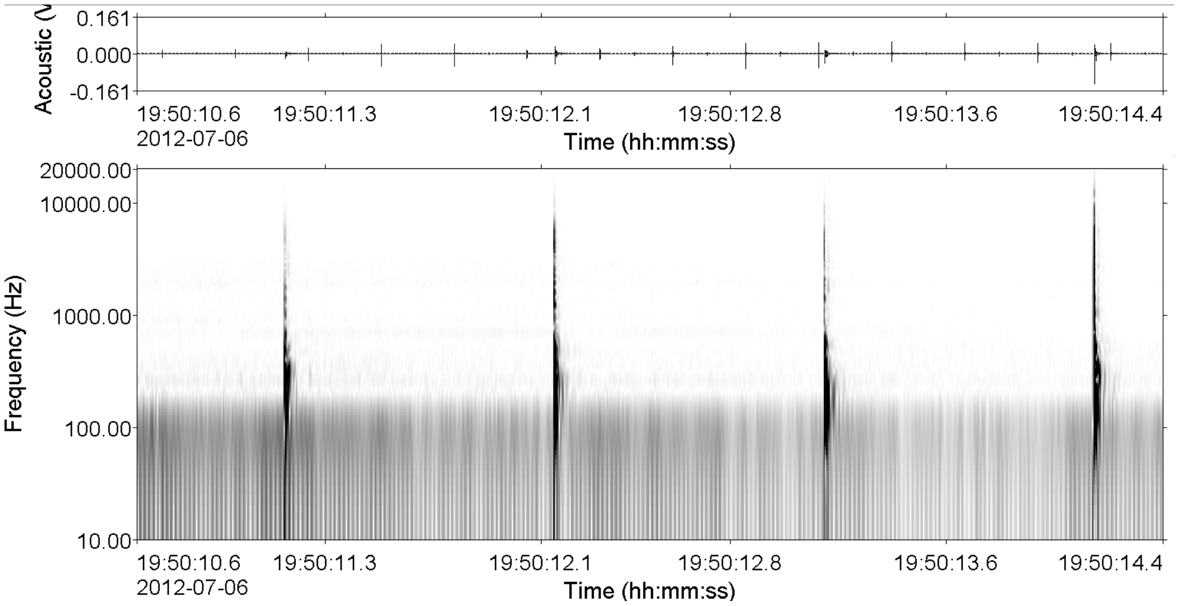


Figure 2. Spectrogram of dual-plate boomer (1000 J) pulses at the closest point of approach. Majority of energy is between 100 and 1000 Hz, with some energy at up to 10 kHz. (131,072 point FFT, 7000 data points, 3500 point overlap, Figure 15 in Martin et al. (2012)).

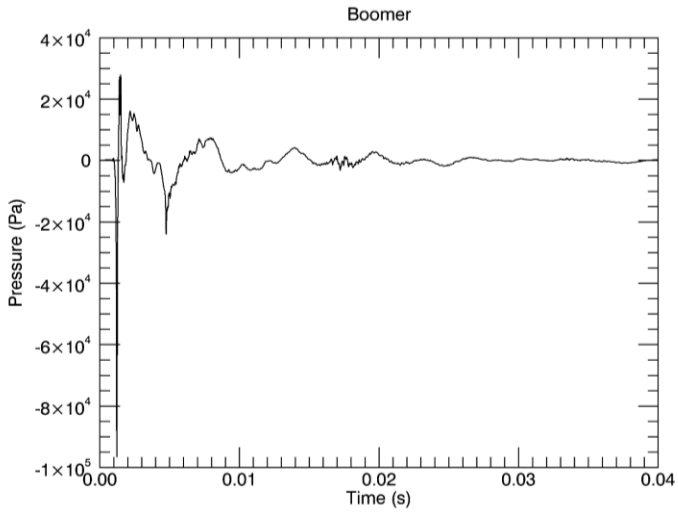


Figure 3. Back-propagated and scaled boomer source signature calculated from measurements (Martin et al. 2012).

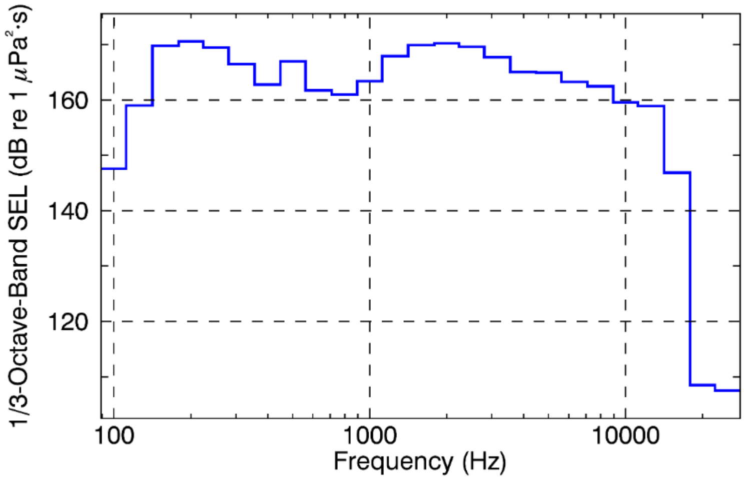


Figure 4. Boomer source spectra calculated from measurements (Martin et al. 2012).

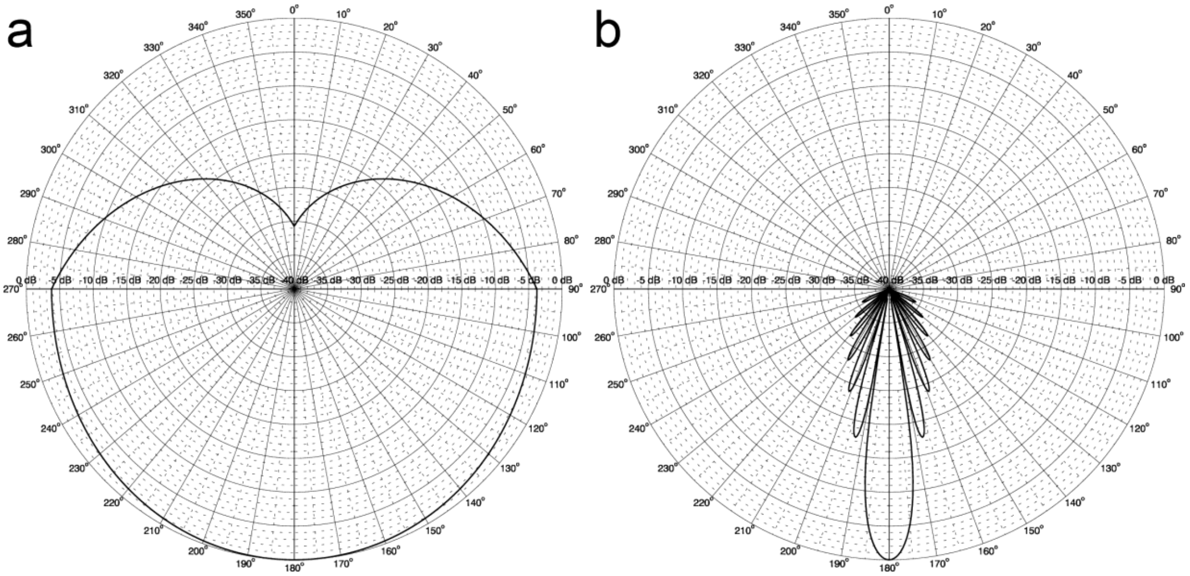


Figure 5. Calculated beam pattern vertical slice for the AA202 boomer plate at (a) 1.25 and (b) 16.0 kHz; across-track direction.

3.1.2. Sub-bottom Profiler: EdgeTech X-Star

The representative sub-bottom profiler system for geophysical survey operations is the EdgeTech X-Star (manufactured by EdgeTech). The system is equipped with a SBP-216 tow-fish. The transducer installed on the SBP-216 tow-fish transmits a chirp pulse that spans an operator-selectable frequency band. The lower and upper limits of the sonar's frequency band are 2 and 16 kHz, respectively. The system projects a single beam directed vertically down. The projected beamwidth depends on the operating frequency, and it can vary in range from 10° to 20°.

The source function was determined by using data obtained from the same measurement campaign as the boomer (Martin et al. (2012).To determine a source function usable for modelling the signal underwent a degree of post-processing. A clip from the recording measured at the closest point of approach was selected for processing (Figure 6). By assuming a point-like source and with no significant reflections or pulse dilation, the source level was determined by back-propagation methods assuming spherical spreading (Figure 7). The SEL band levels were determined from the back-propagated signal and are shown in Figure 8. The calculated source specifications are provided in Table 5. The width of the pulse encompassing 90% of the energy (T_{90}) was 8.1 ms, providing a SPL of 191.7 dB re 1 µPa @ 1 m.

For the purposes of modelling a source depth of 3 m was used, based on the assumed tow depth of a tow-fish. Since the echosounder's transducer projects a circular beam that is aimed vertically down, the source is effectively omnidirectional in the horizontal plane.

Table 5. Specifications of the Edgetech X-Star sub-bottom profiling system towed at a depth of 3 m used for the modelling

Specification	Specification	Source
Operating frequency:	2-16 kHz	System specification document
Beam width	10-20°	
Tilt angle (below horizontal plane)	90°	
Peak pressure source level	197.6 dB re 1 µPa @ 1 m	Estimated from field measurements; Martin et al. (2012).
Peak-Peak pressure source level	204.7 dB re 1 µPa @ 1 m	
SPL source level	191.7 dB re 1 µPa @ 1 m	
Pulse length (T_{90})	8.1 ms	
Per-pulse SEL source level	171.4 dB re 1 µPa^2·s @ 1 m	

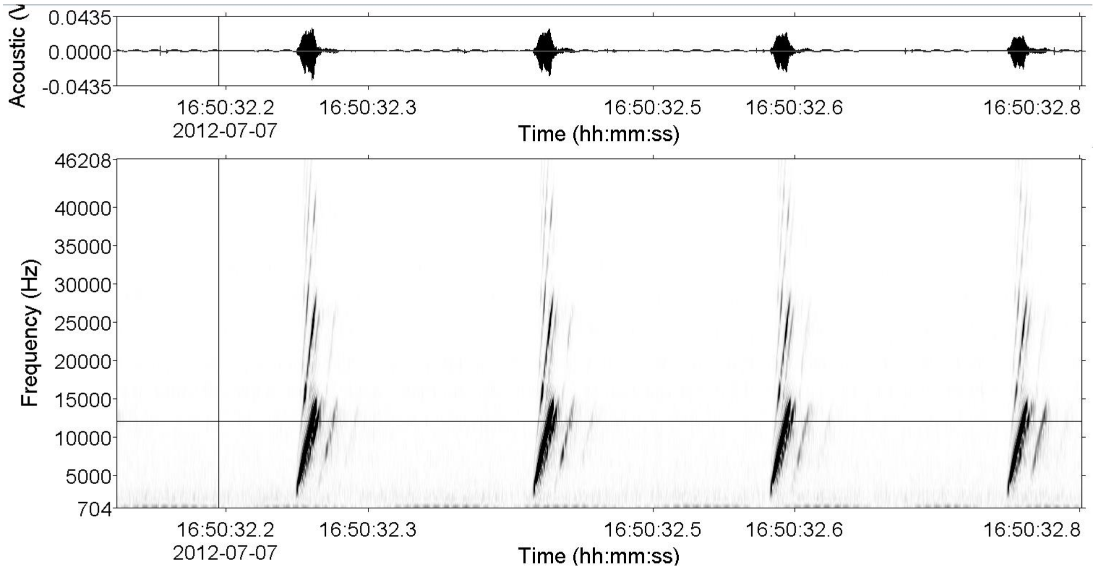


Figure 6. Spectrogram of X-Star SB-216S Sub-Bottom Profiler at closest-point of approach. The centroid frequency of the pulses was approximately 10 kHz, with 90% of the energy between 6 and 13 kHz. Aliased energy is visible above the main pulse. The bottom reflection is visible about 15 ms after the main pulse. (131,072 point FFT, 690 real data points, 345 point overlap.)

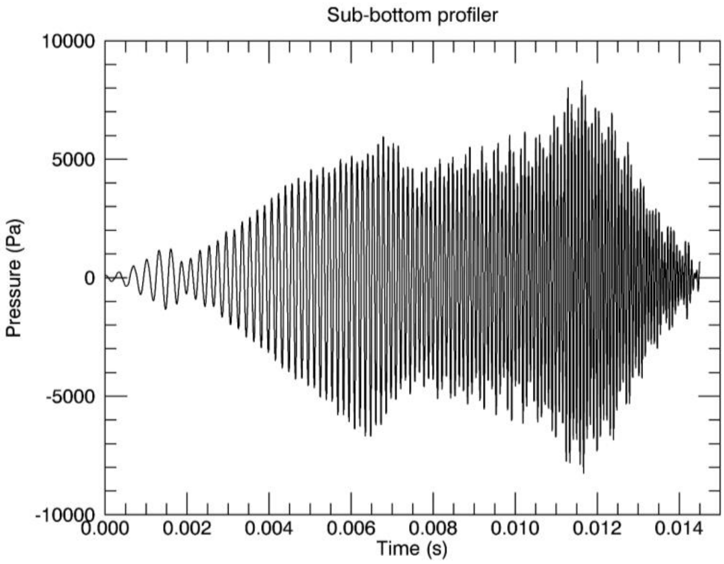


Figure 7. Back-propagated and scaled sub-bottom profiler source signature calculated from measurements (Martin et al. 2012).

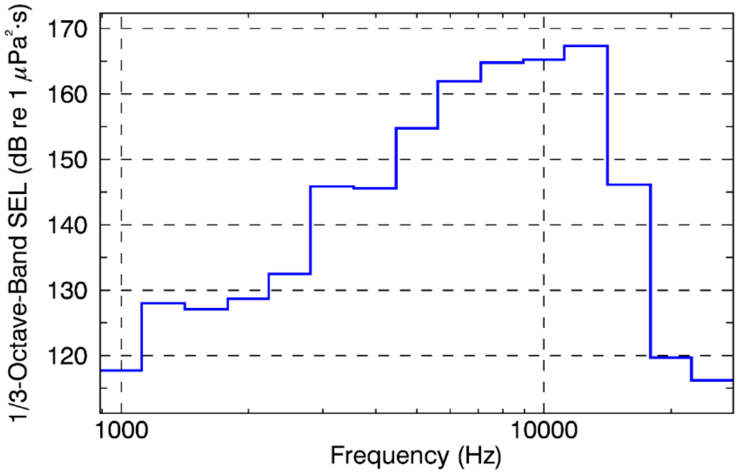


Figure 8. Sub-bottom profiler source spectra calculated from measurements (Martin et al. 2012).

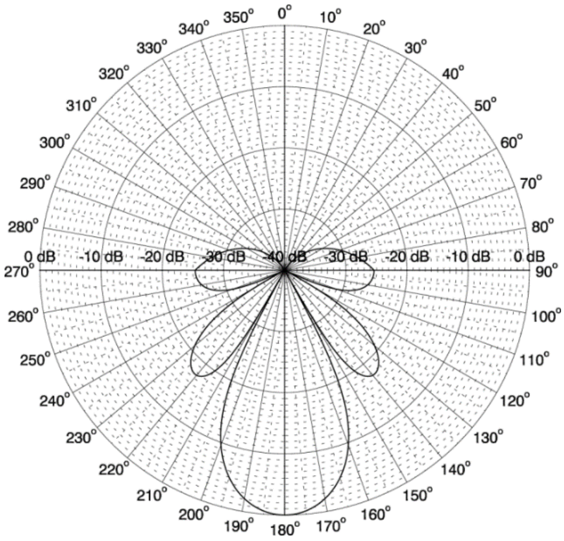


Figure 9. Calculated beam pattern vertical slice for the EdgeTech X-Star sub-bottom profiler at central frequency of 9 kHz.

3.1.3. VSP

The VSP airgun array under consideration is a 450 in^3 array consisting of 3 150 in^3 airguns operated at a centroid depth of 6 m, Figure 10 and Table 6.

The source levels and directivity of the airgun array were predicted with JASCO's Airgun Array Source Model (AASM), which accounts for:

- Array layout
- Volume, tow depth, and firing pressure of each airgun
- Interactions between different airguns in the array

The array was modelled over AASM's full frequency range, up to 25 kHz. Details of the model are described in Appendix B.

The model considered the following specifications:

- A 450 in^3 firing volume seismic airgun array for VSP.
- Airguns operated at a firing pressure of 2000 psi. The type was not specified, however Bolt 1900 LLX were used for the modelling.

- An array layout consisting of three 150 in³ airguns with a centroid depth of 6.0 m.

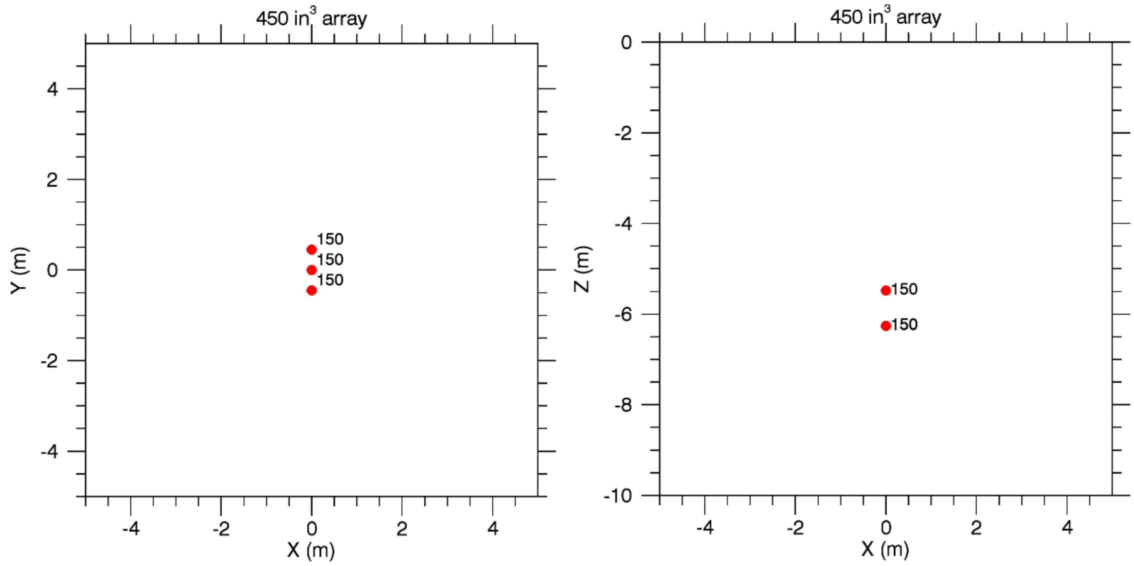


Figure 10. Layout of the modelled 450 in³ VSP array, plan view (left) and side view (right). Centroid operating depth is 6 m. The labels indicate the firing volume (in cubic inches) for each airgun. The convention is that the array is towed in the positive x direction. Also see Table 6.

Table 6. Layout of the modelled 450 in³ VSP array.Centroid operating depth is 6 m. Firing pressure for all guns is 2000 psi. The tow direction is assumed to be in the positive *x* direction.

Gun	*x* (m)	*y* (m)	*z* (m)	Volume (in³)
1	0.0	0	5.48	150
2	0.0	0.45	6.26	150
3	0.0	- 0.45	6.26	150

3.2. Sound Propagation Models

3.2.1. Boomer

The boomer source can be treated as an omnidirectional source for the frequencies of 1000 Hz and lower. For frequencies higher than 1000 Hz, the directionality of the boomer was taken into account. Due The acoustic field projected by the boomer source in 1/3-octave-bands was modelled using two propagation models: for frequencies of 1000 Hz and below MONM-RAM was used, while frequencies above 1000 Hz were modelled using MONM-BELLHOP. These were combined in post processing to determine the acoustic field across the entire frequency range. To determine the maximum range to PK, and PK-PK thresholds, spherical spreading laws were applied to the source level in the downward direction; these are usable due to the short ranges associated with the identified threshold levels within which no appreciable pulse dilation will occur nor reflections.

The acoustic propagation modelling was conducted in terms of PK, PK-PK and SEL units. The conversion to the SPL units was done based on Equation A-5 considering the T_{90} equal to 0.2 ms for the distances from the source less than 20 m, and 10 ms for the distances greater than 20 m from the source.

3.2.2. Sub-bottom Profiler

As the sub-bottom profiler was found only to have significant energy above 1 kHz it was assumed to be directional throughout its operational range. Consequently, MONM-BELLHOP was employed to model the entire frequency range of the SEL acoustic field in terms of 1/3-octave-bands. The ranges to PK and PK-PK levels were determined using spherical spreading laws.

The conversion to the SPL units was done based on Equation A-5 considering the T_{90} equal to 8 ms as determined by the measurement study.

3.2.3. VSP

Four sound propagation models (Appendix C) were used to predict the acoustic field around the VSP array for frequencies from 5 Hz to 25 kHz:

- Range-dependent parabolic equation model (Marine Operations Noise Model, MONM)
- Range-dependent ray tracing model (BELLHOP)
- Full Waveform Range-dependent Acoustic Model (FWRAM)
- Wavenumber integration model (VSTACK).

The models were used in combination to characterise the acoustic fields at short and long ranges in terms of SEL, SPL, PK, and PK-PK.

3.3. Accumulated SEL

3.3.1. Method overview

During a geophysical survey, a new portion of sound energy is introduced into the environment with each pulse from the survey equipment. An accurate assessment of the cumulative acoustic field depends not only on the parameters of each impulse, but also on the number of impulses delivered over a period and the relative position of the impulses. Consideration of the total acoustic energy marine fauna is subjected to over the survey operations is required for comparison to the relevant effect criteria (Section 2).

When there are many pulses, it becomes computationally prohibitive to perform sound propagation modelling for every single event. The offset between the consecutive seismic impulses is small enough, however, that the environmental parameters that influence sound propagation are virtually the same for many impulse points. The acoustic fields can, therefore, be modelled for a subset of pulses and estimated at several adjacent ones. After sound fields from representative impulse locations are calculated, they are adjusted to account for the source position for nearby impulses.

Although estimating the cumulative sound field with the described approach is not as precise as modelling sound propagation at every impulse location, small-scale, site-specific sound propagation features tend to blur and become less relevant when sound fields from adjacent impulses are summed. Larger scale sound propagation features, primarily dependent on water depth, dominate the cumulative field. The accuracy of the present method acceptably reflects those large-scale features, thus providing a meaningful estimate of a wide area SEL field in a computationally feasible framework.

3.3.2. Scenario definition

Four regions were identified for the cumulative study, each requiring many thousands of individual impulses. In each region a representative single pulse noise field for the relevant source is shifted in space and noise fields summed to provide a composite field. For the Thylacine location, two possible surveys were combined into a single scenario, referred to as Thylacine Combined. This scenario included a total of 38 lines each being 7.025 km in length (total estimated time of 51 h including turns). The other three scenarios, Geographe 3 (G3), Artisan (ARTISAN) and VICP69 Meeki (MEEKI), each featured 41 lines, of 4.0 km length (total estimated time of 40.2 h. Along each line the operating sequence was to alternate between the sub-bottom profiler and the boomer with the vessel travelling at 4.5 knots and a turn time of 30 minutes during which no source would be operated. The proposed areas are shown in Figure 11.

To produce maps of cumulative received sound level distribution and calculate distances to specified sound level thresholds at the seafloor, the sound level was calculated at a subset of points within the modelled region. The radial grids of sound levels of the modelled sites at each point were then resampled (by linear triangulation) to produce a regular Cartesian grid. These grids were transposed geographically to each impulse location along the survey lines. The sound field grids from all impulses were summed, using Equation A-4, to produce the cumulative sound field grid. The produced grids had a cell size of 5 m. The contours and threshold ranges were calculated from these flat Cartesian projections of the modelled acoustic fields.

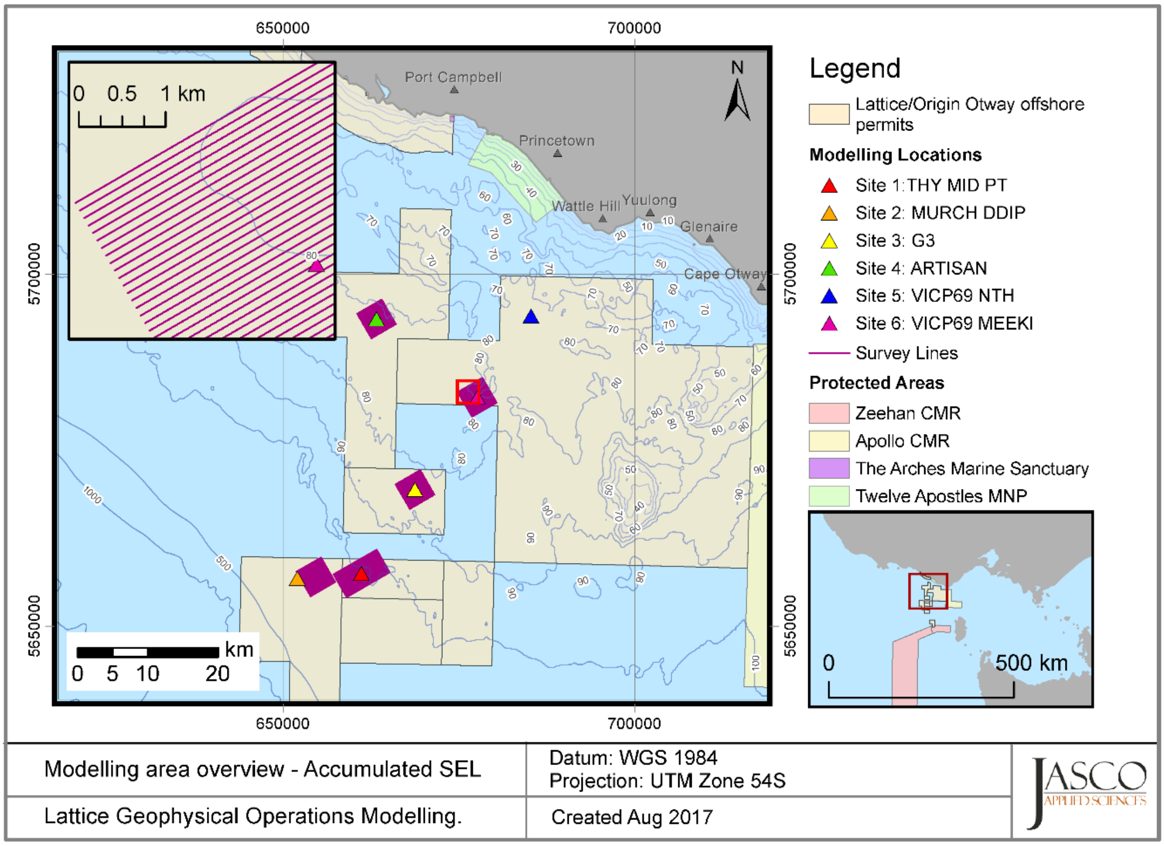


Figure 11. Overview of site surveys (and survey lines) under consideration. The site surveys are referred to by the name of the modelling location located at the same site.

3.4. Geometry and Modelled Regions

The modelled regions were defined based on the anticipated noise footprint of each of the sources. The VSP is significantly louder than either the boomer or the sub-bottom profiler, as well as having greater energy at lower frequencies that would typically propagate further than higher frequencies. The VSP, therefore was modelled in MONM in a series of radial slices with a maximum length of 56 km; the radial slices were 2.5° apart providing a total of 144 individual two-dimensional sound fields that were interpolated onto a regular three-dimensional grid to determine the output metrics. The range step in MONM was 10 m, used across the entire frequency range of 10 to 2000 Hz.

To determine the conversion factor from SEL to SPL, FWRAM was used with four transects modelled (cardinal directions). The Full Waveform Range-dependent Acoustic Model (FWRAM) employs a frequency dependent range step varying from 50 m at 10 Hz to 10 m at 1000 Hz. To calculate the near-field results the VSP was modelled in VSTACK, a wavenumber integration model; results were generated up to a frequency of 1 kHz up to 500 m away. Only a single range-independent transect was modelled using VSTACK.

The boomer and the sub-bottom profiler sources are more strongly directional than the VSP and operate at higher frequencies; consequently, the modelling was principally performed using BELLHOP, the beam-tracing model. The field was modelled in radial slices each 10° apart to provide 36 modelled transects, up to a maximum range of 3.5 km, with a range step of 1 m to provide high-resolution outputs. Where the boomer was omnidirectional (at 1 kHz), MONM was used to generate the contribution; otherwise, BELLHOP was used throughout. These modelling runs were performed separately for each of the six identified single pulse sites.

4. Results

This section presents the model results as distances to sound level thresholds and as sound field contour maps.

4.1. Acoustic Source Levels and Directivity

4.1.1. VSP Array

The pressure signatures of the individual airguns and the composite 1/3-octave-band point-source equivalent directional levels of the arrays were modelled with AASM (Section 3.1). Although AASM accounts for the effects of surface-reflected signals on bubble oscillations and inter-bubble interactions in the notional pressure signatures of each airgun, the signal reflected off the water surface (known as surface ghost) is not included in the far-field source signatures; however, the acoustic propagation models account for those surface reflections because they are a property of the propagating medium rather than the source.

The horizontal and vertical overpressure signatures, corresponding power spectrum levels, and the horizontal directivity plots for array is provided in Appendix B.4.

To help compare these results to the outputs of other airgun array source models, Table 7 presents the vertical source level that accounts for the surface ghost, and lists the broadband PK, and per-pulse SEL source levels of the array in the endfire, broadside, and vertical directions.

Table 7. Source level specifications in the horizontal plane for the 450 in^3 VSP array, for a 6 m centroid depth.

Direction	PK (dB re 1 µPa @ 1 m)	SEL (dB re 1 µPa^2·s @ 1 m)	
		10–2000 Hz	2000–25000 Hz
Broadside	237.6	213.6	167.7
Endfire	237.8	213.7	173.4
Vertical (no ghost)	237.6	213.6	171.1
Vertical (with ghost)	237.6	215.7	174.1

4.2. Single Pulse Sound Fields

4.2.1. Tabulated Results

4.2.1.1. Boomer

The single pulse sound fields for the representative boomer (an AP3000 triple plate boomer) are presented in terms of maximum-over depth SPL for marine mammal and turtle behavioural thresholds (Table 8), maximum-over-depth and seafloor per-pulse SEL (Tables 9 and 10), and water column PK-PK and PK (Tables 11 and 12). Water column PK-PK and PK are included as the levels referenced for benthic invertebrates in Section 2.1 are not reached at the seafloor.

Table 8. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in m) from the boomer to modelled maximum-over-depth marine mammal and turtle behavioural response thresholds.

	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
Marine mammal behaviour SPL: 160 dB re 1 µPa	142	139	75	72	140	136	138	134	136	132	145	134
Turtle behaviour, SPL: 166 dB re 1 µPa	36	35	36	35	36	35	36	35	36	35	36	35

Table 9. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in m) from the boomer to modelled maximum-over-depth per-pulse SEL isopleths.

Per-pulse SEL (dB re 1 µPa²·s)	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
	R_{max}	$R_{95\%}$	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}
160	7	7	7	7	6	6	7	6	7	7	6	6
155	13	12	12	12	13	12	12	12	12	12	12	12
150	21	21	21	21	21	21	22	21	21	21	22	21
145	38	37	38	37	38	37	39	38	38	37	38	37
140	84	77	70	67	136	134	131	127	134	129	135	129
135	233	226	244	229	226	208	288	208	303	215	253	216
130	768	609	604	504	738	559	868	725	908	671	762	628
125	2070	1500	1810	1220	1900	1380	1740	1490	1810	1520	1880	1310
120	3260	2660	3250	2480	3210	2480	3000	2460	3070	2460	3100	2440

Table 10. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in m) from the boomer to modelled seafloor per-pulse SEL isopleths. A dash indicates the level is not reached.

Per-pulse SEL (dB re 1 µPa²·s)	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
	R_{max}	$R_{95\%}$	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}
160	—	—	—	—	—	—	—	—	—	—	—	—
155	1	1	—	—	—	—	—	—	—	—	—	—

Per-pulse SEL (dB re 1 µPa²·s)	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
	R_{max}	$R_{95\%}$	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}	R_{max}
150	3	3	2	2	1	1	1	1	1	1	1	1
145	6	5	5	5	4	4	3	3	4	4	4	4
140	62	60	13	12	136	135	131	127	134	130	135	130
135	232	226	243	229	226	208	288	208	303	213	253	209
130	668	607	602	504	634	547	868	636	908	661	762	651
125	1960	1500	1810	1170	1690	1310	1740	1510	1810	1540	1880	1280
120	3240	2580	3230	2410	3060	2380	3000	2330	3070	2390	2920	2370

Table 11. Maximum (R_{max}) vertical distances down (in m) from the boomer to modelled PK-PK isopleths in the water column. The source is operated at 2 m depth, the results are site independent.

PK-PK (dB re 1 µPa)	Vertical Distance from source (m)
215	2.4
212	3.4
210	4.3
209	4.8
205	7.6
202	10.8

Table 12. Maximum (R_{max}) vertical distances down (in m) from the boomer to modelled PK isopleths in the water column. The source is operated at 2 m depth, the results are site independent.

PK (dB re 1 µPa)	Vertical Distance from source (m)
213	0.6
210	0.8
207	1.6

4.2.1.2. Sub-bottom Profiler

The single pulse sound fields for the representative sub-bottom profiler (an EdgeTech X-Star SBP-216) are presented in terms of maximum-over depth SPL for marine mammal and turtle behavioural thresholds (Table 13), maximum-over-depth and seafloor per-pulse SEL (Tables 14 and 15), and water column PK-PK and PK (Tables 16 and 17). Water column PK-PK and PK are included as the levels referenced for benthic invertebrates in Section 2.1 are not reached at the seafloor.

Table 13. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in m) from the sub-bottom profiler to modelled maximum-over-depth applied marine mammal and turtle behavioural response thresholds. A dash indicates the threshold is not reached.

Per-pulse SEL (dB re 1 µPa^2·s)	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
Marine mammal behaviour SPL: 160 dB re 1 µPa	2	2	2	2	2	2	2	2	2	2	2	2
Turtle behaviour, SPL: 166 dB re 1 µPa	—	—	—	—	—	—	—	—	—	—	—	—

Table 14. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in m) from the sub-bottom profiler to modelled maximum-over-depth per-pulse SEL isopleths. A dash indicates the level is not reached.

Per-pulse SEL (dB re 1 µPa^2·s)	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
145	—	—	—	—	—	—	—	—	—	—	—	—
140	1	1	1	1	1	1	1	1	1	1	1	1
135	4	4	4	4	4	4	4	4	4	4	4	4
130	8	8	8	7	7	7	7	7	7	7	7	7
125	13	12	13	13	11	11	10	10	10	10	11	10
120	16	16	19	18	14	13	13	12	13	13	13	13

Table 15. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in m) from the sub-bottom profiler to modelled seafloor per-pulse SEL isopleths. A dash indicates the level is not reached.

Per-pulse SEL (dB re 1 µPa^2·s)	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$	R_{max}	$R_{95\%}$
135	—	—	—	—	—	—	—	—	—	—	—	—
130	—	—	—	—	—	—	5	5	6	6	6	6
125	10	10	13	13	9	9	8	8	8	8	10	9
120	15	14	19	18	13	12	12	12	13	12	13	13

Table 16. Maximum (R_{max}) vertical distances down (in m) from the boomer to modelled PK-PK isopleths in the water column. The source is operated at 3 m depth, the results are site independent.

PK-PK (dB re 1 µPa)	Vertical Distance from source (m)
215	0.3
212	0.4
210	0.5
209	0.6
205	1.0

PK-PK (dB re 1 µPa)	Vertical Distance from source (m)
202	1.4

Table 17. Maximum (R_{max}) vertical distances down (in m) from the boomer to modelled PK isopleths in the water column. The source is operated at 3 m depth, the results are site independent.

PK (dB re 1 µPa)	Vertical Distance from source (m)
213	0.1
210	0.2
207	0.3

4.2.1.3. VSP

The single pulse results for the 450 in^3 VSP array operating in 72 m of water at Site 5 are presented in terms of maximum-over-depth per-pulse SEL and SPL (Tables 18 and 19), and seafloor per-pulse SEL, PK-PK and PK (Tables 20–22).

Table 18. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 450 in^3 VSP array to modelled maximum-over-depth per-pulse SEL isopleths at Site 5. The 160 dB re 1 µPa²·s isopleth (bold values) is associated with the DEWHA (2008) criterion.

Per-pulse SEL (dB re 1 µPa²·s)	Distance (km)	
	R_{max}	$R_{95\%}$
190	<0.02	<0.02
180	0.04	0.04
170	0.23	0.22
160	**1.06**	**1.03**
150	3.55	3.10
140	8.76	7.80
130	>23.0	>19.0

Table 19. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the 450 in^3 VSP array to modelled maximum-over-depth SPL isopleths at Site 5 The 166 and 160 dB re 1 µPa isopleths (bold values) are associated with the turtle and marine mammal behavioural response thresholds.

SPL (dB re 1 µPa)	Distance (km)	
	R_{max}	$R_{95\%}$
190	<0.04	<0.04
180	0.22	0.21
170	0.89	0.86
166	**1.55**	**1.45**
160	**2.56**	**2.44**
150	6.96	6.24

SPL (dB re 1 µPa)	Distance (km)	
	R_{max}	$R_{95\%}$
140	19.9	16.8
130	>48.0	>42.0

Table 20. Maximum (R_{max}) horizontal distances (in m) from the 450 in^3 VSP array to modelled seafloor per-pulse SEL isopleths at Site 5 using VSTACK. A dash indicates the level is not reached.

Per-pulse SEL (dB re 1 µPa²·s)	Distance (m)
185	-
180	35
178	65
176	105
174	145
172	180
170	210

Table 21. Maximum (R_{max}) horizontal distances (in m) from the VSP array at Site 5 to modelled seafloor PK-PK isopleths. A dash indicates the level is not reached.

PK-PK (dB re 1 µPa)	Distance (m)
212	–
210	–
209	–
208	30
207	55
206	75
205	100
202	185

Table 22. Maximum (R_{max}) horizontal distances (in m) from the VSP array at Site 5 to modelled seafloor PK isopleths. A dash indicates the level is not reached.

PK (dB re 1 µPa)	Distance (m)
213	–
207	–
204	20
202	60
200	110

PK (dB re 1 µPa)	Distance (m)
198	165

4.2.2. Maps and Graphs

4.2.2.1. Boomer

Maps of the per-pulse SEL at the seafloor along with vertical slices for the representative boomer are shown for two representative sites, Site 1 (Thylacine Midpoint: Figures 12 and 13) and Site 4 (Artisan: Figures 14 and 15). The shape of the footprint at all six modelled sites (Table 1) is almost identical.

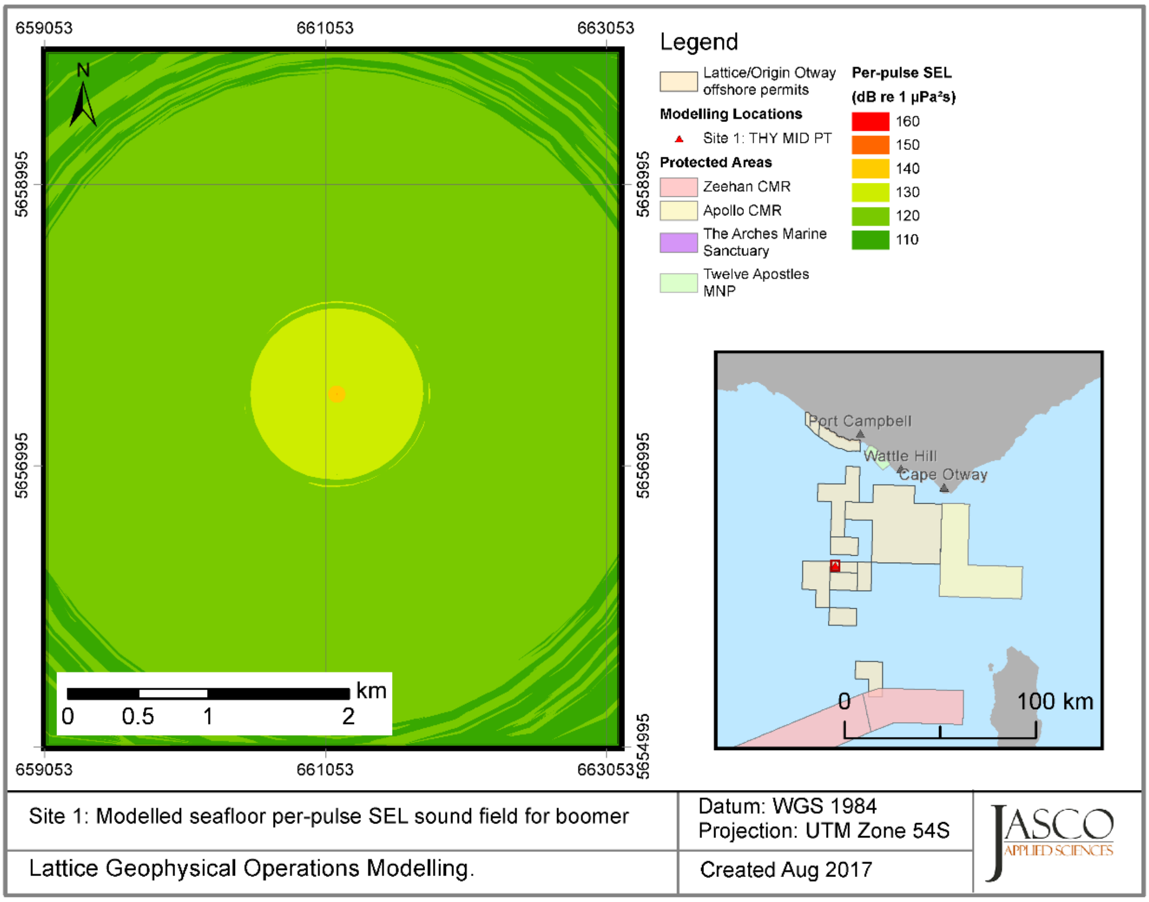


Figure 12. Boomer, Site 1: Sound level contour map showing unweighted seafloor per-pulse SEL results for the boomer towed at 2 m depth.

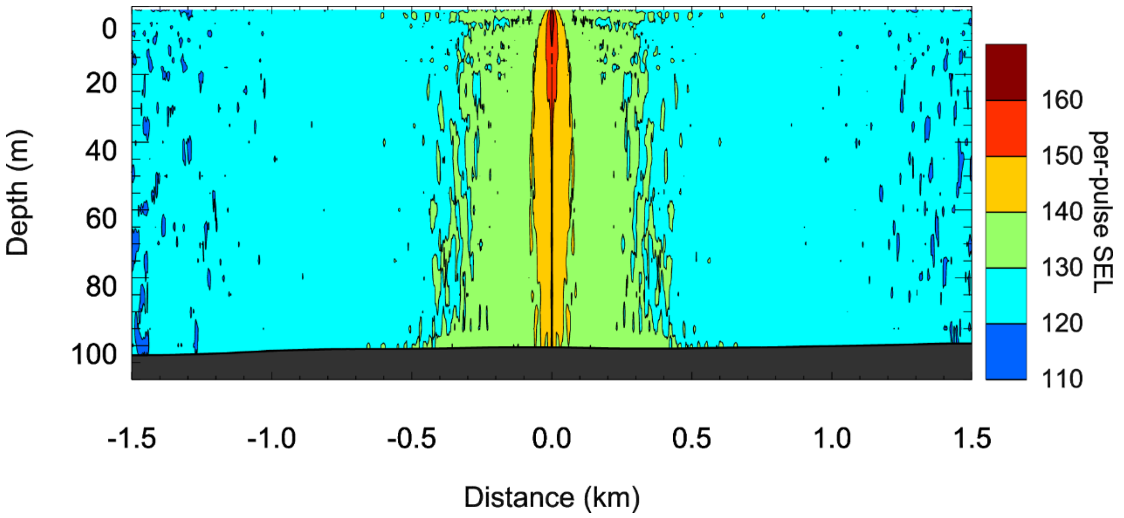


Figure 13. Boomer, Site 1: Predicted unweighted per-pulse SEL for the boomer towed at 2 m depth as vertical slices. Levels are shown from south to north.

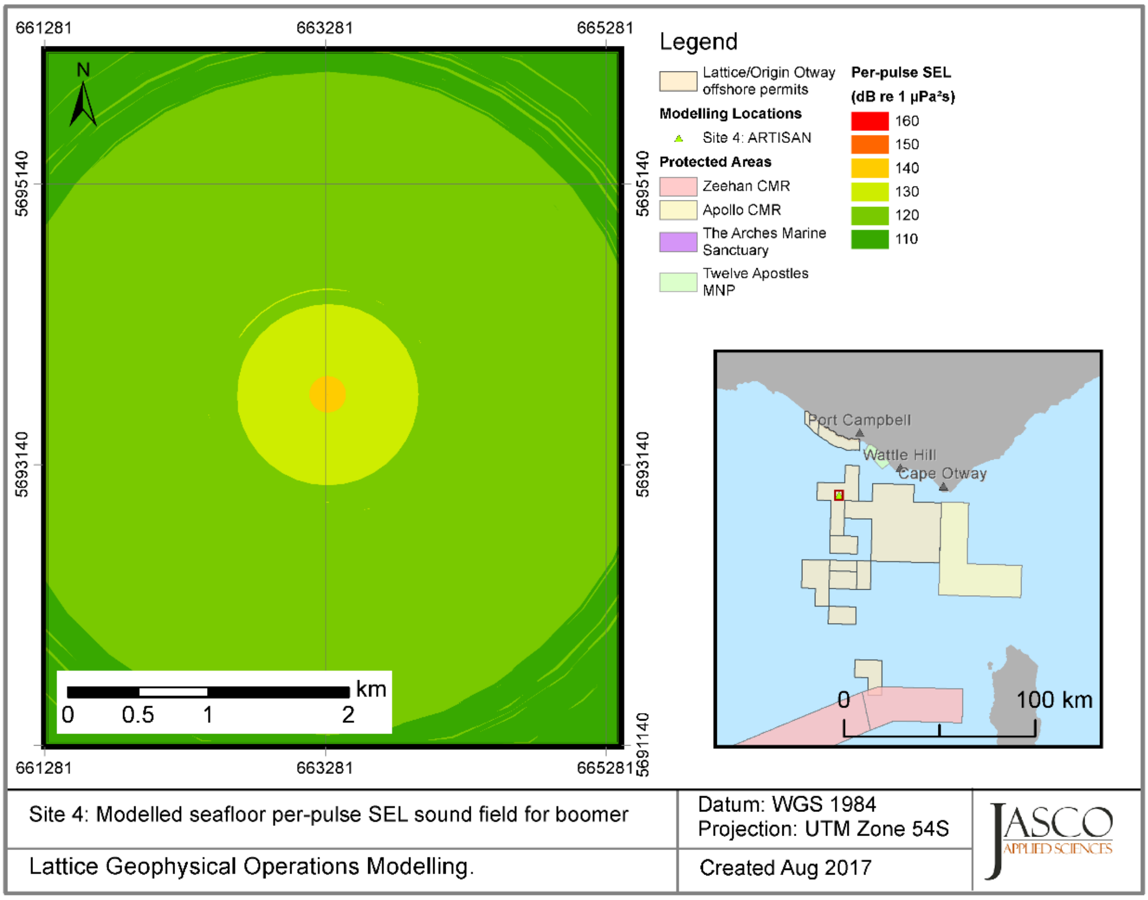


Figure 14. Boomer, Site 4: Sound level contour map showing unweighted seafloor per-pulse SEL results for the boomer towed at 2 m depth.

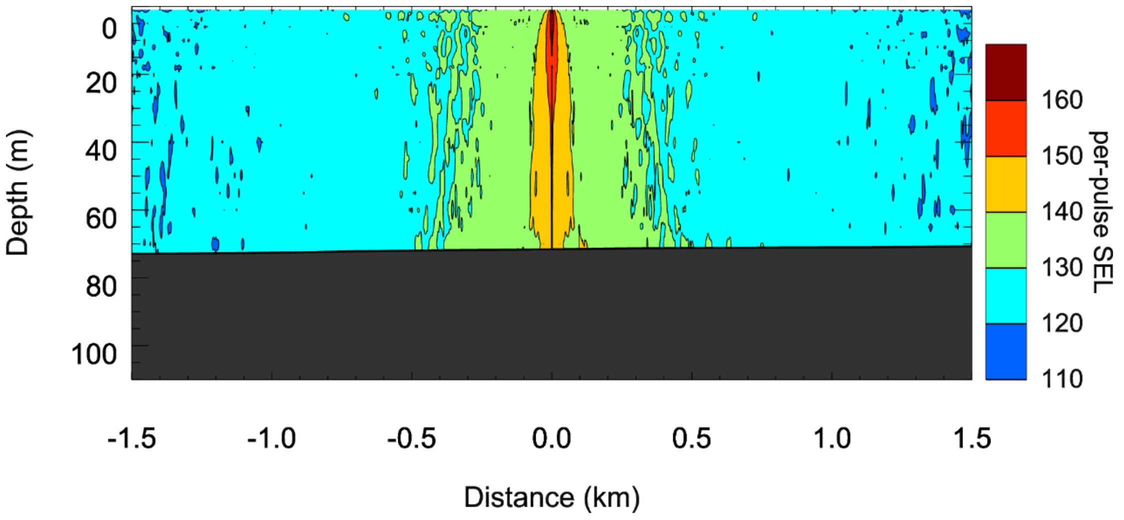


Figure 15. Boomer, Site 4: Predicted unweighted per-pulse SEL for the boomer towed at 2 m depth as vertical slices. Levels are shown from south to north.

4.2.2.2. Sub-bottom Profiler

Maps of the per-pulse SEL at the seafloor along with vertical slices for the representative SBP is shown for two representative sites, Site 1 (Thylacine Midpoint: Figures 16 and 17) and Site 4 (Artisan: Figures 18 and 19). The shape of the footprint at all six modelled sites (Table 1) is almost identical.

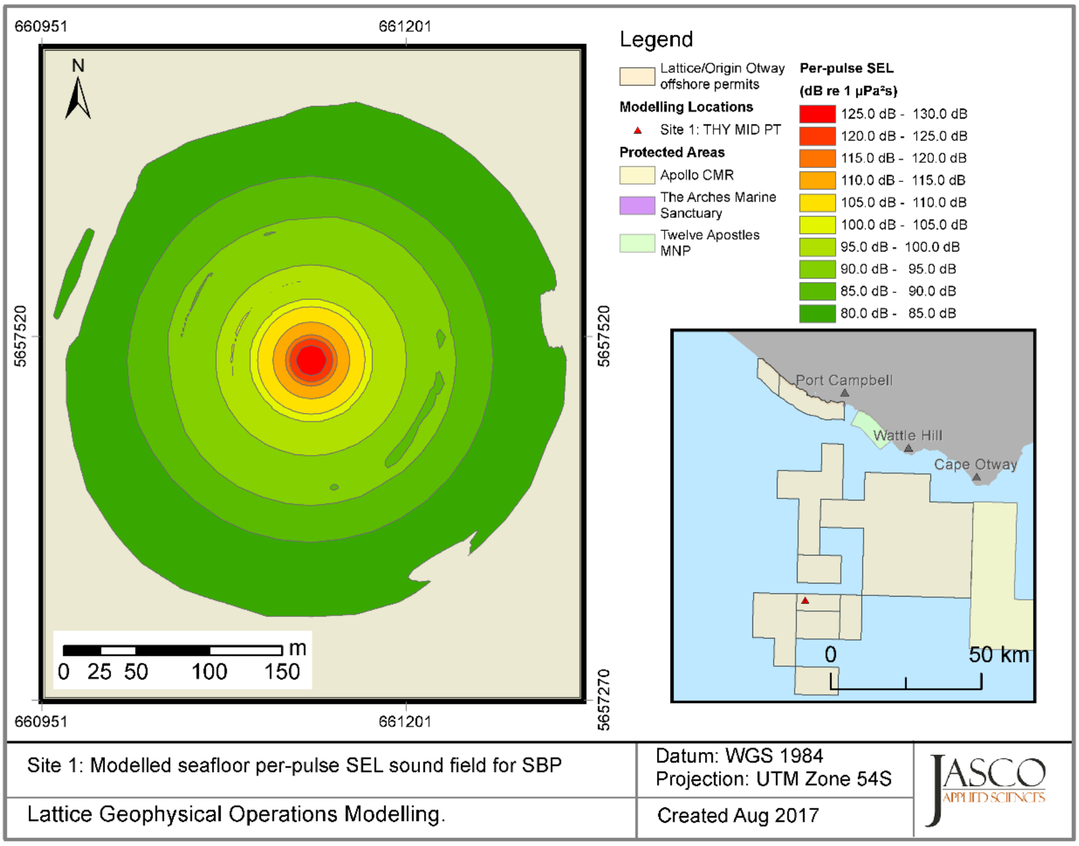


Figure 16. SBP, Site 1: Sound level contour map showing unweighted seafloor per-pulse SEL results for the SBP towed at 3 m depth.

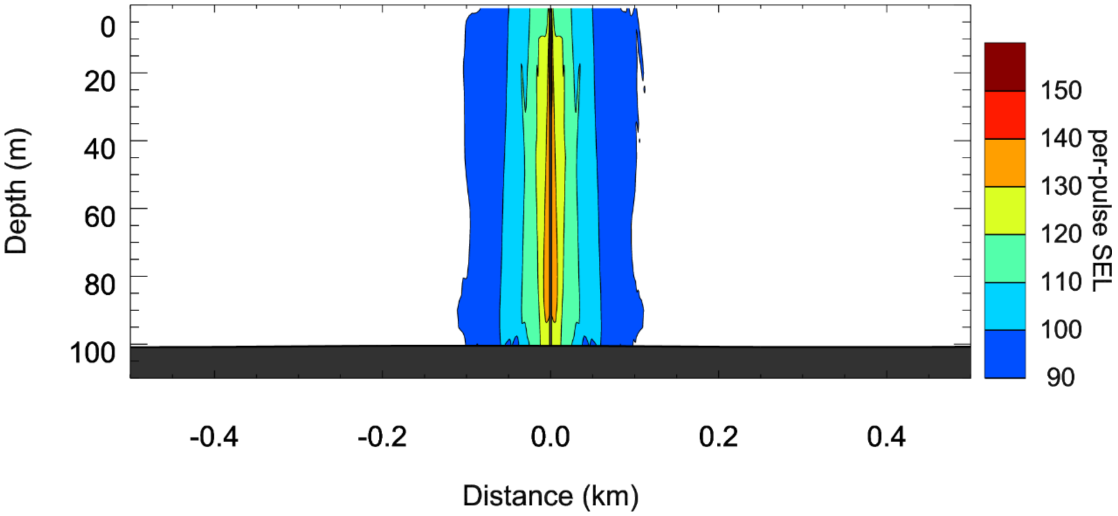


Figure 17. SBP, Site 1: Predicted unweighted per-pulse SEL for the SBP towed at 3 m depth as a vertical slice. Levels are shown from south to north.

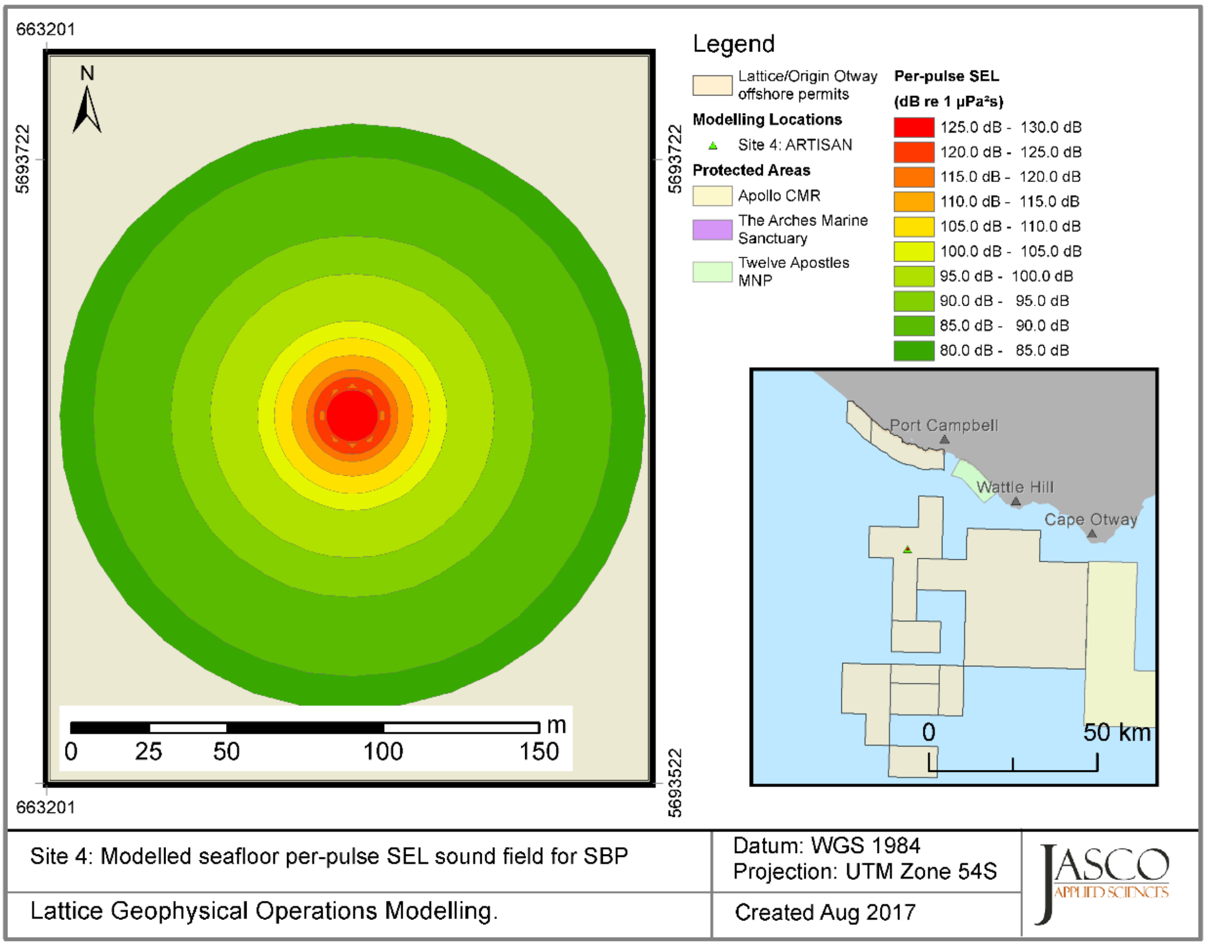


Figure 18. SBP, Site 4: Sound level contour map showing unweighted seafloor per-pulse SEL results for the SBP towed at 3 m depth.

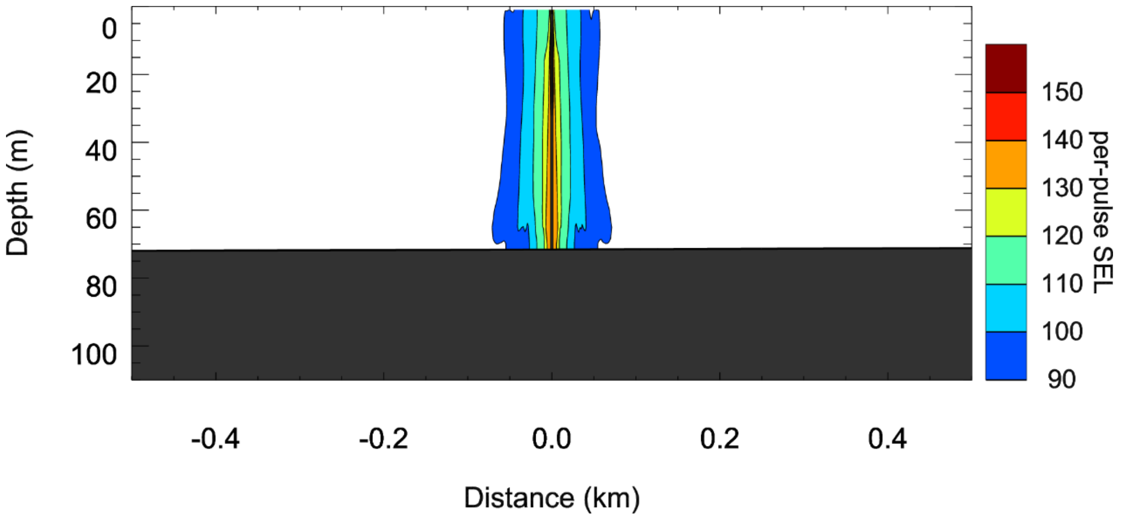


Figure 19. SBP, Site 4: Predicted unweighted per-pulse SEL for the SBP towed at 3 m depth as a vertical slice. Levels are shown from south to north.

4.2.2.3. VSP

Maps of the per-pulse SEL as maximum-over-depth along with vertical slices for the VSP is shown at Site 5, Block VICP69, North (Figures 20 and 21). Additionally, the PK and PK-PK at the seafloor out to 300 m is shown in Figure 22.

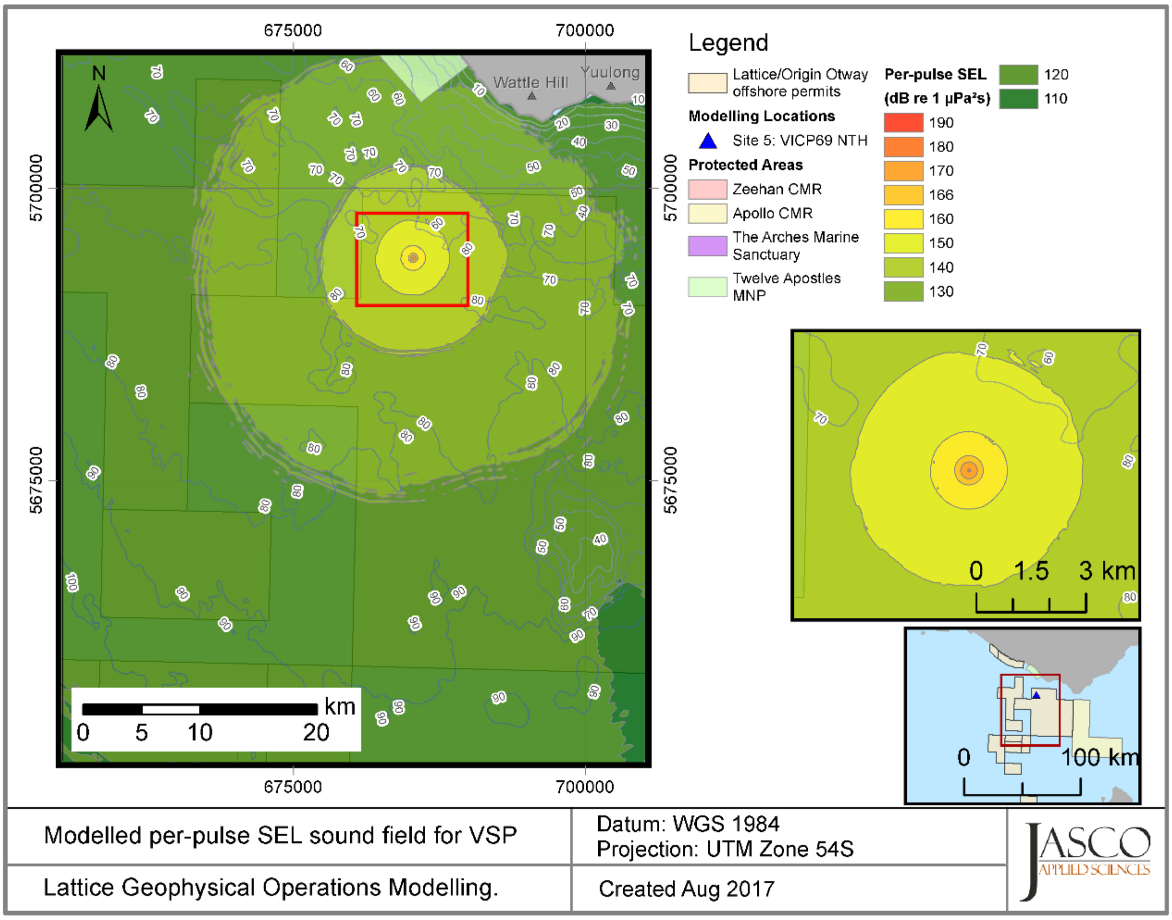


Figure 20. Sound level contour map showing unweighted maximum-over-depth per-pulse SEL results for the 450 in³ VSP array operated at 6 m depth at Site 5.

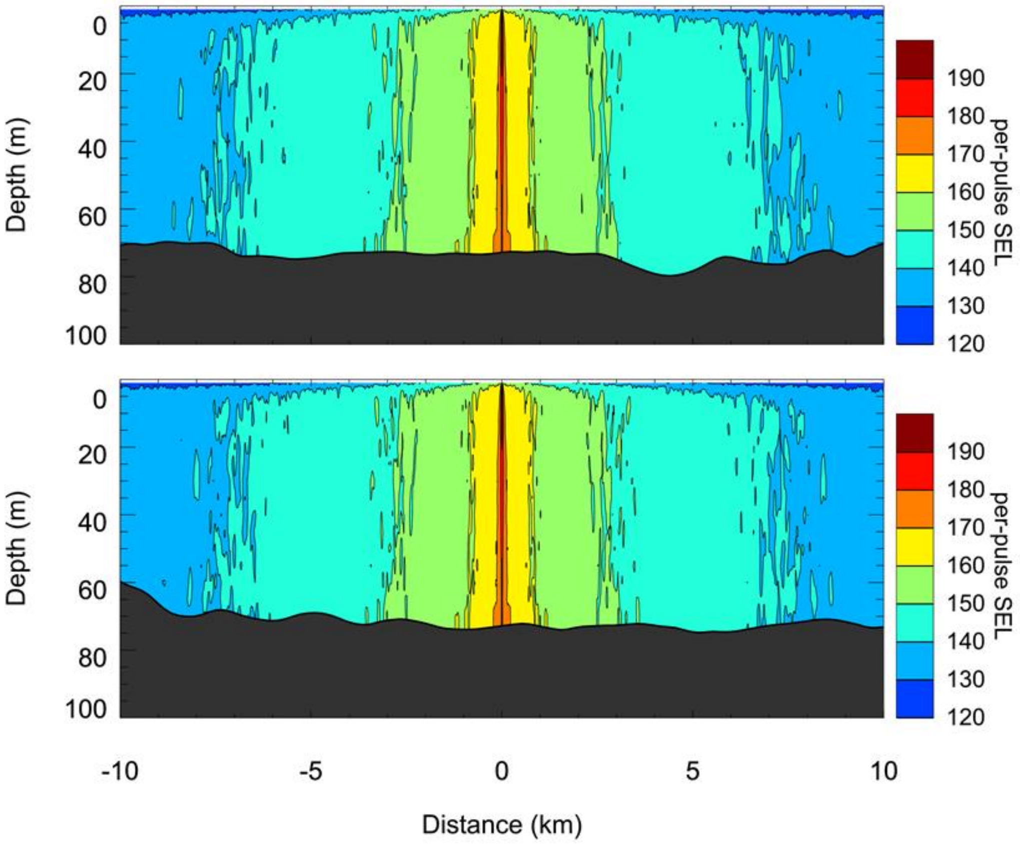


Figure 21. Predicted unweighted per-pulse SEL as vertical slices. Levels are shown in the broadside (top) and endfire directions (bottom). The source depth is 6 m.

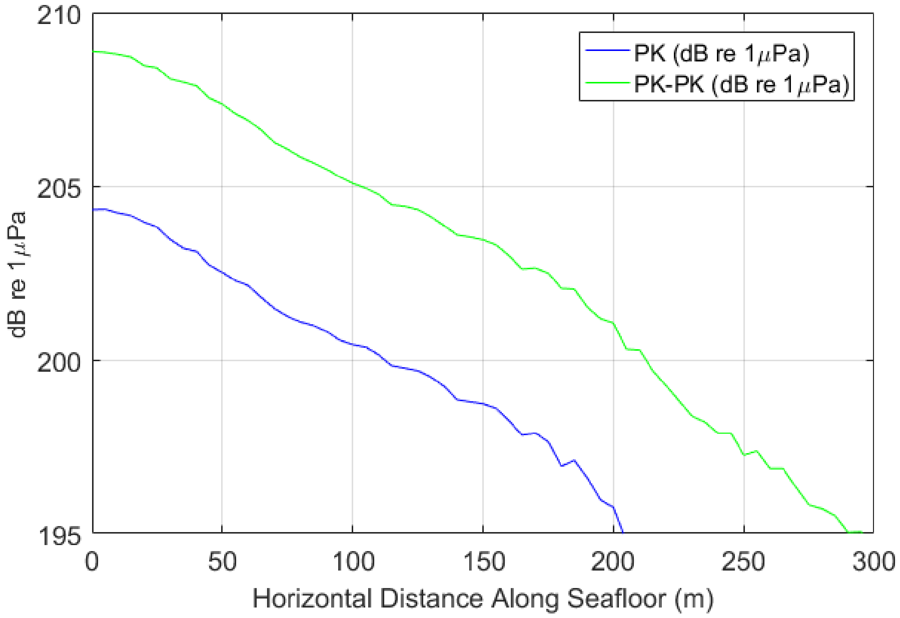


Figure 22. Predicted maximum PK and PK-PK in the endfire direction at the seafloor at Site 5, 72.8 m depth. The source depth is 6 m.

4.3. Accumulated Sound Exposure Levels

4.3.1. Tabulated Results

A cumulative noise study was performed for the four regions, Thylacine Combined, Geographe 3, Artisan, and Block VICP69 Meeki, as indicated in Figure 11. The study involved multiple survey lines with alternating pulses of the boomer and the sub-bottom profiler. Table 23 shows the distances to cumulative SEL thresholds at the seafloor where the accumulation period covers the entire survey.

Table 23. Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the survey areas to modelled seafloor cumulative SEL isopleths, and the ensonified area to the specified threshold (in km²). A dash indicates that the level was not exceeded at the seafloor.

SEL (dB re 1 µPa²·s)	**Thylacine Combined**			**Geographe 3**			**Artisan**			**Block VICP69, Meeki**		
	R_{max} (km)	$R_{95\%}$ (km)	*Area* (km²)	R_{max} (km)	R_{max} (km)	*Area* (km²)	R_{max} (km)	R_{max} (km)	*Area* (km²)	R_{max} (km)	R_{max} (km)	*Area* (km²)
170	—	—	—	—	—	—	—	—	—	—	—	—
165	0.11	0.05	12.52	0.05	0.05	8.86	0.09	0.05	9.46	0.05	0.05	9.08
160	1.7	1.2	38.9	1.1	0.8	22.7	1.2	0.8	22.7	1.1	0.8	22.7
155	6.9	5.3	189	4.8	4.1	107	4.8	3.9	106	5.5	4.2	114
150	9.6	6.9	287	8.2	6.4	221	8.1	6.4	220	8.3	6.4	221
145	>10	>10	NA	>10	>10	NA	>10	>10	NA	>10	>10	NA

4.3.2. Sound Level Contour Maps

Maps of the accumulated SEL at the seafloor for the combined operations of the boomer and the SBP over the duration of the surveys (described in Section 3.3.2) are shown for the four considered surveys. These are at the Thylacine Combined (Figure 23), Geographe 3 (Figure 24), Artisan (Figure 25) and Block VICP69, Meeki (Figure 26) locations.

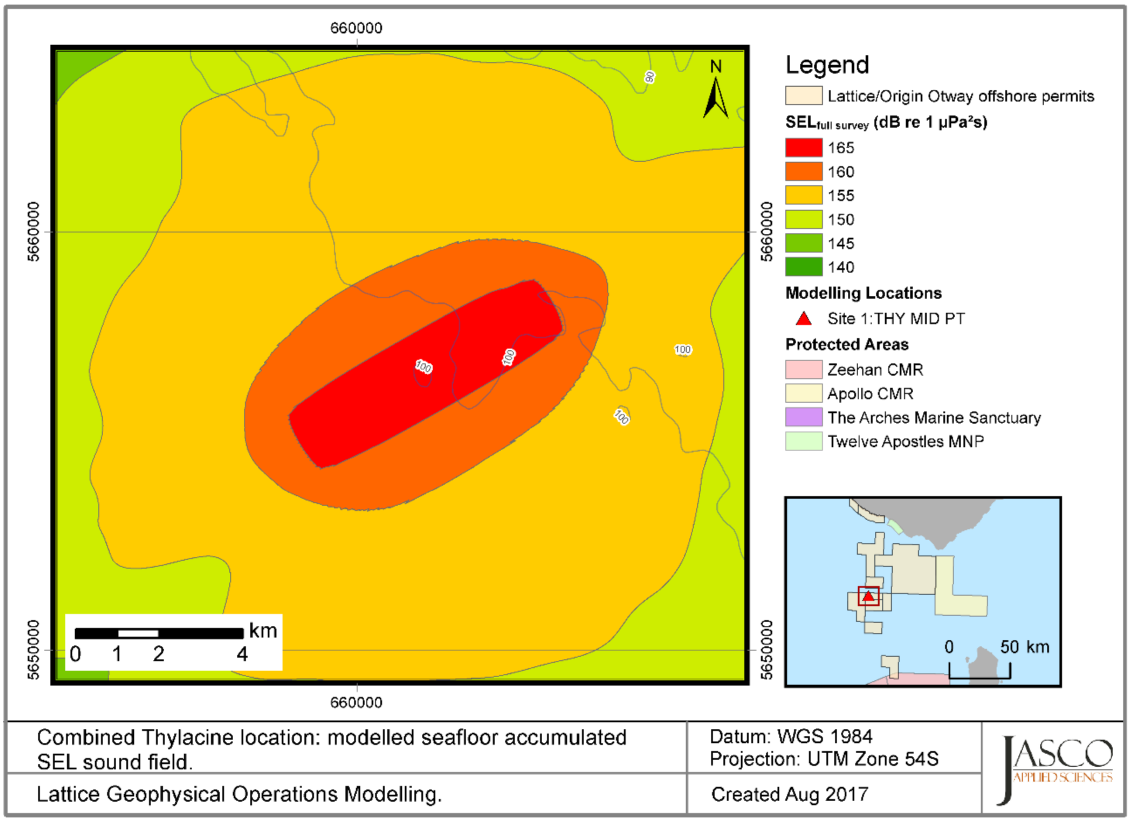


Figure 23. Thylacine Combined location: Sound level contour map of seafloor accumulated SEL over the full survey for the boomer and SBP operations.

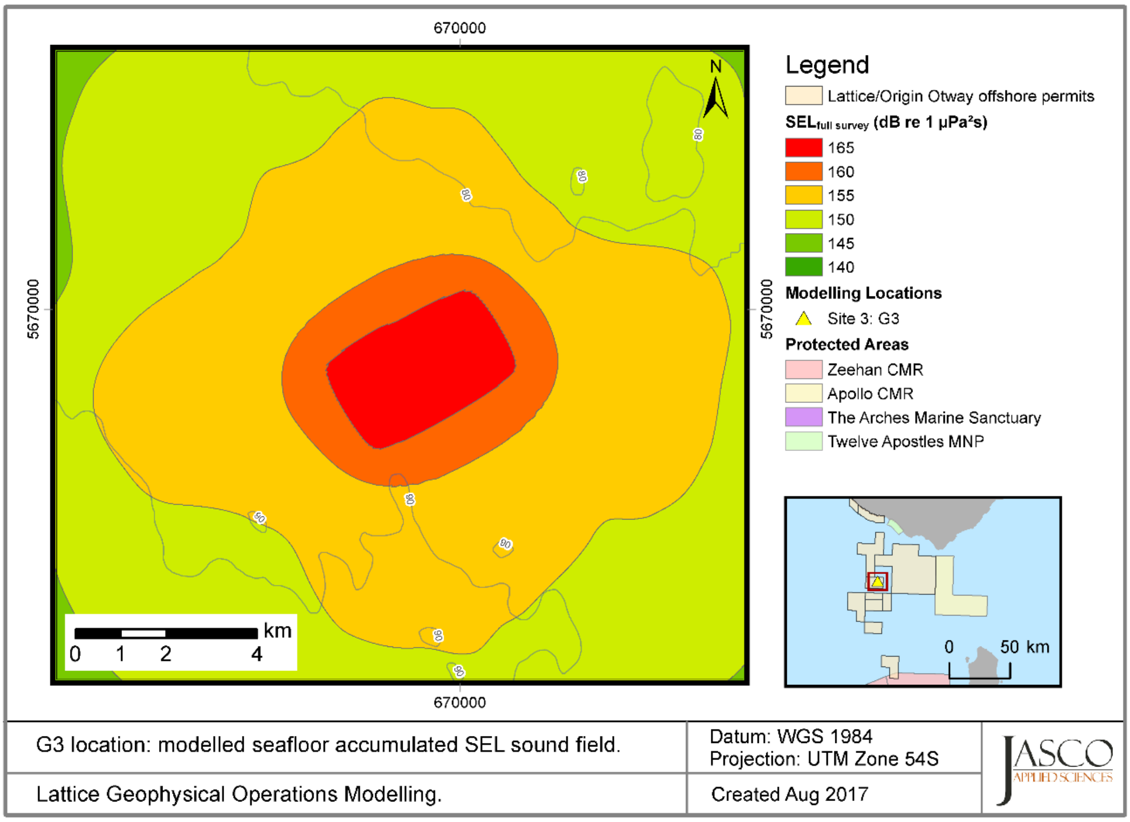


Figure 24. G3 location: Sound level contour map of seafloor accumulated SEL over the full survey for the boomer and SBP operations.

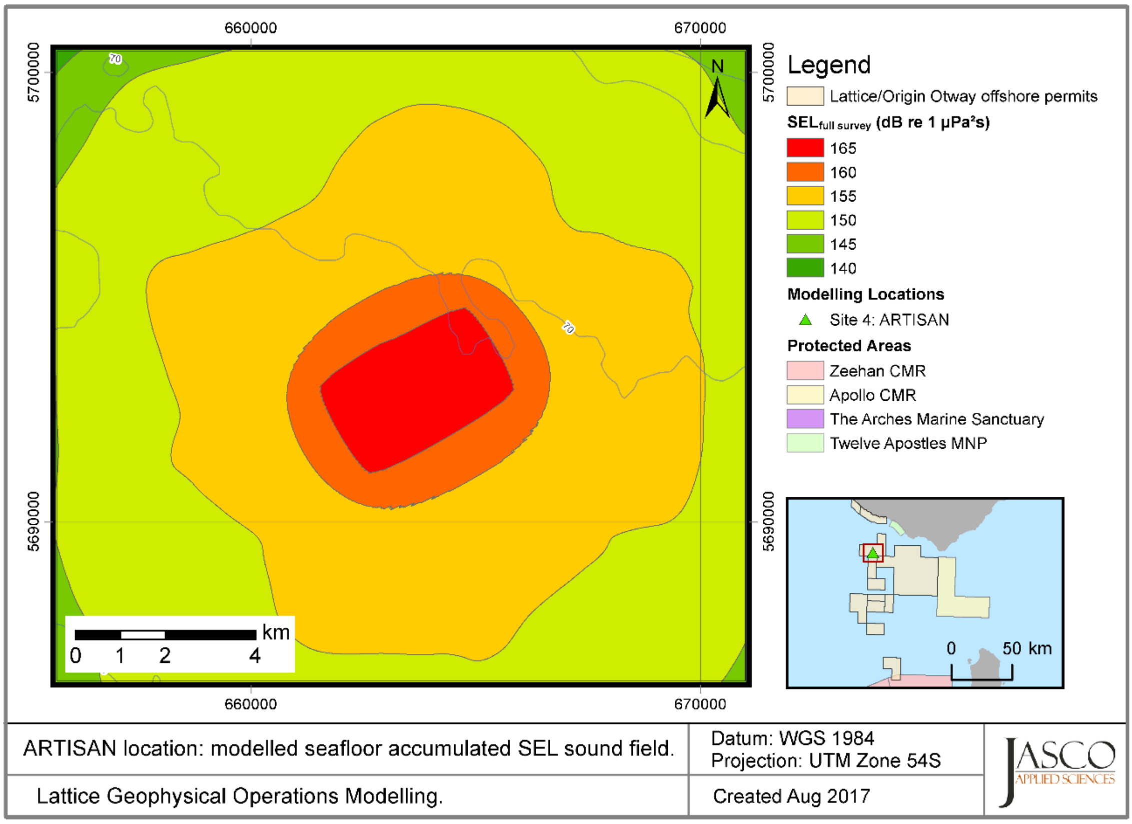


Figure 25. ARTISAN location: Sound level contour map of seafloor accumulated SEL over the full survey for the boomer and SBP operations.

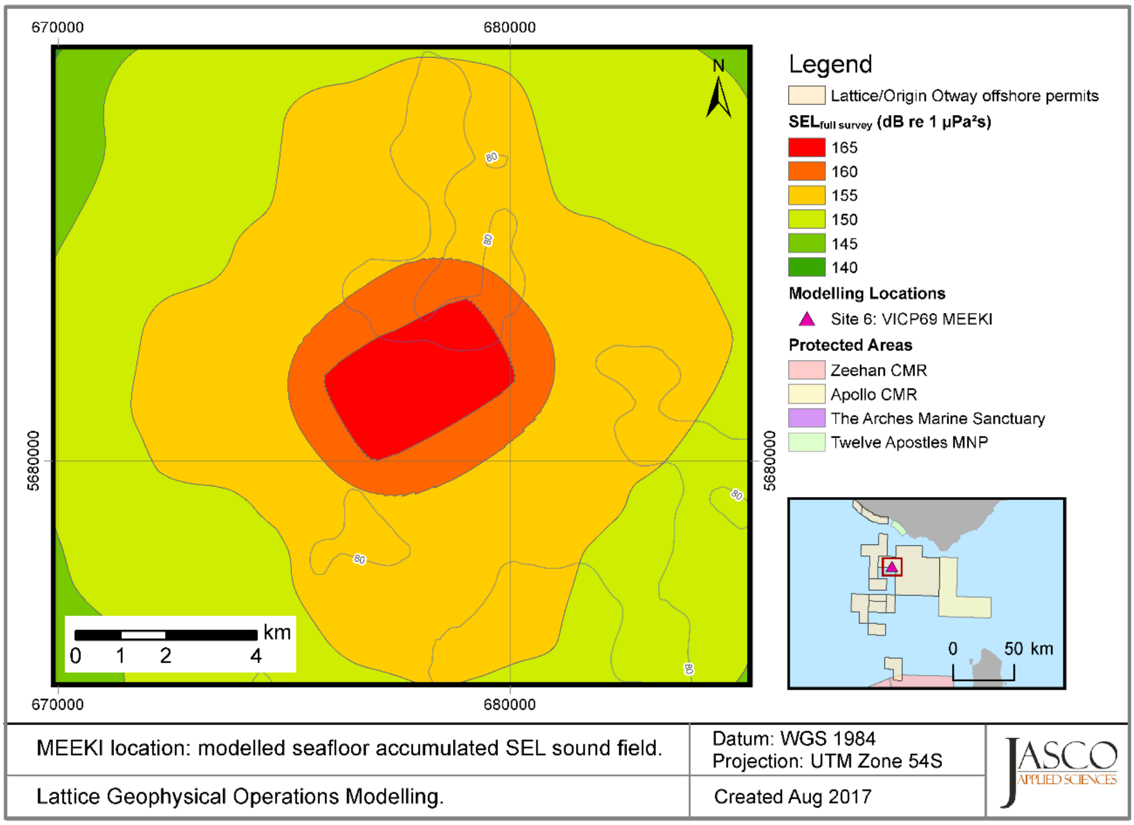


Figure 26. MEEKI location: Sound level contour map of seafloor accumulated SEL over the full survey for the boomer and SBP operations.

5. Discussion and Conclusion

5.1. Overview and source levels

This modelling study predicted underwater sound levels associated with the specified geophysical operations of the VSP, and surveys including boomer and sub-bottom profiler sources. Due to a lack of available literature on source functions for the high-frequency sources, the boomer and the sub-bottom profiler source inputs were determined from a previous JASCO measurement campaign (Sections 3.1.1 and 3.1.2). It was determined that the per-pulse SEL source level of the boomer was 180.0 dB re 1 µPa²·s @ 1 m, and for the sub-bottom profiler it was 171.4 dB re 1 µPa²·s @ 1 m; further metrics for the back propagated source levels are shown in Tables 4 and 5 respectively. The boomer was found to be a relatively broadband source with appreciable energy across the range of 160 Hz to 12.5 kHz (Figure 4). The sub-bottom profiler had the majority of energy at higher frequencies, between 5 kHz and 12.5 kHz.

The 450 in³ VSP was modelled using AASM at a centroid depth of 6 m (Section 3.1.3). The SEL source level of the VSP was 213.7 dB re 1 µPa²·s @ 1 m in the endfire direction, and 213.6 dB re 1 µPa²·s @ 1 m in the broadside direction; further source metrics are shown in Table 7. Most of the acoustic energy is output at lower frequencies, in the tens to hundreds of hertz. Due to the geometry of the array, the VSP is practically an omnidirectional source.

The modelling was performed using a typical September sound speed profile, as the setting most likely to achieve the greatest transmission, such that a precautionary estimation of distances can be made for the surveys (Section D.3.2). The lithography of the regions place Sites 1 & 2 in a region typified by a hard caprock, Sites 3, 4, and 6 in a region with a shallow sand layer over increasingly consolidated calcarenite, and Site 5 with a deeper sand layer over the calcarenite; this is detailed in Section D.3.3. The modelling also accounted for variations in site-specific bathymetry (Section D.3.1)

5.2. Single pulse sound fields

The results for the single pulse sound fields are presented in Section 4.2.

Across all sites, the maximum range for the boomer to exceed the marine mammal behavioural threshold (SPL of 160 dB re 1 µPa) is 145 m (Site 6), and to exceed the turtle behavioural threshold (SPL of 166 dB re 1 µPa) is 36 m, which is consistent across all sites (Table 8). The consistency for the turtle behavioural threshold is due to the levels being reached before influences from the site-dependent environment factors (bathymetry and geoacoustics). The range to the marine mammal behavioural threshold level at Site 2 is significantly shorter than at the other sites; this is due to the greater water depth and consequent lack of constructive noise fields within 150 m horizontally from the source.

The PK-PK ranges for the boomer are shown in Table 11. Due to the high threshold levels, the ranges were calculated assuming an acoustic field that is initially spherically spreading. This is valid where the source can be considered a point source, and there is no influence from reflecting surfaces. Due also to the directionality of the source, the ranges to the thresholds on-axis are going to be significantly greater than those off-axis and thus the vertical ranges from the sources are presented. It is shown that for the triple-plate boomer, the level drops below all relevant isopleths within 11 m of the source. Similar principles apply for PK levels in Table 12; the greatest range to a specified threshold is 1.6 m.

The SBP is a higher-frequency, more directional, and lower energy source than the boomer; consequently, the ranges are consistently lower. Using the generated source levels, the threshold for turtle behaviour is not reached at any horizontal distance from the source, and the marine mammal behavioural threshold is exceeded up to 2 m horizontally from the source (Table 13). Additionally, the ranges to thresholds at the seafloor are accordingly small (Table 15); here it is of note that the 115 and 120 dB re 1 µPa²·s SEL levels are at their greatest ranges at Site 2 due to the greater distance the conical beam may propagate, and thus widen, before reaching the interface.

For the SBP, the PK-PK and PK results were treated in the same way as for the boomer; results are shown for a spherically spreading noise field with the on-axis sound pressure analysed to determine ranges to thresholds. For the identified thresholds of interest for the SBP, the vertical distance does not exceed 1.4 m. In summary, sound fields from the boomer and the SBP do not reach any of the assessed thresholds for benthic crustaceans or fish (Section 2) at the seafloor.

The single pulse results for the VSP operated at Site 5 are shown in Section 4.2.1.3. The source has a significantly higher source level than either the boomer or the sub-bottom profiler. The maximum range to the DEWHA (2008) criterion of 160 dB re 1 µPa²·s SEL is 1.06 km, while the $R_{95\%}$ range is predicted to be 1.03 km. The maximum ranges to the marine mammal and turtle behavioural thresholds of 160 and 166 dB re 1 µPa SPL are 2.56 and 1.55 km respectively. The per-pulse SEL levels at the seafloor were modelled using VSTACK to allow for levels to be determined at high propagation angles. The maximum per-pulse SEL on the seafloor below the array is 181 dB re 1 µPa²·s, therefore the levels from Day et al. (2016b) of 190, 188 and 186 dB re 1 µPa²·s, are not reached at the seafloor.

In the case of the VSP source, PK thresholds of interest are reached at the seafloor and so it was modelled fully with all environmental parameters considered, rather than the spherical spreading approach used for the other two sources. The results show that the lowest isopleth of interest derived from Day et al. (2016b), 209 dB re 1 µPa, is not reached at the seafloor, and the horizontal range along the seafloor to the 202 dB re 1 µPa PK-PK level from Payne et al. (2007) is 185 m. PK metrics relevant to the Popper et al. (2014) criteria for fish are also not reached at the seafloor.

In this modelling study, both the boomer and sub-bottom profiler sources were directed straight down. Consequently, the sound channels constructed as a result of the sound speed profile are unlikely to influence the propagation of sound greatly. It is of note, that if either high-frequency source is directed toward the sea surface then the sound channels are likely to enhance the propagation of these sources. As the VSP is typically a low-frequency source, the fine details in the sound speed profile near the surface are unlikely to influence the propagation.

5.3. Multiple pulse sound fields

The study included modelling to assess the cumulative effect of noise generated for four separate survey areas. The surveys themselves comprise multiple lines along which the boomer and sub-bottom profiler sources are fired alternately. In total, more than 27000 pulses were included for the Thylacine Combined survey over the estimated 51 h of survey, and more than 21000 pulses for each of the other three surveys over the estimated 40.2 h. Sound levels were assessed only at the seafloor with results shown in Table 14. The modelling results show that the SEL at the seafloor did not exceed 170 dB re 1 µPa²·s for any single survey. This is below any of the relevant isopleths for benthic invertebrates, including the 183 dB re 1 µPa²·s 'no effect' accumulated SEL (McCauley and Duncan 2016). Due to the identical sources, and sound speed profiles, and similar depths and geoacoustics, the ranges between the surveys are similar. The greatest ranges are realised for the Thylacine Combined survey; here, the survey is in deeper water than the others as well as featuring the caprock layer that is likely to produce stronger reflections off the sediment layer.

Glossary

3-D
Three-dimensional

1/3-octave-band
Non-overlapping passbands that are one-third of an octave wide (where an octave is a doubling of frequency). Three adjacent 1/3-octave-bands comprise a one octave-band. One-third-octave-bands become wider with increasing frequency. Also see octave.

90% time window
The time interval over which the cumulative energy rises from 5% to 95% of the total pulse energy. This interval contains 90% of the total pulse energy. Symbol: T_{90}.

90% sound pressure level (SPL(T_{90}))
The root-mean-square sound pressure levels calculated over the 90%-energy time window of a pulse. Used only for pulsed sounds.

attenuation
The gradual loss of acoustic energy from absorption and scattering as sound propagates through a medium.

audiogram
A graph of hearing threshold level (sound pressure levels) as a function of frequency, which describes the hearing sensitivity of an animal over its hearing range.

azimuth
A horizontal angle relative to a reference direction, which is often magnetic north or the direction of travel. In navigation it is also called bearing.

bandwidth
The range of frequencies over which a sound occurs. Broadband refers to a source that produces sound over a broad range of frequencies (e.g., seismic airguns, vessels) whereas narrowband sources produce sounds over a narrow frequency range (e.g., sonar) (ANSI/ASA S1.13-2005 R2010).

BIA
Biologically Important Area (http://www.environment.gov.au/marine/marine-species/bias)

broadside direction
Perpendicular to the travel direction of a source. Compare to endfire direction.

cetacean
Any animal in the order Cetacea. These are aquatic, mostly marine mammals and include whales, dolphins, and porpoises.

decibel (dB)
One-tenth of a bel. Unit of level when the base of the logarithm is the tenth root of ten, and the quantities concerned are proportional to power (ANSI S1.1-1994 R2004).

endfire direction
Parallel to the travel direction of a source. Also see broadside direction.

ensonified area
The total area ensonified in conjunction with a specified isopleth.

frequency
The rate of oscillation of a periodic function measured in cycles-per-unit-time. The reciprocal of the period. Unit: hertz (Hz). Symbol: *f*. 1 Hz is equal to 1 cycle per second.

functional hearing group
Grouping of marine mammal species with similar estimated hearing ranges. Southall et al. (2007) proposed the following functional hearing groups: low-, mid-, and high-frequency cetaceans, pinnipeds in water, and pinnipeds in air.

geoacoustic
Relating to the acoustic properties of the seafloor.

hearing threshold
The sound pressure level that is barely audible for a given individual in the absence of significant background noise during a specific percentage of experimental trials.

hertz (Hz)
A unit of frequency defined as one cycle per second.

high-frequency cetacean
The functional hearing group that represents odontocetes specialised for using high frequencies.

impulsive sound
Sound that is typically brief and intermittent with rapid (within a few seconds) rise time and decay back to ambient levels (NOAA 2013, ANSI S12.7-1986 R2006). For example, seismic airguns and impact pile driving.

low-frequency cetacean
The functional hearing group that represents mysticetes (baleen whales).

maximum-over-depth (MOD)
The maximum value over all modelled depths above the sea floor.

mid-frequency cetacean
The functional hearing group that represents some odontocetes (dolphins, toothed whales, beaked whales, and bottlenose whales).

mysticete
Mysticeti, a suborder of cetaceans, use their baleen plates, rather than teeth, to filter food from water. They are not known to echolocate, but use sound for communication. Members of this group include rorquals (Balaenopteridae), right whales (Balaenidae), and the grey whale (*Eschrichtius robustus*).

non-impulsive sound
Sound that is broadband, narrowband or tonal, brief or prolonged, continuous or intermittent, and typically does not have a high peak pressure with rapid rise time (typically only small fluctuations in decibel level) that impulsive signals have (ANSI/ASA S3.20-1995 R2008). Marine vessels, aircraft, machinery, construction, and vibratory pile driving are examples.

octave
The interval between a sound and another sound with double or half the frequency. For example, one octave above 200 Hz is 400 Hz, and one octave below 200 Hz is 100 Hz.

odontocete
The presence of teeth, rather than baleen, characterises these whales. Members of the Odontoceti are a suborder of cetaceans, a group comprised of whales, dolphins, and porpoises. The toothed whales' skulls are mostly asymmetric, an adaptation for their echolocation. This group includes sperm whales, killer whales, belugas, narwhals, dolphins, and porpoises.

parabolic equation method
A computationally-efficient solution to the acoustic wave equation that is used to model transmission loss. The parabolic equation approximation omits effects of back-scattered sound, simplifying the computation of transmission loss. The effect of back-scattered sound is negligible for most ocean-acoustic propagation problems.

peak sound pressure level (PK)
The maximum instantaneous sound pressure level, in a stated frequency band, within a stated period. Also called zero-to-peak sound pressure level. Unit: dB re 1 µPa

permanent threshold shift (PTS)
A permanent loss of hearing sensitivity caused by excessive noise exposure. PTS is considered auditory injury.

pinniped
A common term used to describe all three groups that form the superfamily Pinnipedia: phocids (true seals or earless seals), otariids (eared seals or fur seals and sea lions), and walrus.

point source
A source that radiates sound as if from a single point (ANSI S1.1-1994 R2004).

power spectrum density
The acoustic signal power per unit frequency as measured at a single frequency. Unit: µPa^2/Hz, or µPa^2·s.

power spectrum density level
The decibel level ($10\log_{10}$) of the power spectrum density, usually presented in 1 Hz bins. Unit: dB re 1 µPa^2/Hz.

pressure, acoustic
The deviation from the ambient hydrostatic pressure caused by a sound wave. Also called overpressure. Unit: pascal (Pa). Symbol: p.

pulsed sound
Discrete sounds with durations less than a few seconds. Sounds with longer durations are called continuous sounds.

received level
The sound level measured at a receiver.

signature
Pressure signal generated by a source.

sound
A time-varying pressure disturbance generated by mechanical vibration waves travelling through a fluid medium such as air or water.

sound exposure
Time integral of squared, instantaneous frequency-weighted sound pressure over a stated time interval or event. Unit: pascal-squared second (Pa^2·s) (ANSI S1.1-1994 R2004).

sound exposure level (SEL)
A measure related to the sound energy in one or more pulses. Unit: dB re 1 µPa^2·s.

sound field
Region containing sound waves (ANSI S1.1-1994 R2004).

sound pressure level (SPL)

The decibel ratio of the time-mean-square sound pressure, in a stated frequency band, to the square of the reference sound pressure (ANSI S1.1-1994 R2004).

For sound in water, the reference sound pressure is one micropascal (p_0 = 1 µPa) and the unit for SPL is dB re 1 µPa:

$$\mathrm{SPL} = 10\log_{10}\left(p^2 / p_0^2\right) = 20\log_{10}\left(p / p_0\right)$$

Unless otherwise stated, SPL refers to the root-mean-square sound pressure level Unit: dB re 1 µPa.

sound speed profile

The speed of sound in the water column as a function of depth below the water surface.

source level (SL)

The sound pressure level or sound exposure level measured 1 metre from a theoretical point source that radiates the same total sound power as the actual source. Unit: dB re 1 µPa @ 1 m or dB re 1 µPa^2·s.

spectrum

An acoustic signal represented in terms of its power (or energy) distribution versus frequency.

SBP

Sub-bottom profiler.

temporary threshold shift (TTS)

Temporary loss of hearing sensitivity caused by excessive noise exposure.

transmission loss (TL)

Also called propagation loss, this refers to the decibel reduction in sound level between two stated points that results from sound spreading away from an acoustic source subject to the influence of the surrounding environment.

VSP

Vertical Seismic Profiler.

wavelength

Distance over which a wave completes one oscillation cycle. Unit: meter (m). Symbol: λ.

Literature Cited

[DEWHA] Department of the Environment, W., Heritage and the Arts. 2008. *EPBC Act Policy Statement 2.1 - Interaction Between Offshore Seismic Exploration and Whales*. *In*: Department of the Environment, W., Heritage and the Arts. 14 pp.

[ISO] International Organization for Standardization. 2016. *ISO/DIS 18405.2:2017. Underwater acoustics—Terminology*. Geneva. https://www.iso.org/standard/62406.html.

[ITC] International Transducer Corporation. 1993. *Application Equations for Underwater Sound Transducers* (pamphlet). International Transducer Corporation, Santa Barbara, CA.

[NMFS] National Marine Fisheries Service. 2013. *Marine Mammals: Interim Sound Threshold Guidance* (webpage). National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce. http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/threshold_guidance.html.

[NMFS] National Marine Fisheries Service. 2016. *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts*. U.S. Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-55. 178 pp. http://www.nmfs.noaa.gov/pr/acoustics/Acoustic%20Guidance%20Files/opr-55_acoustic_guidance_tech_memo.pdf.

[NOAA] National Oceanic and Atmospheric Administration. 2013. *Draft guidance for assessing the effects of anthropogenic sound on marine mammals: Acoustic threshold levels for onset of permanent and temporary threshold shifts*, December 2013, 76 pp. Silver Spring, Maryland: NMFS Office of Protected Resources. http://www.nmfs.noaa.gov/pr/acoustics/draft_acoustic_guidance_2013.pdf.

[NSF] National Science Foundation (U.S.), U.S. Geological Survey, and [NOAA] National Oceanic and Atmospheric Administration (U.S.). 2011. *Final Programmatic Environmental Impact Statement/Overseas. Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey*. National Science Foundation, Arlington, VA.

Aerts, L., M. Blees, S. Blackwell, C. Greene, K. Kim, D. Hannay, and M. Austin. 2008. *Marine mammal monitoring and mitigation during BP Liberty OBC seismic survey in Foggy Island Bay, Beaufort Sea, July-August 2008: 90-day report*. Document Number LGL Report P1011-1. Report by LGL Alaska Research Associates Inc., LGL Ltd., Greeneridge Sciences Inc. and JASCO Applied Sciences for BP Exploration Alaska. 199 pp. http://www.nmfs.noaa.gov/pr/pdfs/permits/bp_liberty_monitoring.pdf.

ANSI S12.7-1986. R2006. *American National Standard Methods for Measurements of Impulsive Noise*. American National Standards Institute, New York.

ANSI S1.1-1994. R2004. *American National Standard Acoustical Terminology*. American National Standards Institute, New York.

ANSI S1.1-2013. R2013. *American National Standard Acoustical Terminology*. American National Standards Institute, New York.

ANSI/ASA S1.13-2005. R2010. *American National Standard Measurement of Sound Pressure Levels in Air*. American National Standards Institute and Acoustical Society of America, New York.

ANSI/ASA S3.20-1995. R2008. *American National Standard Bioacoustical Terminology*. American National Standards Institute and Acoustical Society of America, New York.

Applied Acoustics Engineering. 2013. *AA2xx Series Seismic Source Operation Manual*. https://www.seatronics-group.com/files/3714/1753/6053/Applied_Acoustic_A200_Boomer_Plate_-_Manual.pdf

Carnes, M.R. 2009. *Description and Evaluation of GDEM-V 3.0*. Document Number NRL Memorandum Report 7330-09-9165. US Naval Research Laboratory, Stennis Space Center, MS. 21 pp.

Collins, M.D. 1993. A split-step Padé solution for the parabolic equation method. *Journal of the Acoustical Society of America* 93(4): 1736-1742.

Collins, M.D., R.J. Cederberg, D.B. King, and S. Chin-Bing. 1996. Comparison of algorithms for solving parabolic wave equations. *Journal of the Acoustical Society of America* 100(1): 178-182.

Coppens, A.B. 1981. Simple equations for the speed of sound in Neptunian waters. *Journal of the Acoustical Society of America* 69(3): 862-863. http://link.aip.org/link/?JAS/69/862/1.

Day, R., D., R.D. McCauley, Q.P. Fitzgibbon, K. Hartmann, J.M. Semmens, and Institute for Marine and Antarctic Studies. 2016a. *Assessing the Impact of Marine Seismic Surveys on Southeast Australian Scallop and Lobster Fisheries. FRDC Project No 2012/008*. Impacts of Marine Seismic Surveys on Scallop and Lobster Fisheries. Fisheries Ressearch & Development Corporation, University of Tasmania, Hobart. 159 pp.

Day, R.D., R.D. McCauley, Q.P. Fitzgibbon, and J.M. Semmens. 2016b. Seismic air gun exposure during early-stage embryonic development does not negatively affect spiny lobster *Jasus edwardsii larvae* (Decapoda:Palinuridae). *Scientific Reports* 6: 1-9. http://dx.doi.org/10.1038/srep22723.

Dragoset, W.H. 1984. A comprehensive method for evaluating the design of airguns and airgun arrays. *16th Annual Proc. Offshore Tech. Conf.* Volume 3. 75–84 pp.

Duncan, A. 2017. *In-field validation of modelled underwater sound levels from the Crowes Foot 3D seismic survey*. Report Number 2016-35. Report by CMST for Origin Energy. 23 pp.

Fisher, F.H. and V.P. Simmons. 1977. Sound absorption in sea water. *Journal of the Acoustical Society of America* 62(3): 558-564. http://link.aip.org/link/?JAS/62/558/1.

Funk, D., D. Hannay, D. Ireland, R. Rodrigues, and W. Koski (eds.). 2008. *Marine mammal monitoring and mitigation during open water seismic exploration by Shell Offshore Inc. in the Chukchi and Beaufort Seas, July–November 2007: 90-day report*. LGL Report P969-1. Prepared by LGL Alaska Research Associates Inc., LGL Ltd., and JASCO Research Ltd. for Shell Offshore Inc., National Marine Fisheries Service (US), and US Fish and Wildlife Service. 218 pp.

Gedamke, J., N. Gales, and S. Frydman. 2011. Assessing risk of baleen whale hearing loss from seismic surveys: The effect of uncertainty and individual variation. *Journal of the Acoustical Society of America* 129(1): 496-506. http://www.ncbi.nlm.nih.gov/pubmed/21303030.

Hamilton, E.L. 1980. Geoacoustic modeling of the sea floor. *Journal of the Acoustical Society of America* 68(5): 1313-1340.

Hannay, D. and R. Racca. 2005. *Acoustic Model Validation*. Document Number 0000-S-90-04-T-7006-00-E, Revision 02. Technical report for Sakhalin Energy Investment Company Ltd. by JASCO Research Ltd. 34 pp.

Ireland, D.S., R. Rodrigues, D. Funk, W. Koski, and D. Hannay. 2009. *Marine mammal monitoring and mitigation during open water seismic exploration by Shell Offshore Inc. in the Chukchi and Beaufort Seas, July–October 2008: 90-Day Report*. Document Number LGL Report P1049-1. 277 pp.

Kinsler, L.E., A.R. Frey, A.B. Coppens, and J.V. Sanders. 1950. *Fundamentals of acoustics*. John Wiley & Sons Inc., New York.

Landro, M. 1992. Modeling of GI gun signatures. *Geophysical Prospecting* 40: 721–747.

Laws, M., L. Hatton, and M. Haartsen. 1990. Computer modeling of clustered airguns. *First Break* 8: 331–338.

Lurton, X. 2002. *An Introduction to Underwater Acoustics: Principles and Applications.* Springer, Chichester, U.K.

MacGillivray, A.O. and N.R. Chapman. 2012. Modeling underwater sound propagation from an airgun array using the parabolic equation method. *Canadian Acoustics* 40(1): 19-25. http://jcaa.caa-aca.ca/index.php/jcaa/article/view/2502.

Martin, B., J. MacDonnell, N.E. Chorney, and D. Zeddies. 2012. Appendix A: Sound Source Verification of Fugro Geotechnical Sources. *In ESS Group, Inc. Renewal Application for Incidental Harassment Authorization for the Non-Lethal Taking of Marine Mammals Resulting from Pre-Construction High Resolution Geophysical Survey*. For Cape Wind Associates, LLC. http://www.nmfs.noaa.gov/pr/pdfs/permits/capewind_iha_application_renewal.pdf.

Martin, B., K. Broker, M.-N.R. Matthews, J. MacDonnell, and L. Bailey. 2015. *Comparison of measured and modeled air-gun array sound levels in Baffin Bay, West Greenland. OceanNoise 2015*, 11-15 May, Barcelona, Spain.

Massa, D.P. 2003. Acoustic transducers. *In Wiley Encyclopedia of Telecommunications*. John Wiley & Sons, Inc.

Mattsson, A. and M. Jenkerson. 2008. *Single Airgun and Cluster Measurement Project*. *Joint Industry Programme (JIP) on Exploration and Production Sound and Marine Life Proramme Review*, October 28-30. International Association of Oil and Gas Producers, Houston, TX.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adihyta, J. Murdoch, et al. 2000. Marine seismic surveys: A study of environmental implications. *Australian Petroleum Production Exploration Association (APPEA) Journal* 40: 692-708.

McCauley, R.D. and A. Duncan. 2016. *Estimation of sound exposure levels at "Big Reef" from proposed Crowes Foot seismic survey, Victoria 2016*. Report 2016-26 by CMST for ERM / Origin Energy Ltd.

Moein, S.E., J.A. Musick, J.A. Keinath, D.E. Barnard, M.L. Lenhardt, and R. George. 1995. *Evaluation of Seismic Sources for Repelling Sea Turtles from Hopper Dredges, in Sea Turtle Research Program: Summary Report*. *In*: Hales, L.Z. (ed.). Report from U.S. Army Engineer Division, South Atlantic, Atlanta GA, and U.S. Naval Submarine Base, Kings Bay GA. Technical Report CERC-95. 90 pp.

O'Neill, C., D. Leary, and A. McCrodan. 2010. Sound Source Verification. (Chapter 3) *In* Blees, M.K., K.G. Hartin, D.S. Ireland, and D. Hannay (eds.). *Marine mammal monitoring and mitigation during open water seismic exploration by Statoil USA E&P Inc. in the Chukchi Sea, August-October 2010: 90-day report*. LGL Report P1119. Prepared by LGL Alaska Research Associates Inc., LGL Ltd., and JASCO Applied Sciences Ltd. for Statoil USA E&P Inc., National Marine Fisheries Service (US), and US Fish and Wildlife Service. 1-34.

Payne, J.F., C. Andrews, L. Fancey, A.L. Cook, and J.R. Christian. 2007. *Pilot study on the effects of seismic air gun noise on lobster (Homarus americanus)*. Report Number 2712.

Payne, J.F., C. Andrews, L. Fancey, D. White, and J. Christian. 2008. *Potential Effects of Seismic Energy on Fish and Shellfish: An Update since 2003*. Report Number 2008/060. Canadian Science Advisory Secretariat. 22 pp.

Popper, A.N., A.D. Hawkins, R.R. Fay, D.A. Mann, S. Bartol, T.J. Carlson, S. Coombs, W.T. Ellison, R.L. Gentry, et al. 2014. *Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI*. SpringerBriefs in Oceanography, Volume ASA S3/SC1.4 TR-2014. ASA Press.

Popper, A.N., T.J. Carlson, J.A. Gross, A.D. Hawkins, D. Zeddies, L. Powell, and J. Young. 2016. Effects of Seismic Air Guns on Pallid Sturgeon and Paddlefish. *Adv Exp Med Biol* 875: 871-8. NLM.

Porter, M.B. and Y.-C. Liu. 1994. Finite-element ray tracing. *In*: Lee, D. and M.H. Schultz (eds.). *Proceedings of the International Conference on Theoretical and Computational Acoustics*. Volume 2. World Scientific Publishing Co. 947-956 pp.

Racca, R., A. Rutenko, K. Bröker, and M. Austin. 2012a. A line in the water - design and enactment of a closed loop, model based sound level boundary estimation strategy for mitigation of behavioural impacts from a seismic survey. *11th European Conference on Underwater Acoustics 2012*. Volume 34(3), Edinburgh, United Kingdom.

Racca, R., A. Rutenko, K. Bröker, and G. Gailey. 2012b. *Model based sound level estimation and in-field adjustment for real-time mitigation of behavioural impacts from a seismic survey and post-event evaluation of sound exposure for individual whales*. *Acoustics 2012 Fremantle: Acoustics, Development and the Environment*, Fremantle, Australia. http://www.acoustics.asn.au/conference_proceedings/AAS2012/papers/p92.pdf.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene, Jr., D. Kastak, D.R. Ketten, J.H. Miller, et al. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals* 33(4): 411-521.

Teague, W.J., M.J. Carron, and P.J. Hogan. 1990. A comparison between the Generalized Digital Environmental Model and Levitus climatologies. *Journal of Geophysical Research* 95(C5): 7167-7183.

Verbeek, N.H. and T.M. McGee. 1995. Characteristics of high-resolution marine reflection profiling sources. *Journal of Applied Geophysics* 33(4): 251-269.

Warner, G., C. Erbe, and D. Hannay. 2010. Underwater Sound Measurements. (Chapter 3) *In* Reiser, C.M., D.W. Funk, R. Rodrigues, and D. Hannay (eds.). *Marine Mammal Monitoring and Mitigation during Open Water Shallow Hazards and Site Clearance Surveys by Shell Offshore Inc. in the Alaskan Chukchi Sea, July-October 2009: 90-Day Report*. LGL Report P1112-1. Report by LGL Alaska Research Associates Inc. and JASCO Applied Sciences for Shell Offshore Inc., National Marine Fisheries Service (US), and US Fish and Wildlife Service. 1-54.

Zhang, Y. and C. Tindle. 1995. Improved equivalent fluid approximations for a low shear speed ocean bottom. *Journal of the Acoustical Society of America* 98(6): 3391-3396. http://scitation.aip.org/content/asa/journal/jasa/98/6/10.1121/1.413789.

Ziolkowski, A. 1970. A method for calculating the output pressure waveform from an air gun. *Geophysical Journal of the Royal Astronomical Society* 21(2): 137-161.

Zykov, M. 2013. *Underwater Sound Modeling of Low Energy Geophysical Equipment Operations*. Document Number 00600 Version 1.0. Technical report for CSA Ocean Sciences by JASCO Applied Sciences Ltd. http://www.slc.ca.gov/Programs/OGPP/AppG.pdf.

Appendix A. Acoustic Metrics

Underwater sound pressure amplitude is measured in decibels (dB) relative to a fixed reference pressure of $p_0 = 1$ µPa. Because the perceived loudness of sound, especially impulsive noise such as from seismic airguns, pile driving, and sonar, is not generally proportional to the instantaneous acoustic pressure, several sound level metrics are commonly used to evaluate noise and its effects on marine life. We provide specific definitions of relevant metrics used in the accompanying report. Where possible we follow the ANSI and ISO standard definitions and symbols for sound metrics, but these standards are not always consistent.

The zero-to-peak sound pressure level, or peak sound pressure level (PK; dB re 1 µPa), is the maximum instantaneous sound pressure level in a stated frequency band attained by an acoustic pressure signal, $p(t)$:

$$L_{p,pk} = 20\log_{10}\left[\frac{\max\left(|p(t)|\right)}{p_0}\right] \tag{A-1}$$

$L_{p,pk}$ is often included as a criterion for assessing whether a sound is potentially injurious; however, because it does not account for the duration of a noise event, it is generally a poor indicator of perceived loudness.

The root-mean-square (rms) sound pressure level (SPL; dB re 1 µPa) is the rms pressure level in a stated frequency band over a specified time window (T, s) containing the acoustic event of interest. It is important to note that SPL always refers to an rms pressure level and, therefore, not instantaneous pressure:

$$L_p = 10\log_{10}\left(\frac{1}{T}\int_T p^2(t)dt \Big/ p_0^2\right) \tag{A-2}$$

The SPL represents a nominal effective continuous sound over the duration of an acoustic event, such as the emission of one acoustic pulse, a marine mammal vocalisation, the passage of a vessel, or over a fixed duration. Because the window length, T, is the divisor, events with similar sound exposure level (SEL) but more spread out in time have a lower SPL. Throughout this study, a fixed time window of 125 ms is used as the integration period.

The sound exposure level (SEL, dB re 1 µPa²·s) is a measure related to the acoustic energy contained in one or more acoustic events (N). The SEL for a single event is computed from the time-integral of the squared pressure over the full event duration (T):

$$L_E = 10\log_{10}\left(\int_T p^2(t)dt \Big/ T_0 p_0^2\right) \tag{A-3}$$

where T_0 is a reference time interval of 1 s. The SEL continues to increase with time when non-zero pressure signals are present. It therefore can be construed as a dose-type measurement so the integration time used must be carefully considered in terms of relevance for impact to the exposed recipients.

SEL can be calculated over periods with multiple acoustic events or over a fixed duration. For a fixed duration, the square pressure is integrated over the duration of interest. For multiple events, the SEL can be computed by summing (in linear units) the SEL of the N individual events:

$$L_{E,N} = 10\log_{10}\left(\sum_{i=1}^{N} 10^{\frac{L_{E,i}}{10}}\right) \tag{A-4}$$

If applied, the frequency weighting of an acoustic event should be specified, as in the case of M-weighted SEL (e.g., $\text{SEL}_{\text{LFC,24h}}$). The use of fast, slow, or impulse exponential-time-averaging, or other time-related characteristics should else be specified.

Because the SPL and SEL are both computed from the integral of square pressure, these metrics are related by a simple expression, which depends only on the duration of the 90% energy time window T_{90}:

$$L_E = L_{p90} + 10\log_{10}(T_{90}) + 0.458 \tag{A-5}$$

where the 0.458 dB factor accounts for the SPL containing 90% of the total energy from the per-pulse SEL.

Appendix B. Acoustic Source Modelling

B.1. Transducer Beam Theory

Mid- and high-frequency underwater acoustic sources for geophysical measurements create an oscillatory overpressure through rapid vibration of a surface, using either electromagnetic forces or the piezoelectric effect of materials. A vibratory source based on the piezoelectric effect is commonly referred to as a transducer, and may be capable of receiving as well as emitting signals. Transducers are usually designed to produce an acoustic wave of a specific frequency, often in a highly directive beam. The directional capability increases with increasing operating frequency. The main parameter characterizing directivity is the beamwidth, defined as the angle subtended by diametrically opposite "half power" (-3 dB) points of the main lobe (Massa 2003). For different transducers, the beamwidth varies from 180° (almost omnidirectional) to a few degrees.

Transducers are usually built with either circular or rectangular active surfaces. For circular transducers, the beam pattern in the horizontal plane (assuming a downward pointing main beam) is equal in all directions. The beam pattern of a rectangular transducer is variable with the azimuth in the horizontal plane.

The acoustic radiation pattern, or beam pattern, of a transducer is the relative measure of acoustic transmitting or receiving power as a function of spatial angle. Directionality is generally measured in decibels relative to the maximum radiation level along the central axis perpendicular to the transducer surface. The pattern is defined largely by the operating frequency of the device and the size and shape of the transducer. Beam patterns generally consist of a main lobe, extending along the central axis of the transducer, and multiple secondary lobes separated by nulls. The width of the main lobe depends on the size of the active surface relative to the sound wavelength in the medium. Larger transducers produce narrower beams. Figure B-1 shows a 3-dimensional (3-D) visualisation of a typical beam pattern for a circular transducer.

The true beam pattern of a transducer can be obtained only by in situ measurement of the emitted energy around the device. Such data, however, are not always available, and for propagation modelling it is often sufficient to estimate the beam pattern of the source based on transducer beam theory. An example of a measured beam pattern is shown in Figure B-2.

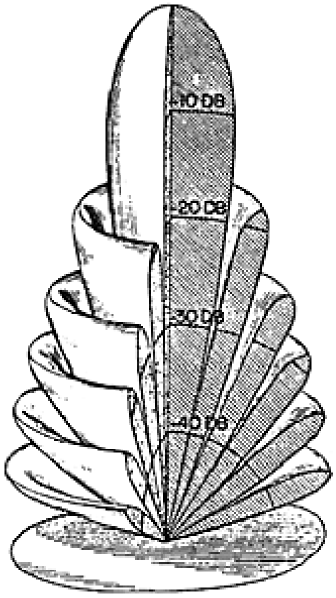


Figure B-1. Typical 3-D beam pattern for a circular transducer (Massa 2003).

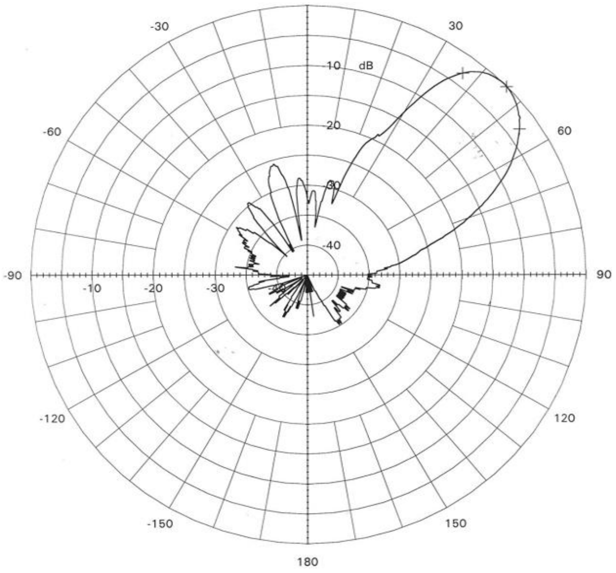


Figure B-2. Vertical cross section of a beam pattern measured in situ from a transducer used by Kongsberg (source: Zykov (2013)).

B.2. Circular Transducers

The beam of an ideal circular transducer is symmetrical about the main axis; the radiated level depends only on the depression angle. In this study, beam directivities were calculated from the standard formula for the beam pattern of a circular transducer (Kinsler et al. 1950, [ITC] International Transducer Corporation 1993). The directivity function of a conical beam relative to the on-axis pressure amplitude is:

$$R(\phi) = \frac{2 \cdot J_1\left(\pi\, D_\lambda \sin(\phi)\right)}{\pi\, D_\lambda \sin(\phi)} \text{ and } D_\lambda = \frac{60}{\theta_{bw}}, \tag{1}$$

where J_1 is the first-order Bessel function, D_λ is the transducer dimension in wavelengths of sound in the medium, θ_{bw} is the beamwidth in degrees, and ϕ is the beam angle from the transducer axis. The beam pattern of a circular transducer can be calculated from the transducer's specified beamwidth or from the diameter of the active surface and the operating frequency. The calculated beam pattern for a circular transducer with a beamwidth of 20° is shown in Figure B-3. The grayscale represents the source level (dB re 1 µPa @ 1 m) and the declination angle is relative to a central vector (0°, 0°) pointing down.

Although some acoustic energy is emitted at the back of the transducer, the theory accounts for the beam power in only the front half-space ($\phi < 90°$) and assumes no energy directed into the back half-space. The relative power at these rearward angles is significantly lower, generally by more than 30 dB, and consequently the emission in the back half-space can be estimated by applying a simple decay rate, in decibels per angular degree, which gives a beam power at $\phi = 90°$ of 30 dB less than that at $\phi = 0°$. This is a conservative estimate of the beam power in the back half-space.

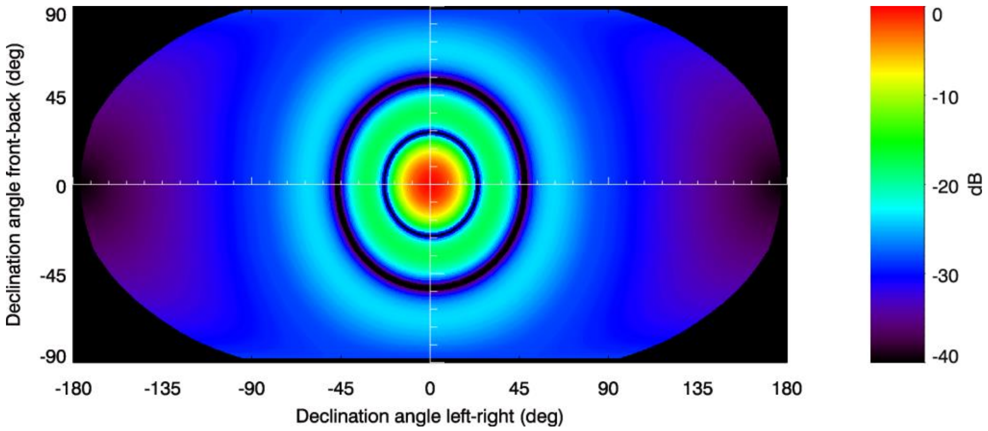


Figure B-3. Calculated beam pattern for a circular transducer with a beamwidth of 20°. The beam power function is shown relative to the on-axis level using the Robinson projection.

B.3. VSP Modelling

The source levels and directivity of the airgun array were predicted with JASCO's Airgun Array Source Model (AASM). AASM includes low- and high-frequency modules for predicting different components of the airgun array spectrum. The low-frequency module is based on the physics of oscillation and radiation of airgun bubbles, as originally described by Ziolkowski (1970), that solves the set of parallel differential equations that govern bubble oscillations. Physical effects accounted for in the simulation include pressure interactions between airguns, port throttling, bubble damping, and generator-injector (GI) gun behaviour discussed by Dragoset (1984), Laws et al. (1990), and Landro (1992). A global optimisation algorithm tunes free parameters in the model to a large library of airgun source signatures.

Whilst airgun signatures are highly repeatable at the low frequencies, which are used for seismic imaging, their sound emissions have a large random component at higher frequencies that cannot be predicted deterministically. Therefore, the high-frequency module of AASM uses a stochastic simulation to predict the sound emissions of individual airguns above 800 Hz, using a multivariate statistical model. The current version of AASM has been tuned to fit a large library of high quality seismic source signature data obtained from the Joint Industry Program (JIP) on Sound and Marine Life (Mattsson and Jenkerson 2008). The stochastic model uses a Monte-Carlo simulation of the random component of the high-frequency spectrum of each airgun in an array. The mean high-frequency spectra from the stochastic model augment the low-frequency signatures from the physical model, allowing AASM to predict airgun source levels at frequencies up to 25,000 Hz.

AASM produces a set of “notional” signatures for each array element based on:

- Array layout
- Volume, tow depth, and firing pressure of each airgun
- Interactions between different airguns in the array

These notional signatures are the pressure waveforms of the individual airguns at a standard reference distance of 1 m; they account for the interactions with the other airguns in the array. The signatures are summed with the appropriate phase delays to obtain the far-field source signature of the entire array in all directions. This far-field array signature is filtered into 1/3-octave-bands to compute the source levels of the array as a function of frequency band and azimuthal angle in the horizontal plane (at the source depth), after which it is considered to be a directional point source in the far field.

A seismic array consists of many sources and the point-source assumption is invalid in the near field where the array elements add incoherently. The maximum extent of the near field of an array (R_{nf}) is:

$$R_{\mathrm{nf}} < \frac{l^2}{4\lambda} \tag{B-2}$$

where λ is the sound wavelength and *l* is the longest dimension of the array (Lurton 2002, §5.2.4). For example, an airgun array length of *l* = 21 m yields a near-field range of 147 m at 2 kHz and 7 m at 100 Hz. Beyond this R_{nf} range, the array is assumed to radiate like a directional point source and is treated as such for propagation modelling.

The interactions between individual elements of the array create directionality in the overall acoustic emission. Generally, this directionality is prominent mainly at frequencies in the mid-range between tens of hertz to several hundred hertz. At lower frequencies, with acoustic wavelengths much larger than the inter-airgun separation distances, the directionality is small. At higher frequencies, the pattern of lobes is too finely spaced to be resolved and the effective directivity is less.

B.4. VSP Acoustic Source Levels and Directivity Results

Figure B-4 shows the broadside (perpendicular to the tow direction), endfire (parallel to the tow direction), and vertical overpressure signatures and corresponding power spectrum levels for the 3090 in^3 array. The signatures consist of a strong primary peak, related to the initial release of high-pressure air, followed by a series of pulses associated with bubble oscillations. Most energy is produced at frequencies below 200 Hz. Frequency-dependent peaks and nulls in the spectrum result from interference among airguns in the array, and correspond with the volumes and relative locations of the airguns to each other.

Horizontal 1/3-octave-band source levels are shown as a function of band centre frequency and azimuth (Figure B-5); directivity in the sound field is most noticeable at mid-frequencies as described in the model detail in Appendix B.3.

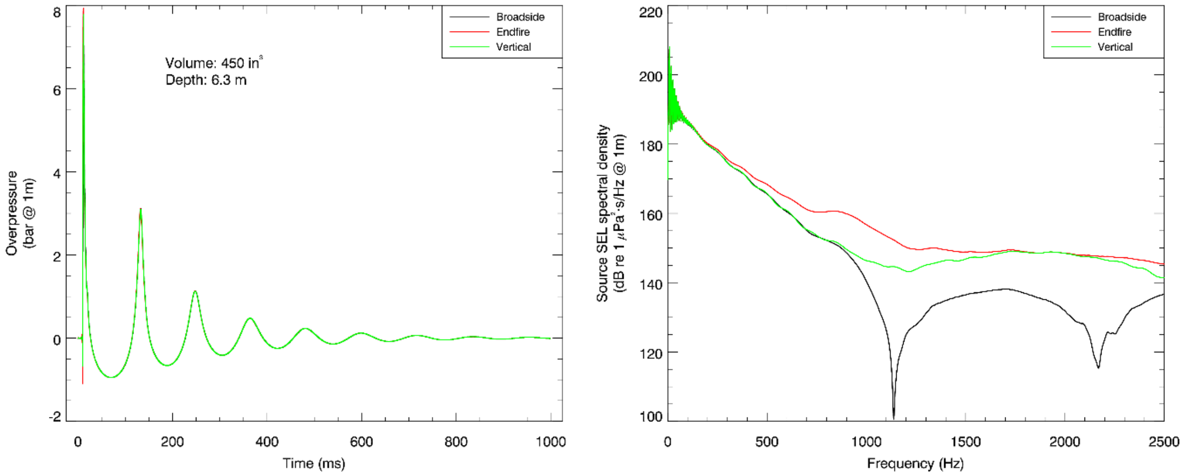


Figure B-4. Predicted source level details for the 450 in^3 VSP array operated at a centroid depth of 6 m. (Left) the overpressure signature and (right) the power spectrum for broadside (perpendicular to tow direction) and endfire (directly aft of the array) directions, and for vertically down.

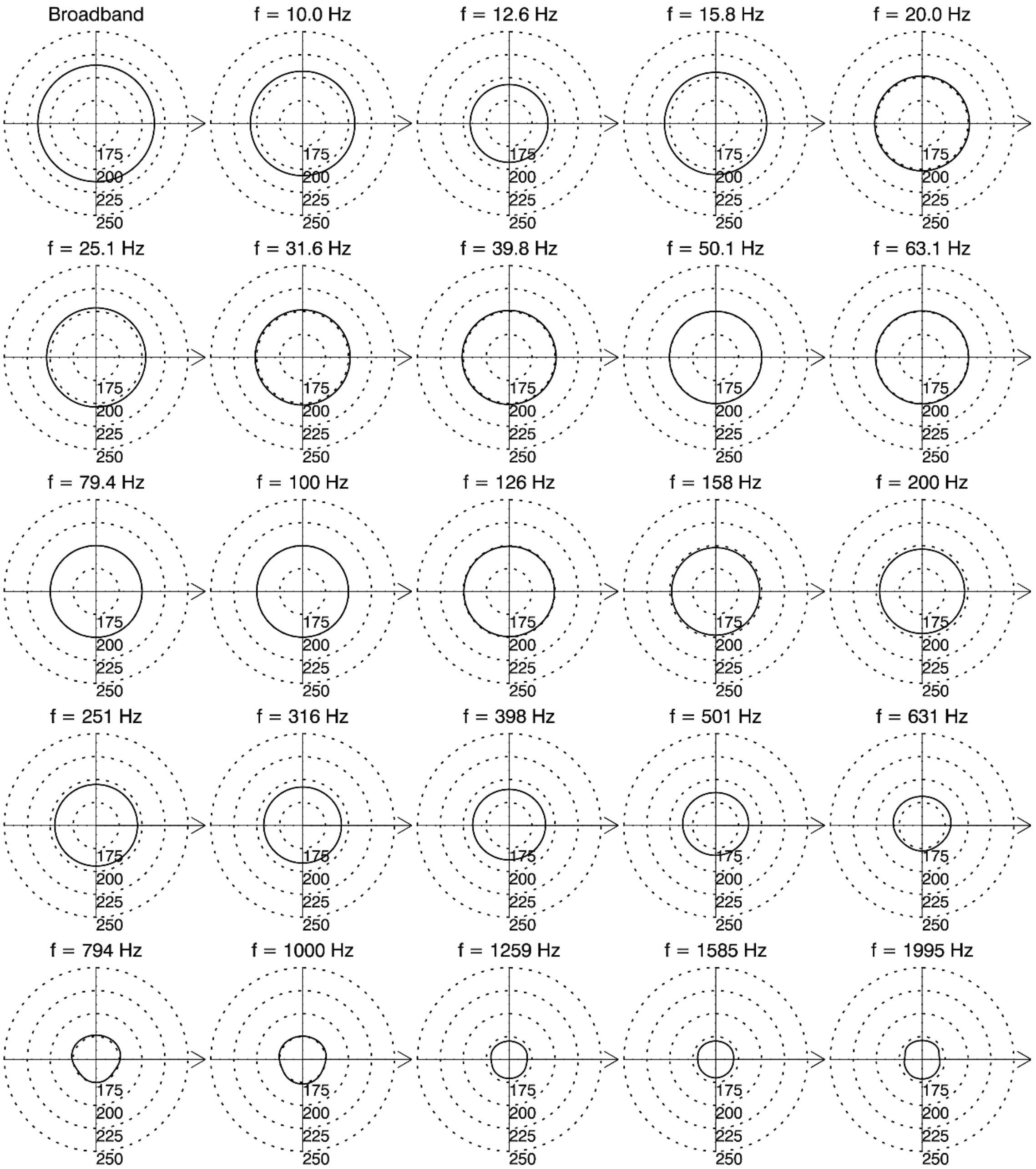


Figure B-5. Directionality of the predicted horizontal source levels for the 450 in^3 array, 5–2000 Hz. Source levels (in dB re 1 µPa^2·s) are shown as a function of azimuth for the centre frequencies of the 1/3-octave-bands modelled; frequencies are shown above the plots. Tow direction is to the right. Operating depth is 6 m (see Section 3.1.3).

Appendix C. Sound Propagation Models

C.1. MONM-BELLHOP

Underwater sound propagation (i.e., transmission loss) was predicted with JASCO's Marine Operations Noise Model (MONM). This model computes sound propagation at frequencies of 5 Hz to 1.25 kHz via a wide-angle parabolic equation solution to the acoustic wave equation (Collins 1993) based on a version of the U.S. Naval Research Laboratory's Range-dependent Acoustic Model (RAM), which has been modified to account for a solid seabed (Zhang and Tindle 1995). MONM computes sound propagation at frequencies > 1.25 kHz via the BELLHOP Gaussian beam acoustic ray-trace model (Porter and Liu 1994).

The parabolic equation method has been extensively benchmarked and is widely employed in the underwater acoustics community (Collins et al. 1996). MONM accounts for the additional reflection loss at the seabed, which results from partial conversion of incident compressional waves to shear waves at the seabed and sub-bottom interfaces, and it includes wave attenuations in all layers. MONM incorporates the following site-specific environmental properties: a bathymetric grid of the modelled area, underwater sound speed as a function of depth, and a geoacoustic profile based on the overall stratified composition of the seafloor.

This version of MONM accounts for sound attenuation due to energy absorption through ion relaxation and viscosity of water in addition to acoustic attenuation due to reflection at the medium boundaries and internal layers (Fisher and Simmons 1977). The former type of sound attenuation is significant for frequencies higher than 5 kHz and cannot be neglected without noticeably affecting the model results.

MONM computes acoustic fields in three dimensions by modelling transmission loss within two-dimensional (2-D) vertical planes aligned along radials covering a 360° swath from the source, an approach commonly referred to as N×2-D. These vertical radial planes are separated by an angular step size of $\Delta\theta$, yielding $N = 360°/\Delta\theta$ number of planes (Figure C-1).

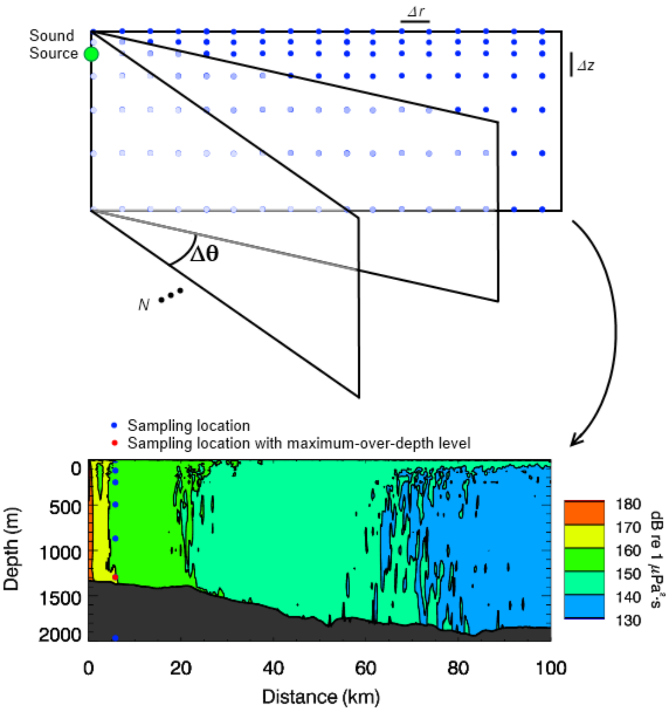


Figure C-1. The N×2-D and maximum-over-depth modelling approach used by MONM.

MONM treats frequency dependence by computing acoustic transmission loss at the centre frequencies of 1/3-octave-bands. Sufficiently many 1/3-octave-bands, starting at 10 Hz, are modelled to include most acoustic energy emitted by the source. At each centre frequency, the transmission loss is modelled within each of the N vertical planes as a function of depth and range from the source.

The 1/3-octave-band received per-pulse SELs are computed by subtracting the band transmission loss values from the directional source level in that frequency band. Composite broadband received SELs are then computed by summing the received 1/3-octave-band levels.

The received per-pulse SEL sound field within each vertical radial plane is sampled at various ranges from the source, generally with a fixed radial step size. At each sampling range along the surface, the sound field is sampled at various depths, with the step size between samples increasing with depth below the surface. The step sizes are chosen to provide increased coverage near the depth of the source and at depths of interest in terms of the sound speed profile. For areas with deep water, sampling is not performed at depths beyond those reachable by marine mammals. The received per-pulse SEL at a surface sampling receiver location is taken as the maximum value that occurs over all samples within the water column, i.e., the maximum-over-depth received per-pulse SEL. These maximum-over-depth per-pulse SELs are presented as colour contours around the source.

MONM's predictions have been validated against experimental data from several underwater acoustic measurement programs conducted by JASCO (Hannay and Racca 2005, Aerts et al. 2008, Funk et al. 2008, Ireland et al. 2009, O'Neill et al. 2010, Warner et al. 2010, Racca et al. 2012a, Racca et al. 2012b, Martin et al. 2015).

C.2. FWRAM

For impulsive sounds from the seismic array, time-domain representations of the pressure waves generated in the water are required to calculate SPL and peak pressure level. Furthermore, the airgun array must be represented as a distributed source to accurately characterise vertical directivity effects in the near-field zone. For this study, synthetic pressure waveforms were computed using FWRAM, which is a time-domain acoustic model based on the same wide-angle parabolic equation (PE) algorithm as MONM. FWRAM computes synthetic pressure waveforms versus range and depth for range-varying marine acoustic environments, and it takes the same environmental inputs as MONM (bathymetry, water sound speed profile, and seafloor geoacoustic profile). Unlike MONM, FWRAM computes pressure waveforms via Fourier synthesis of the modelled acoustic transfer function in closely spaced frequency bands. FWRAM employs the array starter method to accurately model sound propagation from a spatially distributed source (MacGillivray and Chapman 2012).

Besides providing direct calculations of the peak pressure level and SPL, the synthetic waveforms from FWRAM can also be used to convert the SEL values from MONM to SPL.

C.3. Wavenumber Integration Model

Sound pressure levels near the airgun array were modelled using JASCO's VSTACK wavenumber integration model. VSTACK computes synthetic pressure waveforms versus depth and range for arbitrarily layered, range-independent acoustic environments using the wavenumber integration approach to solving the exact (range-independent) acoustic wave equation. This model is valid over the full angular range of the wave equation and can fully account for the elasto-acoustic properties of the sub-bottom. Wavenumber integration methods are extensively used in the field of underwater acoustics and seismology where they are often referred to as reflectivity methods or discrete wavenumber methods. VSTACK computes sound propagation in arbitrarily stratified water and seabed layers by decomposing the outgoing field into a continuum of outward-propagating plane cylindrical waves. Seabed reflectivity in the model is dependent on the seabed layer properties: compressional and shear wave speeds, attenuation coefficients, and layer densities. The output of the model can be post-processed to yield estimates of the SEL, SPL, and PK.

VSTACK accurately predicts steep-angle propagation in the proximity of the source, but is computationally slow at predicting sound pressures at large distances due to the need for smaller wavenumber steps with increasing distance. Additionally, VSTACK assumes range-invariant bathymetry with a horizontally stratified medium (i.e., a range-independent environment) which is azimuthally symmetric about the source. VSTACK is thus best suited to modelling the sound field near the source.

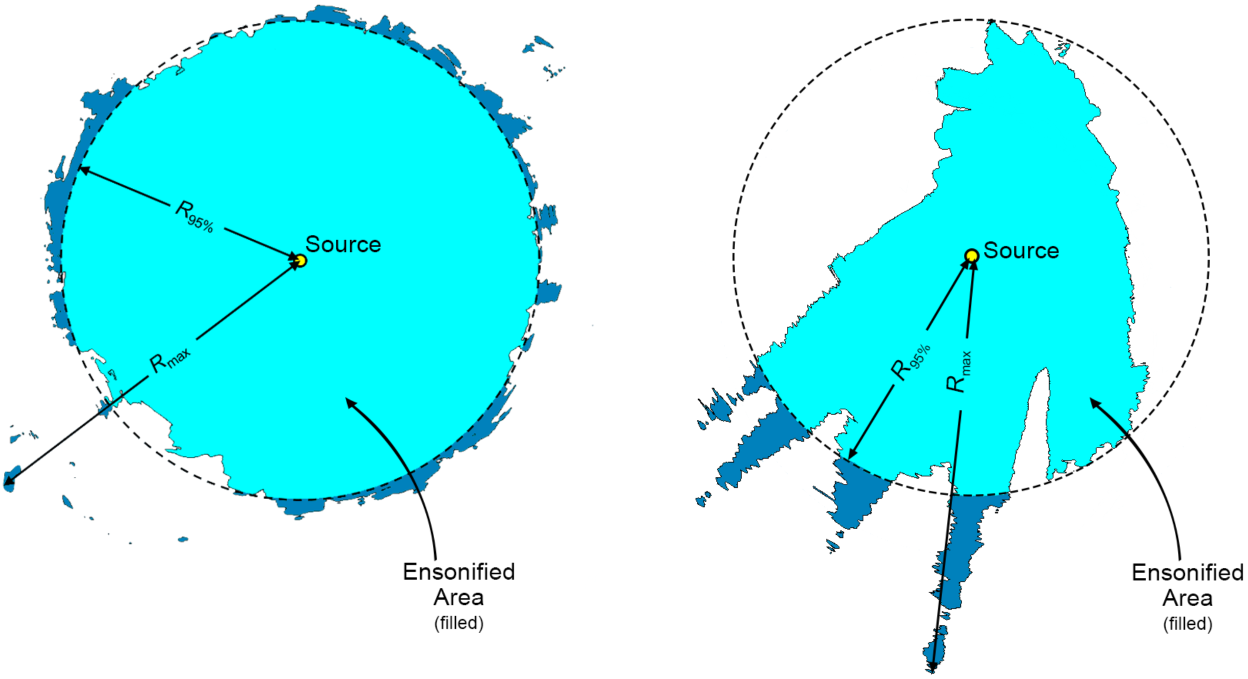
Appendix D. Methods and Parameters

This section describes the specifications of the airgun array source that was used at all sites and the environmental parameters used in the propagation models.

D.1. Estimating Range to Thresholds Levels

Sound level contours were calculated based on the underwater sound fields predicted by the propagation models, sampled by taking the maximum value over all modelled depths above the sea floor for each location in the modelled region. The predicted distances to specific levels were computed from these contours. Two distances relative to the source are reported for each sound level: 1) R_{max}, the maximum range to the given sound level over all azimuths, and 2) $R_{95\%}$, the range to the given sound level after the 5% farthest points were excluded (see examples in Figure D-1).

The $R_{95\%}$ is used because sound field footprints are often irregular in shape. In some cases, a sound level contour might have small protrusions or anomalous isolated fringes. This is demonstrated in the image in Figure D-1(a). In cases such as this, where relatively few points are excluded in any given direction, R_{max} can misrepresent the area of the region exposed to such effects, and $R_{95\%}$ is considered more representative. In strongly asymmetric cases such as shown in Figure D-1(b), on the other hand, $R_{95\%}$ neglects to account for significant protrusions in the footprint. In such cases R_{max} might better represent the region of effect in specific directions. Cases such as this are usually associated with bathymetric features affecting propagation. The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the non-uniformity of the acoustic environment.



(a) (b)

Figure D-1. Sample areas ensonified to an arbitrary sound level with R_{max} and $R_{95\%}$ ranges shown for two different scenarios. (a) Largely symmetric sound level contour with small protrusions. (b) Strongly asymmetric sound level contour with long protrusions. Light blue indicates the ensonified areas bounded by $R_{95\%}$; darker blue indicates the areas outside this boundary which determine R_{max}.

D.2. Estimating SPL from Modelled SEL Results

The SEL of individual sound pulses is an energy-like metric related to the dose of sound received over the pulse's duration. The SPL on the other hand is related to the pulses intensity over a specified time interval (Appendix A). The time interval applied in this report is fixed at 125 ms.

Seismic pulses typically lengthen in duration as they propagate away from their source due to seafloor and surface reflections and other waveguide dispersion effects. The changes in pulse length affect the numeric relationship between SPL and SEL because the amount of pulse energy within the specified time interval changes. Full-waveform modelling is necessary to estimate SPL, but this type of modelling is computationally intensive and can be prohibitively time consuming when run at high spatial resolution over large areas.

The current study, modelled synthetic seismic pulses from 5–1024 Hz with FWRAM (Appendix C.2).

FWRAM uses Fourier synthesis to recreate the signal in the time domain so that both the SEL and SPL can be calculated from the propagated signal. SPL was calculated using a 125 ms fixed time window positioned to maximise the SPL over the pulse duration. The difference between the SEL and SPL was extracted for all ranges and depths corresponded to those generated in the high spatial-resolution MONM results. The resulting SEL-to-SPL offsets were then averaged in 0.5 km range bins. The final range-dependent conversion function for each site correspond to the 90th percentile curve derived from the SEL-to-SPL offsets along all radials at that site. These range-dependent conversion functions were applied to predicted per-pulse SEL results from MONM and BELLHOP to model SPLs. The range-dependent conversion function for the VSP at Site 5 is shown in Figure D-2.

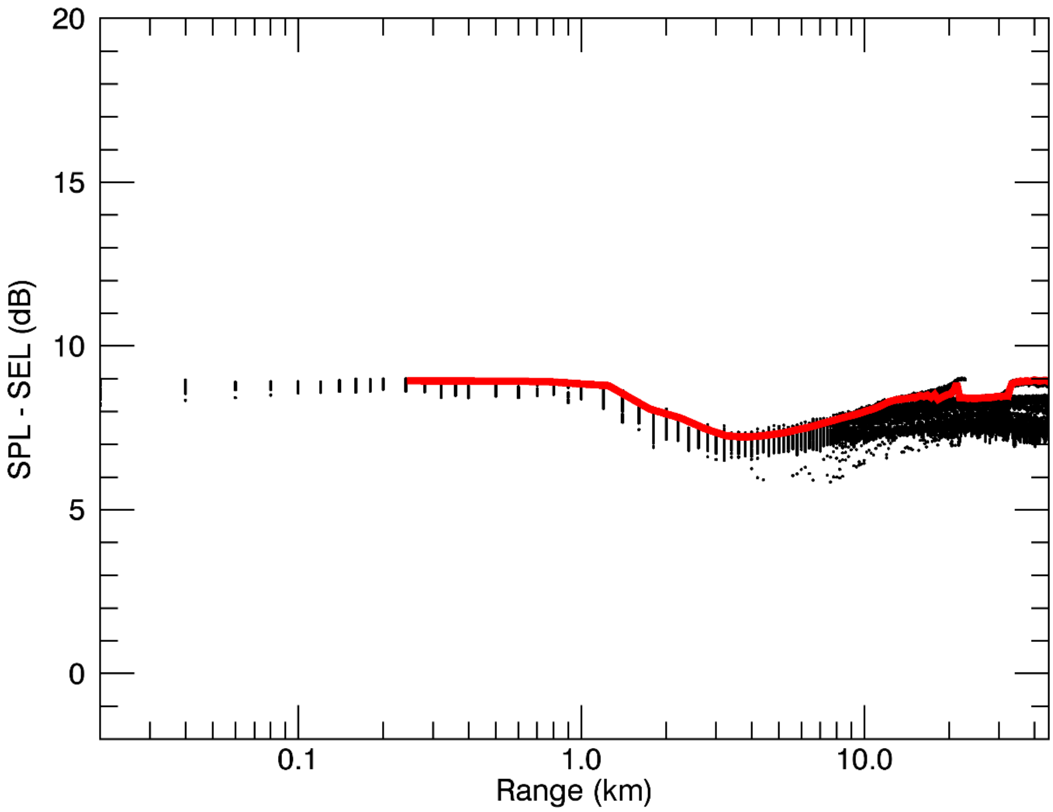


Figure D-2. Conversion Factor applied: Range-dependent conversion function for converting single-pulse SEL to SPL for the 450 in^3 VSP array.

D.3. Environmental Parameters

D.3.1. Bathymetry

Water depths throughout the modelled area were supplied by the client. The bathymetric data was re-gridded onto a Cartesian grid with a regular grid spacing of 50 × 50 m; this grid was used for all modelled sites in this study.

D.3.2. Sound speed profile

The sound speed profiles for the modelled sites were derived from temperature and salinity profiles from the U.S. Naval Oceanographic Office's *Generalized Digital Environmental Model V 3.0* (GDEM; Teague et al. 1990, Carnes 2009). GDEM provides an ocean climatology of temperature and salinity for the world's oceans on a latitude-longitude grid with 0.25° resolution, with a temporal resolution of one month, based on global historical observations from the U.S. Navy's Master Oceanographic Observational Data Set (MOODS). The temperature and salinity profiles were converted to sound speed profiles according to the equations of Coppens (1981).

The sound speed profiles across the year were calculated across the area encompassing all sites, with the median sound speed at each depth retained for comparison. It was found that the sound speed profile for September provided the greatest propagation and is consequently used for the modelling. Since the profiles did not extend to the maximum water depth in the modelling area, they were supplemented with a deeper nearby offshore profile.

The final profile features a sound channel at 70 m, as well as a surface duct that may allow for enhanced high frequency propagation. Due to the bathymetry of the modelling region, most propagation is within the top two-hundred metres. At greater depths, the profile is downwardly refracting until 1300 m depth. The sound speed profile used throughout the modelling is shown in Figure D-3.

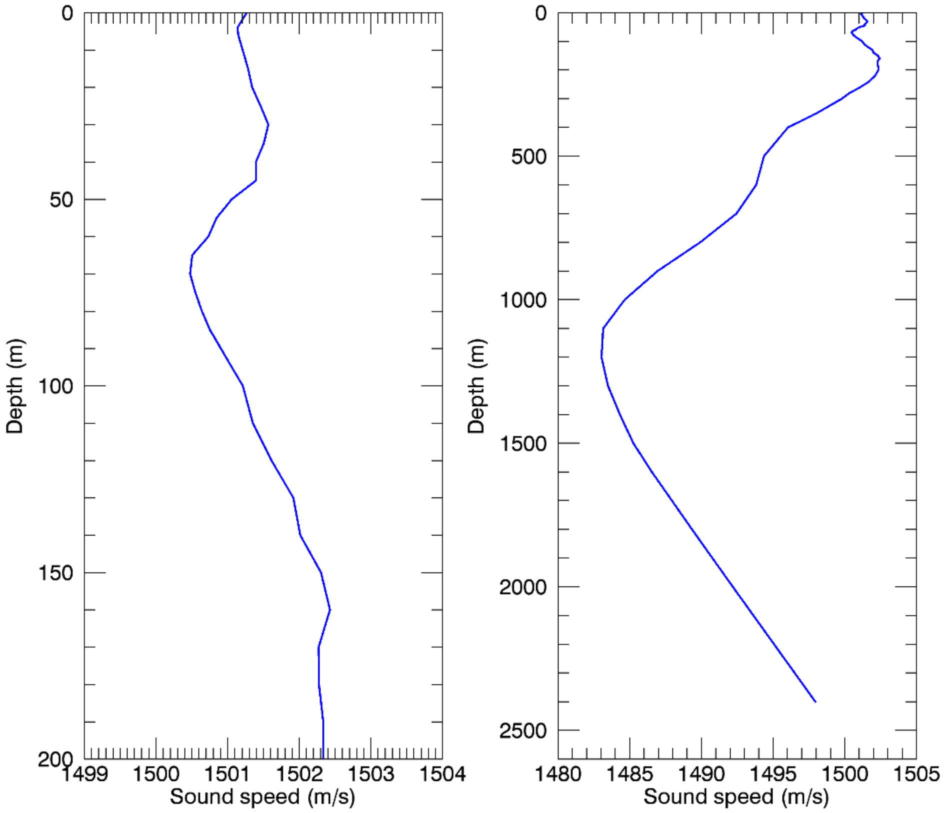


Figure D-3. The sound speed profile for September across the modelling region for the first 200 m (left), and over the entire range of depths (right). The profile was calculated from temperature and salinity profiles from GDEM V 3.0 (GDEM; Teague et al. 1990, Carnes 2009).

D.3.3. Geoacoustics

Each of the models used in this study utilise a single geoacoustic profile for each site. The geoacoustics determine how sound is reflected from the seabed, as well as how it is coupled into the sediment layers. The geoacoustic description for Site 5 are taken from a ground truthing report due to its proximity to the location (Duncan 2017). The geoacoustic profiles for the other sites were generated using lithographic descriptions from the geotechnical reports supplied by the client. Sites 1 and 2 located towards the south of the region were found typically to feature a well-cemented calcarenite caprock over a softer calcarenite layer. Sites 3, 4, and 6 typically exhibited a sand layer that sat above increasingly cemented calcarenite. In all cases, the calcarenite layer was found to extend to many hundreds of metres below the seafloor.

Geoacoustic values for Calcarenite have been taken from Duncan et al. 2013; where the calarenite is indicated to be increasingly consolidated with depth, the properties have been linearly interpolated. The geoacoustic parameters for sand are generated using models proposed by Hamilton (Hamilton 1980). The three final geoacoutics profiles used for the modelling are presented in Tables D-1 to D-3.

Table D-1. Geoacoustic profile used as the input to the models at Sites 1 & 2.

Depth below seafloor (m)	Material	Density (g/cm^3)	P-wave speed (m/s)	P-wave attenuation (dB/λ)	S-wave speed (m/s)	S-wave attenuation (dB/λ)
0-1	Well-cemented carbonate caprock	2.7	2600	0.5	1200	0.5
1-20	Increasingly cemented calcarenite	2.2	2000	0.3	900	0.27
20-40		2.3	2120	0.34	960	0.316
40-60		2.4	2240	0.38	1020	0.362
60-80		2.5	2360	0.42	1080	0.408
80-10		2.6	2480	0.46	1140	0.454
>100	Well-cemented calcarenite	2.7	2600	0.5	1200	0.5

Table D-2. Geoacoustic profile used as the input to the models at Sites 3, 4, & 6.

Depth below seafloor (m)	Material	Density (g/cm^3)	P-wave speed (m/s)	P-wave attenuation (dB/λ)	S-wave speed (m/s)	S-wave attenuation (dB/λ)
0-0.5	Coarse carbonate sand	2.03	1803.1	0.85	300	6.2
0.5-20	Increasingly cemented calcarenite	2.2	2000	0.3	900	0.27
20-40		2.3	2120	0.34	960	0.316
40-60		2.4	2240	0.38	1020	0.362
60-80		2.5	2360	0.42	1080	0.408
80-100		2.6	2480	0.46	1140	0.454
>100	Well-cemented calcarenite	2.7	2600	0.5	1200	0.5

Table D-3. Geoacoustic profile used as the input to the models at Site 5.

Depth below seafloor (m)	Material	Density (g/cm^3)	P-wave speed (m/s)	P-wave attenuation (dB/λ)	S-wave speed (m/s)	S-wave attenuation (dB/λ)
0	Coarse carbonate sand	2.03	1802.2	0.85	300	6.2
20		2.07	1836.27	0.84	320	6.5
20-36	Increasingly cemented calcarenite	2.2	2000	0.3	900	0.27
36-52		2.3	2120	0.34	960	0.316
52-68		2.4	2240	0.38	1020	0.362
68-84		2.5	2360	0.42	1080	0.408
84-100		2.6	2480	0.46	1140	0.454
>100	Well-cemented calcarenite	2.7	2600	0.5	1200	0.5

Appendix J: Sound Modelling Report – Wood and McPherson 2019

Technical Note

Supplemental modelling results for *Otway Basin Geophysical Operations Acoustic Modelling: Acoustic Modelling for Assessing Marine Fauna Sound Exposures*

From: Michael Wood and Craig McPherson
JASCO Applied Sciences (Australia) Pty Ltd

Date: 02 April 2019

Document: 01777

This technical note provides additional modelling results that supplement the original report: *Otway Basin Geophysical Operations Acoustic Modelling: Acoustic Modelling for Assessing Marine Fauna Sound Exposures* (McPherson and Wood 2017).

Tabulated ranges are provided to impact thresholds defined by NMFS (2018) for cetaceans and pinnipeds from operations involving the boomer and sub-bottom profiler (SBP) sound sources, and from the 450 in³ vertical seismic profiling (VSP) array.

The sound exposure level (SEL) results for the different auditory classes of marine mammal are frequency-weighted in accordance with NMFS (2018); the weighting functions are described in Appendix A; peak pressure levels (PK) are unweighted.

Results are presented for the Boomer and SBP in Section 1, and for the VSP in Section 2, while Section 3 discusses potential alternative sources for the study.

1. Boomer and SBP

1.1. Impact ranges from PK for high-frequency cetaceans

The ranges to identified impact thresholds for high-frequency cetaceans from the PK levels of the Boomer and SBP are shown in Table 1. The threshold levels for the equivalent effect in low- and mid-frequency cetaceans are appreciably higher, and thus were not reached.

Table 1. Maximum ranges to identified impact thresholds due to PK levels defined by NMFS for high-frequency cetaceans from SBP and Boomer operations.

PK Threshold Level dB re 1 µPa	Effect	SBP Range (m)	Boomer AP3000 Range (m)
202	PTS	0.6	2.8
196	TTS	1.2	5.5

1.2. Maximum ranges to impact thresholds from SEL_{24h} for marine mammals

The ranges to recommended impact thresholds from the Boomer and SBP are presented in Table 2. In all cases, the frequency-weighted levels are not high enough to reach the impact thresholds except for TTS in low-frequency cetaceans; the maximum range in this case is 10 m from the acoustic centre of the source.

Table 2. Maximum ranges to identified impact thresholds due to frequency-weighted SEL_{24h} levels defined by NMFS from SBP and Boomer operations.

Auditory group	Effect	Frequency-weighted Threshold Level dB re 1 µPa²·s	Artisan Range (m)	G3 Range (m)	Meeki Range (m)	Thy Comb Range (m)
Low-frequency Cetaceans	PTS	183	—	—	—	—
	TTS	168	10	<10	<10	<10
Mid-frequency Cetaceans	PTS	185	—	—	—	—
	TTS	170	—	—	—	—
High-frequency Cetaceans	PTS	155	—	—	—	—
	TTS	140	—	—	—	—
Phocid pinnipeds	PTS	185	—	—	—	—
	TTS	170	—	—	—	—
Otariid pinnipeds	PTS	203	—	—	—	—
	TTS	188	—	—	—	—

2. VSP

The ranges to recommended impact thresholds resulting from the VSP are presented in Table 3. Results assume both stationary source and receivers. Results are frequency-weighted in accordance with NMFS (2018). Maximum ranges are shown for 1, 5, 10, 15, 25, 144, and 360 impulses within a 24-hour period. Ranges up to 2.5 km calculated using 1 m resolution modelling on 5 m resolution gridded sound fields; ranges greater 2.5 km calculated using 10 m resolution modelling on 25 m resolution gridded sound fields.

Table 3. Maximum ranges to identified impact thresholds due to frequency-weighted SEL_{24h} defined by NMFS from VSP operations assuming different numbers of impulses during a 24-hour period.

Auditory group	Effect	Frequency-weighted Threshold Level dB re 1 µPa²·s	Number of impulses						
			1 R_{max} (m)	5 R_{max} (m)	10 R_{max} (m)	15 R_{max} (m)	25 R_{max} (m)	144 R_{max} (m)	360 R_{max} (m)
Low-frequency Cetaceans	PTS	183	11	30	45	56	72	323	738
	TTS	168	81	335	625	924	1227	3051	4743
Mid-frequency Cetaceans	PTS	185	—	—	—	—	—	—	—
	TTS	170	—	—	—	—	—	<10	<10
High-frequency Cetaceans	PTS	155	—	—	—	<10	<10	18	32
	TTS	140	<10	21	29	36	51	149	256
Phocid pinnipeds	PTS	185	—	—	—	<10	<10	21	34
	TTS	170	<10	22	32	40	55	222	409
Otariid pinnipeds	PTS	203	—	—	—	—	—	—	—
	TTS	188	—	—	—	—	—	<10	14

3. Comparison of sources

Beach Energy solicited tenders for the geophysical survey, and received three responses which proposed alternative equipment to that considered in McPherson and Wood (2017). These three responses have been evaluated, with the findings summarised below.

The primary sources of concern are the boomer and sub-bottom profiler, with other the potential sources for this project such as multi-beam echo sounders and side-scan-sonars being high frequency devices only, with centre frequencies over 100 Hz. As no mid-frequency multi-beam sonars are being considered, the potential for overlap between marine fauna hearing ranges and multi-beam sonar signals of concern is extremely limited.

The proposed sub-bottom profiler is the Edgetech X-star system, which is the same source as considered in the modelling study. Alternative boomers suggested as potential sources instead of the AP3000 include the AA251, AA300 and AA301. The modelled AP3000 signature was based upon scaling the signature of an AA202 single boomer plate. The frequency spectrum components of these potential sources are very similar to the modelled AP3000, and they will also exhibit a similar beam pattern. The peak source pressure level of the alternative boomers is slightly higher than the AP3000, which has a peak source pressure level of 210.8 dB re 1 μPa^{2}m^2, with that for the AA251 being of 212 dB re 1 μPa^{2}m^2 and AA301's 215 dB re 1 μPa^{2}m^2. This results in slightly greater ranges to PK thresholds for high-frequency cetaceans (Table 4), however criteria for other mammal auditory groups are not reached. There is also an increase in distance to PK-PK sound levels of interest, however the resulting ranges are still small, with no PK-PK sound level applied in the impact assessment exceeded more than 18 m from the source (Table 5). However, as both the Boomer and SBP are both towed at 3 m, the maximum depth at which the sound level of 202 dB re 1 μPa will be reached will be 21 m. As the shallowest modelling site of interest (Artisan, Table 1 in McPherson and Wood (2017)) has a depth of 71 m, no PK-PK sound levels of interest for benthic invertebrates will be reached at the seafloor.

Despite the differences in peak source pressure level between the modelled and potential alternative boomers, there is estimated to be only a very minor change in the per-pulse source sound exposure level (SEL), partly due to the length of the impulse from these alternative sources. Due to minor changes expected in term of per-pulse SEL, the modelling results presented in McPherson and Wood (2017) for SEL$_{24h}$ are considered to be appropriate approximations of the potential sound fields and ranges to SEL$_{24h}$ impact criteria.

Table 4. Maximum ranges to identified impact thresholds due to PK levels defined by NMFS for high-frequency cetaceans for the modelled boomer (AP3000) and two potential alternative boomers.

PK Threshold level dB re 1 µPa	Effect	Boomer AP3000 Range (m)	Boomer AA251 Range (m)	Boomer AA301 Range (m)
202	PTS	2.8	3.2	4.5
196	TTS	5.5	6.3	8.9

Table 5. Maximum ranges to identified PK-PK sound levels for the modelled boomer (AP3000) and two potential alternative boomers.

PK-PK dB re 1 µPa	Boomer AP3000 Range (m)	Boomer AA251 Range (m)	Boomer AA301 Range (m)
215	2.4	2.8	3.9
212	3.4	3.9	5.5
210	4.3	4.9	7.0
209	4.8	5.5	7.8
205	7.6	8.7	12.4
202	10.8	12.4	17.5

References

[NMFS] National Marine Fisheries Service. 2018. *2018 Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts*. U.S. Department of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-59. 167 pp. https://www.fisheries.noaa.gov/webdam/download/75962998.

Finneran, J.J. 2015. *Auditory weighting functions and TTS/PTS exposure functions for cetaceans and marine carnivores*. Technical report by SSC Pacific, San Diego, CA.

Finneran, J.J. 2016. *Auditory weighting functions and TTS/PTS exposure functions for marine mammals exposed to underwater noise*. Technical Report for Space and Naval Warfare Systems Center Pacific, San Diego, CA. 49 pp. http://www.dtic.mil/dtic/tr/fulltext/u2/1026445.pdf.

McPherson, C.R. and M.A. Wood. 2017. *Otway Basin Geophysical Operations Acoustic Modelling*. Document Number 01473. Technical report by JASCO Applied Sciences for Lattice Energy.

Appendix A.

NMFS (2018) Frequency weighting functions

In 2015, a U.S. Navy technical report by Finneran (2015) recommended new auditory weighting functions. The auditory weighting functions for marine mammals are applied in a similar way as A-weighting for noise level assessments for humans. The new frequency-weighting functions are expressed as:

$$G(f) = K + 10\log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a[1+(f/f_2)^2]^b}\right\} \quad \text{(A-1)}$$

Finneran (2015) proposed five functional hearing groups for marine mammals in water: low-, mid- and high-frequency cetaceans (LF, MF, and HF cetaceans, respectively), phocid pinnipeds, and otariid pinnipeds. The parameters for these frequency-weighting functions were further modified the following year (Finneran 2016) and were adopted in NOAA's technical guidance that assesses noise impacts on marine mammals (NMFS 2018). Table A-1 lists the frequency-weighting parameters for each hearing group. Figure A-1 shows the resulting frequency-weighting curves.

Table A-1. Parameters for the auditory weighting functions recommended by NMFS (2018).

Functional hearing group	***a***	***b***	**f_1 (Hz)**	**f_2 (Hz)**	**K (dB)**
Low-frequency cetaceans	1.0	2	200	19,000	0.13
Mid-frequency cetaceans	1.6	2	8,800	110,000	1.20
High-frequency cetaceans	1.8	2	12,000	140,000	1.36
Phocid pinnipeds in water	1.0	2	1,900	30,000	0.75
Otariid pinnipeds in water	2.0	2	940	25,000	0.64

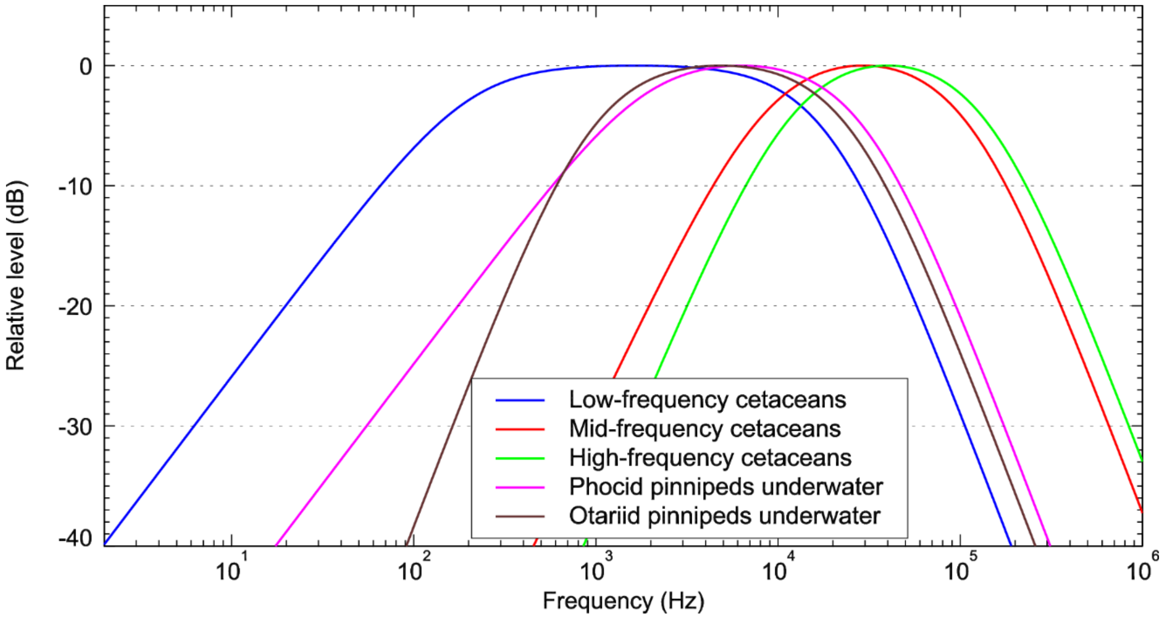


Figure A-1. Auditory weighting functions for the functional marine mammal hearing groups as recommended by NMFS (2018).

Appendix K: Project GHG Assessment Report

Beach Energy Limited

Otway Offshore Gas Victoria Project

GHG Emissions Report

ASSIGNMENT P100383-S01
DOCUMENT P-100383-S01-A-REPT-001

XODUS

Perth

Level 1
1 William Street . Perth
WA 6000 . Australia

T +61 (0)86555 5600
E matthew.holding@xodusgroup.com

www.xodusgroup.com

REVISIONS & APPROVALS

This report has been prepared by Xodus Group exclusively for the benefit and use of Beach Energy Limited. Xodus Group expressly disclaims any and all liability to third parties (parties or persons other than Beach Energy Limited) which may be based on this report.

The information contained in this report is strictly confidential and intended only for the use of Beach Energy Limited. This report shall not be reproduced, distributed, quoted or made available – in whole or in part – to any third party other than for the purpose for which it was originally produced without the prior written consent of Xodus Group.

The authenticity, completeness and accuracy of any information provided to Xodus Group in relation to this report has not been independently verified. No representation or warranty express or implied, is or will be made in relation to, and no responsibility or liability will be accepted by Xodus Group as to or in relation to, the accuracy or completeness of this report. Xodus Group expressly disclaims any and all liability which may be based on such information, errors therein or omissions therefrom.

REV	DATE	DESCRIPTION	ISSUED	CHECKED	APPROVED	CLIENT
A02	19/12/23	Issue for use	KS	MH	MH	Beach
R02	11/12/23	Issued for review	KS	MH	MH	Beach
A01	07/09/23	Issue for use	KS	MH	MH	Beach
R01	18/08/23	Issued for review	KS	MH	MH	Beach

CONTENTS

Abbreviations

ACRYONM	DESCRIPTION
AHTS	Anchor Handling Tug Supply Vessel
API	American Petroleum Institute
CRA	Corrosion Resistant Alloy
EF	Emission Factor
FLEM	Flowline Ending Manifold
GHG	Greenhouse Gas
GWP	Global Warming Potential
IMR	Inspection, Maintenance and Repair
ISV	Installation Support Vessel
LPG	Liquefied Petroleum Gas
MDO	Marine Diesel Oil
MODU	Mobile Offshore Drilling Unit
NGER	National Greenhouse Gas and Energy Reporting
OPP	Offshore Project Proposal
PLV	Pipe Lay Vessel
PSV	Platform Support Vessel
PTS	Pipeline Termination Structure
SBDF	Synthetic Based Drilling Fluid
TMD	Total Measured Depth (of well)
WBDF	Water Based Drilling Fluid

1 INTRODUCTION

Beach Energy Limited ('Beach') has engaged Xodus to develop a Greenhouse Gas (GHG) emissions study ('this report') for the Otway Offshore Gas Victoria Project ('the Project') to inform the Offshore Project Proposal (OPP). Beach defined the scope boundary as the Project, as outlined in Figure 1, with estimates of GHG emissions downstream of the Project within the Otway Development using background data.

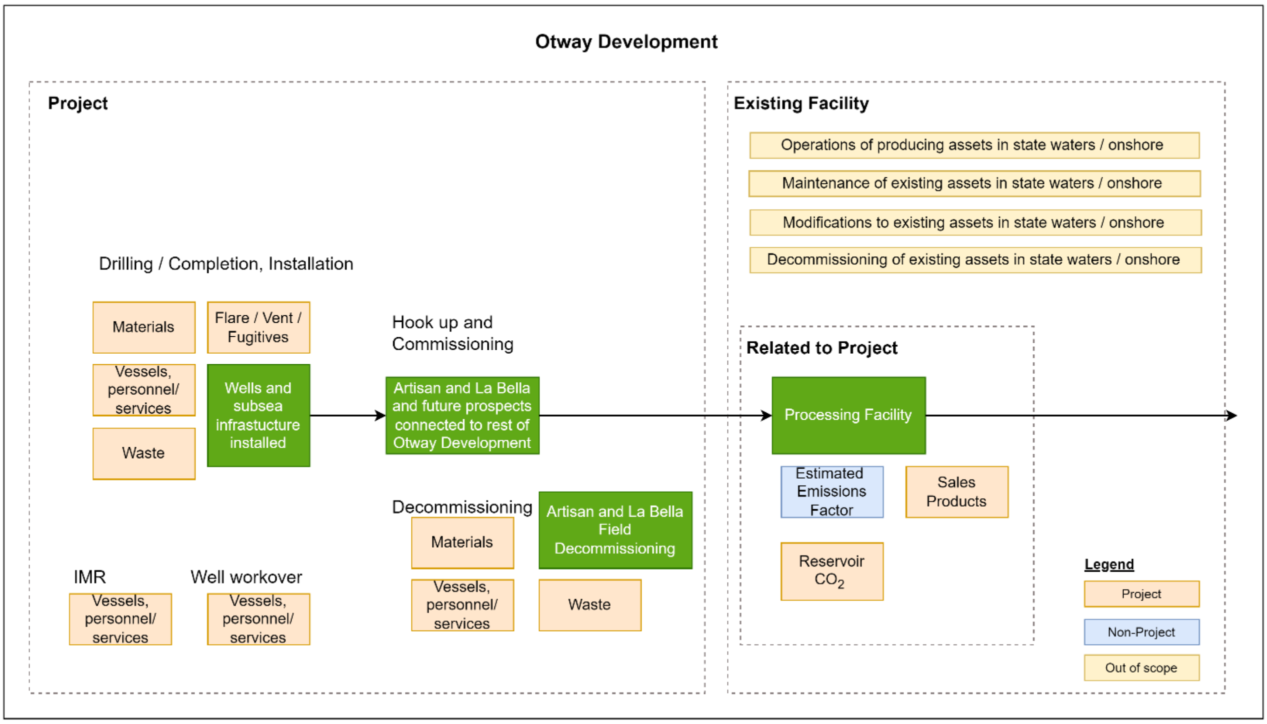


Figure 1: Boundary showing the Otway Development, and relationship between the Project and Existing Otway Facilities.

Details of the boundary and assumptions are given in Appendix A. The key activities and source emissions are:

- Drilling of up to 16 wells between 2025 and 2030 (Note Artisan has been drilled, making a total of 17 wells in scope of the Project).
- Completions of up to 17 wells between 2026 and 2030.
- Installation of associated infrastructure and flowlines for up to 17 wells between 2026 and 2030.
- Production from initial wells and future prospects for up to 30 years.
- Operations, and decommissioning of up to 17 wells and associated infrastructure by 2058.

The characteristics of the hydrocarbons, including CO_2 content, from the La Bella and Artisan fields are based on samples from these fields. Compositions from nearby fields targeting similar geological formations (Artisan and

Thylacine) were used as representative samples for the future prospects for this inventory assessment. Note that the assumptions and boundary conditions for the GHG emissions inventory assumed that all wells will be developed.

1.1 Source and emission categorisation

Emissions are categorised as direct or indirect Project emissions:

- Project direct emissions: GHG emissions directly emitted within the Project boundary from sources owned or controlled by the Project.
- Project indirect emissions: GHG emissions from sources not owned or operated by the Project, including embodied carbon from materials and equipment used within the boundary of the Project; and GHG emissions owned by the Project but transferred outside the boundary of the Project to the Otway Development, e.g., reservoir CO_2.

Table 1 summarises the activities and sources that emit GHG emissions over the lifecycle of the Project.

Table 1: GHG emissions categorisation

Categorisation	Phase	Sub-Category	Source / Activities
Project Direct Emissions	Drilling and Completions; Production	Flaring & Venting	Well cleanup and completion, well testing. Well intervention.
	Production	Fugitive Emissions	Fugitive emissions from wells and flowlines (including flow through Thylacine platform)
Project Indirect Emissions	Support Activities (all stages)	Vessels	Variations of fleet including Mobile Offshore Drilling Unit (MODU) and support vessels and helicopters required for • Drilling • Installation • Inspection, Maintenance and Repair (IMR) • Well workover • Decommissioning
	Production	Reservoir CO_2	Reservoir CO_2 from Artisan, La Bella and future prospects emitted at Otway Gas Plant (OGP).
	Production	Vessels	Inspection, Maintenance and Repair (IMR).
	Production	Sales Product	Transport and use of sales gas, condensate from Artisan, La Bella and future prospects.
	Drilling and Completions, Installation, Decommissioning	Materials	Wells, flowlines, subsea equipment, cement, drilling mud.

Categorisation	Phase	Sub-Category	Source / Activities
	Production	Onshore gas processing	Estimated fuel use apportioned to the processing of well fluids from Artisan, La Bella and future prospects; fugitive emissions. Cold venting from Thylacine Platform.

2 METHODOLOGY

2.1 Source and activity identification

The boundary and assumptions list (Appendix A) co-developed by Beach and Xodus defines the inclusions and exclusions for the Project GHG emissions inventory.

2.2 Calculations

2.2.1 Fuel use and related emissions

The National Greenhouse and Energy Reporting (Measurement) Determination 2008 (Compilation 16) emission factors for Method 1 were applied for combustion related calculations across the Otway Development. No site-specific emissions factors were available for the existing facility. In general, the calculation for combustion related emissions is as follows:

- Emissions [CH_4, CO_2, N_2O] (tonnes CO_2e) = Activity / Source [e.g., condensate product] × EF [CH_4, CO_2, N_2O]

2.2.2 Embodied carbon

No supplier / reference dataset for materials and equipment, or design basis was available. Thus, the embodied carbon emissions were estimated a range of Xodus propriety tools and methodologies, and publicly available databases. Note that the embodied carbon is based on the assumptions stated in Appendix A.

The general calculation approach for embodied carbon is as follows:

- Emissions (tonnes CO_2e) = Material / Equipment × EF [material, equipment]

2.2.3 Vented emissions

The global warming potentials (GWP) from the NGER Regulations (Compilation 26) was used to convert vented substances to CO_2-e, e.g., for methane emissions, the 100-year GWP of 28 was applied, i.e., 1 tonne methane vented is equivalent to 28 tonnes CO_2-e.

2.2.4 Project well fluid onshore processing

The following factors were used to estimate the apportionment of energy use from the OGP:

- Years 2025 – 2045: 40 TJ/bcf raw gas processed.
- Years 2045+: 100 TJ/bcf raw gas processed.

The basis for these factors relates to the throughput from the OGP and considered the expected production volume forecast over the 30-year life of the Project. This includes initial developments from Artisan and La Bella fields in addition to future tiebacks from currently identified prospects in the Project Area.

- Production volume from 2025 to 2040 remains relatively constant at about 55bcf per annum raw gas.
- Production volume decreases from 2040 with average at about 20bcf per annum raw gas.
- Post 2045, significant decrease in throughput.
- Fuel use remains somewhat constant regardless of throughput.

2.2.5 Sold product

All products sold are assumed to combusted. Fugitive emissions post sales gate is not included in the inventory.

3 RESULTS

The results presented are credible high estimates, i.e., outcome accounts for extended contingencies beyond a typical schedule. The inventory covers the period from 2025 to 2058.

3.1 Project emissions summary

Table 2 is a summary of the GHG emissions over the Project lifecycle.

Table 2: GHG emissions from the Project over its lifecycle in tonnes CO_2-e.

Direct Emissions	Indirect Emissions - Vessels	Indirect Emissions - Reservoir CO_2	Indirect Emissions - Embodied Carbon	Indirect Emissions - Processing	Indirect Emissions - Sales
76,971	943,537	1,723,805	158,777	1,480,737	29,845,031
<1%	3%	5%	<1%	4%	87%

Breakdown of Direct Emissions

Phase	Venting	Flaring	Fugitive Emissions
Completions and Well Clean Up	823	37,332	-
Production	411	22,365	16,040

3.2 Embodied carbon emissions

Table 3 details the outcomes of embodied carbon emissions calculated for identified materials and equipment, and waste for the Project.

Table 3: Embodied carbon emissions of material / equipment including waste, per phase, over Project lifecycle.

Phase	Material / Equipment	CO_2-e High Credible (tonnes)	Notes
Drilling	Cement	6,907	
	Well casing	25,391	Steel / CRA
	WBDF	212	20% Bentonite/ Polymer
Installation	10" flowline	56,652	3LPP coating for all lines.

Phase	Material / Equipment	CO_2-e High Credible (tonnes)	Notes
	8" umbilical	43,098	
	Subsea equipment	19,169	Estimated per piece equipment as weights not available
	Oily water discharge	<<1	15ppmv; negligible
Decommissioning	Cement	7,130	
	WBDF	219	20% Bentonite/ Polymer

3.3 Annualised Project emissions

Table 4 details the annualised GHG emissions from the Project.

Table 4: GHG emissions calculated for the Project lifecycle from fuel use and emissions from production in tonnes CO_2-e.

Year	Direct Emissions	Indirect Emissions - Vessels	Indirect Emissions - Reservoir CO_2	Indirect Emissions - Sales	Indirect Emissions - Processing	Indirect Emissions - Embodied Carbon
2025	7,592	45,177	-	-	-	11,762
2026	22,776	34,266	-	-	-	-
2027	-	320,554	-	-	-	78,429
2028	7,872	56,471	11,766	1,081,580	42,840	10,374
2029	475	68,265	31,905	1,439,305	56,266	17,083
2030	280	61,620	89,187	1,439,814	57,209	33,780
2031	680	-	86,985	2,169,465	84,462	-
2032	8,272	23,610	97,793	2,108,245	83,496	-
2033	680	-	96,537	1,987,365	81,393	-
2034	680	-	86,146	1,773,660	73,591	-
2035	680	-	93,193	1,930,804	77,860	-
2036	680	-	79,631	1,880,369	72,663	-
2037	680	17,156	97,400	1,863,803	72,397	-
2038	680	-	108,758	1,836,455	71,602	-
2039	8,272	6,454	100,877	1,670,171	65,478	-
2040	680	-	73,932	1,375,261	54,405	-

Year	Direct Emissions	Indirect Emissions - Vessels	Indirect Emissions - Reservoir CO_2	Indirect Emissions - Sales	Indirect Emissions - Processing	Indirect Emissions - Embodied Carbon
2041	640	3,227	43,118	1,052,849	42,459	230
2042	640	17,156	32,914	781,149	32,647	-
2043	640	6,162	164,322	766,918	32,108	-
2044	640	-	162,619	693,342	29,456	-
2045	640	-	104,985	623,139	63,786	-
2046	8,232	6,454	24,589	561,197	58,254	-
2047	640	17,156	22,407	496,215	53,266	-
2048	640	-	20,471	443,255	48,855	-
2049	640	-	18,619	396,425	44,678	-
2050	640	-	16,857	345,069	39,926	-
2051	400	3,227	15,308	304,532	36,189	230
2052	400	17,156	13,959	272,134	33,187	-
2053	400	6,162	12,651	241,005	30,292	-
2054	400	-	11,490	213,329	27,719	-
2055	400	-	5,385	98,175	14,251	-
2056	-	98,592	-	-	-	4,593
2057	-	112,084	-	-	-	2,296
2058	-	22,589	-	-	-	-
Total	76,971	943,537	1,723,805	29,845,031	1,480,737	158,777

4 CONCLUSIONS

The Project scope boundary aligns with the assessment approach of the OPP assessment. The boundary selection does not align with the GHG Protocol Corporate Accounting and Reporting Standard. Given this, the categorisation of GHG in terms of scope 1, 2 and 3 emissions would not correctly reflect these definitions and was not used.

Direct GHG emissions include flaring and venting from well completions activities and well intervention, and fugitive emissions from Operations. Indirect GHG emissions include embodied carbon from materials and equipment used within the boundary of the Project, and vessels used on the Project.

The calculated direct and indirect emissions total was 76,971 tonnes CO_2-e, and 34,173,998 tonnes CO_2-e, respectively. A breakdown of the calculated GHG emissions is presented in Table 5.

Table 5: GHG emissions summary

Category	Phase	Sub-Category	Source / Activities	CO_2-e (tonnes)
Project Direct Emissions	Drilling and Completions; Production	Flaring & Venting	Well cleanup and completion, well testing. Well intervention.	60,931
	Production	Fugitive Emissions	Fugitive emissions from wells and flowlines (including flow through Thylacine platform).	16,040
Project Indirect Emissions	Support Activities (all stages)	Vessels	Variations of fleet including Mobile Offshore Drilling Unit (MODU) and support vessels and helicopters required for • Drilling • Installation • Inspection, Maintenance and Repair (IMR) • Well workover • Decommissioning	943,537
	Production	Reservoir CO_2	Reservoir CO_2 from Artisan + La Bella and future prospects emitted at Gas Processing Facility.	1,723,805
	Production	Sales Product	Sales gas, condensate etc., from Artisan + La Bella and future prospects.	29,845,031
	Drilling and Completions, Installation, Decommissioning	Materials	Wells, flowlines, subsea equipment, cement, drilling mud.	158,777
	Production	Onshore gas processing	Estimated fuel use apportioned to the processing of well fluids from Artisan + La Bella and future prospects; fugitive emissions. Cold venting from Thylacine Platform.	1,480,737

APPENDIX A BOUNDARY AND ASSUMPTION LIST

PHASE	INCLUSIONS	ASSUMPTIONS / GIVENS	JUSTIFICATIONS
General (Project Wide)		Chartered support vessel emissions project-wide considered as scope 3 emissions.	Beach inputs aligned to GHG Protocol.
		The input values provided are considered "credible high" values – credible high values account for extended contingencies beyond a typical schedule of an activity.	Beach inputs.
		Existing facilities (background data used to estimate emissions factor only, see processing facilities emission factor): Onshore gas processing & Thylacine platform. OPP (this scope): Artisan, La Bella, and future prospects with up to 17 wells in total. GHG emissions inventory assumed all 17 wells and associated infrastructure developed.	Beach inputs.
		Processing facilities emission factor • For years to 2045, 40 TJ/bcf raw gas • For years 2045 onwards, 100TJ/bcf raw gas The emission factor is estimated based on the total throughput of the OPP and existing facility, i.e., the emissions factor would be higher if the forecasted throughput from the OPP is not achieved, since a similar amount of fuel gas is required to operate the facility at a lower throughput.	Xodus estimate based on Beach data, agreed with Beach.
		Exploration well activities are included in the GHG emissions inventory.	Beach inputs.
		Electricity is not purchased or sold; all generated electricity is consumed.	Confirmed by Beach.
		Fuel gas and sales gas are identical in composition.	Xodus assumptions agreed with Beach.

PHASE	INCLUSIONS	ASSUMPTIONS / GIVENS	JUSTIFICATIONS
		Fuel gas and diesel usage accounts for onshore and offshore (Thylacine platform) consumption.	Beach inputs.
		No bunkering of vessels is required for all phases.	Xodus assumptions agreed with Beach.
		Physical Properties (for conversions and calculations): • Marine Diesel Oil: 38.6 MJ/l • Aviation Kerosene: 36.8 MJ/l • Condensate: 46.5GJ/tonne • LPG: 25.7 GJ/kl; 46 GJ/tonne • Natural gas (fuel gas, flare gas, sales gas): 39.3MJ/m^3	Aligned with NGER and agreed with Beach.
		• CO_2: 1.847 g/l • Condensate: 0.8 g/l	Xodus assumptions agreed with Beach.
Activity duration (expected, credible high)		Expected duration of activities with emissions. • Drilling: 33 days per well + 7days contingency – Total of up to 16 wells (excluding the drilled Artisan well) • Completions: 25+5 days per well. • Installation: 25 days +5 days per flowline / umbilical • Production – Products, fuel use etc., per production profile for OPP scope. – IMR: 180 days every 5 years for all production wells. – Well workover: 30 days • Decommissioning: – P&A: 15 days +5days per well. – Infrastructure: 30 days for each associated well infrastructure.	Beach inputs.
Activity schedule		Expected schedule of activities with emissions. • Drilling: – La Bella & prospects: 2025. – Future prospects: 2027/28. • Completions: – Artisan La Bella, & prospects: 2026. – Future prospects: 2028/29. • Installation: – Artisan, La Bella and prospects: 2027.	Beach inputs.

PHASE	INCLUSIONS	ASSUMPTIONS / GIVENS	JUSTIFICATIONS
		– Future prospects: 2029/30. • Production: – IMR: new wells every 5 years – Well workover: 1 well requiring workover every 7 years. • Decomm: – Artisan: 2051/53 (well/ infrastructure). – La Bella: 2041/43. – Future prospects: start 2056.	
Fuel consumption rate		Fuel consumption on daily rate basis. • MODU: 15m^3 MDO. • AHTS: 15m^3 MDO. • ISV: 15m^3 MDO. • PSV: 15m^3 MDO. • Mulitcat: 5m^3 MDO. • PLV: 56m^3 MDO. • Helicopters (Transport): 13m^3 Aviation kerosene.	Beach inputs, and Xodus judgement and agreed with Beach.
Drilling and completions		Artisan drilling has finished and is not included.	Beach inputs.
	Vessels (including supply and services, and transport)	• 1× MODU • 3× AHTS • Helicopter flights: 8 flights a week.	Beach inputs.
	Materials (La Bella)	• Cement: 222.8 tonnes dry basis • Well casing/conductor: API 160m 36" (119lb/ft), 650m 13 3/8" (83lb/ft), rest to 2,205m TMD 9 5/8" (47lb/ft). • Water based drilling fluid: 114m^3.	Beach inputs, and Xodus assumptions agreed with Beach.
	Materials (Prospects) per well basis	• Cement: 445.6 tonnes dry basis • Well casing/conductor: API 160m 36" (119lb/ft), 650m 13 3/8" (83lb/ft), rest to 4,500m TMD 9 5/8" (47lb/ft). • Water based drilling fluid: 228m^3. Note up to 30% SBM may be required; the SBM is recovered and not flared.	Beach inputs.
	Waste	Water based drilling fluid and waste cement all disposed at sea with no further treatment. Negligible GHG emissions.	Beach inputs, and Xodus assumptions agreed with Beach.
Well clean up and completion	Flaring	Flare rate of 65MMscfd for up to 2 days.	Beach inputs.
	Venting	To estimate using NGER 3.46AB Method 1. Item 4.	Xodus assumptions agreed with Beach.

PHASE	INCLUSIONS	ASSUMPTIONS / GIVENS	JUSTIFICATIONS
Per well basis	Vessels (including supply and services, and transport)	• 1× MODU • 3× AHTS • Helicopter flights: 8 flights a week.	Beach inputs.
	Materials	N/A	Beach inputs.
	Waste	N/A	Beach inputs.
Installation	Flaring and venting	No changes to production requirements.	Beach inputs, and Xodus assumptions agreed with Beach.
Including hook up and commissioning	Stabilisation material	Not included.	Beach inputs.
	Flowline (material)	Assume flowlines are all API 5L X65 XS piping: 55lb/ft; 5% waste. 3LPP coating.	Beach inputs, and Xodus assumptions agreed with Beach.
	Flowline (main)	10" flowline from La Bella to Artisan - 21km. 10" flowline - 65km farthest well south of Thylacine.	Beach inputs, and Xodus assumptions agreed with Beach.
	Flowlines (to each prospective well, 15 in addition to the 2 above)	10" flowline 9 to 10 km connecting each well.	Beach inputs, and Xodus assumptions agreed with Beach.
	Umbilical (main)	8" Umbilical from Thylacine to Artisan - 45 km. 8" Umbilical from farthest well south of Thylacine to Thylacine - 65km.	Beach inputs.
	Umbilical (15, to each prospective well, in addition to main)	8" Umbilical - 10km	Beach inputs.
	Vessels (including supply and services, and transport)	• 1× ISV • 1× PLV • 1× Multicat • 1x DSV (hot tap assembly - 5 days) • Helicopter flights: 1 flight a week.	Beach inputs.
	Materials (other infrastructure)	For each well, • 2× PTS • 1× diverless interface skid • 1× FLEM	Beach inputs.

PHASE	INCLUSIONS	ASSUMPTIONS / GIVENS	JUSTIFICATIONS
	Waste	Oily water discharged. Assume volume of discharge at 1.5× flowline volume with hydrocarbon concentration of 15ppmv. Considered immaterial.	Xodus assumptions agreed with Beach.
Production	Product	All products are assumed to be combusted as end-use. Fugitive emissions post sales gate not included.	Xodus assumptions agreed with Beach.
	Fugitive emissions (offshore)	For wells proposed in OPP, 40 tonnes per annum CO_2-e each.	Beach inputs and Xodus assumptions.
	Materials	N/A	Beach inputs.
	Waste	N/A	Beach inputs.
IMR	Vessels (including supply and services, and transport)	• 1× ISV • 1× PSV • 1× Multicat • Helicopter flights: 1 flight a week.	Beach inputs, Xodus assumptions agreed with Beach.
Well intervention	Vessels	• 1× MODU • 3× AHTS • Helicopter flights: 6 – 8 flights a week. • Flaring and venting	Beach inputs
Decommissioning		Assume decommissioning requires the same equipment for drilling and installation/commissioning. Durations are based on previous decommissioning campaigns.	Advised by Beach.
	Flaring and venting	No flaring and venting during decommissioning.	Beach inputs.
	Materials (La Bella)	• Cement: 222.8 tonnes dry basis. • Water based drilling fluid: 114m^3.	Beach inputs.
	Materials (all others)	• Cement: 445.6 tonnes dry basis. • Water based drilling fluid: 228m^3. Note up to 30% SBM may be required; the SBM is recovered and not flared.	Beach inputs.
	Waste (La Bella)	Water based drilling fluid and waste cement all disposed at sea with no further treatment. Negligible GHG emissions.	Beach inputs, and Xodus assumptions agreed with Beach.

Appendix L: Hydrotest Discharge Modelling Report

OFFSHORE GAS VICTORIA

Hydrotest Dispersion Modelling

MAQ1296J
Rev1
17 August 2023

Document status

Version	Purpose of document	Authored by	Reviewed by	Approved by	Review date
A	Draft for internal review	Dr. Larissa Perez	Dr. Ryan Dunn	Nathan Benfer	10 August 2023
0	Draft issued for Client review			Nathan Benfer	11 August 2023
1	Draft issued for Client review	Dr. Larissa Perez		Nathan Benfer	17 August 2023

Approval for issue

Nathan Benfer		17 August 2023

Prepared by:

RPS

Nathan Benfer
Principal Consultant

Lakehouse Corporate Space, Suite 425
Level 2, 34-38 Glenferrie Drive
Robina, QLD, 4226

T +61 7 5553 6900
E Nathan.Benfer@rpsgroup.com

Prepared for:

Beach Energy Ltd

Phil Wemyss
Principal Environmental Advisor

80 Flinders Street,
Adelaide, SA, 5001

T +61 8 8433 2394
E Phil.Wemyss@beachenergy.com.au

Contents

Tables

Figures

EXECUTIVE SUMMARY

Background

Beach Energy Limited (Beach) has plans for development within the Otway Basin.

In order to support the environmental approvals, Beach commissioned RPS to undertake a detailed discharge modelling study of chemically treated seawater used to undertake system hydrotesting of the infield subsea facilities before being used to deliver the product.

The principal aim of the study was to determine the potential area of exposure from the preservation chemical within the treated seawater discharge. A detailed dewater discharge modelling study was commissioned, which examined a 6,000 m^3 discharge of treated seawater over a period of 42.9 hours (140 m^3/hr), 2 m above the seafloor. The initial concentration of the preservation chemical was assumed to be 550 mg/L (or parts per million (ppm)). The treated seawater will have the same water temperature and salinity as the surrounding seawater.

The predicted extent of the preservation chemical is reported as an annual assessment (i.e. any time of year).

Methodology

The modelling study was carried out in stages. Firstly, a 10-year current dataset (2010–2019) that includes the combined influence of large-scale ocean and tidal currents was prepared. Secondly, the near-field plume dynamics based on the discharge configuration and treated seawater characteristics was assessed under weak, moderate, and strong static current speeds. This step assessed the initial dilution of the treated water plume, which was then followed by an investigation of the far-field mixing. Different modelling approaches are required for calculating the near-field and far-field dilutions due to the differing hydrodynamic scales.

A total of 100 far-field simulations were run, with each simulation having a different start time to ensure a range of current conditions were sampled to assess the mixing and dispersion (i.e. dilution) of the preservation chemical. Once the simulations were complete, the individual outputs were combined to determine the maximum distances to achieved dilutions of the preservation chemical as an annual assessment, based on the 95th, 99th and 100th percentiles.

Summary of Modelling Results

- The near-field modelling revealed the results showed that treated seawater would initially project upward at a 45-degree angle due to the diffuser orientation and the high exit velocity. Once the plume lost its momentum, the plume descended slightly till it was neutrally buoyant with the ambient water and then mixed laterally due to ambient currents.
- The far-field modelling results indicate that for the 99th and 100th percentile analysis (i.e. 99% and 100% of the time), the maximum distances from the Release Location to the predicted dilutions of 1:550 (i.e. 1 mg/L which represents the impact threshold concentration/trigger value) contour were 20 m and 156 m, respectively. Based on the 95th percentile analysis (or 95% of the time), the 1:550 dilution was achieved very close to the release location (20 m).

1 INTRODUCTION

1.1 Background

Beach Energy Limited (Beach) has plans for development within the Otway Basin.

In order to support the environmental approvals, Beach commissioned RPS to undertake a detailed discharge modelling study of chemically treated seawater used to undertake system hydrotesting of the infield subsea facilities before being used to deliver the product.

The principal aim of the study was to determine the potential area of exposure from the preservation chemical within the treated seawater discharge. A detailed dewater discharge modelling study was commissioned, which examined a 6,000 m^3 discharge of treated seawater over a period of 42.9 hours (140 m^3/hr), 2 m above the seafloor. The initial concentration of the preservation chemical was assumed to be 550 mg/L (or parts per million (ppm)). The treated seawater will have the same water temperature and salinity as the surrounding seawater.

The coordinates of the Release Location is presented in Table 1-1 and illustrated in Figure 1-1.

The predicted extent of the preservation chemical is reported as an annual assessment (i.e. any time of year).

Table 1-1 Coordinates Release Location used for the treated seawater discharge modelling assessment.

Release Location	Latitude*	Longitude*	Water depth (m)
Release Location South	39.7485° S	143.1637° E	~155

*Datum: WGS 1984

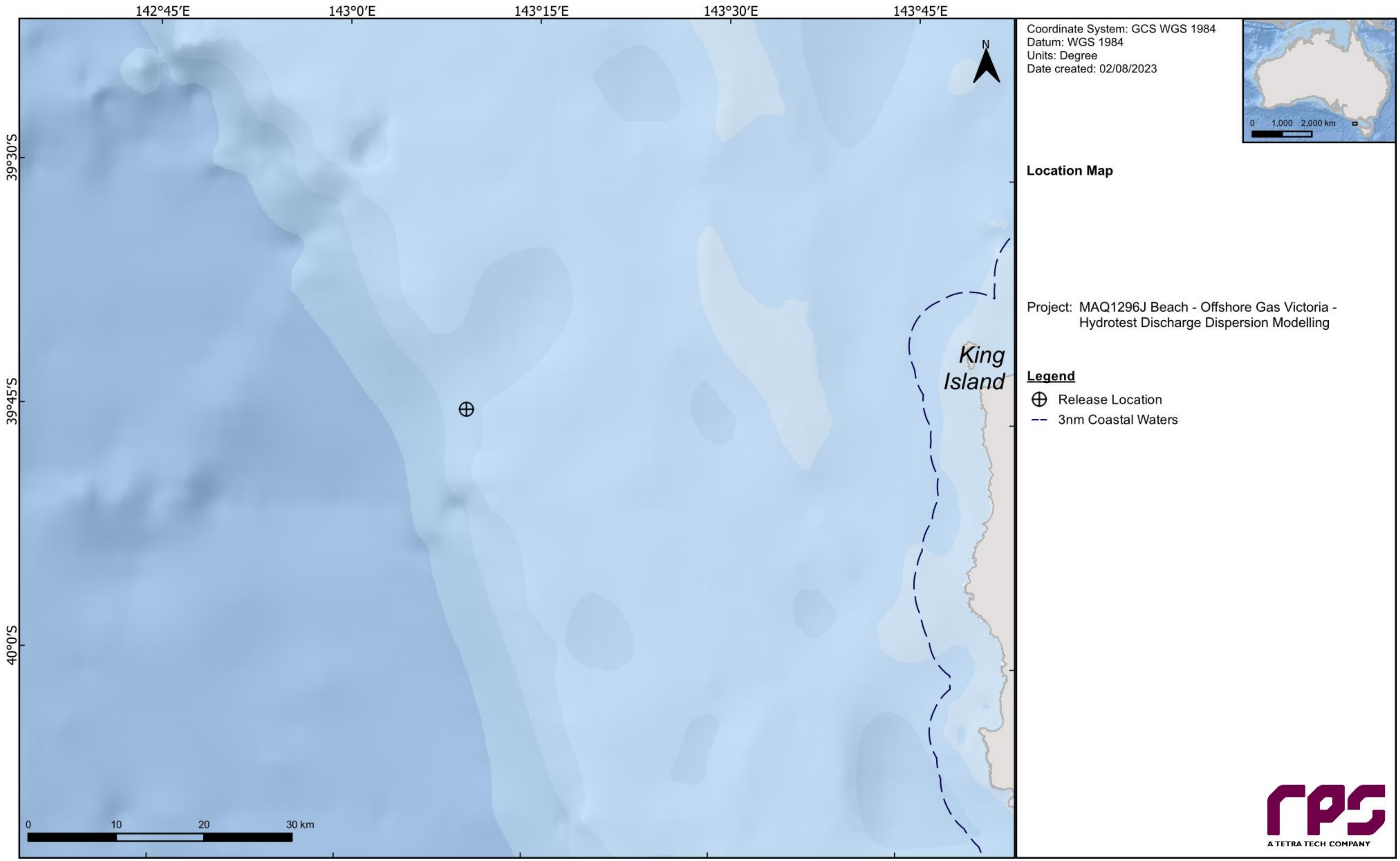


Figure 1-1 Location of the release site used for the treated seawater discharge modelling assessment.

2 SCOPE OF WORK

The physical mixing of the discharge can be separated into two distinct zones: near-field and far-field. The near-field zone focusses on the mixing of the treated seawater; while the mixing of the preservation chemical is assessed in the far-field. The near-field zone is defined by the region that is controlled by the plume's initial jet momentum and the static current. Normally, the buoyancy difference is considered in the near-field, however, it is negligible in this instance given that the treated seawater has the same density as the surrounding seawater. Once the near-field assessment is complete, the far-field phase examined the transport and mixing of the corrosion inhibitor by the ambient currents. Therefore, the scope of work included the following components:

1. Generate 10-years (2010-2019) of three-dimensional current data, that includes the combined influence of drift and tidal currents and is suitably long to be indicative of interannual variability in ocean currents;
2. Analyse the 10-year current dataset and identify the weak (5th percentile), moderate (50th percentile) and strong (95th percentile) current speeds, which were used as inputs in the near-field model;
3. Calculate the near-field plume dynamics (or initial dilution) based on the diffuser configuration and treated seawater characteristics under weak, moderate and strong static current speeds;
4. Run 100 far-field simulations, with each simulation having randomly selected start dates and times between 2010-2019 to ensure a range of current conditions were sampled to assess the mixing and dispersion of the preservation chemical; and
5. Combine the results for all 100 simulations and determine the maximum distances from the Release Location and total areas of exposure for the achieved far-field dilutions of the preservation chemical, including a dilutions equivalent to the impact threshold of 1 ppm (equivalent to 1 mg/L), based on 95th, 99th and 100th percentile outcomes.

3 REGIONAL CURRENTS

Bass Strait is a body of water separating Tasmania from the southern Australian mainland, specifically the state of Victoria. The strait is a relatively shallow area of the continental shelf, connecting the southeast Indian Ocean with the Tasman Sea. Currents within the straight are primarily driven by tides, winds, incident continental shelf waves and density driven flows; high winds and strong tidal currents are frequent within the area (Jones, 1980).

The varied geography and bathymetry of the region, in addition to the forcing of the south-eastern Indian Ocean and local meteorology lead to complex shelf and slope circulation patterns (Middleton & Bye, 2007). Figure 3-1 displays seasonal current trends within the Bass Strait. During winter there is a strong eastward water flow due to the strengthening of the South Australian Current (fed by the Leeuwin Current in the Northwest Shelf), which bifurcates with one extension moving though the Bass Strait, and another forming the Zeehan Current off western Tasmania (Sandery & Kämpf, 2007). During summer, water flow reverses off Tasmania, King Island and the Otway Basin travelling eastward, as the coastal current develops due to south-easterly winds.

To accurately describe the variability in currents between the inshore and offshore region, a hybrid regional dataset was developed by combining deep ocean predictions obtained from HYCOM (Hybrid Coordinate Ocean Model) with surface tidal currents developed by RPS. The following sections provide a summary of the hybrid regional dataset.

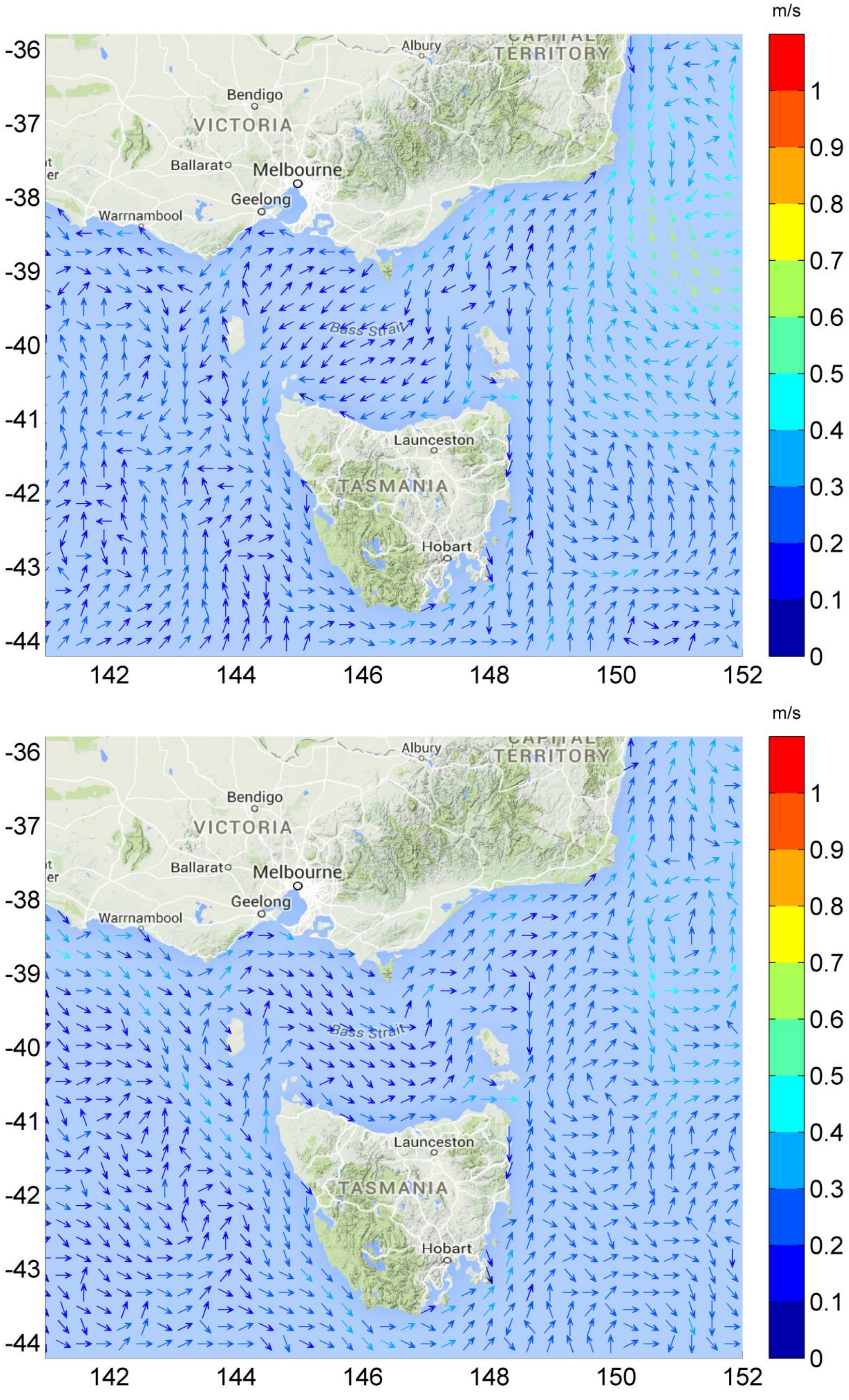


Figure 3-1 HYCOM averaged seasonal surface drift currents during summer (upper image) and winter (lower image).

3.1 Tidal Currents

Tidal current data was generated using RPS's advanced ocean/coastal model, HYDROMAP. The HYDROMAP model has been thoroughly tested and verified through field measurements throughout the world over the past 38 years (Isaji & Spaulding, 1984; Isaji et al., 2001; Zigic et al., 2003). HYDROMAP tidal current data has been used as input to forecast (in the future) and hindcast (in the past) pollutant spills in Australian waters and forms part of the Australian National Oil Spill Emergency Response System operated by AMSA (Australian Maritime Safety Authority).

HYDROMAP employs a sophisticated sub-gridding strategy, which supports up to six levels of spatial resolution, halving the grid cell size as each level of resolution is employed. The sub-gridding allows for higher resolution of currents within areas of greater bathymetric and coastline complexity, and/or of particular interest to a study.

The numerical solution methodology follows that of Davies (1977a and 1977b) with further developments for model efficiency by Owen (1980) and Gordon (1982). A more detailed presentation of the model can be found in Isaji & Spaulding (1984) and Isaji et al. (2001).

3.1.1 Grid Setup

The tidal model domain was sub-gridded to a resolution of 500 m for shallow and coastal regions, starting from an offshore (or deep water) resolution of 8 km. The finer grids are progressively allocated in a step-wise fashion to more accurately resolve flows along the coastline, around islands and over regions with more complex bathymetry. Figure 3-2 shows the tidal model grid covering the study domain.

A combination of datasets was used and merged to describe the shape of the seabed within the grid domain (Figure 3-3). These included spot depths and contours which were digitised from nautical charts released by the hydrographic offices as well as Geoscience Australia database and depths extracted from the Shuttle Radar Topography Mission (SRTM30_PLUS) Plus dataset (see Becker et al., 2009).

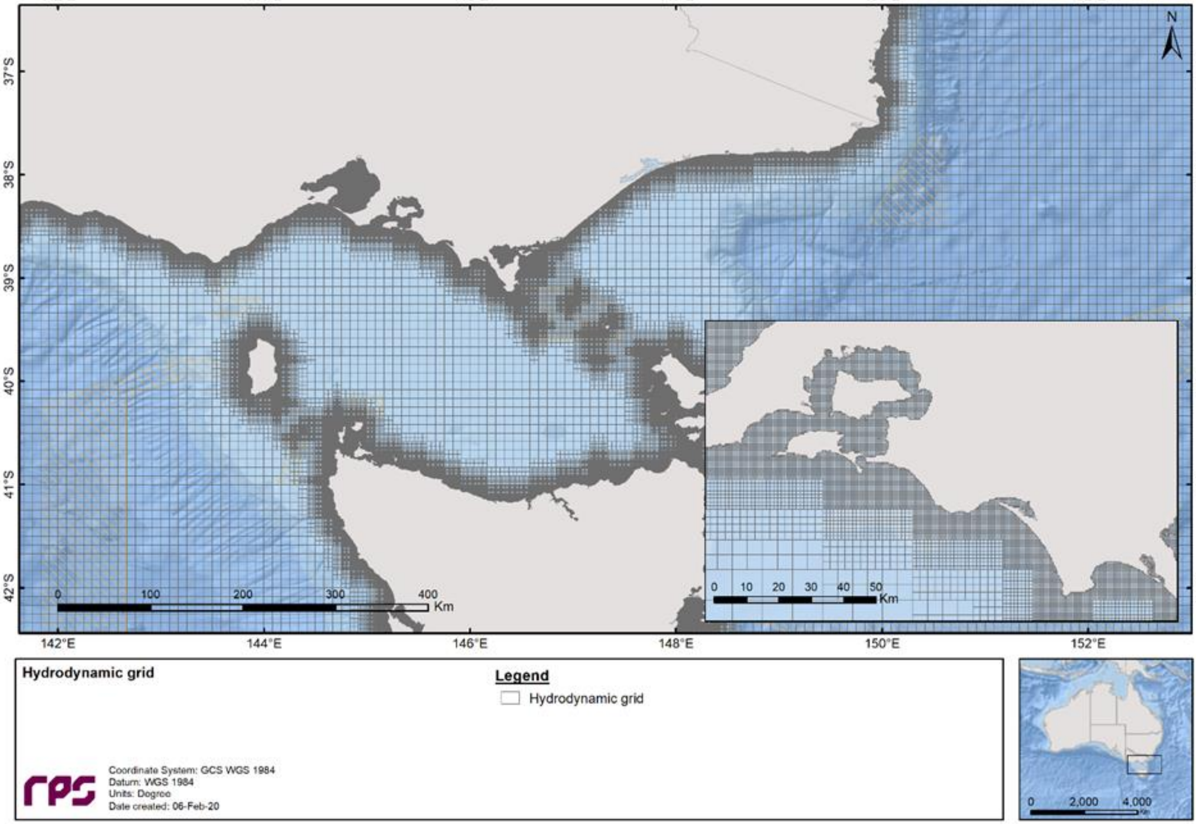


Figure 3-2 Sample of the model grid used to generate the tidal currents for the study region. Higher resolution areas are shown by the denser mesh.

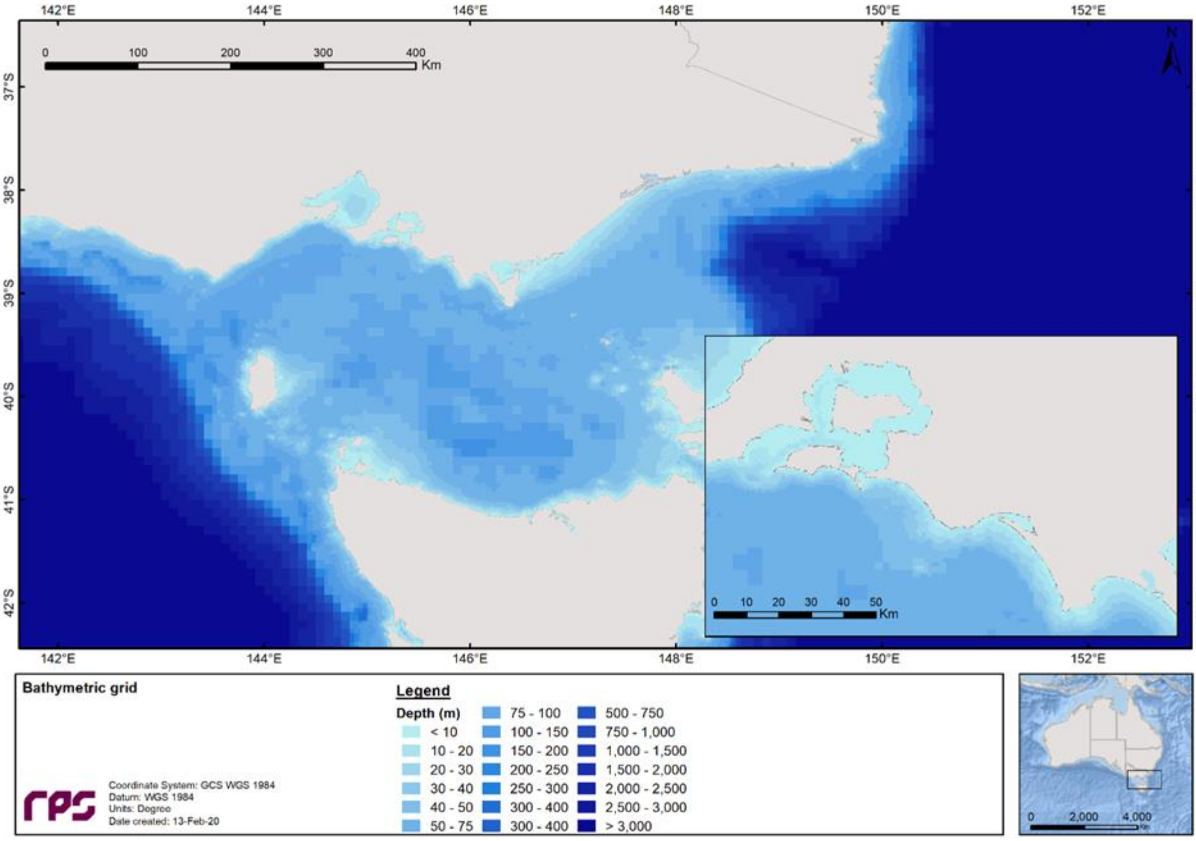


Figure 3-3 Bathymetry defined throughout the tidal model domain.

3.1.2 Tidal Conditions

The ocean boundary data for the regional model was obtained from satellite measured altimetry data (TOPEX/Poseidon 7.2) which provided estimates of the eight dominant tidal constituents at a horizontal scale of approximately 0.25 degrees. The eight major tidal constituents used were K_2, S_2, M_2, N_2, K_1, P_1, O_1 and Q_1. Using the tidal data, surface heights were firstly calculated along the open boundaries, at each time step in the model.

The TOPEX/Poseidon satellite data has a global resolution of 0.25 degrees and is produced and quality controlled by NASA (National Aeronautics and Space Administration). The satellites equipped with two highly accurate altimeters and capable of taking sea level measurements with an accuracy of ± 5 cm measured oceanic surface elevations (and the resultant tides) for over 13 years (1992–2005). In total, these satellites carried out 62,000 orbits of the planet.

The TOPEX/Poseidon tidal data has been widely used amongst the oceanographic community, being included in more than 2,100 research publications (e.g. Andersen, 1995; Ludicone et al., 1998; Matsumoto et al., 2000; Kostianoy et al., 2003; Yaremchuk & Tangdong, 2004; Qiu & Chen 2010). As such the TOPEX/Poseidon tidal data is considered suitably accurate for this study.

3.2 Ocean Currents

Data describing the flow of ocean currents was obtained from HYCOM (Hybrid Coordinate Ocean Model, (Chassignet et al., 2007), which is operated by the HYCOM Consortium, sponsored by the National Ocean Partnership Program (NOPP), as part of the U.S. Global Ocean Data Assimilation Experiment (GODAE). HYCOM is a data-assimilative, three-dimensional ocean model that is run as a hindcast (for a past period), assimilating time-varying observations of sea surface height, sea surface temperature and in-situ temperature and salinity measurements (Chassignet et al., 2009). The HYCOM predictions for drift currents are produced at a horizontal spatial resolution of approximately 8.25 km (1/12th of a degree) over the region, at a frequency of every 3 hours. HYCOM uses isopycnal layers in the open, stratified ocean, but uses the layered continuity equation to make a dynamically smooth transition to a terrain following coordinate in shallow coastal regions, and to z-level coordinates in the mixed layer and/or unstratified seas.

For this study, the HYCOM hindcast currents were obtained for the years 2010 to 2019 (inclusive).

3.3 Near-seabed Currents

Figure 3-4 and Figure 3-5 present the monthly and annual current rose plots, respectively, in the vicinity of the Release Location based on combined tidal and ocean currents.

Note the convention for defining current direction throughout this report is the direction the current flows towards. Each branch of the current rose distribution represents the currents flowing to that direction, with north to the top of the diagram. The branches are divided into segments of different colour, which represent the current speed ranges for each direction. Speed intervals of 0.2 m/s are typically used in these current roses. The length of each coloured segment within a branch is proportional to the frequency of currents flowing within the corresponding speed and direction.

The data showed that the currents predominantly flowed along the southwest–northeast axis. Average monthly current speeds ranged between 0.08 m/s and 0.11 m/s. Additionally, the maximum monthly near-seabed current speeds ranged between 0.20 m/s (December) and 0.39 m/s (July, Table 3-1).

Table 3-1 Predicted monthly average, maximum and percentile near-seabed currents at the Release Location South. Data were based on conditions between 2010 and 2019.

Month	Maximum current speed (m/s)	Average current speed (m/s)	5th Percentile current speed (m/s)	50th Percentile current speed (m/s)	95th Percentile current speed (m/s)
January	0.27	0.08	0.02	0.07	0.14
February	0.23	0.08	0.02	0.07	0.14
March	0.25	0.08	0.02	0.08	0.15
April	0.26	0.08	0.02	0.07	0.15
May	0.34	0.09	0.02	0.08	0.18
June	0.28	0.09	0.02	0.09	0.18
July	0.39	0.11	0.03	0.10	0.21
August	0.33	0.10	0.03	0.09	0.20
September	0.28	0.09	0.03	0.09	0.16
October	0.35	0.08	0.02	0.08	0.15
November	0.21	0.08	0.02	0.08	0.14
December	0.20	0.08	0.02	0.08	0.14
Minimum	**0.20**	**0.08**	**0.02**	**0.07**	**0.14**
Maximum	**0.39**	**0.11**	**0.03**	**0.10**	**0.21**

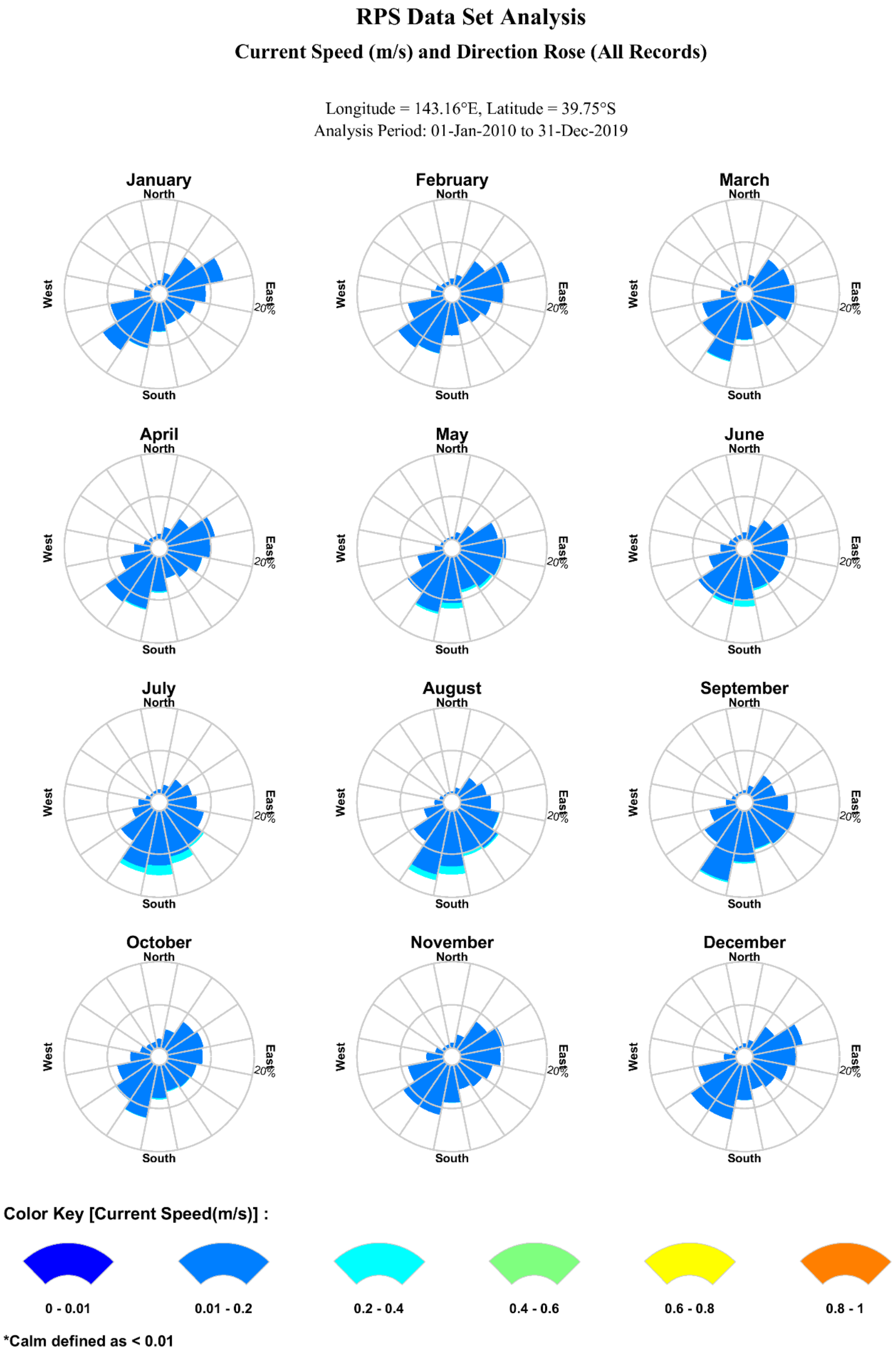


Figure 3-4 Monthly near-seabed current rose plots adjacent to the Release Location, derived from the 2010 to 2019 modelled dataset.

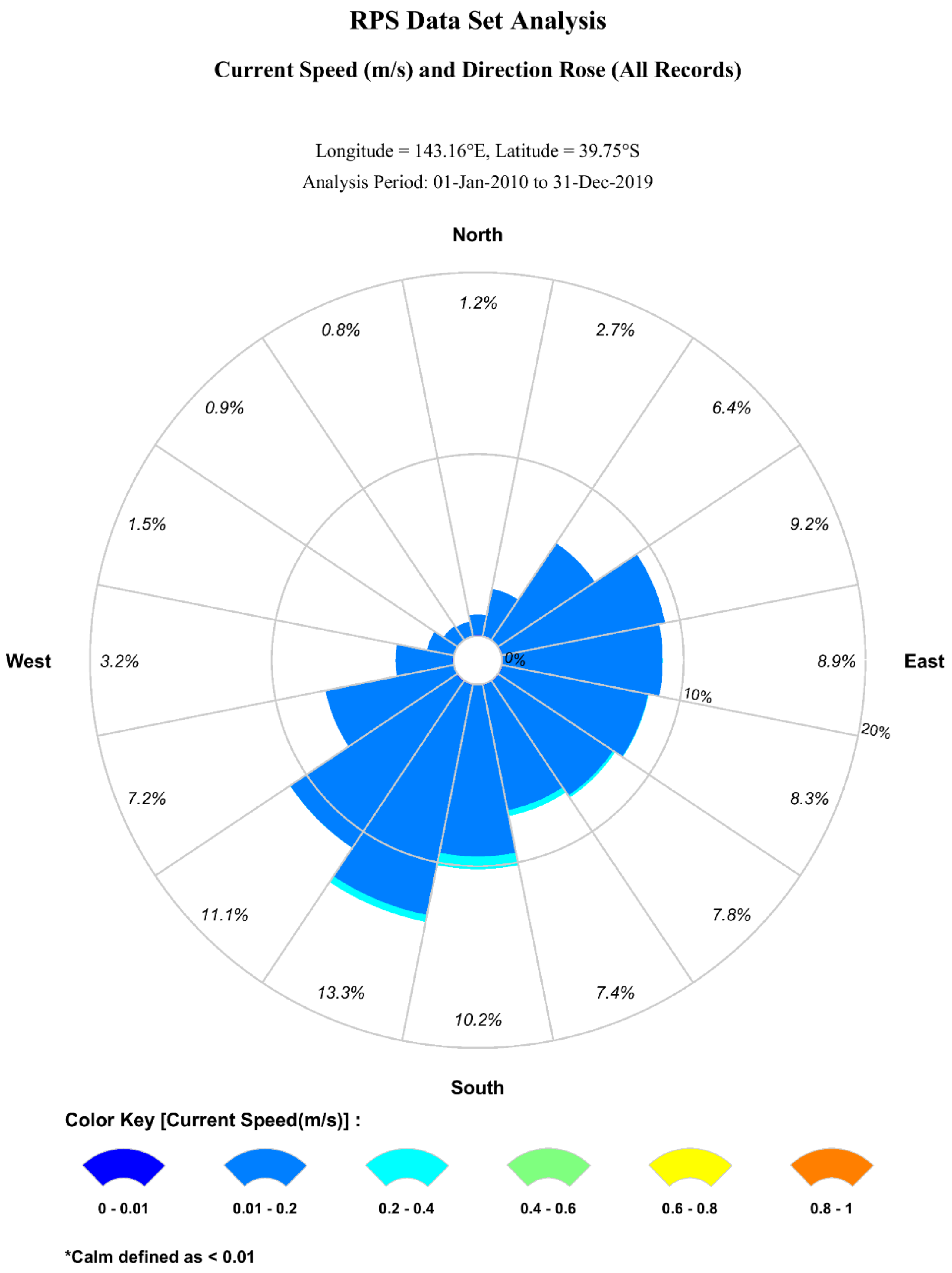


Figure 3-5 Annual near-seabed current rose plots adjacent to the Release Location, derived from the 2010 to 2019 modelled dataset.

4 WATER TEMPERATURE AND SALINITY

Table 4-1Table 4-1 shows the temperature and salinity data used as part of the near and far field modelling, which was obtained from the World Ocean Atlas 2018 database produced by the National Oceanographic Data Centre (National Oceanic and Atmospheric Administration) and its co-located World Data Center for Oceanography (Levitus et al., 2013). March and October conditions were used to represent summer and winter condition, as these were the months which revealed the highest and lowest temperatures, respectively.

Near-seabed (150 m) temperatures ranged between 11.5 ˚C (winter) and 12.7 ˚C (summer). Additionally, the summer and winter temperature profile exhibits reducing temperature with increasing depth (e.g. ~7 ˚C difference between the surface and bottom water layers). Salinity levels are generally consistent with season, and depth indicating a vertically well-mixed water body ranging between 35.3-35.4 psu through the water column.

Table 4-1 Summer and winter water temperature and salinity through the water column adjacent to the release location. March and October conditions were used to represent summer and winter condition, as these were the months which revealed the highest and lowest temperatures, respectively.

Water Depth (m)	Temperature (°C) Summer	Salinity (psu) Summer	Temperature (°C) Winter	Salinity (psu) Winter
0	18.4	35.4	13.3	35.4
2	18.4	35.4	13.3	35.4
4	18.4	35.4	13.3	35.4
6	18.4	35.4	13.3	35.4
8	18.4	35.4	13.3	35.4
10	18.4	35.4	13.3	35.4
12	18.4	35.4	13.3	35.4
15	18.4	35.4	13.3	35.4
20	18.4	35.4	13.2	35.4
25	18.4	35.4	13.2	35.4
30	18.3	35.4	13.2	35.4
35	18.2	35.4	13.2	35.4
40	18.1	35.4	13.2	35.4
45	18.0	35.4	13.2	35.4
50	17.7	35.4	13.1	35.4
60	16.2	35.3	13.1	35.4
70	14.8	35.2	13.1	35.4
80	13.9	35.2	13.0	35.4
90	13.1	35.2	13.0	35.4
100	12.6	35.2	13.0	35.4
125	12.0	35.1	12.8	35.4
150	11.5	35.1	12.7	35.3

5 ENVIRONMENTAL REPORTING CRITERIA

Beach plan to use a preservation chemical such as Hydrosure 0-3670R to treat the seawater that will be potentially discharged from the flowline. As per the ConocoPhillips Barossa OPP (ConocoPhillips, 2017) and Shell Crux OPP (Shell Australia Pty Ltd, 2020) an impact threshold concentration/trigger value of 1 ppm (equivalent to 1 mg/L) of the preservation chemical was used as part of this study. According to both OPPs, an impact threshold of 1 mg/L for the preservation chemical was defined as it was considered that concentrations below this threshold would not result in significant environmental impacts. It is a threshold, which is consistent with published acute toxicity test data for aquatic species for typical biocides including the Wheatstone Project Offshore Facilities and Produced Formation Water Discharge Management Plan: Stage 1 (Chevron Australia, 2015) which had identified an acute toxicity threshold of 1 ppm for Hydrosure, a representative preservation product. The Safety Data Sheet for Hydrosure O-3670R states the 96-hour LC_{50} as 3.09 mg/L for fish in marine waters, with a 48-hour EC_{50} of 5.66 mg/L for aquatic invertebrates (Champion Technologies, 2013). Note that ecotoxicological studies are typically undertaken using constant doses for periods ranging from 24 to 96 hours under controlled conditions when establishing ecotoxicological threshold of interest.

This approach is in contrast to the natural environment, where the concentration and exposure durations can vary widely. For the purpose of this assessment, selection of an impact threshold of 1 ppm provides a conservative basis to evaluate the potential effects of biocide in the receiving environment.

6 MODELLING METHODOLOGY

6.1 Near-Field Modelling

6.1.1 Description of the Near-Field Model: CORMIX

The near-field mixing and dispersion of the treated water discharge was simulated using the three-dimensional flow model, CORMIX. CORMIX is a mixing zone model and decision support system for environmental impact assessment of regulatory mixing zones. CORMIX contains a series of elements for the analysis and design of single or multi-port discharges. Discharges may be submerged or above surface, buoyant or denser than receiving water and the receiving water may be stratified or unstratified. The emphasis of the model is the influence of the geometry and dilution characteristics on the initial mixing zone (Doneker & Jirka, 1990; Jirka et al., 1991). CORMIX is widely applied worldwide and has been validated in many independent studies (http://www.cormix.info/validations.php).

CORMIX is a collection of analytic solutions to simplified forms of the mathematical equations describing transport and dispersion of water borne constituents. The simplifications are established through a range of assumptions about the source configuration, source characteristics (discharge and buoyancy) and the ambient environment. These assumptions effectively limit the domain within which the analytic solutions apply.

Although CORMIX does calculate far-field dispersion, the assumptions of the algorithms limit application to homogeneous environments with no eddies in the ambient flow and little recirculation. For this reason, the CORMIX component of the calculations for this study were limited to the near-field zone.

CORMIX specifies the average dilution or bulk dilution (flux averaged) as 1.7 times the centreline dilution. The centreline is defined by the points of maximum concentration (maximum temperature, minimum dilution etc) at each vertical section along the longitudinal axis. Accordingly, centreline depth is defined as the depth of the maximum concentration point (maximum temperature, minimum dilution) along the longitudinal axis.

6.1.2 Near-Field Model Setup

Summary of the treated seawater discharge characteristics are presented in Table 6-1. The discharge was anticipated to occur 2 m above the seabed through a single outlet from a diffuser orientated vertically upwards at 45 degrees with a 2 inch diameter. The discharge was anticipated to have a salinity and temperature as per ambient waters (see Section 4 Water Temperature and Salinity).

Table 6-1 Summary of the treated seawater discharge characteristics.

Parameter	Inputs
Total Discharge Volume	6,000 m^3
Discharge flow rate	140 m^3/hr
Diameter of discharge pipe	2"
Depth of discharge (below MSL)	153 m
Discharge Configuration (i.e. up, down, horizontal, number of ports)	Vertical upwards at 45 degrees
Surrounding water depth	155 m
Discharge temperature	Ambient
Discharge salinity	Ambient

Inputs to the CORMIX model also included constant current speeds. The 10-year data was statistically analysed to determine the 5th, 50th and 95th percentile current speeds at varying depths (Table 6-2) for input to the near-field model to reflect contrasting mixing and advection cases:

- 5th percentile current speed: weak currents, low mixing and slow advection;
- 50th percentile (median) current speed: average currents, moderate mixing and advection; and
- 95th percentile current speed: strong currents, high mixing and rapid advection to nearby areas.

The 5th, 50th and 95th percentile values are referenced as weak, medium and strong current speeds, respectively.

Table 6-2 Adopted ambient current conditions adjacent to the Release Location.

Depth (m)	5th percentile (weak) current speed (m/s)	50th percentile (medium) current speed (m/s)	95th percentile (strong) current speed (m/s)
Near-seabed	0.02	0.08	0.16

6.2 Far-Field Modelling

6.2.1 Overview

The far-field modelling expands on the near-field work by allowing the time-varying nature of currents to be included and for the potential for localised build-up when current speeds are low (e.g. at the turning of the tide) and recirculation of the plume back to the discharge location might occur. In this case, concentrations near the discharge point can be increased due to the discharge plume mixing with the remnant plume from an earlier time. This may be a potential source of episodic increases in pollutant concentrations in the receiving waters.

6.2.2 Description of Far-Field Model: MUDMAP

The mixing and dispersion of the preservation chemical was predicted using the three-dimensional discharge and plume behaviour model, MUDMAP. The far-field calculation (passive dispersion stage) employs a particle-based, random walk procedure. Any chemicals (constituents) within the discharge stream are represented by a sample of Lagrangian particles. These particles are moved in three dimensions over each subsequent time step according to the prevailing local current data as well as horizontal and vertical mixing coefficients.

MUDMAP treats the Lagrangian particles as conservative tracers (i.e. they are not removed over time to account for chemical interactions, decay or precipitation). Predicted concentrations will therefore be conservative overestimates where these processes actually do occur. Each particle represents a proportion of the discharge, by mass, and particles are released at a given rate to represent the rate of the discharge (mass per unit time). Concentrations of constituents are predicted over time by counting the number of particles that occur within a given depth level and grid square and converting this value to mass per unit volume.

The system has been extensively validated and applied for discharge operations in Australian waters (e.g. Burns et al., 1999; King & McAllister, 1997, 1998).

6.2.3 Far-Field Model Setup

Table 6-3 presents a summary of the far-field model inputs used to calculate the transport and mixing of the preservation chemical by the ambient currents. 100 simulations were run and each simulation had randomly selected (different) start dates and times (between 2010–2019), which ensured a range of current conditions were sampled.

Table 6-3 Summary of the chemical preservation far-field discharge characteristics.

Parameter	Inputs
Hindcast modelling period	2010–2019
Seasons	Annual
Total volume of treated water released (m^3)	6,000
Duration of release (hours)	42.9
Preservation chemical (mg/L or ppm)	550
Simulated period (days)	3

6.2.3.1 Mixing Parameters

The horizontal and vertical dispersion coefficients represent the mixing and diffusion caused by turbulence, both of which are sub-grid-scale processes. Both coefficients are expressed in units of rate of area change per second (m^2/s). Increasing the horizontal dispersion coefficient will increase the horizontal spread of the discharge plume and decrease the centreline concentrations faster. Increasing the vertical dispersion coefficient spreads the discharge across the vertical layers (or depths) faster.

Spatially constant, conservative dispersion coefficients of 0.15 m^2/s and 0.001 m^2/s were used to control the spreading of the plume in the horizontal and vertical directions, respectively. Each of the mixing parameters was selected following extensive sensitivity testing to recreate the plume characteristics predicted by the near-field modelling. It would be expected that the in-situ mixing dynamics would be greater under average and high energy conditions by a factor of 10 (King & McAllister, 1997; 1998) and thus the far-field model results are designed to produce a conservative result for concentration extents.

6.2.3.2 Grid Configuration

MUDMAP uses a three-dimensional grid to represent the geographic region under study (water depth and bathymetric profiles). A resolution of 10 m x 10 m was to track the movement and fate of the preservation chemical horizontally. The vertical resolution (z-axis) was set to 10 m. It is important to note, that the grid cell sizes were selected following extensive sensitivity testing in order to achieve similar dilution rates reflecting those predicted for the end of near-field mixing.

6.2.4 Interpretation of Percentile Dilution Contours

Once the simulations were complete, the individual outputs were combined and a statistical analysis performed to produce percentile dilutions. In the following sections, outcomes are presented for 95th 99th percentile and 100th (maximum) percentile dilution.

Note that the percentile figures represent concentrations that had occurred at each grid cell derived from 100 simulations and all time steps.

Moreover, the dilutions presented assume the background concentration of the preservation chemical in the receiving waters is zero and there is no biodegradation.

7 MODELLING RESULTS

7.1 Near-Field Modelling

Table 7-1 summarises the near-field modelling results. The near-field results showed that the treated seawater would initially propel upward at a 45 degree angle due to the diffuser orientation and the high exit velocity. The high exit velocity is also responsible for the initial mixing of the discharge plume and receiving waters that takes place. Once the plume lost its momentum, the plume descended slightly till it was neutrally buoyant with the ambient water and then mixed laterally due to ambient currents.

Within 30 m of the discharge, the predicted dilutions resulted in reductions of the initial concentration (550 mg/L) of the preservation chemical from to 3.6 mg/L (1:154.7 dilution), 2.6 mg/L (1:212.5 dilution) and 2.5 mg/L (or ppm; 1:222.5 dilution) under weak, medium and strong current conditions, respectively. Note that the required dilution corresponding to the impact threshold concentration/trigger value of 1 mg/L is 1:550 (see Section 5 Environmental Reporting Criteria). Importantly, the reported near-field predictions (Table 7-1) rely on the persistence of constant current speed(s) and direction over time and do not account for the build-up of the plume under time-varying hydrodynamic conditions (e.g. recirculation of the plume back to the Release Location).

Vertical cross-section and plan views of the predicted dilutions for the discharge under the modelled low, moderate and high currents are presented in Figure 7-1 to Figure 7-3, respectively.

Table 7-1 Predicted treated seawater near-field plume characteristics at 10 m and 30 m from the Release Location under weak, medium and strong current speeds during annualised conditions.

Surface current speed (m/s)	Distance from the Release Location (m)	Minimum centreline dilution (1:x)	Plume centre concentration (mg/L) following initial concentration of 550 mg/L	Plume diameter (m)
Weak (0.02)	10	55.1	10.0	3.2
	30	154.7	3.6	9.0
Medium (0.08)	10	66.6	8.3	3.4
	30	212.5	2.6	7.8
Strong (0.16)	10	75.1	7.3	3.0
	30	222.5	2.5	6.2

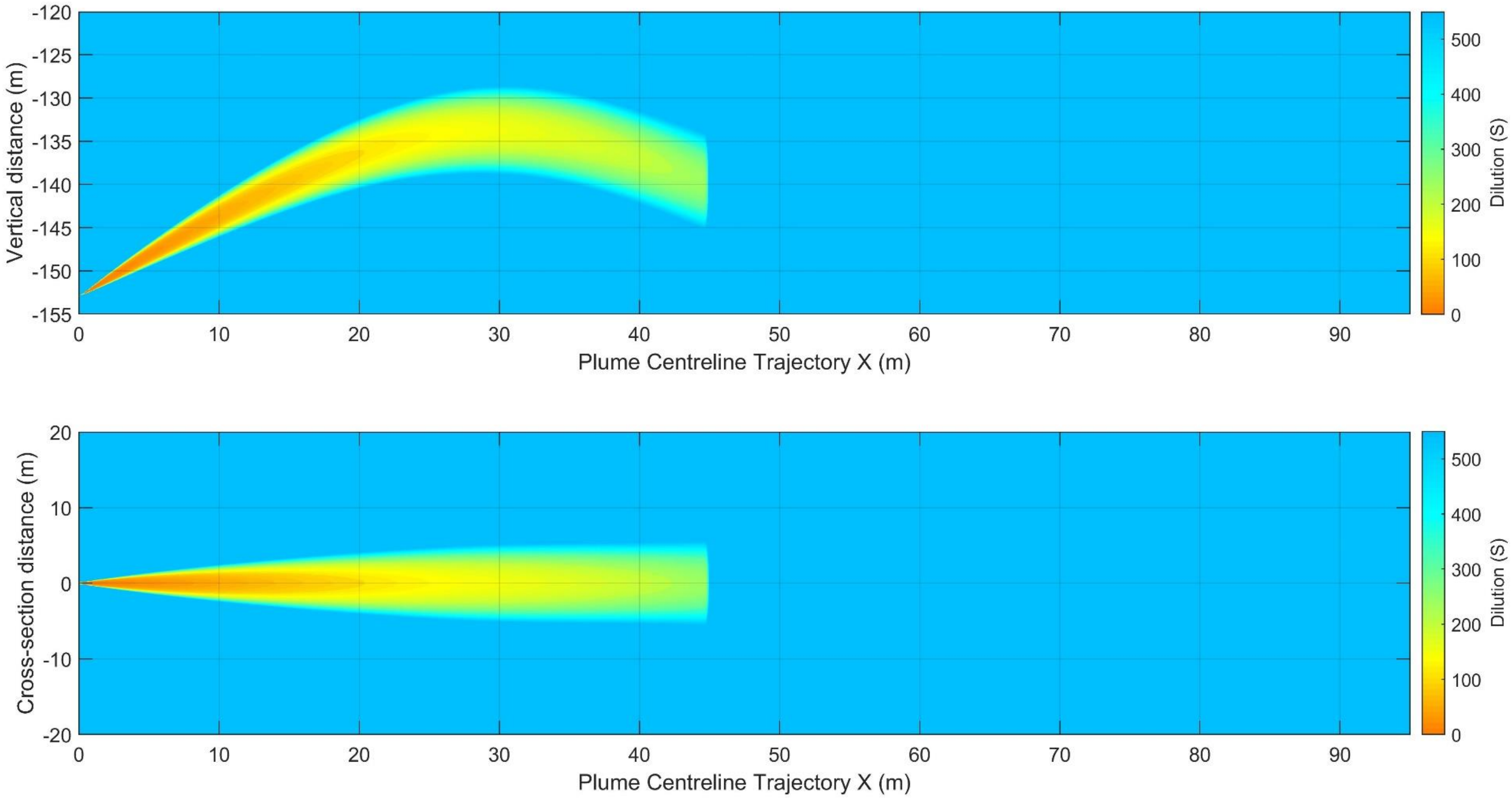


Figure 7-1 Vertical cross-section (top panel) and plan view (bottom panel) dilutions (1:S) for the discharge under low currents.

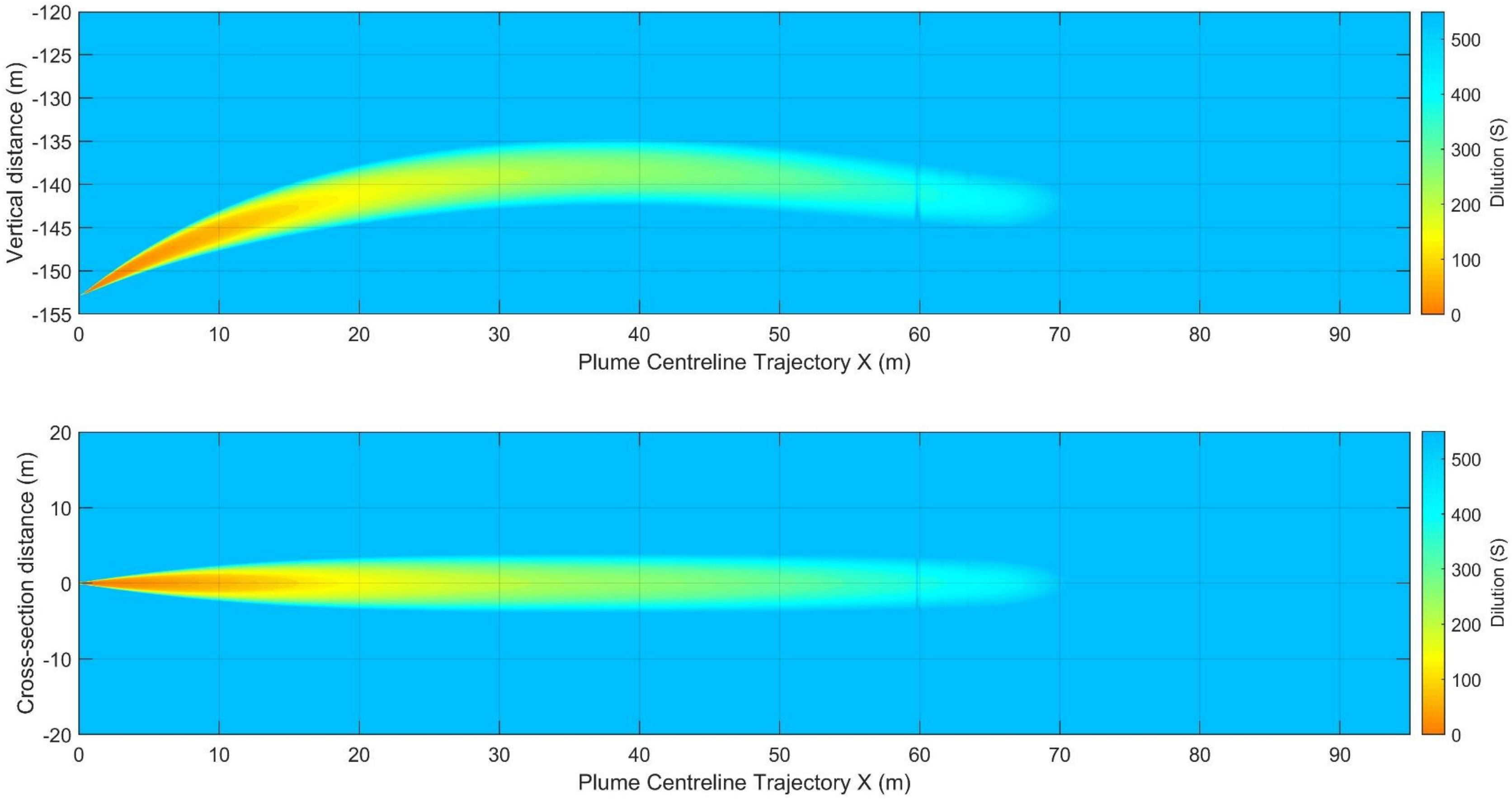


Figure 7-2 Vertical cross-section (top panel) and plan view (bottom panel) dilutions (1:S) for the discharge under moderate currents.

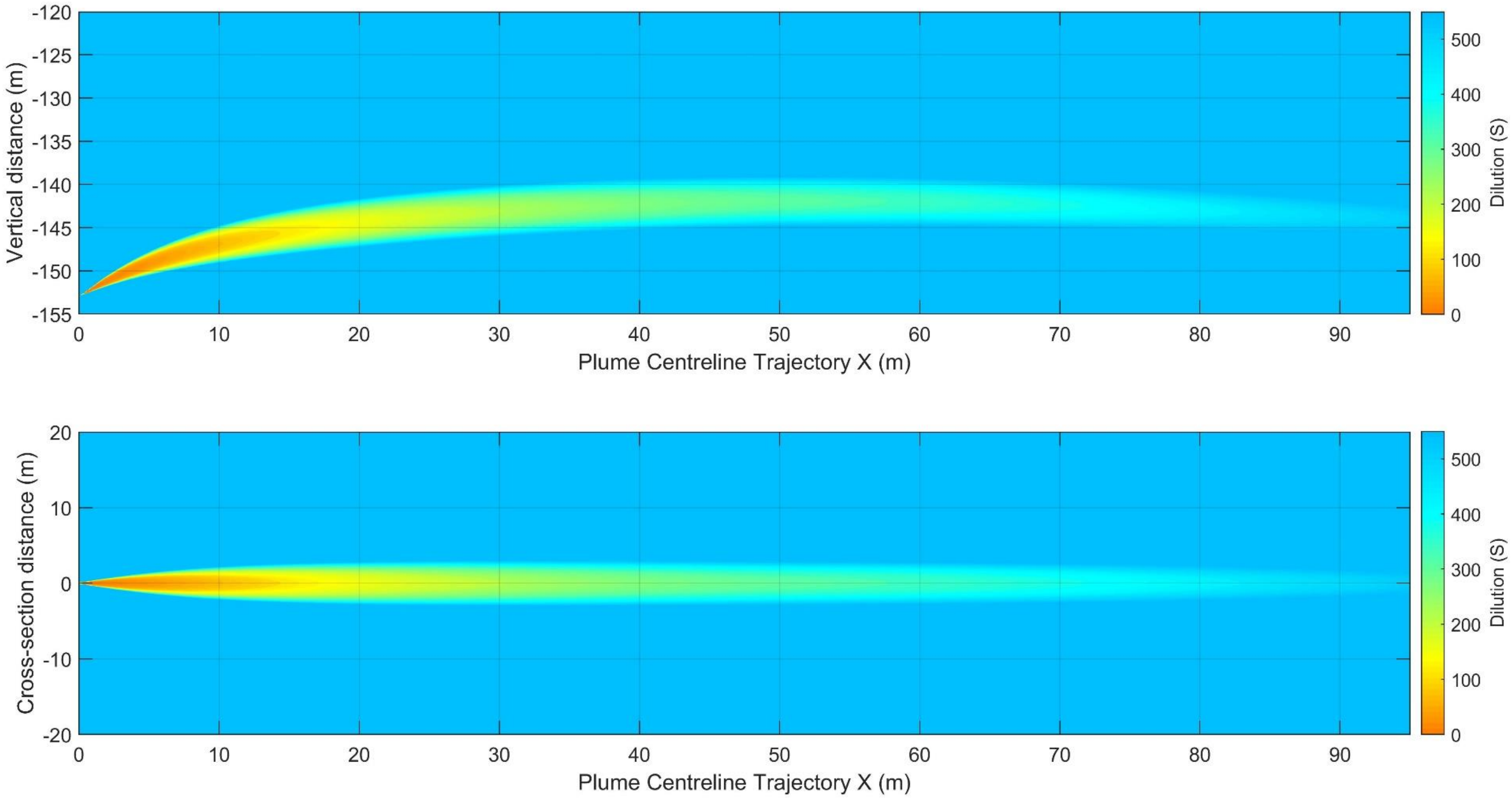


Figure 7-3 Vertical cross-section (top panel) and plan view (bottom panel) dilutions (1:S) for the discharge under high currents.

7.2 Far-Field Modelling

7.2.1 General Observations

Figure 7-4and Figure 7-5 present snapshots of predicted concentrations for a single simulation at +3, +6, +12 and +24 hours. The intention of the snapshots is to illustrate the spatially-varying orientation of the plume and the rapidly-varying nature of the achieved dilutions that could be observed under general conditions.

The far-field results demonstrated the dewatering discharge plume drifted horizontally through the water column in all directions from the Release Locations, whilst maintaining a low profile above the seafloor.

The snapshots illustrate that the dilutions became more variable over time because of changes in current speed and direction. Higher dilutions (i.e. lower concentrations) were predicted during periods of increased current speed, whereas patches of lower dilutions (i.e. higher concentrations) tended to accumulate during the turning of the tide or during periods of weak currents. During prolonged periods of lowered current speeds, the plume had a more continuous appearance, with higher-concentrated patches moving as a unified group.

Findings are agreeable with the research of King & McAllister (1997; 1998) who noted that concentrations within discharge plumes generated from offshore releases were patchy and likely to peak around the reversal of the tides.

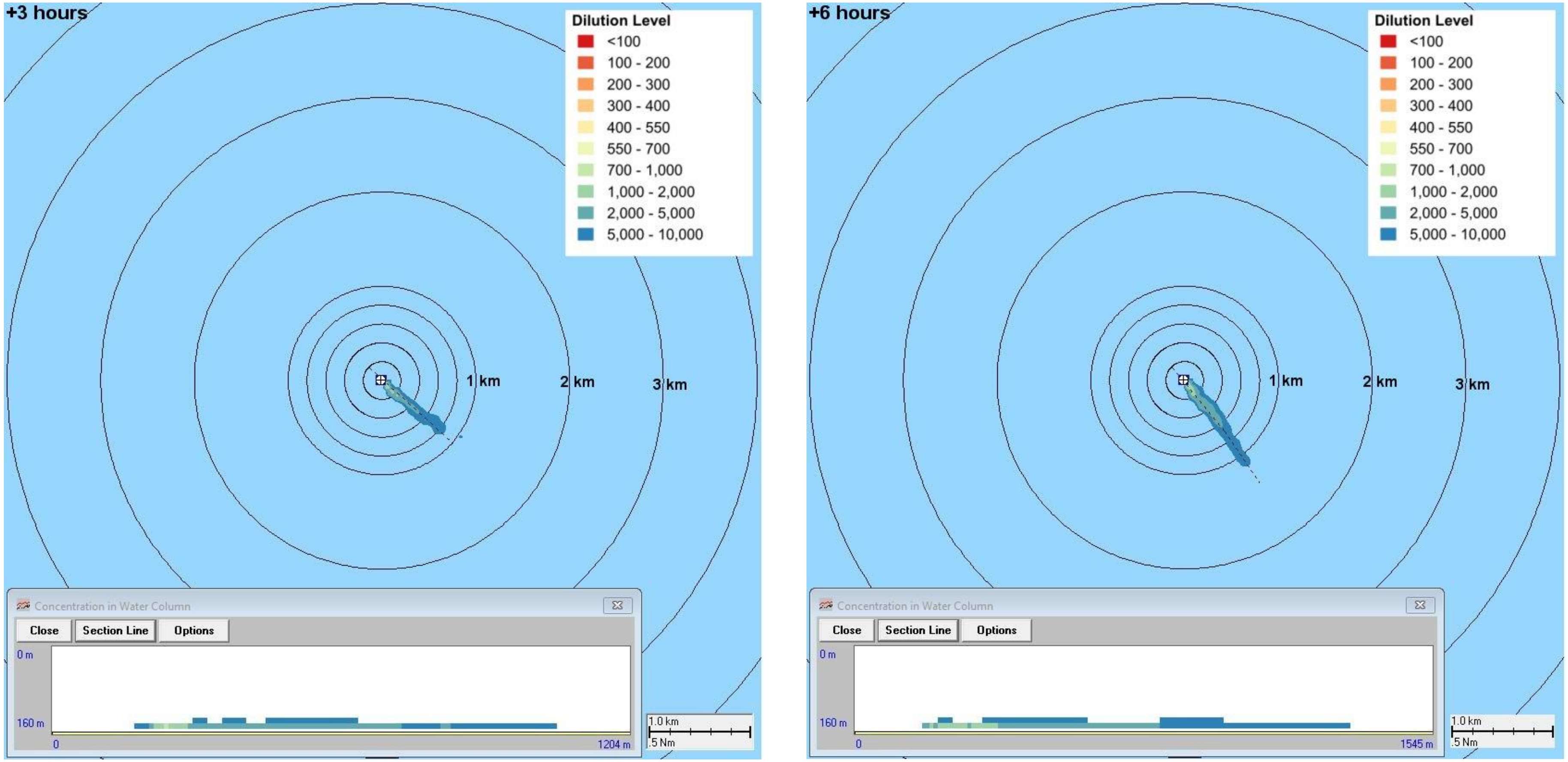


Figure 7-4 Example snapshots of predicted maximum concentrations, at +3 and +6 hours for a single simulation.

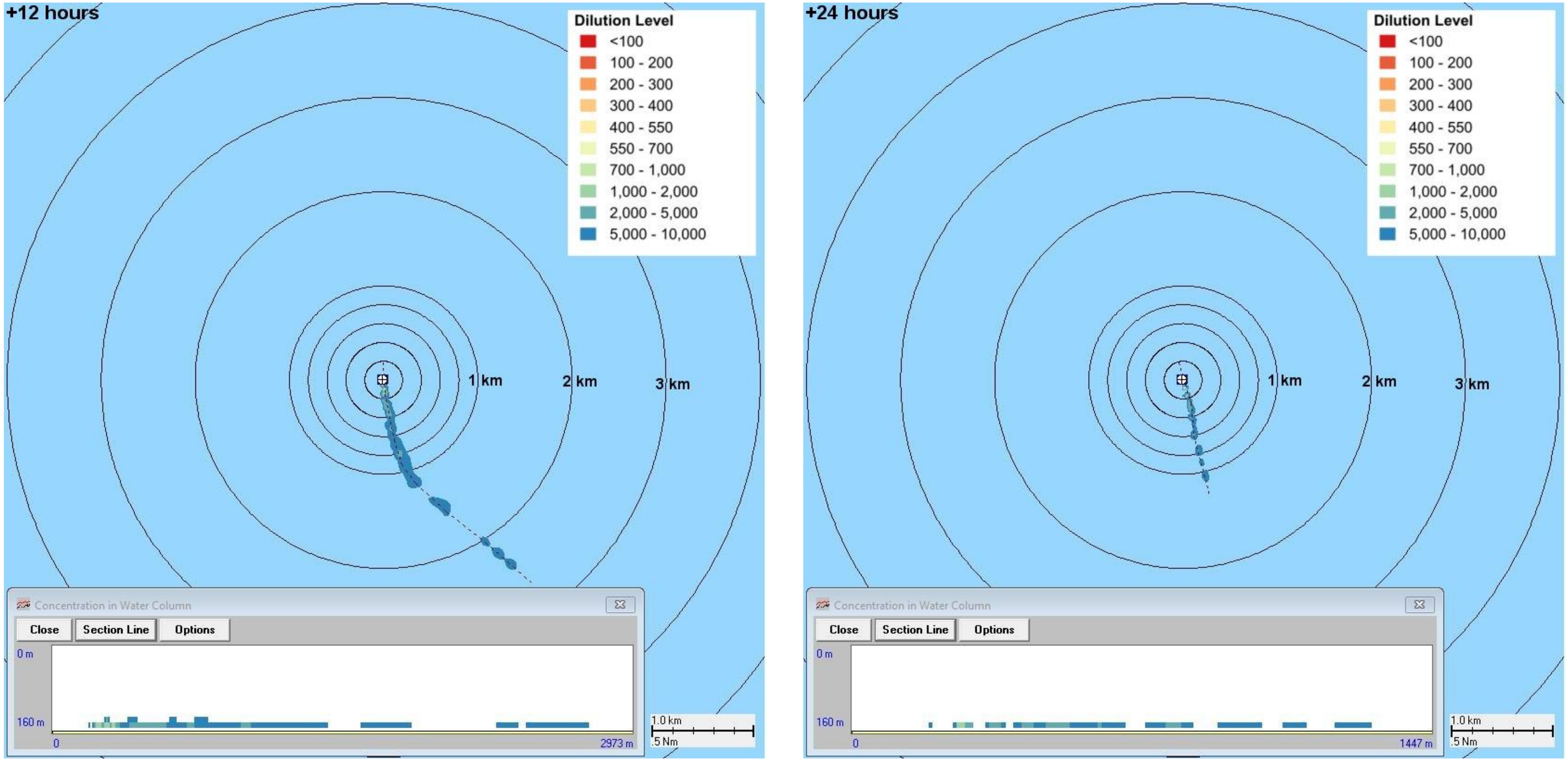


Figure 7-5 Continuing example snapshots of predicted maximum concentrations, at +12 and +24 hours for the single simulation presented in Figure 7-4.

7.2.2 Annualised Results

The results from all 100 simulations were combined and presented on an annualised basis.

Table 7-2 summarises the maximum distances from the discharge location to achieving dilutions up to 1:10,000. The results indicate that for the 99th and 100th percentiles, the maximum distances from the Release Location to instances of achieved dilutions of 1:550 (i.e. 1 mg/L which represents the impact threshold concentration/trigger value) were predicted to occur 20 m and 156 m from the Release Location, respectively. For the 95th percentile 1:550 dilutions are reached very close to the Release Location (20 m).

Figure 7-6 to Figure 7-10 present the results for the 95th, 99th and 100th percentile concentrations.

Table 7-2 Maximum distances from the Release Location to achieve selected dilutions. The results were calculated from 100 simulations and presented as an annual assessment.

Dilutions	Maximum distance (m) from discharge location to achieve selected dilutions		
	95th percentile	99th percentile	100th percentile
0-100	<10	<10	<10
100-200	<10	<10	<10
200-300	<10	<10	24
300-400	<10	<10	45
400-550	<10	20	156
550-700	<10	43	227
700-1,000	<10	112	231
1,000-2,000	125	201	819
2,000-5,000	344	592	5,779
5,000-10,000	782	1,389	6,253

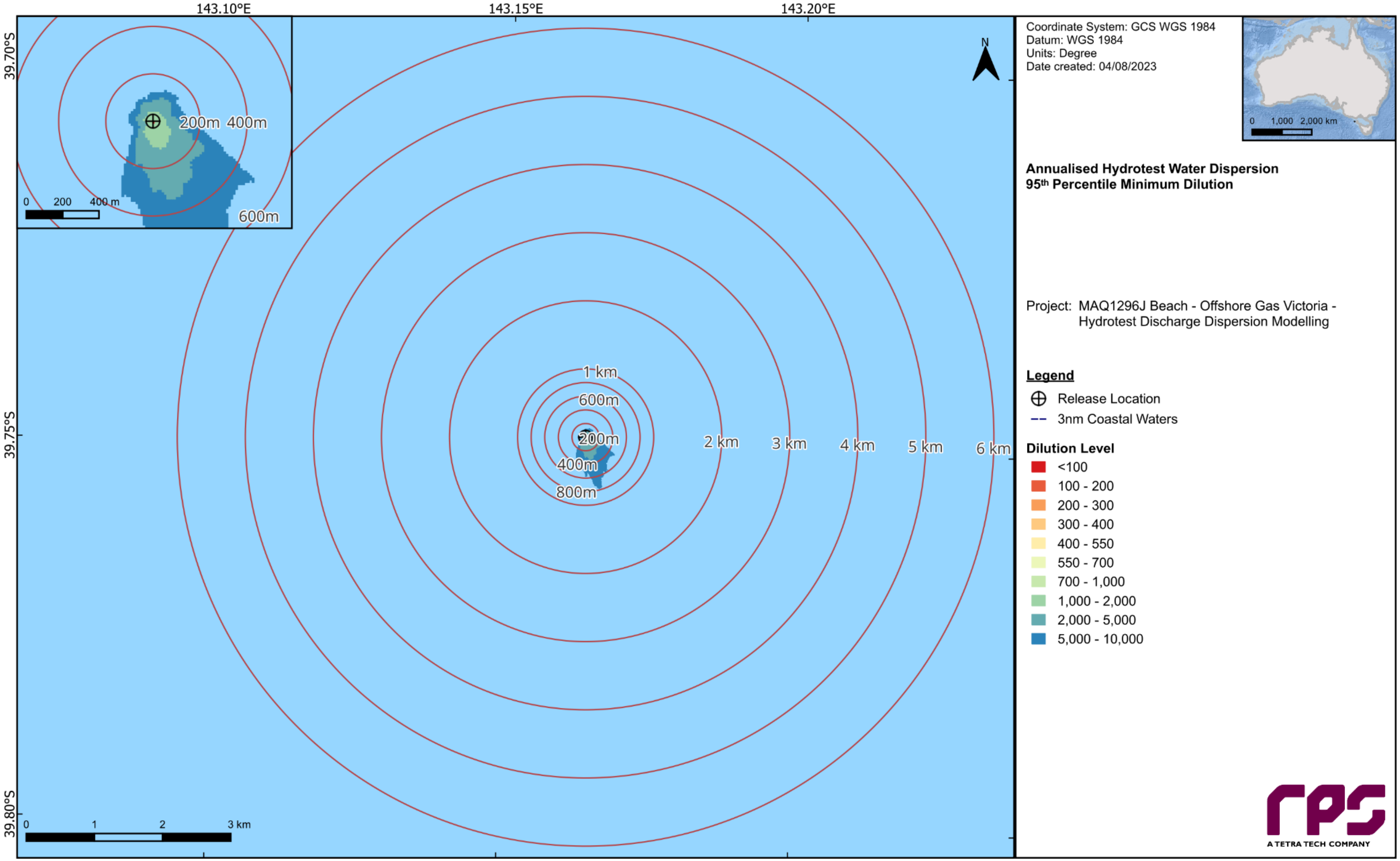


Figure 7-6 Predicted 95th percentile concentrations of the preservation chemical. The results were calculated from 100 simulations and presented as an annual assessment.

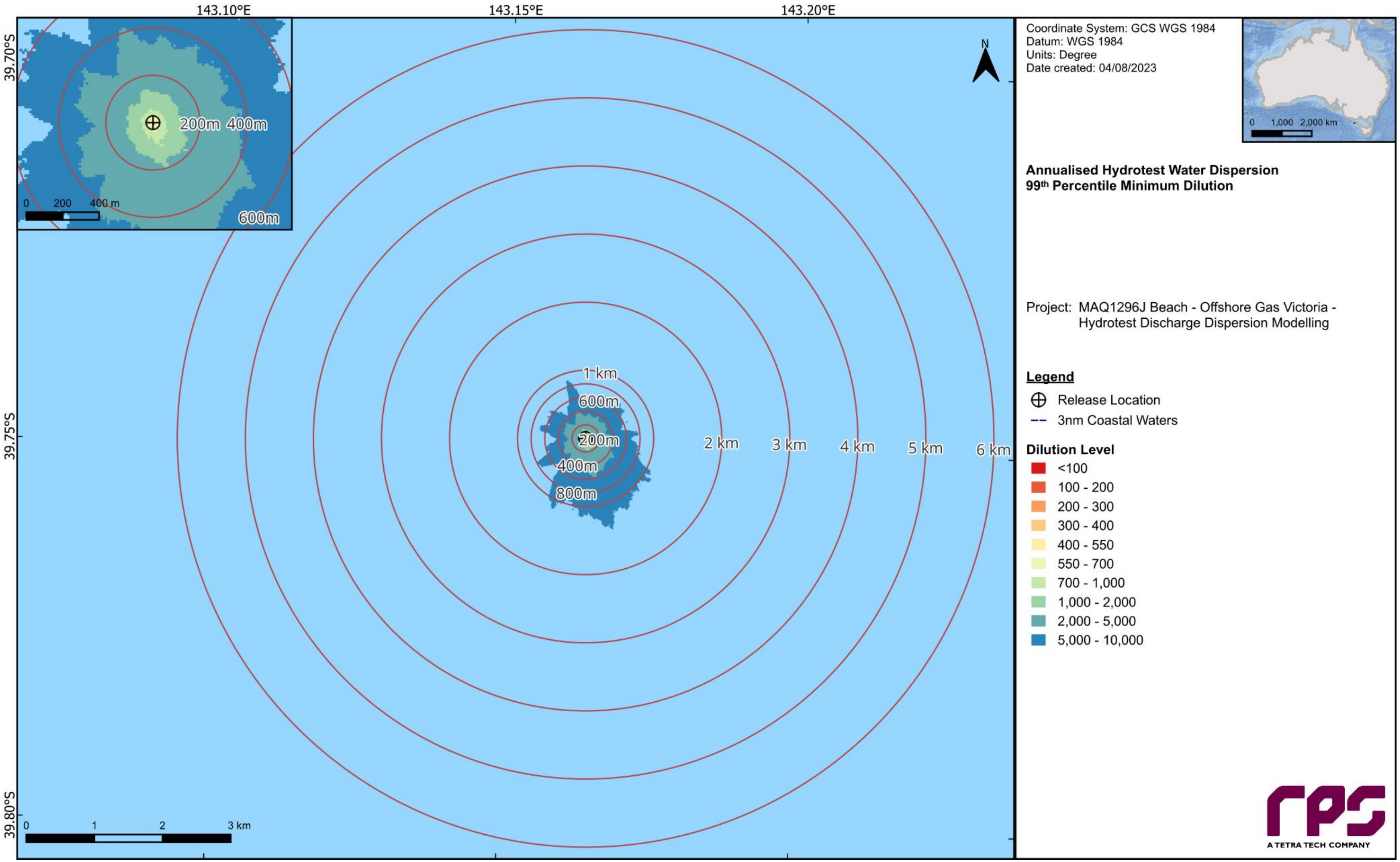


Figure 7-7 Predicted 99th percentile concentrations of the preservation chemical. The results were calculated from 100 simulations and presented as an annual assessment.

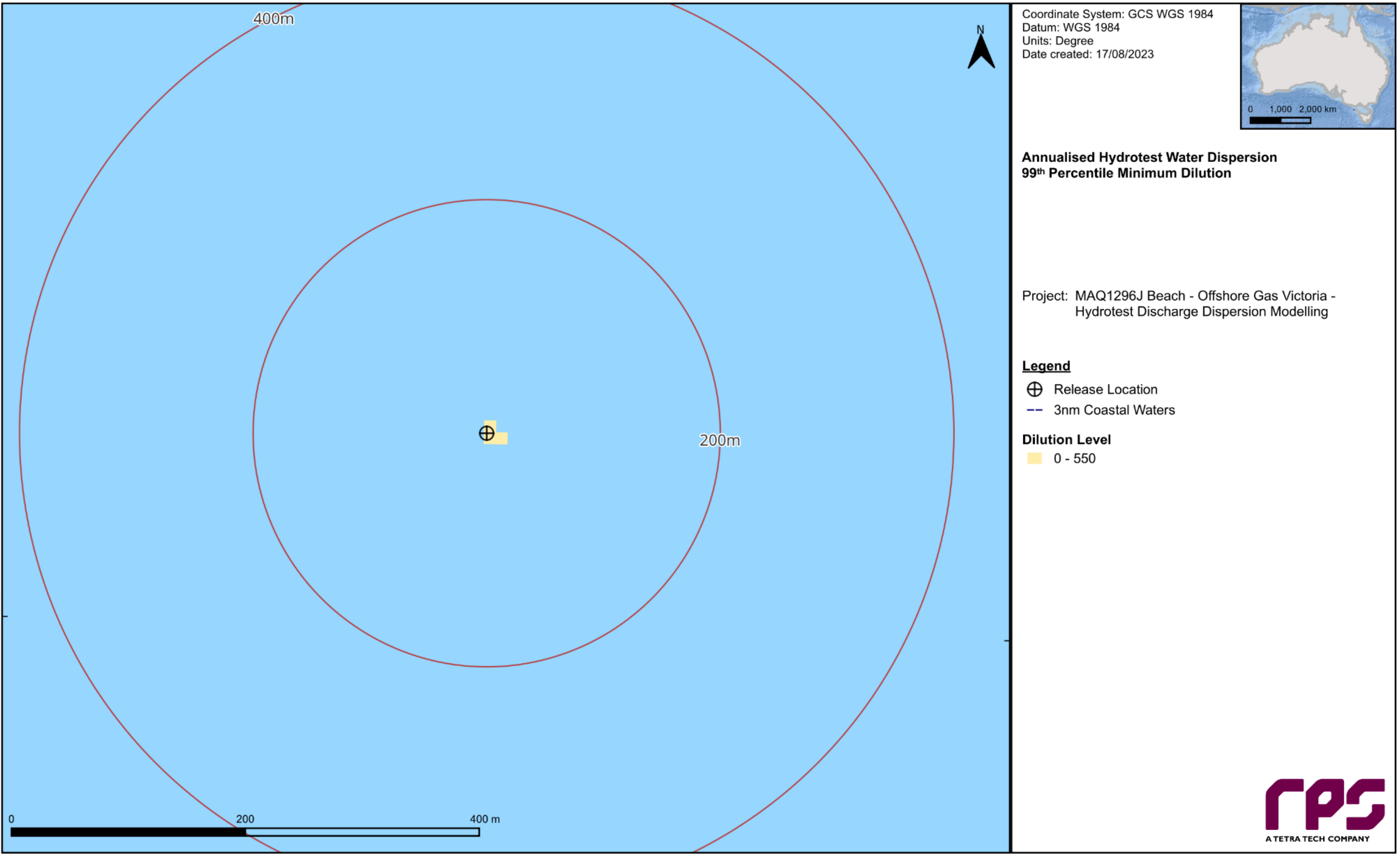


Figure 7-8 Predicted 99th percentile concentrations of the preservation chemical up until 550 dilutions (1 ppm). The results were calculated from 100 simulations and presented as an annual assessment.

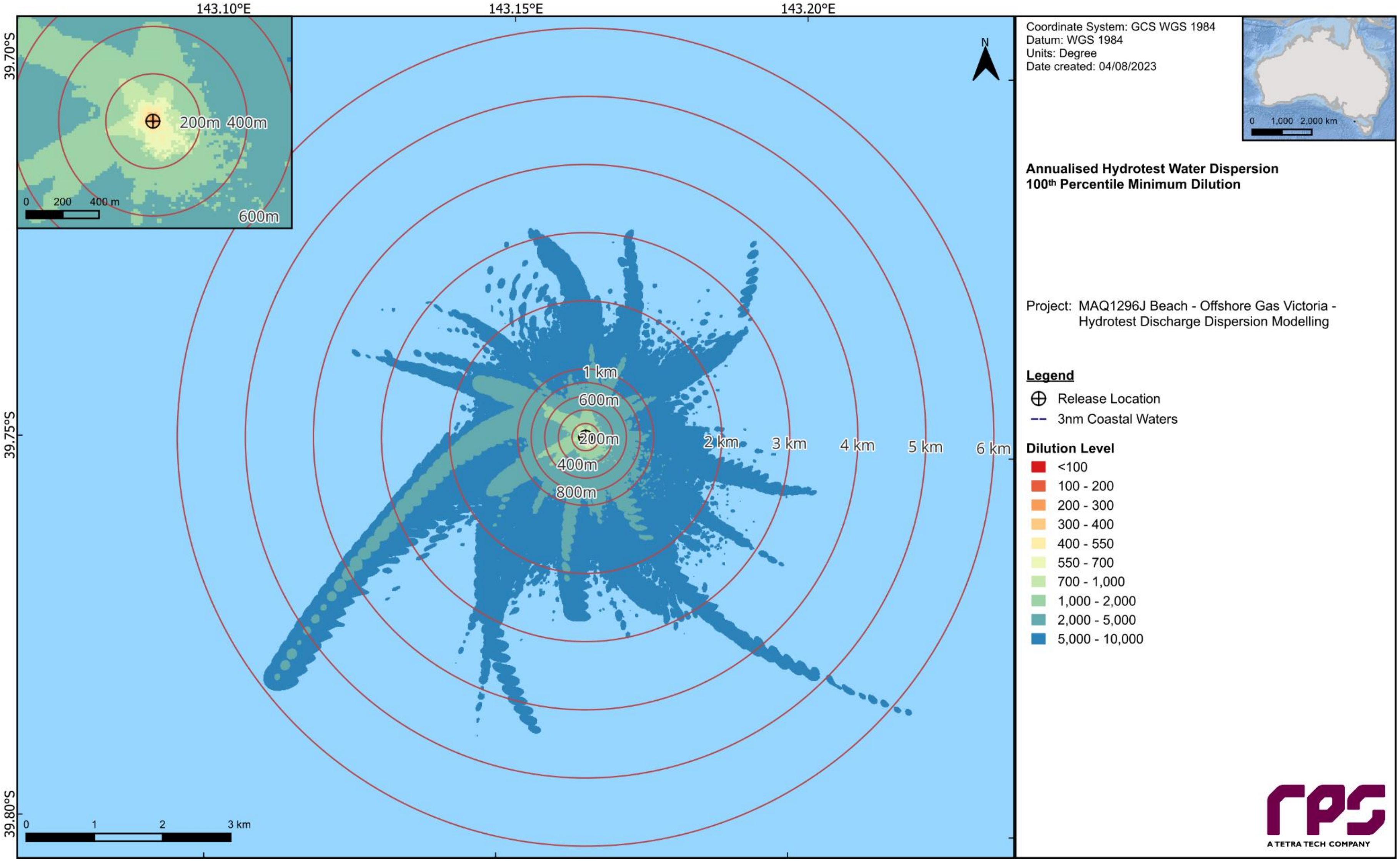


Figure 7-9 Predicted 100th percentile concentrations of the preservation chemical. The results were calculated from 100 simulations and presented as an annual assessment.

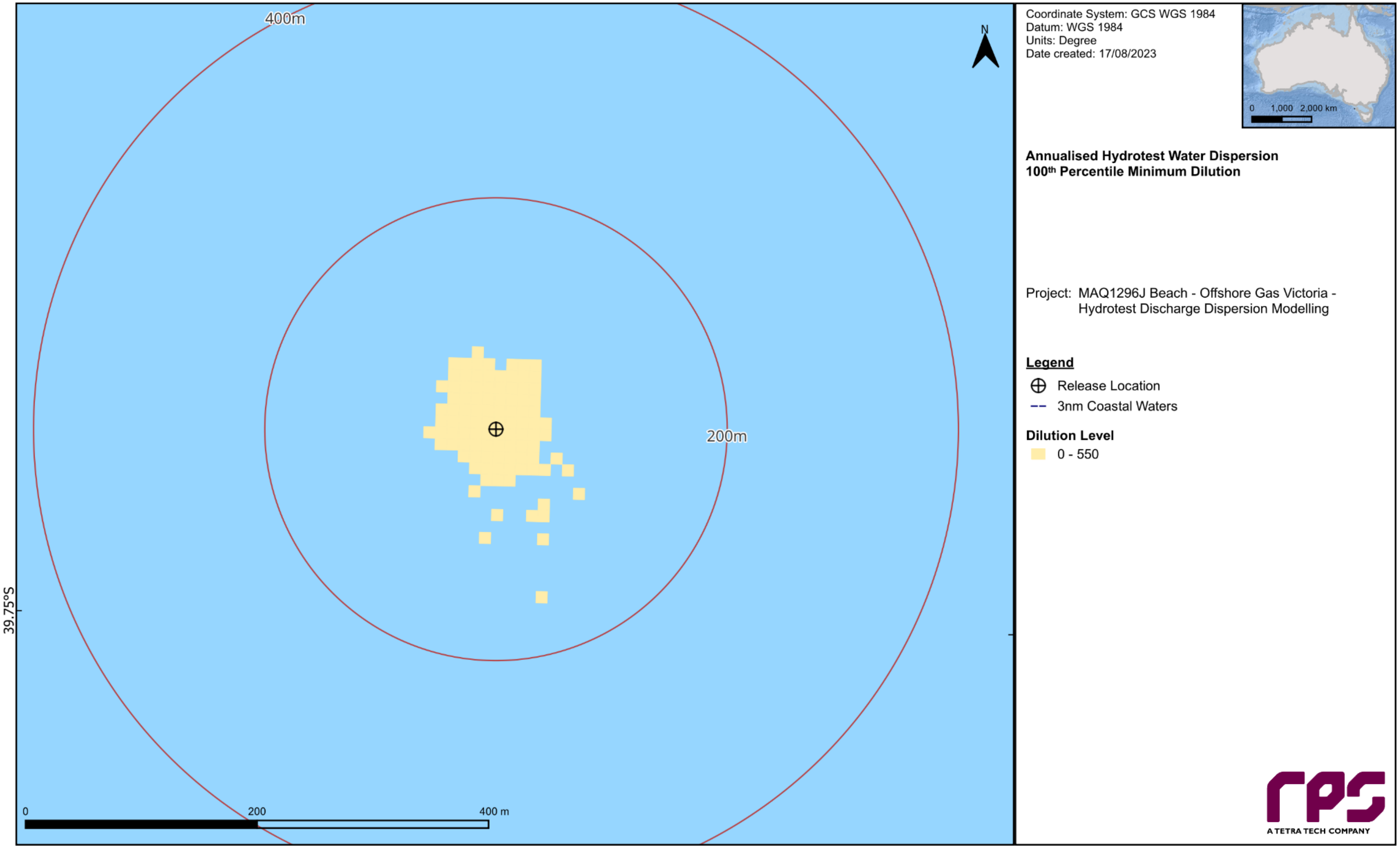


Figure 7-10 Predicted 100th percentile concentrations of the preservation chemical up until 550 dilutions (1 ppm). The results were calculated from 100 simulations and presented as an annual assessment

8 REFERENCES

Andersen, OB 1995, ‘Global ocean tides from ERS 1 and TOPEX/POSEIDON altimetry’. *Journal of Geophysical Research: Oceans*, vol. 100, no. C12, pp. 25249–25259.

Australian Maritime Safety Authority (AMSA) 2002, *National marine oil spill contingency plan*, Australian Maritime Safety Authority, Canberra, ACT, Australia.

Becker, JJ, Sandwell, DT, Smith, WHF, Braud, J, Binder, B, Depner, J, Fabre, D, Factor, J, Ingalls, S, Kim, S-H, Ladner, R, Marks, K, Nelson, S, Pharaoh, A, Trimmer, R, Von Rosenberg, J, Wallace, G, Weatherall, P 2009, ‘Global bathymetry and evaluation data at 30 arc seconds resolution: SRTM30_PLUS’, *Marine Geodesy*, vol. 32, no. 4, pp. 355–371.

Burns, K, Codi, S, Furnas, M, Heggie, D, Holdway, D, King, B & McAllister, F 1999, ‘Dispersion and fate of produced formation water constituents in an Australian Northwest Shelf shallow water ecosystem’, *Marine Pollution Bulletin*, vol. 38, pp. 593-603.

Champion Technologies 2013, ‘Hydrosure 0-3670R Safety Data Sheet’ https://safety365.sevron.co.uk/substances/accessSDS/SDS-5742-58d0d0dc9c5e59.78331216 (accessed 30 March 2023).

Chassignet, EP, Hurlburt, HE, Smedstad, OM, Halliwell, GR, Hogan, PJ, Wallcraft, AJ, Baraille, R, Bleck, R 2007, ‘The HYCOM (HYbrid Coordinate Ocean Model) data assimilative system’, *Journal of Marine Systems,* pp. 65, 60–83.

Chassignet, EP, Hurlburt, HE, Metzger, E, Smedstad, OM, Cummings, J & Halliwell, GR 2009, ‘U.S. GODAE: Global ocean prediction with the HYbrid Coordinate Ocean Model (HYCOM)’, *Oceanography*, vol. 22, no. 2, pp. 64-75.

Chevron Australia, 2015. Wheatstone Project Offshore Facilities and Produced Formation Water Discharge Management Plan: Stage 1 (Document No. WS0-0000-HES-PLN-CVX-000-00101–000). Chevron Australia Pty Ltd, Perth, Western Australia.

Davies, AM 1977a, ‘The numerical solutions of the three-dimensional hydrodynamic equations using a B-spline representation of the vertical current profile’. In: Nihoul, J.C. (ed). Bottom Turbulence: Proceedings of the 8th Liège Colloquium on Ocean Hydrodynamics, Elsevier Scientific, Amsterdam, pp. 1–25.

Davies, AM 1977b, ‘Three-dimensional model with depth-varying eddy viscosity’. In: Nihoul, J.C. (ed), Bottom Turbulence: Proceedings of the 8th Liège Colloquium on Ocean Hydrodynamics, Elsevier Scientific, Amsterdam, pp. 27–48.

Doneker, R & Jirka, G 1990, ‘Expert System for Hydrodynamic Mixing Zone Analysis of Conventional and Toxic Submerged Single Port Discharges (CORMIX1)’, EPA/600/3-90/012, U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, Georgia.

Gordon, R 1982, ‘Wind driven circulation in Narragansett Bay’, PhD thesis, University of Rhode Island, Kingston, RI, USA.

Isaji, T & Spaulding, M 1984, ‘A model of the tidally induced residual circulation in the Gulf of Maine and Georges Bank’. *Journal of Physical Oceanography*, vol. 14, no. 6, pp. 1119–1126.

Isaji, T, Howlett, E, Dalton C, Anderson, E 2001, ‘Stepwise-continuous-variable-rectangular grid hydrodynamics model’, Proceedings of the 24th Arctic and Marine Oil Spill Program (AMOP) Technical Seminar (including 18th TSOCS and 3rd PHYTO). Environment Canada, Edmonton, pp. 597–610.

Jirka, GH, Doneker, RL, & Barnwell, TO, 1991, ‘CORMIX: an expert system for mixing zone analysis’, *Water Science and Technology*, vol. 24, no. 6, pp. 267–274.

Jones, ISF 1980, ‘Tidal and wind driven currents in Bass Strait’, *Australian Journal of Marine and Freshwater Research*, vol. 31, pp 109–117.

King, B & McAllister, FA 1997, ‘The application of MUDMAP to investigate the dilution and mixing of the above water discharge at the Harriet A petroleum platform on the Northwest Shelf’, in *Modelling the Dispersion of Produced Water Discharge in Australia*, Australian Institute of Marine Science, Canberra, ACT, Australia.

King, B & McAllister, FA 1998, ‘Modelling the dispersion of produced water discharges’, *APPEA Journal*, pp. 681–691.

Kostianoy, AG, Ginzburg, AI, Lebedev, SA, Frankignoulle, M, Delille, B 2003, ‘Fronts and mesoscale variability in the southern Indian Ocean as inferred from the TOPEX/POSEIDON and ERS-2 Altimetry data’, *Oceanology*, vol. 43, no. 5, pp. 632–642.

Levitus, S, Antonov, JI, Baranova, OK, Boyer, TP, Coleman, CL, Garcia, HE, Grodsky, AI, Johnson, DR, Locarnini, RA, Mishonov, AV, Reagan, JR, Sazama, CL, Seidov, D, Smolyar, I, Yarosh, ES & Zweng, MM 2013, ‘The world ocean database’, *Data Science Journal*, vol. 12, pp. WDS229-WDS234.

Ludicone, D, Santoleri, R, Marullo, S, Gerosa, P 1998, ‘Sea level variability and surface eddy statistics in the Mediterranean Sea from TOPEX/POSEIDON data’, *Journal of Geophysical Research*, vol. 103, no. C2, pp. 2995–3011.

Matsumoto, K, Takanezawa, T, Ooe, M 2000, ‘Ocean tide models developed by assimilating TOPEX/POSEIDON altimeter data into hydrodynamical model: A global model and a regional model around Japan’. *Journal of Oceanography*, vol. 56, no.5, pp. 567–581.

Middleton, JF & Bye AT 2007, ‘A review of shelf-slope circulation along Australia’s southern shelves: Cape Leeuwin to Portland, *Progress in Oceanography*, vol. 75: 1–41

Owen, A 1980, ‘A three-dimensional model of the Bristol Channel’, *Journal of Physical Oceanography*, vol. 10, no. 8, pp. 1290–1302.

Qiu, B & Chen, S 2010, ‘Eddy-mean flow interaction in the decadally modulating Kuroshio Extension system’, *Deep-Sea Research II*, vol. 57, no. 13, 1098–1110.

Sandery, P & Kämpf, J 2007, ‘Transport timescales for identifying seasonal variation in Bass Strait, south-eastern Australia’, *Estuarine, Coastal and Shelf Science*, vol. 74, pp 684–696.

Shell Australia Pty Ltd 2020, ‘Crux Project, Offshore Project Proposal, June 2020’, https://www.nopsema.gov.au/sites/default/files/documents/2021-03/A742335.pdf (accessed 29 March 2023).

Yaremchuk, M & Tangdong, Q 2004, ‘Seasonal variability of the large-scale currents near the coast of the Philippines’, *Journal of Physical Oceanography*, vol. 34, no., 4, pp. 844–855.

Zigic, S, Zapata, M, Isaji,T, King, B, Lemckert, C 2003, ‘Modelling of Moreton Bay using an ocean/coastal circulation model’, Proceedings of the 16th Australasian Coastal and Ocean Engineering Conference, the 9th Australasian Port and Harbour Conference and the Annual New Zealand Coastal Society Conference, Institution of Engineers Australia, Auckland, paper 170.

Appendix M: Oil Spill Modelling Report

OFFSHORE GAS VICTORIA

Oil Spill Modelling

MAQ1296J
3 August 2023

rpsgroup.com

Document status

Version	Purpose of document	Authored by	Reviewed by	Approved by	Review date
Ver. A	Internal Draft	N. Benfer L. Perez	R. Dunn		14 July 2023
Ver. 0	Draft issued to client		R. Dunn	N. Benfer	17 July 2023
Ver. 1	Final issued to client	L. Perez	N. Benfer	N. Benfer	3 August 2023

Approval for issue

Nathan Benfer		3 August 2023

Prepared by:

RPS

Nathan Benfer
Principal Consultant

Lakehouse Corporate Space, Suite 425
Level 2, 34-38 Glenferrie Drive
Robina, QLD, 4226

T +61 7 5553 6900
E Nathan.Benfer@rpsgroup.com

Prepared for:

Beach Energy Ltd.

Phil Wemyss
Principal Environment Advisor

80 Flinders Street,
Adelaide, SA, 5001

T +61 8 8433 2394
E Phil.Wemyss@beachenergy.com.au

Contents

Tables

Figures

TERMS AND ABBREVIATIONS

AMP	Australian Marine Park
AMSA	Australian Maritime Safety Authority
ANZECC	Australian and New Zealand Environment and Conservation Council
API	American Petroleum Institute gravity. A measure of how heavy or light a petroleum liquid is compared to water.
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BIA	Biologically Important Areas
Bonn Agreement	An agreement for cooperation in dealing with pollution of the North Sea by oil and other harmful substances, 1983, includes: Governments of the Kingdom of Belgium, the Kingdom of Denmark, the French Republic, the Federal Republic of Germany, the Republic of Ireland, the Kingdom of the Netherlands, the Kingdom of Norway, the Kingdom of Sweden, the United Kingdom of Great Britain and Northern Ireland and the European Union.
BP	Boiling point. The temperature at which the vapor pressure of the liquid is equal to the pressure exerted on it by the surrounding atmosphere
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
Decay	The process where oil components are changed either chemically or biologically (biodegradation) to another compound. It includes breakdown to simpler organic carbon compounds by bacteria and other organisms, photo-oxidation by solar energy, and other chemical reactions.
Deterministic (single) oil spill modelling	Oil spill modelling involving a computer simulation of a single hypothetical oil spill event subject to a single sequence of wind, current and other sea conditions over time. Single oil spill modelling, also referred to as “deterministic modelling” provides a simulation of one possible outcome of a given spill scenario, subject to the metocean conditions that are imposed. Single oil spill modelling is commonly used to consider the fate and effects of ‘worst-case’ oil spill scenarios that are carefully selected in consideration of the nature and scale of the offshore petroleum activity and the local environment (NOPSEMA, 2017). Because the outcomes of a single oil spill simulation can only represent the outcome of that scenario under one sequence of metocean conditions, worst-case conditions are often identified from stochastic modelling. It is impossible to calculate the likelihood of any outcome from a single oil spill simulation. Single oil spill modelling is generally used for response planning, preparedness planning and for supporting oil spill response operations in the event of an actual spill
Dynamic viscosity	The dynamic viscosity of a fluid expresses its resistance to shearing flows, where adjacent layers move parallel to each other with different speeds.
Floating oil exposure	Contact by floating oil on the sea surface at concentrations equal to or exceeding defined threshold concentrations. The consequence will vary depending on the threshold and the receptors
HYCOM	Hybrid Coordinate Ocean Model. A data-assimilative, three-dimensional ocean model
HYDROMAP	Advanced ocean/coastal tidal model used to predict tidal water levels, current speed and current direction.
IMCRA	Integrated marine and coastal regionalisation areas
KEF	Key Ecological Feature
LGA	Local Government Areas
MAHs	Monoaromatic Hydrocarbons
MNP	Marine National Park
MP	Marine Park
MS	Marine Sanctuary
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NP	National Park

NR	Nature Reserve
PAH	Polynuclear Aromatic Hydrocarbons
Pour Point	The pour point of a liquid is the temperature below which the liquid loses its flow characteristics
Ramsar site	A site listed under the Ramsar Convention on wetlands which is an international intergovernmental treaty that provides the framework for the conservation and wise use of wetlands and their resources.
RSB	Reefs, Shoals and Banks
Shoreline accumulation	Arrival of oil at or near shorelines at on-water concentrations equal to or exceeding defined threshold concentrations. Shoreline contact is judged for floating oil arriving within a 2 km buffer zone from any shoreline as a conservative measure
SIMAP	Spill Impact Model Application Package. SIMAP is designed to simulate the fate and effects of spilled hydrocarbons for surface or subsea releases
Stochastic (multiple) oil spill modelling	Stochastic oil spill modelling is created by overlaying and statistically analysing the outcomes of many single oil-spill simulations of a defined spill scenario, where each simulation was subject to a different sequence of metocean conditions, selected objectively (typically by random selection) from a long sequence of historic conditions for the study area. Analysis of this larger set of simulations provides a more accurate indication of the environment that maybe affected (EMBA) and indicates which locations are more likely to be affected (as well as other statistics). Stochastic oil spill modelling avoids biases that affect single oil spill modelling (due to the reliance on only one possible sequence of conditions). However, when interpreting stochastic modelling, which is based on a wide range of potential conditions that might happen to occur, it is essential to understand that calculations will encompass a much larger area than could be affected in any single spill event, where a more limited set of conditions will occur. Consequently, it is misleading to imply that the region derived from stochastic modelling indicate the outcomes expected from a single spill event (NOPSEMA, 2017) Stochastic modelling is generally used for risk assessment and preparedness planning by indicating locations that could be exposed and may require response or subsequent impact assessment
Sub-LGA	Sub-Local Government Areas
Shoreline accumulation	Arrival of oil at or near shorelines at on-water concentrations equal to or exceeding defined threshold concentrations.

EXECUTIVE SUMMARY

Background

Beach Energy Limited (Beach) plans exploration drilling at several new locations within the Otway Basin. The Release Location South and Release Location North locations were selected as the two representative locations for assessment due to their location and potential flow rates for a loss of well control incident.

In order to support the Offshore Gas Victoria EP, Beach commissioned a detailed oil spill modelling study assessing the following hypothetical scenarios:

- A 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South
- A 603.7 m^3 surface release of marine diesel over 6 hours from a loss of containment from vessel collision at the Release Location South
- A 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North; and
- A 603.7 m^3 surface release of marine diesel over 6 hours from a loss of containment from vessel collision at the Release Location North.

The modelling assessment was undertaken on a seasonal basis as follows:

- Summer (November through to March); and
- Winter (April to October)

The purpose of the modelling is to provide an understanding of a conservative ‘outer envelope’ of the potential area that may be affected in the unlikely event of hydrocarbon spill. The modelling does not take into consideration any of the spill prevention, mitigation and response strategies that would be implemented in response to a spill. Therefore, the modelling results represent the maximum extent that the released hydrocarbon may influence.

The spill modelling was performed using an advanced three-dimensional trajectory and fates model; Spill Impact Model Application Program (SIMAP). The SIMAP model calculates the transport, spreading, entrainment and evaporation of spilled hydrocarbons over time, based on the prevailing wind and current conditions and the physical and chemical properties.

Methodology

The modelling study was carried out in several stages. Firstly, a 10-year wind and current dataset (2010–2019) was generated and the currents included the combined influence of three-dimensional large-scale ocean currents and tidal currents. Secondly, the currents, winds and detailed hydrocarbon characteristics were used as inputs in the three-dimensional oil spill model (SIMAP) to simulate the drift, spread, weathering and fate of the spilled hydrocarbons.

As spills can occur during any set of wind and current conditions, modelling was conducted using a stochastic (random or non-deterministic) approach, which involved running 100 randomly selected single trajectory simulations per season, with each simulation having the same spill information (spill volume, duration and composition of hydrocarbons) but varying start times. This ensured that each spill simulation was subject to a unique set of wind and current conditions.

The SIMAP system, the methods and analysis presented herein, use modelling algorithms which have been anonymously peer reviewed and published in international journals. Further, RPS warrants that this work meets and exceeds the ASTM Standard F2067-13 “*Standard Practice for Development and Use of Oil Spill Models*”.

Oil Properties

Thylacine condensate has an API of 44.3 and a density of 804.6 kg/m^3 (at 15ºC) with a viscosity value (0.87.0 cP) classifying it as a Group I (not-persistent) oil according to the International Tankers Owners Pollution Federation (ITOPF, 2020) and US EPA/USCG classifications.

The condensate is a mixture of volatile and persistent hydrocarbons with high proportions of volatile and semi- to low-volatile components. In favourable evaporation conditions, 64.0% of the oil mass should evaporate within the first 12 hours (BP < 180°C), a further 19.0% is expected to evaporate within the first 24 hours (180°C < BP < 265°C) and a further 16.0% should evaporate over several days (265°C < BP < 380°C). Approximately 1.0% of the condensate is shown to be persistent.

Marine diesel (MDO) has an API of 37.6 and a density of 829.1 kg/m^3 (at 25ºC) with a viscosity value (4.0 cP) classifying it as a Group II (light-persistent) oil according to the International Tankers Owners Pollution Federation (ITOPF, 2014) and US EPA/USCG classifications.

The MDO is a mixture of volatile and persistent hydrocarbons with high proportions of volatile and semi- to low-volatile components. In favourable evaporation conditions, about 6.0% of the oil mass should evaporate within the first 12 hours (BP < 180°C); a further 34.6% should evaporate within the first 24 hours (180°C < BP < 265°C); and a further 54.4% should evaporate over several days (265°C < BP < 380°C). Approximately 5.0% of the oil is shown to be persistent.

Results

Scenario: 86-day Loss of Well Control at Release Location South

- The maximum distance from the release location to the low (1–10 g/m^2), moderate (10–50 g/m^2) and high (>50 g/m^2) exposure zones was 79 km (east-southeast) during winter conditions, 20 km (southeast) during summer conditions and 1 km (west-southwest) during summer and winter conditions, respectively.

- Outside of the receptors that the Release Location South release location resides within, the Pygmy Blue Whale - Known Foraging Area (100% summer and winter), Little Penguin – Foraging (10 % in winter), Southern Right Whale - Connecting habitat (5% in summer and 50% in winter), White Shark – Foraging (2% in winter) and the White-faced Storm-petrel – Foraging (5% in summer and 50% in winter) were the only BIAs predicted to have floating oil exposure above the low threshold;

- The probability of accumulation to any shoreline at, or above, the low level (10 g/m^2) threshold was 89% during summer conditions and 100% during winter conditions;

- King Island recorded the highest probability of shoreline accumulation at the low threshold with 82% (summer) and 100% (winter);

- The maximum volume ashore for a single spill trajectory during the summer and winter conditions was 99 m^3 and 193 m^3, respectively, whilst the maximum length of shoreline accumulation at the low threshold was 115 km and 138 km, respectively;

- Outside of the receptors that the Release Location South resides within, the highest concentration of dissolved hydrocarbon was predicted for the Pygmy Blue Whale - Known Foraging Area (summer – 1,904 ppb, winter – 1,665 ppb) and White-faced Storm-petrel – Foraging (summer – 1,904 ppb, winter – 1,135 ppb) receptors, which also held the highest probabilities of low dissolved hydrocarbon exposure (100% during summer and winter); and

- Outside of the receptors that the Release Location South resides within, the highest concentration of entrained hydrocarbon was predicted for Pygmy Blue Whale - Known Foraging Area (1summer – ,1,454 ppb, winter – 1,464 ppb). The same receptor, along with Pygmy Blue Whale - Known Foraging Area, White-faced Storm-petrel – Foraging and West Tasmania Canyons also presented the highest probability of low entrained hydrocarbon exposure (100% during summer and winter).

Scenario: Loss of Marine Diesel Containment at Release Location South

- The maximum distance from the release location to the low (1–10 g/m^2), moderate (10–50 g/m^2) and high (> 50g/ m^2) exposure zones was 57 km (south-southeast) during winter conditions, and 48 km (south-southeast) during winter conditions and 8 km (south-southeast) during both seasons respectively;Outside of the receptors that the Release Location South resides within, floating oil exposure above the low threshold was predicted at the Zeehan AMP (38% summer and 39% winter) Pygmy Blue Whale - Known Foraging Area BIA (52% summer and 50% winter) and the West Tasmania Canyons KEF (13% summer and 15% winter);

- The probability of accumulation to any shoreline at, or above, the low level (10 g/m^2) threshold was 7% during summer conditions and 47% during winter conditions.

- The maximum volume ashore for a single spill trajectory during the summer and winter conditions was 5 m^3 and 29 m^3, respectively, whilst the maximum length of shoreline accumulation at the low threshold was 13 km and 35 km, respectively.

- Outside of the receptors that the Release Location South resides within, the highest concentration of dissolved hydrocarbon was predicted for the Pygmy Blue Whale - Known Foraging Area BIA (summer – 100 ppb, winter – 105 ppb), which also revealed the highest probability of low dissolved hydrocarbon exposure (summer – 39%, winter – 24%); and.

- Outside of the receptors that the Release Location South resides within, the highest concentration of entrained hydrocarbon was predicted for Pygmy Blue Whale - Known Foraging Area BIA (summer – 4,867 ppb, winter – 5,489 ppb). The same receptor recorded the highest probability of low entrained hydrocarbon exposure (90% summer and 85% winter).

Scenario: 86-day Loss of Well Control at Release Location North

- The maximum distance from the release location to the low (1–10 g/m^2) and moderate (10–50 g/m^2) exposure zones was 53 km (east) during summer conditions and 12 km (south-southeast) during winter conditions, respectively. For the high threshold (> 50 g/m^2), the maximum distance from the release location was 1 km southeast (summer) and northwest (winter);

- Outside of the receptors that the Release Location North resides within, floating oil exposure above the low threshold was predicted at the Pygmy Blue Whale – Foraging(10% summer, 3% winter) and Short-tailed Shearwater – Foraging (19% summer, 13% winter) BIAs;

- The probability of accumulation to any shoreline at, or above, the low level (10 g/m^2) threshold was 100% during summer conditions and 98% during winter conditions;.

- The maximum volume ashore for a single spill trajectory during the summer and winter conditions was 112 m^3 and 143 m^3, respectively, whilst the maximum length of shoreline accumulation at the low threshold was 108 km and 136 km, respectively;;

- Outside of the receptors that the Release Location North resides within, the highest concentration of dissolved hydrocarbon was predicted for Pygmy Blue Whale - Foraging BIA (summer – 1,396 ppb, winter – 1,410 ppb), which also revealed the highest probability of low dissolved hydrocarbon exposure (100% for both seasons); and

- Outside of the receptors that the Release Location North release location resides within, the highest concentration of entrained hydrocarbon was predicted for Pygmy Blue Whale - Foraging (summer – 378 ppb, winter – 332 ppb.

Scenario: Loss of Marine Diesel Containment at Release Location North

- The maximum distance from the release location to the low (1–10 g/m^2), moderate (10–50 g/m^2) and high (> 50 g/m^2) exposure zones was 54 km (east) during winter conditions, 19 km (south-southeast) during winter conditions and 10 km (north-northwest in summer and east in winter);.

- The probability of accumulation to any shoreline at, or above, the low level (10 g/m^2) threshold was 28% during summer conditions and 26% during winter conditions;.

- The maximum volume ashore for a single spill trajectory during the summer and winter conditions was 25 m^3 and 35 m^3, respectively, whilst the maximum length of shoreline accumulation at the low threshold was 26 km and 30 km, respectively;

- Outside of the receptors that the Release Location North resides within, the highest concentration of dissolved hydrocarbon was predicted for the Southern Right Whale - Aggregation BIA in summer (45 ppb) and in Apollo AMP in winter (31 ppb). The highest probability of low dissolved hydrocarbon exposure was recorded for Pygmy Blue Whale - Foraging BIA (summer – 3%, winter – 8%) and Short-tailed Shearwater – Foraging (summer – 3%, winter – 9%); and

- Outside of the receptors that the Release Location North resides within, the highest concentration of entrained hydrocarbon was predicted for Short-tailed Shearwater - Foraging BIA (summer – 801 ppb, winter – 1,326ppb), which also presented the highest probability of low entrained hydrocarbon exposure (summer – 51%, winter – 81%).

1 INTRODUCTION

1.1 Background

Beach Energy Limited (Beach) plans exploration drilling at several new locations within the Otway Basin. The Release Location South and Release Location North locations were selected as the two representative locations for assessment due to their location and potential flow rates for a loss of well control incident.

In order to support the Offshore Gas Victoria EP, Beach commissioned a detailed oil spill modelling study assessing the following hypothetical scenarios:

- A 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South;
- A 603.7 m^3 surface release of marine diesel over 6 hours from a loss of containment from a vessel collision at the Release Location South
- A 69,120.0 m3 subsea release of condensate over 86 days from a loss of well control at the Release Location North; and
- A 603.7 m^3 surface release of marine diesel over 6 hours from a loss of containment from a vessel collision at the Release Location North.

The modelling assessment was undertaken on a seasonal basis as follows:

- Summer (November through to March); and
- Winter (April to October)

The purpose of the modelling is to provide an understanding of a conservative 'outer envelope' of the potential area that may be affected in the unlikely event of hydrocarbon spill. The modelling does not take into consideration any of the spill prevention, mitigation and response strategies that would be implemented in response to a spill. Therefore, the modelling results represent the maximum extent that the released hydrocarbon may influence.

The spill modelling was performed using an advanced three-dimensional trajectory and fates model; Spill Impact Model Application Program (SIMAP). The SIMAP model calculates the transport, spreading, entrainment and evaporation of spilled hydrocarbons over time, based on the prevailing wind and current conditions and the physical and chemical properties.

Table 1-1 Location of assessed release sites.

Well	Latitude	Longitude
Release Location South	39.7485° S	143.1637° E
Release Location North	38.8552° S	142.8381° E

GCS: WGS84

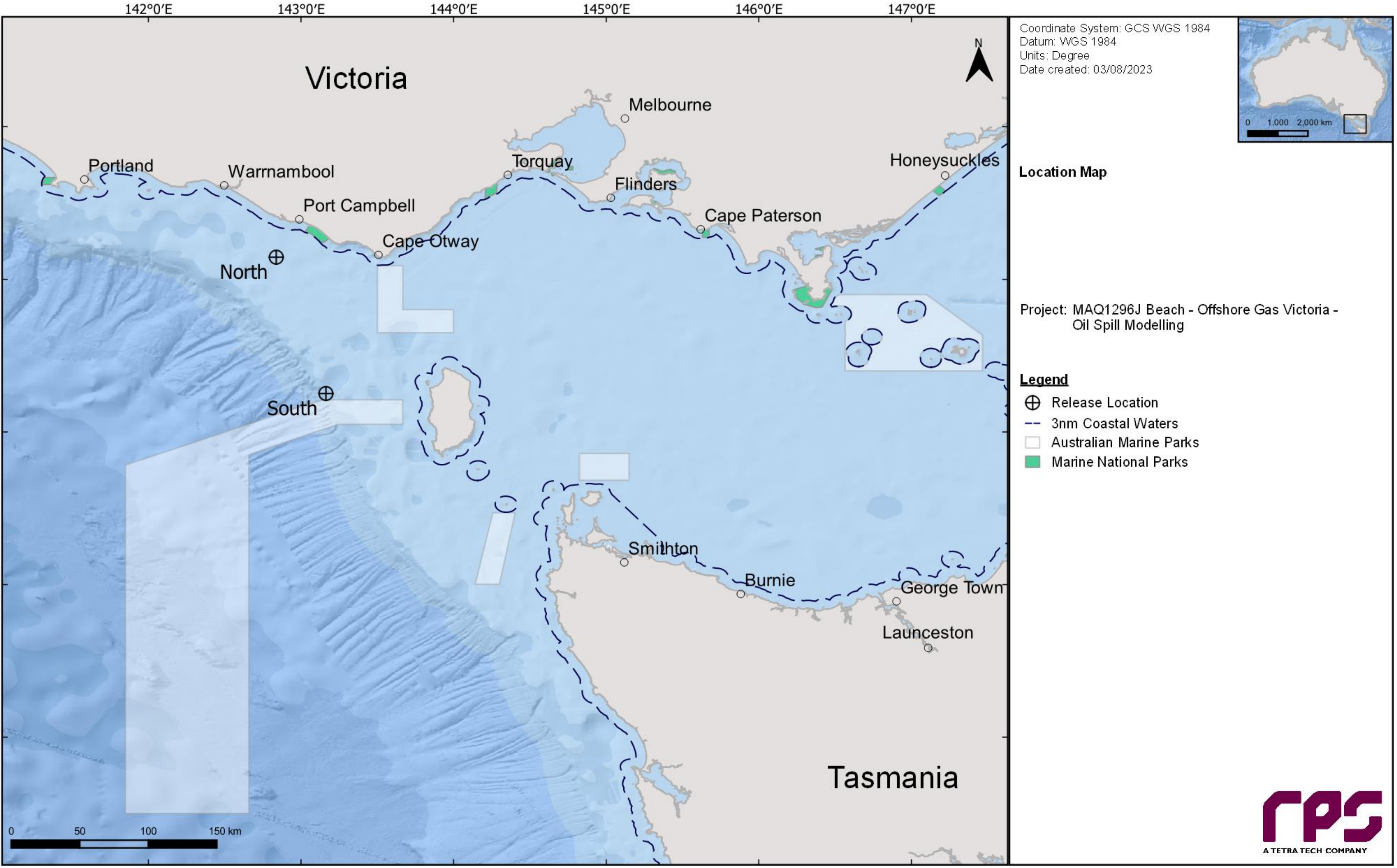


Figure 1-1 Map of the assessed release locations.

1.2 What is Oil Spill Modelling?

Oil spill modelling is a valuable tool widely used for risk assessment, emergency response and contingency planning where it can be particularly helpful to proponents and decision makers. By modelling a series of the most likely oil spill scenarios, decisions concerning suitable response measures and strategic locations for deploying equipment and materials can be made, and the locations at most risk can be identified. The two types of oil spill modelling often used are stochastic (Section 1.2.1) and deterministic (Section 1.2.2) modelling.

1.2.1 Stochastic Modelling (Multiple Spill Simulations)

Stochastic oil spill modelling is created by overlaying a great number (often hundreds) of individual, computer-simulated hypothetical spills (NOPSEMA, 2018; Figure 1.2).

Stochastic modelling is a common means of assessing the potential risks from oil spills related to new projects and facilities. Stochastic modelling typically utilises hydrodynamic data for the location in combination with historic wind data. Typically, 100 iterations of the model will be run utilising the data that is most relevant to the season or timing of the project.

The outcomes are often presented as a probability of exposure and is primarily used for risk assessment purposes in view to understand the range of environments that may be affected or impacted by a spill. Elements of the stochastic modelling can also be used in oil spill preparedness and planning.

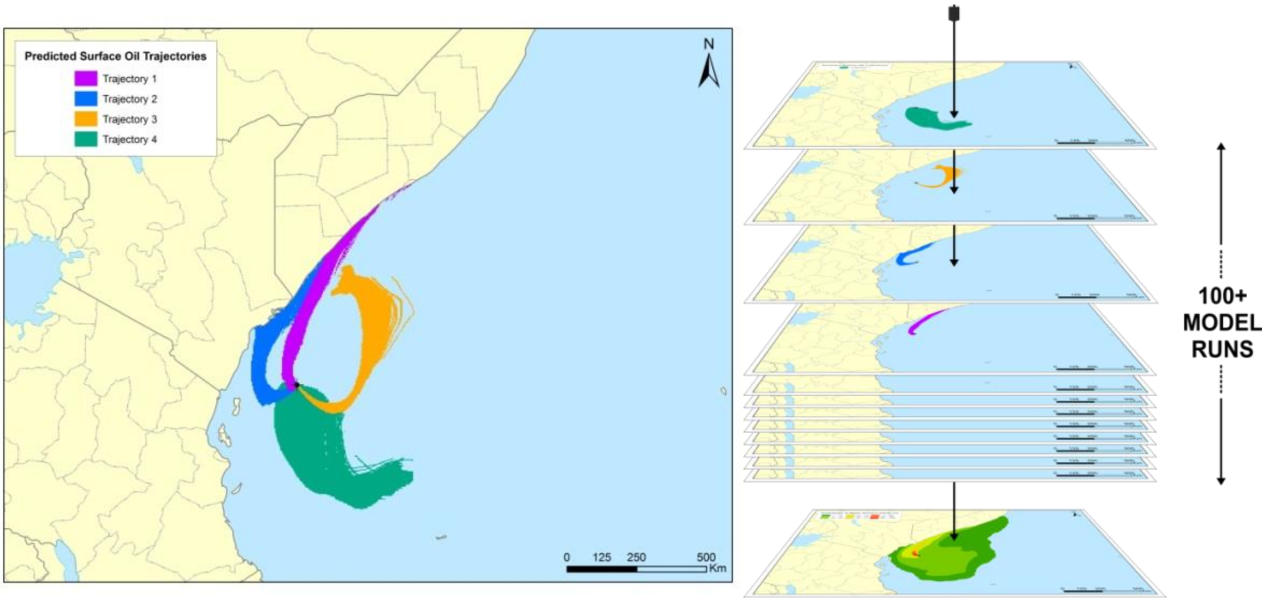


Figure 1-2 Examples of four individual spill trajectories (four replicate simulations) predicted by SIMAP for a spill scenario. The frequency of contact with given locations is used to calculate the probability of impacts during a spill. Essentially, all model runs are overlain (shown as the stacked runs on the right) and the number of times that trajectories contact a given location at a concentration is used to calculate the probability.

1.2.2 Deterministic Modelling (Single Spill Simulation)

Deterministic modelling is the predictive modelling of a single incident subject to a single sample of wind and weather conditions over time (NOPSEMA, 2018; Figure 1-3).

Deterministic modelling is often paired with stochastic modelling to place the large stochastic footprint into perspective. This deterministic analysis is generally a single run selected from the stochastic analysis and serves as the basis for developing the plans and equipment needs for a realistic spill response. Deterministic spills can be selected on several basis such as minimum time to shoreline, largest swept area, maximum volume ashore, longest length of shoreline contacted by oil or largest area of entrained or dissolved hydrocarbons.

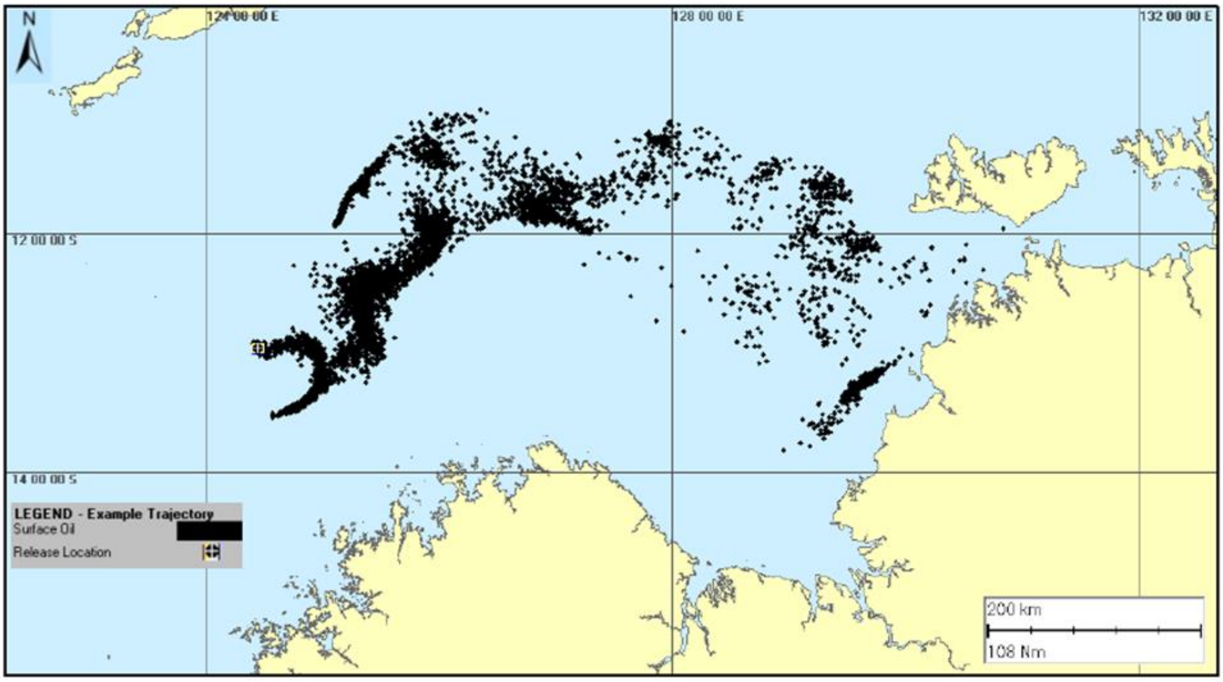


Figure 1-3 Example of an individual spill trajectory predicted by SIMAP for a spill scenario. Note, this image represents surface oil as spillets and do not take any thresholds into consideration.

2 SCOPE OF WORK

The scope of work included the following components:

- Generate 10-years of winds and three-dimensional currents from 2010 to 2019 (inclusive). The currents included the combined influence of tidal and ocean currents;
- Include the wind and current data and characteristics of the released hydrocarbons as input into the three-dimensional oil spill model (SIMAP), to model the movement, spreading, weathering and shoreline contact by hydrocarbons over time;
- Use SIMAP's stochastic model (also known as a probability model) to calculate exposure to surrounding waters and shorelines. This involved running 100 randomly selected single trajectory simulations per season, with each simulation having the same spill information (spill volume, duration and composition of hydrocarbons) but varying start times. This ensured that each spill simulation was subject to a unique set of wind and current conditions; and
- Results were assessed to determine the exposure to waters and contact to shorelines based upon the NOPSEMA thresholds; and

3 REGIONAL CURRENTS

Bass Strait is a body of water separating Tasmania from the southern Australian mainland, specifically the state of Victoria. The strait is a relatively shallow area of the continental shelf, connecting the southeast Indian Ocean with the Tasman Sea. Currents within the straight are primarily driven by tides, winds, incident continental shelf waves and density driven flows; high winds and strong tidal currents are frequent within the area (Jones, 1980).

The varied geography and bathymetry of the region, in addition to the forcing of the south-eastern Indian Ocean and local meteorology lead to complex shelf and slope circulation patterns (Middleton & Bye, 2007). Figure 3-1 displays seasonal current trends within the Bass Strait. During winter there is a strong eastward water flow due to the strengthening of the South Australian Current (fed by the Leeuwin Current in the Northwest Shelf), which bifurcates with one extension moving though the Bass Strait, and another forming the Zeehan Current off western Tasmania (Sandery & Kämpf, 2007). During summer, water flow reverses off Tasmania, King Island and the Otway Basin travelling eastward, as the coastal current develops due to south-easterly winds.

To accurately describe the variability in currents between the inshore and offshore region, a hybrid regional dataset was developed by combining deep ocean predictions obtained from HYCOM (Hybrid Coordinate Ocean Model) with surface tidal currents developed by RPS. The following sections provide a summary of the hybrid regional dataset.

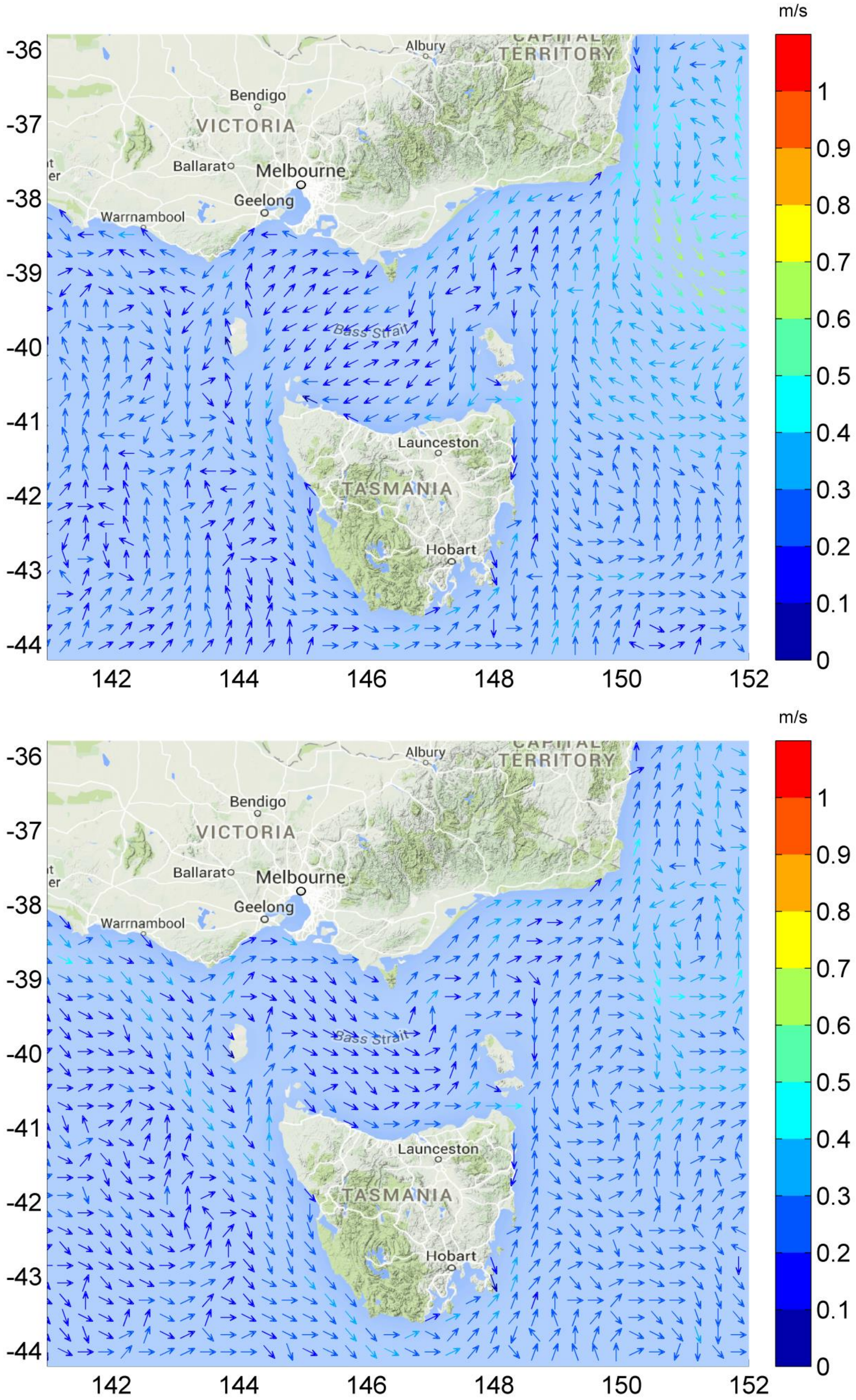


Figure 3-1 HYCOM averaged seasonal surface drift currents during summer (upper image) and winter (lower image).

3.1 Tidal Current Model

Tidal current data was generated using RPS's advanced ocean/coastal model, HYDROMAP. The HYDROMAP model has been thoroughly tested and verified through field measurements throughout the world for more than 30 years (Isaji & Spaulding, 1984; Isaji, et al., 2001; Zigic, et al., 2003). HYDROMAP tidal current data has been used as input to forecast (in the future) and hindcast (in the past) pollutant spills in Australian waters and forms part of the Australian National Oil Spill Emergency Response System operated by AMSA (Australian Maritime Safety Authority).

HYDROMAP employs a sophisticated sub-gridding strategy, which supports up to six levels of spatial resolution, halving the grid cell size as each level of resolution is employed. The sub-gridding allows for higher resolution of currents within areas of greater bathymetric and coastline complexity, and/or of interest to a study.

The numerical solution methodology follows that of Davies (1977a and 1977b) with further developments for model efficiency by Owen (1980) and Gordon (1982). A more detailed presentation of the model can be found in Isaji and Spaulding (1984) and Isaji et al. (2001).

3.1.1 Grid Setup

The tidal model domain is sub-gridded to a resolution of 500 m for shallow and coastal regions, starting from an offshore (or deep water) resolution of 8 km. The finer grids are progressively allocated in a step-wise fashion to more accurately resolve flows along the coastline, around islands and over regions with more complex bathymetry. Figure 3-2 shows the tidal model grid covering the study domain.

A combination of datasets was used and merged to describe the shape of the seabed within the grid domain (Figure 3-3). These included spot depths and contours which were digitised from nautical charts released by the hydrographic offices as well as Geoscience Australia database and depths extracted from the Shuttle Radar Topography Mission (SRTM30_PLUS) Plus dataset (see Becker et al., 2009).

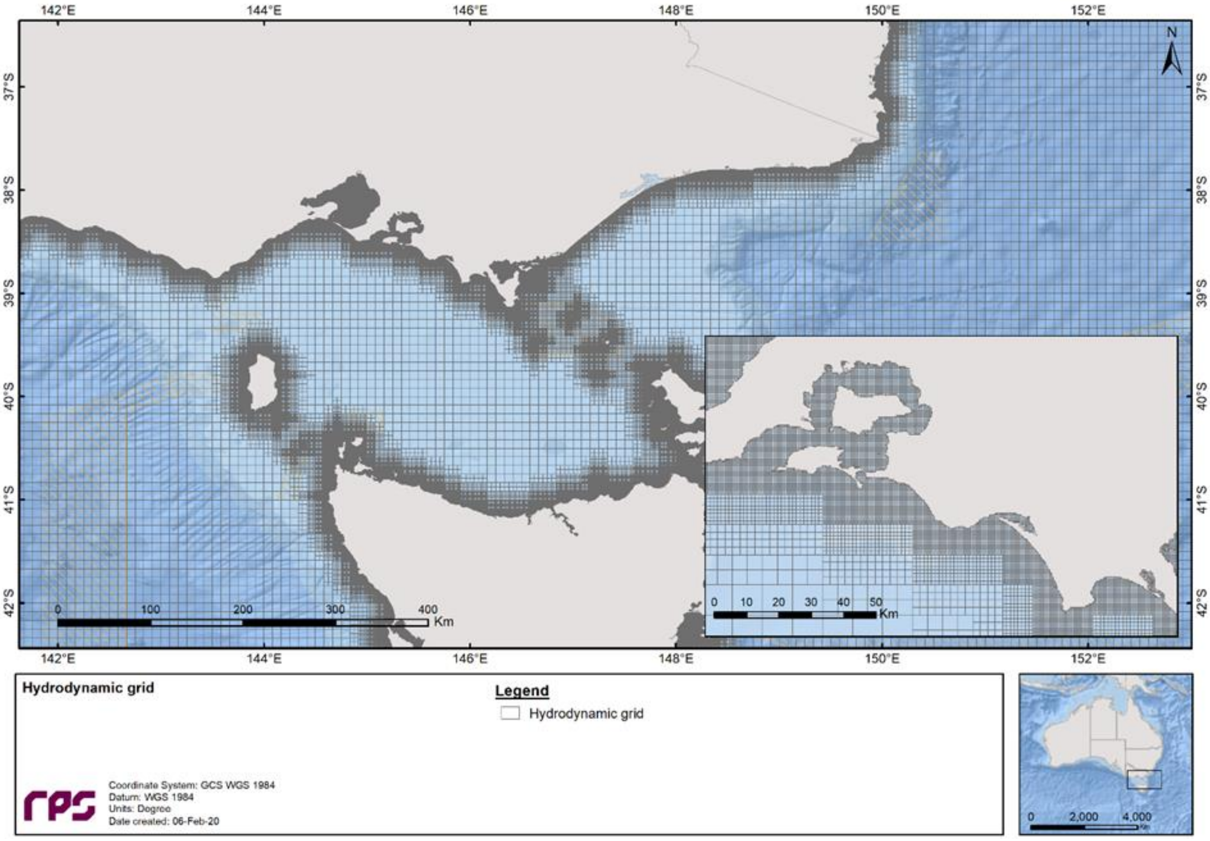


Figure 3-2 Sample of the model grid used to generate the tidal currents for the study region. Higher resolution areas are shown by the denser mesh.

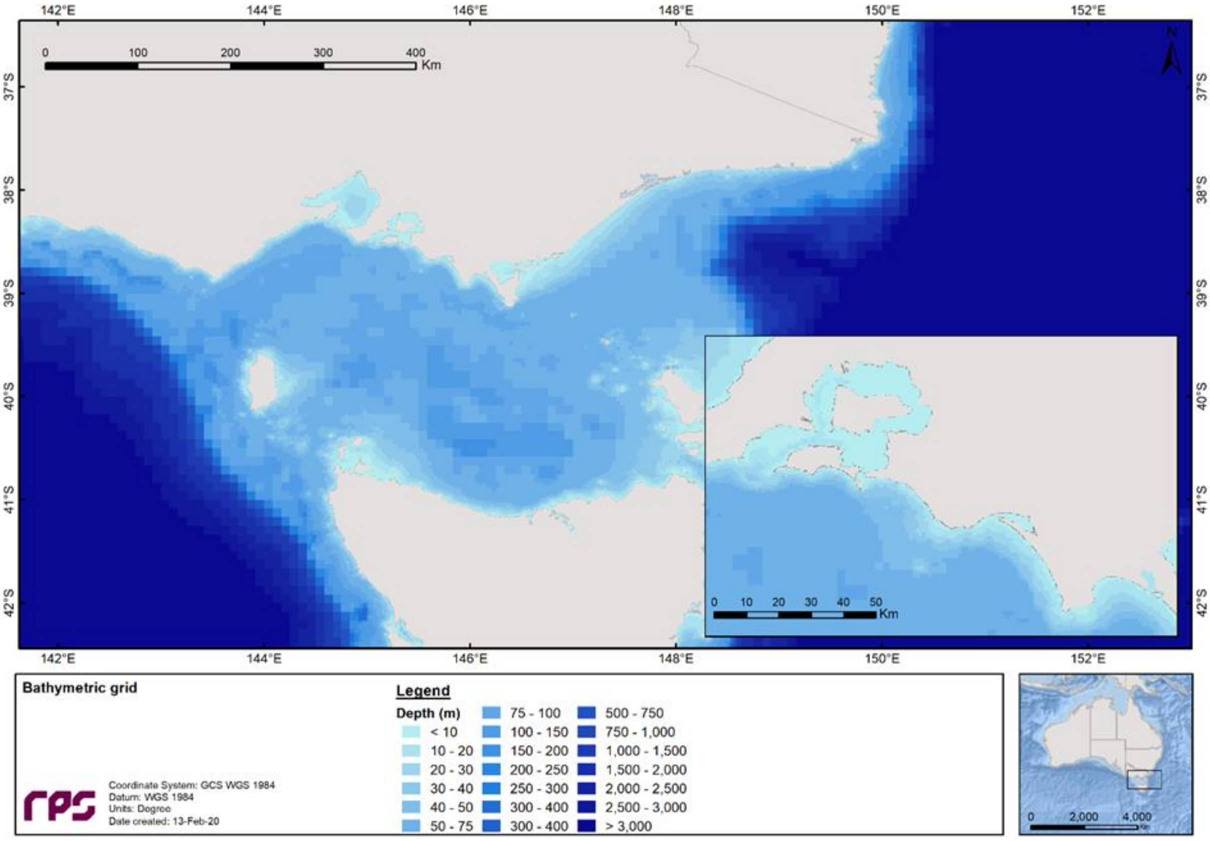


Figure 3-3 Bathymetry defined throughout the tidal model domain.

3.1.2 Tidal Conditions

The ocean boundary data for the regional model was obtained from satellite measured altimetry data (TOPEX/Poseidon 8.0) which provided estimates of the eight dominant tidal constituents at a horizontal scale of approximately 0.25 degrees. The eight major tidal constituents used were K_2, S_2, M_2, N_2, K_1, P_1, O_1 and Q_1. Using the tidal data, time series surface heights were calculated along the open boundaries for the simulation period.

The Topex/Poseidon satellite data has a resolution of 0.25 degrees globally, with higher resolution in coastal regions, and is produced and quality controlled by NASA (National Aeronautics and Space Administration). The data capturing satellites, equipped with two altimeters capable of taking sea level measurements accurate to less than ± 5 cm, measured oceanic surface elevations (and the resultant tides) for the period 1992–2005. In total these satellites carried out 62,000 orbits of the planet. The Topex/Poseidon tidal data has been widely used amongst the oceanographic community, being referenced in more than 2,100 research publications (e.g. Andersen, 1995; Ludicone et al., 1998; Matsumoto et al., 2000; Kostianoy et al., 2003; Yaremchuk & Tangdong, 2004; Qiu & Chen 2010). The Topex/Poseidon tidal data is considered suitably accurate for this study.

3.1.3 Surface Elevation Validation

To ensure that tidal predictions were accurate, predicted surface elevations were compared to data observed at a location situated within the study area (Figure 3-4).

To provide a statistical measure of the model performance, the Index of Agreement (IOA – Willmott, 1981) and the Mean Absolute Error (MAE – Willmott, 1982; Willmott & Matsuura, 2005) were used.

The MAE (Eq.1) is simply the average of the absolute values of the difference between the model-predicted (P) and observed (O) variables. It is a more natural measure of the average error (Willmott and Matsuura, 2005) and more readily understood. The MAE is determined by:

$$MAE = N^{-1} \sum_{i=1}^{N} |P_i - O_i| \qquad \text{Eq.1}$$

Where: N = Number of observations

P_i = Model predicted surface elevation

O_i = Observed surface elevation

The Index of Agreement (IOA; Eq. 2) in contrast, gives a non-dimensional measure of model accuracy or performance. A perfect agreement between the model predicted and observed surface elevations exists if the index gives an agreement value of 1, and complete disagreement between model and observed surface elevations will produce an index measure of 0 (Wilmott, 1981). Willmott et al. (1985) also suggests that values larger than 0.5 may represent good model performance. The IOA is determined by:

$$IOA = 1 - \frac{\sum |X_{model} - X_{obs}|^2}{\sum (|X_{model} - \overline{X_{obs}}| + |X_{obs} - \overline{X_{obs}}|)^2} \qquad \text{Eq.2}$$

Where: X_{model} = Model predicted surface elevation

X_{obs} = Observed surface elevation

Clearly, a greater IOA and lower MAE represent a better model performance.

Figure 3-5 and Figure 3-6 illustrate a comparison of the predicted and observed surface elevations in February 2017. As shown on the graph, the model accurately reproduced the phase and amplitudes throughout the spring and neap tidal cycles.

Table 3-1 shows the IOA and MAE values for the selected tide station locations indicating that the model is performing well.

Table 3-1 Statistical comparison between the observed and HYDROMAP predicted surface elevations.

Tide Station	IOA	MAE (m)
Gabo Island	0.98	0.08
Port MacDonnell	0.98	0.05
Port Welshpool	0.92	0.30
Portland	0.97	0.07
Stack Island	0.96	0.22

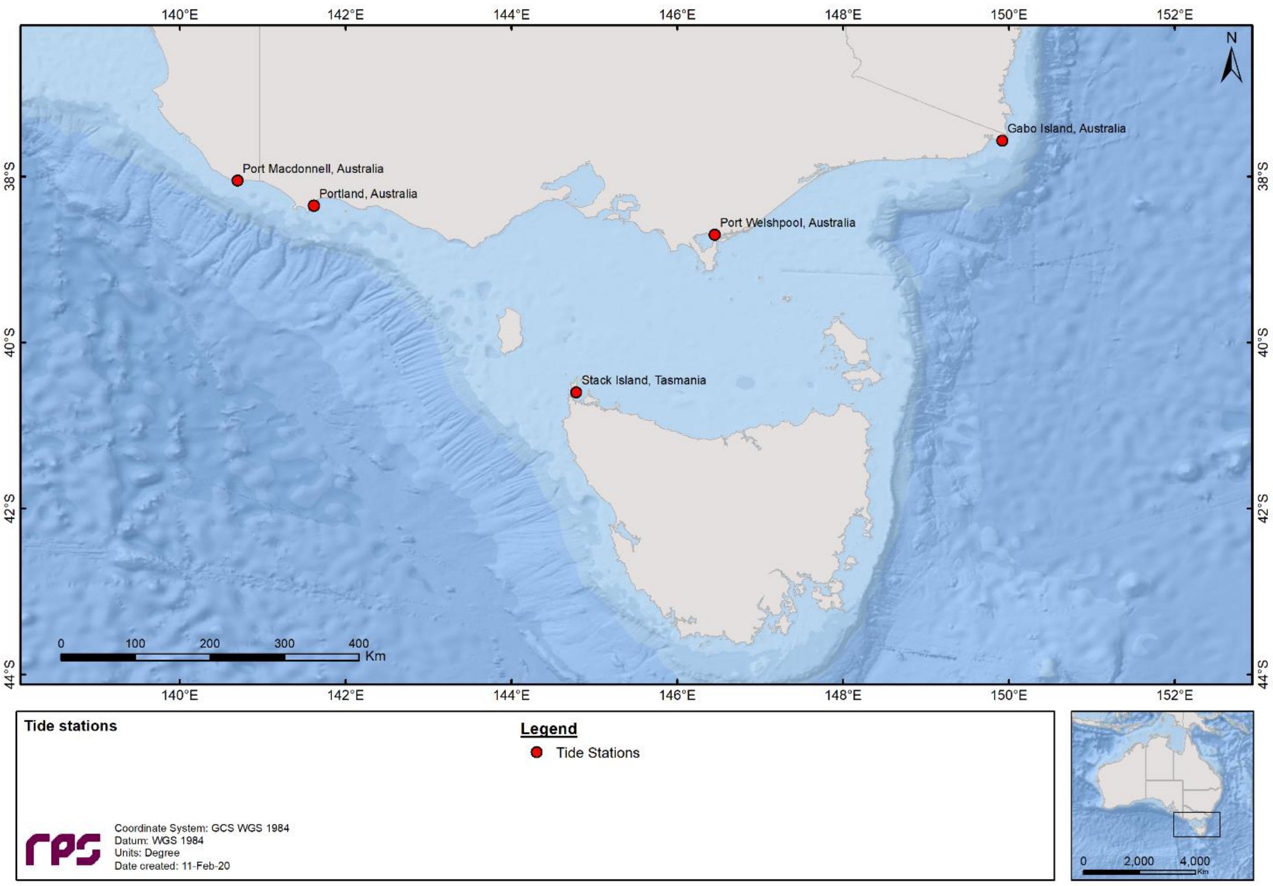


Figure 3-4 Location of the tide stations used in the surface elevation validation.

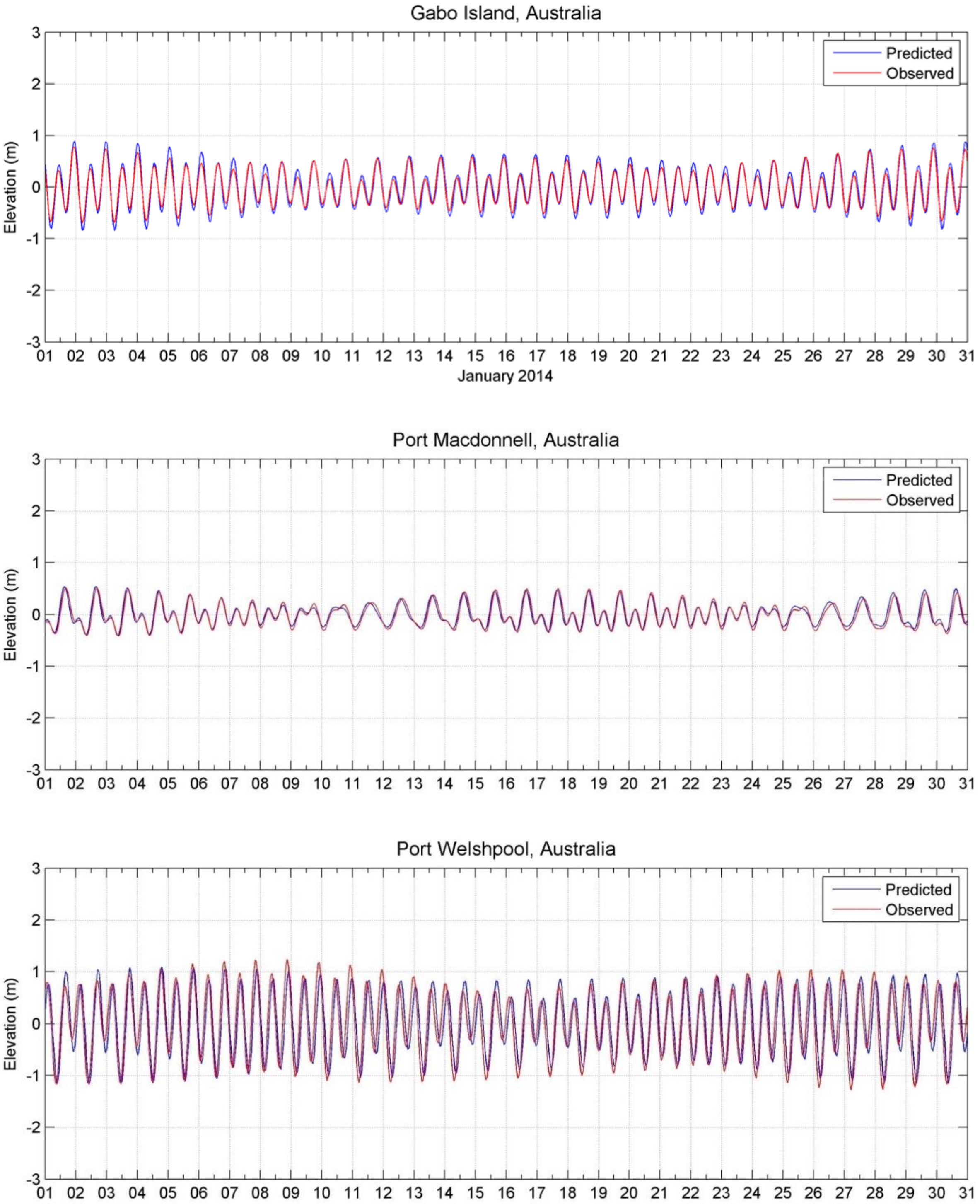


Figure 3-5 Comparison between HYDROMAP predicted (blue line) and observed (red line) surface elevation at tidal stations Gabo Island (upper image), Port MacDonnell (middle image) and Port Welshpool (lower image).

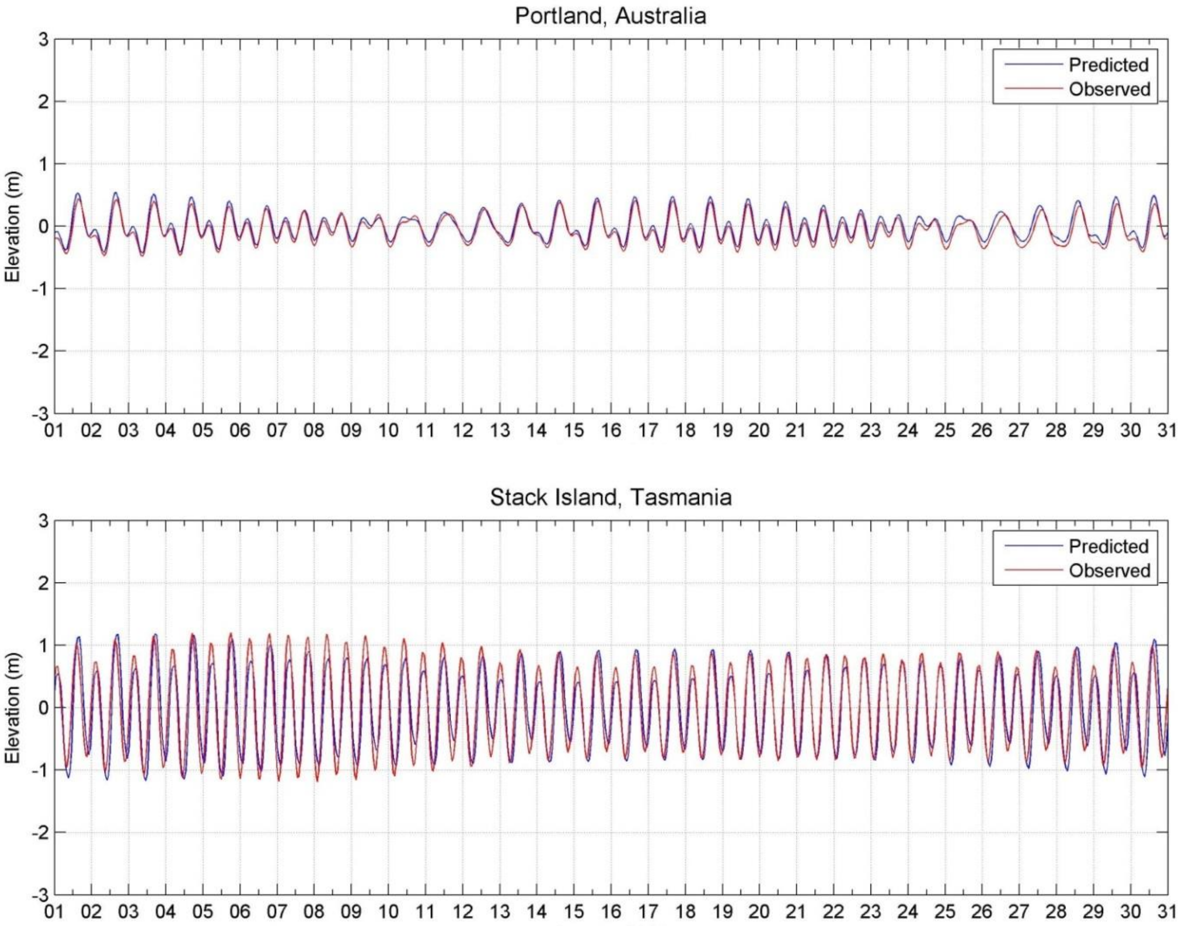


Figure 3-6 Comparison between HYDROMAP predicted (blue line) and observed (red line) surface elevation at tidal stations Portland (upper image) and Stack Island (lower image).

3.2 Ocean Current Model

Data describing the flow of ocean currents for the years 2010 to 2019 (inclusive) was obtained from HYCOM (Hybrid Coordinate Ocean Model, (Chassignet et al., 2007), which is operated by the HYCOM Consortium, sponsored by the Global Ocean Data Assimilation Experiment (GODAE). HYCOM is a data-assimilative, three-dimensional ocean model that is run as a hindcast (for a past period), assimilating time-varying observations of sea surface height, sea surface temperature and in-situ temperature and salinity measurements (Chassignet et al., 2009). The HYCOM predictions for drift currents are produced at a horizontal spatial resolution of approximately 8.25 km (1/12th of a degree) over the region, at a frequency of every 3 hours. HYCOM uses isopycnal layers in the open, stratified ocean, but uses the layered continuity equation to make a dynamically smooth transition to a terrain-following coordinate in shallow coastal regions, and to z-level coordinates in the mixed layer and/or unstratified seas.

3.3 Surface Currents

Table 3-2 and Table 3-3 present the monthly average and maximum net surface current speeds nearby the Release Location South and Release Location North, respectively, by combining the ocean and tidal currents. Current speeds varied throughout the year with monthly maximum current speeds ranging between 0.56 m/s (November) and 0.84 m/s (July) nearby Release Location South and 0.69 m/s (December) and 1.21 m/s (July) nearby Release Location North. The dominant surface current directions throughout the year were identified as (towards) south-southeast and east nearby the Release Location South and Release Location North, respectively.

Figure 3-7 to Figure 3-10 show the monthly and total surface current rose distributions nearby the release locations.

Note the convention for defining current direction is the direction the current flows towards, which is used to reference current direction throughout this report. Each branch of the rose represents the currents flowing to that direction, with north to the top of the diagram. Sixteen directions are used. The branches are divided into segments of different colour, which represent the current speed ranges for each direction. Speed intervals of 0.1 m/s are predominantly used in these current roses. The length of each coloured segment is relative to the proportion of currents flowing within the corresponding speed and direction.

Table 3-2 Predicted monthly average and maximum surface current speeds nearby the Release Location South release location. The data was derived by combining the HYCOM ocean data and HYDROMAP tidal data from 2010–2019 (inclusive).

Month	Average current speed (m/s)	Maximum current speed (m/s)	General direction(s) (towards)
January	0.18	0.76	South
February	0.17	0.78	South
March	0.19	0.68	South-southeast
April	0.20	0.68	South-southeast
May	0.24	0.82	Southeast
June	0.20	0.71	Southeast
July	0.23	0.84	Southeast
August	0.22	0.83	Southeast
September	0.19	0.63	Southeast
October	0.18	0.75	South-southeast
November	0.17	0.56	South-southeast
December	0.19	0.72	South-southeast
Minimum	0.17	0.56	-
Maximum	0.24	0.84	-

Table 3-3 **Predicted monthly average and maximum surface current speeds nearby the Release Location North. The data was derived by combining the HYCOM ocean data and HYDROMAP tidal data from 2010–2019 (inclusive).**

Month	Average current speed (m/s)	Maximum current speed (m/s)	General direction(s) (towards)
January	0.15	0.73	West
February	0.16	0.70	West
March	0.16	0.96	West
April	0.15	0.94	East
May	0.20	1.12	East
June	0.21	1.05	East
July	0.26	1.21	East
August	0.25	1.11	East
September	0.21	1.01	East
October	0.19	0.98	East
November	0.17	0.83	East
December	0.18	0.69	East
Minimum	0.15	0.69	-
Maximum	0.26	1.21	-

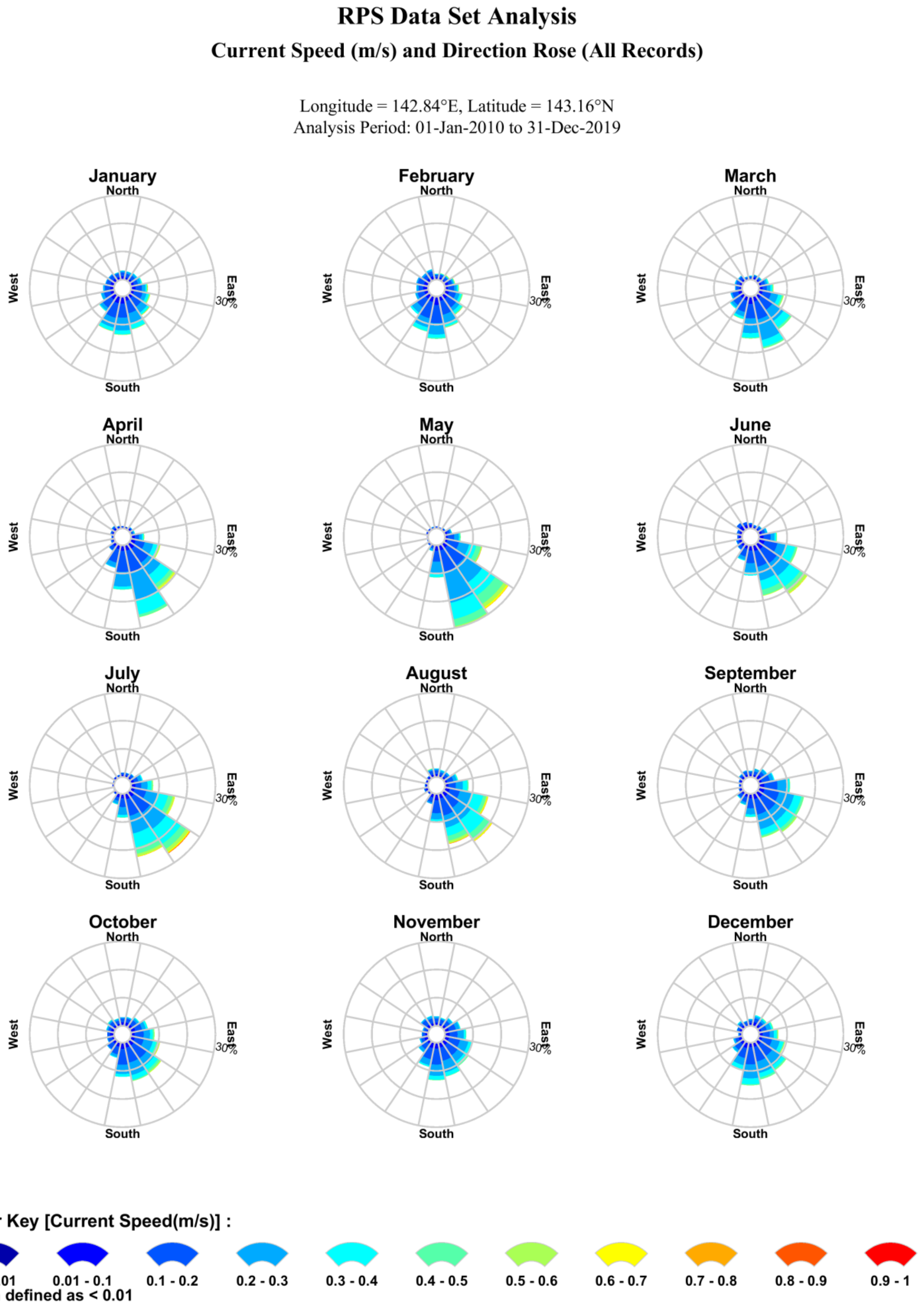


Figure 3-7 Monthly surface current rose plots nearby the Release Location South (derived by combining the HYDROMAP tidal currents and HYCOM ocean currents for 2010–2019 (inclusive).

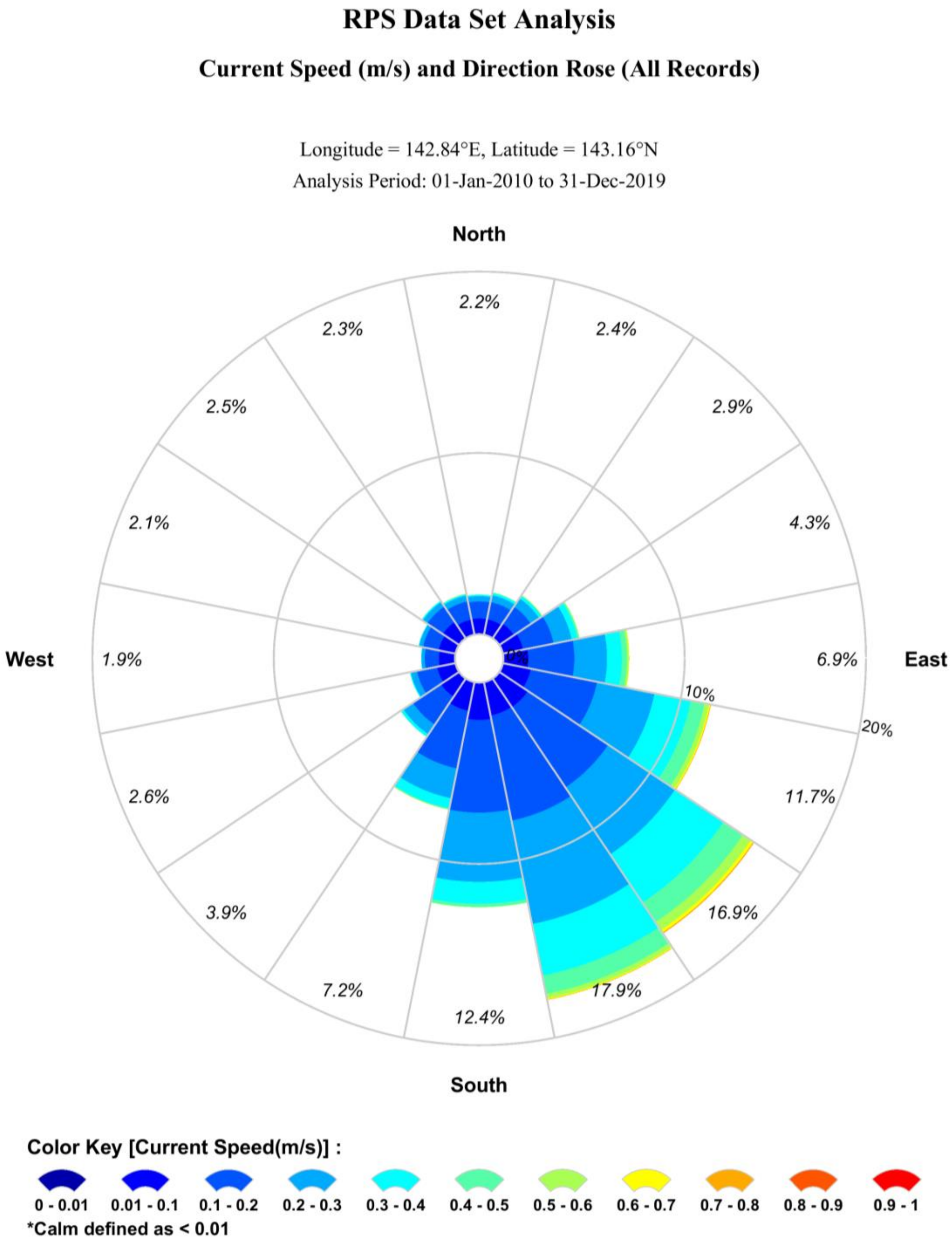


Figure 3-8 Total surface current rose plot nearby the Release Location South (derived by combining the HYDROMAP tidal currents and HYCOM ocean currents for 2010–2019 (inclusive).

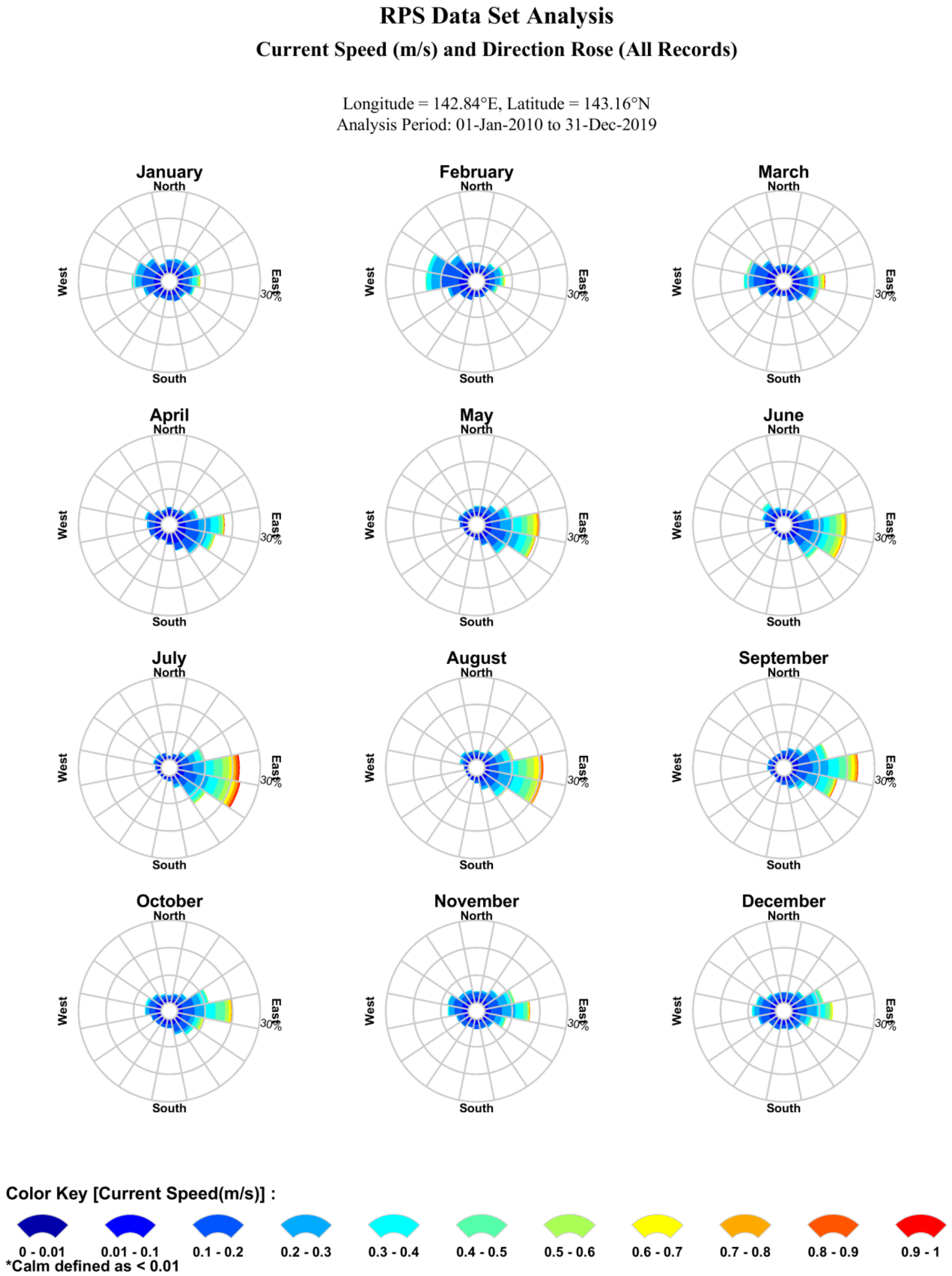


Figure 3-9 **Monthly surface current rose plots nearby the Release Location North (derived by combining the HYDROMAP tidal currents and HYCOM ocean currents for 2010–2019 (inclusive).**

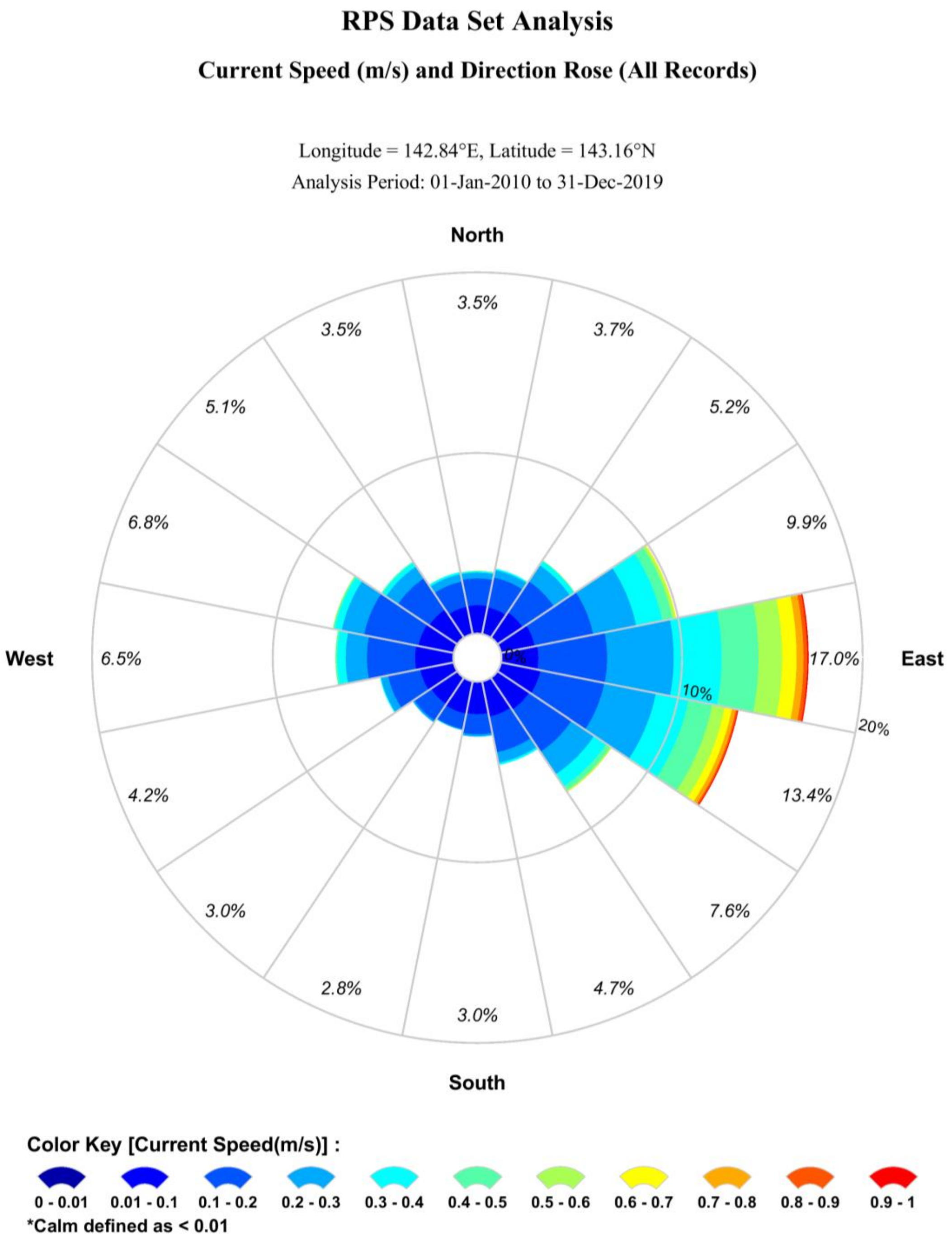


Figure 3-10 Total surface current rose plot nearby the Release Location North (derived by combining the HYDROMAP tidal currents and HYCOM ocean currents for 2010–2019 (inclusive).

4 WIND DATA

High resolution wind data for the years 2010 to 2019 (inclusive) was sourced from the National Centre for Environmental Prediction (NCEP) Climate Forecast System Reanalysis dataset (CFSR; see Saha et al., 2010). The CFSR wind model is a fully coupled, data-assimilative hindcast model representing the interaction between the earth's oceans, land and atmosphere. The gridded wind data output is available at ¼ of a degree resolution (~33 km) and 1-hourly time intervals. Figure 4-1 shows the spatial resolution of the wind field used as input into the oil spill model.

Table 4-1 and Table 4-2 present the monthly average and maximum winds derived from a CFSR wind node nearby the Release Location South and Release Location North, respectively. The wind data demonstrated average monthly wind speeds ranging from 14.20 knots (January) to 19.91 knots (July) with maximums ranging between 38.41 knots (November) and 49.73 knots (September) nearby the Release Location South. Additionally, nearby the Release Location North, average monthly wind speeds varied between 13.75 knots (January) and 19.35 knots (July), whilst maximums ranged from 38.87 knots (January) to 52.61 knots (June).

Near the Release Location South, the dominant wind direction varied throughout the year though was predominantly westerly. Nearby Release Location North the dominant wind direction also varied with winds also predominantly from the west.

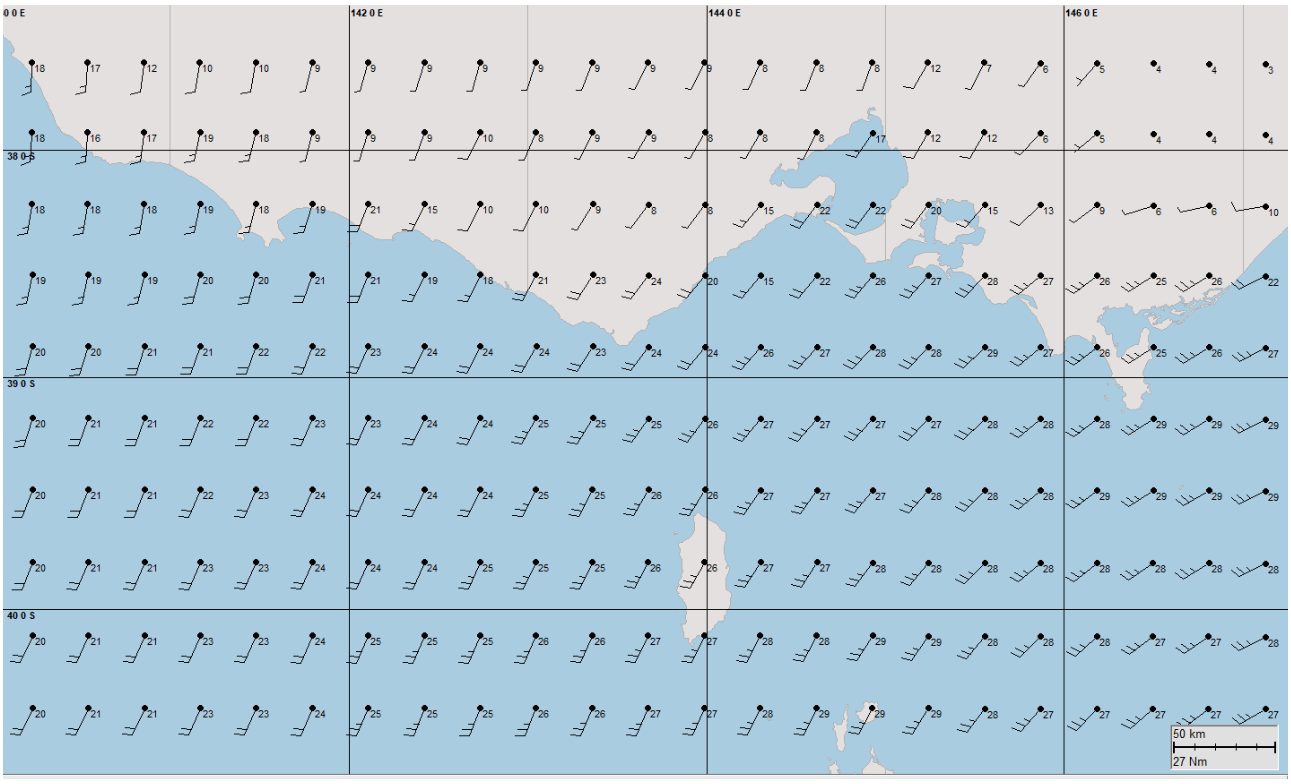


Figure 4-1 Spatial resolution of the CFSR modelled wind data used as input into the oil spill model.

Figure 4-2 to Figure 4-5 show the monthly and total wind rose distributions derived from the CFSR data for the selected node nearby the Release Location South and Release Location North.

Note that the atmospheric convention for defining wind direction, that is, the direction the wind blows from, is used to reference wind direction throughout this report. Each branch of the rose represents wind coming from that direction, with north to the top of the diagram. Sixteen directions are used. The branches are divided into segments of different colour, which represent wind speed ranges from that direction. Speed ranges of 5 knots are predominantly used in these wind roses. The length of each segment within a branch is proportional to the frequency of winds blowing within the corresponding range of speeds from that direction.

Table 4-1 Predicted average and maximum winds representative for the selected node nearby the Release Location South. Data derived from CFSR hindcast model from 2010–2019 (inclusive).

Month	Average wind speed (knots)	Maximum wind speed (knots)	General direction(s) (from)
January	14.20	40.60	Southeast
February	14.97	42.75	Southeast
March	14.94	43.46	West
April	14.99	45.60	West
May	17.45	48.90	West
June	17.54	45.47	Northwest
July	19.91	47.42	West-northwest
August	19.32	46.28	West
September	17.47	49.73	Southwest
October	16.37	45.39	West
November	15.43	38.41	West-southwest
December	14.92	40.75	West
Minimum	14.20	38.41	-
Maximum	19.91	49.73	-

Table 4-2 Predicted average and maximum winds representative for the selected node nearby the Release Location North. Data derived from CFSR hindcast model from 2010–2019 (inclusive).

Month	Average wind speed (knots)	Maximum wind speed (knots)	General direction(s) (from)
January	13.75	38.87	South
February	14.28	41.67	Southeast
March	14.25	44.22	West
April	13.88	42.13	West
May	16.59	45.38	West
June	16.71	52.61	Northwest
July	19.35	45.77	Northwest
August	18.75	47.47	Northwest
September	16.71	48.61	West
October	15.80	44.58	West
November	14.79	43.66	West
December	14.34	40.23	West
Minimum	13.75	38.87	-
Maximum	19.35	52.61	-

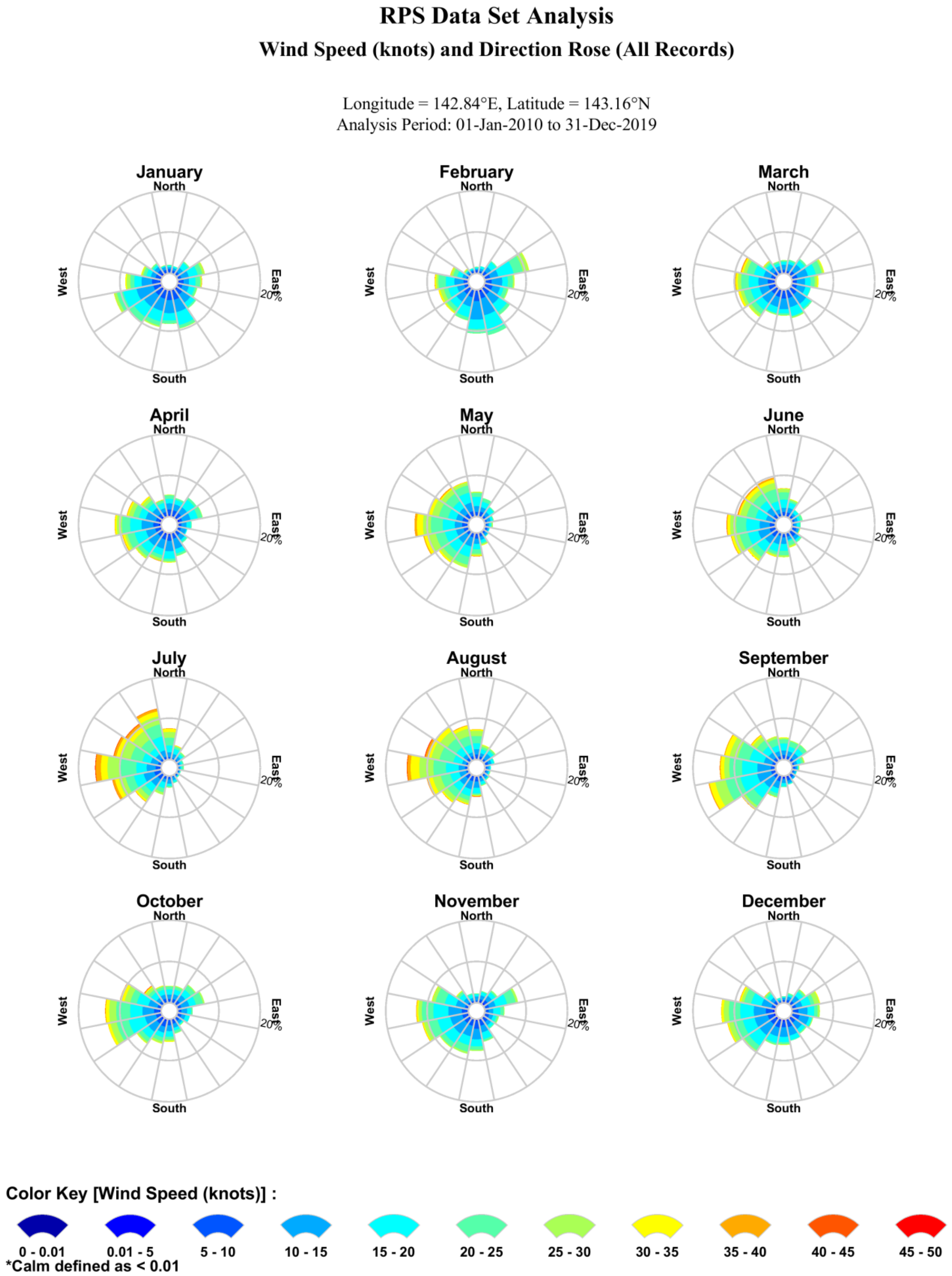


Figure 4-2 Modelled monthly wind rose distributions from 2010–2019 (inclusive) for the node nearby the Release Location South.

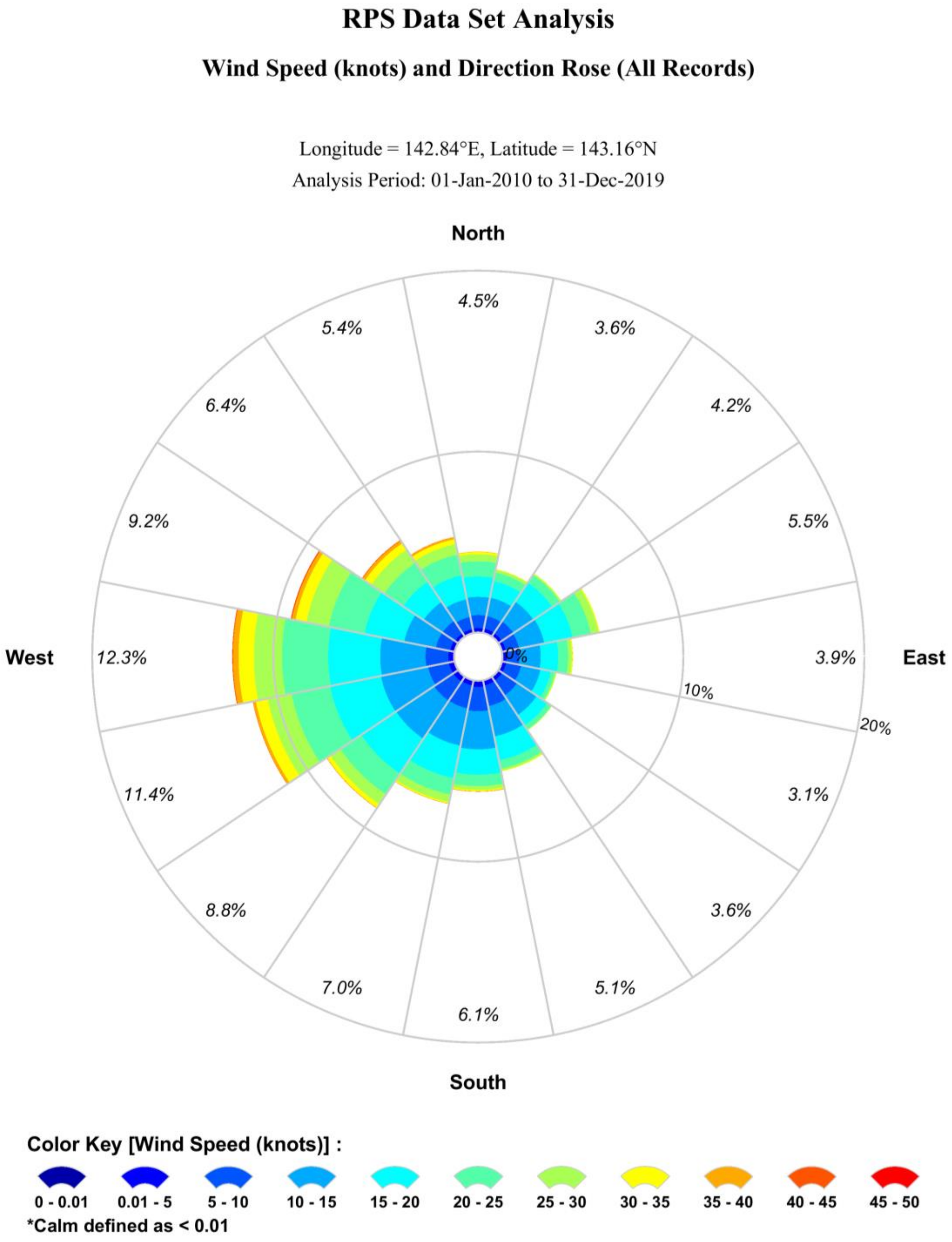


Figure 4-3 Modelled total wind rose distributions from 2010–2019 (inclusive) for the node nearby the Release Location South.

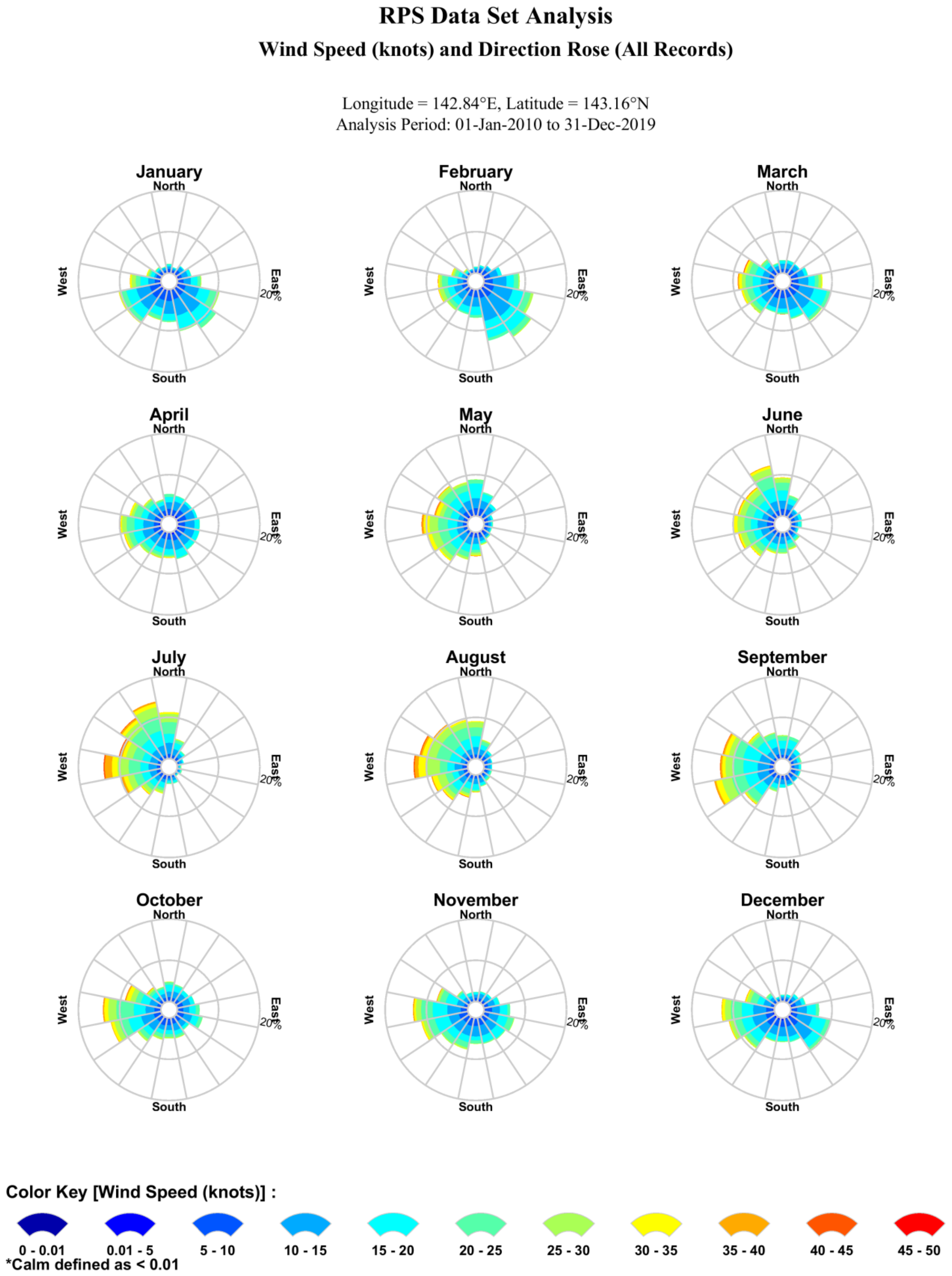


Figure 4-4 **Modelled monthly wind rose distributions from 2010–2019 (inclusive) for the node nearby the Release Location North.**

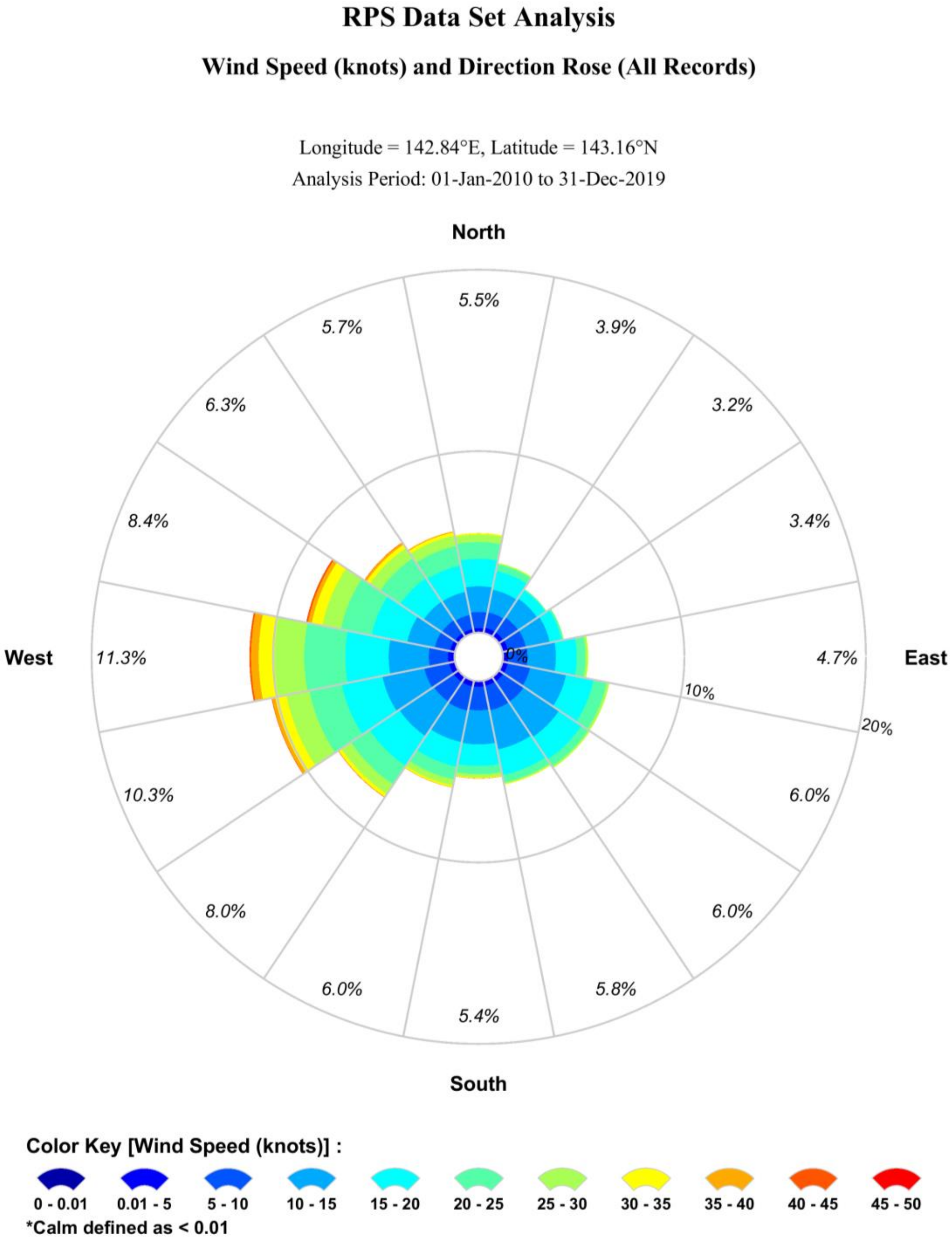


Figure 4-5 Modelled total wind rose distributions from 2010–2019 (inclusive) for the node nearby the Release Location North.

5 WATER TEMPERATURE AND SALINITY

The monthly spatially varying water temperature and salinity profiles across the model domain were obtained from the HYCOM model (Section 3.2).

Figure 5-1 and Figure 5-2 illustrate the vertical profile of sea temperature and salinity nearby the Release Location South and Release Location North, respectively.

Table 5-1 and Table 5-2 present the sea temperature and salinity of the surface layer nearby the release locations. Nearby the Release Location South, the monthly average sea surface temperatures ranged between 13.3°C (September and October) and 18.4°C (March), whilst nearby Release Location North temperatures varied from 13.5°C (September) to 19.0°C (February). The monthly average salinity values remain relatively consistent ranging between 35.3 psu and 35.4 psu nearby Release Location South and 35.3 psu and 35.5 psu nearby Release Location North.

Table 5-1 Monthly average sea surface temperature and salinity nearby the Release Location South.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature (ºC)	17.4	18.4	18.4	17.1	15.7	15.3	14.5	13.8	13.3	13.3	14.3	15.2
Salinity (psu)	35.3	35.4	35.4	35.3	35.4	35.4	35.4	35.4	35.4	35.4	35.3	35.3

Table 5-2 Monthly average sea surface temperature and salinity nearby the Release Location North.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature (ºC)	18.2	19.0	18.9	17.1	15.9	15.2	14.7	14.1	13.5	13.9	14.6	15.9
Salinity (psu)	35.4	35.4	35.4	35.3	35.4	35.4	35.5	35.5	35.4	35.4	35.4	35.3

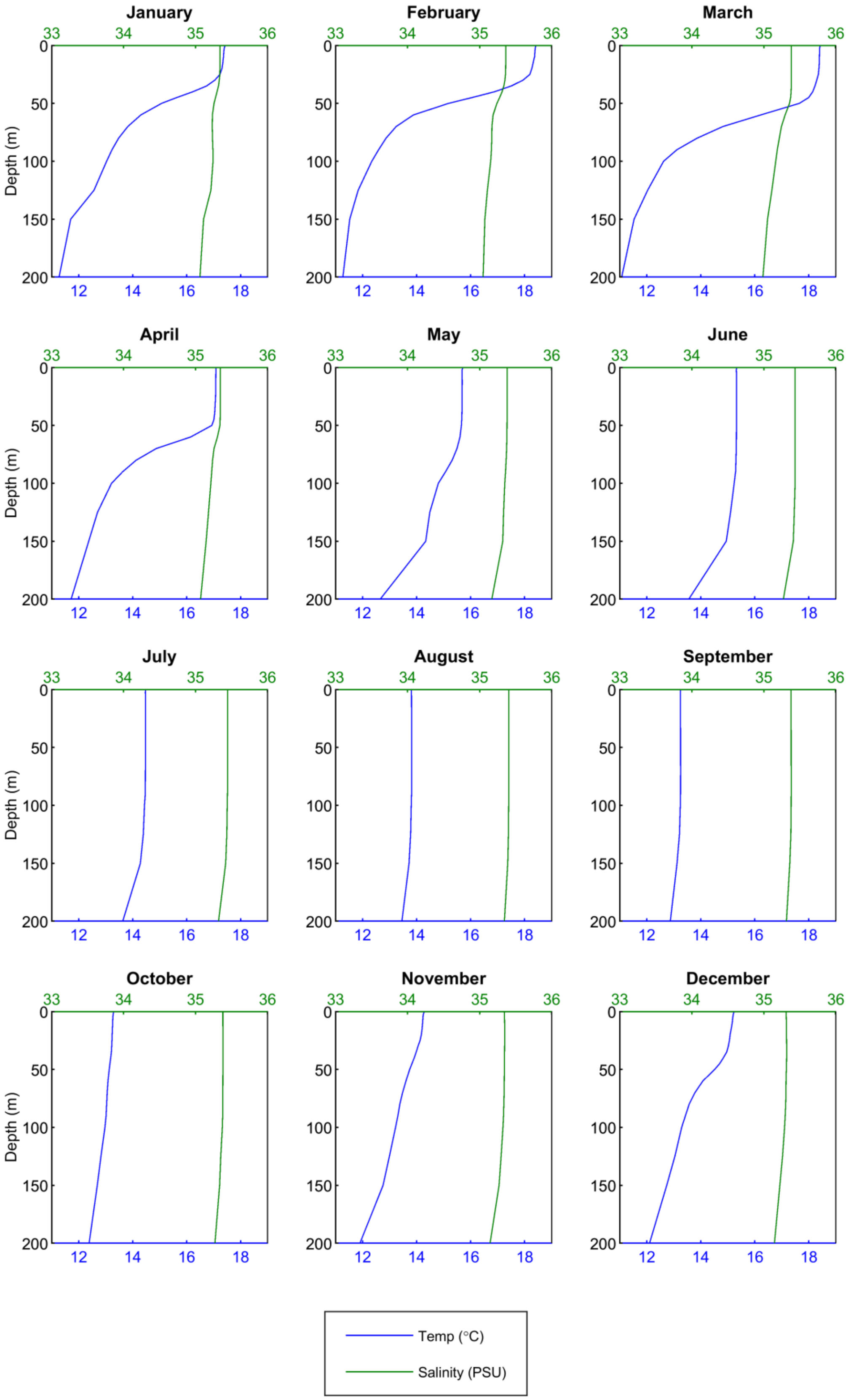


Figure 5-1 Temperature and salinity profiles nearby the Release Location South.

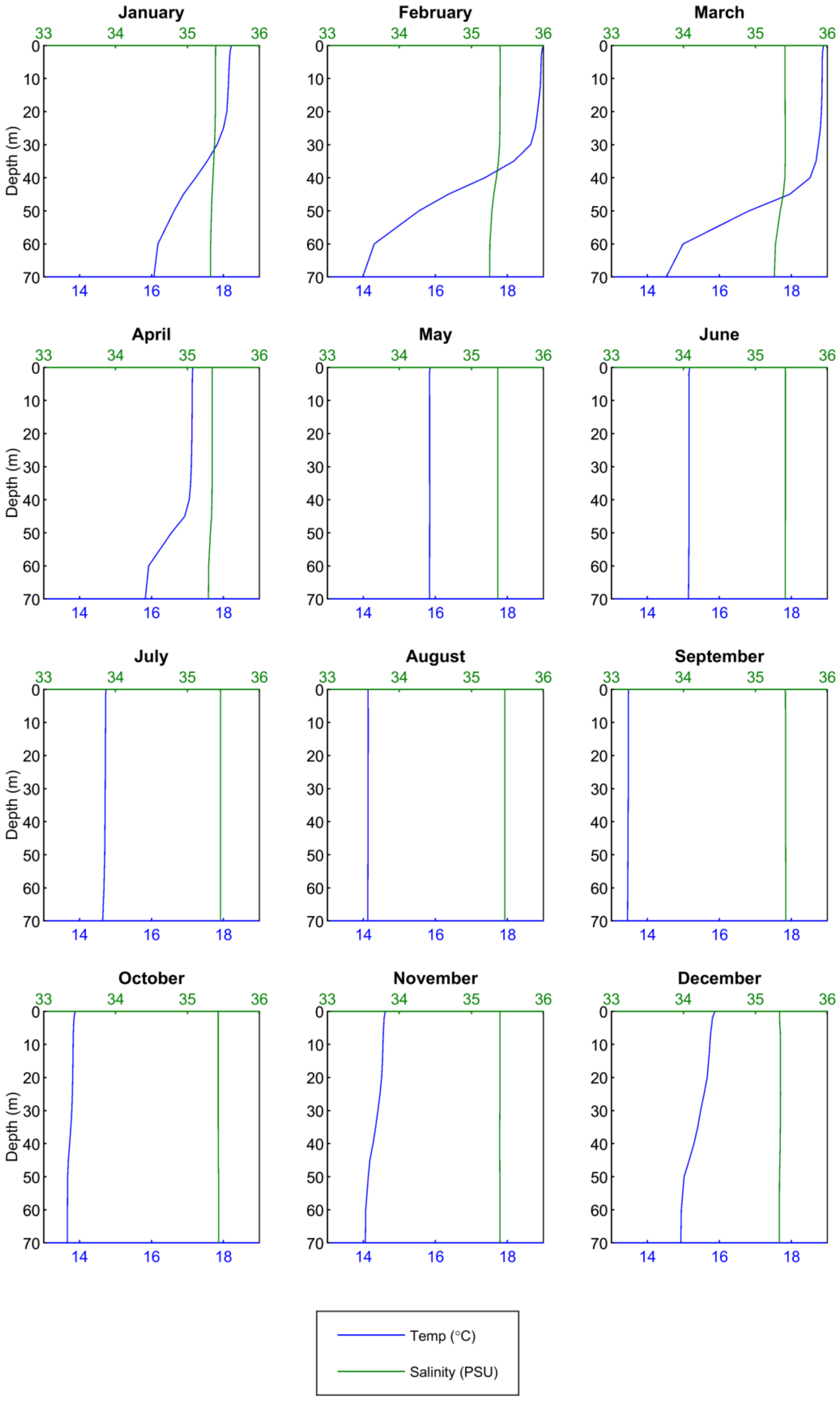


Figure 5-2 Temperature and salinity profiles nearby the Release Location North.

6 SUBSEA PLUME MODEL – OILMAP DEEP

In the event of a subsea release, the gas and condensate will initially behave like a jet, which dissipates in the water column over a short distance (<10 m). The escaping condensate shear into small droplets due to turbulence generated by passing through the exit hole and subsequent turbulence generated in the plume jet. The size-distribution of the droplets will vary with the exit velocity and viscosity of the condensate. Following this phase, the density and buoyancy difference of the gas and condensate mixture relative to the surrounding waters, forces the plume upward. As the plume rises, the volume of gas will increase due to reduction of water pressure, with gas bubbles dividing into an increasing number of bubbles due to the shearing effect exerted by the water column.

In shallow water (<200 m) the rising plume will tend to reach the sea surface before deflecting away from the centre of the plume (Spaulding et al., 2000). Figure 6-1 conceptually illustrates the various stages of a subsea release of oil and gas.

The OILMAP Deep model (Spaulding et al. 2015) was used to simulate the near-field behaviour of the gas-condensate subsea release in two phases – the initial jet phase and the buoyant plume phase. The initial jet phase is predominately driven by the exit velocity. During this phase, the condensate droplet-size-distributions are calculated for a range of classes or bins. Next, the plume model predicts the rise dynamics of the condensate and gas plume to calculate at which point gas lift will be lost (i.e., the trapping height).

Outputs which include the plume trapping height, plume diameter and droplet size distribution are used as input to the SIMAP model to simulate the rise and dispersion of the condensate droplets from this point onwards.

More details on the OILMAP-DEEP model, can be found in Spaulding et al. (2015). The model has been validated against observations from Deepwater Horizon as well as small and large-scale laboratory studies on subsurface oil releases (Brandvik et al 2013, 2014; Belore 2014; Spaulding et al. 2015; Li et al. 2017).

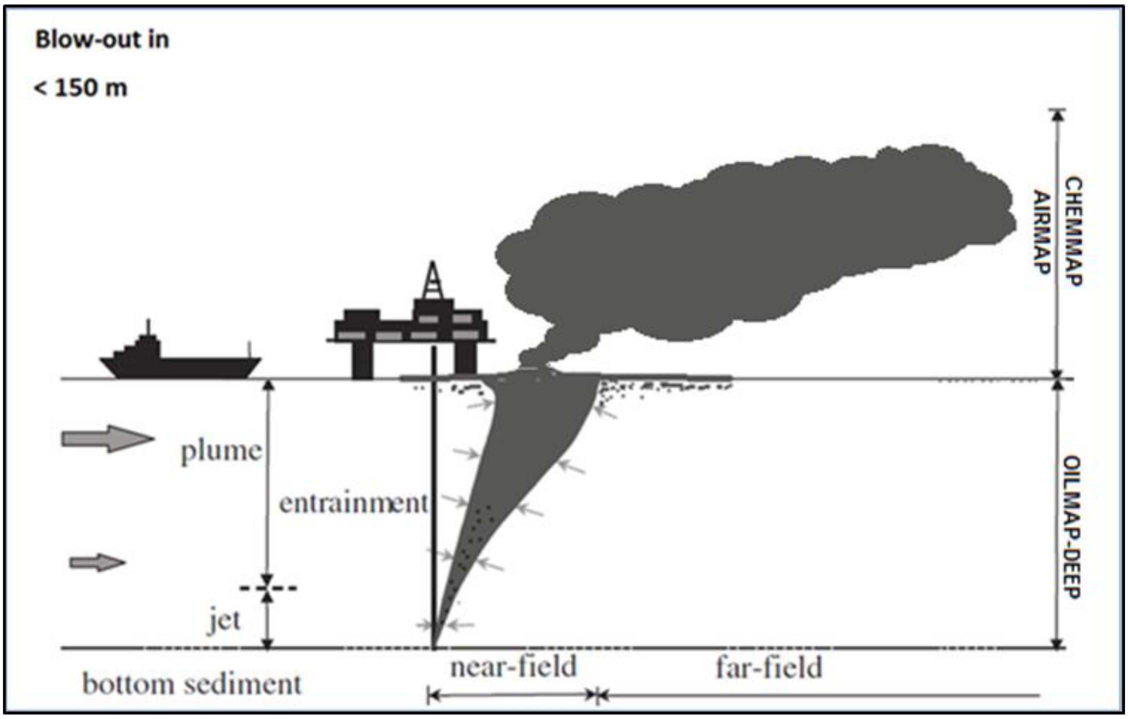


Figure 6-1 Schematic of the various stages of the plume in the water column (Source: ASA, 2011).

Table 6-1 presents the input parameters and key results for the subsea plume modelling.

The subsea modelling showed that in the event of a loss of well control at Release Location South (Scenario 1), the amalgamated gas and condensate would propel rapidly upward from the seabed and breach the sea surface. Droplet sizes would initially range from 124 µm to 537 µm on day-1 and increase in size to 141 µm to 609 µm by day-86.

The subsea modelling showed that in the event of a loss of well control at Release Location North (Scenario 3), the amalgamated gas and condensate would propel rapidly upward from the seabed and also breach the sea surface. Droplet sizes would initially range from 108 µm to 466 µm on day-1 and increase in size to 205 µm to 886 µm by day-86.

Table 6-1 Input data and key results for the subsea plume modelling.

Input Variable	Release Location South	Release Location North
Scenario	Loss of well control	Loss of well control
Water depth	155 m	71.5 m
Tubing diameter	8.5”	8.5”
Condensate discharge rate	Day-1: 7,547 STB/day Day-86: 6,652 STB/day	Day-1: 6,813 STB/day Day-86: 3,559 STB/day
Gas discharge rate	Day-1: 469 MMscf/day Day-86: 415 MMscf/day	Day-1: 407 MMscf/day Day-86: 222 MMscf/day
Formation water discharge rate	Day-1: 1,104 STB/day Day-86: 1,053 STB/day	Day-1: 363 STB/day Day-86: 266 STB/day
Key Results		
Plume execution depth (m BMSL)	0 (Breach the sea surface)	0 (Breach the sea surface)
Droplet sizes (µm)	Day-1: 124 to 537 Day-86: 141 to 609	Day-1: 108 to 466 Day-86: 205 to 886

7 OIL SPILL MODEL – SIMAP

Modelling of the fate of oil was performed using the Spill Impact Model Application Program (SIMAP). SIMAP is designed to simulate the fate and effects of spilled hydrocarbons for both the surface and subsurface releases (Spaulding et al., 1994; French et al., 1999; French-McCay, 2003, 2004; French-McCay et al., 2004).

SIMAP has been used to predict the weathering and fate of oil spills during and after major incidents including: Montara (Australia) well blowout August 2009 in the Timor Sea (Asia-Pacific ASA, 2010); Macondo (USA) well blowout April 2010 in the Gulf of Mexico; Bohai Bay (China) oil spill August 2011; and the pipeline oil spill July 2013 in the Gulf of Thailand.

The SIMAP model calculates the transport, spreading, entrainment, evaporation and decay of surface hydrocarbon slicks as well as the entrained and dissolved oil components in the water column, either from surface slicks or from oil discharged subsea. The movement and weathering of the spilled oil is calculated for specific oil types. Input specifications for oil mixtures include the density, viscosity, pour point, distillation curve (volume lost versus temperature) and the aromatic/aliphatic component ratios within given boiling point (BP) ranges.

SIMAP is a three-dimensional model that allows for various response actions to be modelled including oil removal from skimming, burning, or collection booms, and surface and subsurface dispersant application.

The SIMAP oil spill model includes advanced weathering algorithms, specifically focussed on unique oils that tend to form emulsions and/or tar balls. The weathering algorithms are based on 5 years of extensive research conducted in response to the Deepwater Horizon oil spill in the Gulf of Mexico (French-McCay et al., 2015).

Biodegradation is included in the oil spill model. In the model, SIMAP, degradation is calculated for the surface slick, deposited oil on the shore, the entrained oil and dissolved constituents in the water column, and oil in the sediments. For surface oil, water column oil and sedimented oil a first order degradation rate is specified. Biodegradation rates are relatively high for hydrocarbons in dissolved state or in dispersed small droplets.

7.1 Stochastic Modelling

For the stochastic modelling presented herein, **200 oil spills** (100 per season) were modelled for each of the 4 scenarios using the same spill information (release location, spill volume, duration and oil type) but with varied start dates per scenario. During each simulation, the model records whether any grid cells are exposed to any oil concentrations, the concentrations involved and the elapsed time before exposure. The results of all 100 oil spill simulations per season (per scenario) were analysed to determine the following statistics for every grid cell:

- Exposure load (concentrations);
- Minimum time before exposure;
- Maximum duration of exposure;
- Probability of contact above defined concentrations;
- Volume of oil that may accumulate on shorelines from any single simulation;
- Concentration that might occur on sections of individual shorelines;
- Exposure (instantaneous) to dissolved hydrocarbons in the water column;
- Exposure (instantaneous) to entrained hydrocarbons in the water column; and
- Residence time, or the longest continuous period floating oil, and dissolved and entrained hydrocarbons persisted at a point above a threshold.

7.2 Floating, Shoreline and In-Water Thresholds

The thresholds and their relationship to exposure for the sea surface, shoreline and water column (entrained and dissolved hydrocarbons) are presented in Sections 7.2.1 to 7.2.3. Supporting justifications of the adopted thresholds applied during the study and additional context relating to the area of influence are also provided. It is important to note that the thresholds herein are based on NOPSEMA (2019).

7.2.1 Floating Oil Exposure Thresholds

The modelling results can be presented to any levels; therefore, thresholds have been specified (based on scientific literature) to record floating oil exposure to the sea-surface at meaningful levels only, described in the following paragraphs.

The low threshold to assess the potential for floating oil exposure, was 1 g/m^2, which equates approximately to an average thickness of 1 µm, referred to as visible oil. Oil of this thickness is described as rainbow sheen in appearance, according to the Bonn Agreement Oil Appearance Code (Bonn Agreement, 2009; AMSA, 2014) (see Table 7-1). Figure 7-1 shows photographs highlighting the difference in appearance between a silvery sheen, rainbow sheen and metallic sheen. This threshold is considered below levels which would cause environmental harm and it is more indicative of the areas perceived to be affected due to its visibility on the sea surface and potential to trigger temporary closures of areas (i.e. fishing grounds) as a precautionary measure. Table 7-1 provides a description of the appearance in relation to exposure zone thresholds used to classify the zones of floating oil exposure.

Ecological impact has been estimated to occur at 10 g/m^2 (a film thickness of approximately 10 µm or 0.01 mm) according to French et al. (1996) and French-McCay (2009) as this level of fresh oiling has been observed to mortally impact some birds through adhesion of oil to their feathers, exposing them to secondary effects such as hypothermia. The appearance of oil at this average thickness has been described as a metallic sheen (Bonn Agreement, 2009).

Scholten et al. (1996) and Koops et al. (2004) indicated that at oil concentrations on the sea surface of 25 g/m^2 (or greater), would be harmful for all birds that have landed in an oil film due to potential contamination of their feathers, with secondary effects such as loss of temperature regulation and ingestion of oil through preening. The appearance of oil at this thickness is also described as metallic sheen (Bonn Agreement, 2009). For this study the high exposure threshold was set to 50 g/m^2 and above based on NOPSEMA (2019). This threshold can also be used to inform response planning.

Table 7-2 defines the thresholds used to classify the zones of floating oil exposure reported herein.

Table 7-1 The Bonn Agreement Oil Appearance Code.

Code	Description Appearance	Layer Thickness Interval (g/m^2 or µm)	Litres per km^2
1	Sheen (silvery/grey)	0.04 – 0.30	40 – 300
2	Rainbow	0.30 – 5.0	300 – 5,000
3	Metallic	5.0 – 50	5,000 – 50,000
4	Discontinuous True Oil Colour	50 – 200	50,000 – 200,000
5	Continuous True Oil Colour	≥ 200	≥ 200,000

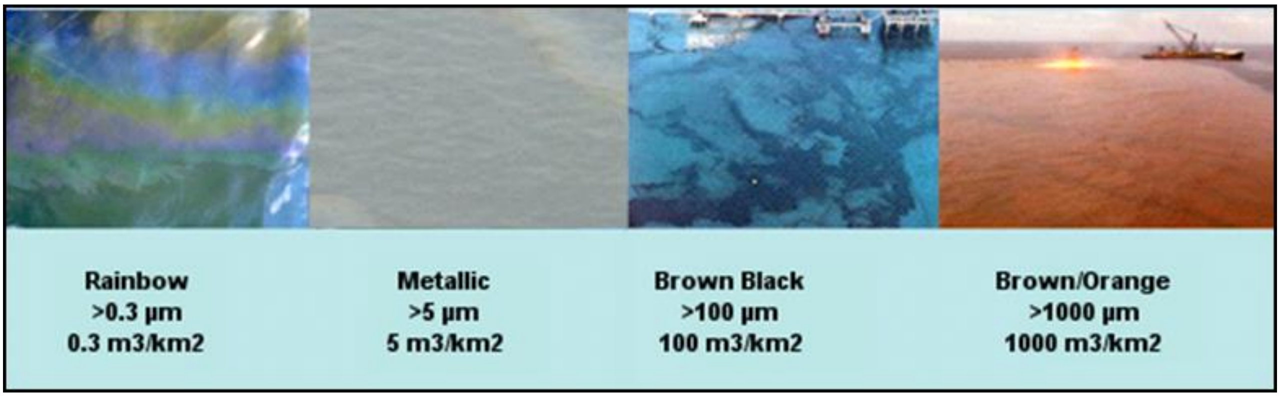


Figure 7-1 Photographs showing the difference between oil colour and thickness on the sea surface (source: adapted from Oil Spill Solutions, 2015).

Table 7-2 Floating oil exposure thresholds used in this report (in alignment with NOPSEMA, 2019).

Threshold level	Floating oil (g/m^2)	Description
Low	1	Approximates range of socioeconomic effects and establishes planning area for scientific monitoring
Moderate	10	Approximates lower limit for harmful exposures to birds and marine mammals
High	50	Approximates surface oil slick and informs response planning

7.2.2 Shoreline Accumulation Thresholds

There are many different types of shorelines, ranging from cliffs, rocky beaches, sandy beaches, mud flats and mangroves, and each of these influences the volume of oil that can remain stranded ashore and its thickness before the shoreline saturation point occurs. For instance, a sandy beach may allow oil to percolate through the sand, thus increasing its ability to hold more oil ashore over tidal cycles and various wave actions than an equivalent area of water; hence oil can increase in thickness onshore over time. A sandy beach shoreline was assumed as the default shoreline type for the modelling herein, as it allows for the highest carrying capacity of oil (of the available open/exposed shoreline types). Hence the results contained herein would be indicative of a worst-case scenario, where the highest volume of oil may be stranded on the shoreline (when compared to other shoreline types, such as exposed rocky shores).

In previous risk assessment studies, French-McCay et al. (2005a; 2005b) used a threshold of 10 g/m^2 to assess the potential for shoreline accumulation. This is a conservative threshold used to define regions of socio-economic impact, such as triggering temporary closures of adjoining fisheries or the need for shore clean-up on beaches or man-made features/amenities (breakwaters, jetties, marinas, etc.). It would equate to approximately 2 teaspoons of hydrocarbon per square meter of shoreline accumulation. The appearance is described as a stain/film. On that basis, the 10 g/m^2 shoreline accumulation threshold has been selected to define the zone of potential “low shoreline accumulation”.

French et al. (1996) and French-McCay (2009) define a shoreline oil accumulation threshold of 100 g/m^2, or above, would potentially harm shorebirds and wildlife (furbearing aquatic mammals and marine reptiles on or along the shore) based on studies for sub-lethal and lethal impacts. This threshold has been used in previous environmental risk assessment studies (see French-McCay, 2003; French-McCay et al., 2004, French-McCay et al., 2011; 2012; NOAA, 2013). Additionally, a shoreline concentration of 100 g/m^2, or above, is the minimum limit that the oil can be effectively cleaned according to the AMSA (2015) guideline. This threshold equates to approximately ½ a cup of oil per square meter of shoreline accumulation. The appearance is described as a thin oil coat. Therefore, 100 g/m^2 has been selected to define the zone of potential “moderate shoreline accumulation”.

Observations by Lin & Mendelssohn (1996) demonstrated that loadings of more than 1,000 g/m^2 of hydrocarbon during the growing season would be required to impact marsh plants significantly. Similar thresholds have been found in studies assessing hydrocarbon impacts on mangroves (Grant et al., 1993; Suprayogi & Murray, 1999). Hence, 1,000 g/m^2 has been selected to define the zone of potential “high shoreline accumulation". It equates to approximately 1 litre of hydrocarbon per square meter of shoreline accumulation. The appearance is described as a hydrocarbon cover.

It is worth noting that the shoreline accumulation thresholds derived from extensive literature review (outlined in Table 7-3) agree with the commonly used threshold values for oil spill modelling specified in NOPSEMA (2019).

Table 7-3 Thresholds used to assess shoreline accumulation.

Threshold level	Shoreline loading (g/m^2)	Description
Low (socioeconomic/sublethal)	10	Predicts potential for some socio-economic impact
Moderate	100	Loading predicts area likely to require clean-up effort
High	> 1,000	Loading predicts area likely to require intensive clean-up effort

7.2.3 In-water Exposure Thresholds

Oil is a mixture of thousands of hydrocarbons of varying physical, chemical, and toxicological characteristics, and therefore, demonstrate varying fates and impacts on organisms. As such, for in-water exposure, the SIMAP model provides separate outputs for dissolved and entrained hydrocarbons from oil droplets. The consequences of exposure to dissolved and entrained components will differ because they have different modes and magnitudes of effect.

Entrained hydrocarbon concentrations were calculated based on oil droplets that are suspended in the water column, though not dissolved. The composition of this oil would vary with the state of weathering (oil age) and may contain soluble hydrocarbons when the oil is fresh. Calculations for dissolved hydrocarbons specifically calculates oil components which are dissolved in water, which are known to be the primary source of toxicity exerted by oil.

In addition to presenting the maximum instantaneous concentrations across the model domain, there are also figures presented for the residence time, which is the longest continuous period of exposure above each threshold. This helps provide context when considering exposure to sensitive receptors.

7.2.3.1 Dissolved Hydrocarbons

Laboratory studies have shown that dissolved hydrocarbons exert most of the toxic effects of oil on aquatic biota (Carls et al., 2008; Nordtug et al., 2011; Redman, 2015). The mode of action is a narcotic effect, which is positively related to the concentration of soluble hydrocarbons in the body tissues of organisms (French-McCay, 2002). Dissolved hydrocarbons are taken up by organisms directly from the water column by absorption through external surfaces and gills, as well as through the digestive tract. Thus, soluble hydrocarbons are termed "bioavailable".

Hydrocarbon compounds vary in water-solubility and the toxicity exerted by individual compounds is inversely related to solubility, however bioavailability will be modified by the volatility of individual compounds (Nirmalakhandan & Speece, 1988; Blum & Speece, 1990; McCarty, 1986; McCarty et al., 1992a, 1992b; Mackay et al., 1992; McCarty & Mackay, 1993; Verhaar et al., 1992, 1999; Swartz et al., 1995; French-McCay, 2002; McGrath and Di Toro, 2009). Of the soluble compounds, the greatest contributor to toxicity for water-column and benthic organisms are the lower-molecular-weight aromatic compounds, which are both volatile and soluble in water. Although they are not the most water-soluble hydrocarbons within most oil types, the polynuclear aromatic hydrocarbons (PAHs) containing 2-3 aromatic ring structures typically exert the largest narcotic effects because they are semi-soluble and not highly volatile, so they persist in the environment long enough for significant accumulation to occur (Anderson et al., 1974, 1987; Neff & Anderson, 1981; Malins & Hodgins, 1981; McAuliffe, 1987; NRC, 2003). The monoaromatic hydrocarbons (MAHs), including the BTEX compounds (benzene, toluene, ethylbenzene, and xylenes), and the soluble alkanes (straight chain hydrocarbons) also contribute to toxicity, but these compounds are highly volatile, so that their contribution will be low when oil is exposed to evaporation and higher when oil is discharged at depth where volatilisation does not occur (French-McCay, 2002).

French-McCay (2002) reviewed available toxicity data, where marine biota was exposed to dissolved hydrocarbons prepared from oil mixtures, finding that 95% of species and life stages exhibited 50% population mortality (LC_{50}) between 6 and 400 ppb total PAH concentration after 96 hrs exposure, with an average of 50 ppb. Hence, concentrations lower than 6 ppb total PAH value should be protective of 97.5% of species and life stages even with exposure periods of days (at least 96 hours). Early life-history stages of fish appear to be more sensitive than older fish stages and invertebrates.

Exceedances of 10, 50 or 400 ppb over a 1-hour timestep (see Table 7-4) was applied to indicate increasing potential for sub-lethal to lethal toxic effects (or low to high), based on NOPSEMA (2019).

7.2.3.2 Entrained Hydrocarbons

Entrained hydrocarbons consist of oil droplets that are suspended in the water column and insoluble. As such, insoluble compounds in oil cannot be absorbed from the water column by aquatic organisms, hence are not bioavailable through absorption of compounds from the water. Exposure to these compounds would require routes of uptake other than absorption of soluble compounds. The route of exposure of organisms to whole oil alone include direct contact with tissues of organisms and uptake of oil by direct consumption, with potential for biomagnification through the food chain (NRC, 2005).

The 10 ppb threshold represents the very lowest concentration and corresponds generally with the lowest trigger levels for chronic exposure for entrained hydrocarbons in the ANZECC & ARMCANZ (2000) water quality guidelines. Due to the requirement for relatively long exposure times (> 24 hours) for these concentrations to be significant, they are likely to be more meaningful for juvenile fish, larvae and planktonic organisms that might be entrained (or otherwise moving) within the entrained plumes, or when entrained hydrocarbons adhere to organisms or trapped against a shoreline for periods of several days or more.

This exposure zone is not considered to be of significant biological impact and is therefore outside the adverse exposure zone. This exposure zone represents the area contacted by the spill. This area does not define the area of influence as it is considered that the environment will not be affected by the entrained hydrocarbon at this level.

Thresholds of 10 ppb and 100 ppb were applied over a 1-hour time exposure (Table 7-4), to cover the range of thresholds outlined in ANZECC & ARMCANZ (2000) water quality guidelines, the incremental change for greater potential effect and is per NOPSEMA (2019).

A complicating factor that should be considered when assessing the consequence of dissolved and entrained oil distributions is that there will be some areas where both physically entrained oil droplets and dissolved hydrocarbons co-exist. Higher concentrations of each will tend to occur close to the source where sea conditions can force mixing of relatively unweathered oil into the water column, resulting in more rapid dissolution of soluble compounds.

Table 7-4 Dissolved and entrained hydrocarbon exposure values assessed over a 1-hour time step, as per NOPSEMA (2019).

Threshold level	Dissolved hydrocarbon concentration (ppb)	Entrained hydrocarbon concentrations (ppb)
Low	10	10
Moderate	50	-
High	400	100

8 OIL PROPERTIES

8.1 Oil Characteristics

Table 8-1 and Table 8-2 present the physical properties and boiling point ranges of Marine Diesel and Thylacine condensate, which was used as the proxy for the study.

Thylacine condensate has an API of 44.3 and a density of 804.6 kg/m³ (at 15ºC) with a viscosity value (0.87.0 cP) classifying it as a Group I (not-persistent) oil according to the International Tankers Owners Pollution Federation (ITOPF, 2020) and US EPA/USCG classifications.

The condensate is a mixture of volatile and persistent hydrocarbons with high proportions of volatile and semi- to low-volatile components. In favourable evaporation conditions, about 64.0% of the oil mass should evaporate within the first 12 hours (BP < 180°C), a further 19.0% should evaporate within the first 24 hours (180°C < BP < 265°C) and a further 16.0% should evaporate over several days (265°C < BP < 380°C). Approximately 1.0% of the oil is shown to be persistent.

Marine diesel (MDO) has an API of 37.6 and a density of 829.1 kg/m³ (at 25ºC) with a viscosity value (4.0 cP) classifying it as a Group II (light-persistent) oil according to the International Tankers Owners Pollution Federation (ITOPF, 2020) and US EPA/USCG classifications.

The MDO is a mixture of volatile and persistent hydrocarbons with high proportions of volatile and semi- to low-volatile components. In favourable evaporation conditions, about 6.0% of the oil mass should evaporate within the first 12 hours (BP < 180°C); a further 34.6% should evaporate within the first 24 hours (180°C < BP < 265°C); and a further 54.4% should evaporate over several days (265°C < BP < 380°C). Approximately 5.0% of the oil is shown to be persistent.

Table 8-1 Physical properties for Thylacine condensate.

Characteristic	Thylacine Condensate	MDO
Density (kg/m³)	804.6 (at 15°C)	829.1 (at 25 °C)
API	44.3	37.6
Dynamic viscosity (cP)	0.87 (at 20°C)	4.0 (at 25 °C)
Pour point (°C)	-50	-14
Hydrocarbon property category	Group I	Group II
Hydrocarbon property classification	Not – Persistent	Light - Persistent

Table 8-2 Boiling point ranges for Thylacine condensate.

Oil Type	Component	Volatile (%)	Semi-volatile (%)	Low-volatile (%)	Residual (%)
	Boiling point (°C)	<180 C_4 to C_{10}	180-265 C_{11} to C_{15}	265-380 C_{16} to C_{20}	>380 $>C_{20}$
Thylacine Condensate	% of total	64.0	19.0	16.0	1.0
Marine Diesel	% of total	6.0	34.6	54.4	5.0

The BP are dictated by the length of the carbon chains, with the longer and more complex compounds having a higher boiling point, and therefore lower volatility and evaporation rate.

Typical evaporation times once the hydrocarbons reach the surface and are exposed to the atmosphere are:

- Up to 12 hours for the C_4 to C_{10} compounds (or <180°C BP).
- Up to 24 hours for the C_{11} to C_{15} compounds (180–265°C BP).
- Several days for the C_{16} to C_{20} compounds (265–380°C BP).
- Not applicable for the residual compounds (BP >380°C), which will resist evaporation, persist in the marine environment for longer periods, and be subject to relatively slow degradation.

The actual fate of oil will depend greatly on the amount that reaches the surface.

8.2 Weathering Characteristics

A series of model weather tests were conducted to illustrate the potential behaviour of Thylacine condensate and marine diesel when exposed to idealised and representative environmental conditions:

- A 50 m^3 surface release over 1-hour under calm wind conditions (constant 5 knots or 2.6 m/s), assuming low seasonal water temperature (15°C) and ambient tidal and drift currents; and
- A 50 m^3 surface release over 1-hour under variable wind conditions (1-12 knots or 1.9-23 m/s, drawn from representative data files), assuming low seasonal water temperature (15°C) and ambient tidal and drift currents.

Note, a surface release is used in the weathering test to solely focus on the weathering and fates of the hydrocarbons when exposed to atmospheric conditions.

The first case is indicative conditions that would not generate entrainment, while the second case may represent conditions that could cause a minor degree of entrainment. Both scenarios provide examples of potential behaviour during a spill once the oil reaches the surface.

Thylacine Condensate Mass Balance Forecasts

The mass balance for the condensate under the constant 5 knot wind case (Figure 8-1) shows that 82.5% of the oil is predicted to evaporate within 24 hours. Under calm conditions, the majority of the remaining oil on the water surface will weather at a slower rate due to being comprised of the longer-chain compounds with higher boiling points. Evaporation shall cease when the residual compounds remain, and they will be subject to more gradual decay through biological and photochemical processes.

Under the variable-wind case (Figure 8-2), where the winds are of greater strength on average, entrainment of the condensate into the water column is predicted to increase. Approximately 24 hours after the spill, 22.1% of the oil mass is forecast to have entrained and a further 69.4% is forecast to have evaporated, leaving only a small proportion of the oil floating on the water surface (<0.1%).

The increased level of entrainment in the variable-wind case result in a higher percentage decaying at an approximate rate of 1.9% per day with or ~10.9% after 7 days, compared to <0.1% per day and a total of 0.8% after 7 days for the constant-wind case. Given the proportion of entrained oil and the tendency for it to remain mixed in the water column, the remaining hydrocarbons will decay over time scales of several weeks.

Marine Diesel Mass Balance Forecasts

The mass balance for the MDO under the constant 5 knot (~2.5 m/s) wind case (Figure 8-3) shows that 40.3% of the oil is predicted to evaporate within 24 hours. Under calm conditions, the majority of the remaining oil on the water surface will weather at a slower rate due to being comprised of the longer-chain compounds with higher boiling points. Evaporation shall cease when the residual compounds remain, and they will be subject to more gradual decay through biological and photochemical processes.

Under the variable-wind case (Figure 8-4), where the winds are of greater strength on average, entrainment of MDO into the water column is predicted to increase. Approximately 24 hours after the spill, 60.1% of the oil mass is forecast to have entrained and a further 38.4% is forecast to have evaporated, leaving only a small proportion of the oil floating on the water surface (<0.1%).

The increased level of entrainment in the variable-wind case result in a higher percentage decaying at an approximate rate of 1.5% per day with or ~10.5% after 7 days, compared to <0.1% per day and a total of 0.9% after 7 days for the constant-wind case. Given the proportion of entrained oil and the tendency for it to remain mixed in the water column, the remaining hydrocarbons will decay over time scales of several weeks.

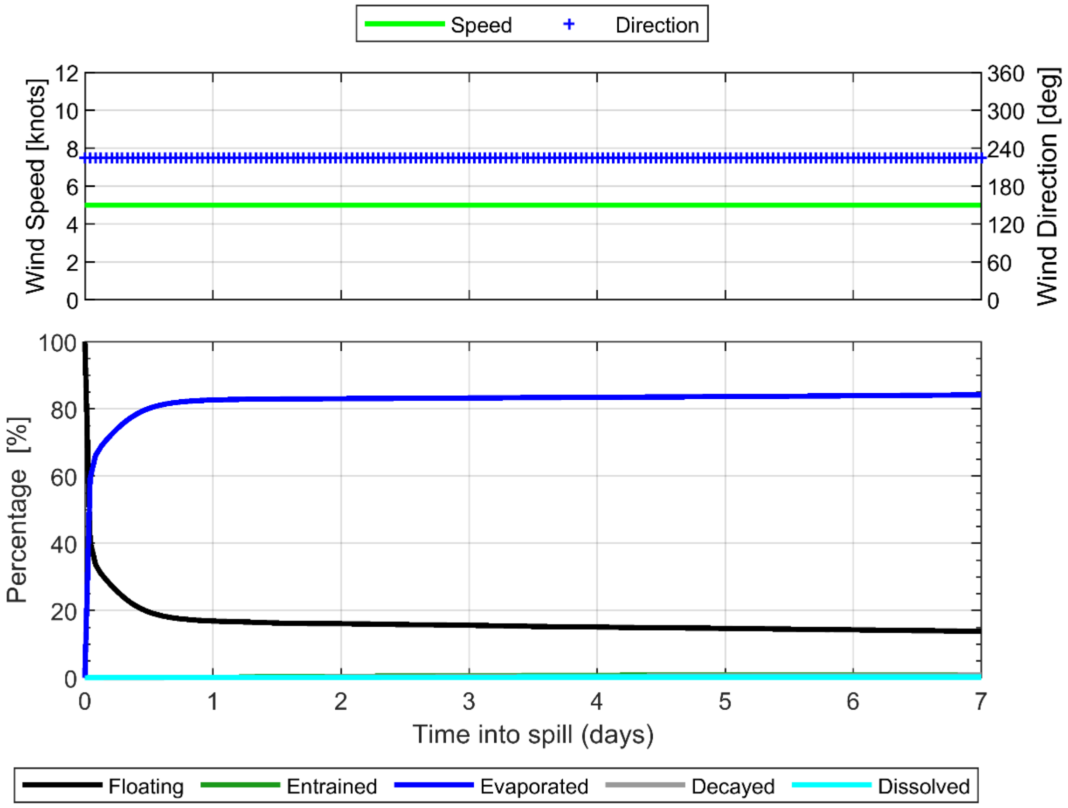


Figure 8-1 Proportional mass balance plot representing the weathering of Thylacine condensate spilled onto the water surface over 1 hour and subject to a constant 5 knots (2.6 m/s) wind speed at 15°C water temperature.

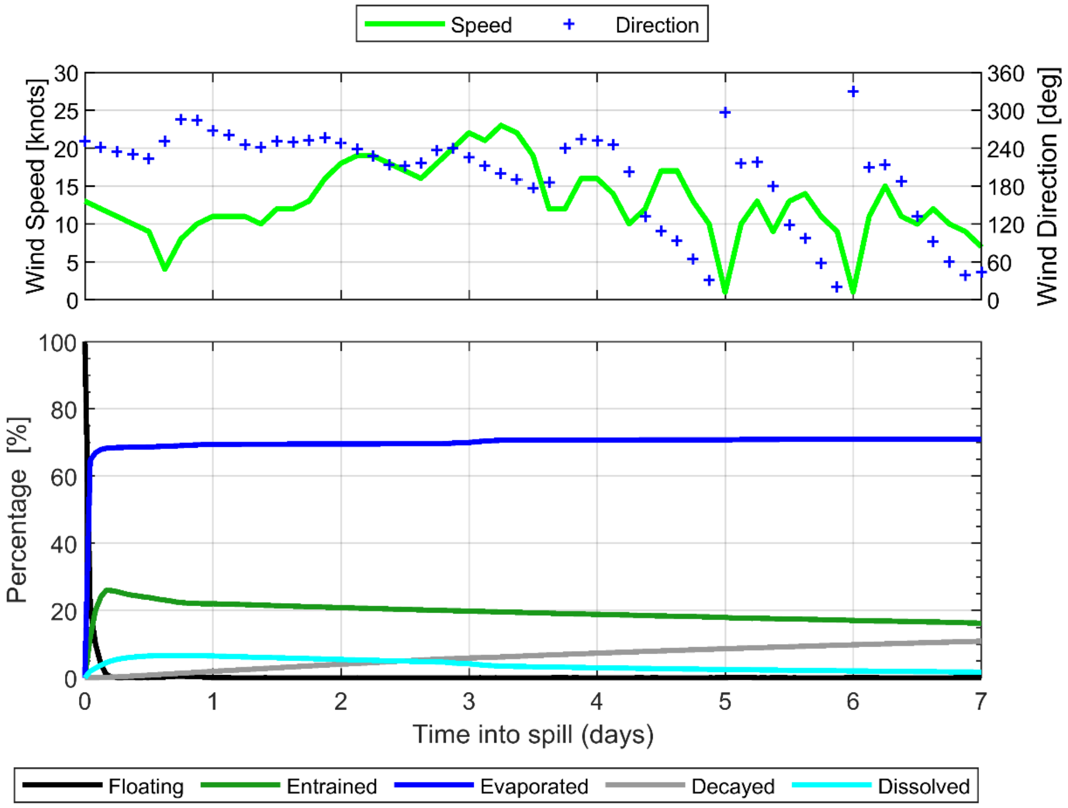


Figure 8-2 Proportional mass balance plot representing the weathering of Thylacine condensate spilled onto the water over 1 hour and subject to variable wind speeds (1-12 knots or 1.9-23 m/s) at 15°C water temperature.

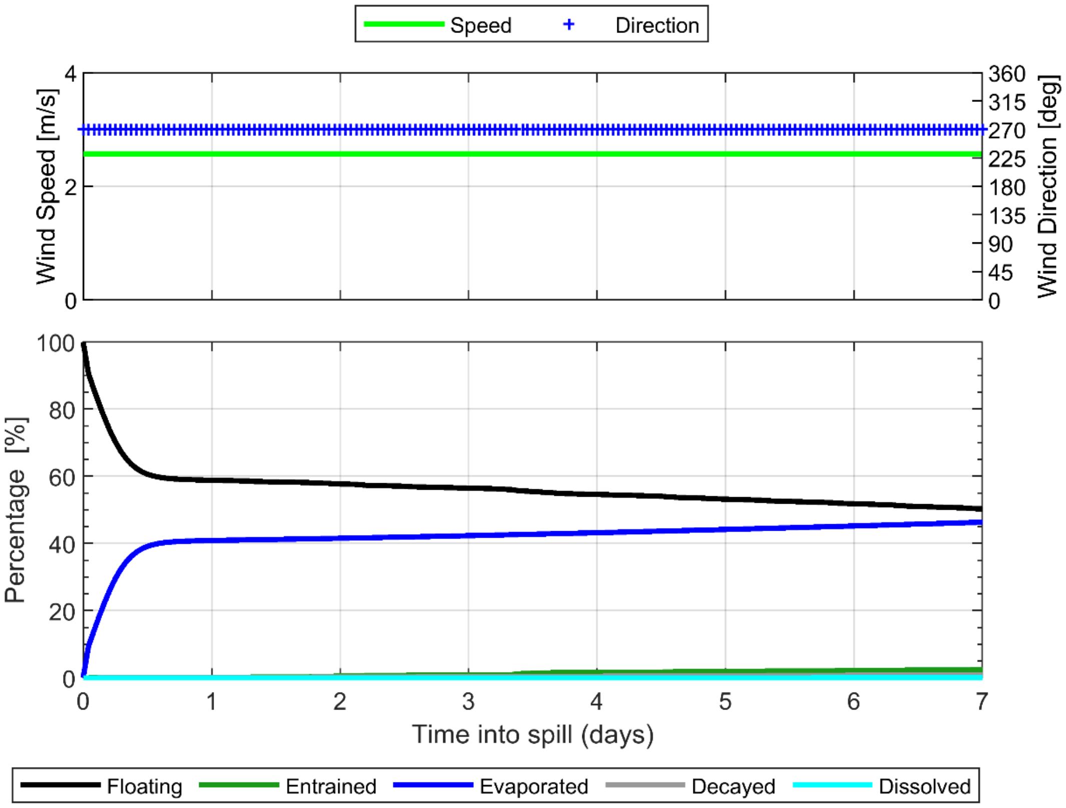


Figure 8-3 Proportional mass balance plot representing the weathering of MDO spilled onto the water surface over 1 hour and subject to a constant 5 knots (2.6 m/s) wind speed at 15°C water temperature.

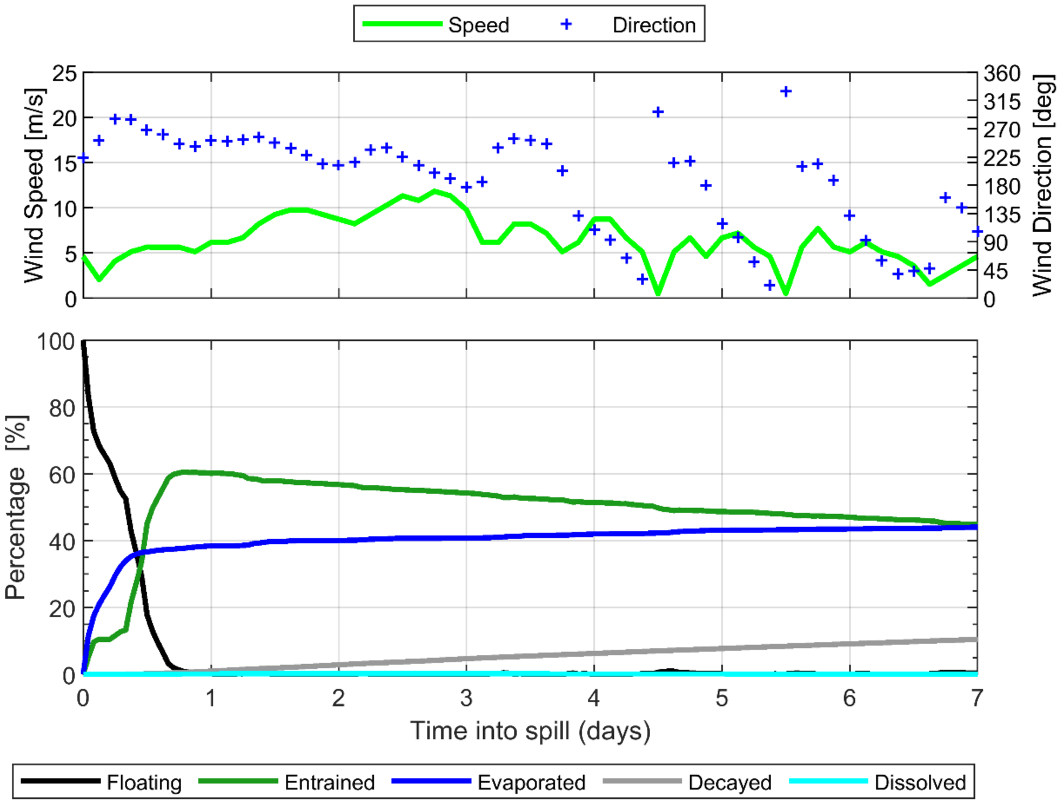


Figure 8-4 Proportional mass balance plot representing the weathering of MDO spilled onto the water over 1 hour and subject to variable wind speeds (1-12 knots) at 15°C water temperature.

9 OIL SPILL SCENARIOS

Table 9-1 provides a summary of the oil spill model settings.

Table 9-1 Summary of the oil spill model settings and thresholds used in this assessment.

Parameter	Release Location South	Release Location South	Release Location North	Release Location North
Description	Loss of well control	Loss of containment	Loss of well control	Loss of containment
Number of randomly selected spill start times	100 per season	100 per season	100 per season	100 per season
Model period	Summer (November through to March) and Winter (April to October)			
Oil type	Thylacine condensate	Marine Diesel	Thylacine condensate	Marine Diesel
Spill volume	97,171.8 m3	603.7 m^3	69,120.0 m^3	603.7 m^3
Release type	Subsea (155 m)	Surface	Subsea (71.5 m)	Surface
Release duration	86 days (variable release rate)	6 hours	86 days (variable release rate)	6 hours
Simulation length	100 days	30 days	100 days	30 days
Surface oil concentration thresholds (g/m^2)^	1 (low); 10 (moderate); 50 (high)			
Shoreline oil accumulation thresholds (g/m^2)^	10 (low); 100 (moderate); 1,000 (high)			
Dissolved hydrocarbon concentrations (ppb)^	10 (low); 50 (moderate); 400 (high)			
Entrained hydrocarbon concentrations (ppb)^	10 (low); 100 (high)			

^Thresholds based on NOPSEMA (2019)

10 PRESENTATION AND INTERPRETATION OF MODEL RESULTS

The results from the modelling study are presented in a number of tables and figures, which aim to provide an understanding of the predicted sea-surface and water column (subsurface) exposure and shoreline accumulation (if predicted).

10.1 Annual Analysis

10.1.1 Statistics

The statistics are based on the following principles:

- The ***greatest distance travelled by a spill trajectory*** – is determined by a) recording the maximum and b) second greatest distance travelled (or 99th percentile) by a single trajectory, within a scenario, from the release location to the identified exposure thresholds.

- The ***probability of oil exposure to a receptor*** – is determined by recording the number of spill trajectories to reach a specified sea surface or subsea threshold within a receptor polygon, divided by the total number of spill trajectories within that scenario.

- The ***minimum time before oil exposure to a receptor*** – is determined by ranking the elapsed time before sea surface exposure, at a specified threshold, to grid cells within a receptor polygon and recording the minimum value.

- The ***maximum residence time for oil exposure within a receptor*** – is determined by recording the longest continuous length of time a grid cell is exposed to either floating, entrained or dissolved hydrocarbon above each threshold, within a receptor.

- The ***probability of oil accumulation at a receptor*** – is determined by recording the number of spill trajectories to reach a specified shoreline accumulation threshold within a receptor polygon, divided by the total number of spill trajectories within that scenario.

- The ***maximum potential oil loading within a receptor*** – is determined by identifying the maximum loading to any grid cell within a receptor polygon, for a scenario.

- The ***dissolved and entrained hydrocarbon exposure*** – is determined by recording the maximum instantaneous concentrations at each grid cell.

- ***Maximum total volume ashore*** (found in shoreline statistics table) – Is the total volume of oil stranded on the shorelines throughout the duration of the simulation.

- ***Maximum instantaneous peak volume ashore*** (found in the deterministic analysis section and derived from the histogram) – Is the peak volume of oil accumulated on shorelines at a single point in time. This peak value does not include oil that came ashore earlier in the simulation and was subsequently lost through evaporation or other weathering processes.

10.2 Receptors Assessed

A range of environmental receptors and shorelines were assessed for floating oil exposure, shoreline accumulation and water column exposure as part of the study (see Figure 10-1 to Figure 10-11). Receptor categories (see Table 10-1) include sections of shorelines which are defined by local government areas (LGAs), sub-LGAs and offshore islands. All other sensitive receptors other than submerged reefs, shoals and banks (RSB) were sourced from Australian Government Department of Climate Change, Energy, the Environment and Water (http://www.environment.gov.au/).

Risks of exposure were separately calculated for each sensitive receptor area and have been tabulated.

Table 10-3 summarises the receptors that the release location resides within.

Table 10-1 Summary of receptors used to assess floating oil, shoreline and in-water exposure to hydrocarbons.

Receptor Category	Acronym	Hydrocarbon Exposure Assessment			Figure reference
		Water Column	Floating oil	Shoreline	
Australian Marine Park	AMP	✓	✓	×	Figure 10-1
Integrated Marine and Coastal Regionalisation Areas	IMCRA	✓	✓	×	Figure 10-2
Marine National Park	MNP	✓	✓	×	Figure 10-3
Marine Park	MP	✓	✓	×	Figure 10-4
Nature Reserve	NR	✓	✓	×	Figure 10-5
Ramsar	Ramsar	✓	✓	✓	Figure 10-6
Reefs, Shoals and Banks	RSB	✓	✓	×	Figure 10-7
Key Ecological Feature	KEF	✓	✓	×	Figure 10-8
State Waters	State Waters	✓	✓	×	
Local Government Areas	LGA	✓ (Reported as: Nearshore Waters)	✓ (Reported as: Nearshore Waters)	✓ (Reported as: Shore)	Figure 10-9 to Figure 10-11

Table 10-2 Summary of the receptors that the Release Location South resides within.

Receptor Type	Receptor Name
BIA	Antipodean Albatross – Foraging
	Black-browed Albatross – Foraging
	Buller's Albatross – Foraging
	Campbell Albatross – Foraging
	Common Diving-petrel – Foraging
	Indian Yellow-nosed Albatross – Foraging
	Pygmy Blue Whale – Distribution
	Pygmy Blue Whale - Foraging
	Pygmy Blue Whale - Foraging (annual high use area)
	Short-tailed Shearwater – Foraging
	Shy Albatross – Foraging
	Southern Right Whale - Known Core Range
	Wandering Albatross – Foraging
	Wedge-tailed Shearwater – Foraging

	White Shark – Distribution
IMCRA	Otway

Table 10-3 Summary of the receptors that the Release Location North resides within.

Receptor Type	Receptor Name
BIA	Antipodean Albatross – Foraging
	Black-browed Albatross – Foraging
	Buller’s Albatross – Foraging
	Campbell Albatross – Foraging
	Common Diving-petrel – Foraging
	Indian Yellow-nosed Albatross – Foraging
	Pygmy Blue Whale – Distribution
	Pygmy Blue Whale - Foraging (annual high use area)
	Shy Albatross – Foraging
	Southern Right Whale - Known Core Range
	Wandering Albatross – Foraging
	Wedge-tailed Shearwater – Foraging
	White Shark – Distribution
IMCRA	Otway

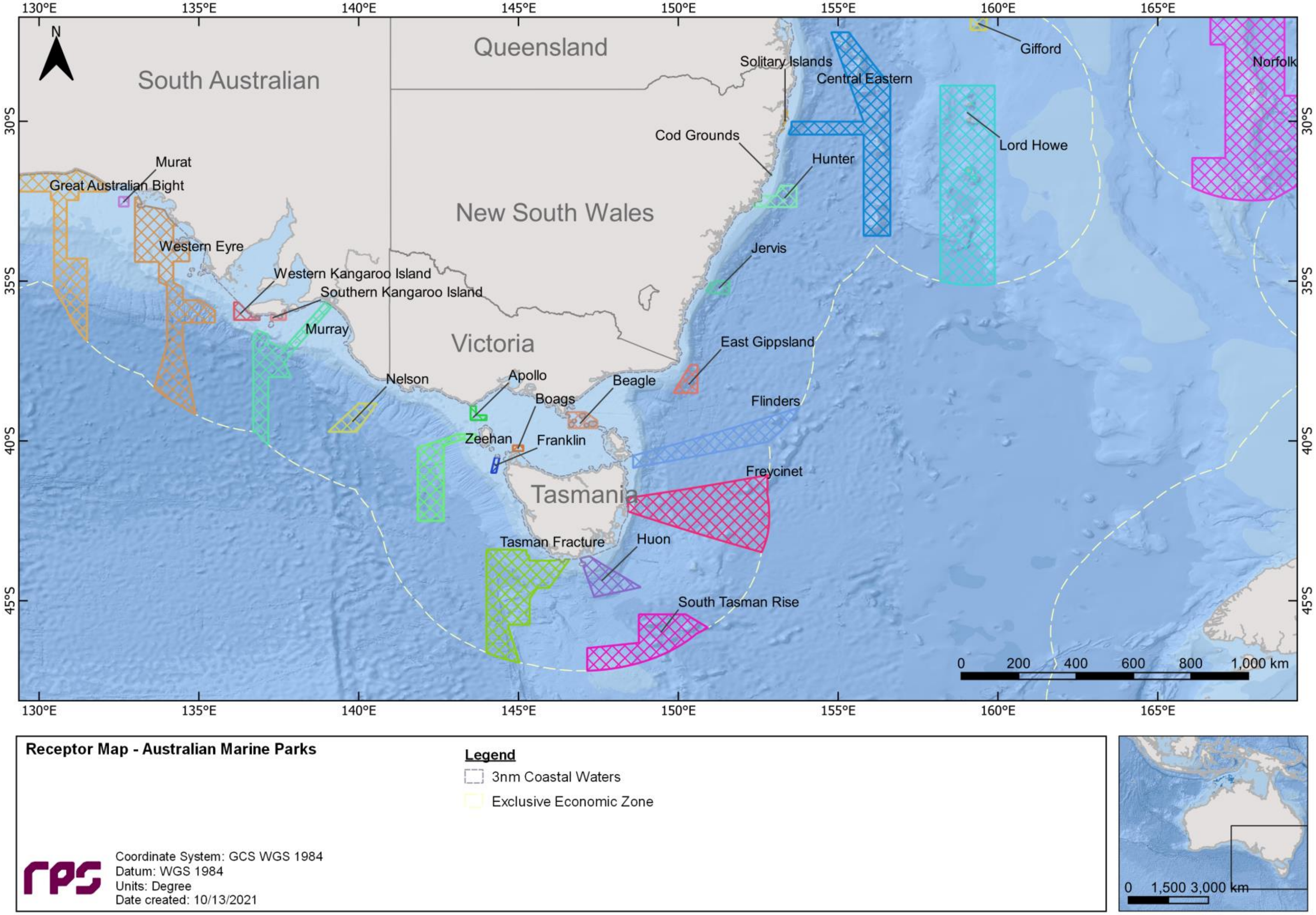


Figure 10-1 Receptor map for Australian Marine Parks (AMP).

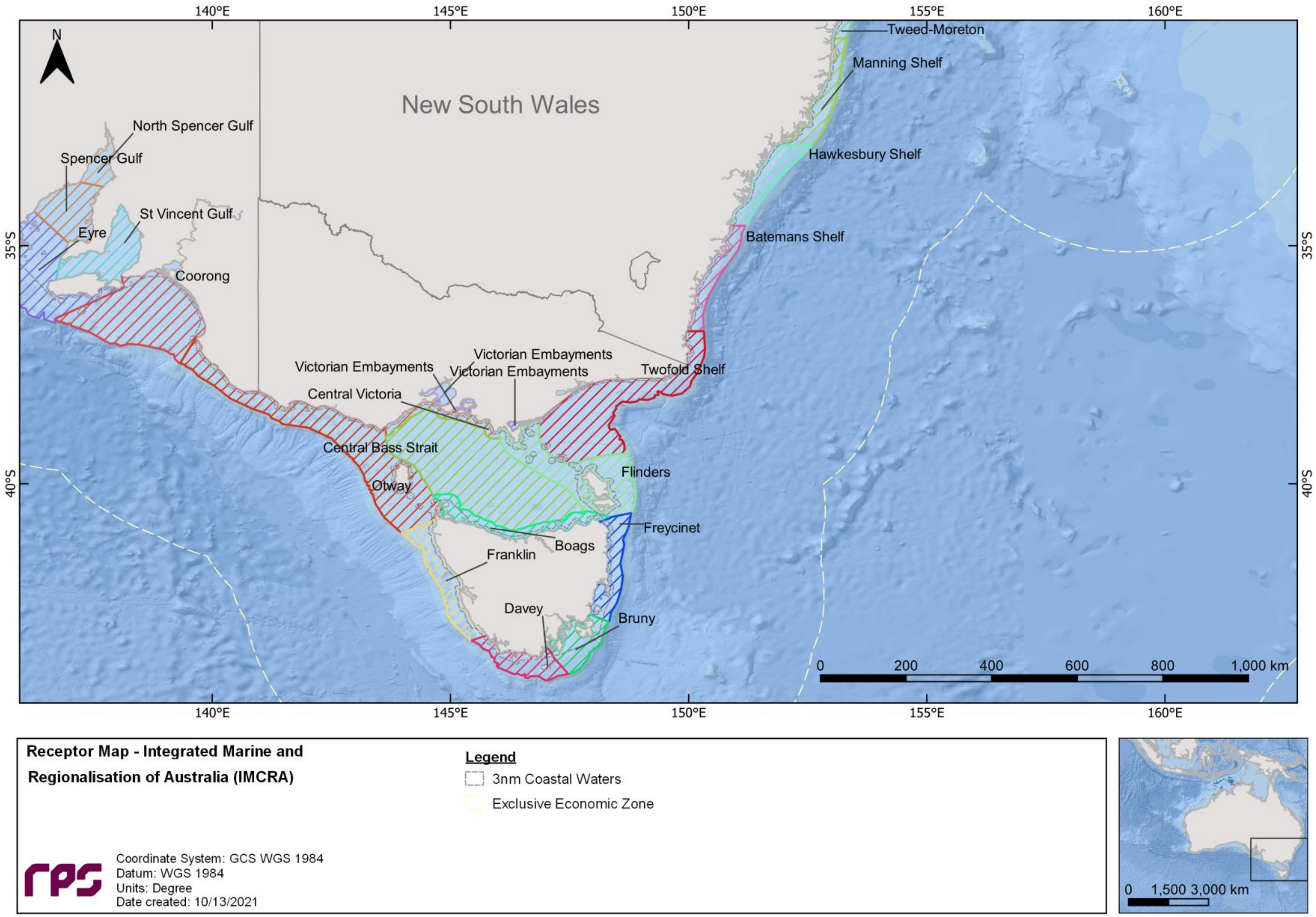


Figure 10-2 Receptor map for integrated marine and coastal regionalisation (IMCRA) areas.

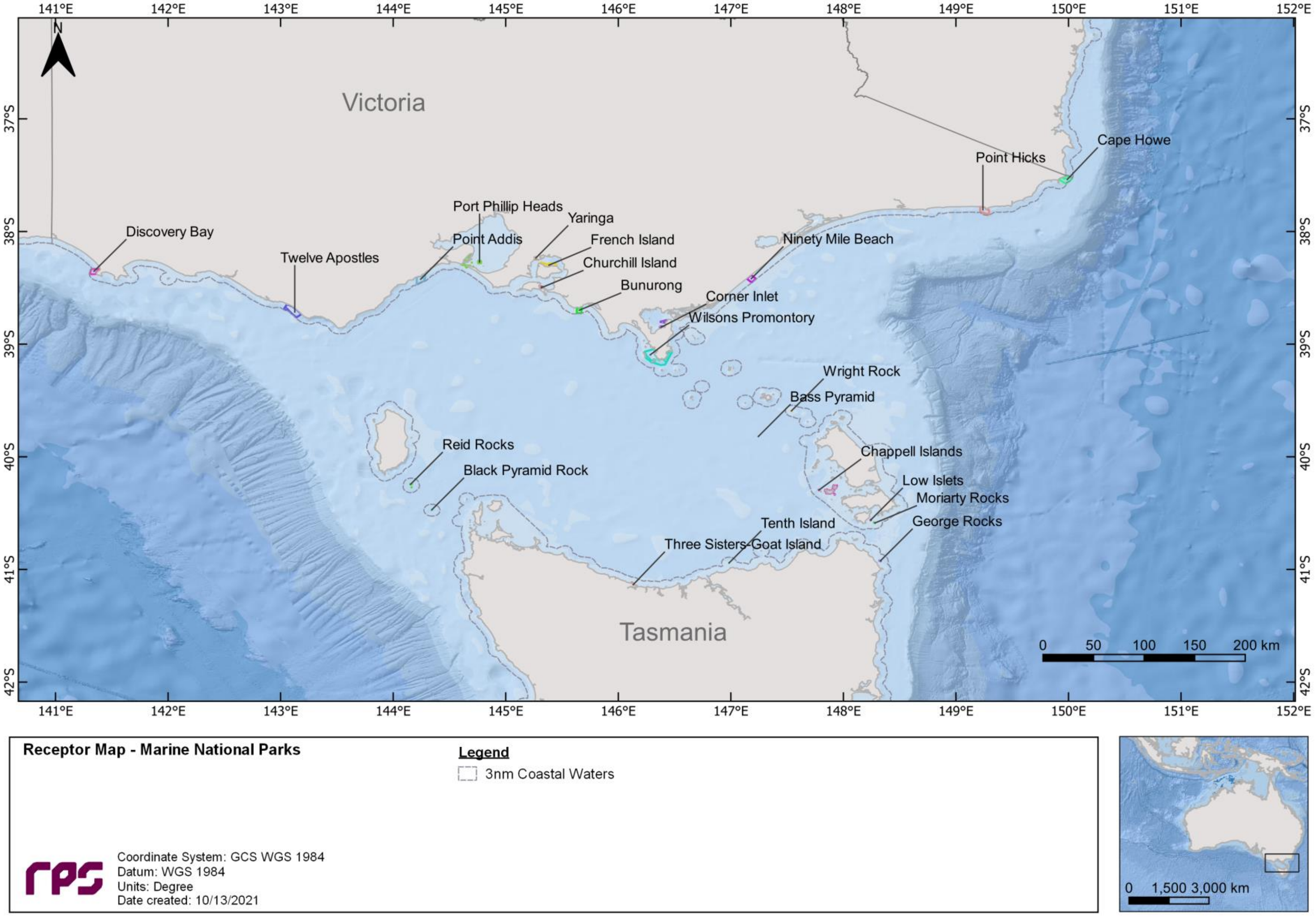


Figure 10-3 Receptor map for Marine National Parks (MNP).

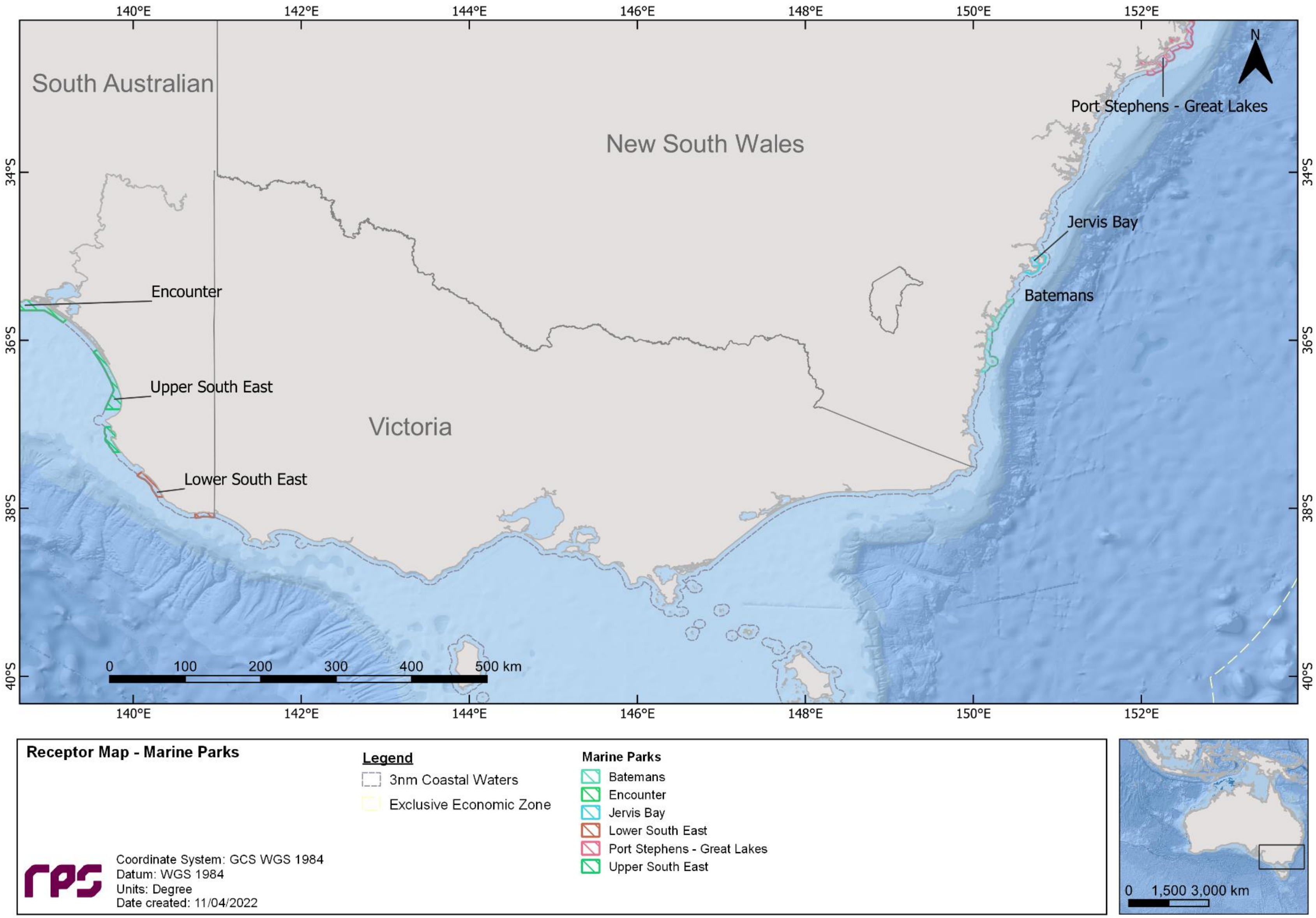


Figure 10-4 **Receptor map for Marine Parks (MP).**

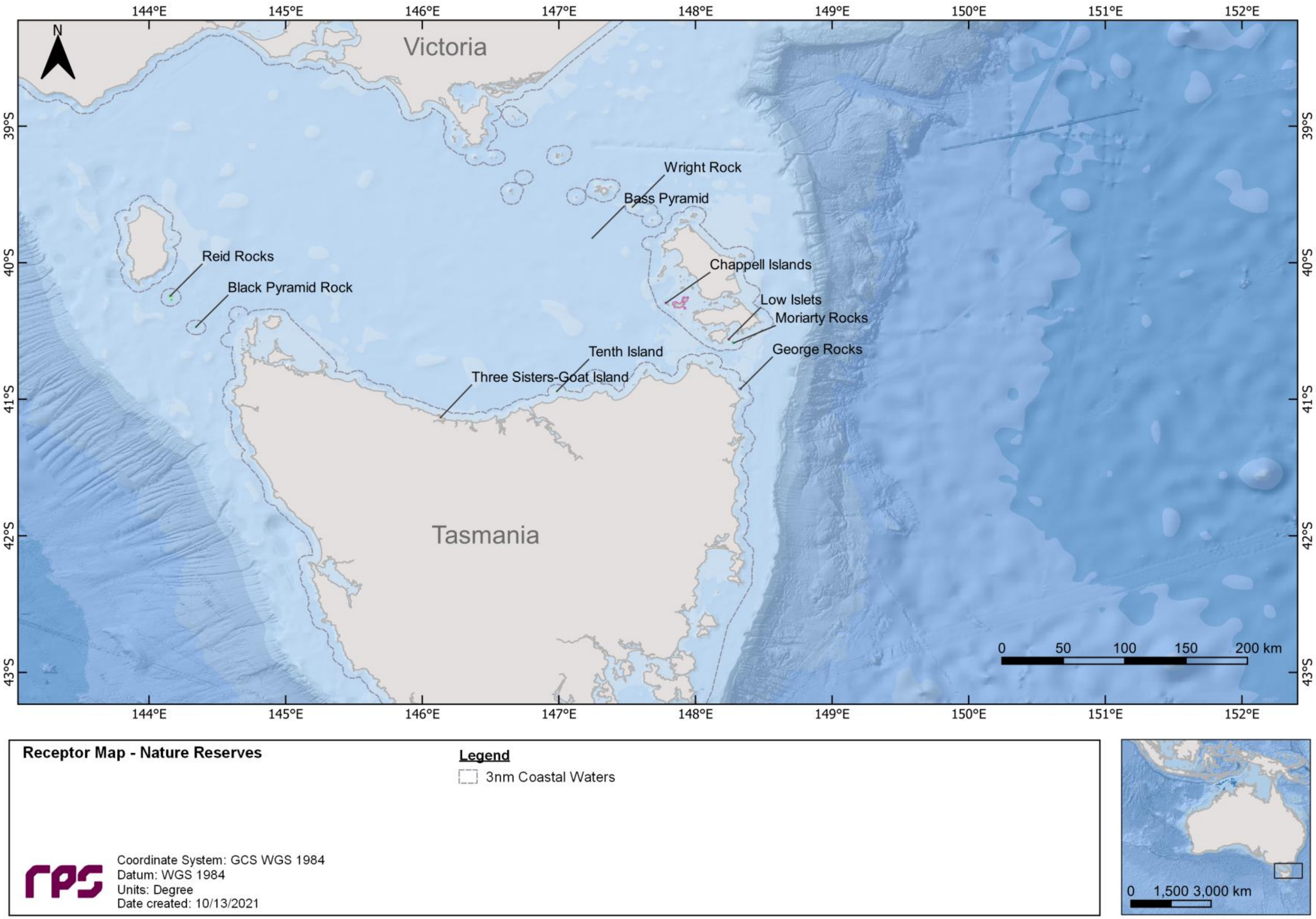


Figure 10-5 Receptor map for Nature Reserves (NR).

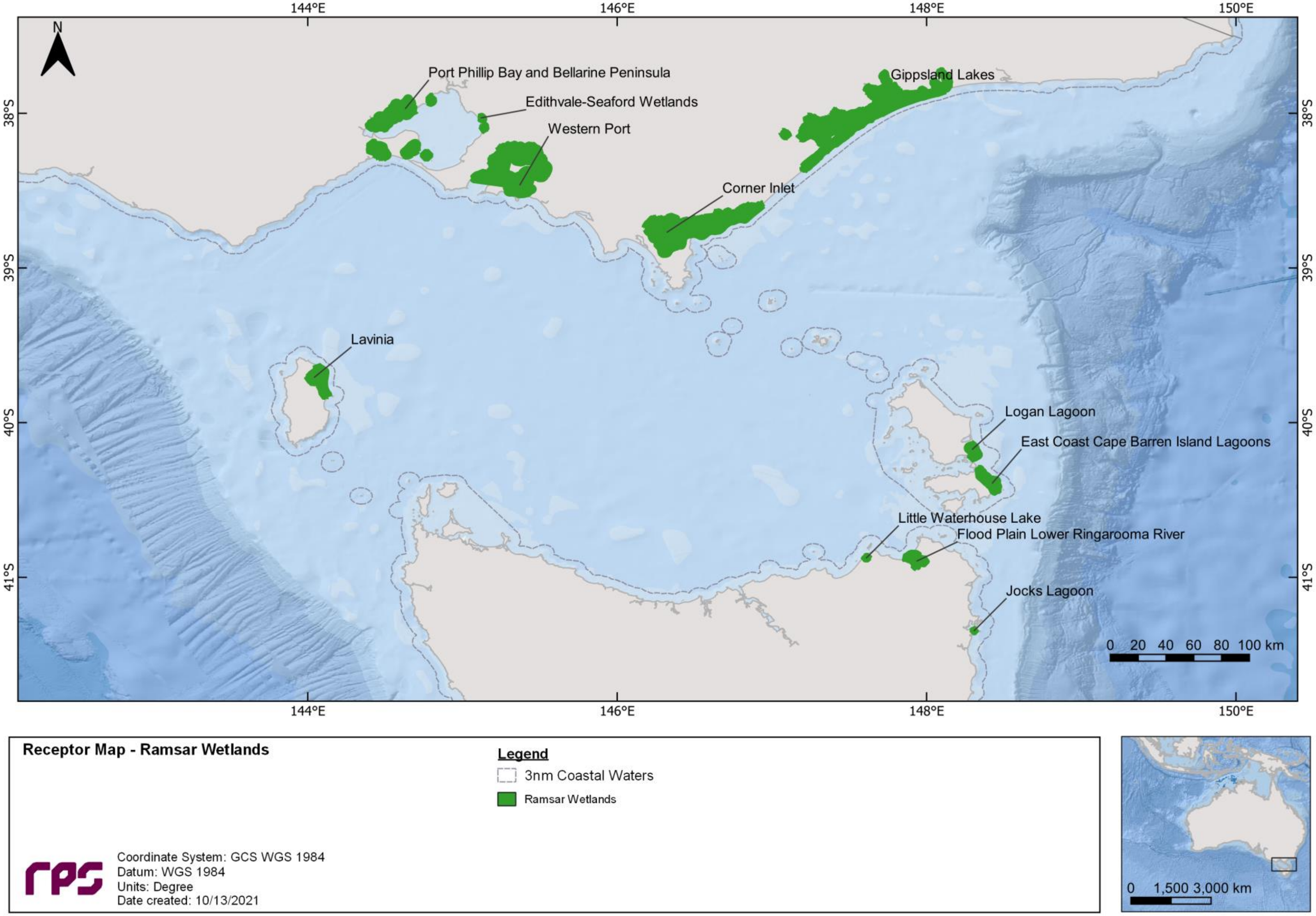


Figure 10-6 Receptor map for Ramsar Sites (Ramsar).

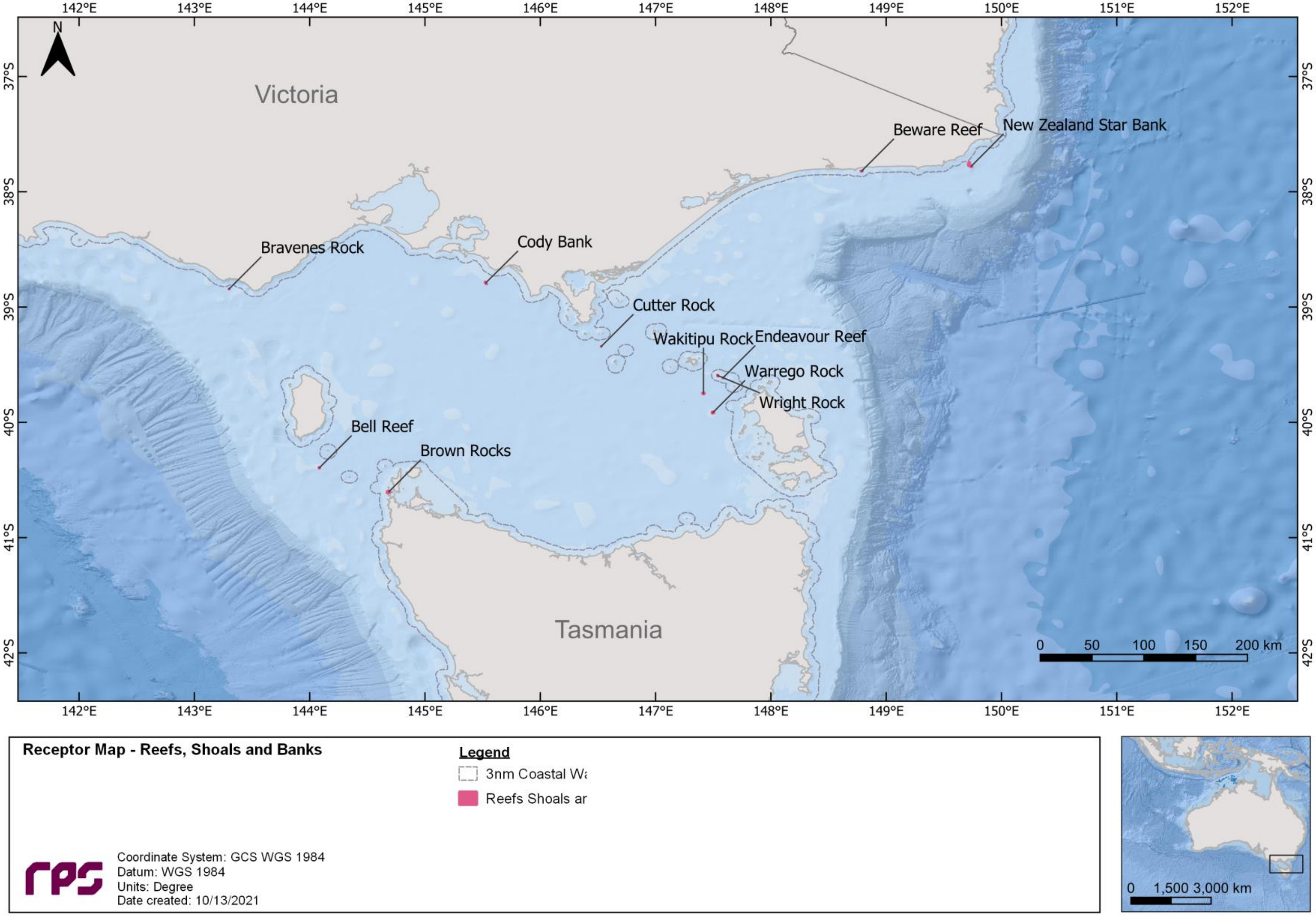


Figure 10-7 Receptor map for Reefs, Shoals and Banks (RSB).

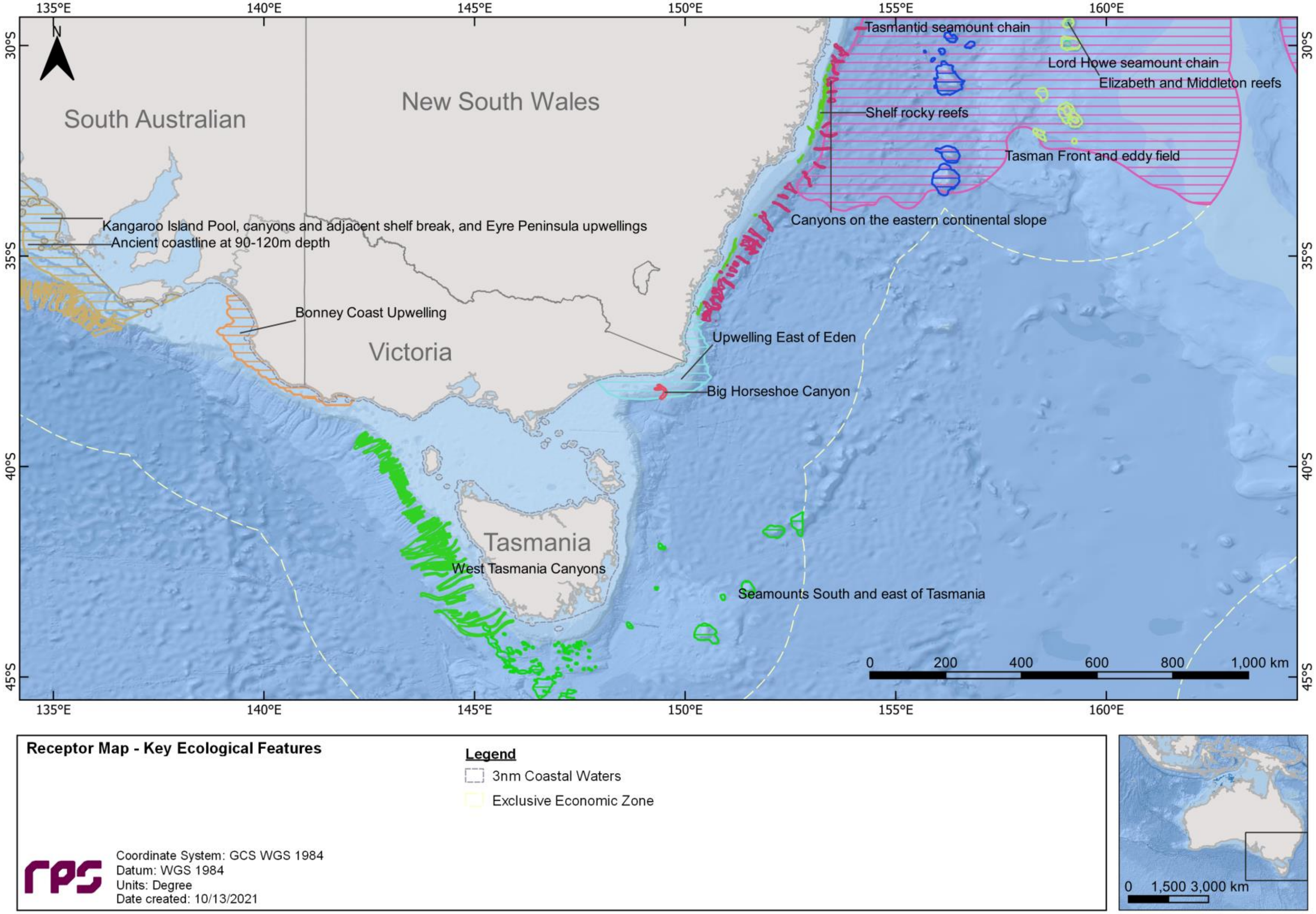


Figure 10-8 Receptor map for Key Ecological Features (KEF).

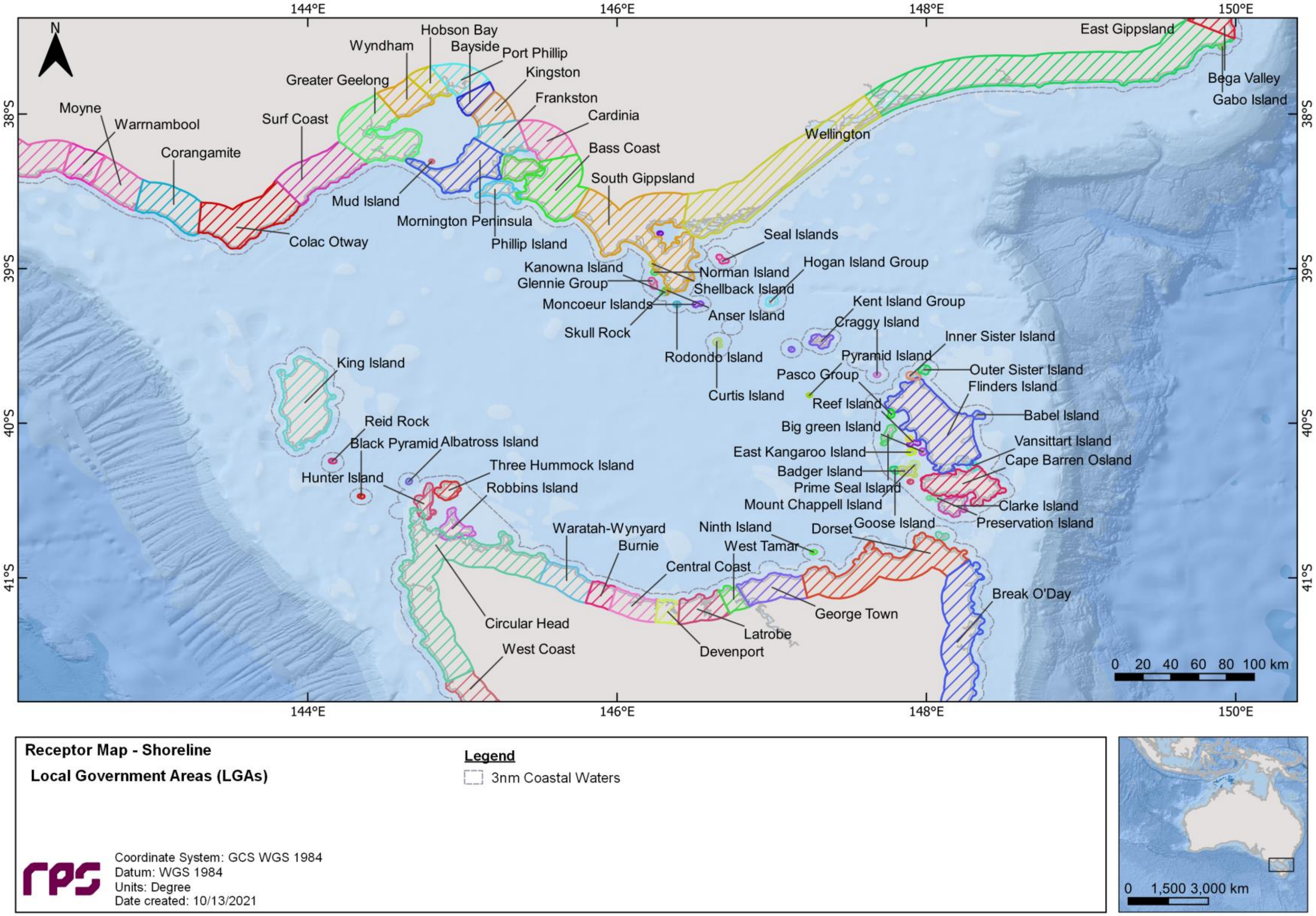


Figure 10-9 Receptor map for shorelines (1 of 3).

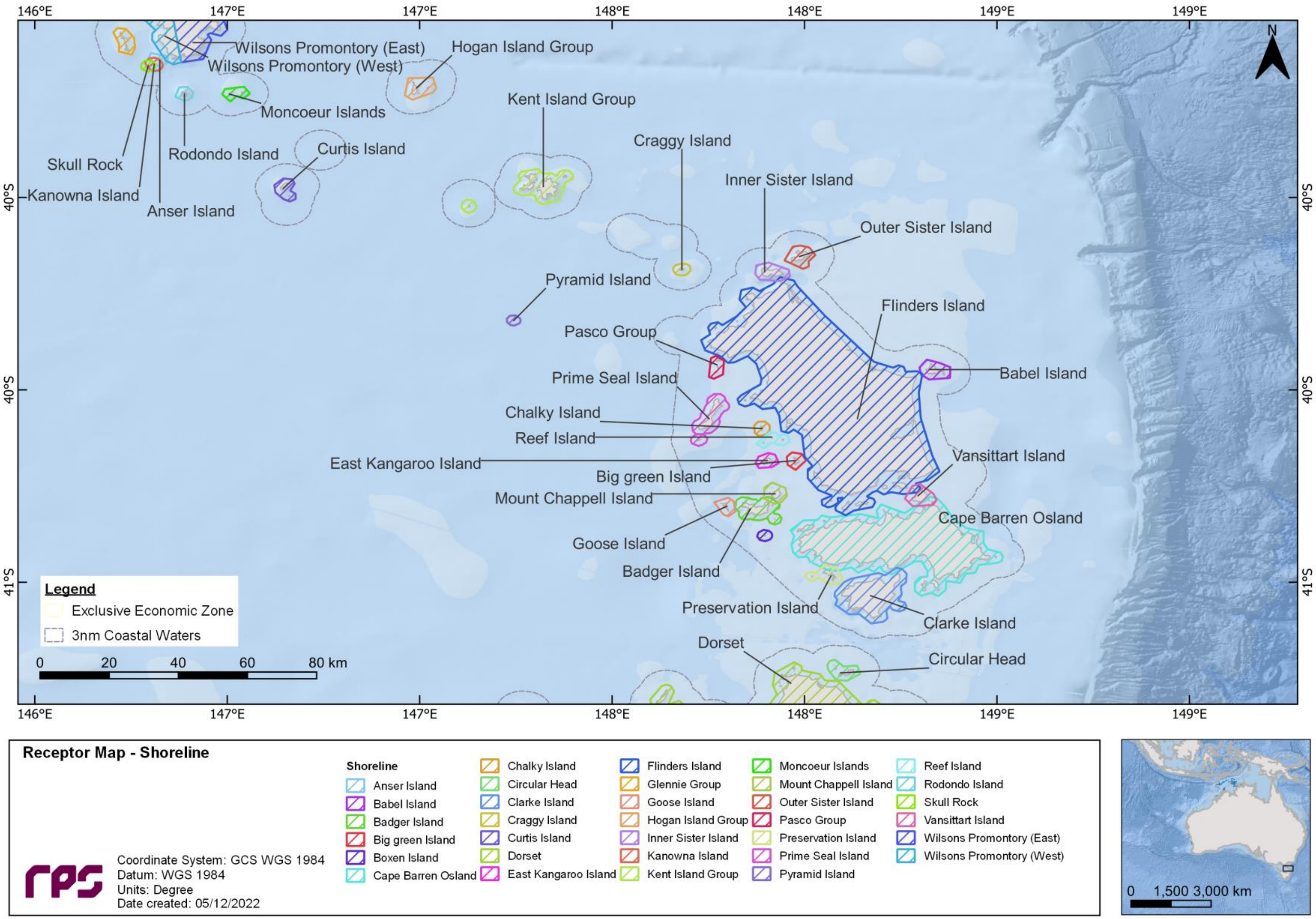


Figure 10-10 Receptor map for shorelines (2 of 3).

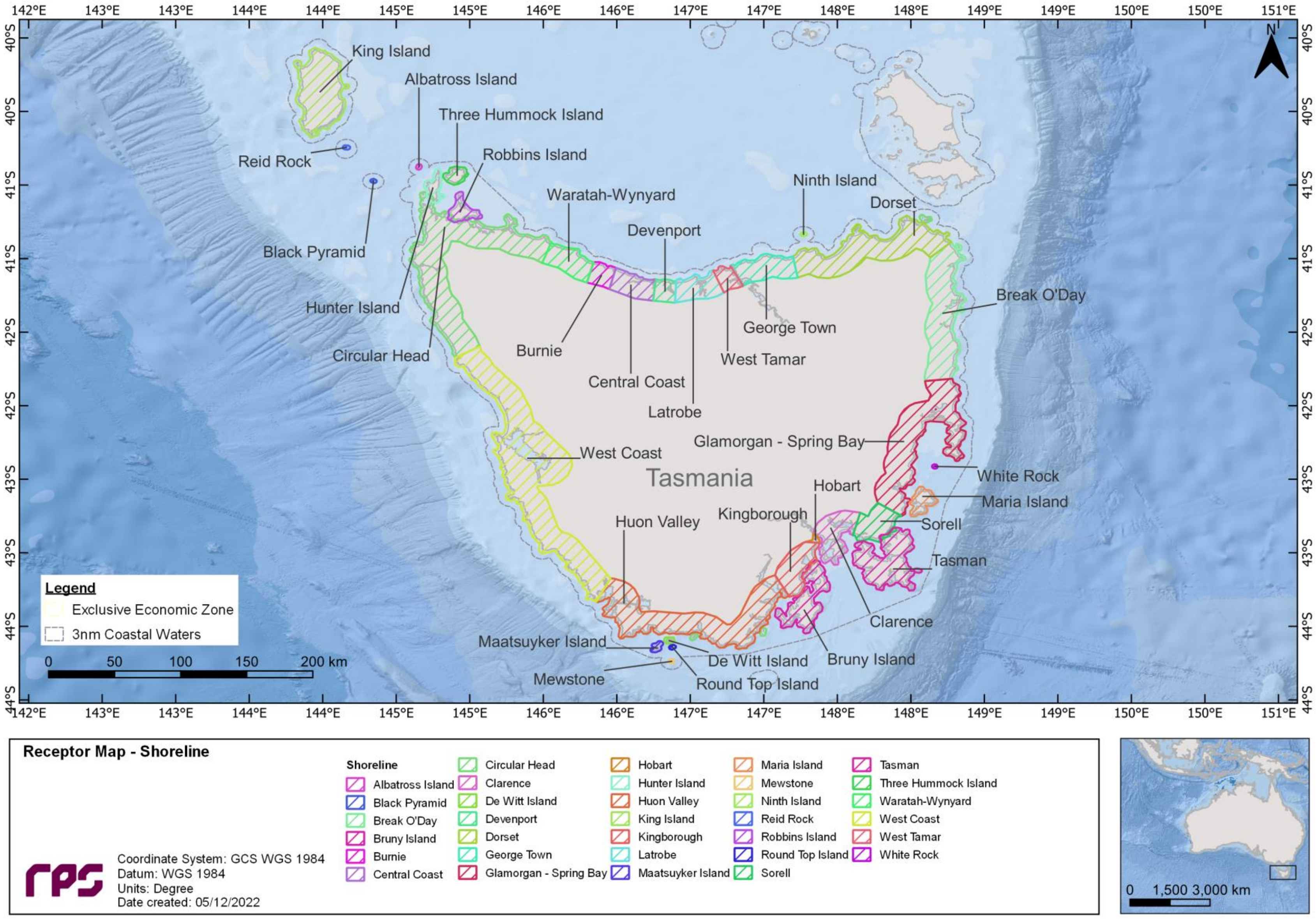


Figure 10-11 Receptor map for shorelines (3 of 3).

11 RESULTS – LOSS OF WELL CONTROL AT RELEASE LOCATION SOUTH

This scenario examined a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. A total of 200 spill simulations were run (i.e., 100 spills per season) and tracked for 100 days. The results for all 100 simulations per season were combined and are presented on a seasonal basis (i.e., summer and winter).

11.1 Stochastic Analysis

11.1.1 Area of Exposure

Figure 11-1 presents the combined area of potential exposure for surface, shoreline, entrained and dissolved, by overlaying the results from all 200 simulations (i.e., 100 per season) during summer and winter conditions.

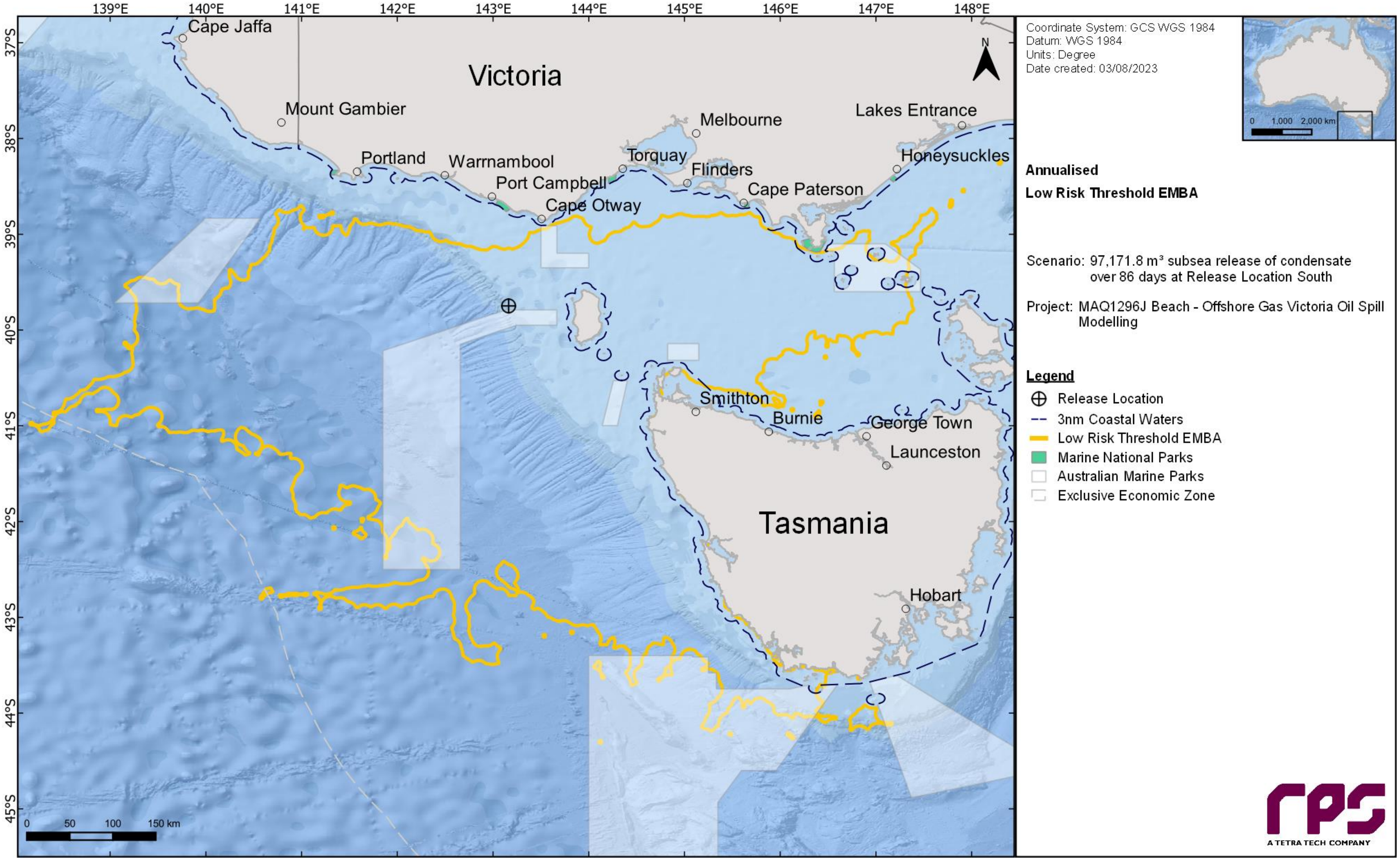


Figure 11-1 Predicted area of exposure for low thresholds produced by overlaying the results from all 200 simulations, resulting from a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South during summer and winter conditions.

11.1.2 Floating Oil Exposure

Table 11-1 summarises the maximum distance travelled by floating oil on the sea surface at each threshold. The maximum distance from the release location to the low (1–10 g/m^2), moderate (10–50 g/m^2) and high (>50 g/m^2) exposure zones was 79 km (east-southeast) during winter conditions, 20 km (southeast) during summer conditions and 1 km (west-southwest) during summer and winter conditions, respectively.

Table 11-2 summarises the potential floating oil exposure to individual receptors during the summer and winter conditions. Outside of the receptors that the Release Location South resides within (refer to Table 10-2), the Pygmy Blue Whale - Known Foraging Area (100% summer and winter), Little Penguin – Foraging (10 % in winter), Southern Right Whale - Connecting habitat (5% in summer and 50% in winter), White Shark – Foraging (2% in winter) and the White-faced Storm-petrel – Foraging (5% in summer and 50% in winter) were the only BIAs predicted to have floating oil exposure above the low threshold.

Table 11-3 presents the maximum residence time of floating oil exposure for each individual grid cell within each individual receptor during summer and winter.

Figure 11-2 and Figure 11-3 present the zones of potential floating oil exposure for all thresholds under summer and winter conditions, respectively.

Figure 11-4 to Figure 11-7 present the maximum residence time of floating oil exposure for the NOPSEMA thresholds during summer and winter, respectively.

Table 11-1 Maximum distance and direction from the release location to the edge of floating oil exposure. Results are based on a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations per season.

Season	Distance and direction travelled	Zones of potential floating oil exposure		
		Low	Moderate	High
Summer	Maximum distance (km) from release location	70	20	1
	Maximum distance (km) from release location (99th percentile)	57	19	1
	Direction	ESE	SE	WSW
Winter	Maximum distance (km) from release location	79	19	1
	Maximum distance (km) from release location (99th percentile)	60	17	1
	Direction	ESE	NW	WSW

Table 11-2 Summary of the potential floating oil exposure to individual receptors. Results are based on a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations per season.

Receptor		Summer (November through to March)						Winter (April to October)					
		Probability of floating oil exposure (%)			Minimum time before floating oil exposure (days)			Probability of floating oil exposure (%)			Minimum time before floating oil exposure (days)		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
AMP	Zeehan	100	96	-	< 1	1	-	100	88	-	< 1	< 1	-
BIA	Antipodean Albatross – Foraging*	100	100	38	< 1	< 1	1	100	100	60	< 1	< 1	< 1
	Black-browed Albatross – Foraging*	100	100	38	< 1	< 1	1	100	100	60	< 1	< 1	< 1
	Black-faced Cormorant – Foraging*	-	-	-	-	-	-	12	-	-	17	-	-
	Bullers Albatross – Foraging*	100	100	38	< 1	< 1	1	100	100	60	< 1	< 1	< 1
	Campbell Albatross – Foraging*	100	100	38	< 1	< 1	1	100	100	60	< 1	< 1	< 1
	Common Diving-petrel – Foraging*	100	100	38	< 1	< 1	1	100	100	60	< 1	< 1	< 1
	Indian Yellow-nosed Albatross – Foraging*	100	100	38	< 1	< 1	1	100	100	60	< 1	< 1	< 1
	Little Penguin – Foraging	-	-	-	-	-	-	10	-	-	18	-	-
	Pygmy Blue Whale – Distribution*	100	100	38	< 1	< 1	1	100	100	60	< 1	< 1	< 1
	Pygmy Blue Whale – Foraging*	100	100	38	< 1	< 1	1	100	100	60	< 1	< 1	< 1
	Pygmy Blue Whale – Foraging (annual high use area)*	100	100	38	< 1	< 1	1	100	100	60	< 1	< 1	< 1
	Pygmy Blue Whale - Known Foraging Area	100	100	-	< 1	< 1	-	100	100	-	< 1	< 1	-
	Short-tailed Shearwater – Foraging*	100	100	38	< 1	< 1	1	100	100	60	< 1	< 1	< 1
	Shy Albatross – Foraging*	100	100	38	< 1	< 1	1	100	100	60	< 1	< 1	< 1
	Southern Right Whale - Connecting habitat	5	-	-	66	-	-	50	-	-	10	-	-
	Southern Right Whale - Known Core Range*	100	100	38	< 1	< 1	1	100	100	60	< 1	< 1	< 1
	Wandering Albatross – Foraging*	100	100	38	< 1	< 1	1	100	100	60	< 1	< 1	< 1
	Wedge-tailed Shearwater – Foraging*	100	100	38	< 1	< 1	1	100	100	60	< 1	< 1	< 1
	White Shark – Distribution	100	100	38	< 1	< 1	1	100	100	60	< 1	< 1	< 1
	White Shark – Foraging	-	-	-	-	-	-	2	-	-	35	-	-
	White-faced Storm-petrel – Foraging	5	-	-	66	-	-	50	-	-	10	-	-
EEZ	Australian *	100	100	38	< 1	< 1	1	100	100	60	< 1	< 1	< 1
IBRA	King Island	5	-	-	66	-	-	50	-	-	10	-	-
IMCRA	Otway*	100	100	38	< 1	< 1	1	100	100	60	< 1	< 1	< 1
KEF	West Tasmania Canyons	100	48	-	< 1	3	-	99	12	-	< 1	2	-
SHORE	King Island	5	-	-	66	-	-	50	-	-	10	-	-
State Waters	Tasmania	5	-	-	66	-	-	50	-	-	10	-	-

*The release location resides within the receptor boundaries.

Table 11-3 Summary of the maximum residence time of floating oil exposure for each individual grid cell within each individual receptor. Results are based on a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations per season.

Receptor		Summer (November through to March) Maximum residence time of floating oil exposure (days)			Winter (April to October) Maximum residence time of floating oil exposure (days)		
		Low	Moderate	High	Low	Moderate	High
AMP	Zeehan	1	< 1	-	1	< 1	-
BIA	Antipodean Albatross - Foraging**	80	64	< 1	86	46	< 1
	Black-browed Albatross - Foraging**	80	64	< 1	86	46	< 1
	Black-faced Cormorant - Foraging	-	-	-	< 1	-	-
	Bullers Albatross - Foraging**	80	64	< 1	86	46	< 1
	Campbell Albatross – Foraging*	80	64	< 1	86	46	< 1
	Common Diving-petrel – Foraging*	80	64	< 1	86	46	< 1
	Indian Yellow-nosed Albatross – Foraging*	80	64	< 1	86	46	< 1
	Little Penguin - Foraging	-	-	-	< 1	-	-
	Pygmy Blue Whale – Distribution*	80	64	< 1	86	46	< 1
	Pygmy Blue Whale – Foraging*	80	64	< 1	86	46	< 1
	Pygmy Blue Whale - Foraging (annual high use area)**	80	64	< 1	86	46	< 1
	Pygmy Blue Whale - Known Foraging Area	2	< 1	-	1	< 1	-
	Short-tailed Shearwater – Foraging*	80	64	< 1	86	46	< 1
	Shy Albatross – Foraging*	80	64	< 1	86	46	< 1
	Southern Right Whale - Connecting habitat	< 1	-	-	1	-	-
	Southern Right Whale - Known Core Range*	80	64	< 1	86	46	< 1
	Wandering Albatross – Foraging*	80	64	< 1	86	46	< 1
	Wedge-tailed Shearwater – Foraging*	80	64	< 1	86	46	< 1
	White Shark – Distribution*	80	64	< 1	86	46	< 1
	White Shark - Foraging	-	-	-	< 1	-	-
	White-faced Storm-petrel - Foraging	< 1	-	-	1	-	-
EEZ	Australian*	80	64	< 1	86	46	< 1
IBRA	King Island	< 1	-	-	1	-	-
IMCRA	Otway*	80	64	< 1	86	46	< 1
KEF	West Tasmania Canyons	1	< 1	-	1	< 1	-
SHORE	King Island	< 1	-	-	1	-	-
State Waters	Tasmania	< 1	-	-	1	-	-

*The release location resides within the receptor boundaries.

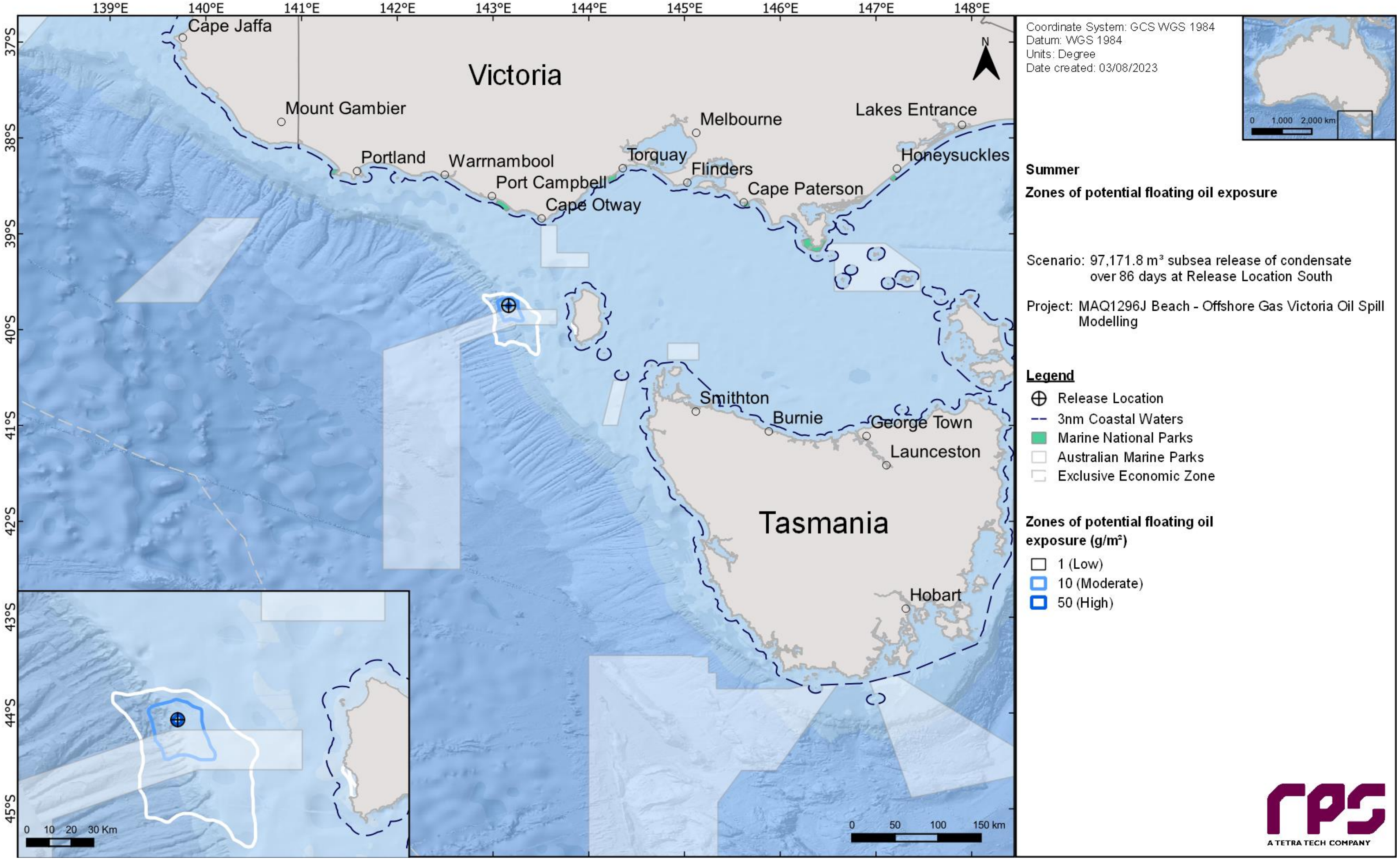


Figure 11-2 Zones of potential floating oil exposure in the event of a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during summer conditions.

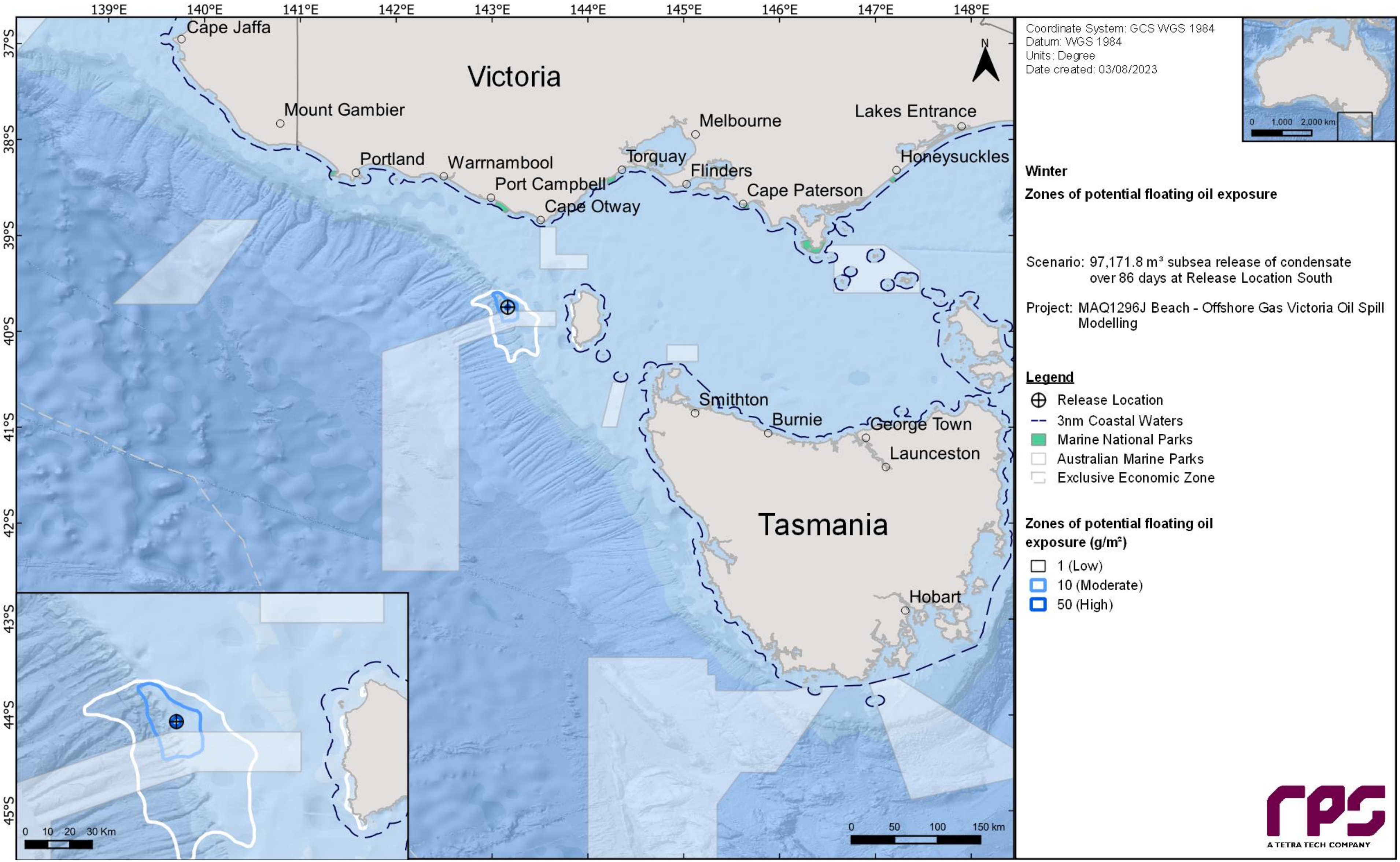


Figure 11-3 Zones of potential floating oil exposure in the event of a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during winter conditions.

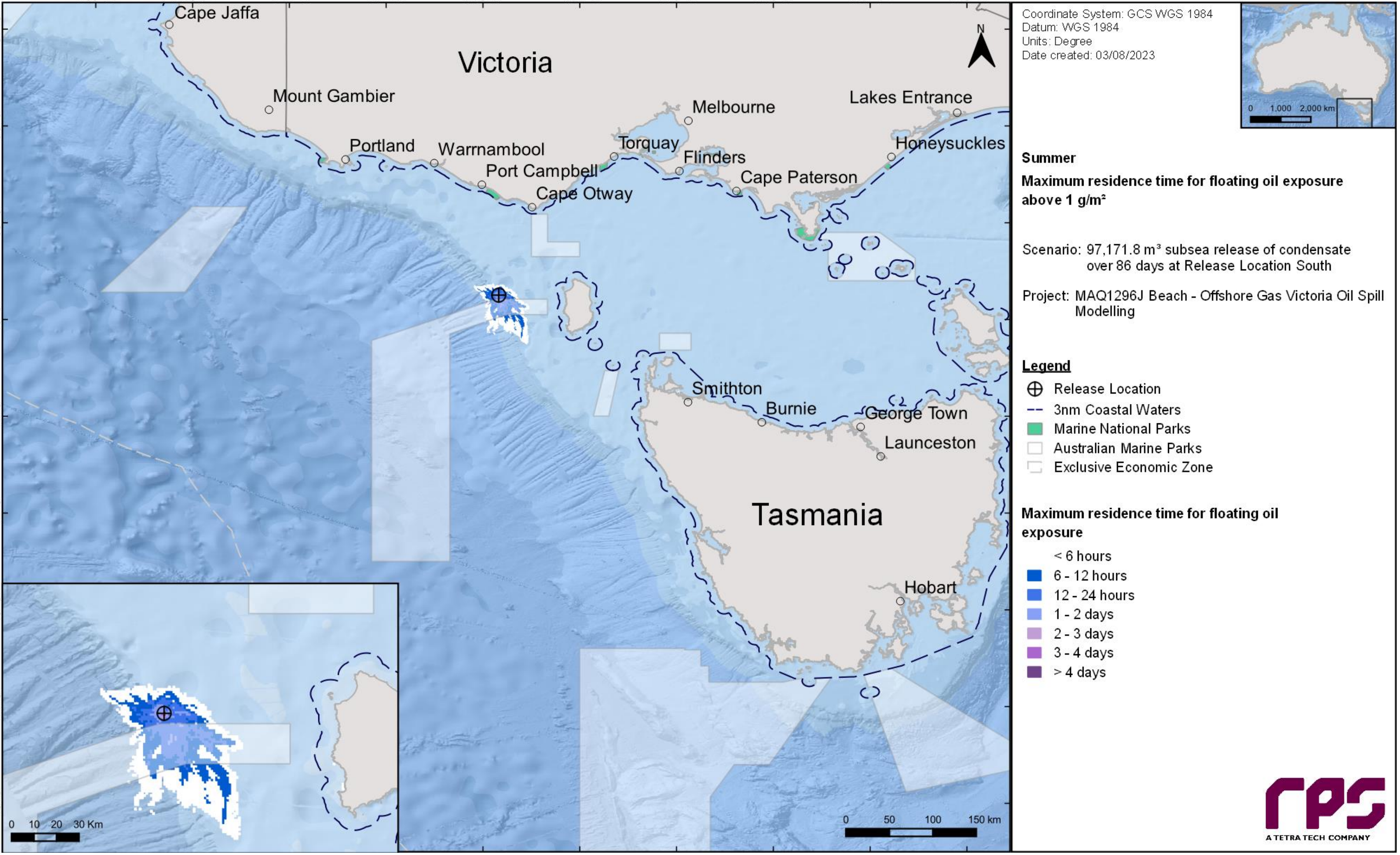


Figure 11-4 Maximum residence time of floating oil exposure above 1 g/m^2, in the event of 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during summer conditions.

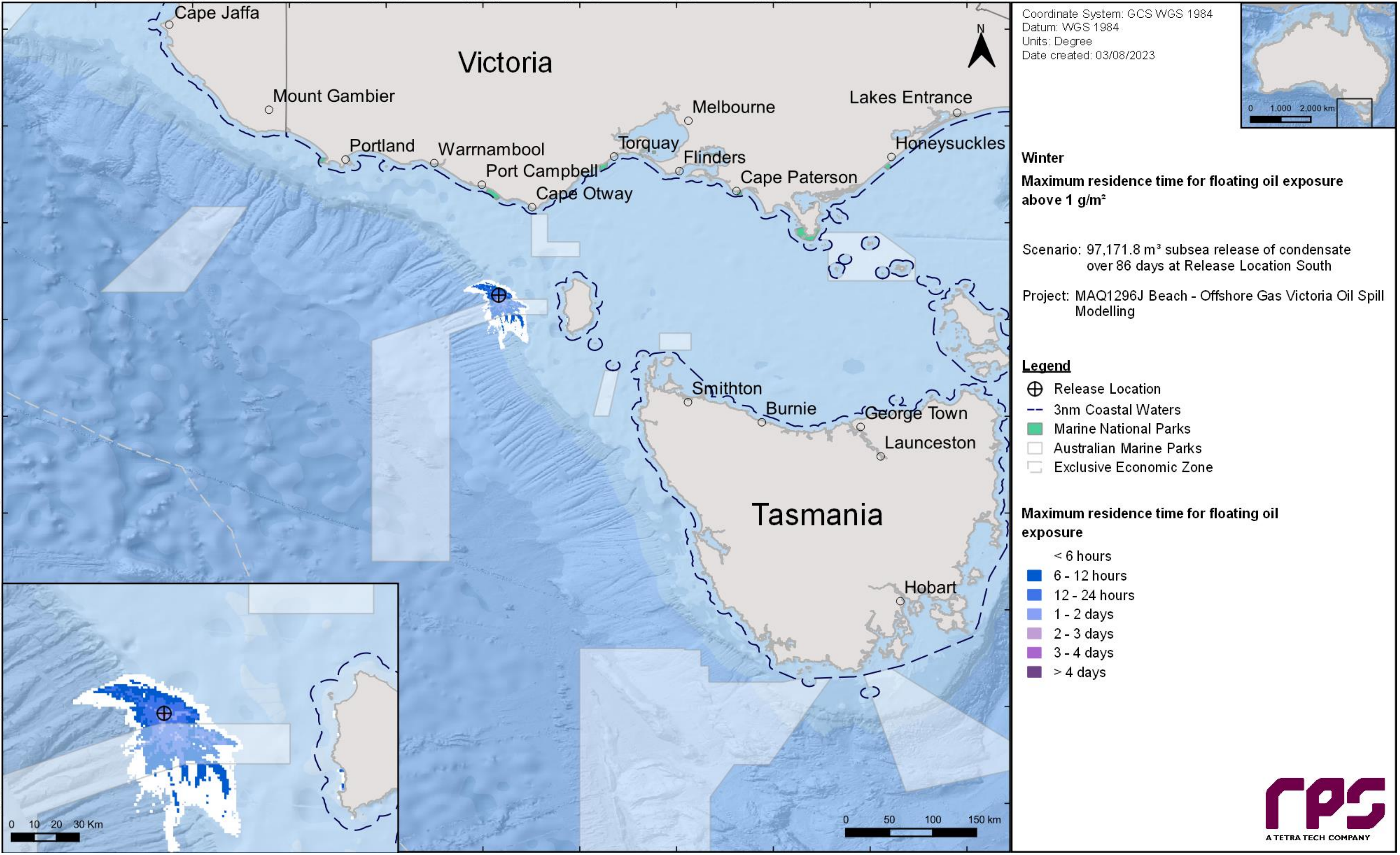


Figure 11-5 Maximum residence time of floating oil exposure above 1 g/m^2, in the event of 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during winter conditions.

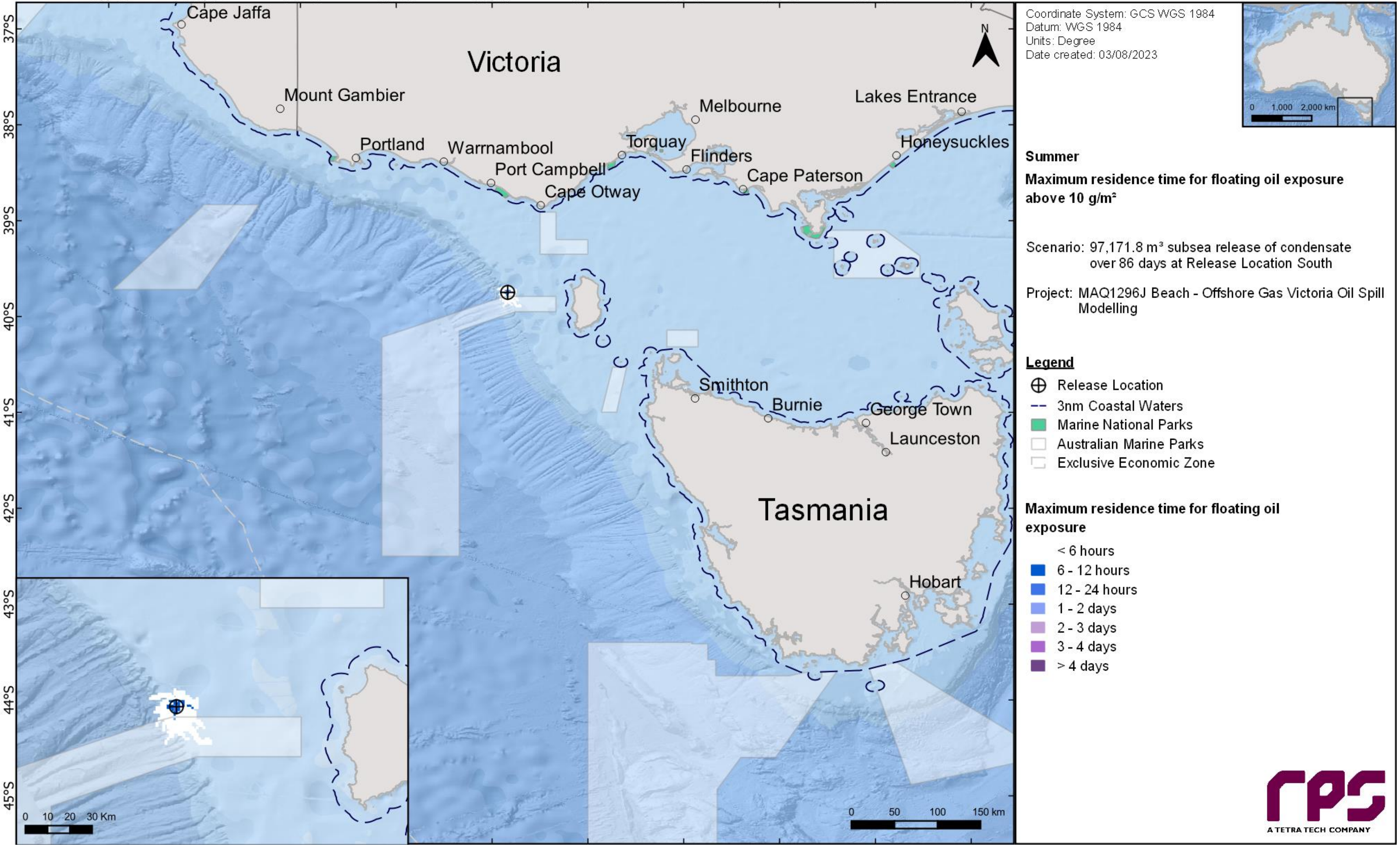


Figure 11-6 Maximum residence time of floating oil exposure above 10 g/m², in the event of 97,171.8 m³ subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during summer conditions.

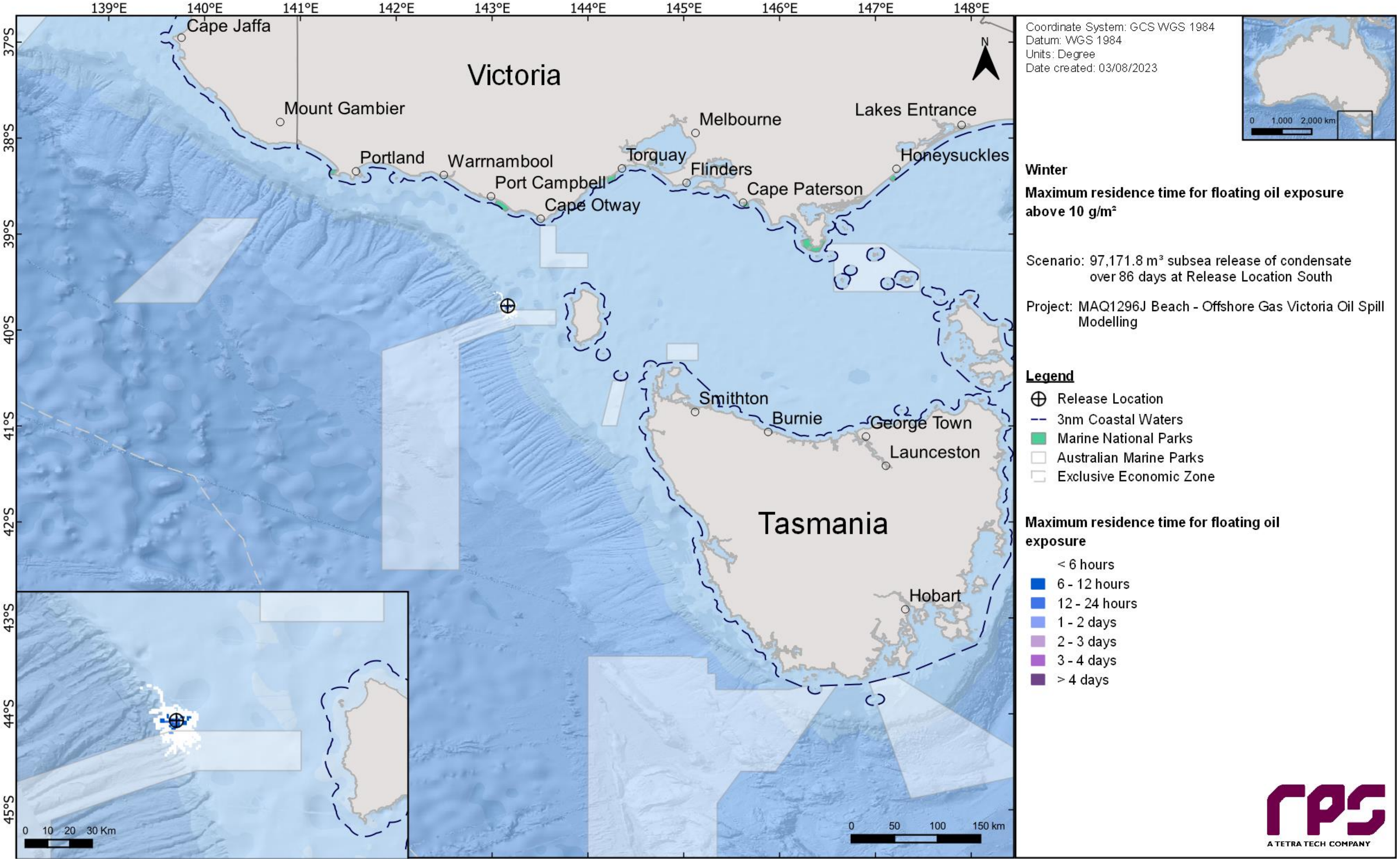


Figure 11-7 **Maximum residence time of floating oil exposure above 10 g/m^2, in the event of 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during winter conditions.**

11.1.3 Shoreline Accumulation

Table 11-4 presents a summary of the predicted potential shoreline accumulation during the summer and winter conditions. The probability of accumulation to any shoreline at, or above, the low level (10 g/m^2) threshold was 89% during summer conditions and 100% during winter conditions. The minimum time before oil accumulation at, or above, the low threshold was 10 days during summer conditions, and 5 days during winter conditions. The maximum volume ashore for a single spill trajectory during the summer and winter conditions was 99 m^3 and 193 m^3, respectively, whilst the maximum length of shoreline accumulation at the low threshold was 115 km and 138 km, respectively. For the moderate threshold, the maximum length of shoreline accumulation was 16 km during summer and 44 km during winter. No accumulation at the high threshold was predicted during summer, but in winter the maximum length of shoreline accumulation was predicted to be 3 km.

Table 11-5 summarises the shoreline accumulation on individual receptors during the summer and winter conditions. King Island recorded the highest probability of shoreline accumulation at the low threshold with 82% (summer) and 100% (winter).

The minimum time before shoreline accumulation above the low threshold was 10 days (summer) and 5 days (winter) predicted for King Island.

The summer and winter conditions maximum potential shoreline loading above the low, moderate and high shoreline thresholds are presented in Figure 11-8 and Figure 11-9, respectively.

Table 11-4 Summary of oil accumulation across all shorelines. Results are based on a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations per season.

Shoreline Statistics	Summer	Winter
Probability of accumulation on any shoreline (%)	89	100
Absolute minimum time for visible oil to shore (days)	10	5
Maximum total volume of hydrocarbons ashore (m^3)	99	193
Average volume of hydrocarbons ashore (m^3)	25	88
Maximum length of the shoreline at **10 g/m^2** (km)	115	138
Average shoreline length (km) at **10 g/m^2** (km)	39	73
Maximum length of the shoreline at **100 g/m^2** (km)	16	44
Average shoreline length (km) at **100 g/m^2** (km)	3	16
Maximum length of the shoreline at **1,000 g/m^2** (km)	-	3
Average shoreline length (km) at **1,000 g/m^2** (km)	-	1

Table 11-5 Summary of oil accumulation on individual shoreline receptors. Results are based on a 97,171.8 m³ subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations per season.

Shoreline Receptor		Summer																Winter															
		Maximum probability of shoreline loading (%)			Minimum time before shoreline accumulation (days)			Load on shoreline (g/m²)		Volume on shoreline (m³)		Mean length of shoreline accumulation (km)			Maximum length of shoreline accumulation (km)			Maximum probability of shoreline loading (%)			Minimum time before shoreline accumulation (days)			Load on shoreline (g/m²)		Volume on shoreline (m³)		Mean length of shoreline accumulation (km)			Maximum length of shoreline accumulation (km)		
		Low	Mod	High	Low	Mod	High	Mean	Peak	Mean	Peak	Low	Mod	High	Low	Mod	High	Low	Mod	High	Low	Mod	High	Mean	Peak	Mean	Peak	Low	Mod	High	Low	Mod	High
SHORE	Black Pyramid	6	-	-	38	-	-	4	21	< 1	1	1	-	-	2	-	-	16	-	-	17	-	-	5	40	< 1	1	1	-	-	2	-	-
	Circular Head	41	-	-	33	-	-	2	56	3	9	6	-	-	15	-	-	42	-	-	30	-	-	2	66	3	10	5	-	-	18	-	-
	Hunter Island	33	-	-	33	-	-	2	48	1	3	3	-	-	6	-	-	29	-	-	20	-	-	2	79	1	4	4	-	-	7	-	-
	Huon Valley	18	-	-	56	-	-	< 1	18	1	3	1	-	-	3	-	-	15	-	-	39	-	-	< 1	68	1	4	2	-	-	6	-	-
	Kent Island Group	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	60	-	-	< 1	16	< 1	1	1	-	-	1	-	-
	King Island	82	37	-	10	11	-	7	704	12	86	21	3	-	72	15	-	100	91	37	5	9	19	37	3,419	77	188	54	14	1	87	40	3
	Maatsuyker Island	48	1	-	35	96	-	3	159	1	3	2	1	-	5	1	-	31	15	-	27	46	-	5	223	1	5	3	1	-	6	2	-
	Reid Rock	37	-	-	21	-	-	6	26	< 1	1	1	-	-	3	-	-	39	-	-	15	-	-	7	27	< 1	1	2	-	-	3	-	-
	West Coast	66	9	-	32	48	-	2	143	8	22	14	1	-	40	2	-	37	2	-	28	57	-	2	111	5	22	18	1	-	40	2	-

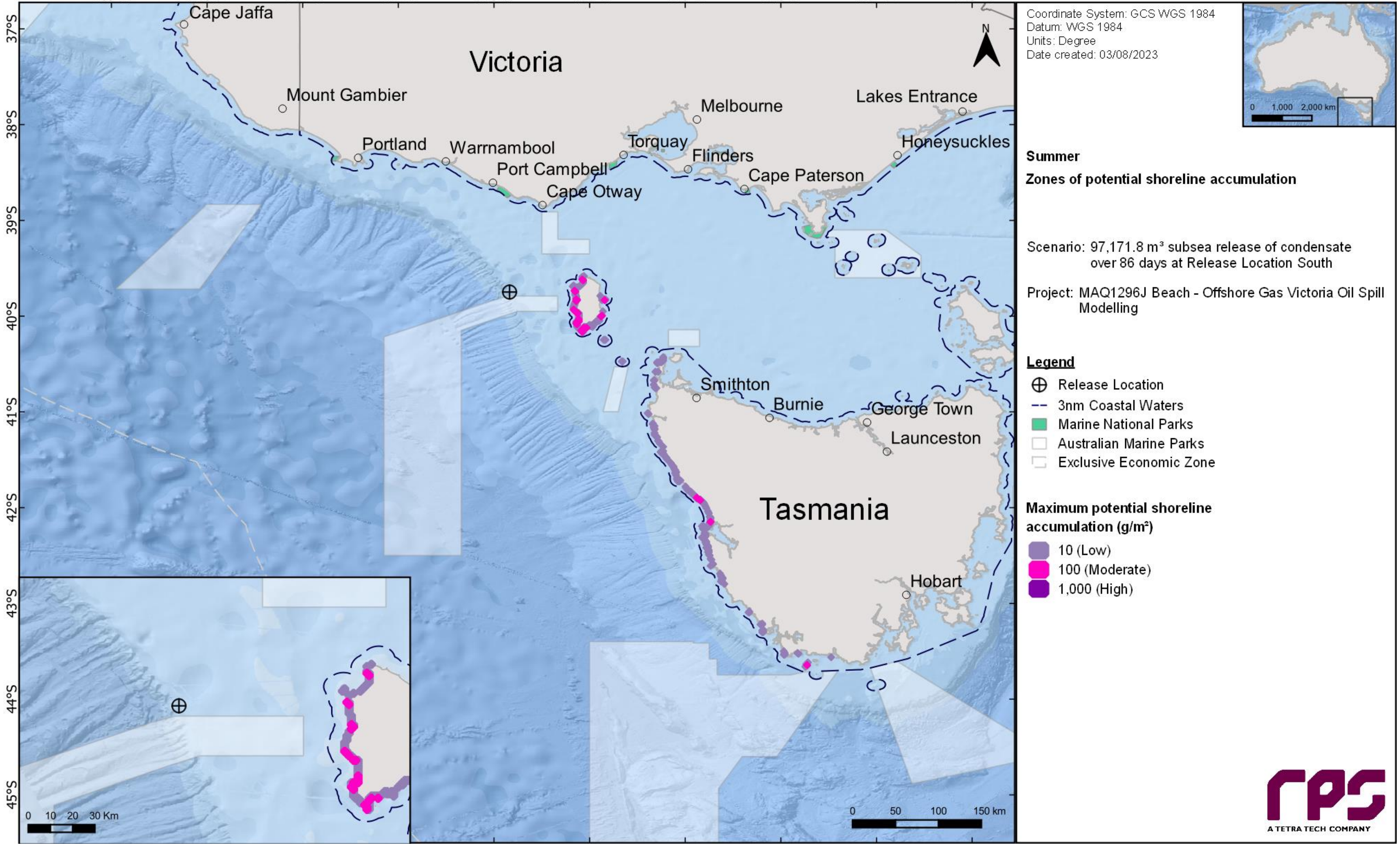


Figure 11-8 Maximum potential shoreline loading in the event of a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during summer conditions.

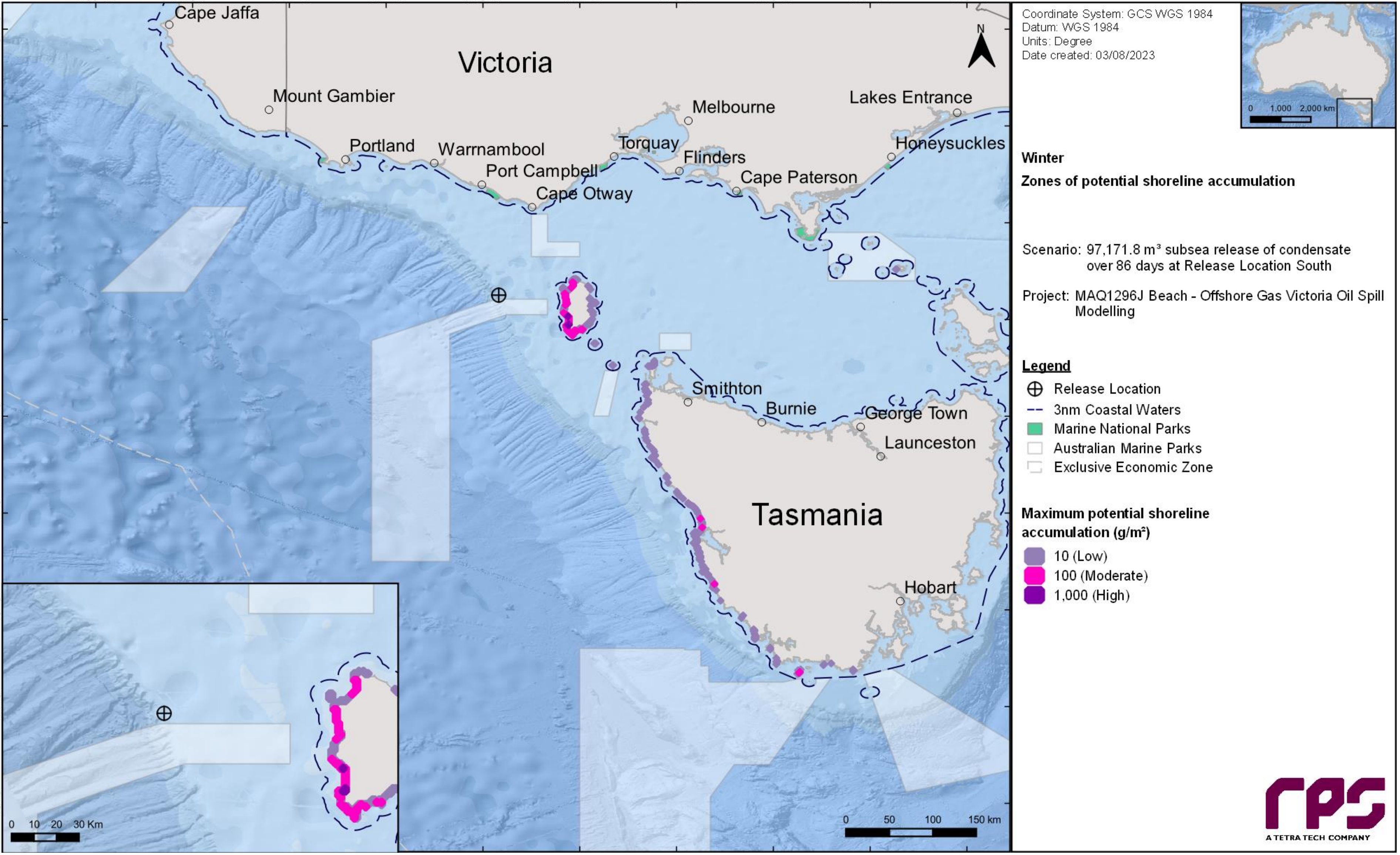


Figure 11-9 Maximum potential shoreline loading in the event of a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during winter conditions.

11.1.4 In-water exposure

11.1.4.1 Dissolved Hydrocarbons

Table 11-6 summarises the probability of exposure to individual receptors from dissolved hydrocarbons in the 0-10 m layer during the summer and winter conditions.

Outside of the receptors that the Release Location South resides within (refer to Table 10-2), the highest concentration of dissolved hydrocarbon was predicted for the Pygmy Blue Whale - Known Foraging Area (summer – 1,904 ppb, winter – 1,665 ppb) and White-faced Storm-petrel – Foraging (summer – 1,904 ppb, winter – 1,135 ppb) receptors, which also held the highest probabilities of low dissolved hydrocarbon exposure (100% during summer and winter).

Table 11-7 presents the predicted minimum time to dissolved hydrocarbon exposure and maximum residence time for dissolved hydrocarbon exposure to individual receptors, in the 0-10 m depth layer, for all seasonal conditions and all thresholds assessed. Outside of the receptors that the Release Location South resides within, the maximum residence time of dissolved hydrocarbon exposure at the low threshold was predicted for Pygmy Blue Whale – Known Foraging Area BIA (summer – 7 days, winter – 6 days).

Figure 11-10 and Figure 11-11 present the zones of potential dissolved hydrocarbon exposure for the 0-10 m depth layer, for each threshold assessed under summer and winter conditions, respectively.

Figure 11-12 to Figure 11.17 presents the maximum residence time of dissolved hydrocarbon exposure for the NOPSEMA thresholds in summer and winter.

Table 11-6 **Probability of dissolved hydrocarbons exposure to marine based receptors in the 0–10 m dept. Results are based on a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations per season.**

Receptor		Summer (November through to March)				Winter (April to October)			
		Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure			Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure		
			Low	Moderate	High		Low	Moderate	High
AMP	Apollo	97	6	1	-	96	7	1	-
	Beagle	57	1	1	-	25	1	-	-
	Boags	84	11	1	-	146	12	3	-
	Franklin	211	68	11	-	312	62	10	-
	Nelson	4	-	-	-	26	2	-	-
	Tasman Fracture	15	1	-	-	23	2	-	-
	Zeehan	1,752	100	100	42	1,665	100	100	41
BIA	Antipodean Albatross - Foraging*	1,904	100	100	88	1,839	100	100	100
	Australasian Gannet - Foraging	542	81	25	1	352	92	35	-
	Black-browed Albatross - Foraging*	1,904	100	100	88	1,839	100	100	100
	Black-faced Cormorant - Foraging	277	24	5	-	609	73	35	1
	Bullers Albatross - Foraging*	1,904	100	100	88	1,839	100	100	100
	Campbell Albatross – Foraging*	1,904	100	100	88	1,839	100	100	100
	Common Diving-petrel – Foraging*	1,904	100	100	88	1,839	100	100	100
	Indian Yellow-nosed Albatross – Foraging*	1,904	100	100	88	1,839	100	100	100
	Little Penguin - Foraging	242	46	7	-	418	71	32	1
	Pygmy Blue Whale – Distribution*	1,904	100	100	88	1,839	100	100	100
	Pygmy Blue Whale – Foraging*	1,904	100	100	88	1,839	100	100	100
	Pygmy Blue Whale - Foraging (annual high use area)*	1,790	100	100	88	1,839	100	100	100
	Pygmy Blue Whale - Known Foraging Area	1,904	100	100	48	1,665	100	100	45
	Short-tailed Shearwater - Breeding	8	-	-	-	10	1	-	-
	Short-tailed Shearwater – Foraging*	1,904	100	100	88	1,839	100	100	100
	Shy Albatross - Breeding	30	5	-	-	19	3	-	-
	Shy Albatross – Foraging*	1,904	100	100	88	1,839	100	100	100
	Soft-plumaged Petrel - Foraging	201	49	6	-	483	21	5	1

Receptor		Summer (November through to March)				Winter (April to October)			
		Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure			Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure		
			Low	Moderate	High		Low	Moderate	High
	Sooty Shearwater - Foraging	27	3	-	-	42	4	-	-
	Southern Right Whale - Connecting habitat	340	31	7	-	617	90	46	1
	Southern Right Whale - Known Core Range*	1,904	100	100	88	1,839	100	100	100
	Wandering Albatross – Foraging*	1,904	100	100	88	1,839	100	100	100
	Wedge-tailed Shearwater – Foraging*	1,790	100	100	88	1,839	100	100	100
	White Shark – Distribution*	1,904	100	100	88	1,839	100	100	100
	White Shark - Foraging	542	72	19	1	617	94	55	1
	White-faced Storm-petrel - Foraging	1,904	100	96	4	1,135	100	97	4
EEZ	Australian*	1,904	100	100	88	1,839	100	100	100
IBRA	Flinders	13	1	-	-	28	1	-	-
	King Island	284	43	7	-	617	90	37	1
	Tasmanian West	50	5	-	-	42	5	-	-
	Wilsons Promontory	0	-	-	-	19	2	-	-
IMCRA	Boags	85	14	1	-	146	9	1	-
	Central Bass Strait	334	30	5	-	385	55	8	-
	Central Victoria	6	-	-	-	29	2	-	-
	Davey	19	1	-	-	35	2	-	-
	Flinders	63	2	1	-	51	3	1	-
	Franklin	354	92	22	-	483	63	10	1
	Otway*	1,904	100	100	88	1,839	100	100	100
	Twofold Shelf	6	-	-	-	28	1	-	-
KEF	Seamounts South and east of Tasmania	4	-	-	-	21	1	-	-
	West Tasmania Canyons	1,632	100	100	32	1,227	100	100	16
NP	Kent Group	6	-	-	-	28	1	-	-
RSB	Bell Reef	123	54	8	-	222	78	16	-
	Brown Rocks	16	2	-	-	13	1	-	-
SHORE	Albatross Island	63	9	1	-	37	5	-	-

Receptor		Summer (November through to March)				Winter (April to October)			
		Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure			Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure		
			Low	Moderate	High		Low	Moderate	High
	Black Pyramid	104	35	5	-	241	46	5	-
	Circular Head	90	9	3	-	65	6	1	-
	Curtis Island	13	1	-	-	9	-	-	-
	De Witt Island	7	-	-	-	13	1	-	-
	Hunter Island	25	3	-	-	17	1	-	-
	Huon Valley	13	1	-	-	10	-	-	-
	Kent Island Group	5	-	-	-	28	1	-	-
	King Island	284	31	7	-	617	90	37	1
	Maatsuyker Island	10	-	-	-	16	1	-	-
	Moncoeur Islands	0	-	-	-	14	2	-	-
	Reid Rock	139	46	5	-	177	77	22	-
	Rodondo Island	0	-	-	-	12	1	-	-
	Round Top Island	5	-	-	-	13	1	-	-
	Three Hummock Island	15	1	-	-	19	1	-	-
	West Coast	43	5	-	-	42	5	-	-
State Waters	Tasmania	445	51	10	1	617	95	59	1
	Victoria	1	-	-	-	40	3	-	-

*The release location resides within the receptor boundaries.

Table 11-7 Predicted minimum time to dissolved hydrocarbon exposure and maximum residence time for dissolved hydrocarbon exposure to individual receptors in the 0-10 m depth layer. Results are based on a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill trajectories per season.

Receptor		Summer (November through to March)						Winter (April to October)					
		Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)			Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
AMP	Apollo	50	67	-	< 1	< 1	-	11	49	-	< 1	< 1	-
	Beagle	56	56	-	< 1	< 1	-	15	-	-	< 1	-	-
	Boags	28	36	-	< 1	< 1	-	12	27	-	< 1	< 1	-
	Franklin	10	13	-	< 1	< 1	-	8	9	-	< 1	< 1	-
	Nelson	-	-	-	-	-	-	30	-	-	< 1	-	-
	Tasman Fracture	25	-	-	< 1	-	-	25	-	-	< 1	-	-
	Zeehan	< 1	< 1	1	5	1	< 1	< 1	< 1	1	5	2	< 1
BIA	Antipodean Albatross - Foraging*	< 1	< 1	< 1	73	15	< 1	< 1	< 1	< 1	87	17	< 1
	Australasian Gannet - Foraging	6	12	74	< 1	< 1	< 1	5	6	-	< 1	< 1	-
	Black-browed Albatross - Foraging*	< 1	< 1	< 1	73	15	< 1	< 1	< 1	< 1	87	17	< 1
	Black-faced Cormorant - Foraging	17	25	-	< 1	< 1	-	4	4	16	1	< 1	< 1
	Bullers Albatross - Foraging*	< 1	< 1	< 1	73	15	< 1	< 1	< 1	< 1	87	17	< 1
	Campbell Albatross – Foraging*	< 1	< 1	< 1	73	15	< 1	< 1	< 1	< 1	87	17	< 1
	Common Diving-petrel – Foraging*	< 1	< 1	< 1	73	15	< 1	< 1	< 1	< 1	87	17	< 1
	Indian Yellow-nosed Albatross – Foraging*	< 1	< 1	< 1	73	15	< 1	< 1	< 1	< 1	87	17	< 1
	Little Penguin - Foraging	13	13	-	< 1	< 1	-	4	5	17	< 1	< 1	< 1
	Pygmy Blue Whale – Distribution*	< 1	< 1	< 1	73	15	< 1	< 1	< 1	< 1	87	17	< 1
	Pygmy Blue Whale – Foraging*	< 1	< 1	< 1	73	15	< 1	< 1	< 1	< 1	87	17	< 1
	Pygmy Blue Whale - Foraging (annual high use area)*	< 1	< 1	< 1	73	15	< 1	< 1	< 1	< 1	87	17	< 1
	Pygmy Blue Whale - Known Foraging Area	< 1	< 1	1	7	2	< 1	< 1	< 1	1	6	2	< 1
	Short-tailed Shearwater - Breeding	-	-	-	-	-	-	27	-	-	< 1	-	-
	Short-tailed Shearwater – Foraging*	< 1	< 1	< 1	73	15	< 1	< 1	< 1	< 1	87	17	< 1
	Shy Albatross - Breeding	34	-	-	< 1	-	-	34	-	-	< 1	-	-
	Shy Albatross – Foraging*	< 1	< 1	< 1	73	15	< 1	< 1	< 1	< 1	87	17	< 1

Receptor		Summer (November through to March)						Winter (April to October)					
		Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)			Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
	Soft-plumaged Petrel - Foraging	10	12	-	< 1	< 1	-	6	9	60	< 1	< 1	< 1
	Sooty Shearwater - Foraging	23	-	-	< 1	-	-	17	-	-	< 1	-	-
	Southern Right Whale - Connecting habitat	8	8	-	< 1	< 1	-	4	5	9	< 1	0	< 1
	Southern Right Whale - Known Core Range*	< 1	< 1	< 1	73	15	< 1	< 1	< 1	< 1	87	17	< 1
	Wandering Albatross – Foraging*	< 1	< 1	< 1	73	15	< 1	< 1	< 1	< 1	87	17	< 1
	Wedge-tailed Shearwater – Foraging*	< 1	< 1	< 1	73	15	< 1	< 1	< 1	< 1	87	17	< 1
	White Shark – Distribution*	< 1	< 1	< 1	73	15	< 1	< 1	< 1	< 1	87	17	< 1
	White Shark - Foraging	6	8	67	< 1	< 1	< 1	4	5	7	< 1	< 1	< 1
	White-faced Storm-petrel - Foraging	2	3	5	1	0	< 1	1	2	4	1	0	< 1
EEZ	Australian*	< 1	< 1	< 1	73	15	< 1	< 1	< 1	< 1	87	17	< 1
IBRA	Flinders	56	-	-	< 1	-	-	33	-	-	< 1	-	-
	King Island	8	8	-	< 1	< 1	-	4	5	52	< 1	< 1	< 1
	Tasmanian West	28	95	-	< 1	< 1	-	24	-	-	< 1	-	-
	Wilsons Promontory	-	-	-	-	-	-	15	-	-	< 1	-	-
IMCRA	Boags	25	69	-	< 1	< 1	-	16	31	-	< 1	< 1	-
	Central Bass Strait	16	30	-	< 1	< 1	-	5	8	83	< 1	< 1	< 1
	Central Victoria	-	-	-	-	-	-	18	31	-	< 1	< 1	-
	Davey	23	-	-	< 1	-	-	19	-	-	< 1	-	-
	Flinders	55	55	-	< 1	< 1	-	15	96	-	< 1	< 1	-
	Franklin	7	8	-	< 1	< 1	-	6	7	59	< 1	< 1	< 1
	Otway*	< 1	< 1	< 1	73	15	< 1	< 1	< 1	< 1	87	17	< 1
	Twofold Shelf	-	-	-	-	-	-	17	-	-	< 1	-	-
KEF	Seamounts South and east of Tasmania	-	-	-	-	-	-	44	-	-	< 1	-	-
	West Tasmania Canyons	< 1	< 1	2	3	1	< 1	< 1	< 1	2	4	1	< 1
NP	Kent Group	-	-	-	-	-	-	39	-	-	< 1	-	-
RSB	Bell Reef	14	25	-	< 1	< 1	-	7	7	-	< 1	< 1	-
	Brown Rocks	41	-	-	< 1	-	-	30	-	-	< 1	-	-

Receptor		Summer (November through to March)						Winter (April to October)					
		Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)			Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
SHORE	Albatross Island	24	78	-	< 1	< 1	-	29	-	-	< 1	-	-
	Black Pyramid	13	18	-	< 1	< 1	-	10	20	-	< 1	< 1	-
	Circular Head	25	78	-	< 1	< 1	-	19	38	-	< 1	< 1	-
	Curtis Island	56	-	-	< 1	-	-	33	-	-	< 1	-	-
	De Witt Island	-	-	-	-	-	-	30	-	-	< 1	-	-
	Hunter Island	41	-	-	< 1	-	-	27	-	-	< 1	-	-
	Huon Valley	46	-	-	< 1	-	-	24	-	-	< 1	-	-
	Kent Island Group	-	-	-	-	-	-	39	-	-	< 1	-	-
	King Island	8	8	-	< 1	< 1	-	4	5	52	< 1	< 1	< 1
	Maatsuyker Island	88	-	-	< 1	-	-	30	-	-	< 1	-	-
	Moncoeur Islands	-	-	-	-	-	-	15	-	-	< 1	-	-
	Reid Rock	13	29	-	< 1	< 1	-	7	8	-	< 1	< 1	-
	Rodondo Island	-	-	-	-	-	-	54	-	-	< 1	-	-
	Round Top Island	-	-	-	-	-	-	30	-	-	< 1	-	-
	Three Hummock Island	67	-	-	< 1	-	-	18	-	-	< 1	-	-
	West Coast	28	95	-	< 1	< 1	-	24	-	-	< 1	-	-
State Waters	Tasmania	8	8	67	< 1	< 1	< 1	3	4	7	1	< 1	< 1
	Victoria	-	-	-	-	-	-	15	-	-	< 1	-	-

*The release location resides within the receptor boundaries.

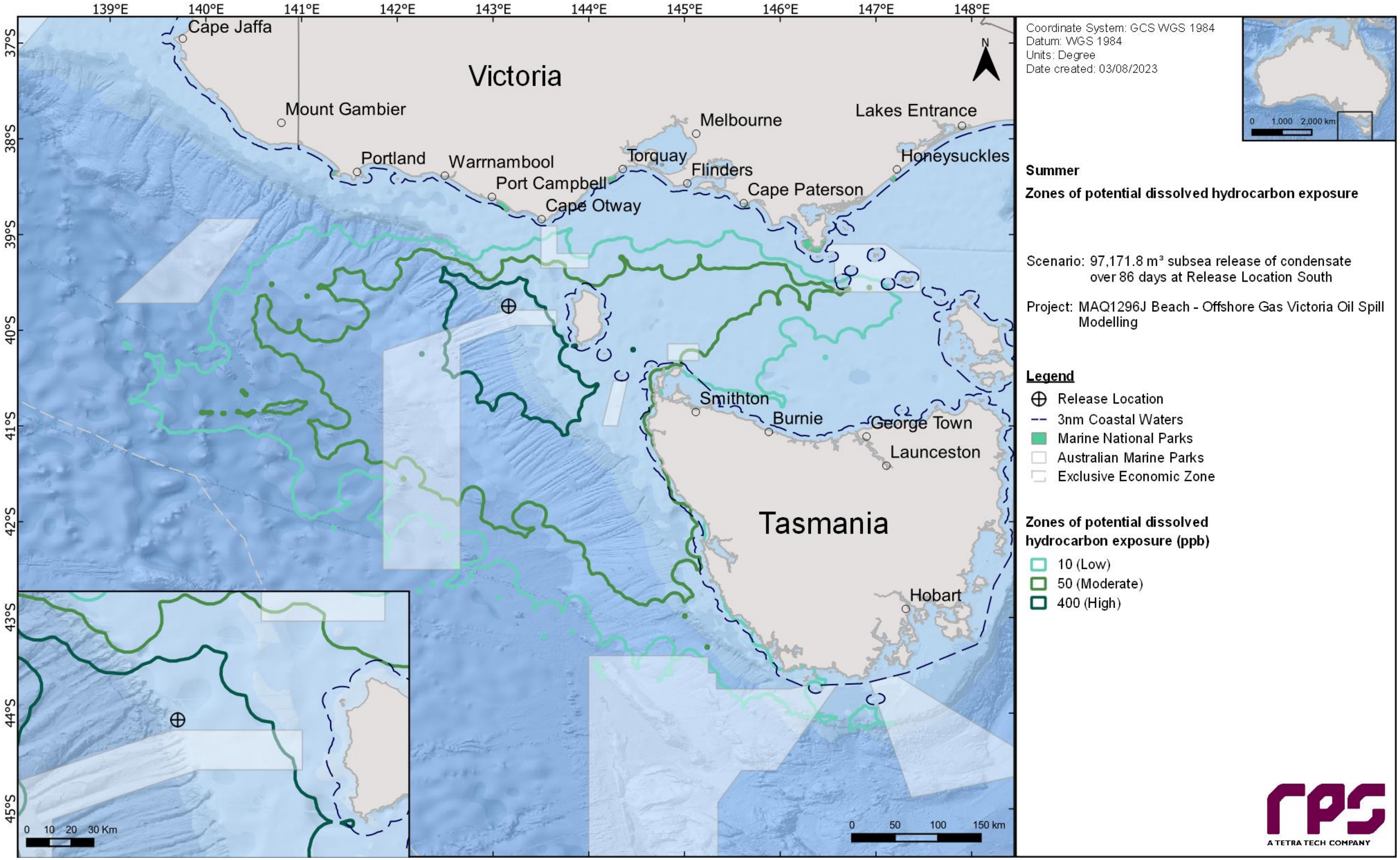


Figure 11-10 Zones of potential dissolved hydrocarbon exposure at 0-10 m below the sea in the event of a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during summer conditions.

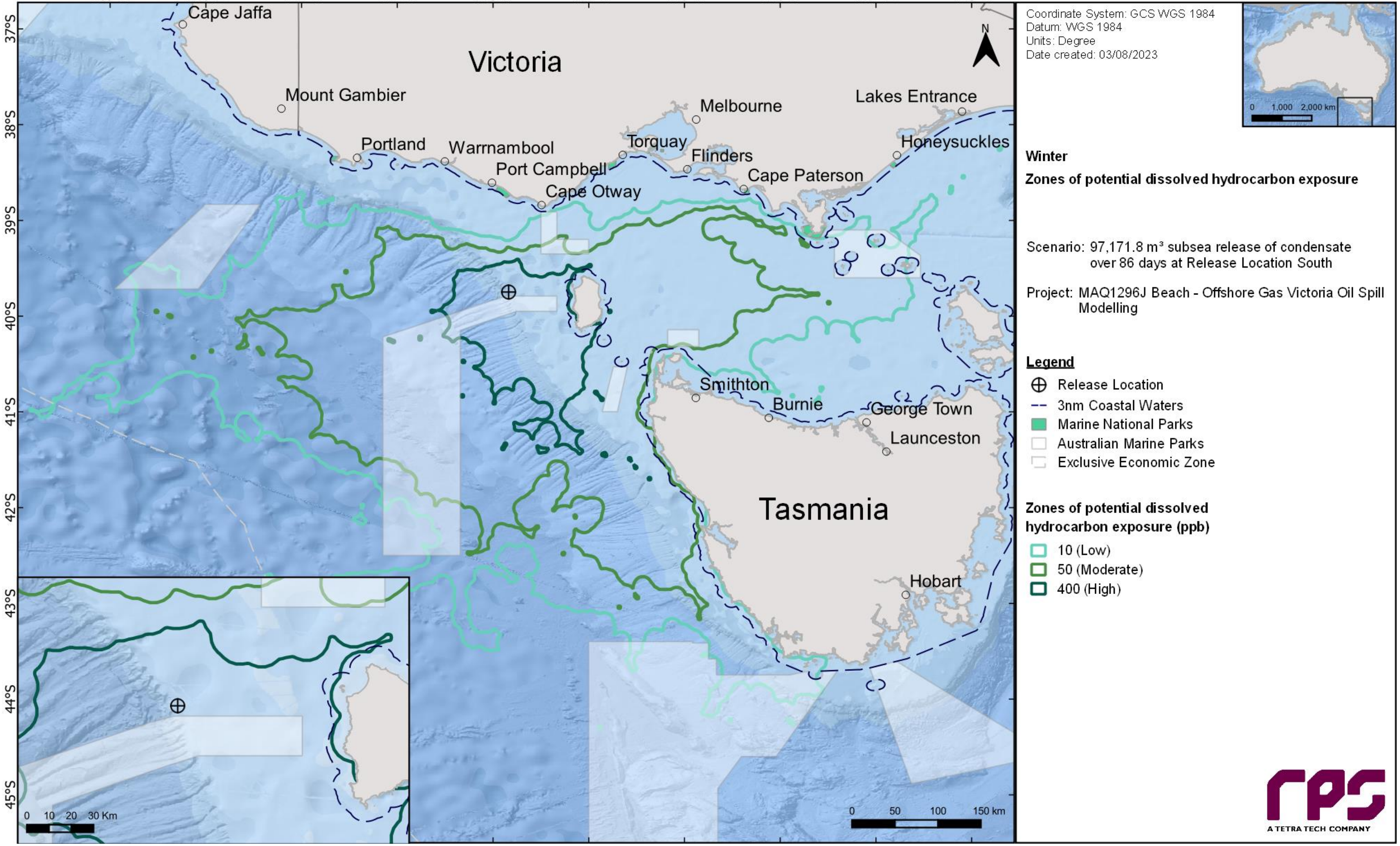


Figure 11-11 Zones of potential dissolved hydrocarbon exposure at 0-10 m below the sea in the event of a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during winter conditions.

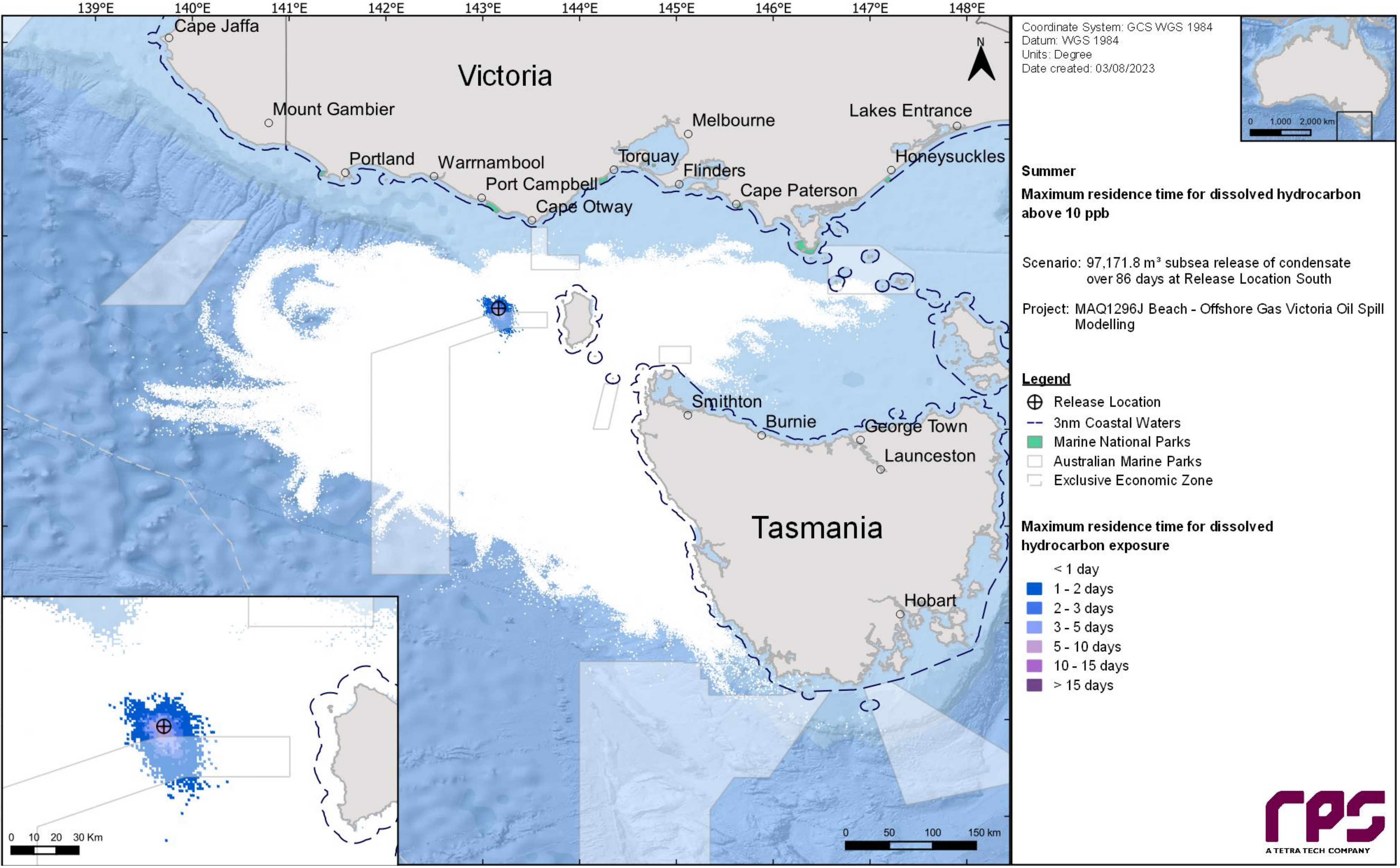


Figure 11-12 Maximum residence time for dissolved hydrocarbon exposure above 10 ppb, at 0-10 m below the sea surface in the event of a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during summer conditions.

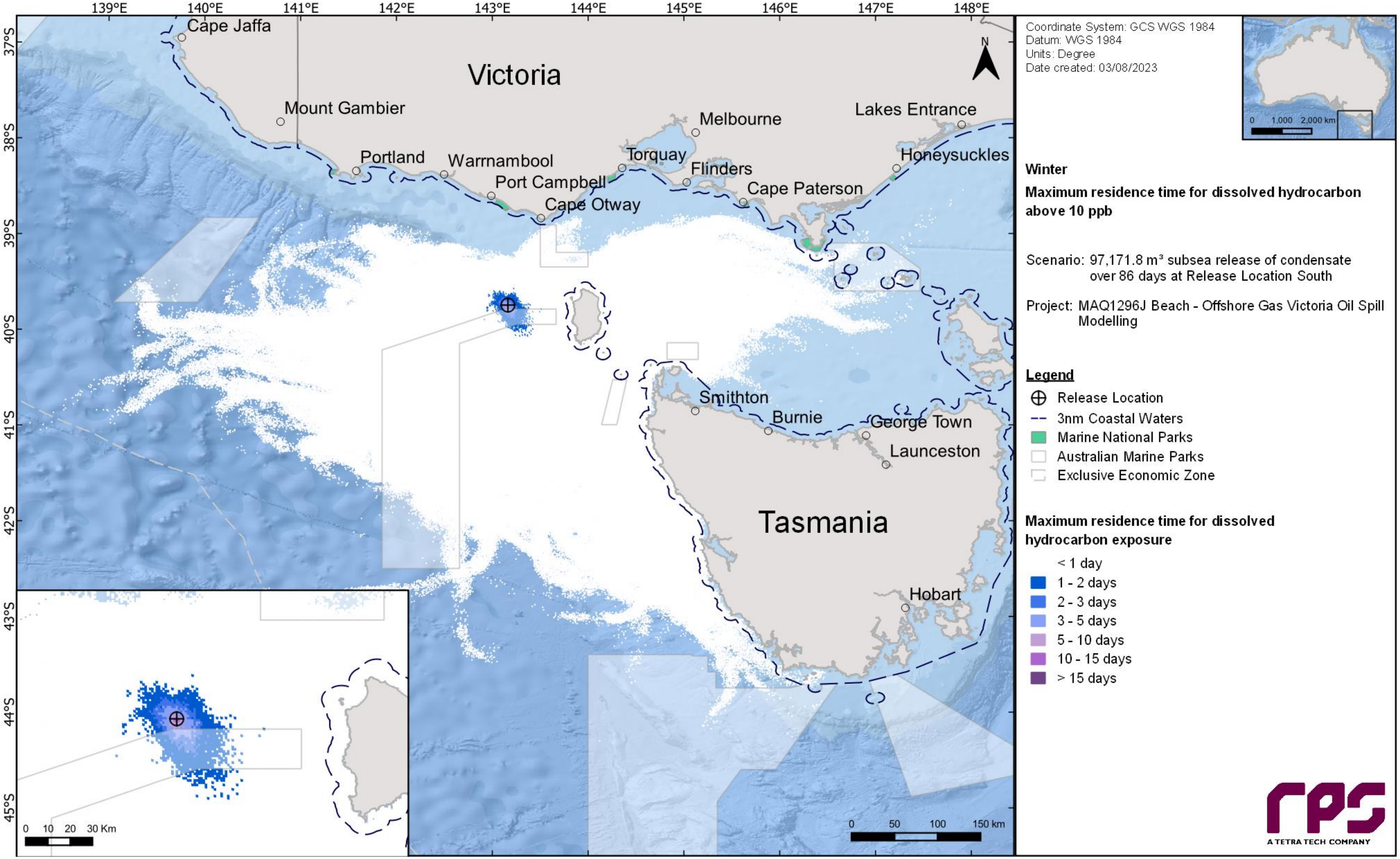


Figure 11.13 Maximum residence time for dissolved hydrocarbon exposure above 10 ppb, at 0-10 m below the sea surface in the event of a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during winter conditions.

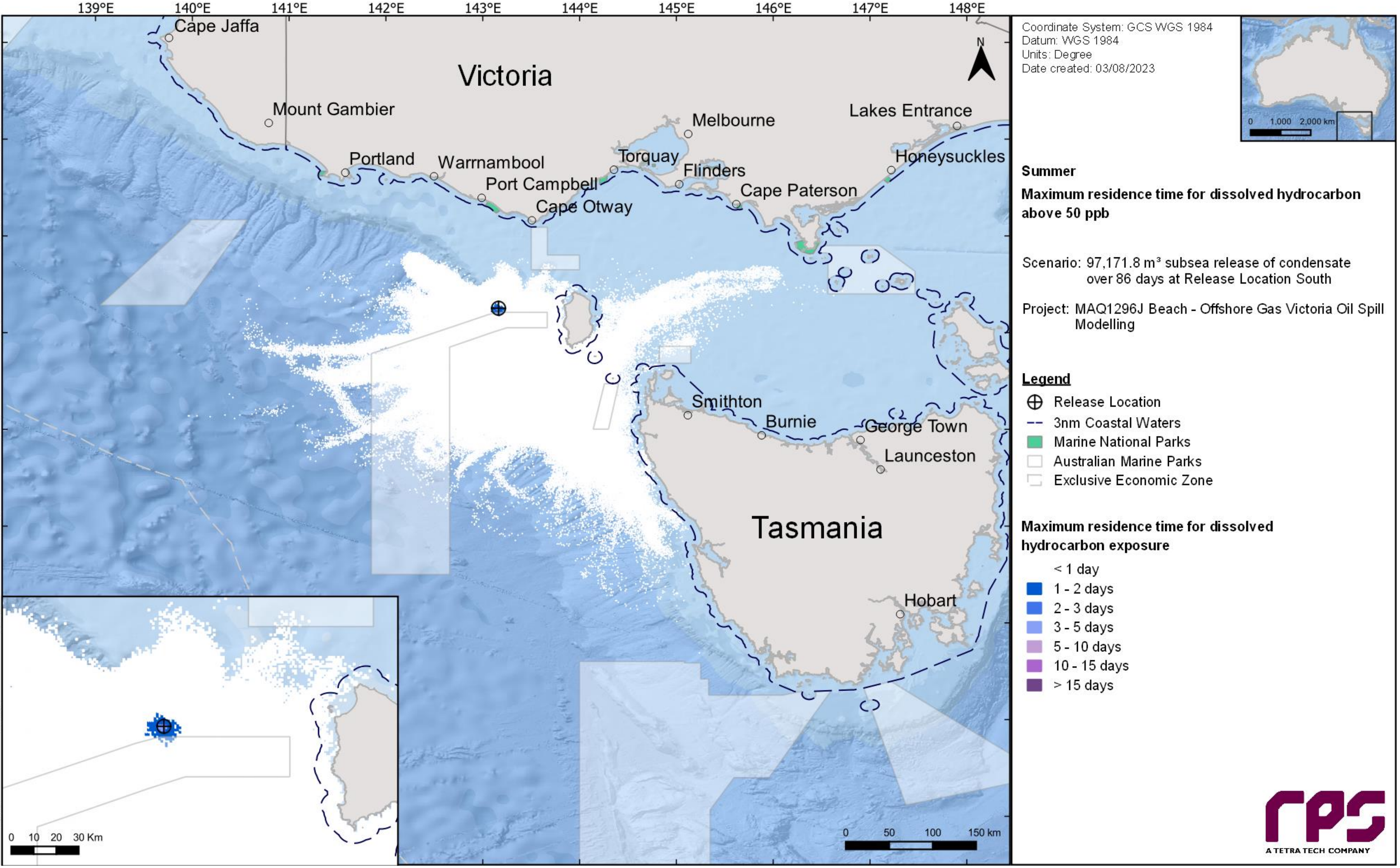


Figure 11.14 Maximum residence time for dissolved hydrocarbon exposure above 50 ppb, at 0-10 m below the sea surface in the event of a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during summer conditions.

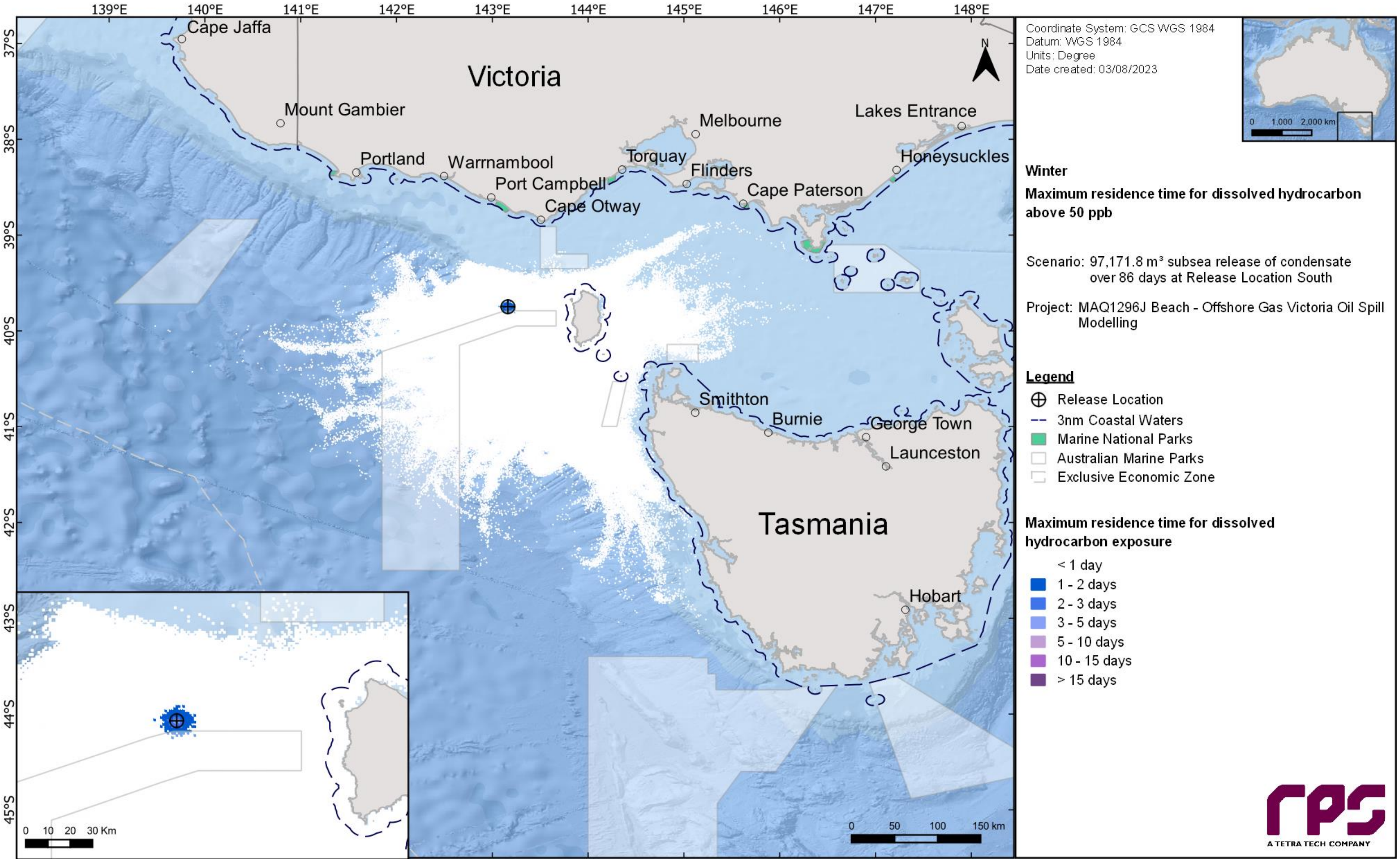


Figure 11.15 Maximum residence time for dissolved hydrocarbon exposure above 50 ppb, at 0-10 m below the sea surface in the event of a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during winter conditions.

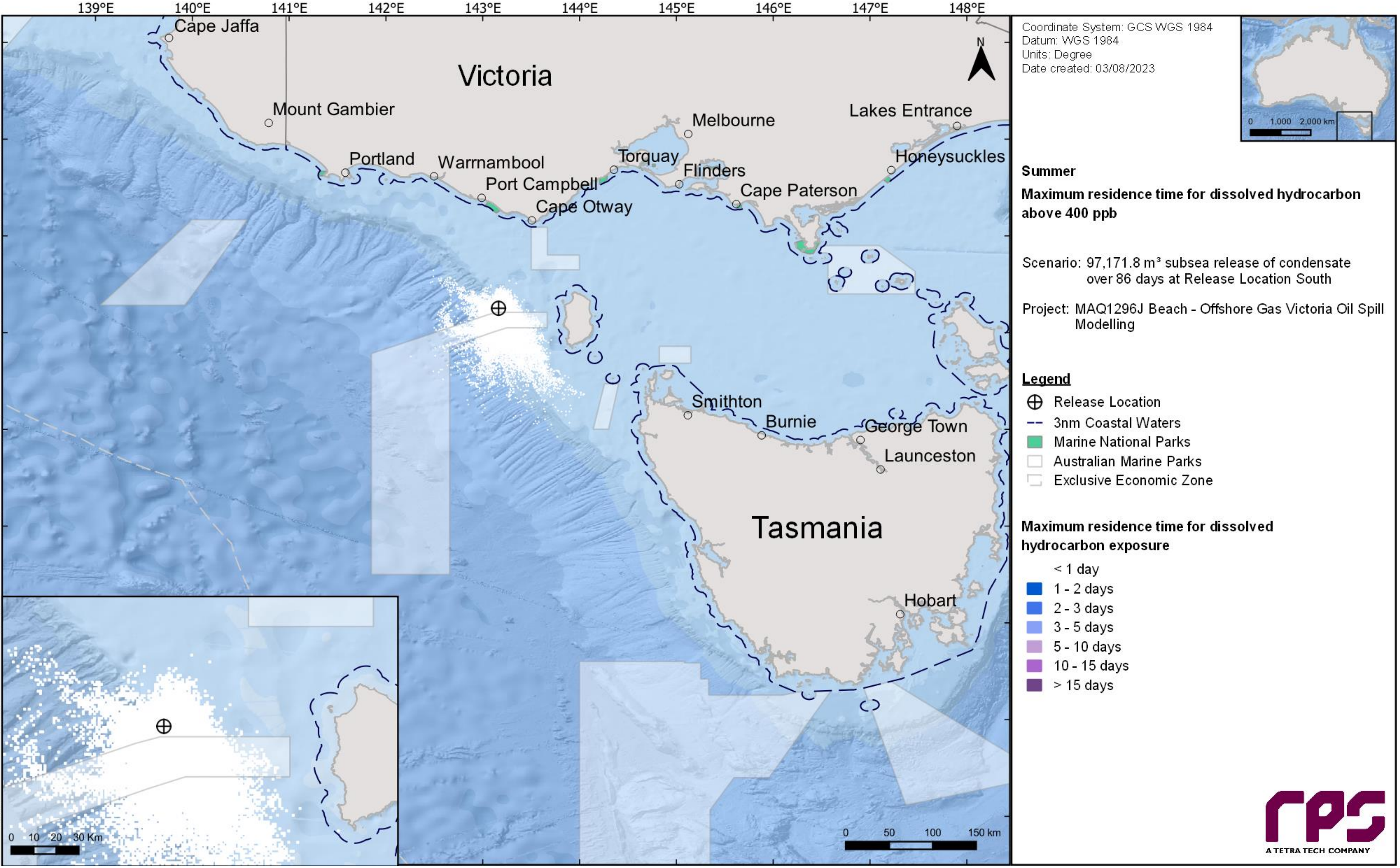


Figure 11.16 Maximum residence time for dissolved hydrocarbon exposure above 400 ppb, at 0-10 m below the sea surface in the event of a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during summer conditions.

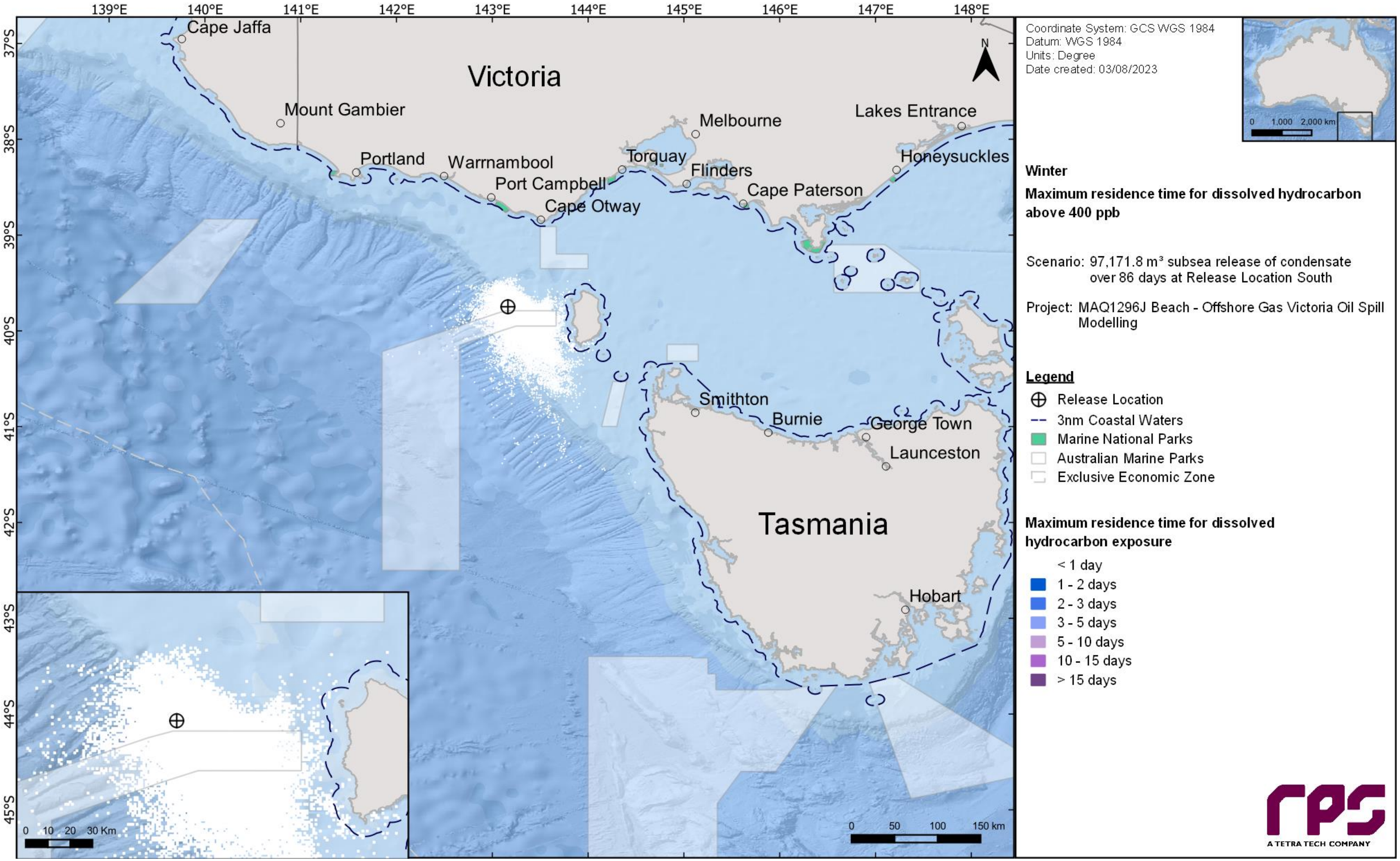


Figure 11.17 Maximum residence time for dissolved hydrocarbon exposure above 400 ppb, at 0-10 m below the sea surface in the event of a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during winter conditions.

11.1.4.2 Entrained Hydrocarbons

Table 11-8 presents the probability of exposure to individual receptors from entrained hydrocarbons in the 0-10 m depth layer for the summer and winter conditions.

Outside of the receptors that the Release Location South resides within (refer to Table 10-2), the highest concentration of entrained hydrocarbon was predicted for Pygmy Blue Whale - Known Foraging Area (1summer –,1,454 ppb, winter – 1,464 ppb). The same receptor, along with Pygmy Blue Whale - Known Foraging Area, White-faced Storm-petrel – Foraging and West Tasmania Canyons also presented the highest probability of low entrained hydrocarbon exposure (100% during summer and winter).

Table 11-9 presents the predicted minimum time to entrained hydrocarbon exposure and maximum residence time for entrained hydrocarbon exposure to individual receptors in the 0-10 m depth layer, for all seasonal conditions and all thresholds assessed.

Figure 11-18 and Figure 11-19 presents the zones of potential entrained hydrocarbon exposure for the 0-10 m depth layer, for each threshold assessed under summer and winter conditions, respectively.

Figure 11-20 to Figure 11-23 presents the maximum residence time of entrained hydrocarbon exposure for the NOPSEMA thresholds in summer and winter.

Table 11-8 **Probability of entrained hydrocarbons exposure to marine based receptors in the 0–10 m depth layer. Results are based on a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations per season.**

Receptor		Summer (November through to March)			Winter (April to October)		
		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure	
			Low	High		Low	High
AMP	Apollo	30	9	-	31	14	-
	Beagle	10	1	-	10	-	-
	Boags	15	9	-	18	10	-
	Franklin	35	65	-	36	62	-
	Tasman Fracture	11	4	-	8	-	-
	Zeehan	1,058	100	100	1,058	100	100
BIA	Antipodean Albatross - Foraging*	4,558	100	100	5,104	100	100
	Australasian Gannet - Foraging	40	88	-	59	98	-
	Black-browed Albatross - Foraging*	4,558	100	100	5,104	100	100
	Black-faced Cormorant - Foraging	85	47	-	164	96	7
	Bullers Albatross - Foraging*	4,558	100	100	5,104	100	100
	Campbell Albatross – Foraging*	4,558	100	100	5,104	100	100
	Common Diving-petrel – Foraging*	4,558	100	100	5,104	100	100
	Indian Yellow-nosed Albatross – Foraging*	4,558	100	100	5,104	100	100
	Little Penguin - Foraging	85	53	-	164	91	6
	Pygmy Blue Whale – Distribution*	4,558	100	100	5,104	100	100
	Pygmy Blue Whale – Foraging*	4,558	100	100	5,104	100	100
	Pygmy Blue Whale - Foraging (annual high use area)*	4,558	100	100	5,104	100	100
	Pygmy Blue Whale - Known Foraging Area	1,454	100	100	1,464	100	100
	Short-tailed Shearwater - Breeding	16	15	-	11	2	-
	Short-tailed Shearwater – Foraging*	4,558	100	100	5,104	100	100
	Shy Albatross - Breeding	11	4	-	9	-	-
	Shy Albatross – Foraging*	4,558	100	100	5,104	100	100
	Soft-plumaged Petrel - Foraging	29	31	-	28	16	-

Receptor		Summer (November through to March)			Winter (April to October)		
		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure	
			Low	High		Low	High
	Sooty Shearwater - Foraging	22	9	-	17	13	-
	Southern Right Whale - Connecting habitat	96	77	-	176	100	17
	Southern Right Whale - Known Core Range*	4,558	100	100	5,104	100	100
	Wandering Albatross – Foraging*	4,558	100	100	5,104	100	100
	Wedge-tailed Shearwater – Foraging*	4,558	100	100	5,104	100	100
	White Shark – Distribution*	4,558	100	100	5,104	100	100
	White Shark - Foraging	103	88	1	176	100	19
	White-faced Storm-petrel - Foraging	161	100	12	190	100	25
EEZ	Australian*	4,558	100	100	5,104	100	100
IBRA	Flinders	10	-	-	10	1	-
	King Island	96	75	-	175	100	15
	Tasmanian West	22	18	-	16	13	-
IMCRA	Boags	16	15	-	21	13	-
	Central Bass Strait	36	44	-	87	77	-
	Central Victoria	3	-	-	14	4	-
	Davey	22	9	-	17	13	-
	Flinders	11	1	-	13	3	-
	Franklin	56	84	-	38	65	-
	Otway*	4,558	100	100	5,104	100	100
	Twofold Shelf	6	-	-	10	1	-
KEF	West Tasmania Canyons	787	100	100	666	100	100
NP	Kent Group	6	-	-	11	1	-
RSB	Bell Reef	25	73	-	41	91	-
SHORE	Albatross Island	14	9	-	10	1	-
	Black Pyramid	30	42	-	29	56	-
	Circular Head	14	6	-	10	-	-
	De Witt Island	13	7	-	14	2	-
	Huon Valley	10	1	-	11	1	-

Receptor		Summer (November through to March)			Winter (April to October)		
		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure	
			Low	High		Low	High
	Kent Island Group	6	-	-	10	1	-
	King Island	96	75	-	175	100	15
	Maatsuyker Island	22	9	-	16	13	-
	Reid Rock	32	71	-	58	90	-
	Round Top Island	11	5	-	10	1	-
	West Coast	19	18	-	14	7	-
State Waters	Tasmania	103	86	1	190	100	24
	Victoria	3	-	-	11	1	-

*The release location resides within the receptor boundaries.

Table 11-9 **Predicted minimum time to entrained hydrocarbon exposure and maximum residence time for entrained hydrocarbon exposure to individual receptors in the 0-10 m depth layer. Results are based on a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill trajectories per season.**

Receptor		Summer (November through to March)				Winter (April to October)			
		Minimum time before entrained hydrocarbon exposure (days)		Maximum residence time for entrained hydrocarbon exposure (days)		Minimum time before entrained hydrocarbon exposure (days)		Maximum residence time for entrained hydrocarbon exposure (days)	
		Low	High	Low	High	Low	High	Low	High
AMP	Apollo	42	-	3	-	13	-	4	-
	Beagle	98	-	< 1	-	-	-	< 1	-
	Boags	47	-	< 1	-	16	-	< 1	-
	Franklin	13	-	4	-	7	-	4	-
	Tasman Fracture	49	-	< 1	-	-	-	-	-
	Zeehan	< 1	< 1	42	7	< 1	< 1	29	5
BIA	Antipodean Albatross - Foraging*	< 1	< 1	43	15	< 1	< 1	94	15
	Australasian Gannet - Foraging	6	-	6	-	5	-	8	-
	Black-browed Albatross - Foraging*	< 1	< 1	43	15	< 1	< 1	94	15
	Black-faced Cormorant - Foraging	6	-	40	-	4	13	75	1
	Bullers Albatross - Foraging*	< 1	< 1	43	15	< 1	< 1	94	15
	Campbell Albatross – Foraging*	< 1	< 1	43	15	< 1	< 1	94	15
	Common Diving-petrel – Foraging*	< 1	< 1	43	15	< 1	< 1	94	15
	Indian Yellow-nosed Albatross – Foraging*	< 1	< 1	43	15	< 1	< 1	94	15
	Little Penguin - Foraging	13	-	39	-	4	22	74	1
	Pygmy Blue Whale – Distribution*	< 1	< 1	43	15	< 1	< 1	94	15
	Pygmy Blue Whale – Foraging*	< 1	< 1	43	15	< 1	< 1	94	15
	Pygmy Blue Whale - Foraging (annual high use area)*	< 1	< 1	33	15	< 1	< 1	65	15
	Pygmy Blue Whale - Known Foraging Area	< 1	< 1	43	7	< 1	< 1	94	7
	Short-tailed Shearwater - Breeding	31	-	1	-	63	-	< 1	-
	Short-tailed Shearwater – Foraging*	< 1	< 1	43	15	< 1	< 1	94	15
	Shy Albatross - Breeding	49	-	< 1	-	-	-	-	-
	Shy Albatross – Foraging*	< 1	< 1	43	15	< 1	< 1	94	15
	Soft-plumaged Petrel - Foraging	11	-	4	-	10	-	2	-

Receptor		Summer (November through to March)				Winter (April to October)			
		Minimum time before entrained hydrocarbon exposure (days)		Maximum residence time for entrained hydrocarbon exposure (days)		Minimum time before entrained hydrocarbon exposure (days)		Maximum residence time for entrained hydrocarbon exposure (days)	
		Low	High	Low	High	Low	High	Low	High
	Sooty Shearwater - Foraging	32	-	4	-	33	-	2	-
	Southern Right Whale - Connecting habitat	8	-	39	-	4	8	92	4
	Southern Right Whale - Known Core Range*	< 1	< 1	40	15	< 1	< 1	94	15
	Wandering Albatross – Foraging*	< 1	< 1	43	15	< 1	< 1	94	15
	Wedge-tailed Shearwater – Foraging*	< 1	< 1	43	15	< 1	< 1	77	15
	White Shark – Distribution*	< 1	< 1	43	15	< 1	< 1	94	15
	White Shark - Foraging	4	34	19	< 1	4	6	57	2
	White-faced Storm-petrel - Foraging	2	7	40	< 1	1	3	94	4
EEZ	Australian*	< 1	< 1	43	15	< 1	< 1	94	15
IBRA	Flinders	-	-	-	-	59	-	0	-
	King Island	8	-	39	-	4	8	89	4
	Tasmanian West	30	-	4	-	27	-	2	-
IMCRA	Boags	35	-	< 1	-	16	-	< 1	-
	Central Bass Strait	14	-	2	-	4	-	5	-
	Central Victoria	-	-	-	-	29	-	< 1	-
	Davey	32	-	4	-	35	-	2	-
	Flinders	67	-	< 1	-	30	-	< 1	-
	Franklin	9	-	4	-	7	-	4	-
	Otway*	< 1	< 1	40	15	< 1	< 1	94	15
	Twofold Shelf	-	-	-	-	59	-	< 1	-
KEF	West Tasmania Canyons	< 1	< 1	34	5	< 1	< 1	21	3
NP	Kent Group	-	-	-	-	59	-	< 1	-
RSB	Bell Reef	12	-	2	-	6	-	3	-
SHORE	Albatross Island	46	-	< 1	-	46	-	< 1	-
	Black Pyramid	14	-	1	-	10	-	2	-
	Circular Head	58	-	< 1	-	-	-	-	-
	De Witt Island	49	-	< 1	-	65	-	< 1	-
	Huon Valley	97	-	< 1	-	39	-	< 1	-

Receptor		Summer (November through to March)				Winter (April to October)			
		Minimum time before entrained hydrocarbon exposure (days)		Maximum residence time for entrained hydrocarbon exposure (days)		Minimum time before entrained hydrocarbon exposure (days)		Maximum residence time for entrained hydrocarbon exposure (days)	
		Low	High	Low	High	Low	High	Low	High
	Kent Island Group	-	-	-	-	59	-	< 1	-
	King Island	8	-	39	-	4	9	89	4
	Maatsuyker Island	32	-	4	-	38	-	2	-
	Reid Rock	12	-	3	-	6	-	3	-
	Round Top Island	50	-	< 1	-	66	-	< 1	-
	West Coast	30	-	3	-	27	-	< 1	-
State Waters	Tasmania	7	34	40	< 1	3	6	94	4
	Victoria	-	-	-	-	35	-	< 1	-

*The release location resides within the receptor boundaries.

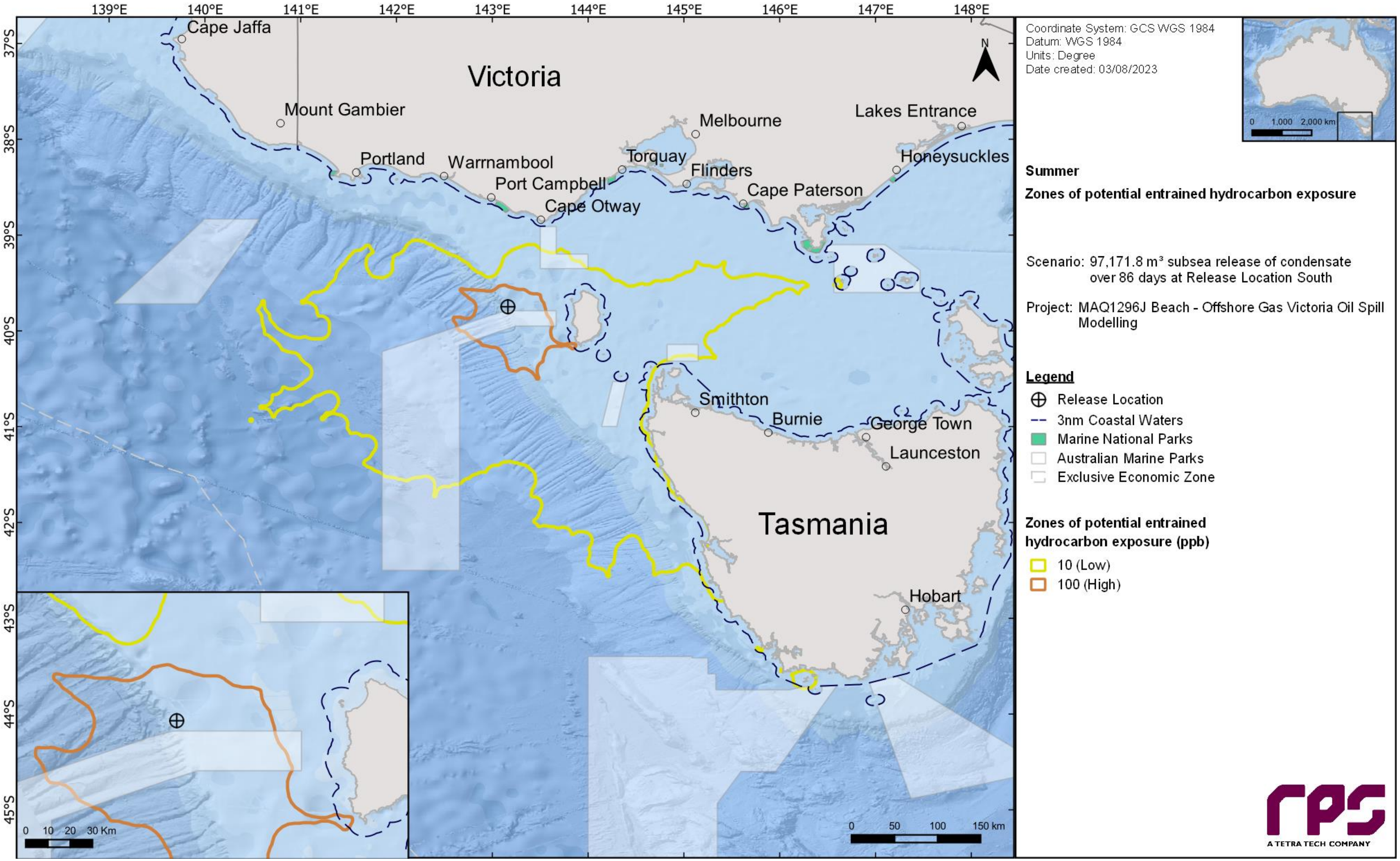


Figure 11-18 Zones of potential entrained hydrocarbon exposure at 0-10 m below the sea surface in the event of a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during summer conditions.

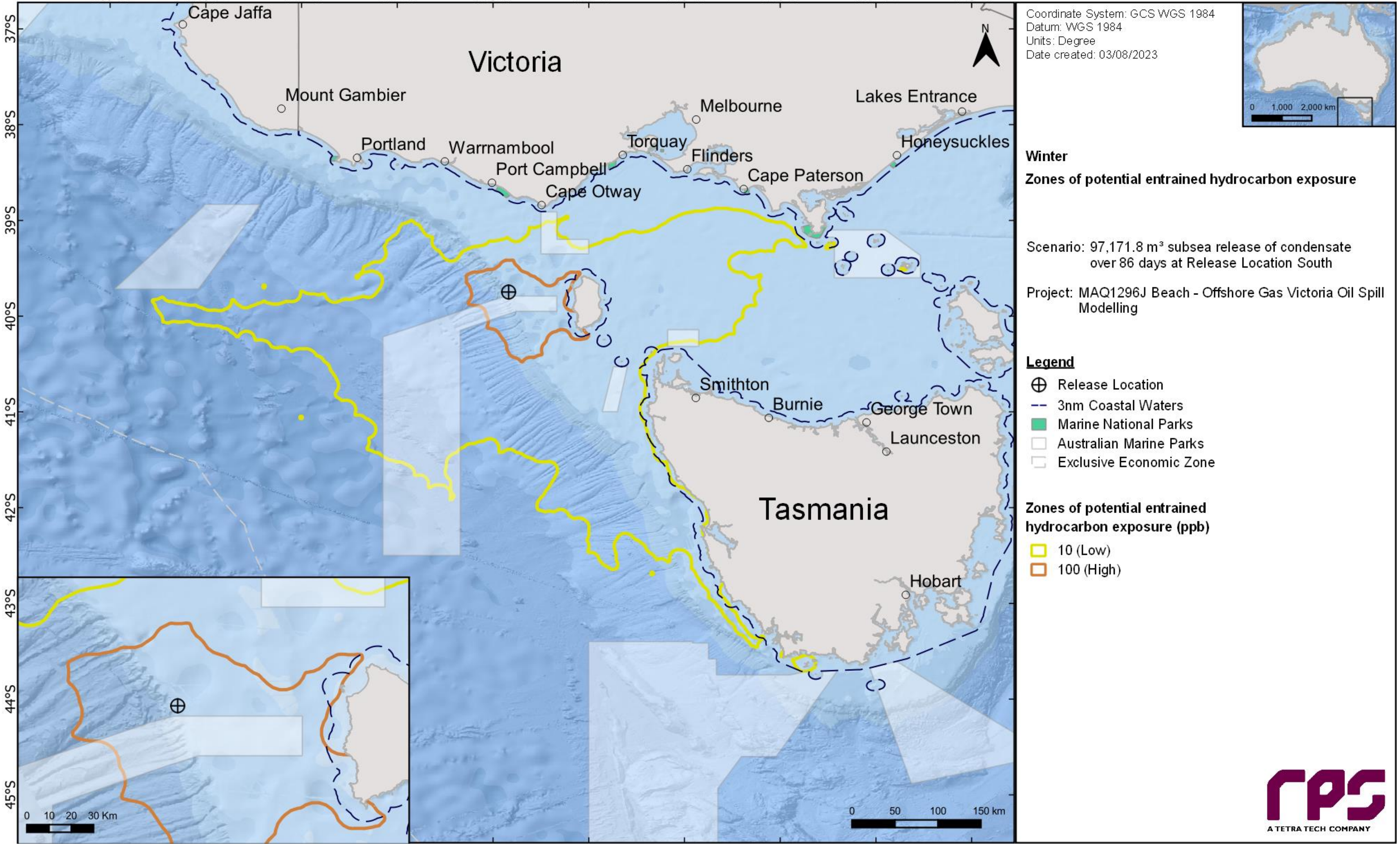


Figure 11-19 Zones of potential entrained hydrocarbon exposure at 0-10 m below the sea surface in the event of a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during winter conditions.

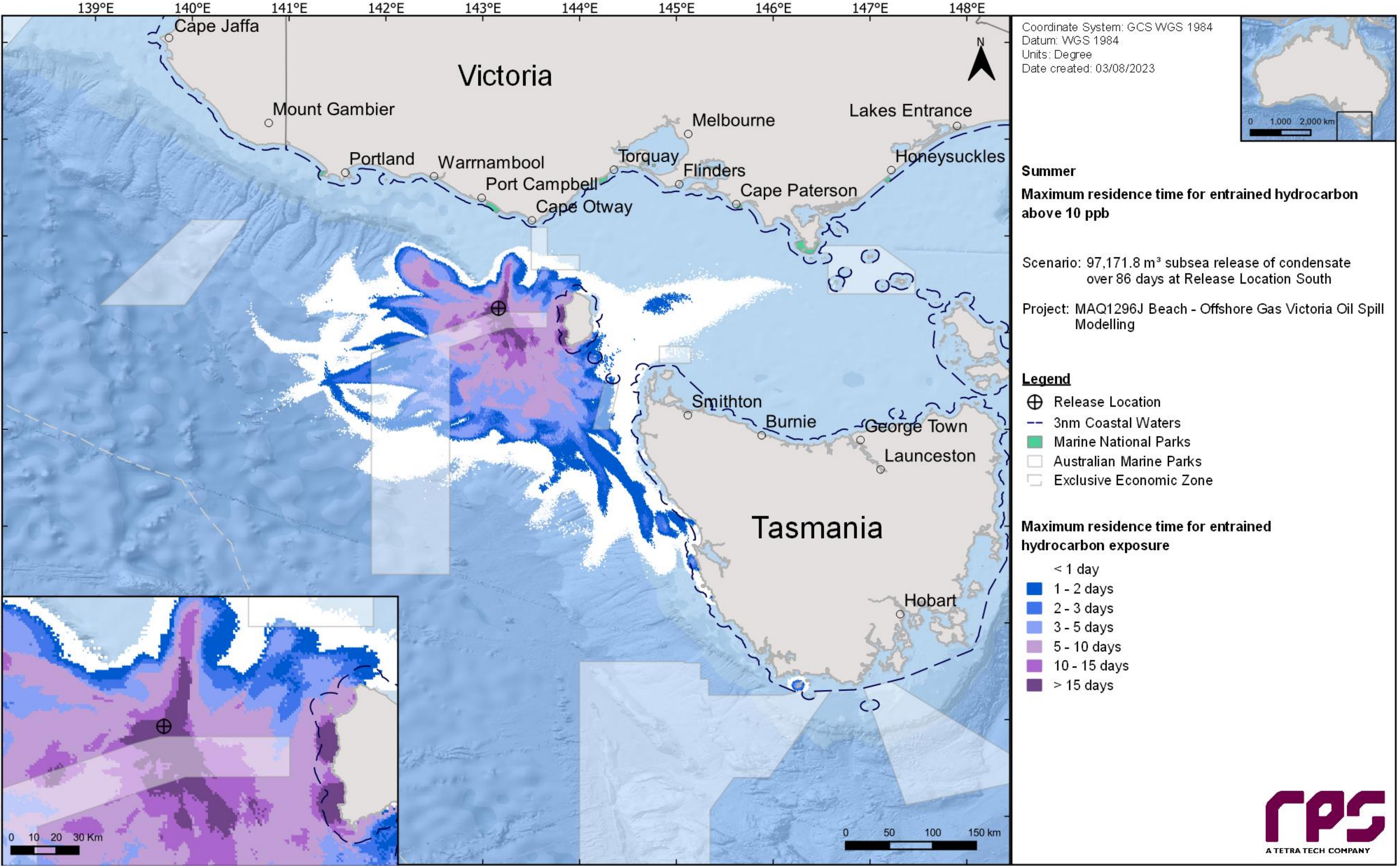


Figure 11-20 Maximum residence time for entrained hydrocarbon exposure above 10 ppb, at 0-10 m below the sea surface in the event of a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during summer conditions.

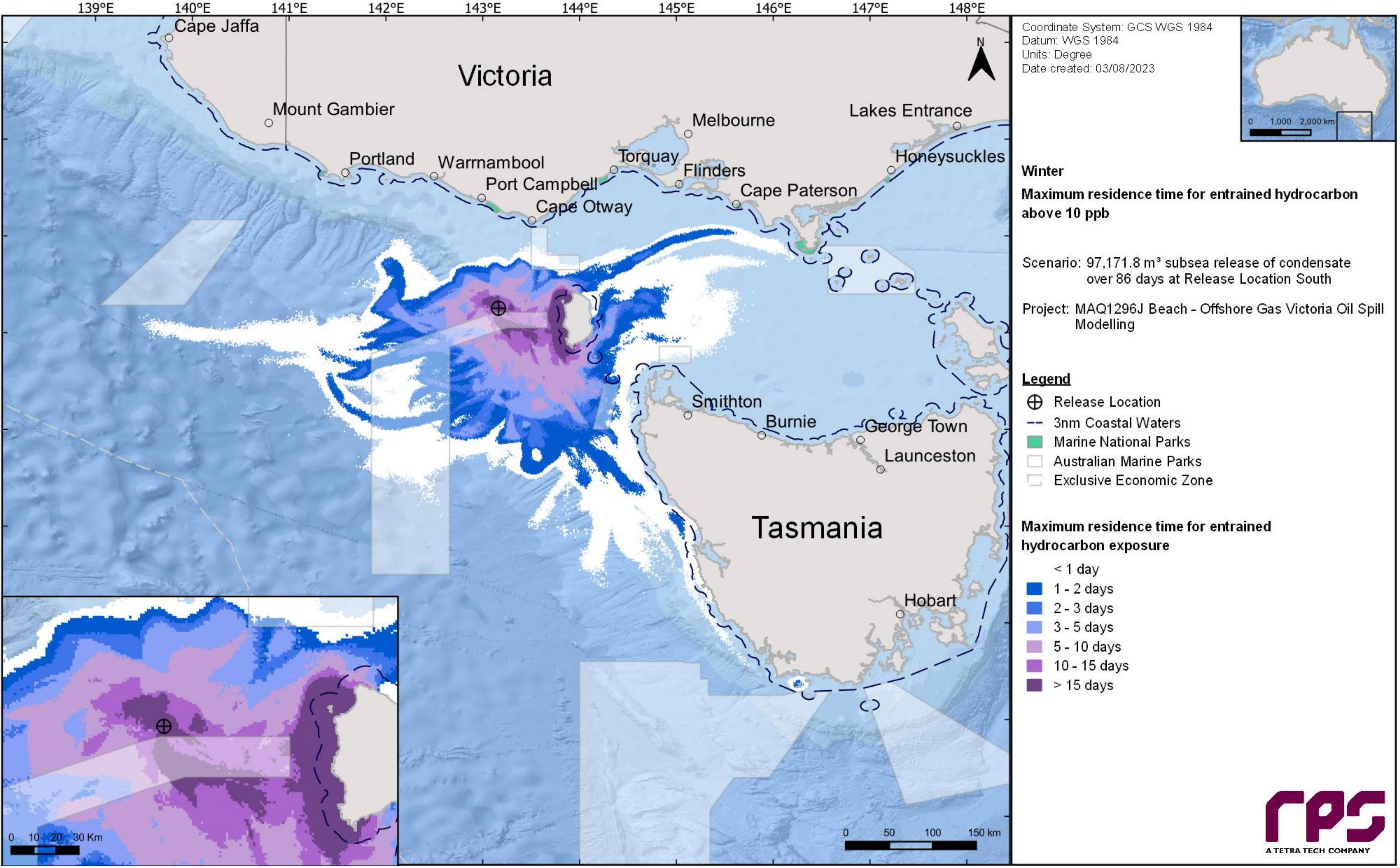


Figure 11-21 Maximum residence time for entrained hydrocarbon exposure above 10 ppb, at 0-10 m below the sea surface in the event of a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during winter conditions.

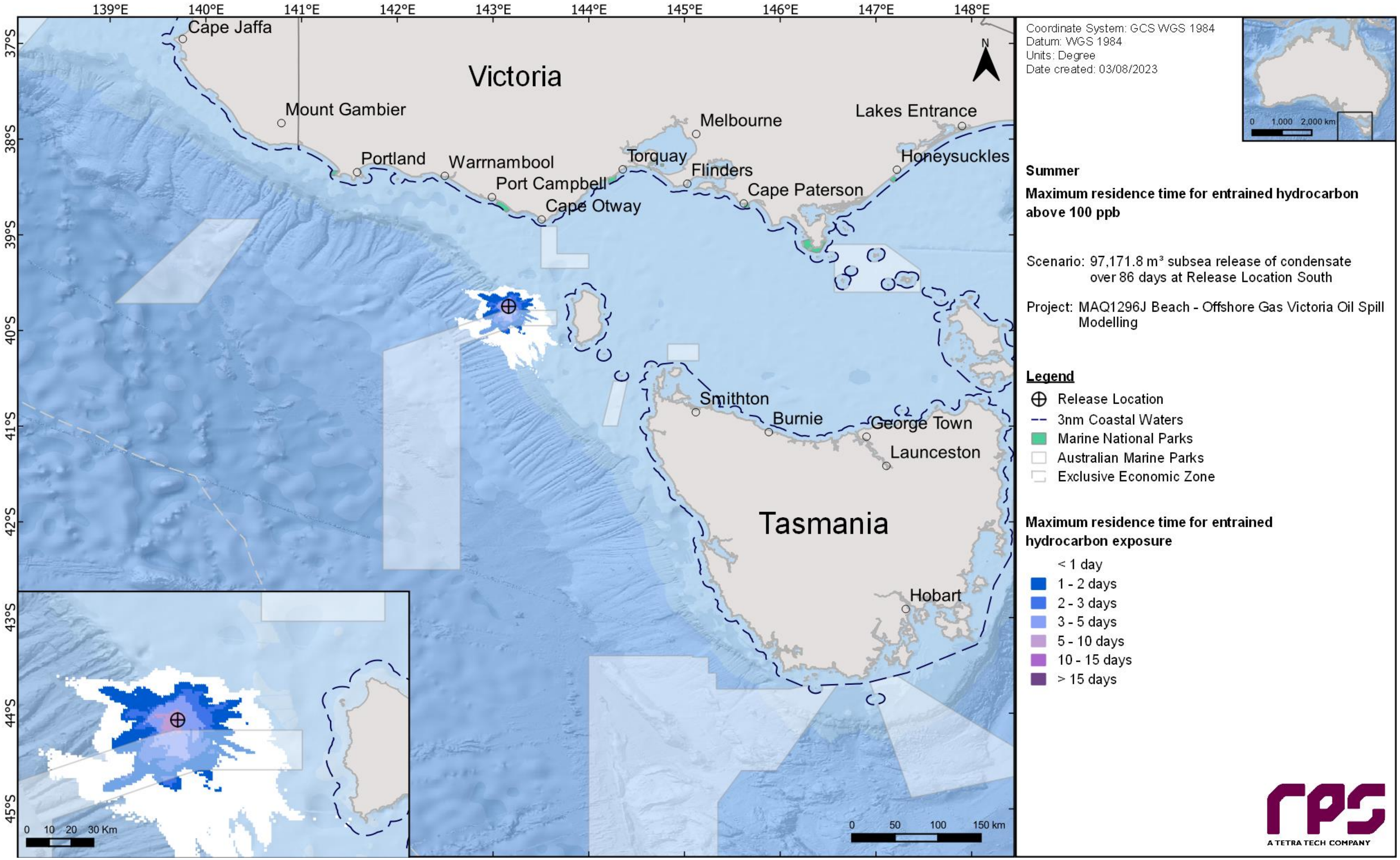


Figure 11-22 Maximum residence time for entrained hydrocarbon exposure above 100 ppb, at 0-10 m below the sea surface in the event of a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during summer conditions.

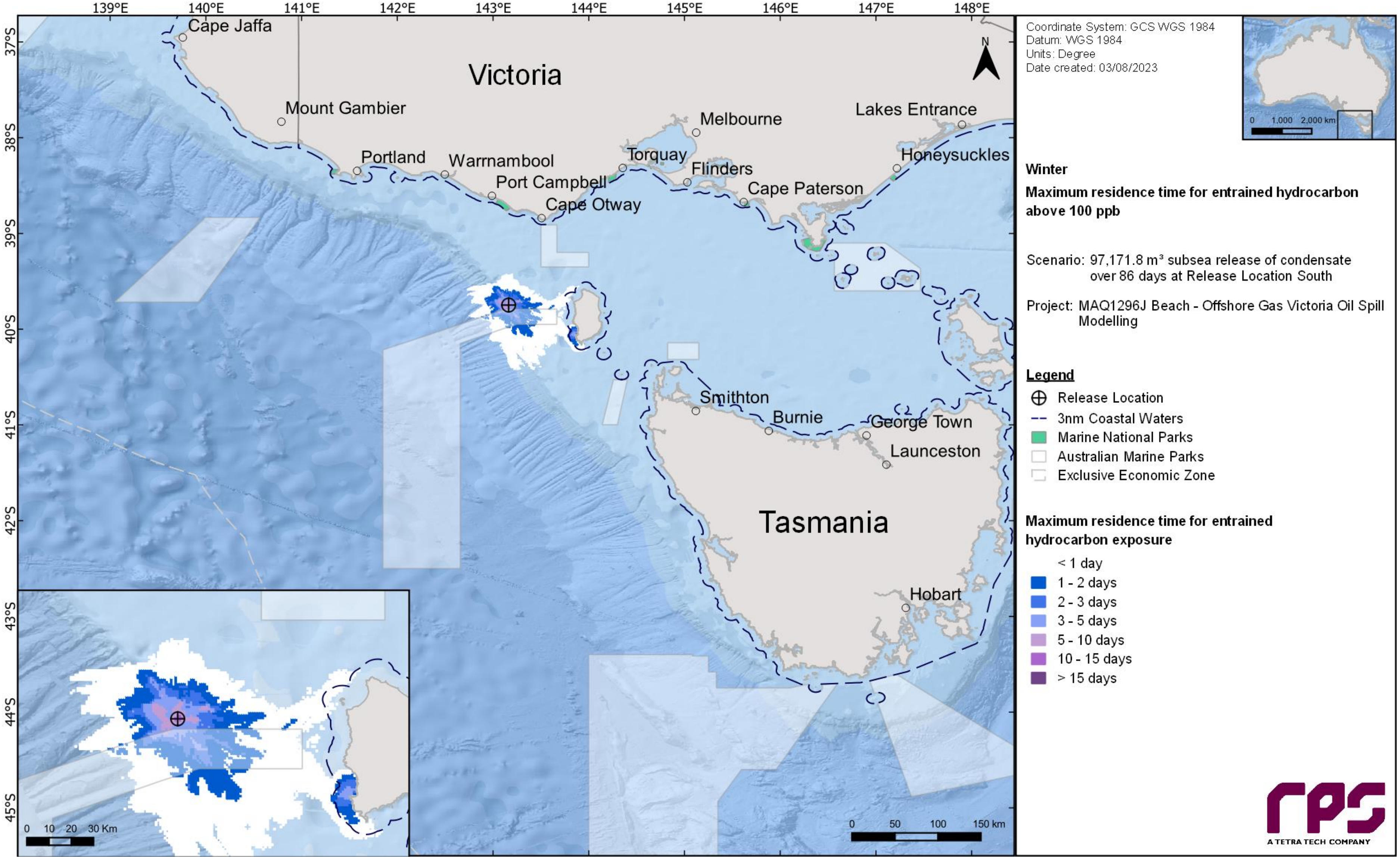


Figure 11-23 Maximum residence time for entrained hydrocarbon exposure above 100 ppb, at 0-10 m below the sea surface in the event of a 97,171.8 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location South. The results were calculated from 100 spill simulations during winter conditions.

12 RESULTS – LOSS OF CONTAINMENT FROM VESSEL COLLISION AT THE RELEASE LOCATION SOUTH FIELD

This scenario examined a 603.7 m^3 surface release of marine diesel from a loss of containment from a vessel collision at the Release Location South field. A total of 200 spill simulations were run (i.e., 100 spills per season) and tracked for 30 days. The results for all 100 simulations per season were combined and are presented on a seasonal basis (i.e., summer and winter).

.

12.1 Stochastic Analysis

12.1.1 Area of Exposure

Figure 12-1 presents the combined area of potential exposure for surface, shoreline, entrained and dissolved, by overlaying the results from all 200 simulations (i.e., 100 per season) during summer and winter conditions.

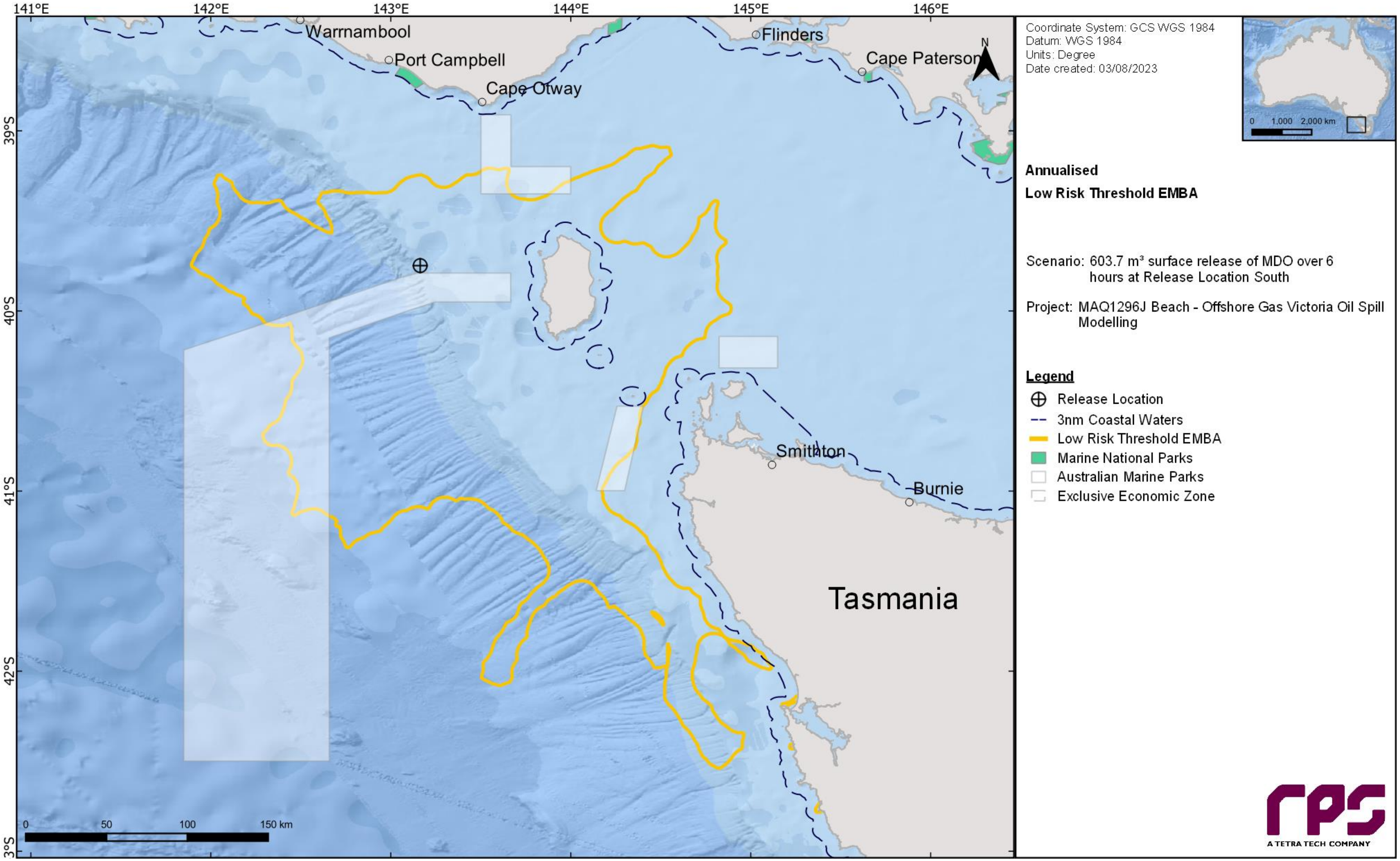


Figure 12-1 Predicted area of exposure for low thresholds produced by overlaying the results from all 200 simulations, resulting from a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field during summer and winter conditions.

12.1.2 Floating Oil Exposure

Table 12-1 summarises the maximum distance travelled by floating oil on the sea surface at each threshold. The maximum distance from the release location to the low (1–10 g/m^2), moderate (10–50 g/m^2) and high (> 50g/ m^2) exposure zones was 57 km (south-southeast) during winter conditions, and 48 km (south-southeast) during winter conditions and 8 km (south-southeast) during both seasons respectively.

Table 12-2 summarises the potential floating oil exposure to individual receptors during the summer and winter conditions. Outside of the receptors that the Release Location South resides within (refer to Table 10-2), floating oil exposure above the low threshold was predicted at the Zeehan AMP (38% summer and 39% winter) Pygmy Blue Whale - Known Foraging Area BIA (52% summer and 50% winter) and the West Tasmania Canyons KEF (13% summer and 15% winter).

Table 12-3 presents the maximum residence time of floating oil exposure for each individual grid cell within each individual receptor during summer and winter.

Figure 12-2 and Figure 12-3 present the zones of potential floating oil exposure for all thresholds under summer and winter conditions, respectively.

Figure 12-4 to Figure 12-9 present the maximum residence time of floating oil exposure for the NOPSEMA thresholds during summer and winter, respectively.

Table 12-1 Maximum distance and direction from the release location to the edge of floating oil exposure. Results are based on a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations per season.

Season	Distance and direction travelled	Zones of potential floating oil exposure		
		Low	Moderate	High
Summer	Maximum distance (km) from release location	31	24	8
	Maximum distance (km) from release location (99th percentile)	29	23	8
	Direction	SE	SSE	SSE
Winter	Maximum distance (km) from release location	57	48	8
	Maximum distance (km) from release location (99th percentile)	54	46	8
	Direction	SSE	SSE	SSE

Table 12-2 Summary of the potential floating oil exposure to individual receptors. Results are based on a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations per season.

Receptor		Summer (November through to March)						Winter (April to October)					
		Probability of floating oil exposure (%)			Minimum time before floating oil exposure (days)			Probability of floating oil exposure (%)			Minimum time before floating oil exposure (days)		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
AMP	Zeehan	38	12	4	< 1	< 1	< 1	39	16	3	< 1	< 1	< 1
BIA	Antipodean Albatross - Foraging*	100	100	71	< 1	< 1	< 1	100	100	64	< 1	< 1	< 1
	Black-browed Albatross - Foraging*	100	100	71	< 1	< 1	< 1	100	100	64	< 1	< 1	< 1
	Bullers Albatross - Foraging*	100	100	71	< 1	< 1	< 1	100	100	64	< 1	< 1	< 1
	Campbell Albatross – Foraging*	100	100	71	< 1	< 1	< 1	100	100	64	< 1	< 1	< 1
	Common Diving-petrel – Foraging*	100	100	71	< 1	< 1	< 1	100	100	64	< 1	< 1	< 1
	Indian Yellow-nosed Albatross – Foraging*	100	100	71	< 1	< 1	< 1	100	100	64	< 1	< 1	< 1
	Pygmy Blue Whale – Distribution*	100	100	71	< 1	< 1	< 1	100	100	64	< 1	< 1	< 1
	Pygmy Blue Whale – Foraging*	100	100	71	< 1	< 1	< 1	100	100	64	< 1	< 1	< 1
	Pygmy Blue Whale - Foraging (annual high use area)*	100	100	71	< 1	< 1	< 1	100	100	64	< 1	< 1	< 1
	Pygmy Blue Whale - Known Foraging Area	52	19	8	< 1	< 1	< 1	50	26	8	< 1	< 1	< 1
	Short-tailed Shearwater – Foraging*	100	100	71	< 1	< 1	< 1	100	100	64	< 1	< 1	< 1
	Shy Albatross – Foraging*	100	100	71	< 1	< 1	< 1	100	100	64	< 1	< 1	< 1
	Southern Right Whale - Known Core Range*	100	100	71	< 1	< 1	< 1	100	100	64	< 1	< 1	< 1
	Wandering Albatross – Foraging*	100	100	71	< 1	< 1	< 1	100	100	64	< 1	< 1	< 1
	Wedge-tailed Shearwater – Foraging*	100	100	71	< 1	< 1	< 1	100	100	64	< 1	< 1	< 1
	White Shark – Distribution*	100	100	71	< 1	< 1	< 1	100	100	64	< 1	< 1	< 1
EEZ	Australian*	100	100	71	< 1	< 1	< 1	100	100	64	< 1	< 1	< 1
IMCRA	Otway*	100	100	71	< 1	< 1	< 1	100	100	64	< 1	< 1	< 1
KEF	West Tasmania Canyons	13	4	-	< 1	< 1	-	15	5	-	< 1	< 1	-

*The release location resides within the receptor boundaries.

Table 12-3 Summary of the maximum residence time of floating oil exposure for each individual grid cell within each individual receptor. Results are based on a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations per season.

Receptor		Summer (November through to March)			Winter (April to October)		
		Maximum residence time of floating oil exposure (days)			Maximum residence time of floating oil exposure (days)		
		Low	Moderate	High	Low	Moderate	High
AMP	Zeehan	1	< 1	< 1	1	< 1	< 1
BIA	Antipodean Albatross - Foraging*	2	2	1	1	1	< 1
	Black-browed Albatross - Foraging*	2	2	1	1	1	< 1
	Bullers Albatross - Foraging*	2	2	1	1	1	< 1
	Campbell Albatross – Foraging*	2	2	1	1	1	< 1
	Common Diving-petrel – Foraging*	2	2	1	1	1	< 1
	Indian Yellow-nosed Albatross – Foraging*	2	2	1	1	1	< 1
	Pygmy Blue Whale – Distribution*	2	2	1	1	1	< 1
	Pygmy Blue Whale – Foraging*	2	2	1	1	1	< 1
	Pygmy Blue Whale - Foraging (annual high use area)*	2	2	1	1	1	< 1
	Pygmy Blue Whale - Known Foraging Area	1	< 1	< 1	1	1	< 1
	Short-tailed Shearwater – Foraging*	2	2	1	1	1	< 1
	Shy Albatross – Foraging*	2	2	1	1	1	< 1
	Southern Right Whale - Known Core Range*	2	2	1	1	1	< 1
	Wandering Albatross – Foraging*	2	2	1	1	1	< 1
	Wedge-tailed Shearwater – Foraging*	2	2	1	1	1	< 1
	White Shark – Distribution*	2	2	1	1	1	< 1
EEZ	Australian*	2	2	1	1	1	< 1
IMCRA	Otway*	2	2	1	1	1	< 1
KEF	West Tasmania Canyons	< 1	< 1	-	< 1	< 1	-

*The release location resides within the receptor boundaries.

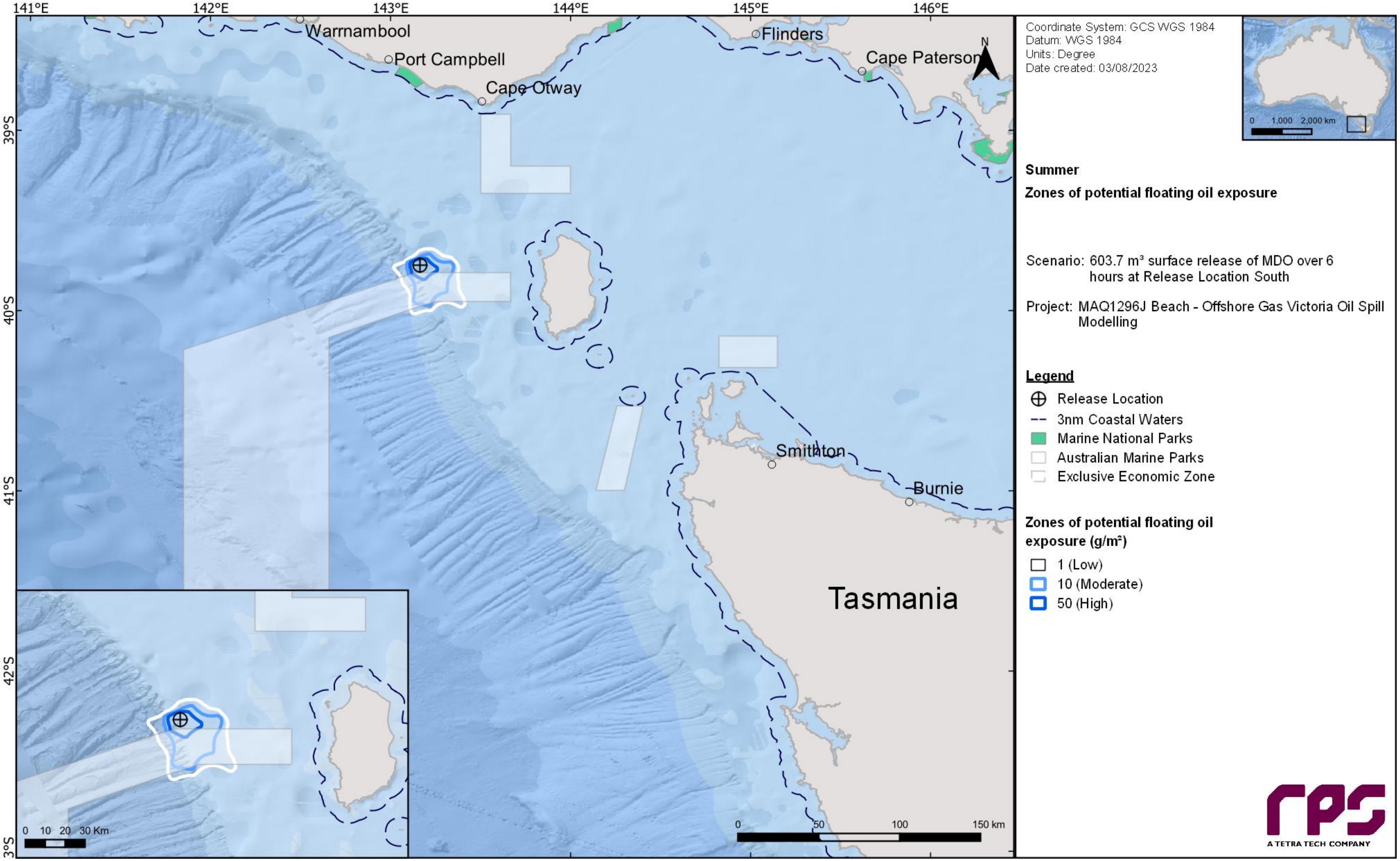


Figure 12-2 Zones of potential floating oil exposure in the event of a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during summer conditions.

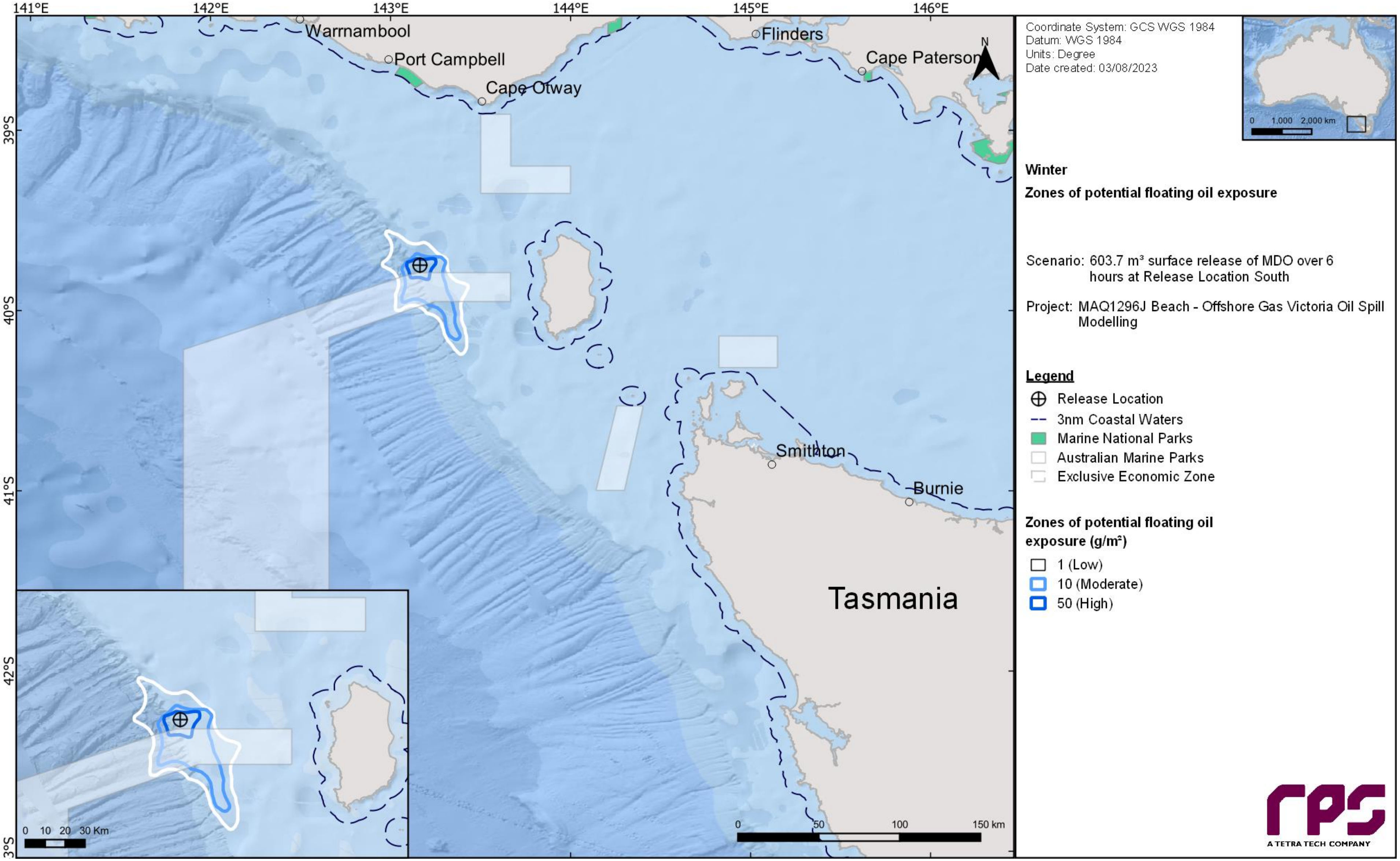


Figure 12-3 Zones of potential floating oil exposure in the event of a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during winter conditions.

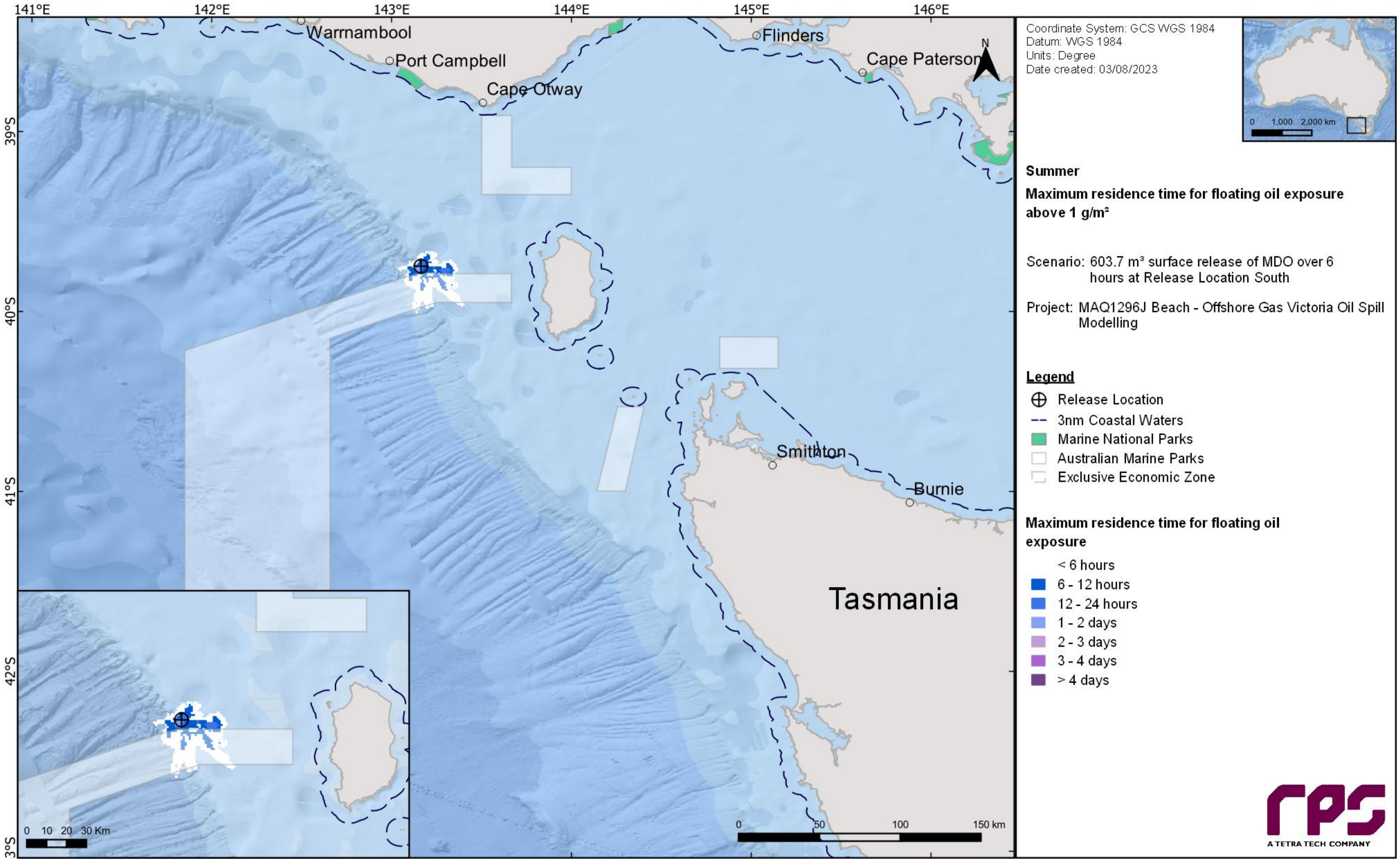


Figure 12-4 Maximum residence time of floating oil exposure above 1 g/m^2, in the event of 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during summer conditions.

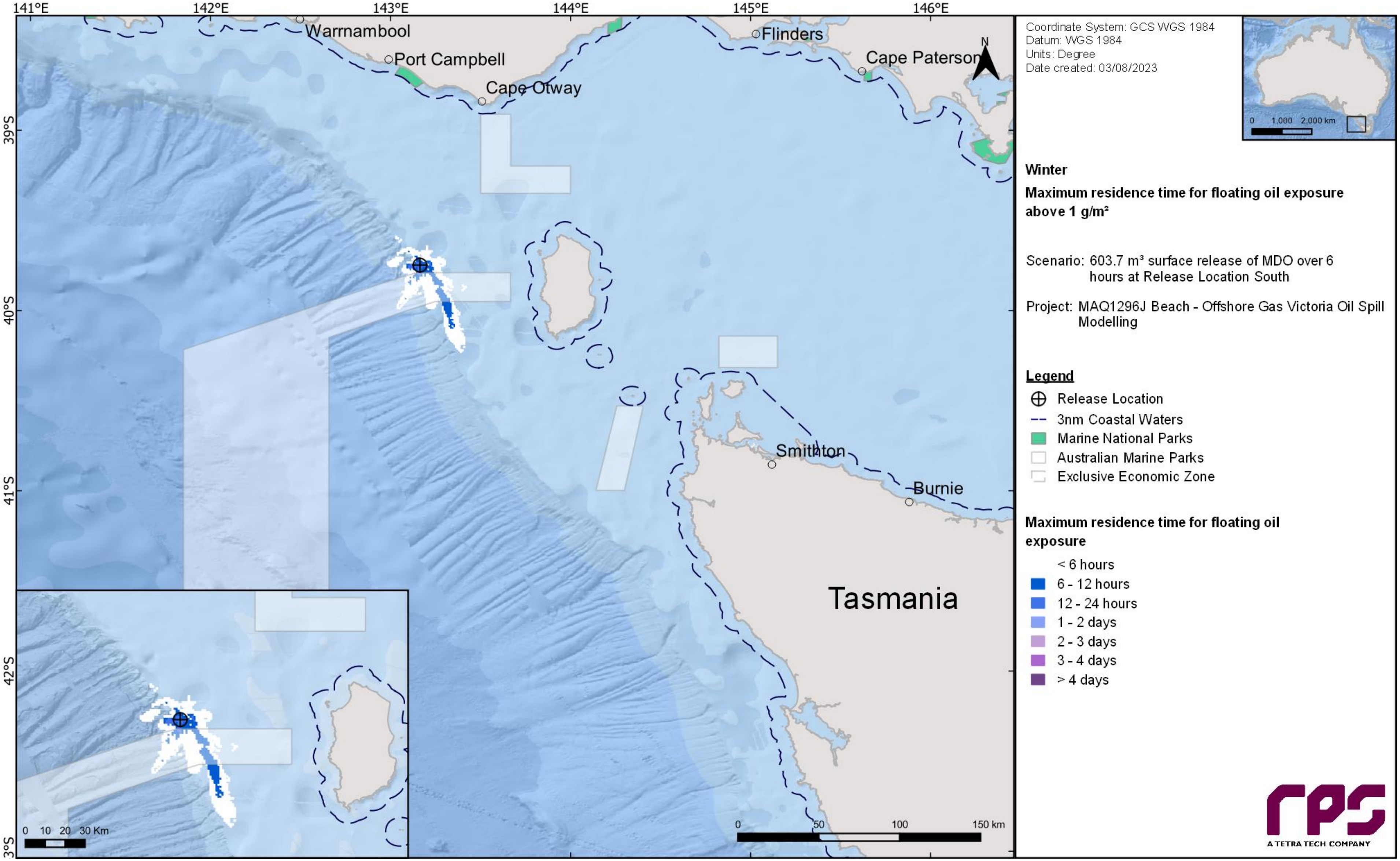


Figure 12-5 Maximum residence time of floating oil exposure above 1 g/m^2, in the event of 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during winter conditions.

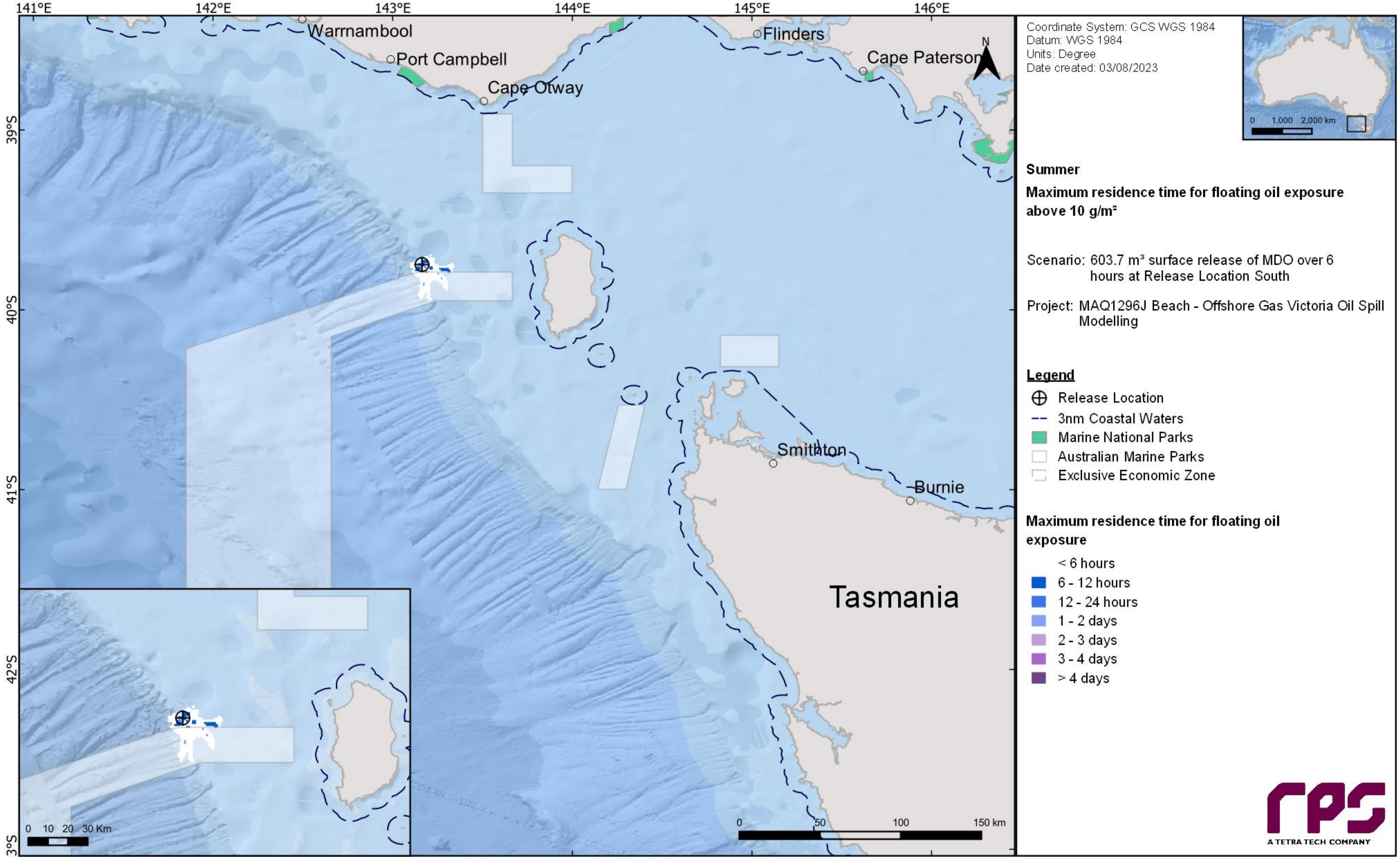


Figure 12-6 Maximum residence time of floating oil exposure above 10 g/m^2, in the event of 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during summer conditions.

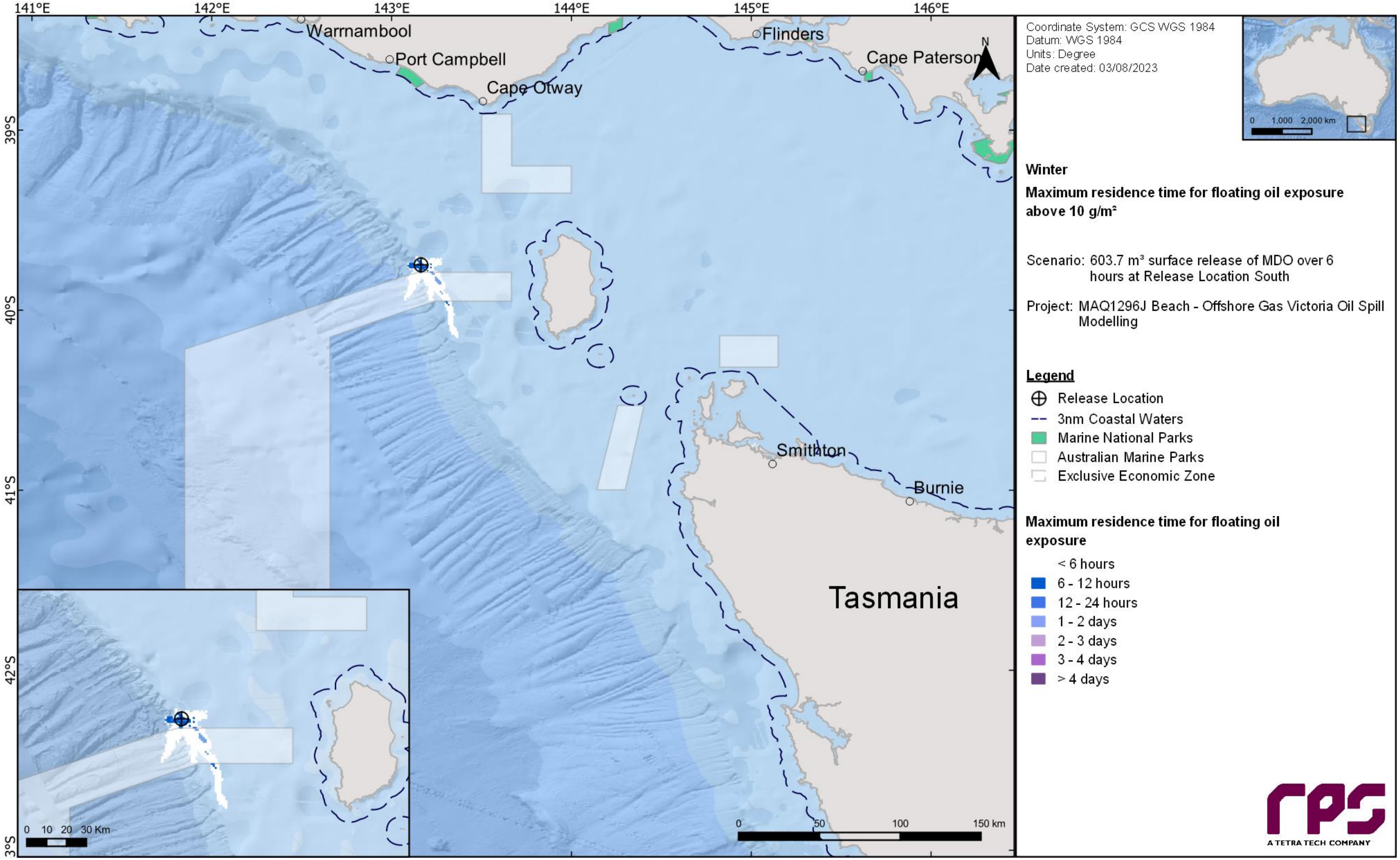


Figure 12-7 Maximum residence time of floating oil exposure above 10 g/m^2, in the event of 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during winter conditions.

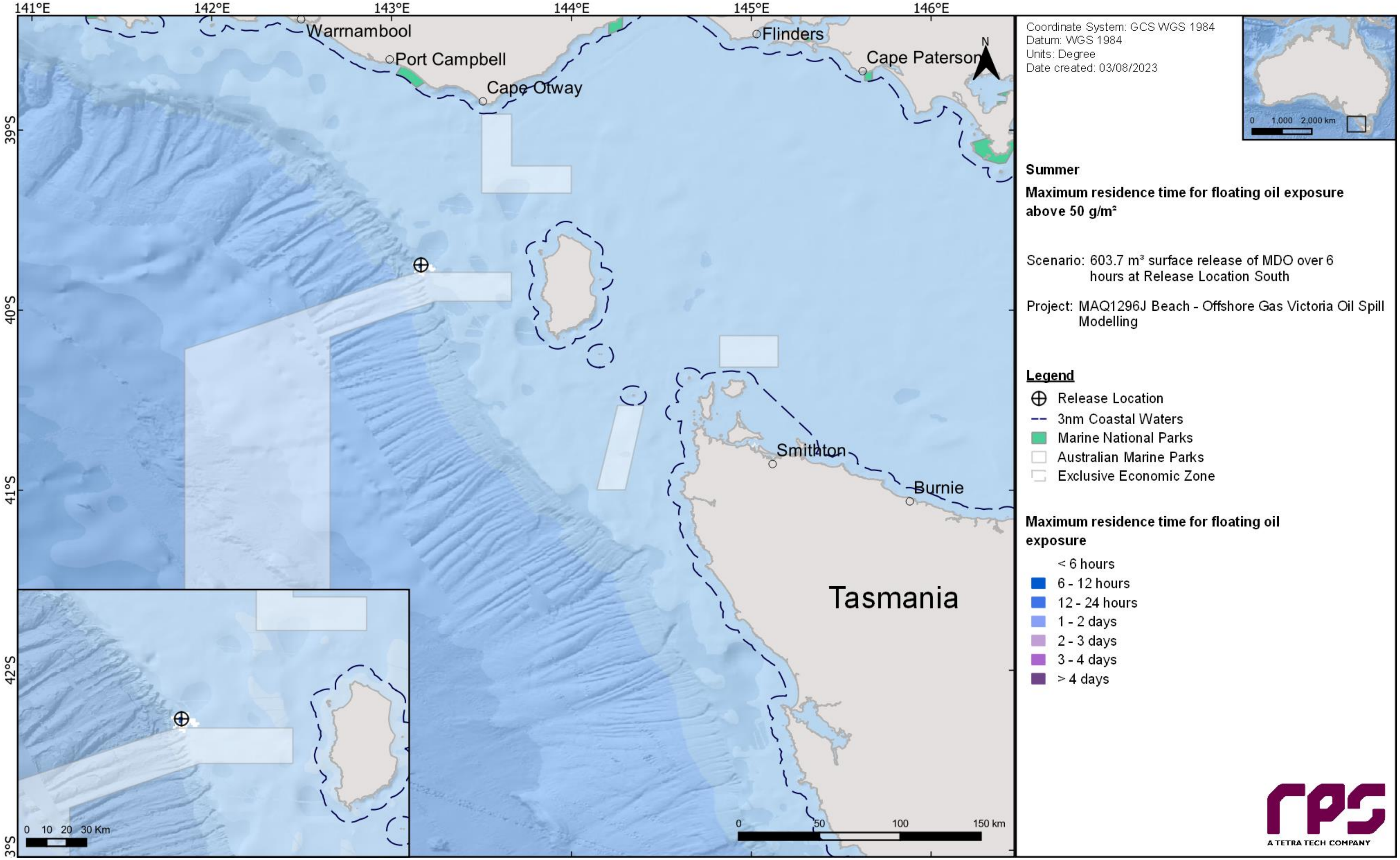


Figure 12-8 Maximum residence time of floating oil exposure above 50 g/m^2, in the event of 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during summer conditions.

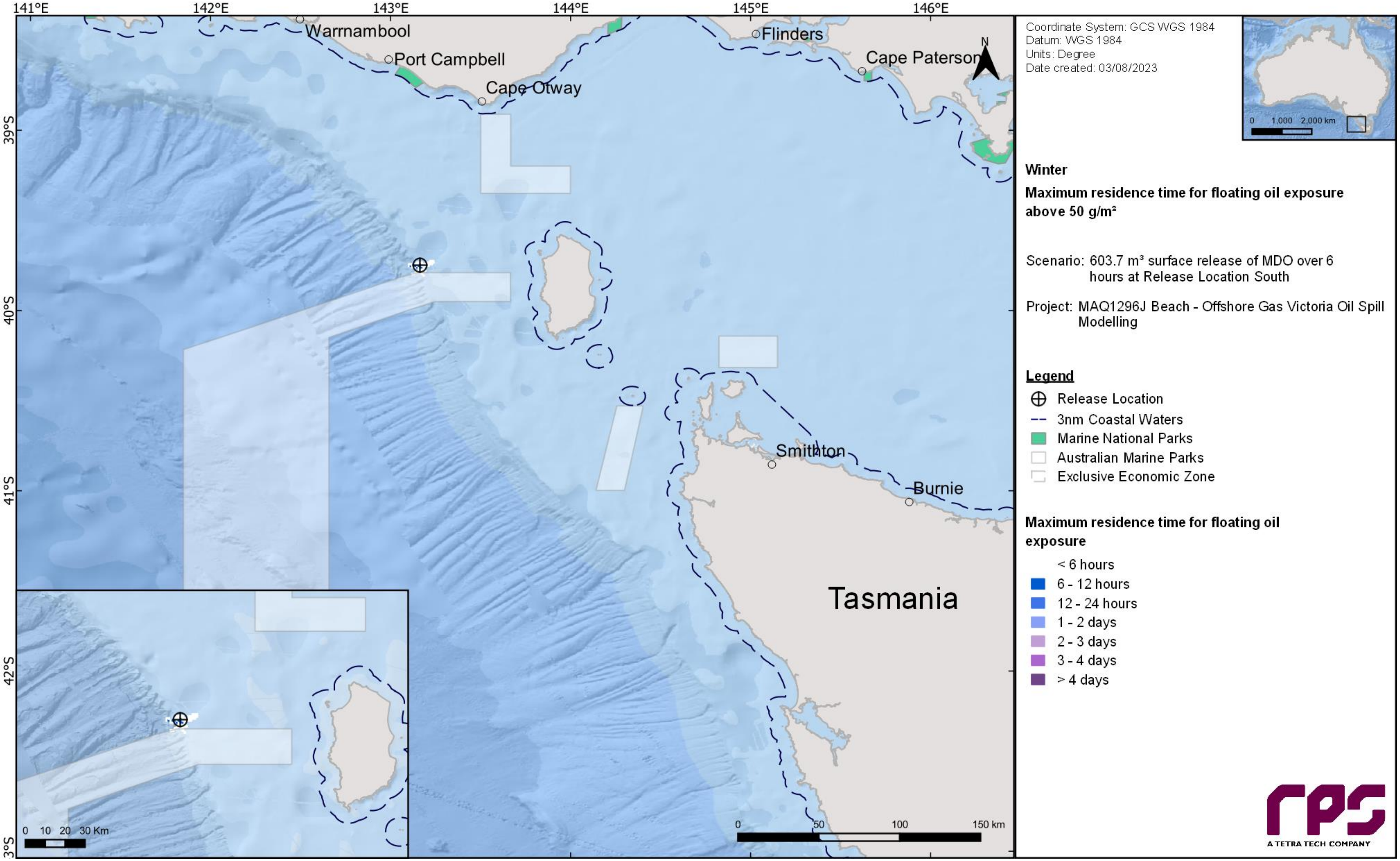


Figure 12-9 Maximum residence time of floating oil exposure above 50 g/m^2, in the event of 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during winter conditions.

12.1.3 Shoreline Accumulation

Table 12-4 presents a summary of the predicted potential shoreline accumulation during the summer and winter conditions. The probability of accumulation to any shoreline at, or above, the low level (10 g/m^2) threshold was 7% during summer conditions and 47% during winter conditions. The minimum time before oil accumulation at, or above, the low threshold was 8 days during summer conditions, and 4 days during winter conditions. The maximum volume ashore for a single spill trajectory during the summer and winter conditions was 5 m^3 and 29 m^3, respectively, whilst the maximum length of shoreline accumulation at the low threshold was 13 km and 35 km, respectively. Only during winter shoreline accumulation was predicted for the moderate threshold (100 g/m^2), with a maximum length of shoreline predicted for 6 km. No shoreline accumulation at the high threshold (1,000 g/m^2) was predicted.

Table 12-5 summarises the shoreline accumulation on individual receptors during the summer and winter conditions. King Island recorded the highest probability of shoreline accumulation at the low threshold with 7% (summer) and 43% (winter) and the largest shoreline accumulation with 4 m^3 and 29 m^3, respectively.

The minimum time before shoreline accumulation above the low threshold was 8 days predicted for King Island during summer conditions and 4 days during the winter conditions.

The summer and winter conditions maximum potential shoreline loading above the low, moderate and high shoreline thresholds are presented in Figure 12-10 and Figure 12-11, respectively.

Table 12-4 Summary of oil accumulation across all shorelines. Results are based on a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations per season.

Shoreline Statistics	Summer	Winter
Probability of accumulation on any shoreline (%)	7	47
Absolute minimum time for visible oil to shore (days)	8	4
Maximum total volume of hydrocarbons ashore (m^3)	5	29
Average volume of hydrocarbons ashore (m^3)	1	4
Maximum length of the shoreline at **10 g/m^2** (km)	13	35
Average shoreline length (km) at **10 g/m^2** (km)	4	10
Maximum length of the shoreline at **100 g/m^2** (km)	-	6
Average shoreline length (km) at **100 g/m^2** (km)	-	3
Maximum length of the shoreline at **1,000 g/m^2** (km)	-	-
Average shoreline length (km) at **1,000 g/m^2** (km)	-	-

Table 12-5 Summary of oil accumulation on individual shoreline receptors. Results are based on a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations per season.

Shoreline Receptor	Summer																Winter															
	Maximum probability of shoreline loading (%)			Minimum time before shoreline accumulation (days)			Load on shoreline (g/m^2)		Volume on shoreline (m^3)		Mean length of shoreline accumulation (km)			Maximum length of shoreline accumulation (km)			Maximum probability of shoreline loading (%)			Minimum time before shoreline accumulation (days)			Load on shoreline (g/m^2)		Volume on shoreline (m^3)		Mean length of shoreline accumulation (km)			Maximum length of shoreline accumulation (km)		
	Low	Mod	High	Low	Mod	High	Mean	Peak	Mean	Peak	Low	Mod	High	Low	Mod	High	Low	Mod	High	Low	Mod	High	Mean	Peak	Mean	Peak	Low	Mod	High	Low	Mod	High
Black Pyramid	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	8	-	-	2	16	< 1	< 1	1	-	-	1	-	-
King Island	7	-	-	8	-	-	2	52	1	4	4	-	-	12	-	-	43	13	-	4	7	-	5	431	4	29	10	3	-	32	6	-
Maatsuyker Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	28	-	-	3	20	< 1	1	2	-	-	2	-	-
Reid Rock	1	-	-	26	-	-	2	13	< 1	< 1	1	-	-	1	-	-	1	-	-	8	-	-	2	11	< 1	< 1	1	-	-	1	-	-
West Coast	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	20	-	-	2	29	1	4	4	-	-	4	-	-

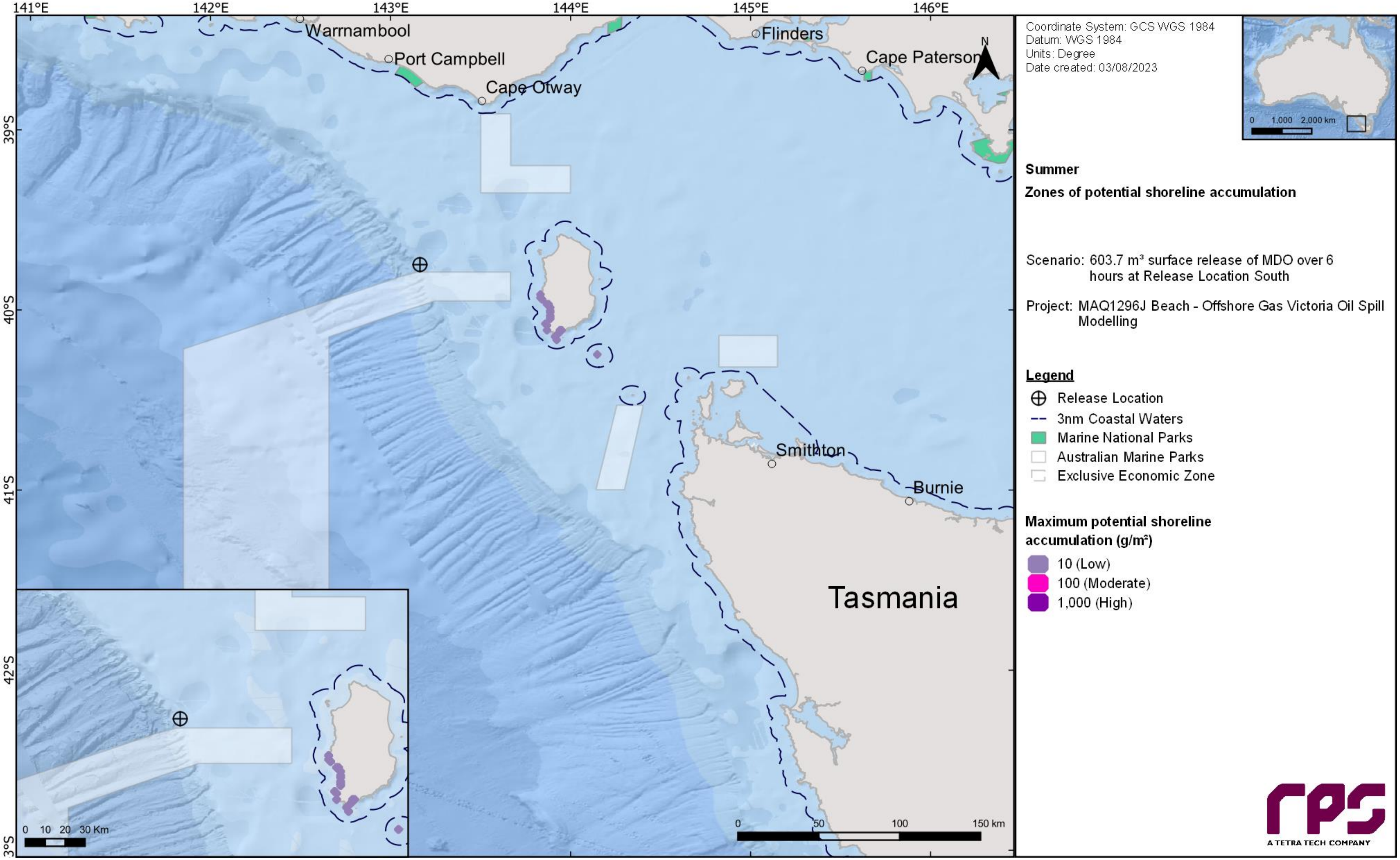


Figure 12-10 Maximum potential shoreline loading in the event of a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during summer conditions.

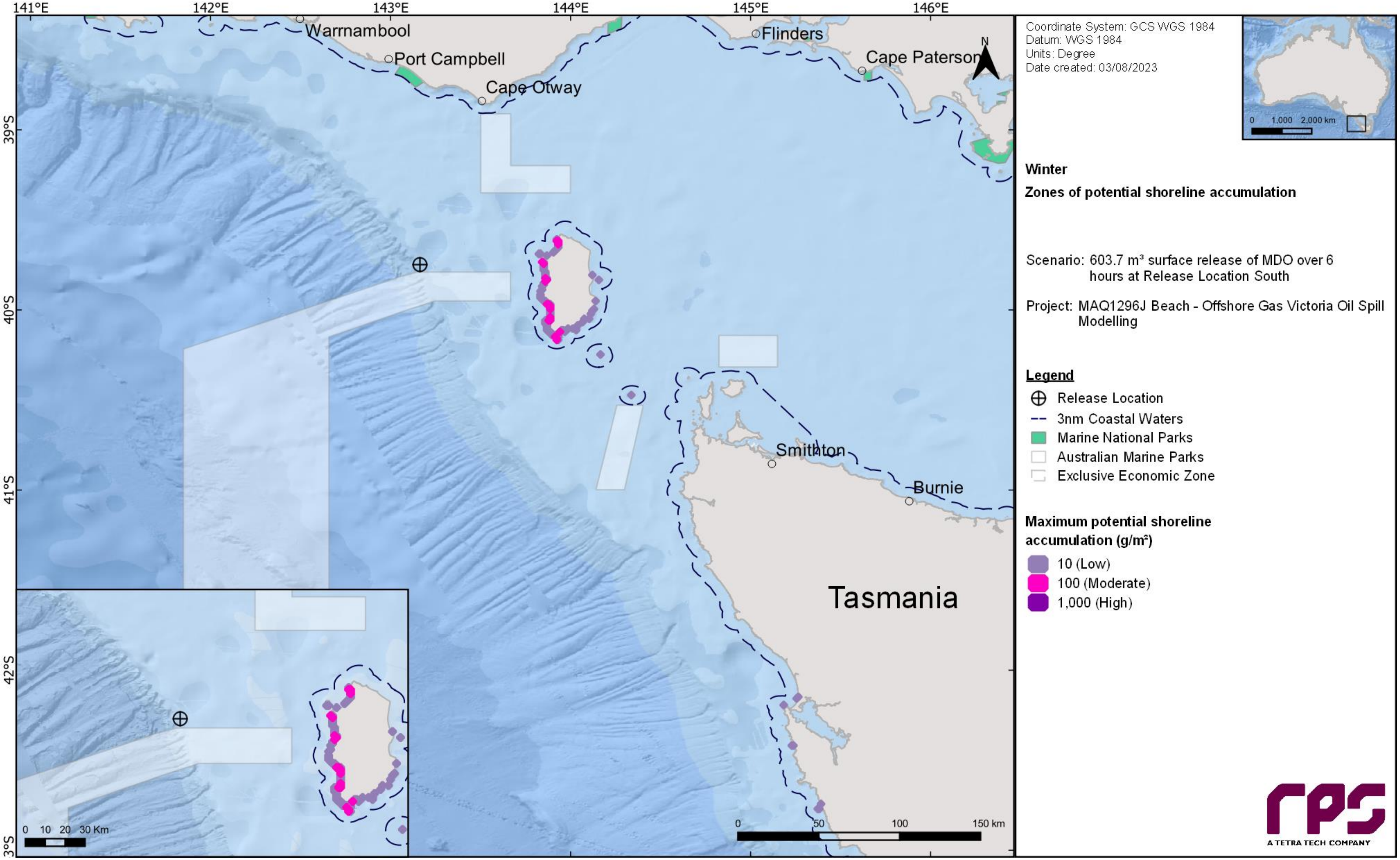


Figure 12-11 Maximum potential shoreline loading in the event of a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during winter conditions.

12.1.4 In-water exposure

12.1.4.1 Dissolved Hydrocarbons

Table 12-6 summarises the probability of exposure to individual receptors from dissolved hydrocarbons in the 0-10 m layer during the summer and winter conditions. No dissolved hydrocarbon exposure at the high (400 ppb) threshold was predicted,

Outside of the receptors that the Release Location South resides within (refer to Table 10-2), the highest concentration of dissolved hydrocarbon was predicted for the Pygmy Blue Whale - Known Foraging Area BIA (summer – 100 ppb, winter – 105 ppb), which also revealed the highest probability of low dissolved hydrocarbon exposure (summer – 39%, winter – 24%).

Table 12-7 presents the predicted minimum time to dissolved hydrocarbon exposure and maximum residence time for dissolved hydrocarbon exposure to individual receptors, in the 0-10 m depth layer, for all seasonal conditions and all thresholds assessed. No receptors revealed residence times above 1 days for the low threshold.

Figure 12-12 and Figure 12-13 present the zones of potential dissolved hydrocarbon exposure for the 0-10 m depth layer, for each threshold assessed under summer and winter conditions, respectively.

Figure 12-14 to Figure 12.17 present the maximum residence time of dissolved hydrocarbon exposure for the NOPSEMA thresholds in summer and winter.

Table 12-6 **Probability of dissolved hydrocarbons exposure to marine based receptors in the 0–10 m dept. Results are based on a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations per season.**

Receptor		Summer (November through to March)				Winter (April to October)			
		Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure			Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure		
			Low	Moderate	High		Low	Moderate	High
AMP	Zeehan	70	21	2	-	100	21	2	-
BIA	Antipodean Albatross - Foraging*	187	75	30	-	178	74	37	-
	Australasian Gannet - Foraging	7	-	-	-	11	1	-	-
	Black-browed Albatross - Foraging*	187	75	30	-	178	74	37	-
	Bullers Albatross - Foraging*	187	75	30	-	178	74	37	-
	Campbell Albatross – Foraging*	187	75	30	-	178	74	37	-
	Common Diving-petrel – Foraging*	187	75	30	-	178	74	37	-
	Indian Yellow-nosed Albatross – Foraging*	187	75	30	-	178	74	37	-
	Pygmy Blue Whale – Distribution*	187	75	30	-	178	74	37	-
	Pygmy Blue Whale – Foraging*	187	75	30	-	178	74	37	-
	Pygmy Blue Whale - Foraging (annual high use area)*	187	75	30	-	178	74	37	-
	Pygmy Blue Whale - Known Foraging Area	100	39	5	-	105	24	6	-
	Short-tailed Shearwater – Foraging*	187	75	30	-	178	74	37	-
	Shy Albatross – Foraging*	187	75	30	-	178	74	37	-
	Southern Right Whale - Known Core Range*	187	75	30	-	178	74	37	-
	Wandering Albatross – Foraging*	187	75	30	-	178	74	37	-
	Wedge-tailed Shearwater – Foraging*	187	75	30	-	178	74	37	-
	White Shark – Distribution*	187	75	30	-	178	74	37	-
	White-faced Storm-petrel - Foraging	43	2	-	-	38	4	-	-
EEZ	Australian*	187	75	30	-	178	74	37	-
IMCRA	Otway*	187	75	30	-	178	74	37	-
KEF	West Tasmania Canyons	69	13	1	-	71	11	1	-
State Waters	Tasmania	3	-	-	-	12	1	-	-

*The release location resides within the receptor boundaries.

Table 12-7 Predicted minimum time to dissolved hydrocarbon exposure and maximum residence time for dissolved hydrocarbon exposure to individual receptors in the 0-10 m depth layer. Results are based on a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill trajectories per season.

Receptor		Summer (November through to March)						Winter (April to October)					
		Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)			Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
AMP	Zeehan	< 1	< 1	-	1	< 1	-	< 1	< 1	-	< 1	< 1	-
BIA	Antipodean Albatross - Foraging*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Australasian Gannet - Foraging	-	-	-	-	-	-	5	-	-	< 1	-	-
	Black-browed Albatross - Foraging*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Bullers Albatross - Foraging*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Campbell Albatross – Foraging*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Common Diving-petrel – Foraging*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Indian Yellow-nosed Albatross – Foraging*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Pygmy Blue Whale – Distribution*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Pygmy Blue Whale – Foraging*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Pygmy Blue Whale - Foraging (annual high use area)*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Pygmy Blue Whale - Known Foraging Area	< 1	< 1	-	1	< 1	-	< 1	< 1	-	< 1	< 1	-
	Short-tailed Shearwater – Foraging*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Shy Albatross – Foraging*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Southern Right Whale - Known Core Range*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Wandering Albatross – Foraging*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Wedge-tailed Shearwater – Foraging*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	White Shark – Distribution*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	White-faced Storm-petrel - Foraging	3	-	-	< 1	-	-	1	2	-	< 1	-	-
EEZ	Australian*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
IMCRA	Otway*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
KEF	West Tasmania Canyons	< 1	1	-	< 1	< 1	-	< 1	1	-	< 1	< 1	-
State Waters	Tasmania	-	-	-	-	-	-	4	-	-	< 1	-	-

*The release location resides within the receptor boundaries.

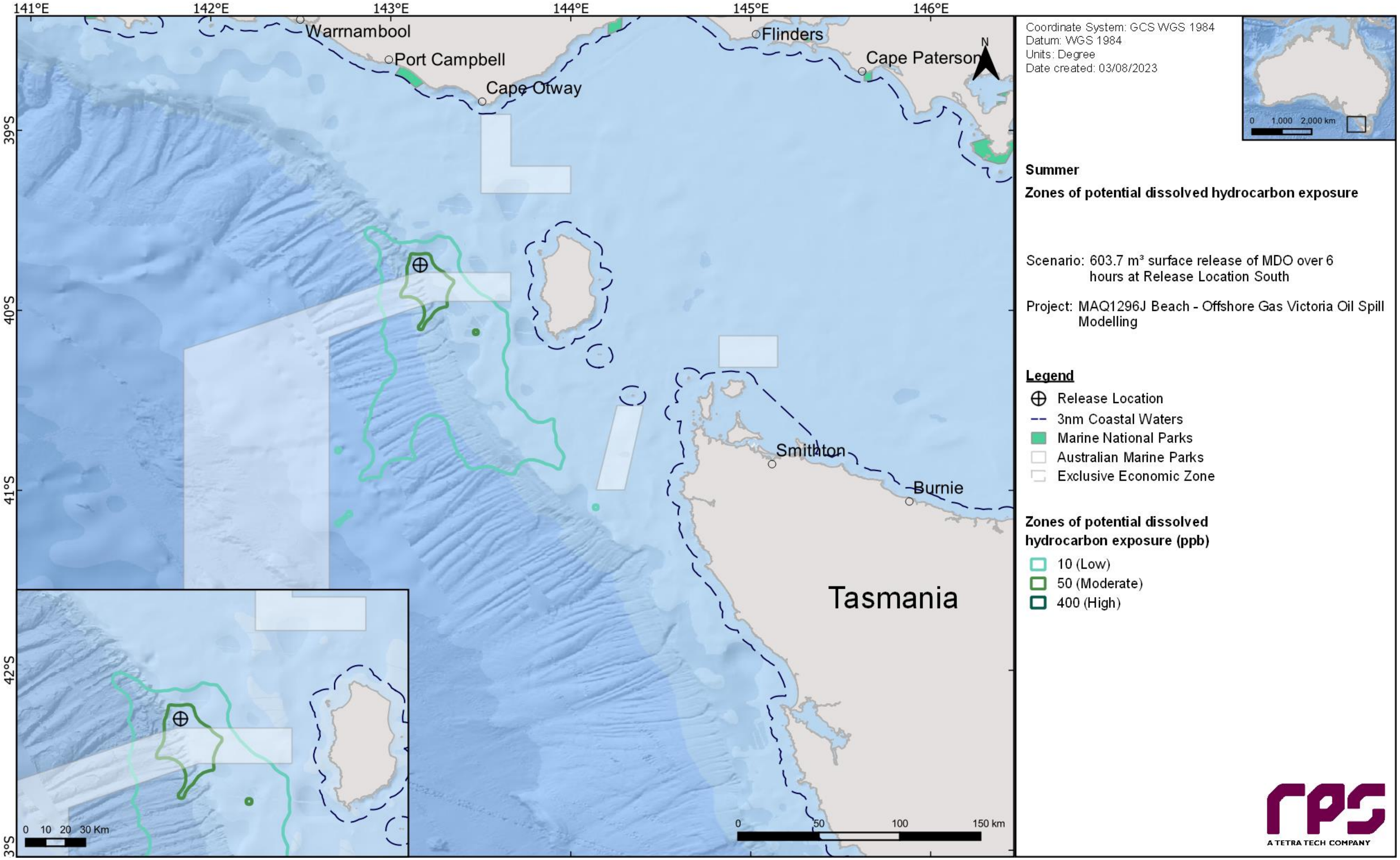


Figure 12-12 Zones of potential dissolved hydrocarbon exposure at 0-10 m below the sea in the event of a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during summer conditions.

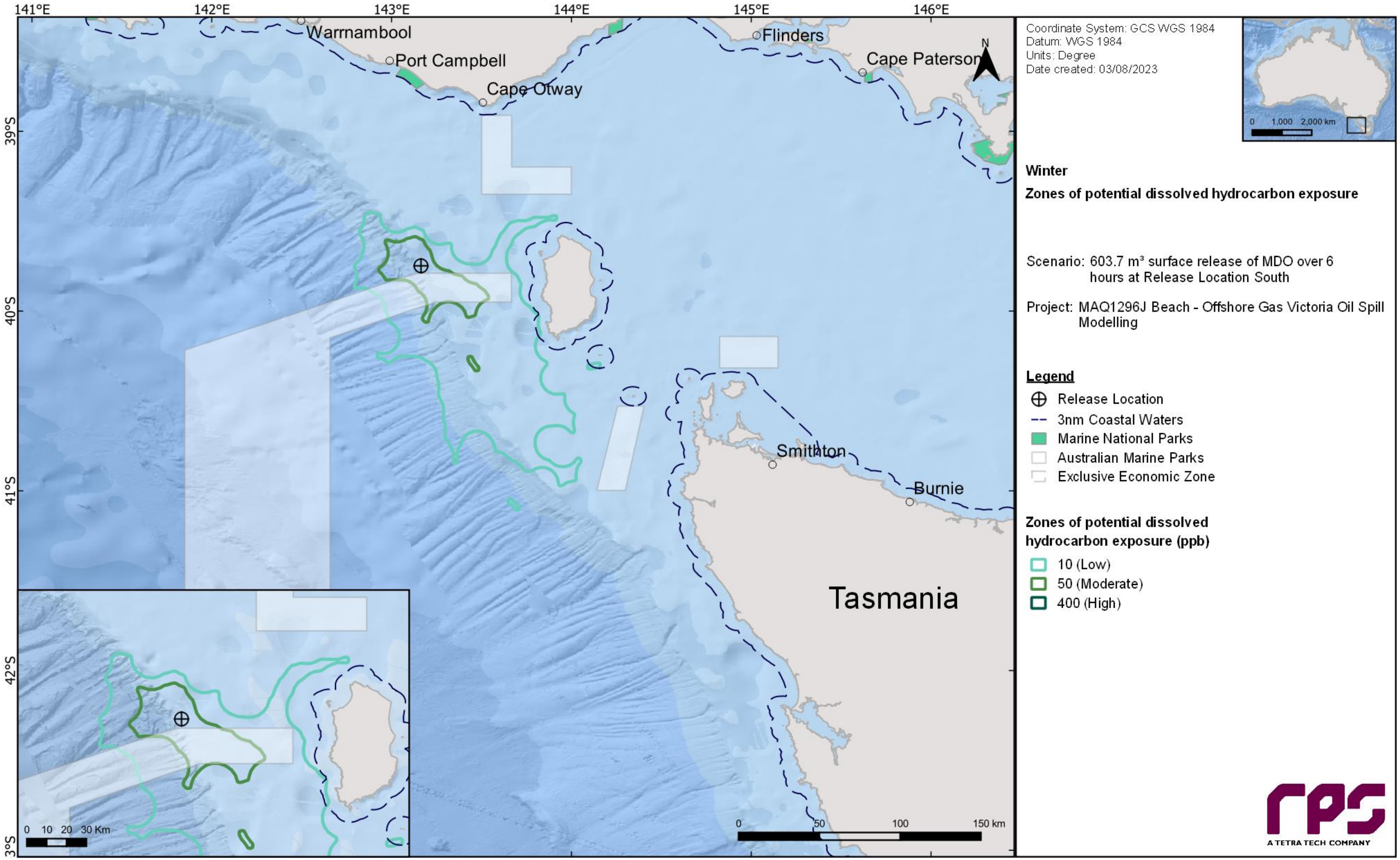


Figure 12-13 Zones of potential dissolved hydrocarbon exposure at 0-10 m below the sea in the event of a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during winter conditions.

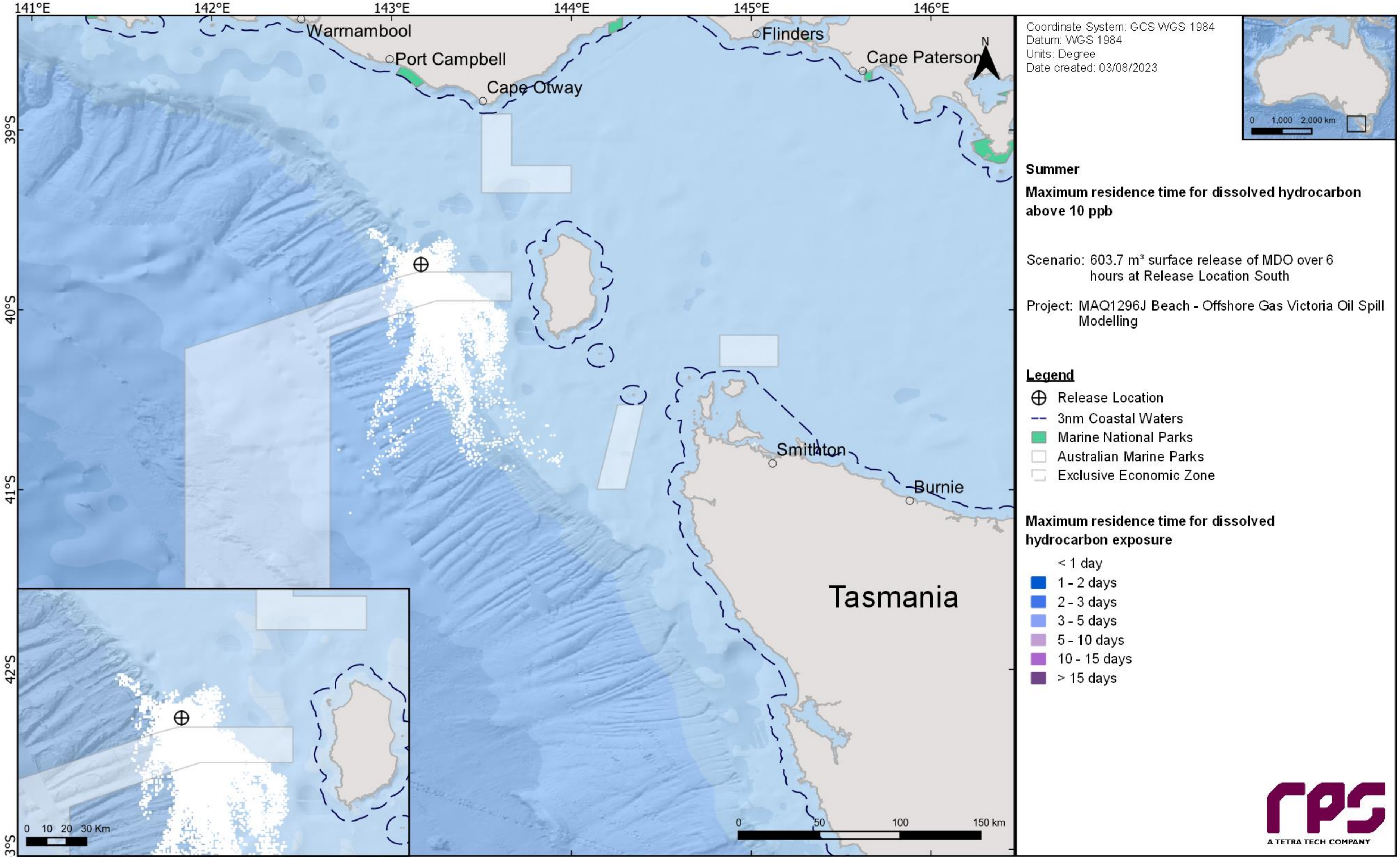


Figure 12-14 Maximum residence time for dissolved hydrocarbon exposure above 10 ppb, at 0-10 m below the sea surface in the event of a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during summer conditions.

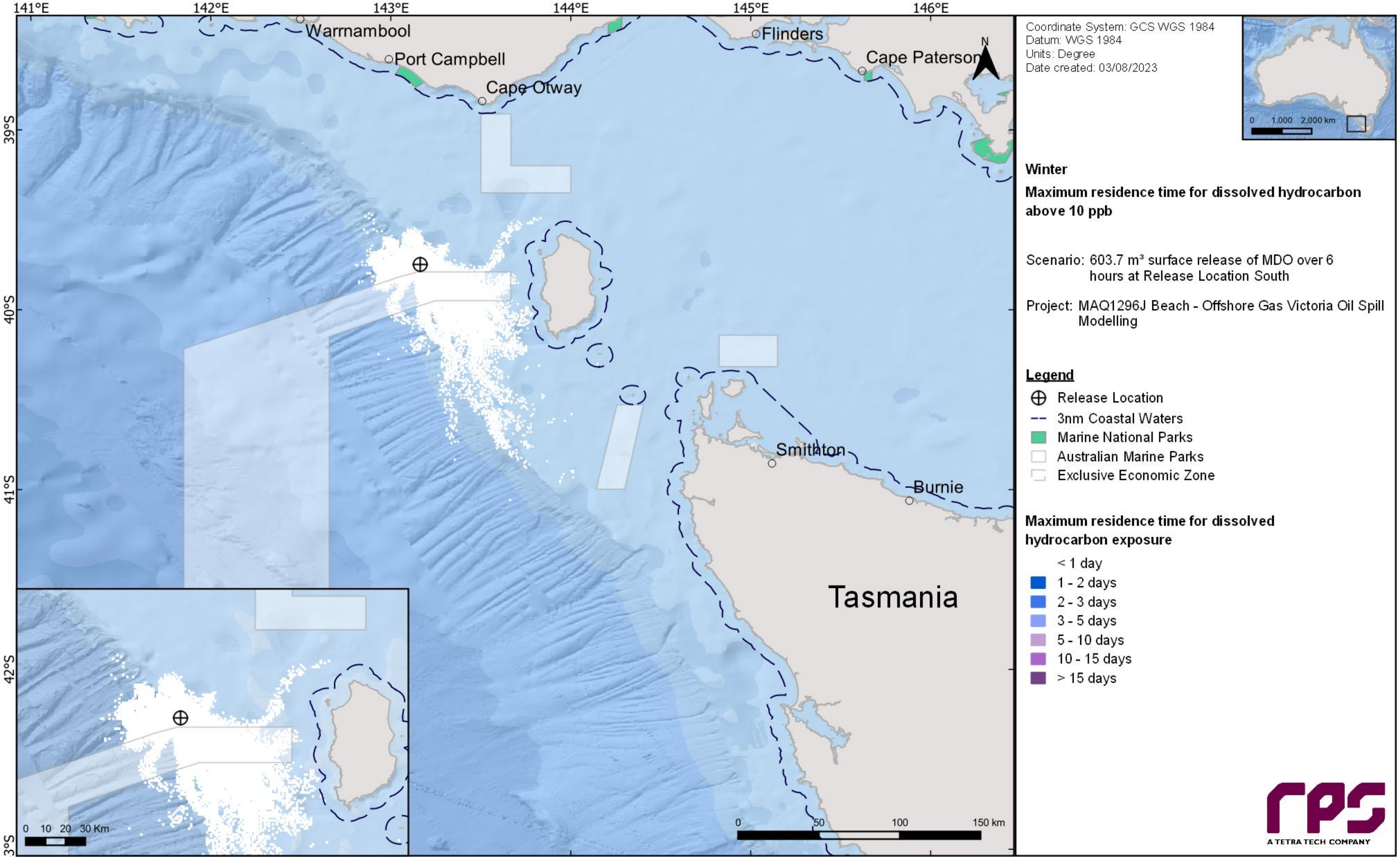


Figure 12.15 Maximum residence time for dissolved hydrocarbon exposure above 10 ppb, at 0-10 m below the sea surface in the event of a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during winter conditions.

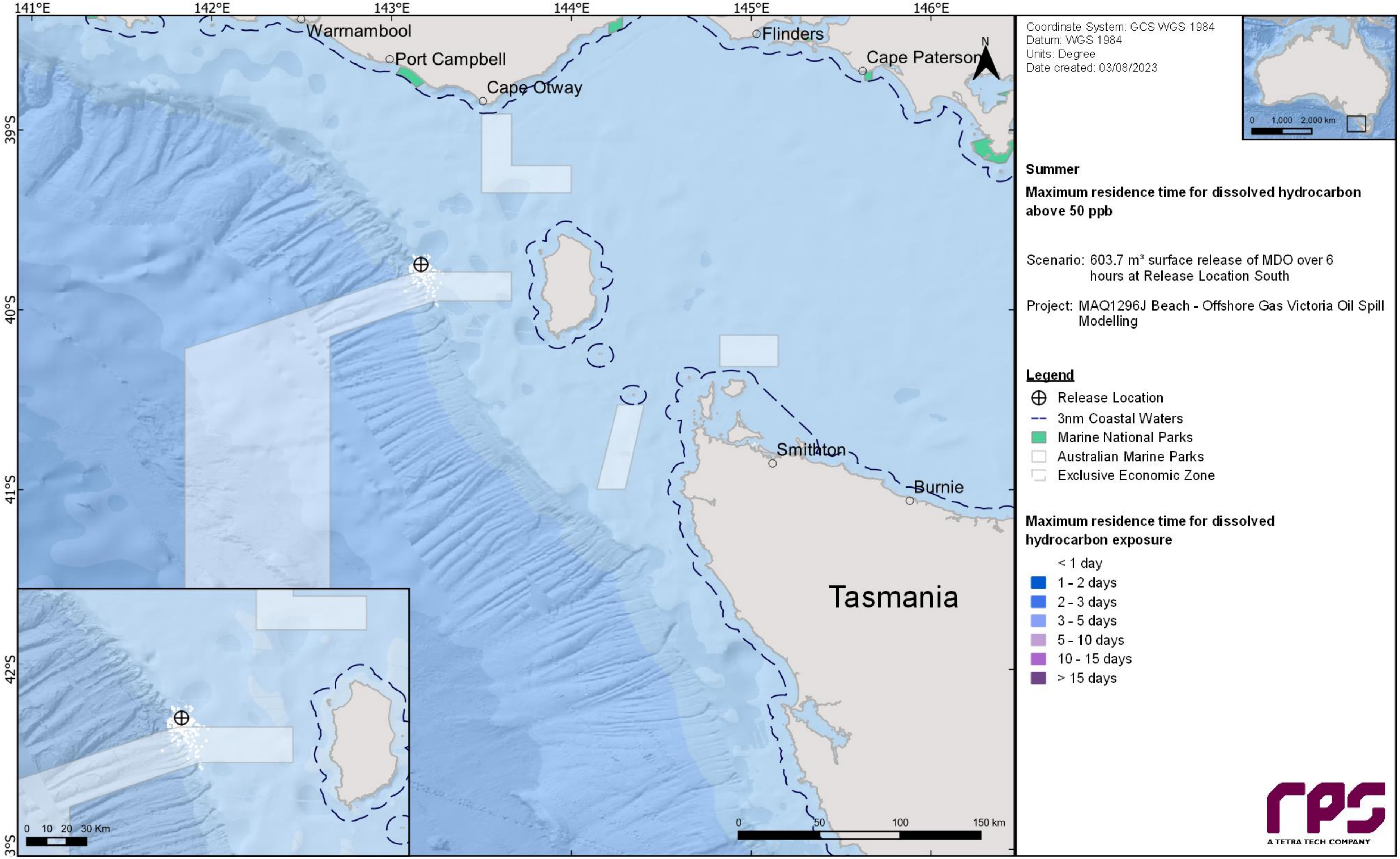


Figure 12.16 Maximum residence time for dissolved hydrocarbon exposure above 50 ppb, at 0-10 m below the sea surface in the event of a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during summer conditions.

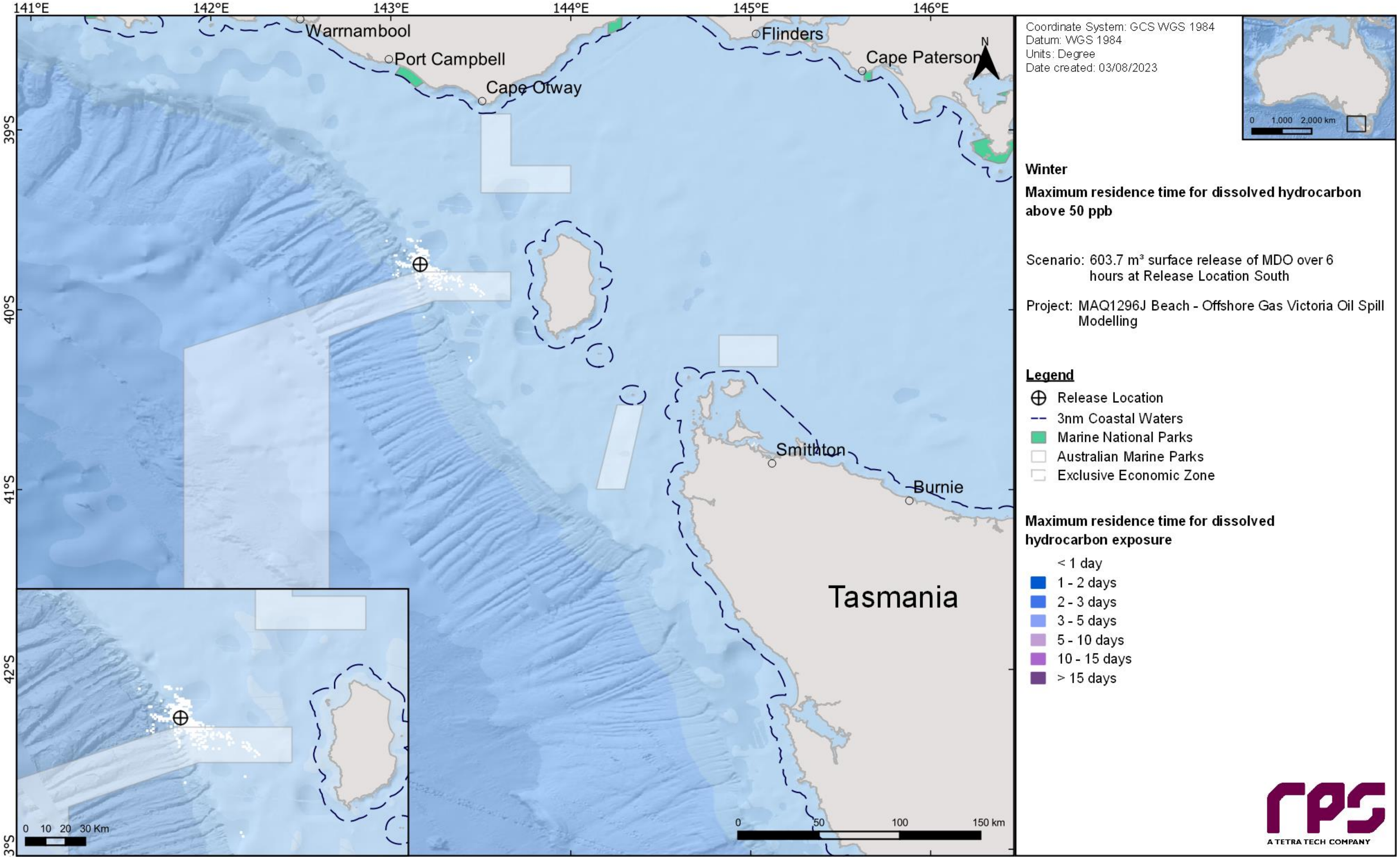


Figure 12.17 Maximum residence time for dissolved hydrocarbon exposure above 50 ppb, at 0-10 m below the sea surface in the event of a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during winter conditions.

12.1.4.2 Entrained Hydrocarbons

Table 12-8 presents the probability of exposure to individual receptors from entrained hydrocarbons in the 0-10 m depth layer for the summer and winter conditions.

Outside of the receptors that the Release Location South resides within (refer to Table 10-2), the highest concentration of entrained hydrocarbon was predicted for Pygmy Blue Whale - Known Foraging Area BIA (summer – 4,867 ppb, winter – 5,489 ppb). The same receptor recorded the highest probability of low entrained hydrocarbon exposure (90% summer and 85% winter).

Table 12-9 presents the predicted minimum time to entrained hydrocarbon exposure and maximum residence time for entrained hydrocarbon exposure to individual receptors in the 0-10 m depth layer, for all seasonal conditions and all thresholds assessed.

Figure 12-18 and Figure 12-19 present the zones of potential entrained hydrocarbon exposure for the 0-10 m depth layer, for each threshold assessed under summer and winter conditions, respectively.

Figure 12-20 to Figure 12-23 present the maximum residence time of entrained hydrocarbon exposure for the NOPSEMA thresholds in summer and winter.

Table 12-8 Probability of entrained hydrocarbons exposure to marine based receptors in the 0–10 m depth layer. Results are based on a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations per season.

Receptor		Summer (November through to March)			Winter (April to October)		
		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure	
			Low	High		Low	High
AMP	Apollo	1	-	-	14	1	-
	Franklin	12	1	-	20	4	-
	Zeehan	3,291	86	64	3,366	80	64
BIA	Antipodean Albatross - Foraging*	16,927	95	91	15,779	99	96
	Australasian Gannet - Foraging	29	6	-	39	11	-
	Black-browed Albatross - Foraging*	16,927	95	91	15,779	99	96
	Black-faced Cormorant - Foraging	9	-	-	62	10	-
	Bullers Albatross - Foraging*	16,927	95	91	15,779	99	96
	Campbell Albatross – Foraging*	16,927	95	91	15,779	99	96
	Common Diving-petrel – Foraging*	16,927	95	91	15,779	99	96
	Indian Yellow-nosed Albatross – Foraging*	16,927	95	91	15,779	99	96
	Little Penguin - Foraging	7	-	-	51	9	-
	Pygmy Blue Whale – Distribution*	16,927	95	91	15,779	99	96
	Pygmy Blue Whale – Foraging*	16,927	95	91	15,779	99	96
	Pygmy Blue Whale - Foraging (annual high use area)*	16,927	95	91	15,779	99	96
	Pygmy Blue Whale - Known Foraging Area	4,867	90	73	5,489	85	67
	Short-tailed Shearwater – Foraging*	16,927	95	91	15,779	99	96
	Shy Albatross – Foraging*	16,927	95	91	15,779	99	96
	Soft-plumaged Petrel - Foraging	14	1	-	23	3	-
	Southern Right Whale - Connecting habitat	20	2	-	101	25	1
	Southern Right Whale - Known Core Range*	16,927	95	91	15,779	99	96
	Wandering Albatross – Foraging*	16,927	95	91	15,779	99	96
	Wedge-tailed Shearwater – Foraging*	16,927	95	91	15,779	99	96
	White Shark – Distribution*	16,927	95	91	15,779	99	96

Receptor		Summer (November through to March)			Winter (April to October)		
		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure	
			Low	High		Low	High
	White Shark - Foraging	36	6	-	114	30	2
	White-faced Storm-petrel - Foraging	147	44	3	398	49	6
EEZ	Australian*	16,927	95	91	15,779	99	96
IBRA	King Island	18	2	-	92	25	-
IMCRA	Central Bass Strait	5	-	-	52	4	-
	Franklin	22	5	-	55	9	-
	Otway*	16,927	95	91	15,779	99	96
KEF	West Tasmania Canyons	2,445	80	54	2,273	59	40
RSB	Bell Reef	14	2	-	23	9	-
SHORE	Black Pyramid	4	-	-	17	3	-
	King Island	18	2	-	86	25	-
	Reid Rock	13	1	-	29	7	-
State Waters	Tasmania	32	5	-	138	30	2

*The release location resides within the receptor boundaries.

Table 12-9 Predicted minimum time to entrained hydrocarbon exposure and maximum residence time for entrained hydrocarbon exposure to individual receptors in the 0-10 m depth layer. Results are based on a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill trajectories per season.

Receptor		Summer (November through to March)				Winter (April to October)			
		Minimum time before entrained hydrocarbon exposure (days)		Maximum residence time for entrained hydrocarbon exposure (days)		Minimum time before entrained hydrocarbon exposure (days)		Maximum residence time for entrained hydrocarbon exposure (days)	
		Low	High	Low	High	Low	High	Low	High
AMP	Apollo	-	-	-	-	6	-	< 1	-
	Franklin	10	-	< 1	-	6	-	1	-
	Zeehan	< 1	< 1	8	2	< 1	< 1	9	2
BIA	Antipodean Albatross - Foraging*	< 1	< 1	9	3	< 1	< 1	9	3
	Australasian Gannet - Foraging	5	-	2	-	5	-	3	-
	Black-browed Albatross - Foraging*	< 1	< 1	9	3	< 1	< 1	9	3
	Black-faced Cormorant - Foraging	-	-	-	-	2	-	14	-
	Bullers Albatross - Foraging*	< 1	< 1	9	3	< 1	< 1	9	3
	Campbell Albatross – Foraging*	< 1	< 1	9	3	< 1	< 1	9	3
	Common Diving-petrel – Foraging*	< 1	< 1	9	3	< 1	< 1	14	3
	Indian Yellow-nosed Albatross – Foraging*	< 1	< 1	9	3	< 1	< 1	9	3
	Little Penguin - Foraging	-	-	-	-	3	-	12	-
	Pygmy Blue Whale – Distribution*	< 1	< 1	9	3	< 1	< 1	14	3
	Pygmy Blue Whale – Foraging*	< 1	< 1	9	3	< 1	< 1	14	3
	Pygmy Blue Whale - Foraging (annual high use area)*	< 1	< 1	9	3	< 1	< 1	10	3
	Pygmy Blue Whale - Known Foraging Area	< 1	< 1	8	3	< 1	< 1	14	3
	Short-tailed Shearwater – Foraging*	< 1	< 1	9	3	< 1	< 1	14	3
	Shy Albatross – Foraging*	< 1	< 1	9	3	< 1	< 1	14	3
	Soft-plumaged Petrel - Foraging	13	-	< 1	-	9	-	1	-
	Southern Right Whale - Connecting habitat	4	-	2	-	3	4	14	< 1
	Southern Right Whale - Known Core Range*	< 1	< 1	9	3	< 1	< 1	14	3
	Wandering Albatross – Foraging*	< 1	< 1	9	3	< 1	< 1	9	3
	Wedge-tailed Shearwater – Foraging*	< 1	< 1	9	3	< 1	< 1	14	3
	White Shark – Distribution*	< 1	< 1	9	3	< 1	< 1	9	3

Receptor		Summer (November through to March)				Winter (April to October)			
		Minimum time before entrained hydrocarbon exposure (days)		Maximum residence time for entrained hydrocarbon exposure (days)		Minimum time before entrained hydrocarbon exposure (days)		Maximum residence time for entrained hydrocarbon exposure (days)	
		Low	High	Low	High	Low	High	Low	High
	White Shark - Foraging	4	-	2	-	3	4	6	< 1
	White-faced Storm-petrel - Foraging	2	2	5	< 1	1	1	14	1
EEZ	Australian*	< 1	< 1	9	3	< 1	< 1	14	3
IBRA	King Island	6	-	1	-	3	-	14	-
IMCRA	Central Bass Strait	-	-	-	-	3	-	2	-
	Franklin	9	-	2	-	6	-	1	-
	Otway*	< 1	< 1	9	3	< 1	< 1	14	3
KEF	West Tasmania Canyons	< 1	< 1	8	2	< 1	< 1	8	2
RSB	Bell Reef	< 1	< 1	< 1	-	5	-	1	-
SHORE	Black Pyramid	-	-	-	-	7	-	< 1	-
	King Island	6	-	1	-	3	-	14	-
	Reid Rock	7	-	< 1	-	6	-	2	-
State Waters	Tasmania	3	-	2	-	3	3	14	< 1

*The release location resides within the receptor boundaries.

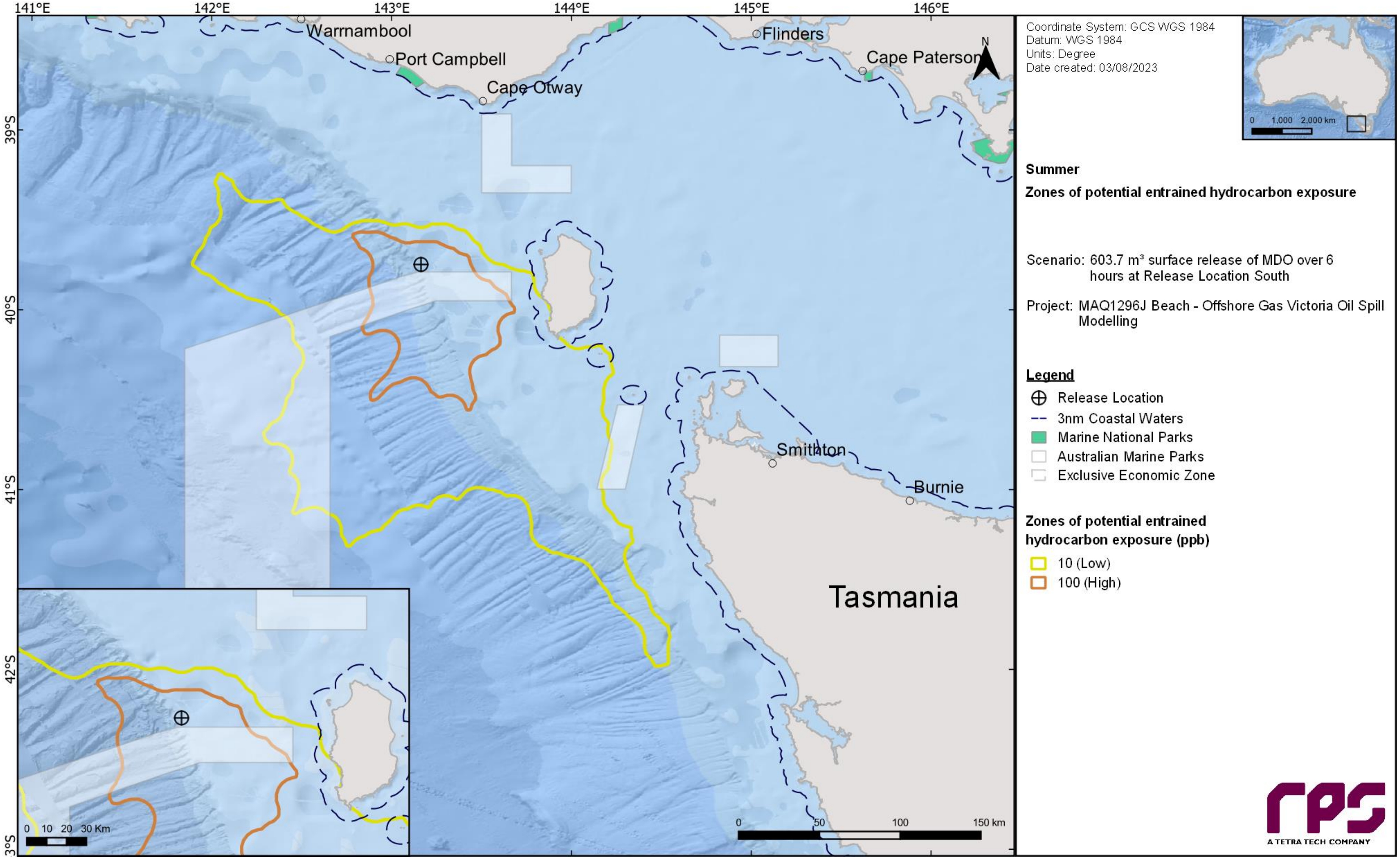


Figure 12-18 Zones of potential entrained hydrocarbon exposure at 0-10 m below the sea surface in the event of a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during summer conditions.

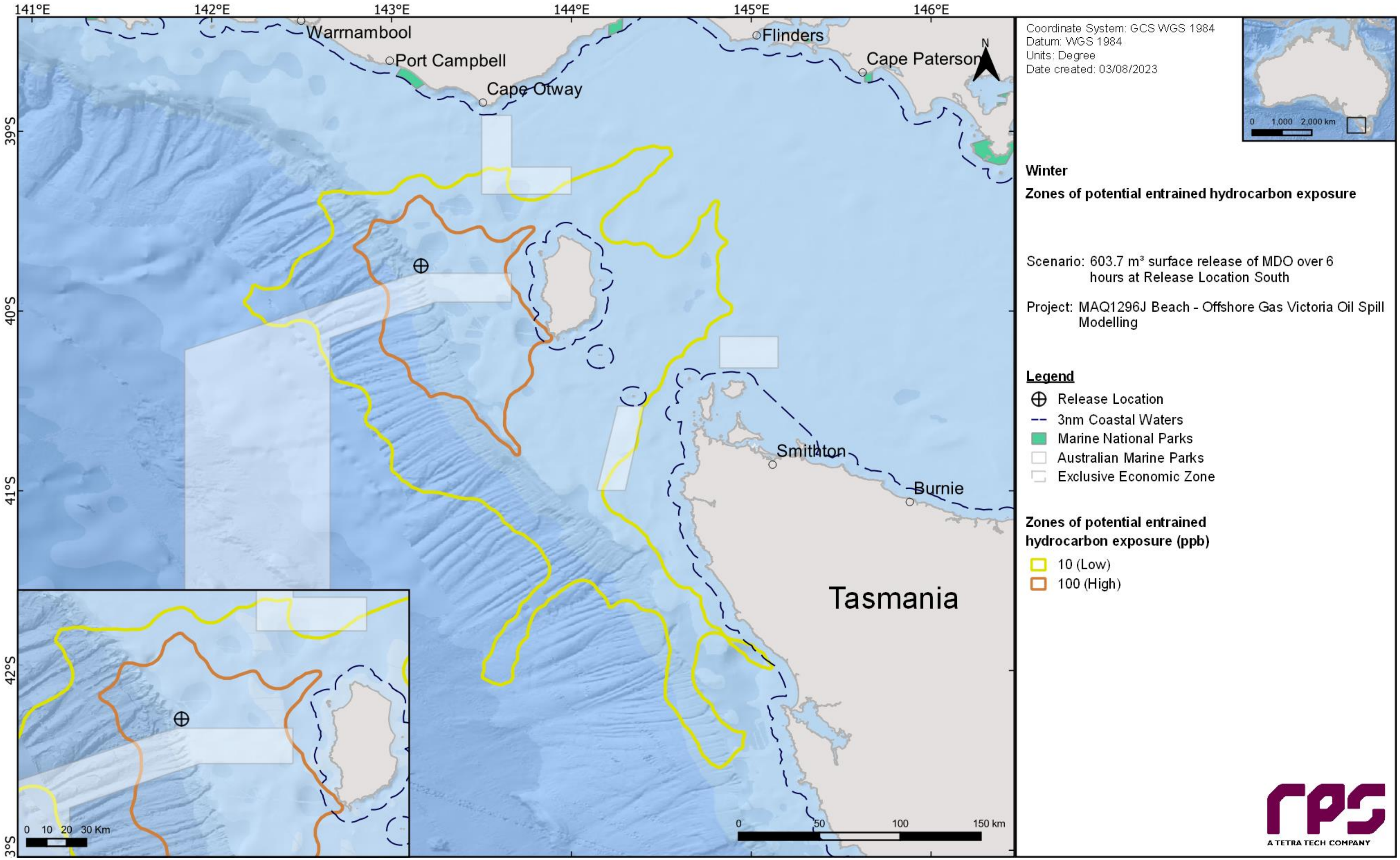


Figure 12-19 Zones of potential entrained hydrocarbon exposure at 0-10 m below the sea surface in the event of a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during winter conditions.

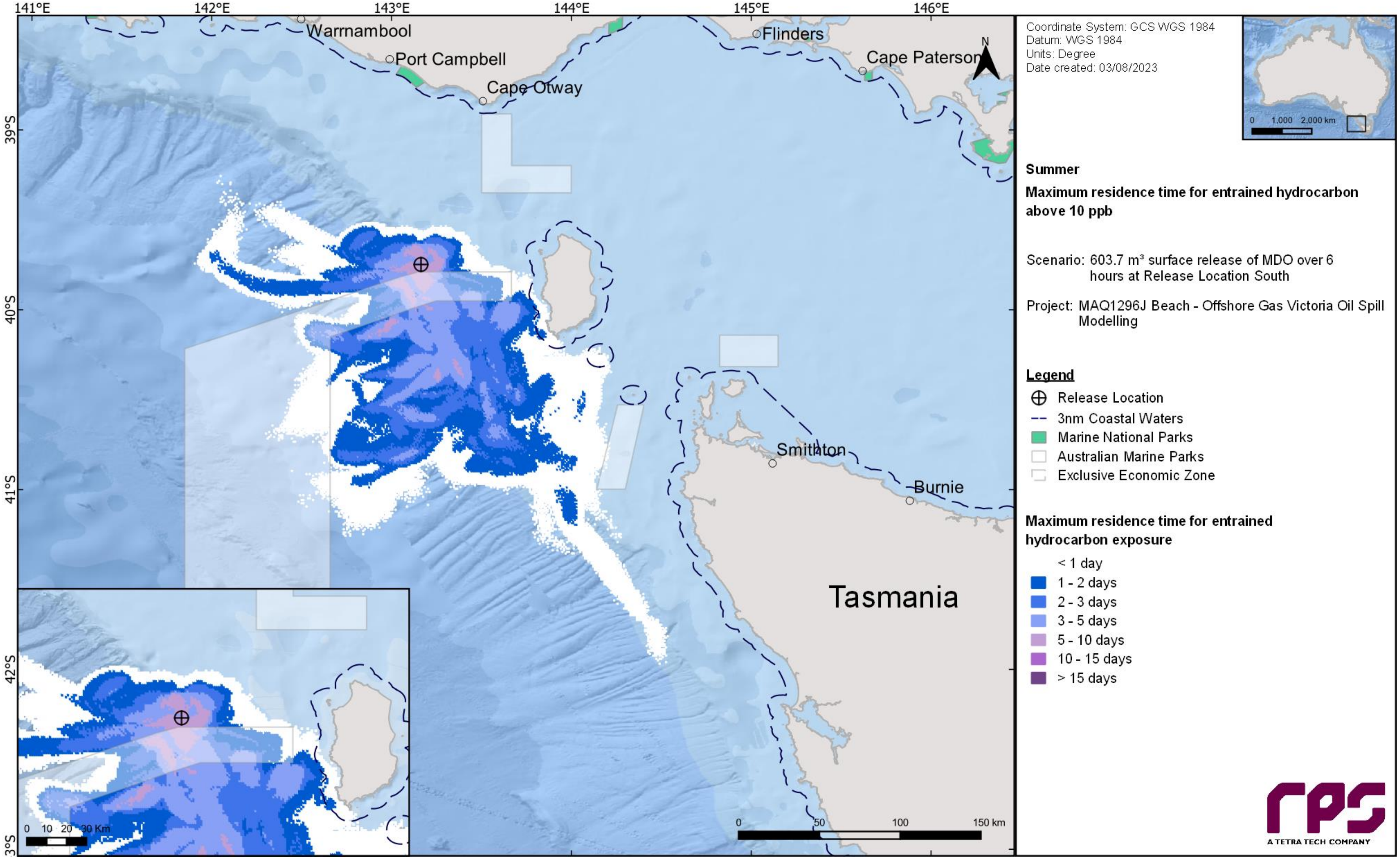


Figure 12-20 Maximum residence time for entrained hydrocarbon exposure above 10 ppb, at 0-10 m below the sea surface in the event of a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during summer conditions.

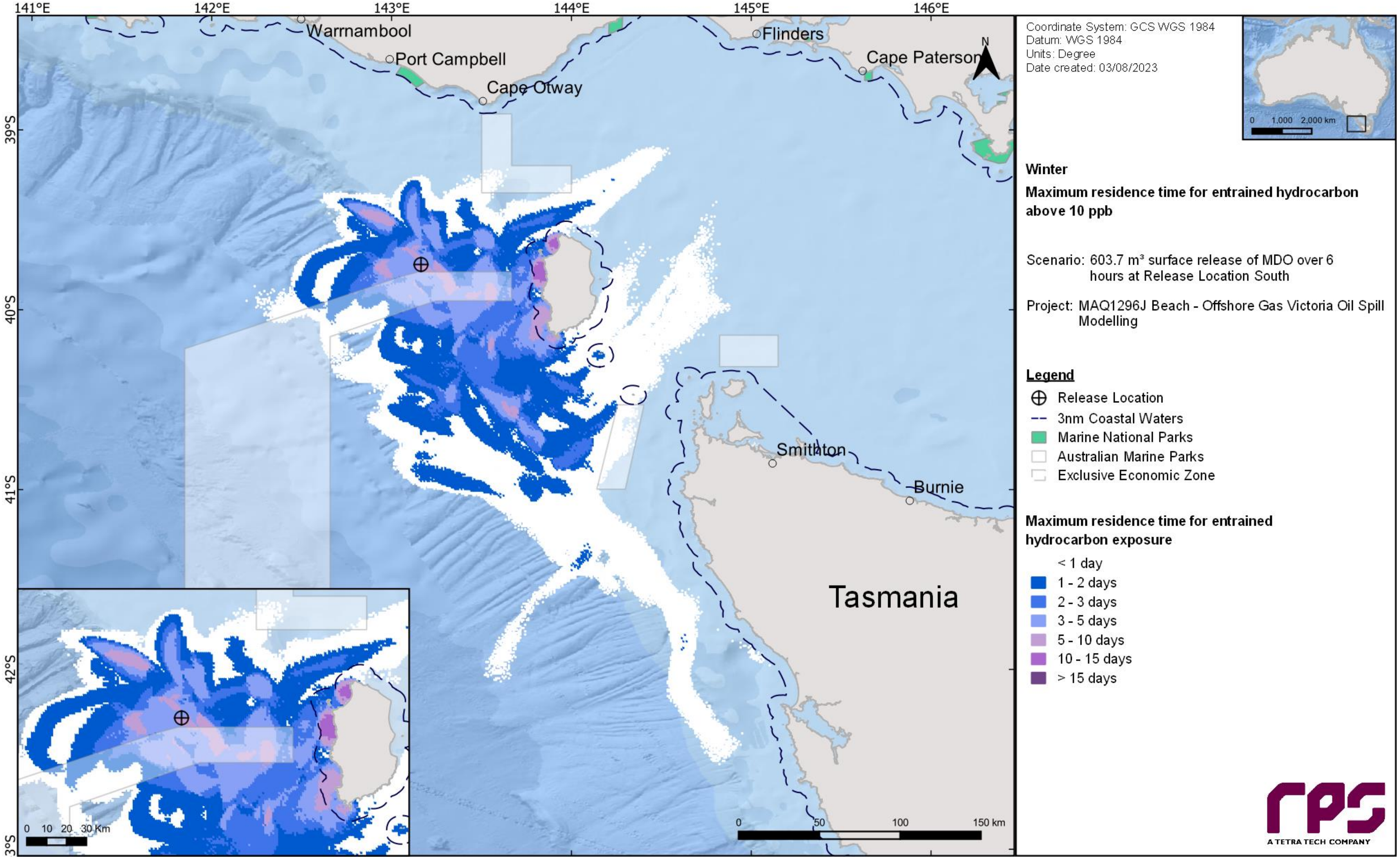


Figure 12-21 Maximum residence time for entrained hydrocarbon exposure above 10 ppb, at 0-10 m below the sea surface in the event of a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during winter conditions.

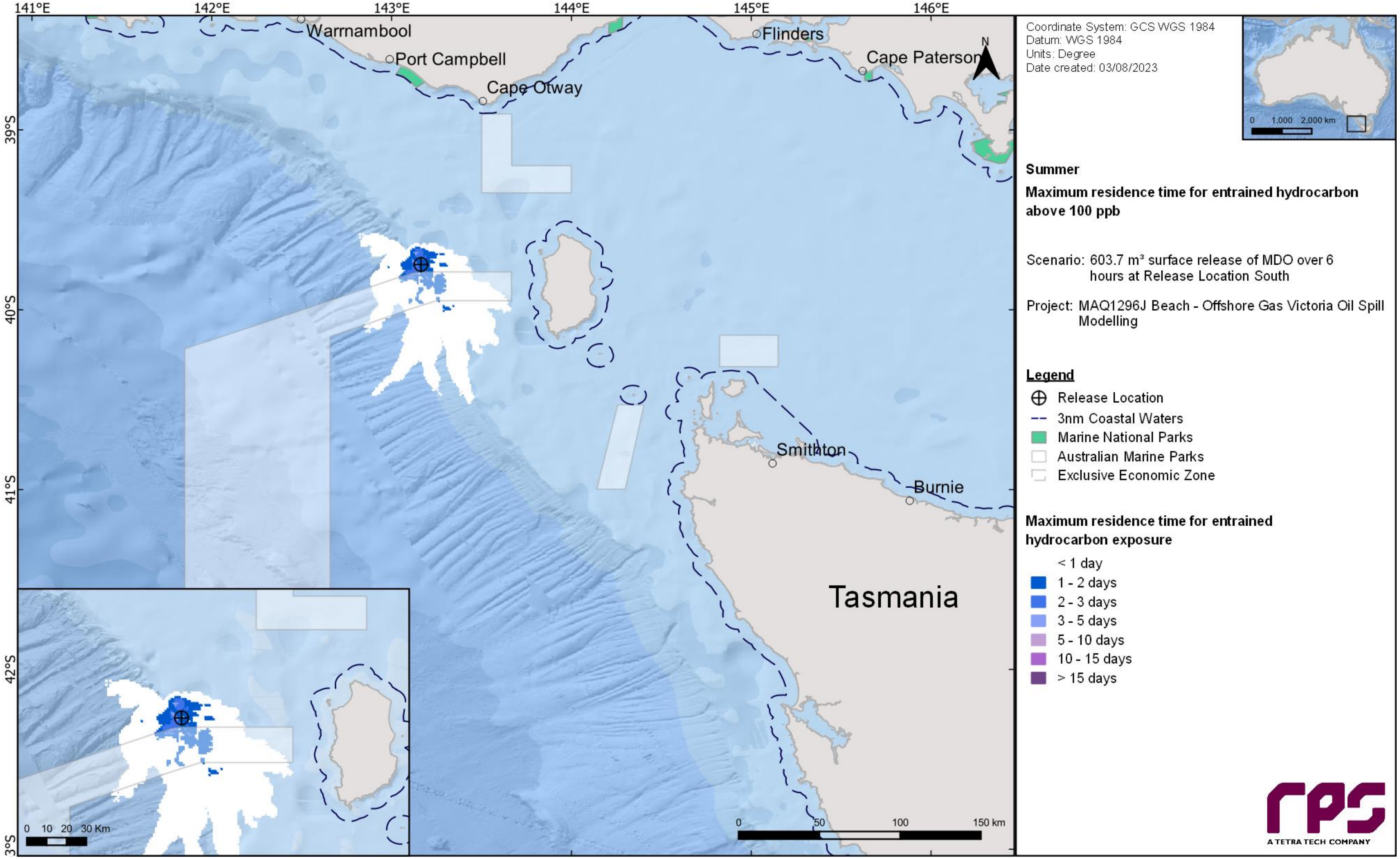


Figure 12-22 Maximum residence time for entrained hydrocarbon exposure above 100 ppb, at 0-10 m below the sea surface in the event of a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during summer conditions.

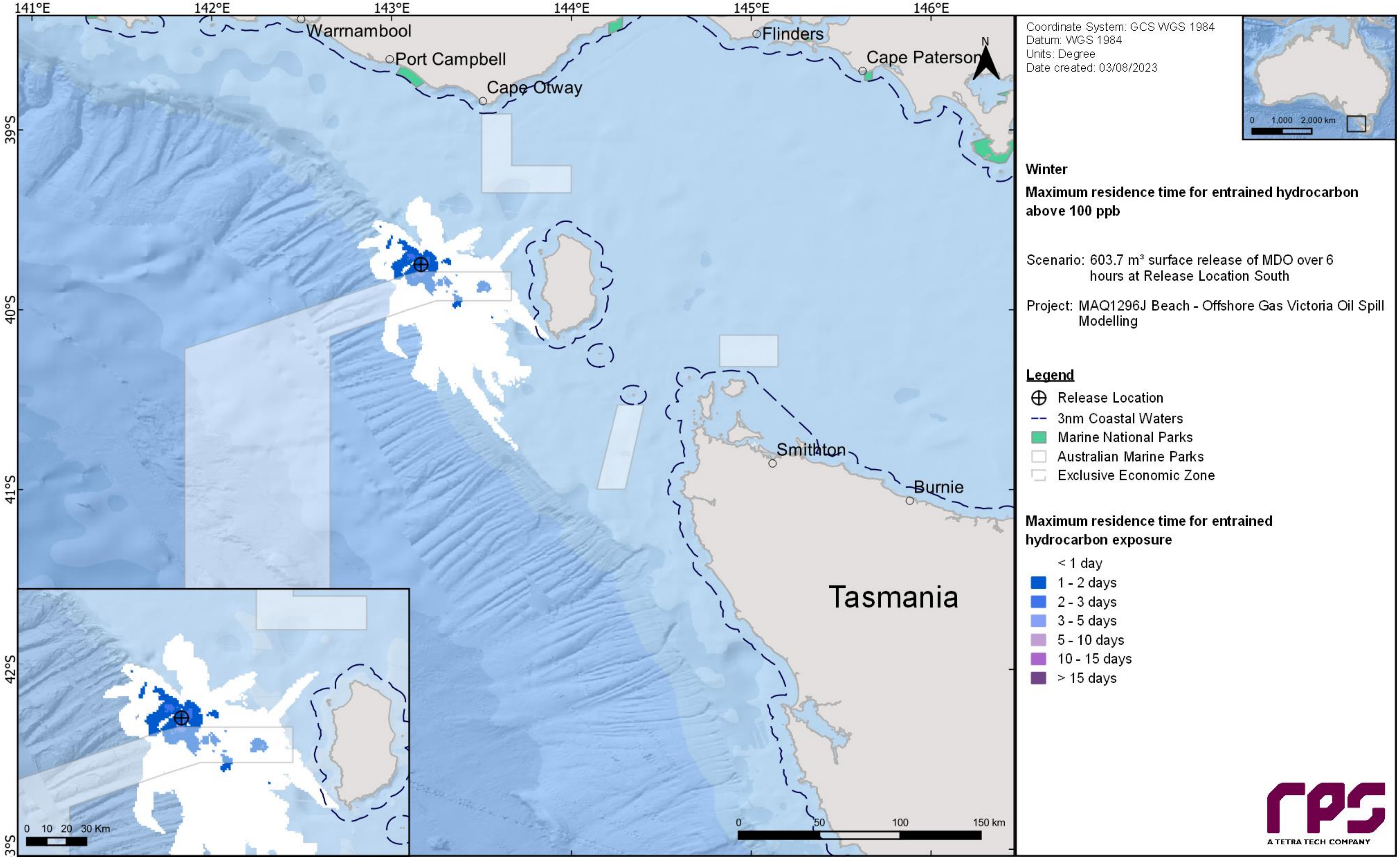


Figure 12-23 Maximum residence time for entrained hydrocarbon exposure above 100 ppb, at 0-10 m below the sea surface in the event of a 603.7 m^3 surface release of marine diesel from a loss of containment from vessel collision at the Release Location South field. The results were calculated from 100 spill simulations during winter conditions.

13 RESULTS – LOSS OF WELL CONTROL AT RELEASE LOCATION NORTH

This scenario examined a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. A total of 200 spill simulations were run (i.e., 100 spills per season) and tracked for 100 days. The results for all 100 simulations per season were combined and are presented on a seasonal basis (i.e., summer and winter).

13.1 Stochastic Analysis

13.1.1 Area of Exposure

Figure 13-1 presents the combined area of potential exposure for surface, shoreline, entrained and dissolved, by overlaying the results from all 200 simulations (i.e., 100 per season) during summer and winter conditions.

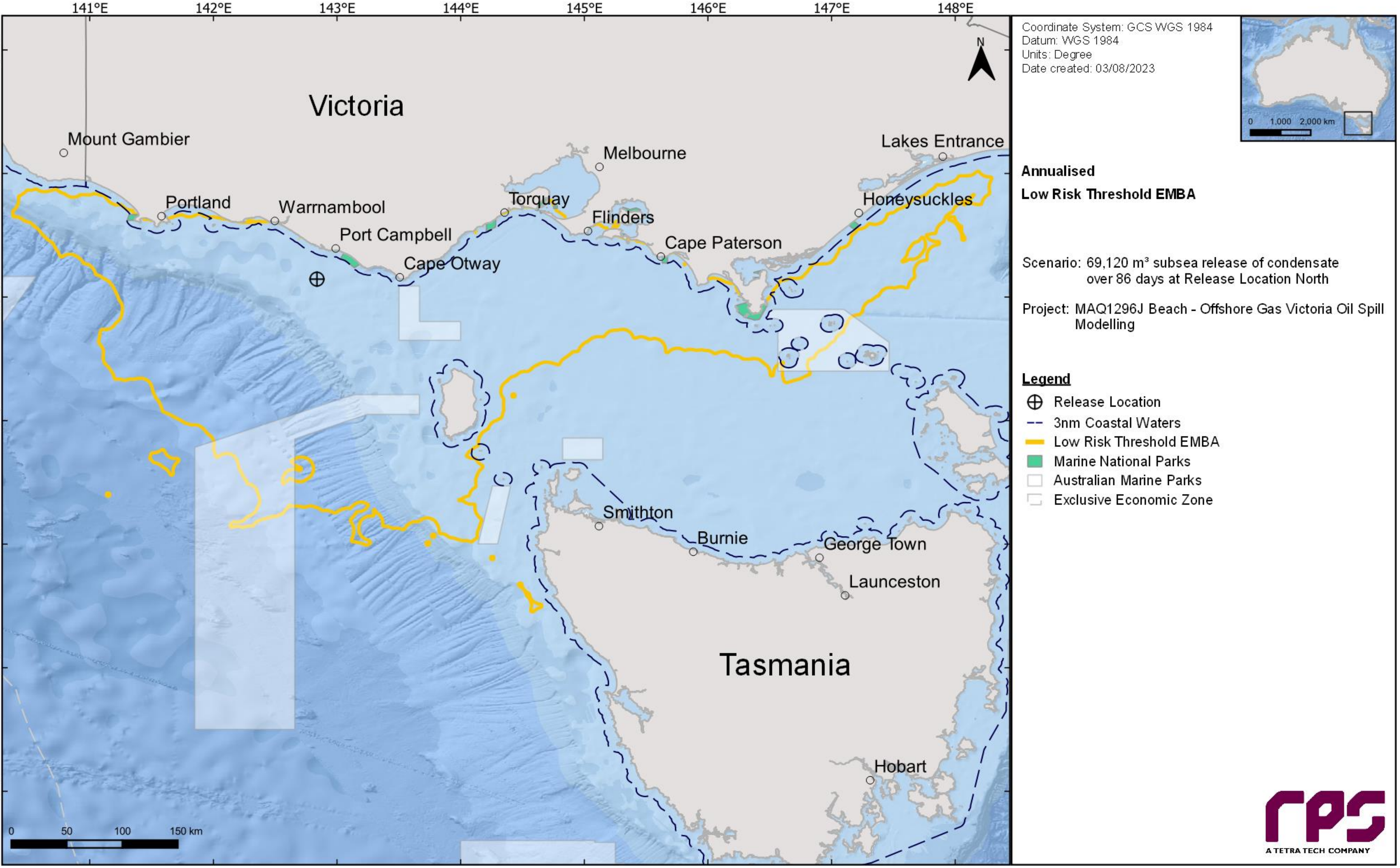


Figure 13-1 Predicted area of exposure for low thresholds produced by overlaying the results from all 200 simulations, resulting from a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location Northduring summer and winter conditions.

13.1.2 Floating Oil Exposure

Table 13-1 summarises the maximum distance travelled by floating oil on the sea surface at each threshold. The maximum distance from the release location to the low (1–10 g/m^2) and moderate (10–50 g/m^2) exposure zones was 53 km (east) during summer conditions and 12 km (south-southeast) during winter conditions, respectively. For the high threshold (> 50 g/m^2), the maximum distance from the release location was 1 km southeast (summer) and northwest (winter).

Table 13-2 summarises the potential floating oil exposure to individual receptors during the summer and winter conditions. Outside of the receptors that the Release Location North resides within (refer to Table 10-3), floating oil exposure above the low threshold was predicted at the Pygmy Blue Whale – Foraging(10% summer, 3% winter) and Short-tailed Shearwater – Foraging (19% summer, 13% winter) BIAs.

Table 13-3 presents the maximum residence time of floating oil exposure for each individual grid cell within each individual receptor during summer and winter.

Figure 13-2 and Figure 13-3 present the zones of potential floating oil exposure for all thresholds under summer and winter conditions, respectively.

Figure 13-4 to Figure 13-7 present the maximum residence time of floating oil exposure for the NOPSEMA thresholds during summer and winter, respectively.

Table 13-1 Maximum distance and direction from the release location to the edge of floating oil exposure. Results are based on a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations per season.

Season	Distance and direction travelled	Zones of potential floating oil exposure		
		Low	Moderate	High
Summer	Maximum distance (km) from release location	51	12	1
	Maximum distance (km) from release location (99th percentile)	26	11	1
	Direction	E	SSE	SE
Winter	Maximum distance (km) from release location	53	11	1
	Maximum distance (km) from release location (99th percentile)	26	10	1
	Direction	E	ESE	NW

Table 13-2 Summary of the potential floating oil exposure to individual receptors. Results are based on a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations per season.

Receptor		Summer (November through to March)						Winter (April to October)					
		Probability of floating oil exposure (%)			Minimum time before floating oil exposure (days)			Probability of floating oil exposure (%)			Minimum time before floating oil exposure (days)		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
BIA	Antipodean Albatross - Foraging*	100	100	5	< 1	< 1	1	100	100	8	< 1	< 1	1
	Black-browed Albatross - Foraging*	100	100	5	< 1	< 1	1	100	100	8	< 1	< 1	1
	Bullers Albatross - Foraging*	100	100	5	< 1	< 1	1	100	100	8	< 1	< 1	1
	Campbell Albatross – Foraging*	100	100	5	< 1	< 1	1	100	100	8	< 1	< 1	1
	Common Diving-petrel – Foraging*	100	100	5	< 1	< 1	1	100	100	8	< 1	< 1	1
	Indian Yellow-nosed Albatross – Foraging*	100	100	5	< 1	< 1	1	100	100	8	< 1	< 1	1
	Pygmy Blue Whale – Distribution*	100	100	5	< 1	< 1	1	100	100	8	< 1	< 1	1
	Pygmy Blue Whale - Foraging	10	-	-	6	-	-	3	-	-	10	-	-
	Pygmy Blue Whale - Foraging (annual high use area)*	100	100	5	< 1	< 1	1	100	100	8	< 1	< 1	1
	Short-tailed Shearwater - Foraging	19	-	-	2	-	-	13	-	-	2	-	-
	Shy Albatross – Foraging*	100	100	5	< 1	< 1	1	100	100	8	< 1	< 1	1
	Southern Right Whale - Known Core Range*	100	100	5	< 1	< 1	1	100	100	8	< 1	< 1	1
	Wandering Albatross – Foraging*	100	100	5	< 1	< 1	1	100	100	8	< 1	< 1	1
	Wedge-tailed Shearwater – Foraging*	100	100	5	< 1	< 1	1	100	100	8	< 1	< 1	1
	White Shark – Distribution*	100	100	5	< 1	< 1	1	100	100	8	< 1	< 1	1
EEZ	Australian*	100	100	5	< 1	< 1	1	100	100	8	< 1	< 1	1
IBRA	Otway Plain	2	-	-	13	-	-	5	-	-	17	-	-
IMCRA	Otway*	100	100	5	< 1	< 1	1	100	100	8	< 1	< 1	1
SHORE	Colac Otway	2	-	-	13	-	-	5	-	-	17	-	-
State Waters	Victoria State Waters	2	-	-	13	-	-	5	-	-	17	-	-
Sub-LGA	Cape Otway West	2	-	-	13	-	-	5	-	-	17	-	-

*The release location resides within the receptor boundaries.

Table 13-3 **Summary of the maximum residence time of floating oil exposure for each individual grid cell within each individual receptor. Results are based on a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations per season.**

Receptor		Summer (November through to March)			Winter (April to October)		
		Maximum residence time of floating oil exposure (days)			Maximum residence time of floating oil exposure (days)		
		Low	Moderate	High	Low	Moderate	High
BIA	Antipodean Albatross - Foraging*	12	5	-	12	4	< 1
	Black-browed Albatross - Foraging*	12	5	-	12	4	< 1
	Bullers Albatross - Foraging*	12	5	-	12	4	< 1
	Campbell Albatross – Foraging*	12	5	-	12	4	< 1
	Common Diving-petrel – Foraging*	12	5	-	12	4	< 1
	Indian Yellow-nosed Albatross – Foraging*	12	5	-	12	4	< 1
	Pygmy Blue Whale – Distribution*	12	5	-	12	4	< 1
	Pygmy Blue Whale - Foraging	1	-	-	< 1	-	-
	Pygmy Blue Whale - Foraging (annual high use area)*	12	5	-	12	4	< 1
	Short-tailed Shearwater - Foraging	1	-	-	1	-	-
	Shy Albatross – Foraging*	12	5	-	12	4	< 1
	Southern Right Whale - Known Core Range*	12	5	-	12	4	< 1
	Wandering Albatross – Foraging*	12	5	-	12	4	< 1
	Wedge-tailed Shearwater – Foraging*	12	5	-	12	4	< 1
	White Shark – Distribution*	12	5	-	12	4	< 1
EEZ	Australian*	12	5	-	12	4	< 1
IBRA	Otway Plain	< 1	-	-	< 1	-	-
IMCRA	Otway*	12	5	-	12	4	< 1
SHORE	Colac Otway	< 1	-	-	< 1	-	-
State Waters	Victoria State Waters	< 1	-	-	< 1	-	-
Sub-LGA	Cape Otway West	< 1	-	-	< 1	-	-

*The release location resides within the receptor boundaries.

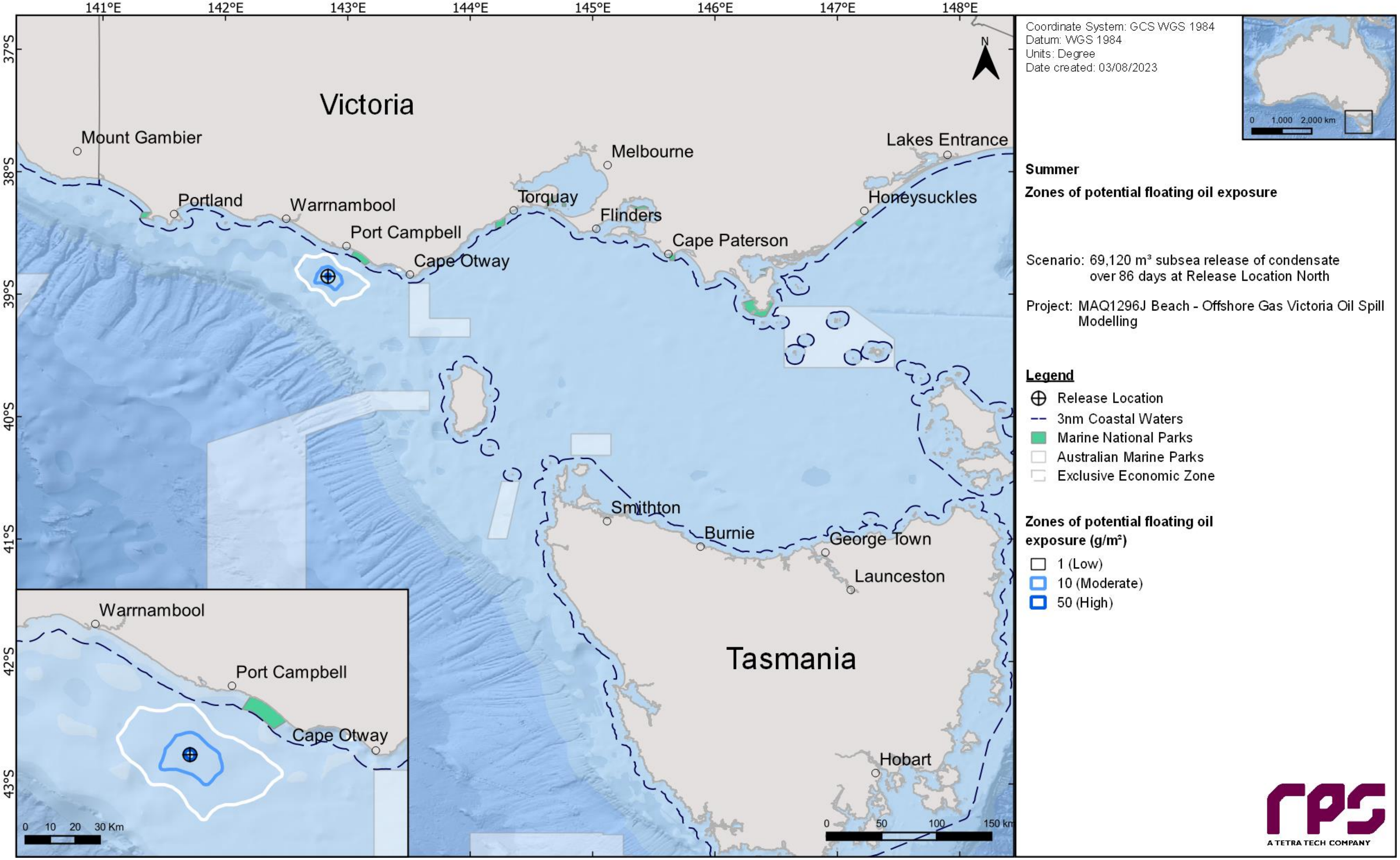


Figure 13-2 Zones of potential floating oil exposure in the event of a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during summer conditions.

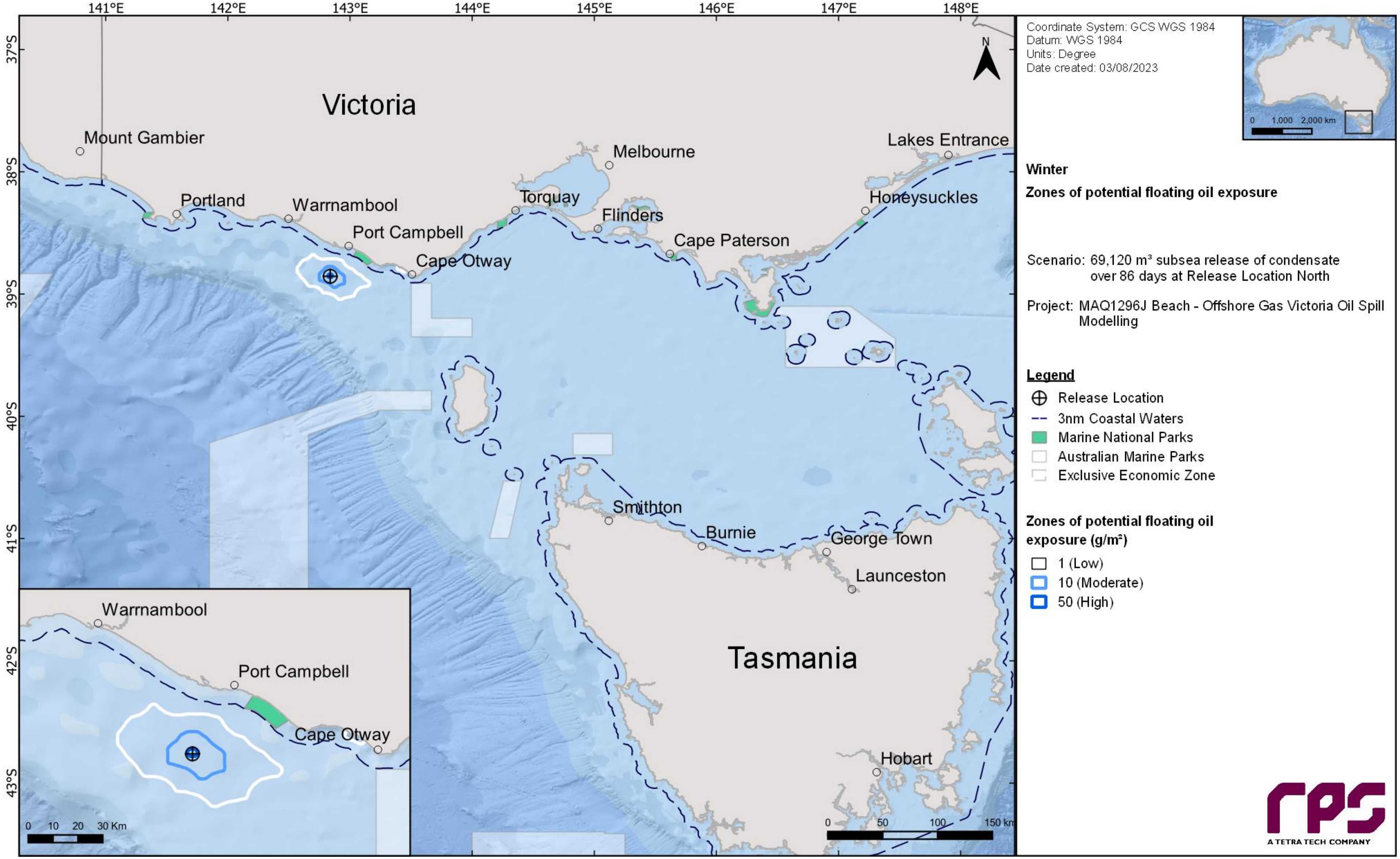


Figure 13-3 Zones of potential floating oil exposure in the event of a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during winter conditions.

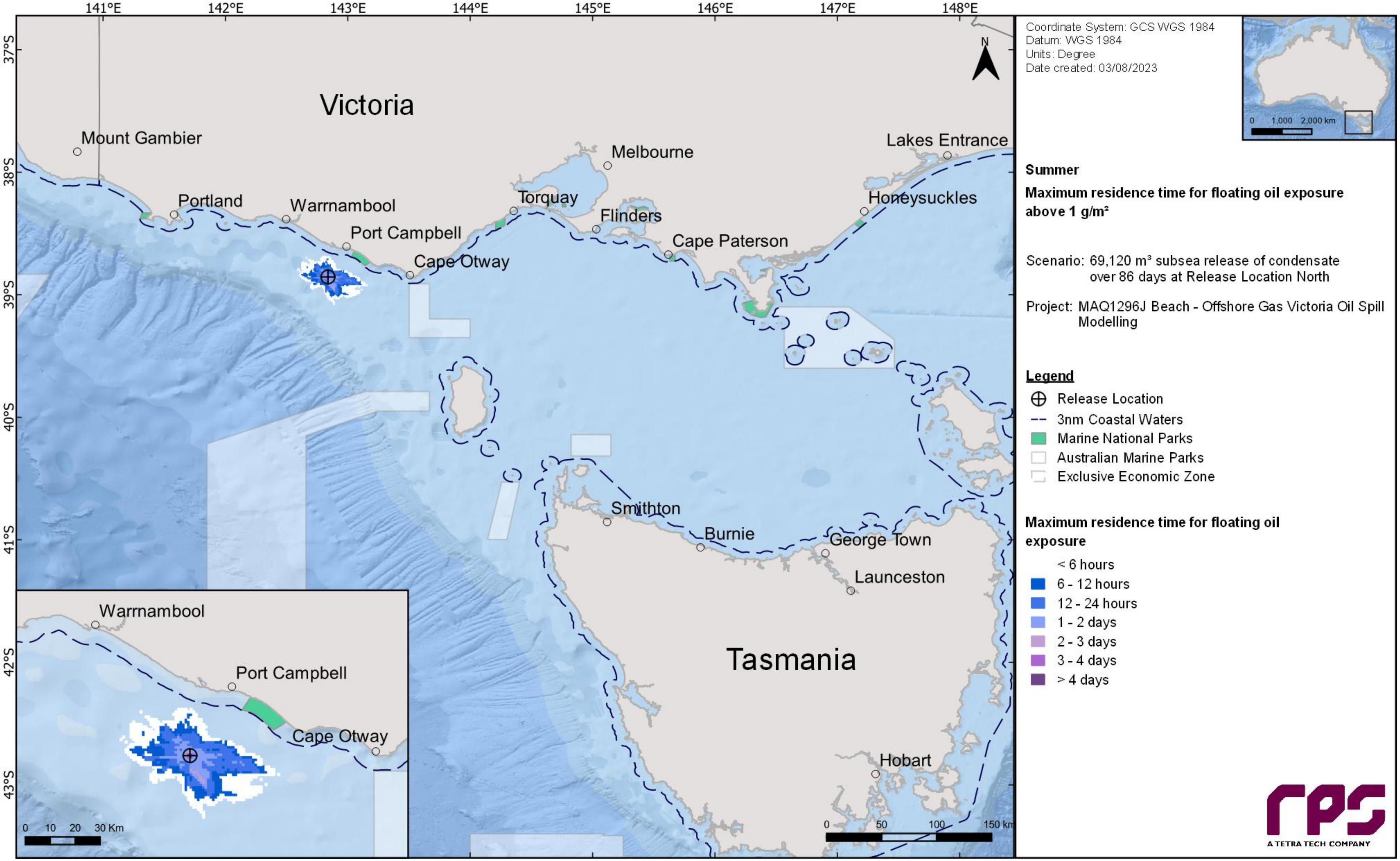


Figure 13-4 Maximum residence time of floating oil exposure above 1 g/m^2, in the event of 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during summer conditions.

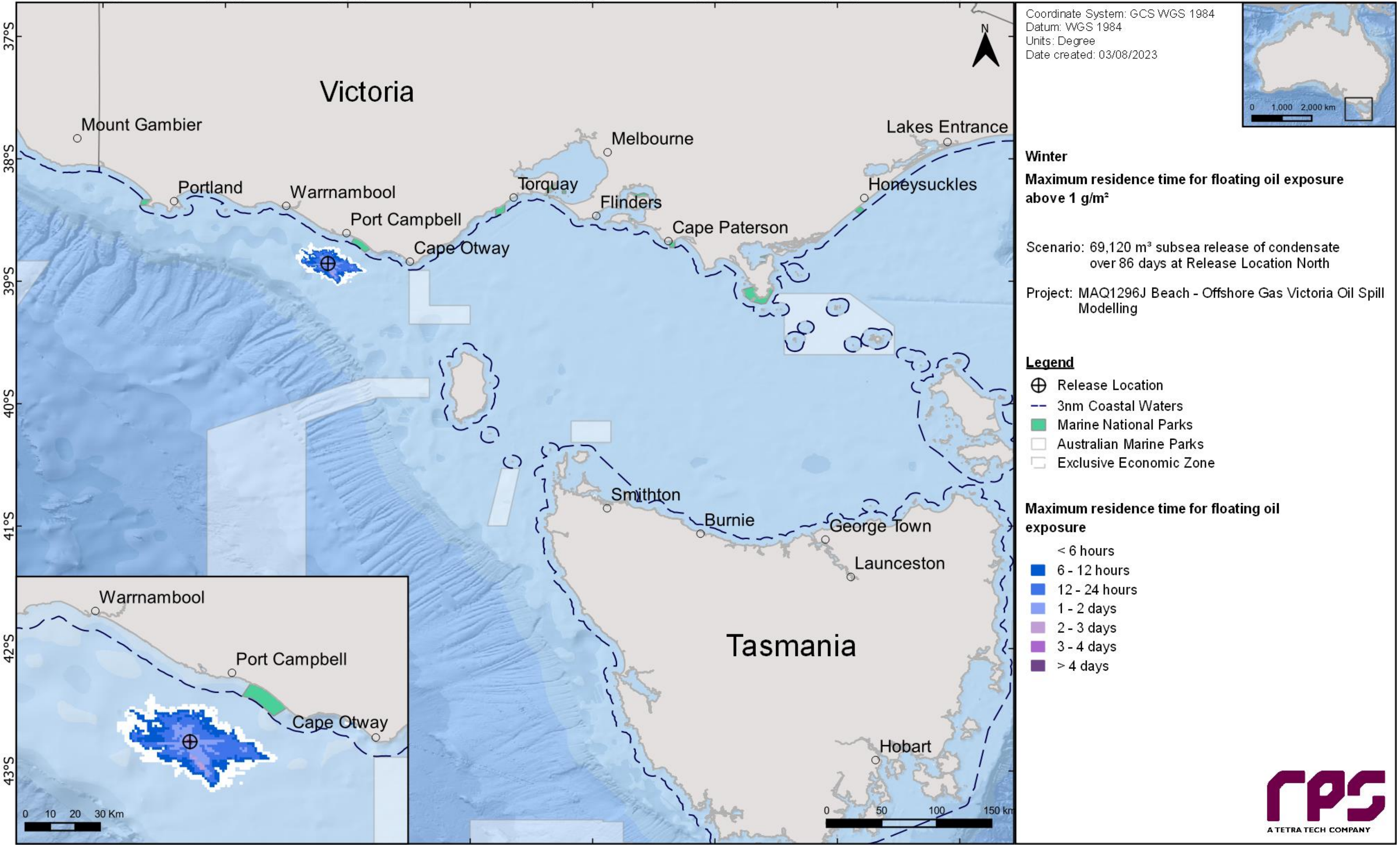


Figure 13-5 Maximum residence time of floating oil exposure above 1 g/m^2, in the event of 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during winter conditions.

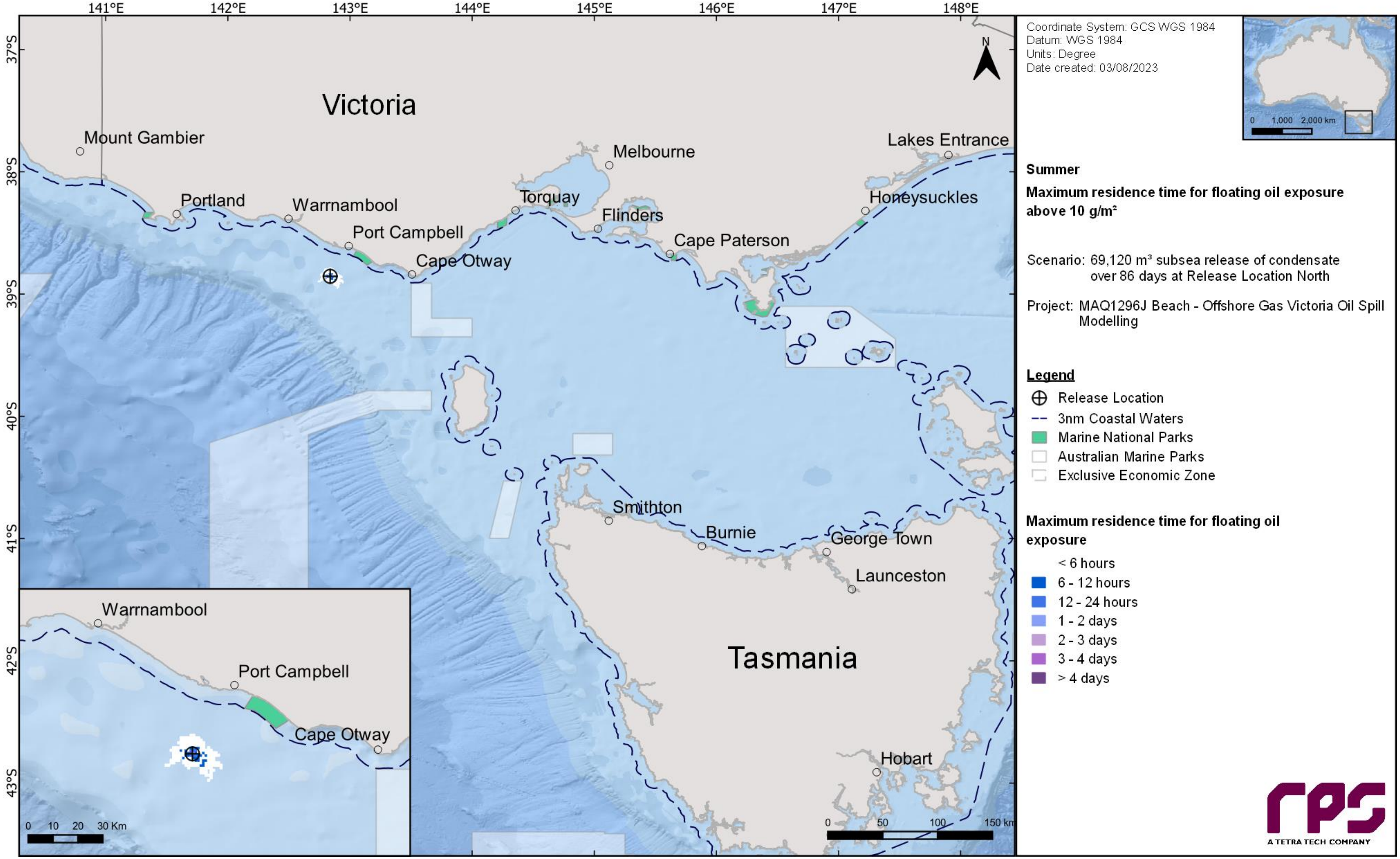


Figure 13-6 Maximum residence time of floating oil exposure above 10 g/m^2, in the event of 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during summer conditions.

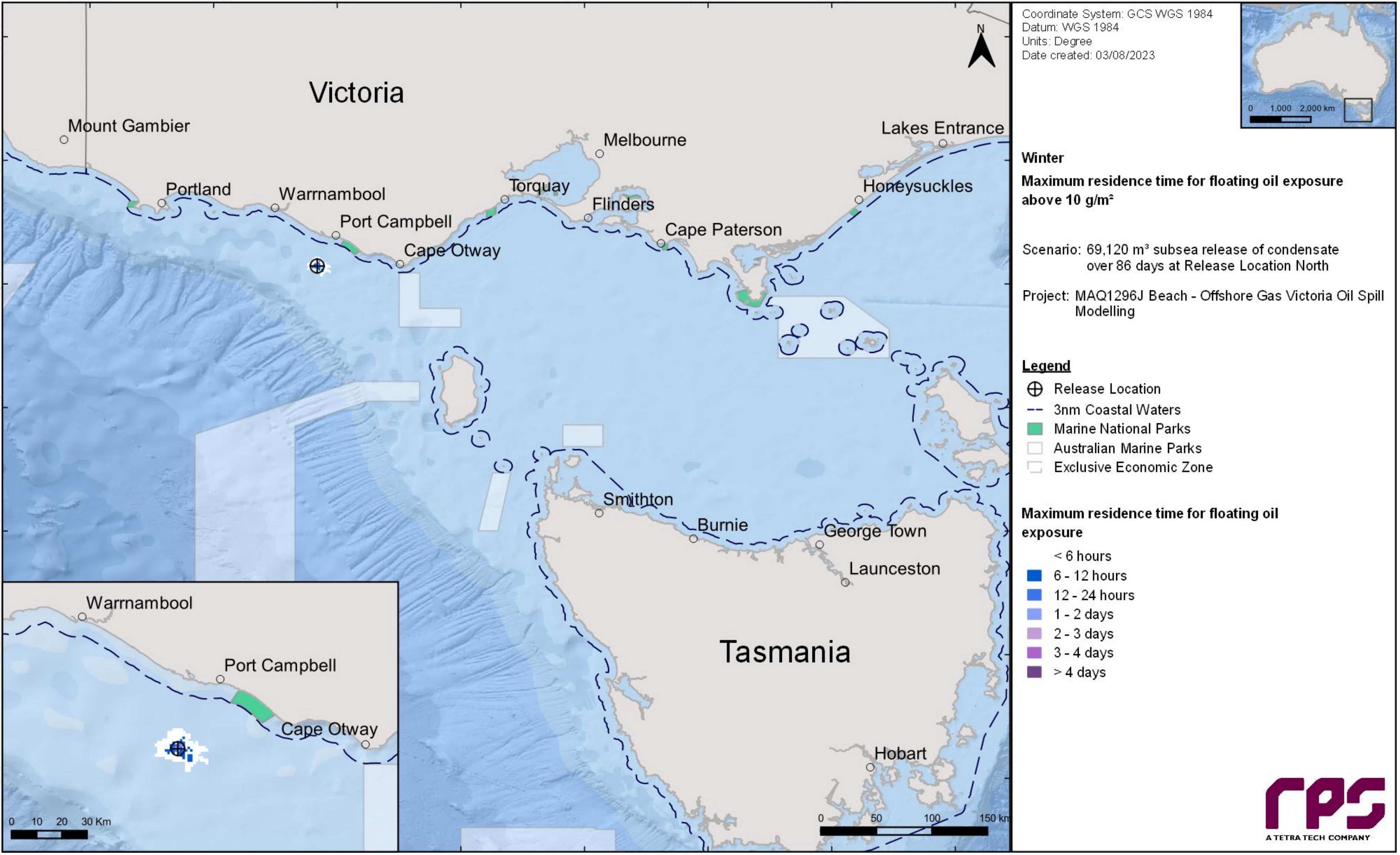


Figure 13-7 Maximum residence time of floating oil exposure above 10 g/m^2, in the event of 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during winter conditions.

13.1.3 Shoreline Accumulation

Table 13-4 presents a summary of the predicted potential shoreline accumulation during the summer and winter conditions. The probability of accumulation to any shoreline at, or above, the low level (10 g/m^2) threshold was 100% during summer conditions and 98% during winter conditions. The minimum time before oil accumulation at, or above, the low threshold was 5 days during summer conditions, and 4 days during winter conditions. The maximum volume ashore for a single spill trajectory during the summer and winter conditions was 112 m^3 and 143 m^3, respectively, whilst the maximum length of shoreline accumulation at the low threshold was 108 km and 136 km, respectively. For the moderate threshold (100 g/m^2), the maximum length of shoreline accumulation predicted was 25 km (summer) and 24 km (winter). No shoreline accumulation was predicted for the high (1,000 g/m^2) threshold.

Table 13-5 summarises the shoreline accumulation on individual receptors during the summer and winter conditions. During summer, Colac Otway shoreline and Cape Otway West Sub-LGA shoreline recorded the highest probability of shoreline accumulation at the low threshold (96% for both in summer, and 96% and 93% respectively in winter).

The minimum time before shoreline accumulation above the low threshold was 5 days predicted for Colac Otway and Cape Otway West during summer conditions and 4 days during the winter conditions predicted for Colac Otway, Corangamite, Apollo Bay, Cape Otway West and Moonlight Head.

The summer and winter conditions maximum potential shoreline loading above the low, moderate and high shoreline thresholds are presented in Figure 13-8 and Figure 13-9, respectively.

Table 13-4 Summary of oil accumulation across all shorelines. Results are based on a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations per season.

Shoreline Statistics	Summer	Winter
Probability of accumulation on any shoreline (%)	100	98
Absolute minimum time for visible oil to shore (days)	5	4
Maximum total volume of hydrocarbons ashore (m^3)	112	143
Average volume of hydrocarbons ashore (m^3)	32	41
Maximum length of the shoreline at **10 g/m^2** (km)	108	136
Average shoreline length (km) at **10 g/m^2** (km)	39	52
Maximum length of the shoreline at **100 g/m^2** (km)	25	24
Average shoreline length (km) at **100 g/m^2** (km)	8	9
Maximum length of the shoreline at **1,000 g/m^2** (km)	-	-
Average shoreline length (km) at **1,000 g/m^2** (km)	-	-

Table 13-5 Summary of oil accumulation on individual shoreline receptors. Results are based on a 69,120.0 m³ subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations per season.

Shoreline Receptor		Summer																Winter															
		Maximum probability of shoreline loading (%)			Minimum time before shoreline accumulation (days)			Load on shoreline (g/m²)		Volume on shoreline (m³)		Mean length of shoreline accumulation (km)			Maximum length of shoreline accumulation (km)			Maximum probability of shoreline loading (%)			Minimum time before shoreline accumulation (days)			Load on shoreline (g/m²)		Volume on shoreline (m³)		Mean length of shoreline accumulation (km)			Maximum length of shoreline accumulation (km)		
		Low	Mod	High	Low	Mod	High	Mean	Peak	Mean	Peak	Low	Mod	High	Low	Mod	High	Low	Mod	High	Low	Mod	High	Mean	Peak	Mean	Peak	Low	Mod	High	Low	Mod	High
SHORE	Anser Island	1	-	-	69	-	-	< 1	11	< 1	< 1	1	-	-	1	-	-	6	-	-	42	-	-	2	12	< 1	< 1	1	-	-	1	-	-
	Bass Coast	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	-	-	14	-	-	1	32	0	2	2	-	-	4	-	-
	Colac Otway	96	72	-	5	7	-	22	823	25	96	27	7	-	60	22	-	96	54	-	4	7	-	22	873	27	94	31	9	-	67	20	-
	Corangamite	81	4	-	9	24	-	5	125	3	15	7	1	-	25	3	-	86	20	-	4	11	-	11	700	7	41	8	4	-	25	6	-
	French Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	34	-	-	< 1	14	< 1	1	1	-	-	1	-	-
	Glenelg	18	-	-	22	-	-	1	41	1	3	4	-	-	7	-	-	1	-	-	88	-	-	1	76	1	5	6	-	-	6	-	-
	Glennie Group	2	-	-	59	-	-	< 1	23	< 1	1	2	-	-	2	-	-	9	-	-	14	-	-	2	20	< 1	1	1	-	-	2	-	-
	Greater Geelong	5	-	-	73	-	-	< 1	20	< 1	2	2	-	-	4	-	-	6	-	-	47	-	-	< 1	19	< 1	2	1	-	-	3	-	-
	Kanowna Island	2	-	-	67	-	-	< 1	15	< 1	1	1	-	-	2	-	-	8	-	-	22	-	-	2	14	< 1	1	1	-	-	2	-	-
	King Island	18	4	-	43	50	-	< 1	244	1	8	2	1	-	7	1	-	14	6	-	20	28	-	2	206	1	8	4	1	-	9	1	-
	Mornington Peninsula	14	-	-	52	-	-	< 1	64	1	7	5	-	-	21	-	-	23	-	-	13	-	-	1	55	1	4	2	-	-	8	-	-
	Moyne	23	4	-	15	68	-	2	180	1	9	5	1	-	12	1	-	24	5	-	5	18	-	3	153	1	12	4	1	-	21	3	-
	Norman Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	19	-	-	1	11	< 1	< 1	1	-	-	1	-	-
	Phillip Island	14	-	-	50	-	-	< 1	40	< 1	2	2	-	-	3	-	-	45	8	-	13	33	-	2	185	1	6	3	1	-	10	1	-
	Seal Islands	1	-	-	73	-	-	< 1	11	< 1	< 1	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Skull Rock	2	-	-	67	-	-	< 1	15	< 1	< 1	1	-	-	1	-	-	6	-	-	22	-	-	2	14	< 1	< 1	1	-	-	1	-	-
	South Gippsland	3	-	-	59	-	-	< 1	21	< 1	3	3	-	-	6	-	-	48	3	-	13	52	-	2	136	1	5	3	1	-	8	1	-
	Surf Coast	12	3	-	24	56	-	1	132	1	6	7	1	-	12	1	-	29	-	-	23	-	-	3	87	2	13	11	-	-	35	-	-
	Warrnambool	2	-	-	64	-	-	< 1	13	< 1	1	1	-	-	1	-	-	2	-	-	8	-	-	1	25	< 1	1	1	-	-	2	-	-
Sub-LGA	Anglesea	6	-	-	50	-	-	1	31	< 1	2	5	-	-	6	-	-	17	-	-	23	-	-	3	61	1	5	6	-	-	15	-	-
	Apollo Bay	78	9	-	8	34	-	10	324	4	17	8	3	-	18	5	-	89	11	-	4	24	-	10	264	4	17	8	2	-	20	4	-
	Bay of Islands	21	4	-	15	68	-	3	180	1	8	4	1	-	9	1	-	23	5	-	5	18	-	3	153	1	9	3	1	-	15	3	-
	Cape Liptrap (NW)	3	-	-	59	-	-	< 1	21	< 1	1	3	-	-	5	-	-	34	-	-	13	-	-	2	42	< 1	1	2	-	-	4	-	-
	Cape Nelson	18	-	-	22	-	-	1	41	1	3	4	-	-	7	-	-	1	-	-	88	-	-	1	76	1	4	6	-	-	6	-	-
	Cape Otway West	96	71	-	5	7	-	41	823	19	63	16	6	-	25	13	-	93	53	-	4	7	-	43	873	20	86	17	8	-	28	15	-
	Cape Patton	43	3	-	10	45	-	4	168	2	13	7	3	-	19	4	-	69	3	-	10	65	-	7	143	3	11	8	2	-	18	2	-
	Childers Cove	9	-	-	53	-	-	1	15	< 1	1	2	-	-	4	-	-	2	-	-	7	-	-	2	27	< 1	3	5	-	-	8	-	-
	Kilcunda	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	18	-	-	< 1	13	< 1	1	1	-	-	1	-	-
	Lorne	23	6	-	15	40	-	3	210	1	10	4	2	-	15	4	-	31	8	-	24	61	-	5	170	2	9	9	1	-	18	2	-
	Moonlight Head	79	1	-	9	24	-	5	125	2	9	5	3	-	15	3	-	86	19	-	4	11	-	16	700	6	40	7	5	-	20	6	-
	Mornington Peninsula (S)	7	-	-	58	-	-	1	41	< 1	2	3	-	-	6	-	-	22	-	-	13	-	-	2	55	< 1	3	2	-	-	6	-	-
	Mornington Peninsula (SW)	13	-	-	52	-	-	1	64	< 1	4	4	-	-	14	-	-	13	-	-	13	-	-	1	33	< 1	2	2	-	-	4	-	-
	Port Campbell	30	3	-	13	69	-	3	116	1	7	6	1	-	12	1	-	22	1	-	7	45	-	2	123	1	7	4	1	-	11	1	-
	Port Fairy	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	95	-	-	< 1	12	< 1	1	1	-	-	1	-	-
	Port Phillip (Queenscliff)	5	-	-	73	-	-	< 1	20	< 1	1	1	-	-	2	-	-	6	-	-	47	-	-	1	19	< 1	1	1	-	-	3	-	-
	Port Phillip (Sorrento Shore)	1	-	-	97	-	-	< 1	54	< 1	3	7	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Shoreline Receptor	Summer																Winter															
	Maximum probability of shoreline loading (%)			Minimum time before shoreline accumulation (days)			Load on shoreline (g/m²)		Volume on shoreline (m³)		Mean length of shoreline accumulation (km)			Maximum length of shoreline accumulation (km)			Maximum probability of shoreline loading (%)			Minimum time before shoreline accumulation (days)			Load on shoreline (g/m²)		Volume on shoreline (m³)		Mean length of shoreline accumulation (km)			Maximum length of shoreline accumulation (km)		
	Low	Mod	High	Low	Mod	High	Mean	Peak	Mean	Peak	Low	Mod	High	Low	Mod	High	Low	Mod	High	Low	Mod	High	Mean	Peak	Mean	Peak	Low	Mod	High	Low	Mod	High
Port Phillip Heads	1	-	-	98	-	-	< 1	17	< 1	1	2	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Torquay	1	-	-	57	-	-	< 1	11	< 1	2	1	-	-	1	-	-	11	-	-	24	-	-	1	26	< 1	2	2	-	-	7	-	-
Venus Bay	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	-	-	14	-	-	1	32	< 1	1	1	-	-	3	-	-
Waratah Bay	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	26	-	-	1	36	< 1	1	1	-	-	2	-	-
Wilsons Promontory (West)	1	-	-	60	-	-	< 1	17	< 1	2	1	-	-	1	-	-	38	3	-	29	52	-	2	136	1	4	2	1	-	5	1	-

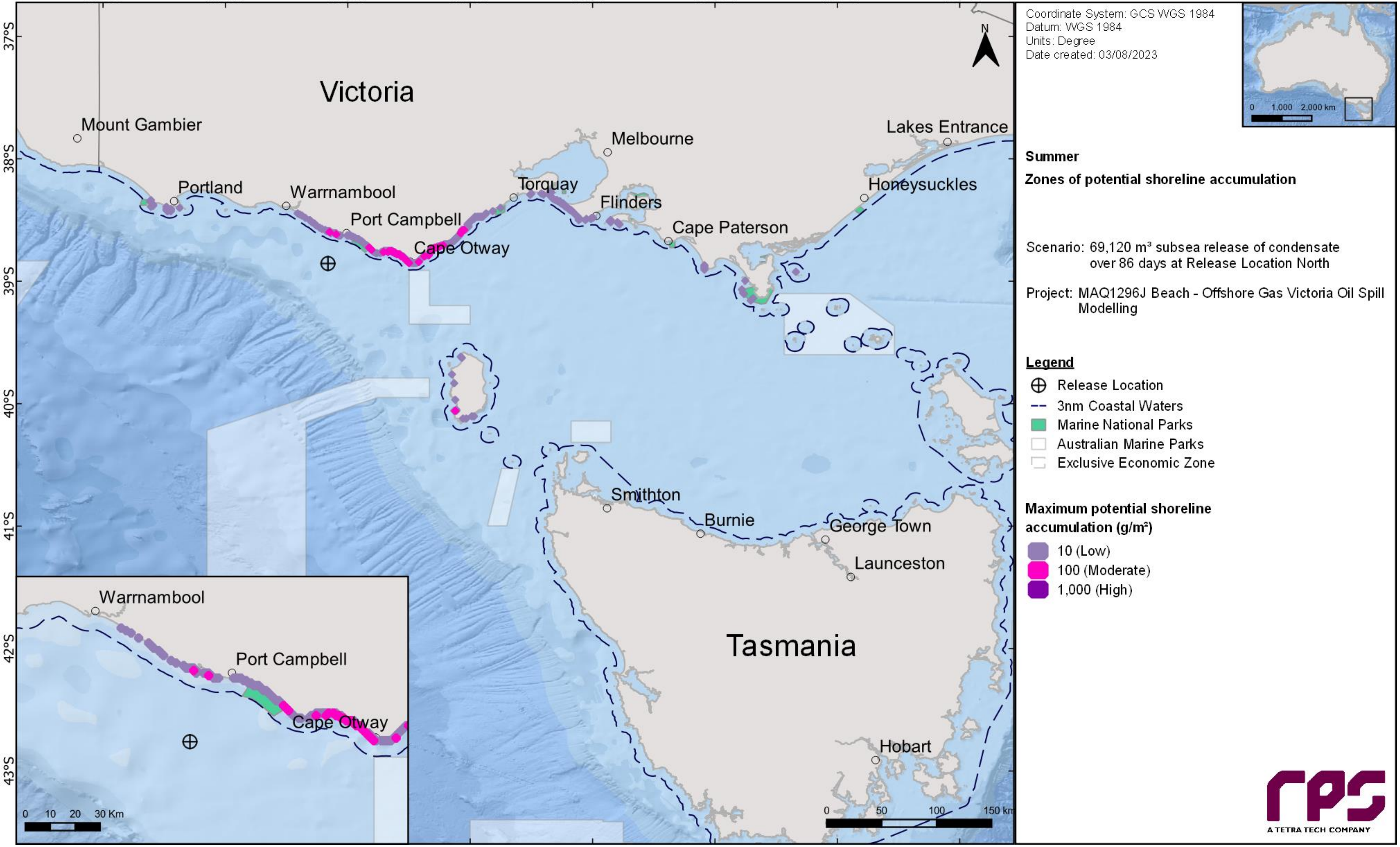


Figure 13-8 Maximum potential shoreline loading in the event of a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during summer conditions.

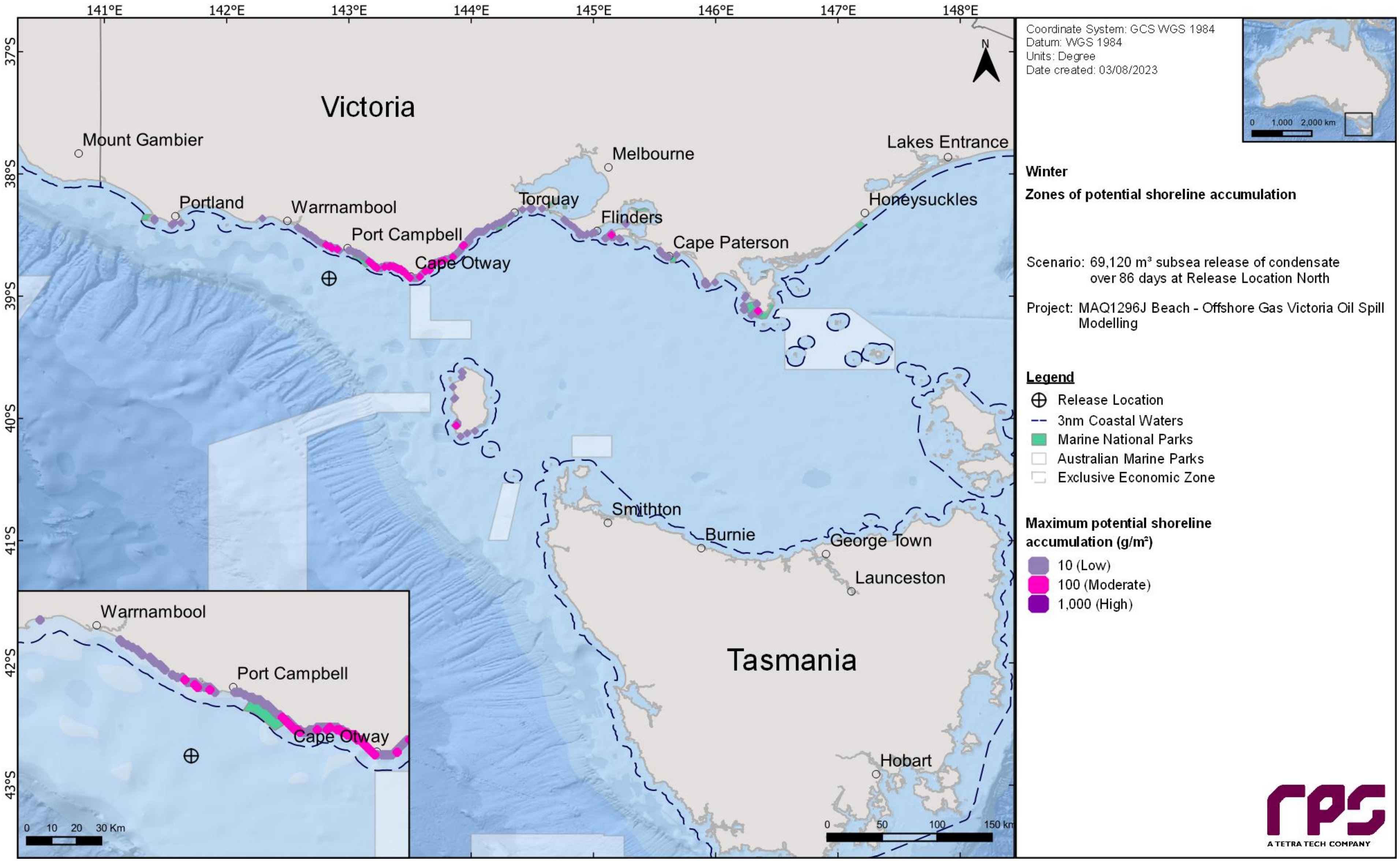


Figure 13-9 Maximum potential shoreline loading in the event of a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during winter conditions.

13.1.4 In-water exposure

13.1.4.1 Dissolved Hydrocarbons

Table 13-6 summarises the probability of exposure to individual receptors from dissolved hydrocarbons in the 0-10 m layer during the summer and winter conditions.

Outside of the receptors that the Release Location North resides within (refer to Table 10-3), the highest concentration of dissolved hydrocarbon was predicted for Pygmy Blue Whale - Foraging BIA (summer – 1,396 ppb, winter – 1,410 ppb), which also revealed the highest probability of low dissolved hydrocarbon exposure (100% for both seasons).

Table 13-7 presents the predicted minimum time to dissolved hydrocarbon exposure and maximum residence time for dissolved hydrocarbon exposure to individual receptors, in the 0-10 m depth layer, for all seasonal conditions and all thresholds assessed. The maximum residence time of dissolved hydrocarbon exposure at the low threshold predicted for receptors which the release location does not reside within was 1 day.

Figure 13-10 and Figure 13-11 present the zones of potential dissolved hydrocarbon exposure for the 0-10 m depth layer, for each threshold assessed under summer and winter conditions, respectively.

Figure 13-12 to Figure 13.17 present the maximum residence time of dissolved hydrocarbon exposure for the NOPSEMA thresholds in summer and winter.

Table 13-6 **Probability of dissolved hydrocarbons exposure to marine based receptors in the 0–10 m dept. Results are based on a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations per season.**

Receptor		Summer (November through to March)				Winter (April to October)			
		Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure			Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure		
			Low	Moderate	High		Low	Moderate	High
AMP	Apollo	789	96	77	3	984	100	98	6
	Beagle	77	3	1	-	76	6	1	-
	Zeehan	75	6	1	-	70	3	1	-
BIA	Antipodean Albatross - Foraging*	1,796	100	100	99	1,709	100	100	90
	Australasian Gannet - Foraging	453	44	14	1	324	39	8	-
	Black-browed Albatross - Foraging*	1,796	100	100	99	1,709	100	100	90
	Black-faced Cormorant - Foraging	23	1	-	-	12	1	-	-
	Bullers Albatross - Foraging*	1,796	100	100	99	1,709	100	100	90
	Campbell Albatross – Foraging*	1,796	100	100	99	1,709	100	100	90
	Common Diving-petrel – Foraging*	1,796	100	100	99	1,709	100	100	90
	Indian Yellow-nosed Albatross – Foraging*	1,796	100	100	99	1,709	100	100	90
	Little Penguin - Foraging	97	5	1	-	151	13	2	-
	Pygmy Blue Whale – Distribution*	1,796	100	100	99	1,709	100	100	90
	Pygmy Blue Whale - Foraging	1,396	100	100	11	1,410	100	100	12
	Pygmy Blue Whale - Foraging (annual high use area)*	1,796	100	100	99	1,709	100	100	90
	Pygmy Blue Whale - Known Foraging Area	1,076	96	69	3	1,216	100	96	4
	Short-tailed Shearwater - Foraging	1,678	100	100	14	1,410	100	100	18
	Shy Albatross – Foraging*	1,796	100	100	99	1,709	100	100	90
	Southern Right Whale - Aggregation	740	91	67	3	840	68	41	2
	Southern Right Whale - Connecting habitat	18	1	-	-	10	1	-	-
	Southern Right Whale - Known Core Range*	1,796	100	100	99	1,709	100	100	90
	Wandering Albatross – Foraging*	1,796	100	100	99	1,709	100	100	90
	Wedge-tailed Shearwater – Foraging*	1,796	100	100	99	1,709	100	100	90
	White Shark - Breeding	92	2	1	-	39	3	-	-
	White Shark – Distribution*	1,796	100	100	99	1,709	100	100	90

Receptor		Summer (November through to March)				Winter (April to October)			
		Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure			Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure		
			Low	Moderate	High		Low	Moderate	High
	White Shark - Foraging	520	57	27	2	320	34	7	-
	White-faced Storm-petrel - Foraging	1,076	96	68	3	1,216	100	93	3
EEZ	Australian*	1,796	100	100	99	1,709	100	100	90
IBRA	Flinders	15	1	-	-	9	-	-	-
	Gippsland Plain	57	3	1	-	84	5	1	-
	Glenelg Plain	18	3	-	-	9	-	-	-
	King Island	17	1	-	-	9	-	-	-
	Otway Plain	812	94	44	2	363	97	55	-
	Otway Ranges	887	87	28	1	320	96	40	-
	Strzelecki Ranges	36	2	-	-	21	5	-	-
	Warrnambool Plain	228	75	14	-	177	76	16	-
	Wilsons Promontory	170	4	2	-	41	7	-	-
IMCRA	Central Bass Strait	1,076	90	54	3	1,216	100	89	3
	Central Victoria	865	96	69	2	801	100	96	4
	Flinders	271	6	2	-	95	11	1	-
	Otway*	1,796	100	100	99	1,709	100	100	90
	Twofold Shelf	31	2	-	-	43	4	-	-
	Victorian Embayments	14	1	-	-	22	3	-	-
KEF	Bonney Coast Upwelling	177	28	4	-	41	2	-	-
	Upwelling East of Eden	11	1	-	-	15	1	-	-
	West Tasmania Canyons	303	13	3	-	176	8	2	-
MNP	Bunurong	83	1	1	-	32	5	-	-
	Discovery Bay	11	1	-	-	3	-	-	-
	Point Addis	20	2	-	-	67	8	1	-
	Port Phillip Heads	12	1	-	-	18	2	-	-
	Twelve Apostles	299	75	16	-	182	72	10	-
	Wilsons Promontory	271	3	2	-	35	7	-	-

Receptor		Summer (November through to March)				Winter (April to October)			
		Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure			Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure		
			Low	Moderate	High		Low	Moderate	High
MS	Mushroom Reef	6	-	-	-	11	1	-	-
NPS4	Bunurong Marine Park	31	1	-	-	46	3	-	-
	Wilsons Promontory Marine Park	16	1	-	-	11	1	-	-
RAMSAR	Port Phillip Bay	5	-	-	-	18	1	-	-
RSB	Bravenes Rock	302	95	38	-	258	97	47	-
	Cody Bank	62	4	1	-	40	14	-	-
SHORE	Anser Island	170	2	1	-	16	3	-	-
	Bass Coast	57	1	1	-	46	4	-	-
	Colac Otway	887	94	44	2	363	97	55	-
	Corangamite	351	75	17	-	177	79	17	-
	Glenelg	18	3	-	-	9	-	-	-
	Glennie Group	117	4	1	-	37	4	-	-
	Greater Geelong	16	1	-	-	18	1	-	-
	Hogan Island Group	15	1	-	-	9	-	-	-
	Kanowna Island	113	3	2	-	26	7	-	-
	King Island	17	1	-	-	9	-	-	-
	Lady Julia Percy Island	31	4	-	-	8	-	-	-
	Laurence Rocks	22	3	-	-	3	-	-	-
	Moncoeur Islands	24	2	-	-	37	7	-	-
	Mornington Peninsula	12	1	-	-	59	4	1	-
	Moyne	101	33	3	-	60	16	1	-
	Norman Island	40	2	-	-	13	2	-	-
	Phillip Island	62	3	1	-	29	5	-	-
	Rodondo Island	36	3	-	-	41	6	-	-
	Seal Islands	51	1	1	-	13	1	-	-
	Shellback Island	19	1	-	-	11	1	-	-
	Skull Rock	113	2	2	-	28	4	-	-

Receptor		Summer (November through to March)				Winter (April to October)			
		Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure			Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure		
			Low	Moderate	High		Low	Moderate	High
	South Gippsland	170	2	1	-	84	5	1	-
	Surf Coast	29	3	-	-	37	12	-	-
	Warrnambool	32	3	-	-	10	1	-	-
State Waters	Tasmania	26	2	-	-	25	2	-	-
	Victoria	887	97	63	4	578	100	86	2
Sub-LGA	Anglesea	10	1	-	-	28	4	-	-
	Apollo Bay	887	91	28	1	320	97	40	-
	Bay of Islands	101	33	3	-	60	16	1	-
	Cape Liptrap	26	1	-	-	84	5	1	-
	Cape Nelson	18	3	-	-	9	-	-	-
	Cape Otway West	488	94	48	3	363	97	55	-
	Cape Patton	291	29	4	-	217	63	9	-
	Childers Cove	38	7	-	-	16	1	-	-
	French Island / San Remo	16	1	-	-	7	-	-	-
	Kilcunda	19	1	-	-	42	2	-	-
	Lorne	32	5	-	-	37	12	-	-
	Moonlight Head	351	75	17	-	177	79	17	-
	Mornington Peninsula (S)	8	-	-	-	59	4	1	-
	Mornington Peninsula (SW)	9	-	-	-	57	4	1	-
	Port Campbell	130	34	5	-	56	17	1	-
	Port Fairy	10	1	-	-	8	-	-	-
	Port Phillip (Queenscliff)	16	1	-	-	13	1	-	-
	Port Phillip (Sorrento Shore)	12	1	-	-	25	4	-	-
	Port Phillip Heads	8	-	-	-	18	1	-	-
	Torquay	16	1	-	-	14	2	-	-
	Venus Bay	57	1	1	-	46	4	-	-
	Waratah Bay	36	2	-	-	21	5	-	-

Receptor		Summer (November through to March)				Winter (April to October)			
		Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure			Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure		
			Low	Moderate	High		Low	Moderate	High
	Warrnambool	15	2	-	-	8	-	-	-
	Westernport	6	-	-	-	21	1	-	-
	Wilsons Promontory (East)	48	2	-	-	21	3	-	-
	Wilsons Promontory (West)	170	2	1	-	27	3	-	-

*The release location resides within the receptor boundaries.

Table 13-7 Predicted minimum time to dissolved hydrocarbon exposure and maximum residence time for dissolved hydrocarbon exposure to individual receptors in the 0-10 m depth layer. Results are based on a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill trajectories per season.

Receptor		Summer (November through to March)						Winter (April to October)					
		Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)			Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
AMP	Apollo	2	3	3	1	< 1	< 1	1	1	3	1	< 1	< 1
	Beagle	55	64	-	< 1	< 1	-	17	49	-	< 1	< 1	-
	Zeehan	14	14	-	< 1	< 1	-	16	17	-	< 1	< 1	-
BIA	Antipodean Albatross - Foraging*	< 1	< 1	< 1	26	8	< 1	< 1	< 1	< 1	27	9	< 1
	Australasian Gannet - Foraging	5	7	14	< 1	< 1	< 1	7	8	-	< 1	< 1	-
	Black-browed Albatross - Foraging*	< 1	< 1	< 1	26	8	< 1	< 1	< 1	< 1	27	9	< 1
	Black-faced Cormorant - Foraging	42	-	-	< 1	-	-	25	-	-	< 1	-	-
	Bullers Albatross - Foraging*	< 1	< 1	< 1	26	8	< 1	< 1	< 1	< 1	27	9	< 1
	Campbell Albatross – Foraging*	< 1	< 1	< 1	26	8	< 1	< 1	< 1	< 1	27	9	< 1
	Common Diving-petrel – Foraging*	< 1	< 1	< 1	26	8	< 1	< 1	< 1	< 1	27	9	< 1
	Indian Yellow-nosed Albatross – Foraging*	< 1	< 1	< 1	26	8	< 1	< 1	< 1	< 1	27	9	< 1
	Little Penguin - Foraging	44	55	-	< 1	< 1	-	9	25	-	< 1	< 1	-
	Pygmy Blue Whale – Distribution*	< 1	< 1	< 1	26	8	< 1	< 1	< 1	< 1	27	9	< 1
	Pygmy Blue Whale - Foraging	1	1	2	1	1	< 1	1	1	2	1	1	< 1
	Pygmy Blue Whale - Foraging (annual high use area)*	< 1	< 1	< 1	26	8	< 1	< 1	< 1	< 1	27	9	< 1
	Pygmy Blue Whale - Known Foraging Area	3	3	3	1	< 1	< 1	1	1	3	1	< 1	< 1
	Short-tailed Shearwater - Foraging	< 1	1	2	1	1	< 1	< 1	1	2	2	1	< 1
	Shy Albatross – Foraging*	< 1	< 1	< 1	26	8	< 1	< 1	< 1	< 1	27	9	< 1
	Southern Right Whale - Aggregation	2	2	3	1	< 1	< 1	1	2	10	1	1	< 1
	Southern Right Whale - Connecting habitat	40	-	-	< 1	-	-	26	-	-	< 1	-	-
	Southern Right Whale - Known Core Range*	< 1	< 1	< 1	26	8	< 1	< 1	< 1	< 1	27	9	< 1
	Wandering Albatross – Foraging*	< 1	< 1	< 1	26	8	< 1	< 1	< 1	< 1	27	9	< 1
	Wedge-tailed Shearwater – Foraging*	< 1	< 1	< 1	26	8	< 1	< 1	< 1	< 1	27	9	< 1

Receptor		Summer (November through to March)						Winter (April to October)					
		Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)			Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
	White Shark - Breeding	56	99	-	< 1	< 1	-	33	-	-	< 1	-	-
	White Shark – Distribution*	< 1	< 1	< 1	26	8	< 1	< 1	< 1	< 1	27	9	< 1
	White Shark - Foraging	4	5	14	< 1	< 1	< 1	7	8	-	< 1	< 1	-
	White-faced Storm-petrel - Foraging	3	3	3	1	< 1	< 1	1	2	3	1	< 1	< 1
EEZ	Australian*	< 1	< 1	< 1	26	8	< 1	< 1	< 1	< 1	27	9	< 1
IBRA	Flinders	59	-	-	< 1	-	-	81	-	-	< 1	-	-
	Gippsland Plain	55	65	-	< 1	< 1	-	11	20	-	< 1	< 1	-
	Glenelg Plain	45	-	-	< 1	-	-	-	-	-	-	-	-
	King Island	42	-	-	< 1	-	-	26	-	-	< 1	-	-
	Otway Plain	4	5	9	< 1	< 1	< 1	2	2	-	< 1	< 1	-
	Otway Ranges	4	5	19	< 1	< 1	< 1	2	4	-	< 1	< 1	-
	Strzelecki Ranges	36	-	-	< 1	-	-	31	-	-	< 1	-	-
	Warrnambool Plain	7	13	-	< 1	< 1	-	3	9	-	< 1	< 1	-
	Wilsons Promontory	56	56	-	< 1	< 1	-	10	29	-	< 1	< 1	-
IMCRA	Central Bass Strait	3	3	5	1	< 1	< 1	2	2	3	1	< 1	< 1
	Central Victoria	3	3	3	1	< 1	< 1	1	1	4	1	< 1	< 1
	Flinders	36	55	-	< 1	< 1	-	9	26	-	< 1	< 1	-
	Otway	< 1	< 1	< 1	26	8	< 1	< 1	< 1	< 1	27	9	< 1
	Twofold Shelf	57	-	-	< 1	-	-	26	-	-	< 1	-	-
	Victorian Embayments	56	-	-	< 1	-	-	17	-	-	< 1	-	-
KEF	Bonney Coast Upwelling	10	15	-	< 1	< 1	-	79	81	-	< 1	< 1	-
	Upwelling East of Eden	81	-	-	< 1	-	-	54	-	-	< 1	-	-
	West Tasmania Canyons	7	11	-	< 1	< 1	-	12	12	-	< 1	< 1	-
MNP	Bunurong	64	65	-	< 1	< 1	-	40	-	-	< 1	-	-
	Discovery Bay	57	-	-	< 1	-	-	-	-	-	-	-	-
	Point Addis	57	-	-	< 1	-	-	15	28	-	< 1	< 1	-
	Port Phillip Heads	71	-	-	< 1	-	-	29	-	-	< 1	-	-

Receptor		Summer (November through to March)						Winter (April to October)					
		Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)			Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
	Twelve Apostles	4	8	-	< 1	< 1	-	5	7	-	< 1	< 1	-
	Wilsons Promontory	55	56	-	< 1	< 1	-	10	48	-	< 1	< 1	-
MS	Mushroom Reef	94	-	-	< 1	-	-	18	-	-	< 1	-	-
NPS4	Bunurong Marine Park	64	67	-	< 1	< 1	-	40	-	-	< 1	-	-
	Wilsons Promontory Marine Park	60	-	-	< 1	-	-	38	-	-	< 1	-	-
RAMSAR	Port Phillip Bay	-	-	-	-	-	-	89	-	-	< 1	-	-
RSB	Bravenes Rock	4	4	-	< 1	< 1	-	3	3	14	< 1	< 1	< 1
	Cody Bank	54	54	-	< 1	< 1	-	10	34	-	< 1	< 1	-
SHORE	Anser Island	56	56	-	< 1	< 1	-	33	-	-	< 1	-	-
	Bass Coast	56	65	-	< 1	< 1	-	40	-	-	< 1	-	-
	Colac Otway	4	5	9	< 1	< 1	< 1	2	2	-	< 1	< 1	-
	Corangamite	4	13	-	< 1	< 1	-	3	7	-	< 1	< 1	-
	Glenelg	45	-	-	< 1	-	-	-	-	-	-	-	-
	Glennie Group	56	56	-	< 1	< 1	-	10	-	-	< 1	-	-
	Greater Geelong	71	-	-	< 1	-	-	48	-	-	< 1	-	-
	Hogan Island Group	62	-	-	< 1	-	-	81	-	-	< 1	-	-
	Kanowna Island	56	56	-	< 1	< 1	-	27	-	-	< 1	-	-
	King Island	42	-	-	< 1	-	-	26	-	-	< 1	-	-
	Lady Julia Percy Island	24	-	-	< 1	-	-	-	-	-	-	-	-
	Laurence Rocks	56	-	-	< 1	-	-	-	-	-	-	-	-
	Moncoeur Islands	57	98	-	< 1	< 1	-	26	29	-	< 1	< 1	-
	Mornington Peninsula	71	-	-	< 1	-	-	11	20	-	< 1	< 1	-
	Moyne	8	22	-	< 1	< 1	-	3	10	-	< 1	< 1	-
	Norman Island	56	-	-	< 1	-	-	33	-	-	< 1	-	-
	Phillip Island	55	55	-	< 1	< 1	-	17	-	-	< 1	-	-
	Rodondo Island	56	-	-	< 1	-	-	25	99	-	< 1	-	-
	Seal Islands	64	99	-	< 1	< 1	-	86	-	-	< 1	-	-

Receptor		Summer (November through to March)						Winter (April to October)					
		Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)			Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
	Shellback Island	56	-	-	< 1	-	-	37	-	-	< 1	-	-
	Skull Rock	56	56	-	< 1	< 1	-	26	82	-	< 1	< 1	-
	South Gippsland	36	56	-	< 1	< 1	-	16	31	-	< 1	< 1	-
	Surf Coast	41	-	-	< 1	-	-	19	28	-	< 1	< 1	-
	Warrnambool	32	-	-	< 1	-	-	10	-	-	< 1	-	-
State Waters	Tasmania	38	-	-	< 1	-	-	26	-	-	< 1	-	-
	Victoria	3	4	6	1	< 1	< 1	1	2	4	1	< 1	< 1
Sub-LGA	Anglesea	54	-	-	< 1	-	-	22	-	-	< 1	-	-
	Apollo Bay	4	5	19	< 1	< 1	< 1	2	4	-	< 1	< 1	-
	Bay of Islands	8	22	-	< 1	< 1	-	4	10	-	< 1	< 1	-
	Cape Liptrap	55	-	-	< 1	-	-	16	31	-	< 1	< 1	-
	Cape Nelson	45	-	-	< 1	-	-	-	-	-	-	-	-
	Cape Otway West	4	5	9	< 1	< 1	< 1	2	2	-	< 1	< 1	-
	Cape Patton	6	11	-	< 1	< 1	-	5	5	-	< 1	< 1	-
	Childers Cove	18	-	-	< 1	-	-	10	-	-	< 1	-	-
	French Island / San Remo	56	-	-	< 1	-	-	-	-	-	-	-	-
	Kilcunda	56	-	-	< 1	-	-	40	-	-	< 1	-	-
	Lorne	21	-	-	< 1	-	-	19	28	-	< 1	< 1	-
	Moonlight Head	4	13	-	< 1	< 1	-	3	7	-	< 1	< 1	-
	Mornington Peninsula (S)	94	-	-	< 1	-	-	16	20	-	< 1	< 1	-
	Mornington Peninsula (SW)	74	-	-	< 1	-	-	11	33	-	< 1	< 1	-
	Port Campbell	7	14	-	< 1	< 1	-	4	19	-	< 1	< 1	-
	Port Fairy	33	-	-	< 1	-	-	90	-	-	< 1	-	-
	Port Phillip (Queenscliff)	71	-	-	< 1	-	-	48	-	-	< 1	-	-
	Port Phillip (Sorrento Shore)	71	-	-	< 1	-	-	29	-	-	< 1	-	-
	Port Phillip Heads	-	-	-	-	-	-	89	-	-	< 1	-	-
	Torquay	70	-	-	< 1	-	-	37	-	-	< 1	-	-

Receptor	Summer (November through to March)						Winter (April to October)					
	Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)			Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)		
	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
Venus Bay	64	65	-	< 1	< 1	-	40	-	-	< 1	-	-
Waratah Bay	36	-	-	< 1	-	-	31	-	-	< 1	-	-
Warrnambool	34	-	-	< 1	-	-	-	-	-	-	-	-
Westernport	-	-	-	-	-	-	18	-	-	< 1	-	-
Wilsons Promontory (East)	56	64	-	< 1	< 1	-	38	-	-	< 1	-	-
Wilsons Promontory (West)	56	56	-	< 1	< 1	-	36	-	-	< 1	-	-

*The release location resides within the receptor boundaries.

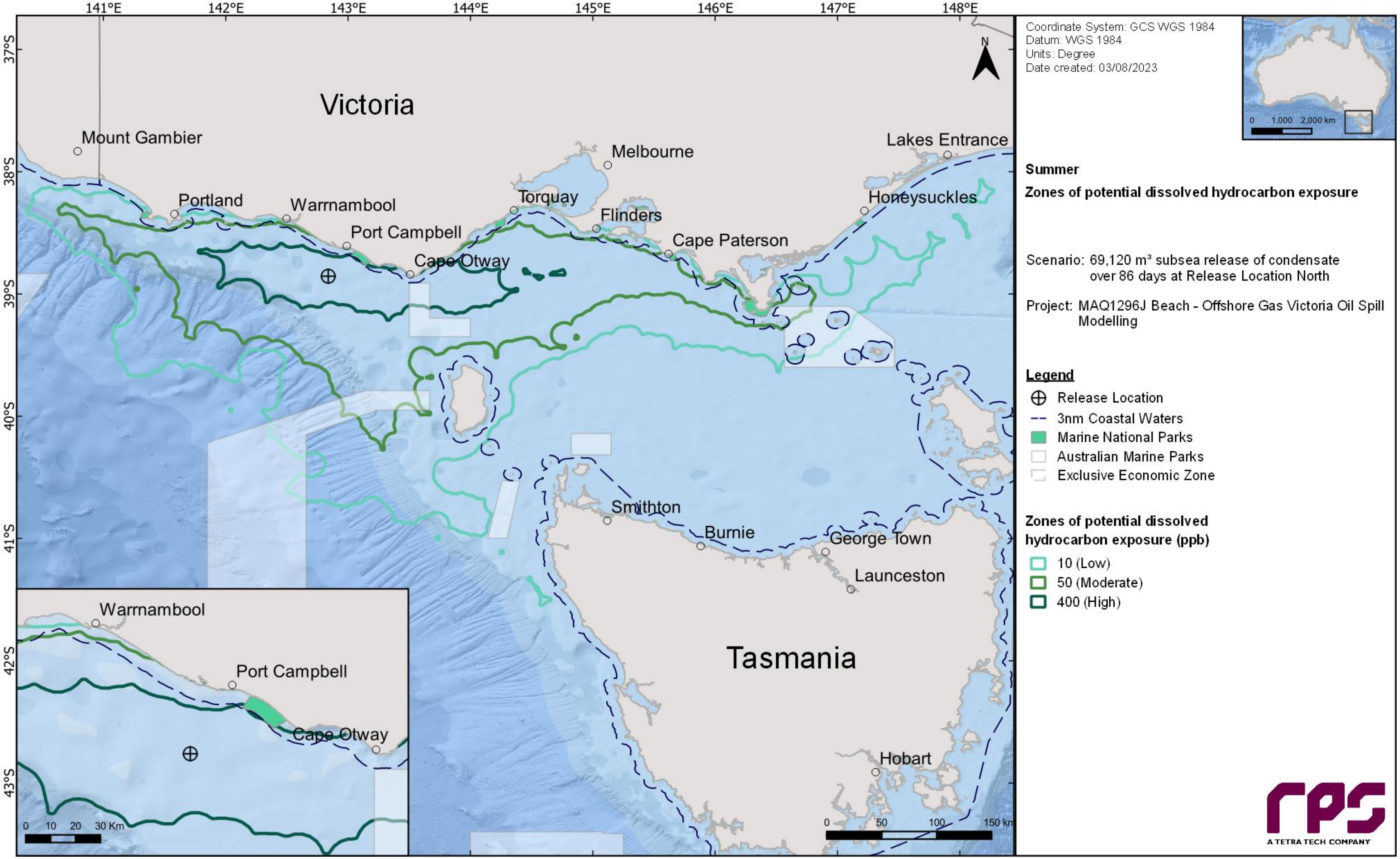


Figure 13-10 Zones of potential dissolved hydrocarbon exposure at 0-10 m below the sea in the event of a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during summer conditions.

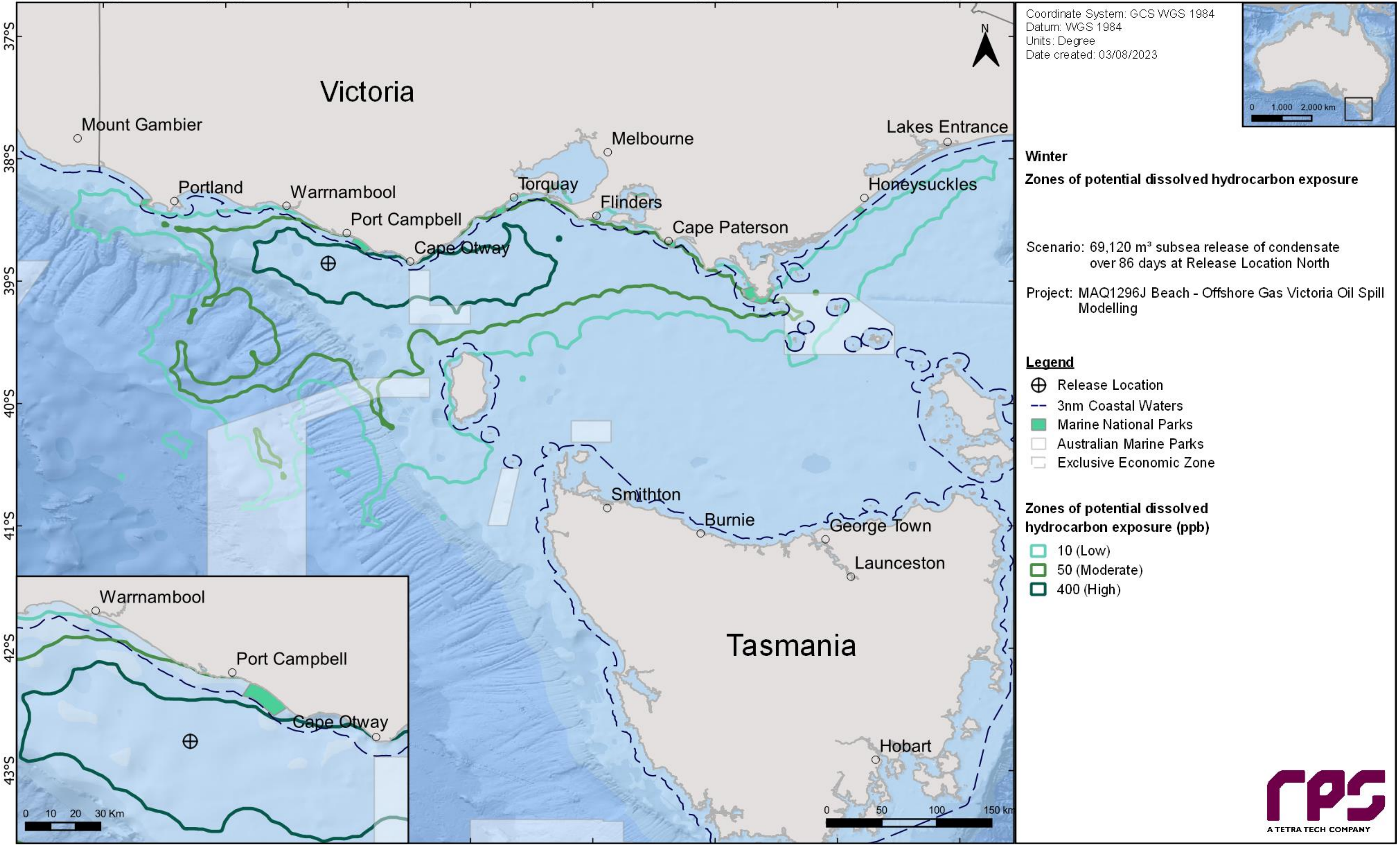


Figure 13-11 Zones of potential dissolved hydrocarbon exposure at 0-10 m below the sea in the event of a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during winter conditions.

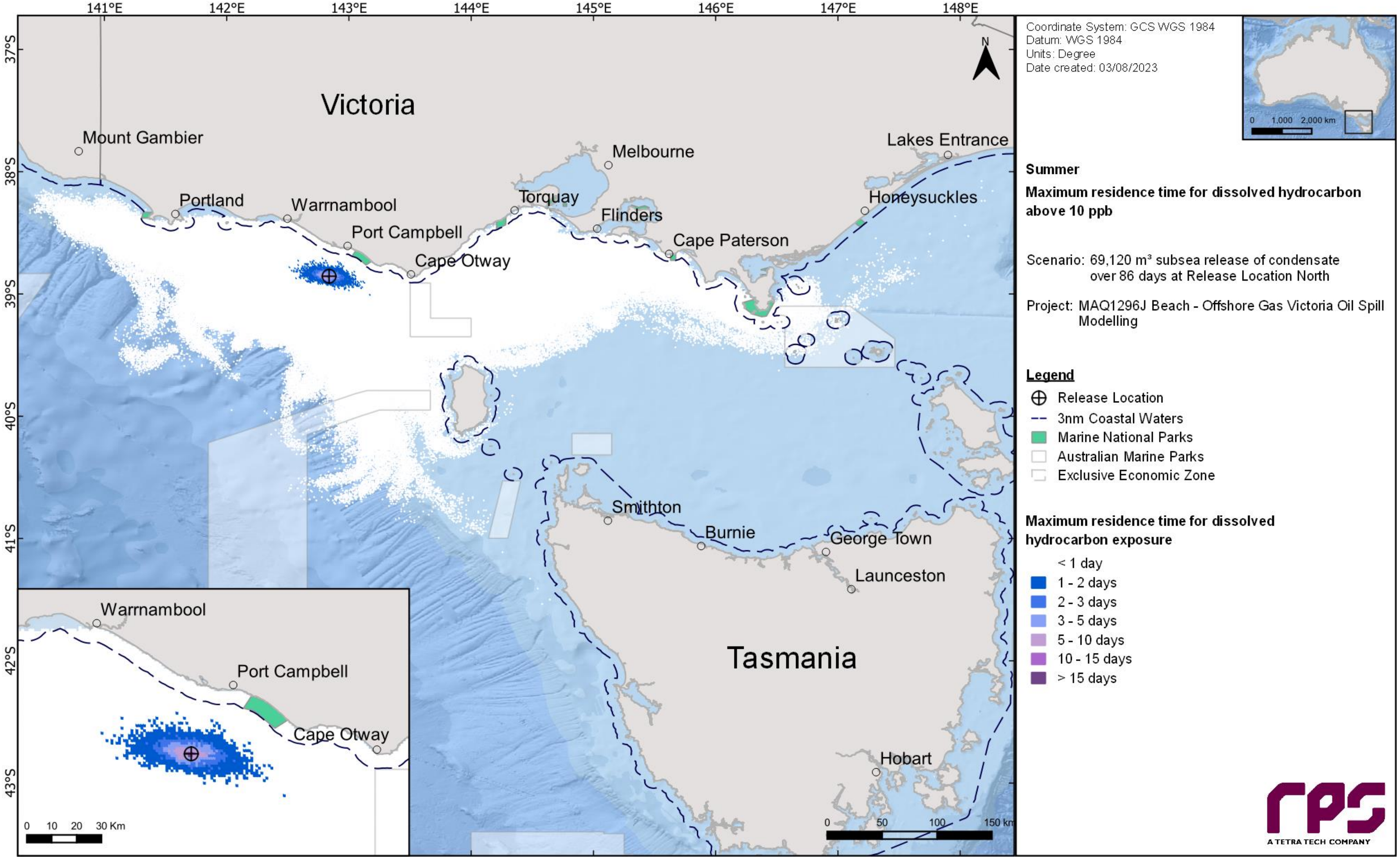


Figure 13-12 Maximum residence time for dissolved hydrocarbon exposure above 10 ppb, at 0-10 m below the sea surface in the event of a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during summer conditions.

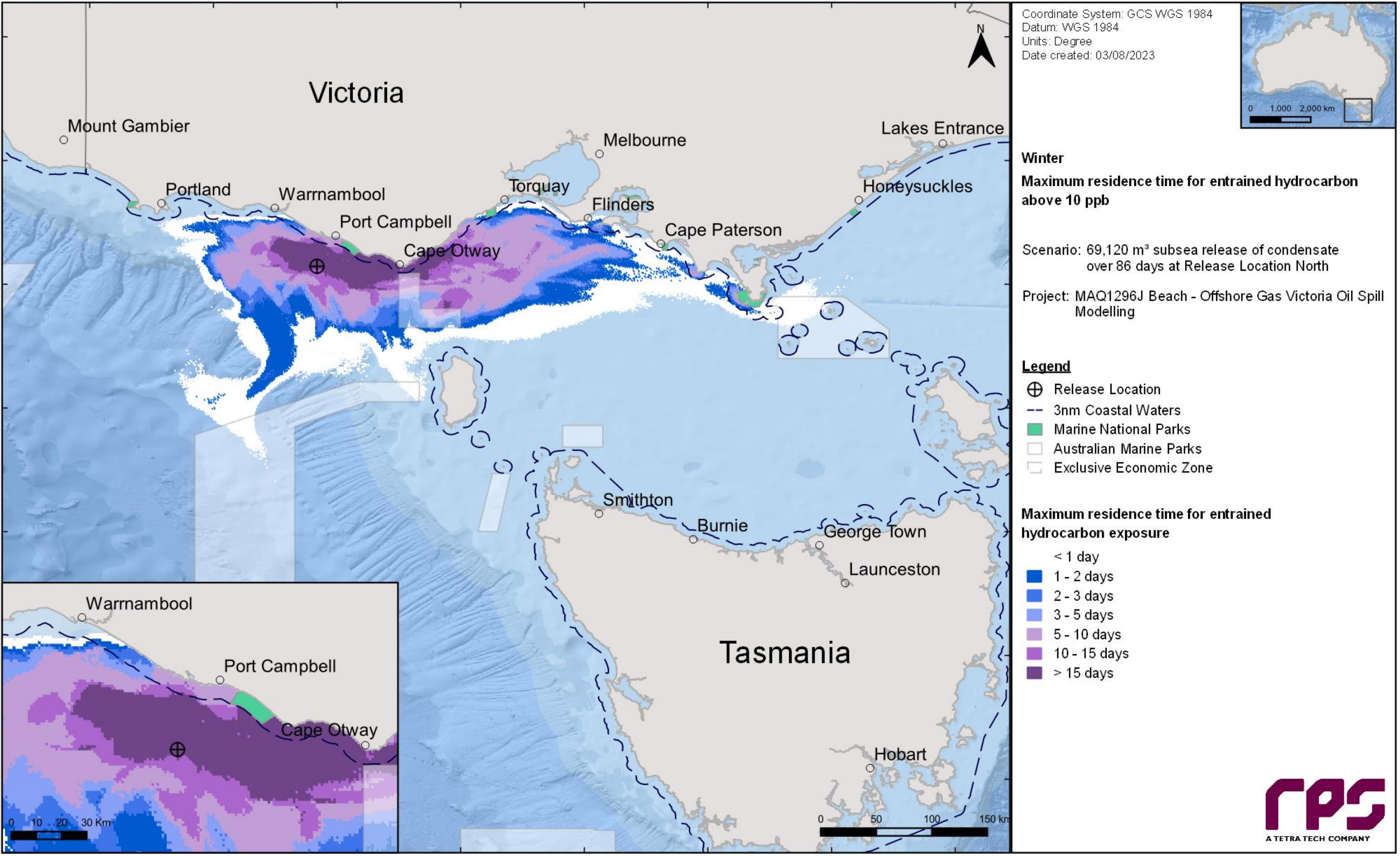


Figure 13.13 Maximum residence time for dissolved hydrocarbon exposure above 10 ppb, at 0-10 m below the sea surface in the event of a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during winter conditions.

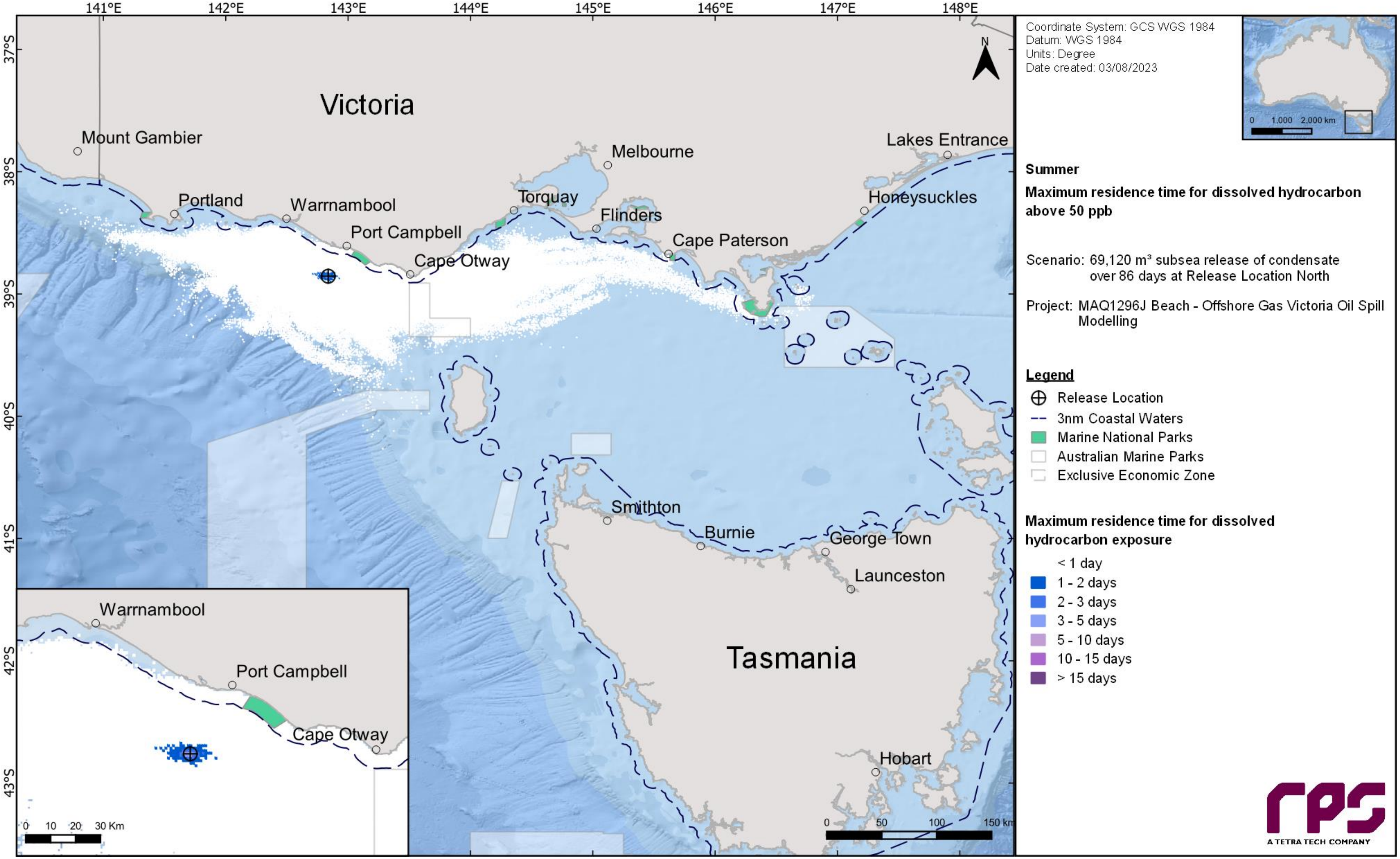


Figure 13.14 Maximum residence time for dissolved hydrocarbon exposure above 50 ppb, at 0-10 m below the sea surface in the event of a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during summer conditions.

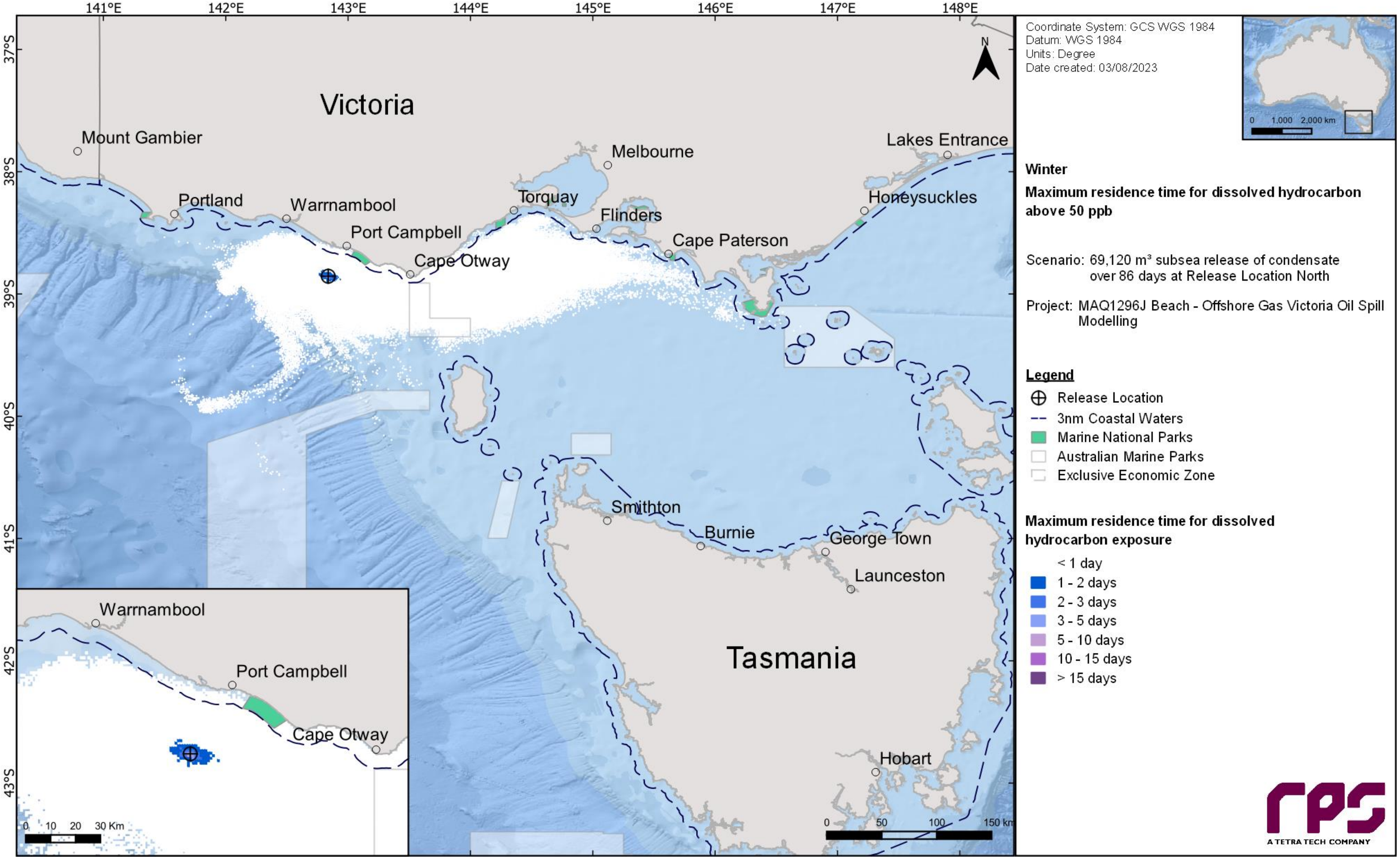


Figure 13.15 Maximum residence time for dissolved hydrocarbon exposure above 50 ppb, at 0-10 m below the sea surface in the event of a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during winter conditions.

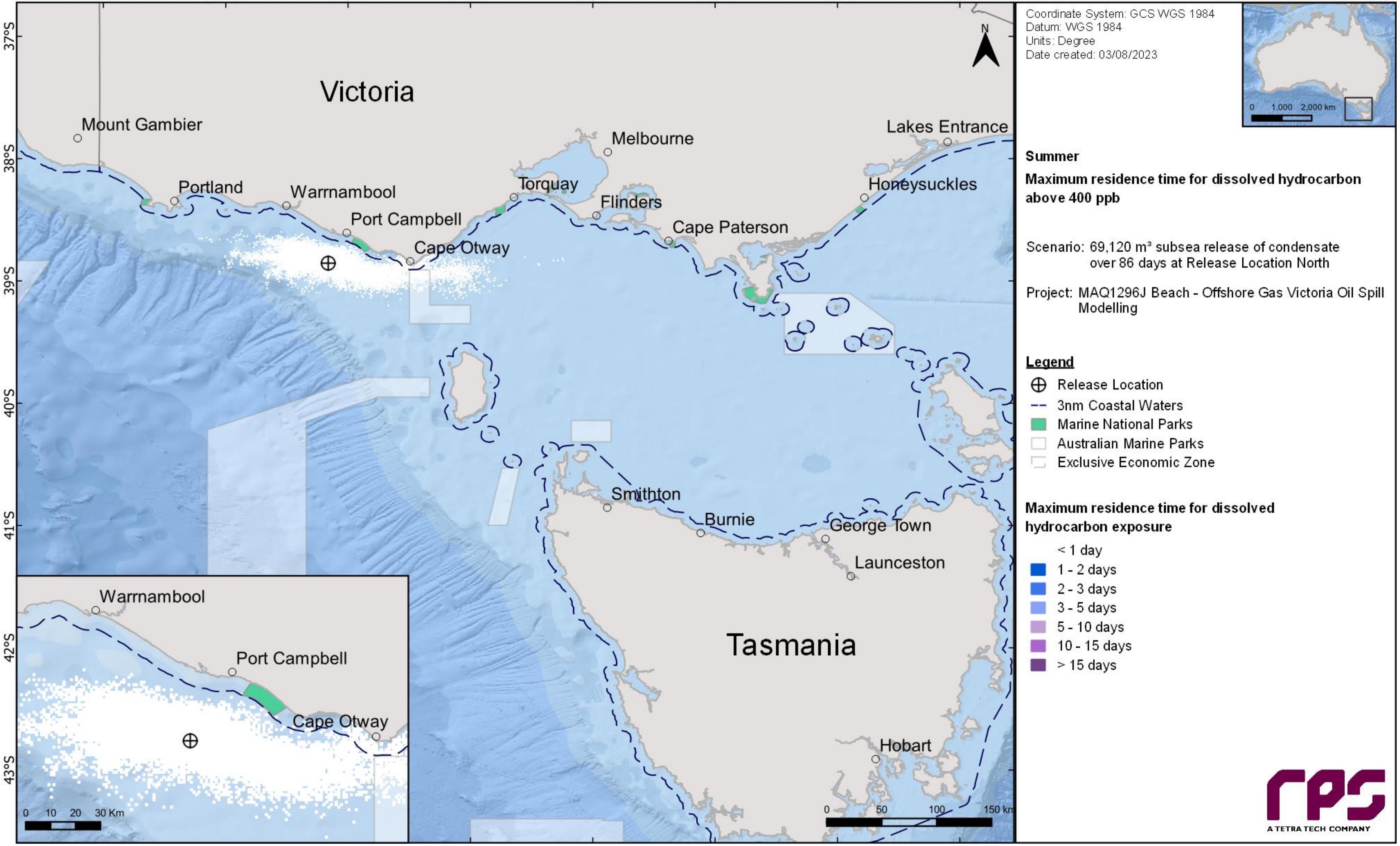


Figure 13.16 Maximum residence time for dissolved hydrocarbon exposure above 400 ppb, at 0-10 m below the sea surface in the event of a 69,120.0 m³ subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during summer conditions.

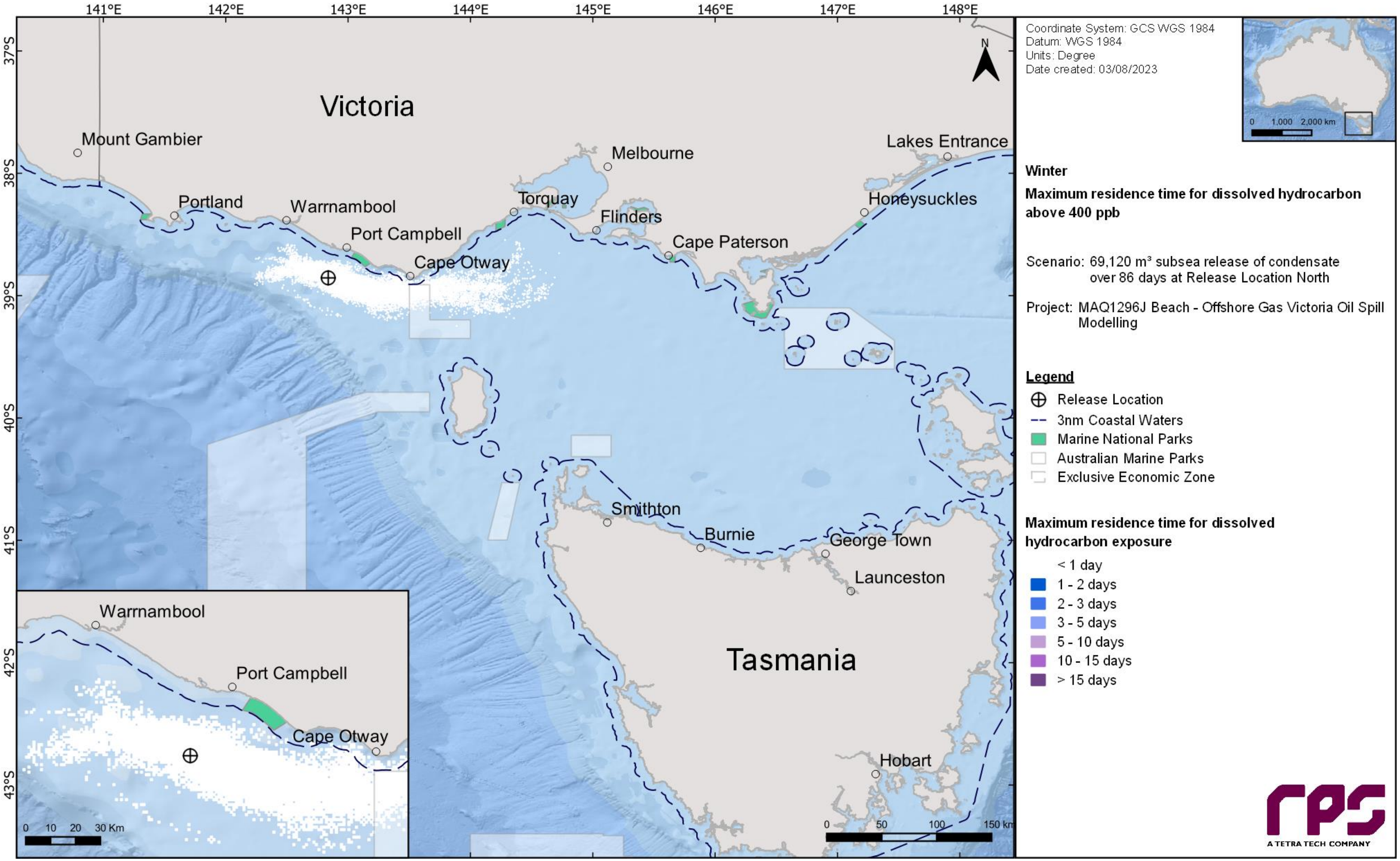


Figure 13.17 Maximum residence time for dissolved hydrocarbon exposure above 400 ppb, at 0-10 m below the sea surface in the event of a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during winter conditions.

13.1.4.2 Entrained Hydrocarbons

Table 13-8 presents the probability of exposure to individual receptors from entrained hydrocarbons in the 0-10 m depth layer for the summer and winter conditions.

Outside of the receptors that the Release Location North resides within (refer to Table 10-3), the highest concentration of entrained hydrocarbon was predicted for Pygmy Blue Whale - Foraging (summer – 378 ppb, winter – 332 ppb).

Table 13-9 presents the predicted minimum time to entrained hydrocarbon exposure and maximum residence time for entrained hydrocarbon exposure to individual receptors in the 0-10 m depth layer, for all seasonal conditions and all thresholds assessed.

Figure 13-18 and Figure 13-19 presents the zones of potential entrained hydrocarbon exposure for the 0-10 m depth layer, for each threshold assessed under summer and winter conditions, respectively.

Figure 13-20 to Figure 13-23 present the maximum residence time of entrained hydrocarbon exposure for the NOPSEMA thresholds in summer and winter.

Table 13-8 **Probability of entrained hydrocarbons exposure to marine based receptors in the 0–10 m depth layer. Results are based on a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations per season.**

Receptor		Summer (November through to March)			Winter (April to October)		
		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure	
			Low	High		Low	High
AMP	Apollo	175	96	28	191	100	23
	Beagle	17	4	-	15	6	-
	Zeehan	14	4	-	18	2	-
BIA	Antipodean Albatross - Foraging*	4,243	100	100	4,005	100	100
	Australasian Gannet - Foraging	53	57	-	60	59	-
	Black-browed Albatross - Foraging*	4,243	100	100	4,005	100	100
	Black-faced Cormorant - Foraging	11	2	-	11	1	-
	Bullers Albatross - Foraging*	4,243	100	100	4,005	100	100
	Campbell Albatross – Foraging*	4,243	100	100	4,005	100	100
	Common Diving-petrel – Foraging*	4,243	100	100	4,005	100	100
	Indian Yellow-nosed Albatross – Foraging*	4,243	100	100	4,005	100	100
	Little Penguin - Foraging	13	3	-	23	30	-
	Pygmy Blue Whale – Distribution*	4,243	100	100	4,005	100	100
	Pygmy Blue Whale - Foraging	378	100	90	332	100	100
	Pygmy Blue Whale - Foraging (annual high use area)*	4,243	100	100	4,005	100	100
	Pygmy Blue Whale - Known Foraging Area	189	96	20	187	100	22
	Short-tailed Shearwater - Foraging	444	100	95	413	100	100
	Shy Albatross – Foraging*	4,243	100	100	4,005	100	100
	Southern Right Whale - Aggregation	136	93	9	156	70	9
	Southern Right Whale - Connecting habitat	10	1	-	10	-	-
	Southern Right Whale - Known Core Range*	4,243	100	100	4,005	100	100
	Wandering Albatross – Foraging*	4,243	100	100	4,005	100	100
	Wedge-tailed Shearwater – Foraging*	4,243	100	100	4,005	100	100
	White Shark - Breeding	14	3	-	10	-	-

Receptor		Summer (November through to March)			Winter (April to October)		
		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure	
			Low	High		Low	High
	White Shark – Distribution*	4,243	100	100	4,005	100	100
	White Shark - Foraging	75	60	-	34	55	-
	White-faced Storm-petrel - Foraging	178	96	16	182	100	17
EEZ	Australian*	4,243	100	100	4,005	100	100
IBRA	Bridgewater	11	1	-	8	-	-
	Flinders	10	1	-	10	-	-
	Gippsland Plain	18	3	-	23	12	-
	Glenelg Plain	11	2	-	9	-	-
	King Island	10	1	-	9	-	-
	Otway Plain	205	96	26	260	100	22
	Otway Ranges	138	96	4	127	100	6
	Strzelecki Ranges	10	-	-	22	9	-
	Warrnambool Plain	54	90	-	80	91	-
	Wilsons Promontory	23	4	-	24	13	-
IMCRA	Central Bass Strait	141	95	11	173	100	15
	Central Victoria	178	96	19	182	100	17
	Flinders	24	5	-	24	15	-
	Otway*	4,243	100	100	4,005	100	100
	Twofold Shelf	10	1	-	12	2	-
	Victorian Embayments	15	1	-	19	11	-
KEF	Bonney Coast Upwelling	22	42	-	18	1	-
	West Tasmania Canyons	32	19	-	52	12	-
MNP	Bunurong	8	-	-	12	3	-
	Discovery Bay	12	1	-	7	-	-
	Point Addis	12	1	-	20	11	-
	Port Phillip Heads	14	1	-	8	-	-
	Twelve Apostles	80	97	-	108	85	1
	Wilsons Promontory	23	4	-	24	13	-

Receptor		Summer (November through to March)			Winter (April to October)		
		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure	
			Low	High		Low	High
MS	Mushroom Reef	7	-	-	13	7	-
NPS4	Bunurong Marine Park	8	-	-	11	2	-
	Wilsons Promontory Marine Park	11	1	-	13	2	-
RSB	Bravenes Rock	103	100	4	104	100	1
	Cody Bank	18	3	-	17	14	-
SHORE	Anser Island	21	4	-	23	10	-
	Bass Coast	8	-	-	13	2	-
	Colac Otway	205	96	26	260	100	22
	Corangamite	54	90	-	80	91	-
	Glenelg	11	2	-	9	-	-
	Glennie Group	19	4	-	22	13	-
	Hogan Island Group	10	1	-	10	-	-
	Kanowna Island	23	4	-	23	12	-
	King Island	10	1	-	9	-	-
	Laurence Rocks	10	1	-	8	-	-
	Moncoeur Islands	14	3	-	16	7	-
	Mornington Peninsula	18	1	-	16	9	-
	Moyne	40	67	-	53	30	-
	Norman Island	18	4	-	19	8	-
	Phillip Island	10	-	-	23	12	-
	Rodondo Island	14	3	-	18	9	-
	Seal Islands	12	3	-	6	-	-
	Shellback Island	11	2	-	13	2	-
	Skull Rock	23	4	-	21	13	-
	South Gippsland	19	3	-	24	10	-
	Surf Coast	17	9	-	25	34	-
	Warrnambool	8	-	-	13	1	-
State Waters	Tasmania	10	1	-	11	2	-

Receptor		Summer (November through to March)			Winter (April to October)		
		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure	
			Low	High		Low	High
	Victoria	234	100	33	260	100	40
Sub-LGA	Anglesea	10	2	-	19	10	-
	Apollo Bay	138	93	4	113	100	3
	Bay of Islands	40	67	-	53	30	-
	Cape Liptrap	9	-	-	22	10	-
	Cape Nelson	11	2	-	9	-	-
	Cape Otway West	205	96	26	260	100	23
	Cape Patton	82	49	-	60	76	-
	Childers Cove	15	4	-	22	11	-
	Kilcunda	7	-	-	11	1	-
	Lorne	19	11	-	26	37	-
	Moonlight Head	54	90	-	80	91	-
	Mornington Peninsula (S)	9	-	-	15	7	-
	Mornington Peninsula (SW)	18	1	-	16	9	-
	Port Campbell	35	65	-	49	38	-
	Port Phillip (Sorrento Shore)	16	1	-	9	-	-
	Torquay	6	-	-	10	1	-
	Venus Bay	8	-	-	13	2	-
	Waratah Bay	10	-	-	22	9	-
	Westernport	7	-	-	12	6	-
	Wilsons Promontory (East)	13	3	-	17	6	-
	Wilsons Promontory (West)	19	3	-	24	8	-

*The release location resides within the receptor boundaries.

Table 13-9 **Predicted minimum time to entrained hydrocarbon exposure and maximum residence time for entrained hydrocarbon exposure to individual receptors in the 0-10 m depth layer. Results are based on a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill trajectories per season.**

Receptor		Summer (November through to March)				Winter (April to October)			
		Minimum time before entrained hydrocarbon exposure (days)		Maximum residence time for entrained hydrocarbon exposure (days)		Minimum time before entrained hydrocarbon exposure (days)		Maximum residence time for entrained hydrocarbon exposure (days)	
		Low	High	Low	High	Low	High	Low	High
AMP	Apollo	2	3	20	1	1	2	20	< 1
	Beagle	55	-	2	-	34	-	< 1	-
	Zeehan	24	-	< 1	-	15	-	1	-
BIA	Antipodean Albatross - Foraging*	< 1	< 1	65	22	< 1	< 1	67	18
	Australasian Gannet - Foraging	5	-	12	-	5	-	9	-
	Black-browed Albatross - Foraging*	< 1	< 1	65	22	< 1	< 1	67	18
	Black-faced Cormorant - Foraging	45	-	< 1	-	23	-	< 1	-
	Bullers Albatross - Foraging*	< 1	< 1	65	22	< 1	< 1	67	18
	Campbell Albatross – Foraging*	< 1	< 1	65	22	< 1	< 1	67	18
	Common Diving-petrel – Foraging*	< 1	< 1	65	22	< 1	< 1	67	18
	Indian Yellow-nosed Albatross – Foraging*	< 1	< 1	65	22	< 1	< 1	67	18
	Little Penguin - Foraging	45	-	< 1	-	8	-	5	-
	Pygmy Blue Whale – Distribution*	< 1	< 1	65	22	< 1	< 1	67	18
	Pygmy Blue Whale - Foraging	< 1	1	46	3	< 1	1	67	5
	Pygmy Blue Whale - Foraging (annual high use area)*	< 1	< 1	65	22	< 1	< 1	67	18
	Pygmy Blue Whale - Known Foraging Area	3	3	34	1	1	3	36	1
	Short-tailed Shearwater - Foraging	< 1	< 1	46	3	< 1	1	67	5
	Shy Albatross – Foraging*	< 1	< 1	65	22	< 1	< 1	67	18
	Southern Right Whale - Aggregation	1	2	31	1	1	5	22	1
	Southern Right Whale - Connecting habitat	48	-	< 1	-	-	-	-	-
	Southern Right Whale - Known Core Range*	< 1	< 1	65	22	< 1	< 1	67	18
	Wandering Albatross – Foraging*	< 1	< 1	65	22	< 1	< 1	67	18
	Wedge-tailed Shearwater – Foraging*	< 1	< 1	65	22	< 1	< 1	67	18
	White Shark - Breeding	55	-	< 1	-	-	-	-	-

Receptor		Summer (November through to March)				Winter (April to October)			
		Minimum time before entrained hydrocarbon exposure (days)		Maximum residence time for entrained hydrocarbon exposure (days)		Minimum time before entrained hydrocarbon exposure (days)		Maximum residence time for entrained hydrocarbon exposure (days)	
		Low	High	Low	High	Low	High	Low	High
	White Shark – Distribution*	< 1	< 1	65	22	< 1	< 1	67	18
	White Shark - Foraging	3	-	13	-	7	-	11	-
	White-faced Storm-petrel - Foraging	3	3	34	1	1	3	36	1
EEZ	Australian*	< 1	< 1	65	22	< 1	< 1	67	18
IBRA	Bridgewater	45	-	< 1	-	-	-	-	-
	Flinders	59	-	< 1	-	-	-	-	-
	Gippsland Plain	56	-	1	-	11	-	6	-
	Glenelg Plain	29	-	< 1	-	-	-	-	-
	King Island	48	-	< 1	-	-	-	-	-
	Otway Plain	4	7	45	2	1	5	40	5
	Otway Ranges	4	18	29	1	2	15	35	< 1
	Strzelecki Ranges	-	-	-	-	15	-	5	-
	Warrnambool Plain	4	-	14	-	2	-	22	-
	Wilsons Promontory	54	-	5	-	16	-	9	-
IMCRA	Central Bass Strait	3	3	19	< 1	2	3	17	< 1
	Central Victoria	3	3	34	1	1	3	36	1
	Flinders	53	-	5	-	10	-	11	-
	Otway*	< 1	< 1	65	22	< 1	< 1	67	18
	Twofold Shelf	59	-	< 1	-	35	-	< 1	-
	Victorian Embayments	99	-	< 1	-	17	-	5	-
KEF	Bonney Coast Upwelling	10	-	2	-	80	-	3	-
	West Tasmania Canyons	7	-	3	-	12	-	2	-
MNP	Bunurong	-	-	-	-	17	-	< 1	-
	Discovery Bay	45	-	< 1	-	-	-	-	-
	Point Addis	43	-	< 1	-	15	-	2	-
	Port Phillip Heads	98	-	< 1	-	-	-	-	-
	Twelve Apostles	4	-	26	-	2	9	23	< 1
	Wilsons Promontory	54	-	5	-	16	-	11	-

Receptor		Summer (November through to March)				Winter (April to October)			
		Minimum time before entrained hydrocarbon exposure (days)		Maximum residence time for entrained hydrocarbon exposure (days)		Minimum time before entrained hydrocarbon exposure (days)		Maximum residence time for entrained hydrocarbon exposure (days)	
		Low	High	Low	High	Low	High	Low	High
MS	Mushroom Reef	-	-	-	-	28	-	< 1	-
NPS4	Bunurong Marine Park	-	-	-	-	54	-	< 1	-
	Wilsons Promontory Marine Park	56	-	< 1	-	54	-	< 1	-
RSB	Bravenes Rock	3	15	16	< 1	2	10	20	< 1
	Cody Bank	53	-	1	-	8	-	1	-
SHORE	Anser Island	54	-	5	-	17	-	8	-
	Bass Coast	-	-	-	-	54	-	< 1	-
	Colac Otway	4	7	45	2	1	5	40	5
	Corangamite	4	-	18	-	2	-	22	-
	Glenelg	29	-	< 1	-	-	-	-	-
	Glennie Group	54	-	5	-	16	-	9	-
	Hogan Island Group	59	-	< 1	-	-	-	-	-
	Kanowna Island	54	-	5	-	17	-	7	-
	King Island	48	-	< 1	-	-	-	-	-
	Laurence Rocks	33	-	< 1	-	-	-	-	-
	Moncoeur Islands	55	-	< 1	-	34	-	1	-
	Mornington Peninsula	97	-	1	-	11	-	1	-
	Moyne	12	-	9	-	2	-	10	-
	Norman Island	55	-	1	-	16	-	4	-
	Phillip Island	-	-	-	-	17	-	5	-
	Rodondo Island	55	-	< 1	-	27	-	1	-
	Seal Islands	56	-	< 1	-	-	-	-	-
	Shellback Island	56	-	< 1	-	53	-	< 1	-
	Skull Rock	54	-	5	-	18	-	8	-
	South Gippsland	55	-	3	-	15	-	7	-
	Surf Coast	33	-	10	-	15	-	10	-
	Warrnambool	-	-	-	-	9	-	< 1	-
	Tasmania	45	-	< 1	-	23	-	< 1	-

Receptor		**Summer (November through to March)**				**Winter (April to October)**			
		Minimum time before entrained hydrocarbon exposure (days)		**Maximum residence time for entrained hydrocarbon exposure (days)**		**Minimum time before entrained hydrocarbon exposure (days)**		**Maximum residence time for entrained hydrocarbon exposure (days)**	
		Low	High	Low	High	Low	High	Low	High
State Waters	Victoria	3	5	46	3	1	2	59	5
Sub-LGA	Anglesea	99	-	< 1	-	23	-	5	-
	Apollo Bay	4	18	25	1	2	15	27	< 1
	Bay of Islands	12	-	9	-	3	-	10	-
	Cape Liptrap	-	-	-	-	15	-	6	-
	Cape Nelson	29	-	< 1	-	-	-	-	-
	Cape Otway West	4	7	44	2	1	5	40	5
	Cape Patton	7	-	29	-	6	-	17	-
	Childers Cove	62	-	1	-	3	-	3	-
	Kilcunda	-	-	-	-	55	-	< 1	-
	Lorne	30	-	10	-	21	-	10	-
	Moonlight Head	4	-	18	-	2	-	22	-
	Mornington Peninsula (S)	-	-	-	-	11	-	1	-
	Mornington Peninsula (SW)	98	-	< 1	-	11	-	1	-
	Port Campbell	10	-	11	-	3	-	17	-
	Port Phillip (Sorrento Shore)	97	-	1	-	-	-	-	-
	Torquay	-	-	-	-	36	-	< 1	-
	Venus Bay	-	-	-	-	54	-	< 1	-
	Waratah Bay	-	-	-	-	15	-	5	-
	Westernport	-	-	-	-	28	-	< 1	-
	Wilsons Promontory (East)	55	-	< 1	-	40	-	4	-
	Wilsons Promontory (West)	55	-	3	-	18	-	7	-

*The release location resides within the receptor boundaries.

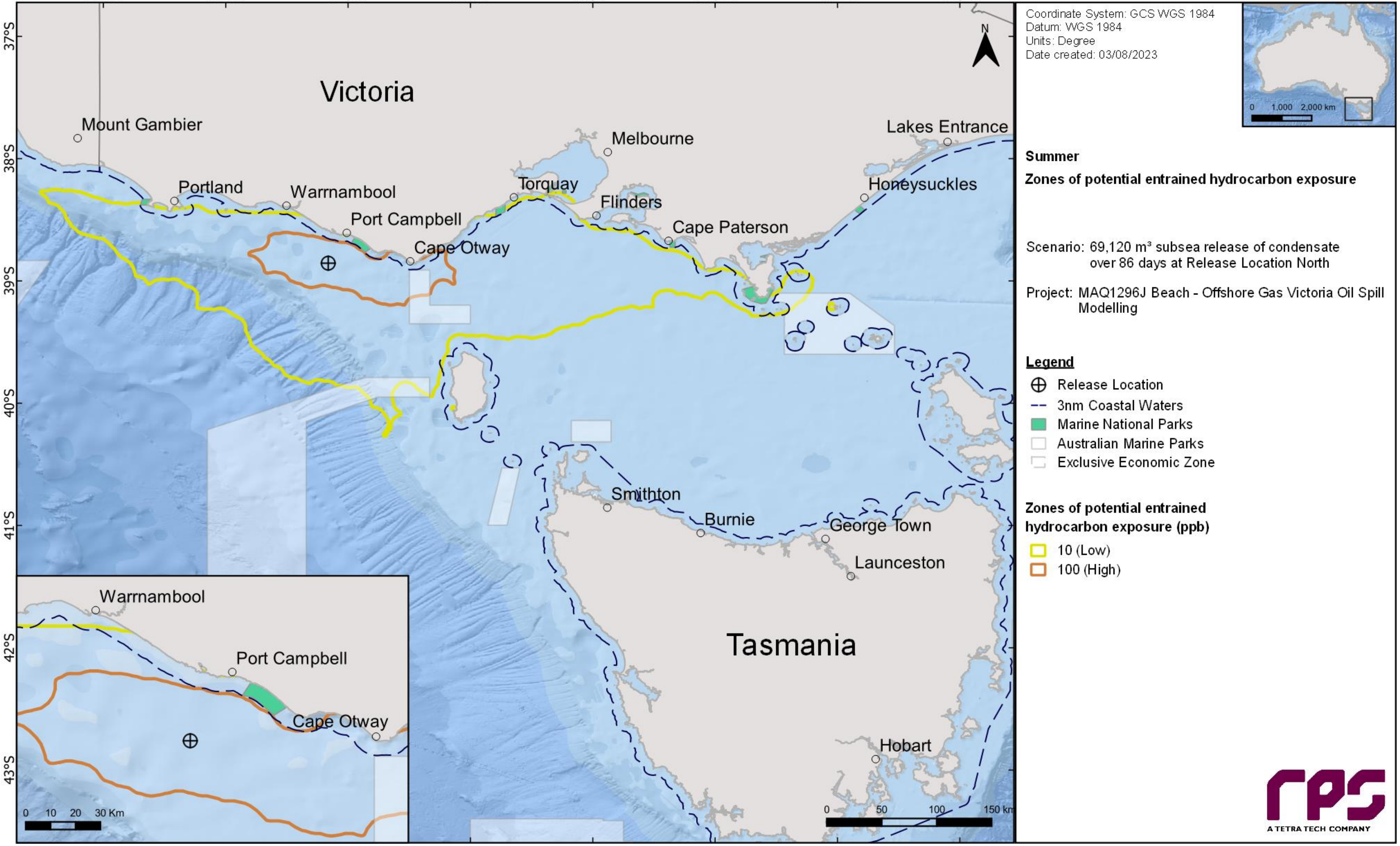


Figure 13-18 Zones of potential entrained hydrocarbon exposure at 0-10 m below the sea surface in the event of a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during summer conditions.

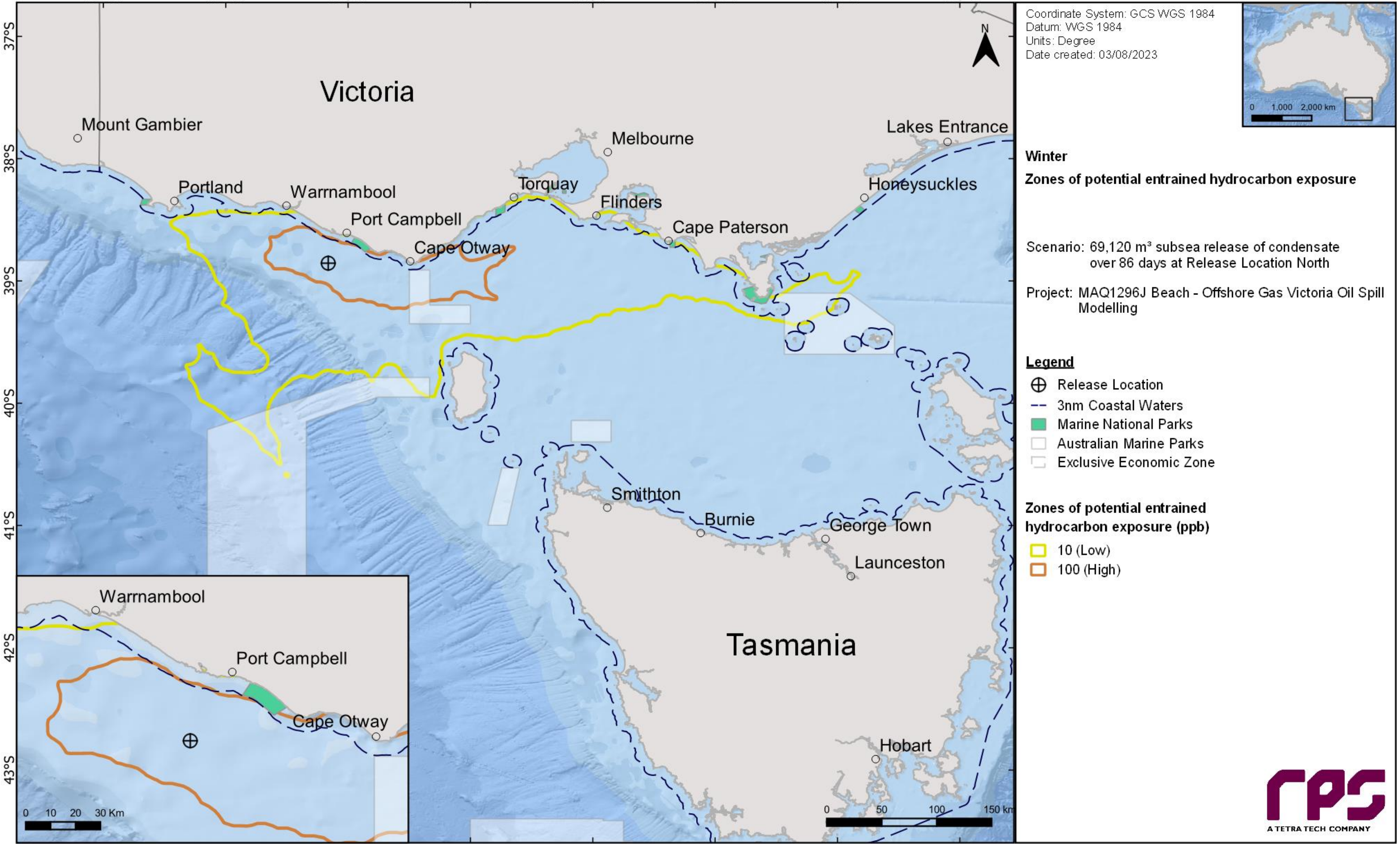


Figure 13-19 Zones of potential entrained hydrocarbon exposure at 0-10 m below the sea surface in the event of a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during winter conditions.

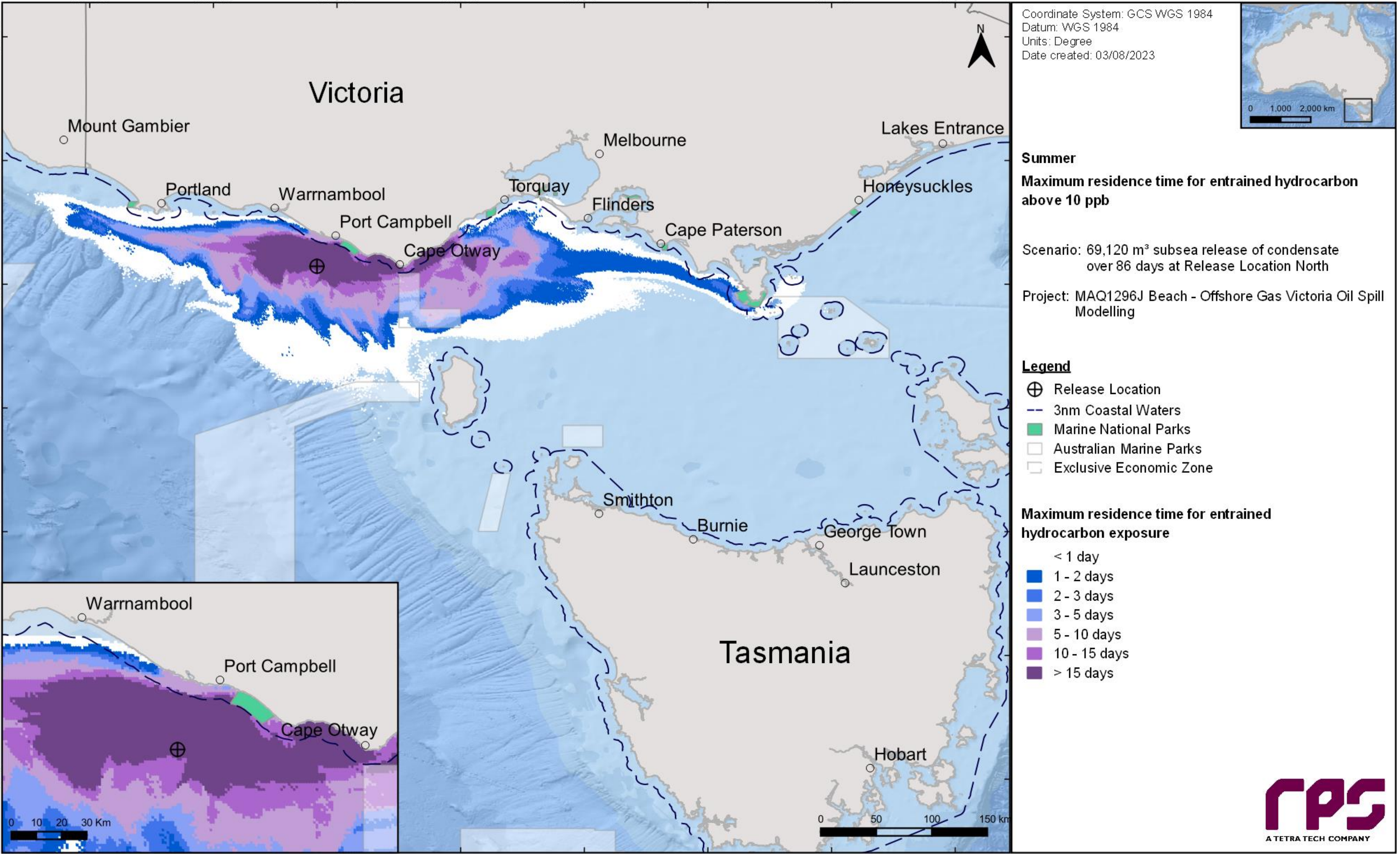


Figure 13-20 Maximum residence time for entrained hydrocarbon exposure above 10 ppb, at 0-10 m below the sea surface in the event of a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during summer conditions.

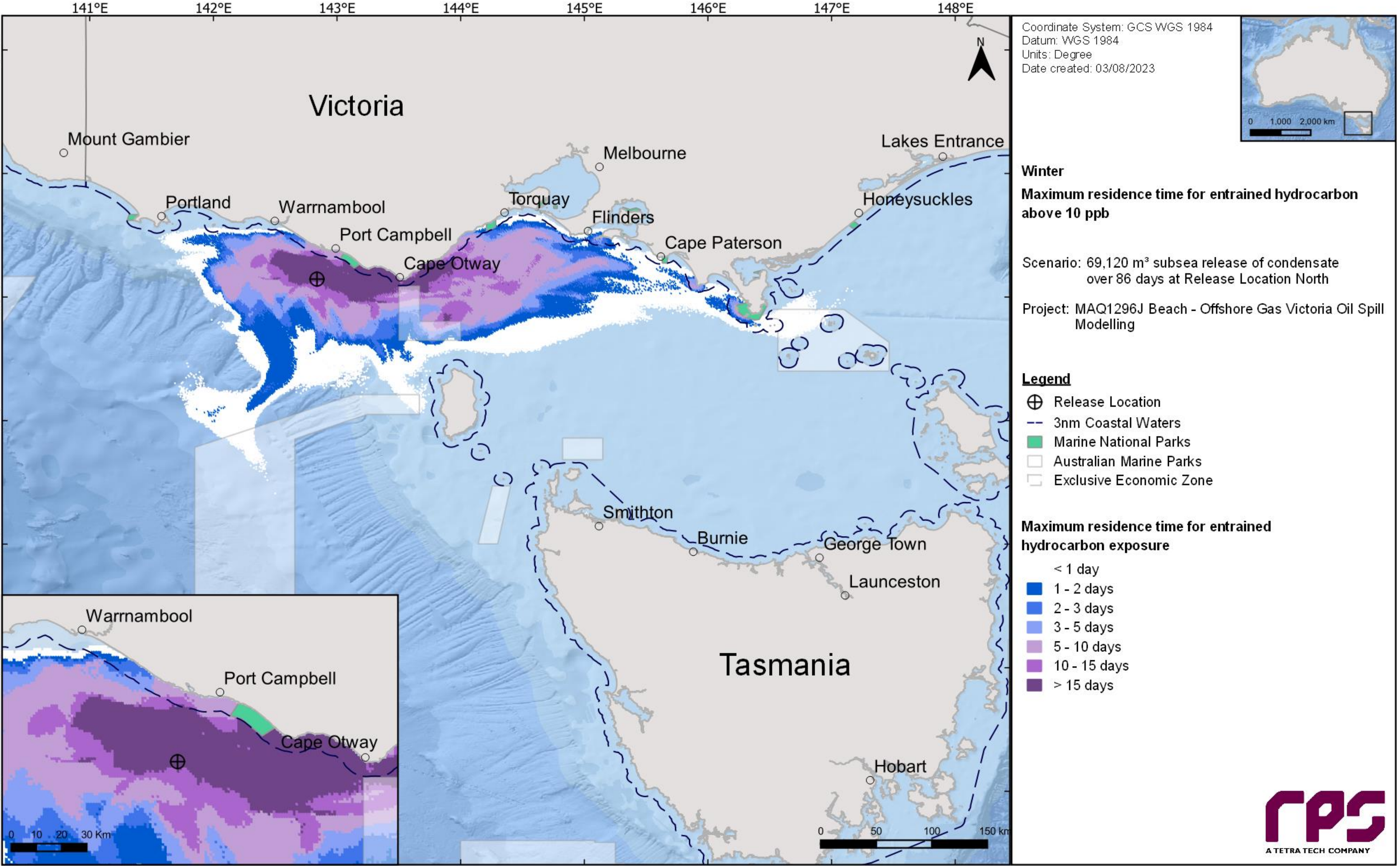


Figure 13-21 Maximum residence time for entrained hydrocarbon exposure above 10 ppb, at 0-10 m below the sea surface in the event of a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during winter conditions.

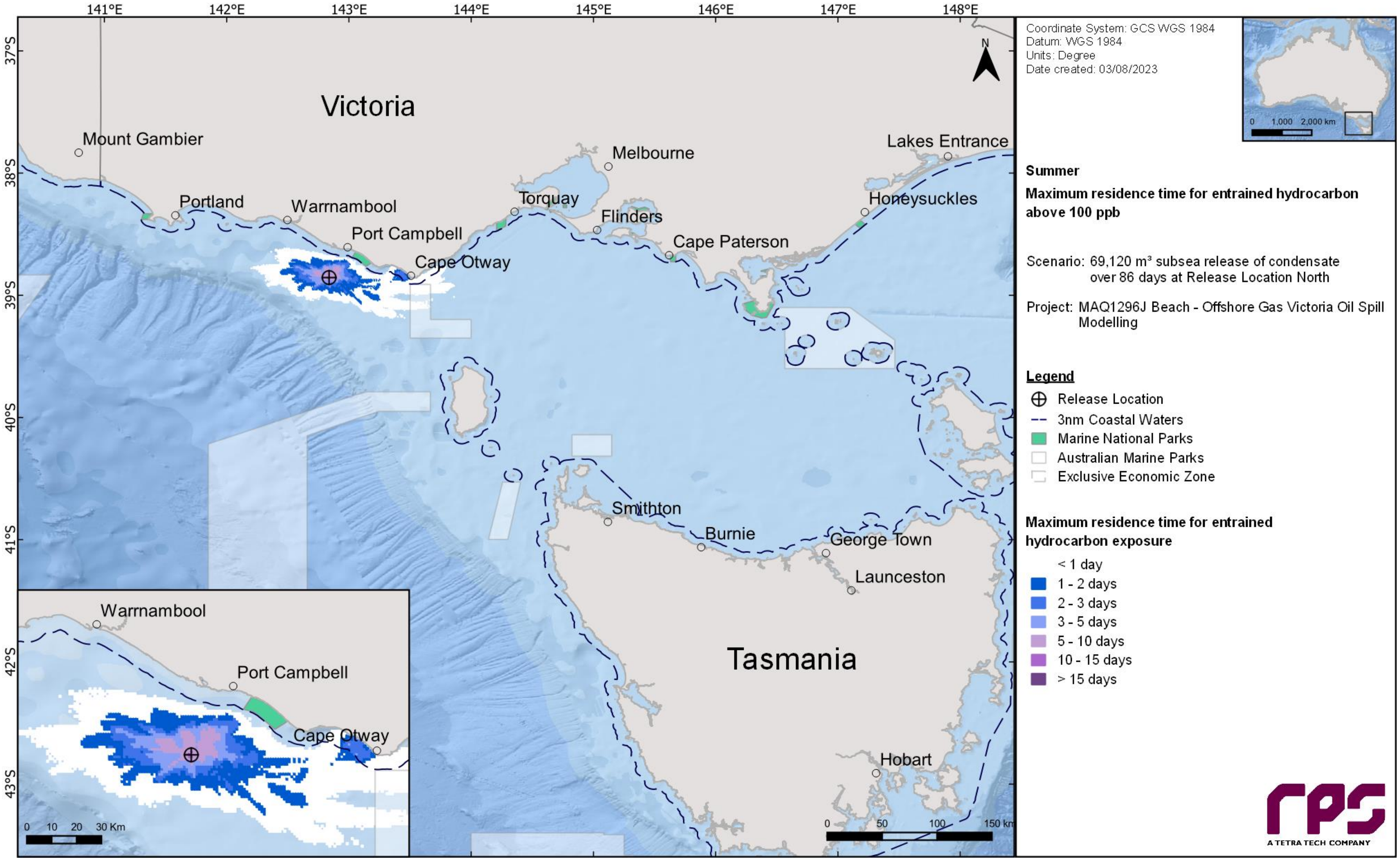


Figure 13-22 Maximum residence time for entrained hydrocarbon exposure above 100 ppb, at 0-10 m below the sea surface in the event of a 69,120.0 m³ subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during summer conditions.

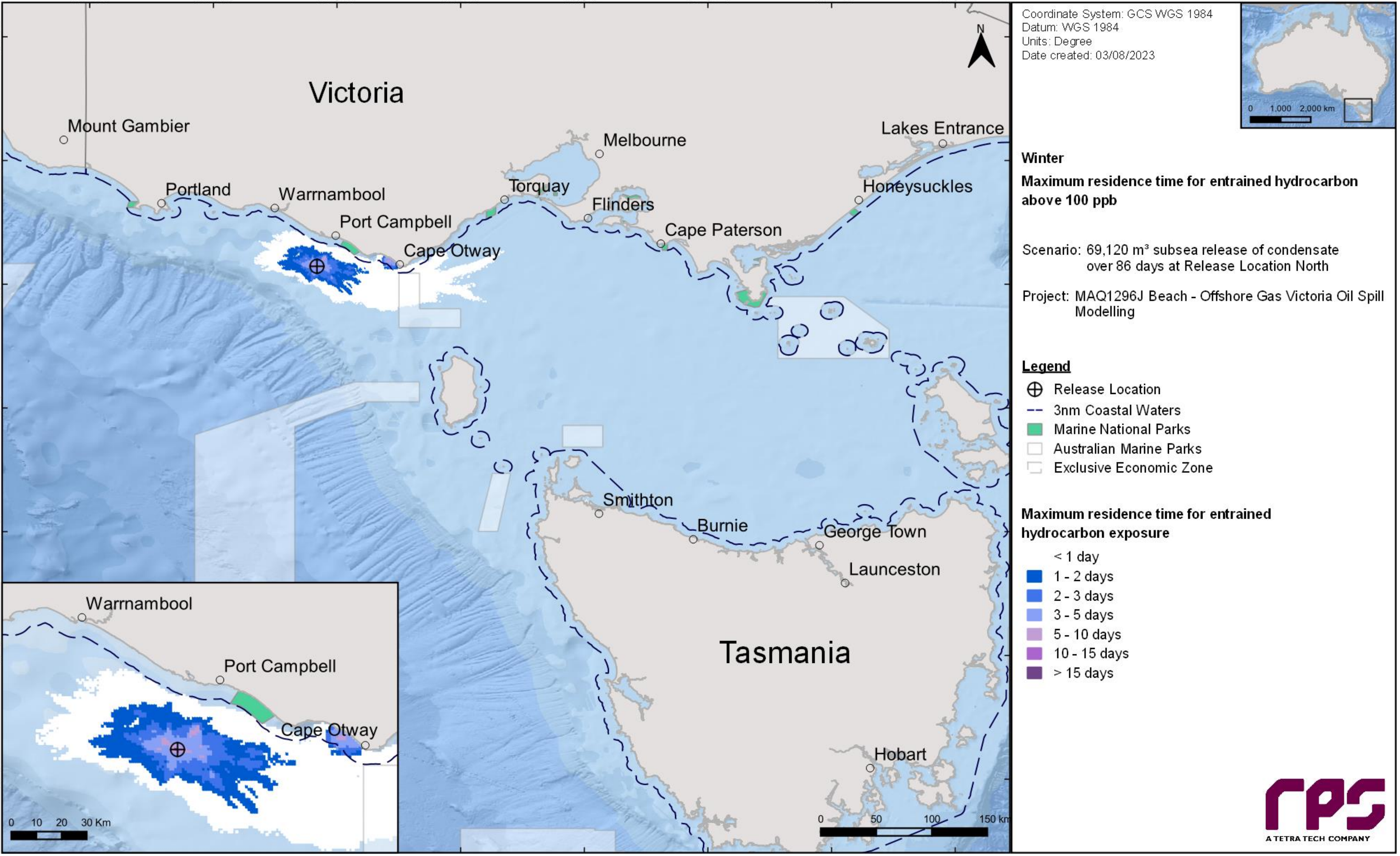


Figure 13-23 Maximum residence time for entrained hydrocarbon exposure above 100 ppb, at 0-10 m below the sea surface in the event of a 69,120.0 m^3 subsea release of condensate over 86 days from a loss of well control at the Release Location North. The results were calculated from 100 spill simulations during winter conditions.

14 RESULTS – LOSS OF CONTAINMENT FROM VESSEL COLLISION AT THE RELEASE LOCATION NORTH FIELD

This scenario examined a 603.7 m^3 surface release of marine diesel for a loss of containment from a vessel collision at the Release Location North field. A total of 200 spill simulations were run (i.e., 100 spills per season) and tracked for 30 days. The results for all 100 simulations per season were combined and are presented on a seasonal basis (i.e., summer and winter).

14.1 Stochastic Analysis

14.1.1 Area of Exposure

Figure 14-1 presents the combined area of potential exposure for surface, shoreline, entrained and dissolved, by overlaying the results from all 200 simulations (i.e., 100 per season) during summer and winter conditions.

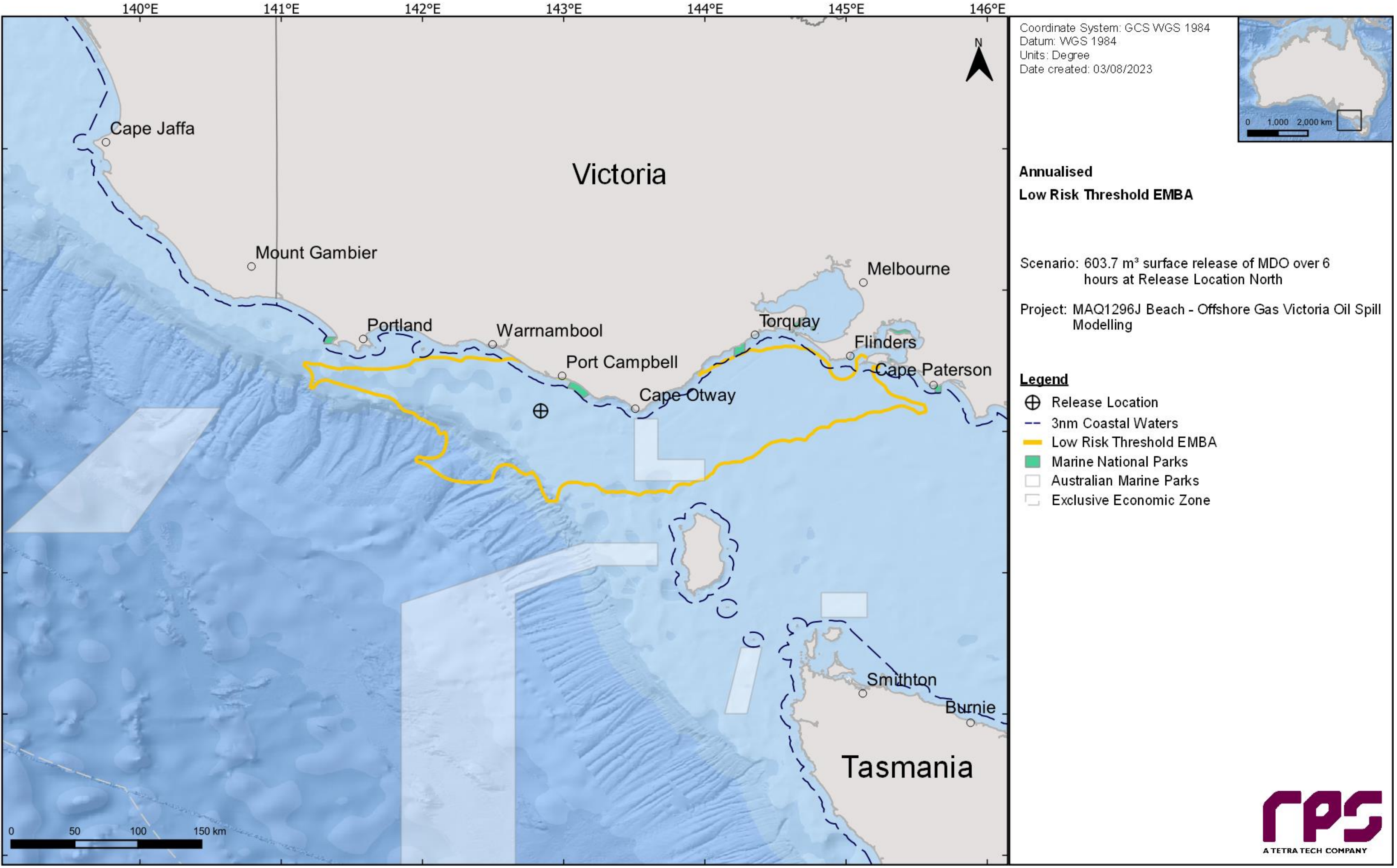


Figure 14-1 Predicted area of exposure for low thresholds produced by overlaying the results from all 200 simulations, resulting from a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field during summer and winter conditions.

14.1.2 Floating Oil Exposure

Table 14-1 summarises the maximum distance travelled by floating oil on the sea surface at each threshold. The maximum distance from the release location to the low (1–10 g/m^2), moderate (10–50 g/m^2) and high (> 50 g/m^2) exposure zones was 54 km (east) during winter conditions, 19 km (south-southeast) during winter conditions and 10 km (north-northwest in summer and east in winter).

Table 14-2 summarises the potential floating oil exposure to individual receptors during the summer and winter conditions. Outside of the receptors that the Release Location North resides within (refer to Table 10-3), floating oil exposure above the low threshold was predicted at the Pygmy Blue Whale – Foraging (1% summer, 3% winter) and Short-tailed Shearwater - Foraging (3% summer, 4% winter) BIAs.

Table 14-3 presents the maximum residence time of floating oil exposure for each individual grid cell within each individual receptor during summer and winter.

Figure 14-2 and Figure 14-3 present the zones of potential floating oil exposure for all thresholds under summer and winter conditions, respectively.

Figure 14-4 to Figure 14-9 present the maximum residence time of floating oil exposure for the NOPSEMA thresholds during summer and winter, respectively.

Table 14-1 Maximum distance and direction from the release location to the edge of floating oil exposure. Results are based on a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations per season.

Season	Distance and direction travelled	Zones of potential floating oil exposure		
		Low	Moderate	High
Summer	Maximum distance (km) from release location	45	17	10
	Maximum distance (km) from release location (99th percentile)	23	16	10
	Direction	E	NW	NNW
Winter	Maximum distance (km) from release location	54	19	9
	Maximum distance (km) from release location (99th percentile)	30	18	9
	Direction	E	SSE	E

Table 14-2 Summary of the potential floating oil exposure to individual receptors. Results are based on a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations per season.

Receptor		Summer (November through to March)						Winter (April to October)					
		Probability of floating oil exposure (%)			Minimum time before floating oil exposure (days)			Probability of floating oil exposure (%)			Minimum time before floating oil exposure (days)		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
BIA	Antipodean Albatross - Foraging*	100	100	76	1	1	1	100	100	69	1	1	1
	Black-browed Albatross - Foraging*	100	100	76	1	1	1	100	100	69	1	1	1
	Bullers Albatross - Foraging*	100	100	76	1	1	1	100	100	69	1	1	1
	Campbell Albatross – Foraging*	100	100	76	1	1	1	100	100	69	1	1	1
	Common Diving-petrel – Foraging*	100	100	76	1	1	1	100	100	69	1	1	1
	Indian Yellow-nosed Albatross – Foraging*	100	100	76	1	1	1	100	100	69	1	1	1
	Pygmy Blue Whale – Distribution*	100	100	76	1	1	1	100	100	69	1	1	1
	Pygmy Blue Whale - Foraging	1	-	-	40	-	-	3	-	-	46	-	-
	Pygmy Blue Whale - Foraging (annual high use area)*	100	100	76	1	1	1	100	100	69	1	1	1
	Short-tailed Shearwater - Foraging	3	-	-	16	-	-	4	-	-	45	-	-
	Shy Albatross – Foraging*	100	100	76	1	1	1	100	100	69	1	1	1
	Southern Right Whale - Known Core Range*	100	100	76	1	1	1	100	100	69	1	1	1
	Wandering Albatross – Foraging*	100	100	76	1	1	1	100	100	69	1	1	1
	Wedge-tailed Shearwater – Foraging*	100	100	76	1	1	1	100	100	69	1	1	1
	White Shark – Distribution*	100	100	76	1	1	1	100	100	69	1	1	1
EEZ	Australian*	100	100	76	1	1	1	100	100	69	1	1	1
IMCRA	Otway*	100	100	76	1	1	1	100	100	69	1	1	1
State Waters	Victoria State Waters	-	-	-	-	-	-	1	-	-	60	-	-

*The release location resides within the receptor boundaries.

Table 14-3 **Summary of the maximum residence time of floating oil exposure for each individual grid cell within each individual receptor. Results are based on a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations per season.**

Receptor		Summer (November through to March)			Winter (April to October)		
		Maximum residence time of floating oil exposure (days)			Maximum residence time of floating oil exposure (days)		
		Low	Moderate	High	Low	Moderate	High
BIA	Antipodean Albatross - Foraging*	1	1	1	2	1	< 1
	Black-browed Albatross - Foraging*	1	1	1	2	1	< 1
	Bullers Albatross - Foraging*	1	1	1	2	1	< 1
	Campbell Albatross – Foraging*	1	1	1	2	1	< 1
	Common Diving-petrel – Foraging*	1	1	1	2	1	< 1
	Indian Yellow-nosed Albatross – Foraging*	1	1	1	2	1	< 1
	Pygmy Blue Whale – Distribution*	1	1	1	2	1	< 1
	Pygmy Blue Whale - Foraging	-	-	-	< 1	-	-
	Pygmy Blue Whale - Foraging (annual high use area)*	1	1	1	2	1	< 1
	Short-tailed Shearwater - Foraging	< 1	-	-	< 1	-	-
	Shy Albatross – Foraging*	1	1	1	2	1	< 1
	Southern Right Whale - Known Core Range*	1	1	1	2	1	< 1
	Wandering Albatross – Foraging*	1	1	1	2	1	< 1
	Wedge-tailed Shearwater – Foraging*	1	1	1	2	1	< 1
	White Shark – Distribution*	1	1	1	2	1	< 1
EEZ	Australian*	1	1	1	2	1	< 1
IMCRA	Otway*	1	1	1	2	1	< 1
State Waters	Victoria State Waters	-	-	-	< 1	-	-

*The release location resides within the receptor boundaries.

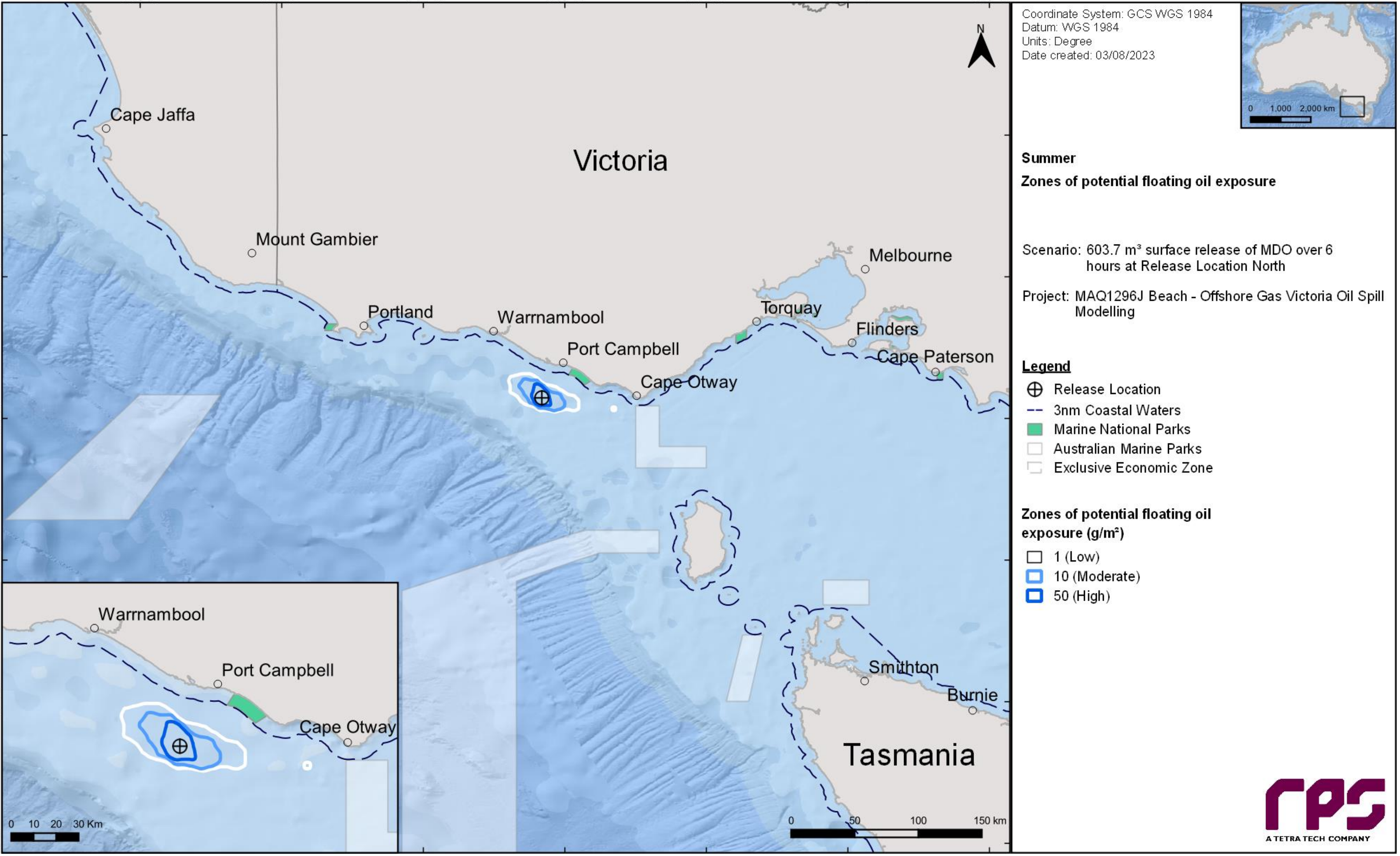


Figure 14-2 Zones of potential floating oil exposure in the event of a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during summer conditions.

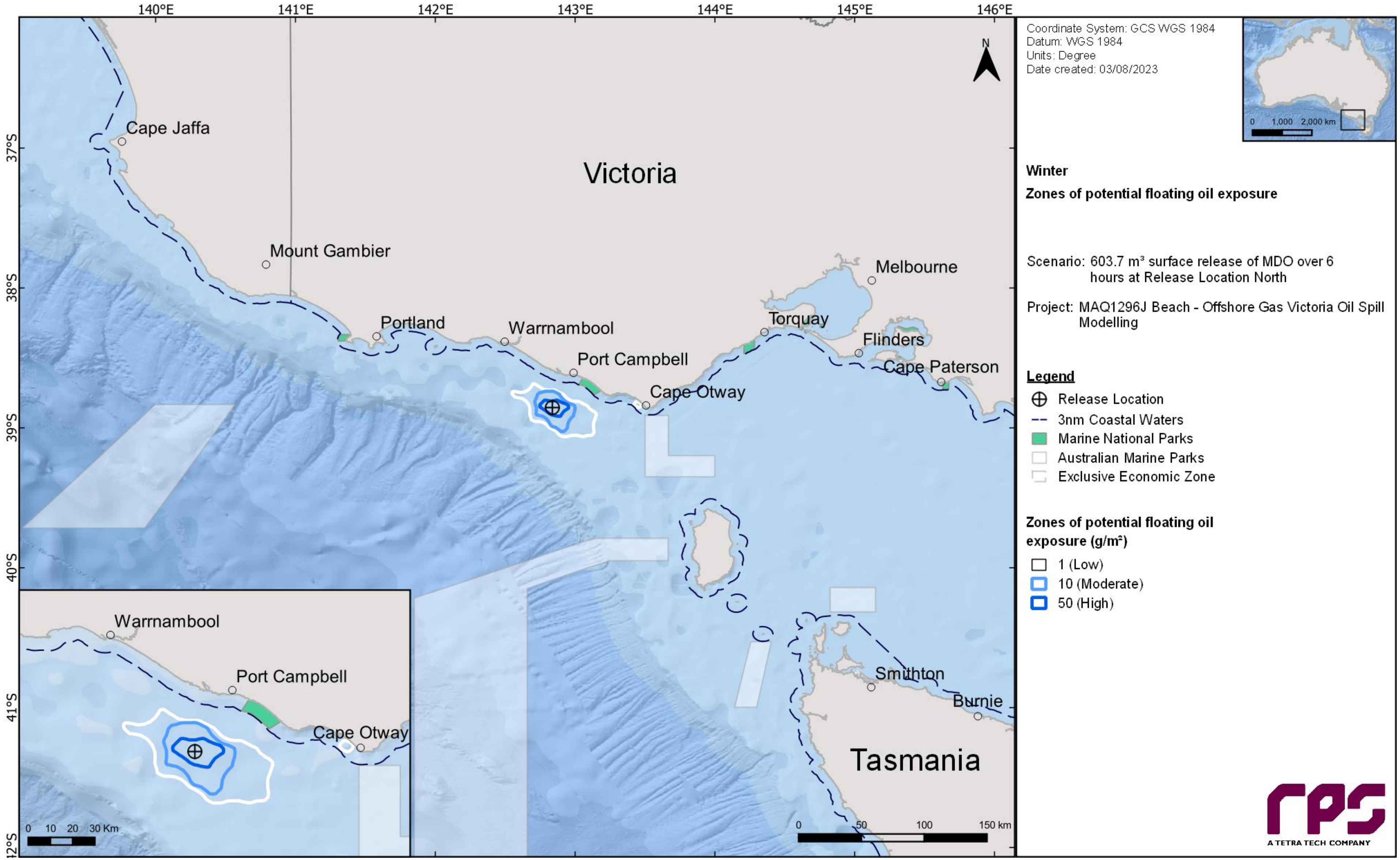


Figure 14-3 Zones of potential floating oil exposure in the event of a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during winter conditions.

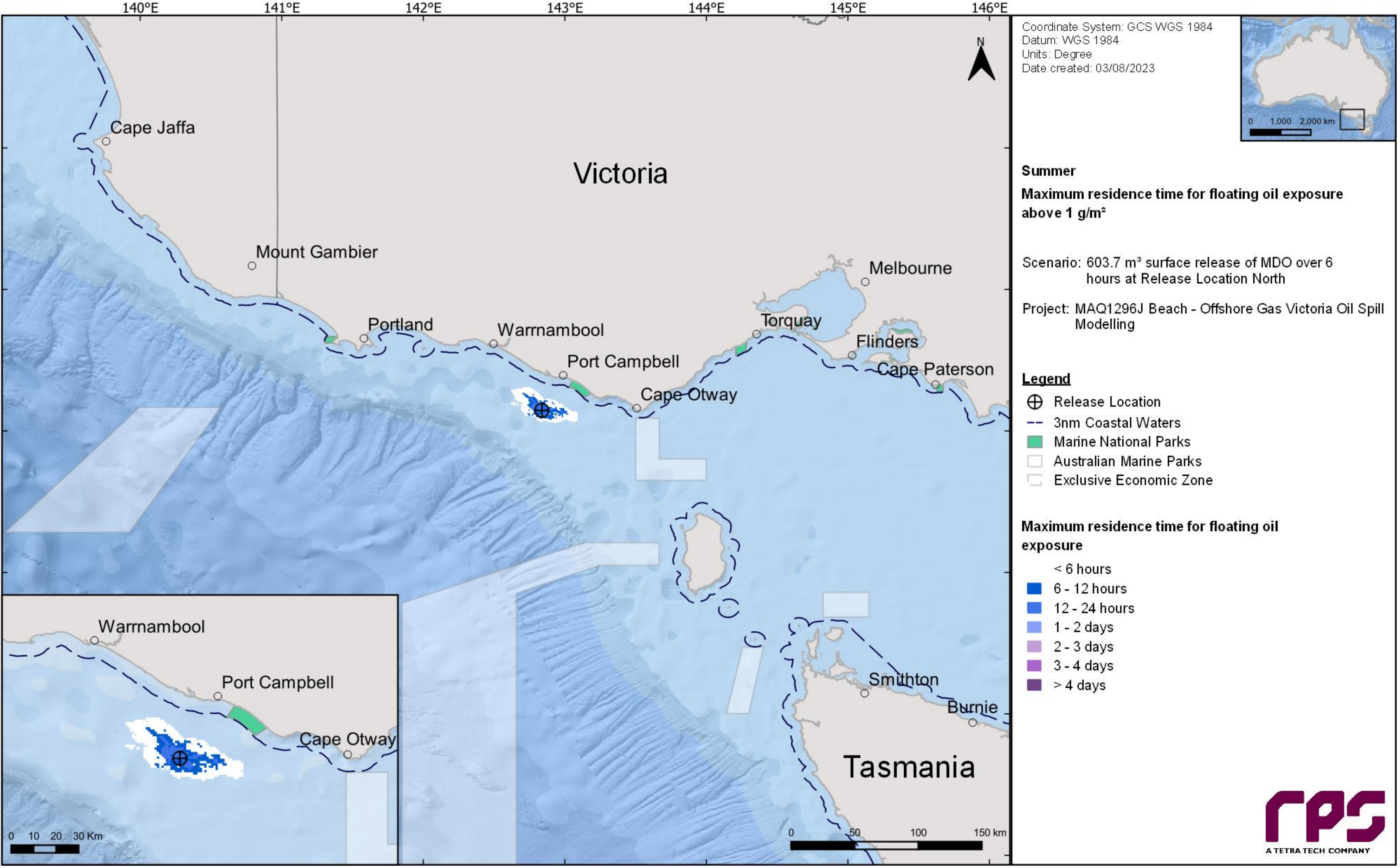


Figure 14-4 Maximum residence time of floating oil exposure above 1 g/m^2, in the event of 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during summer conditions.

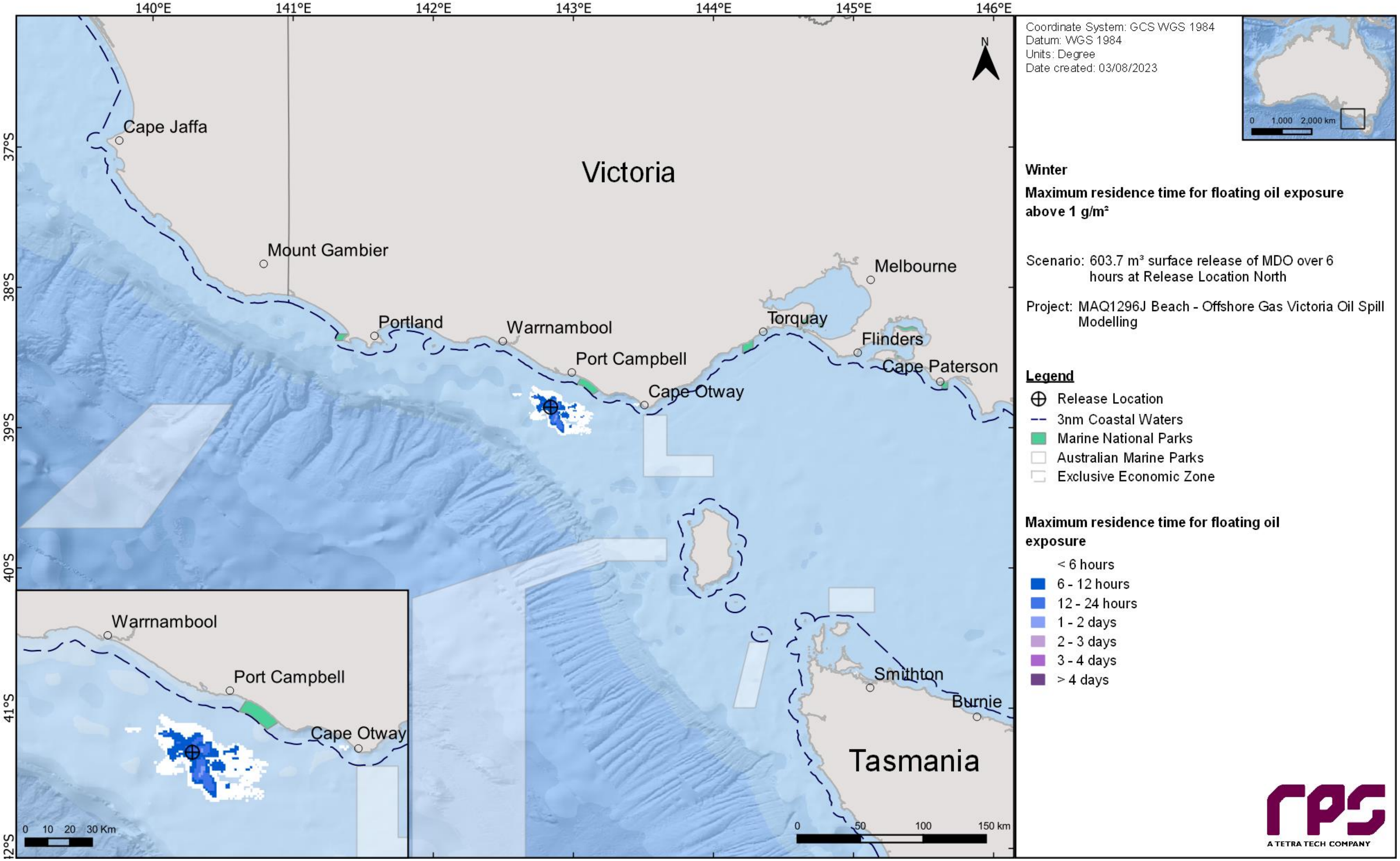


Figure 14-5 Maximum residence time of floating oil exposure above 1 g/m^2, in the event of 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during winter conditions.

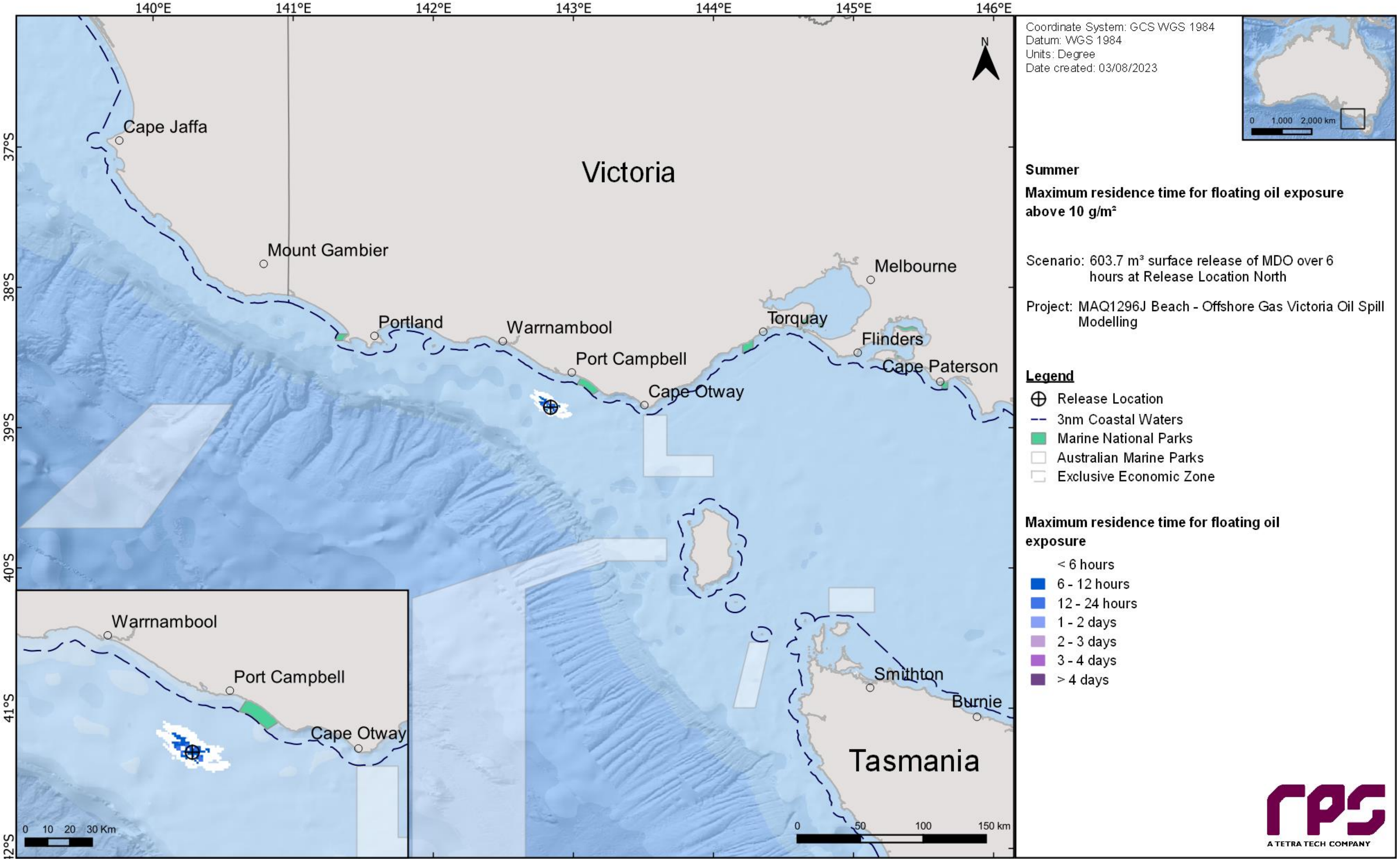


Figure 14-6 Maximum residence time of floating oil exposure above 10 g/m^2, in the event of 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during summer conditions.

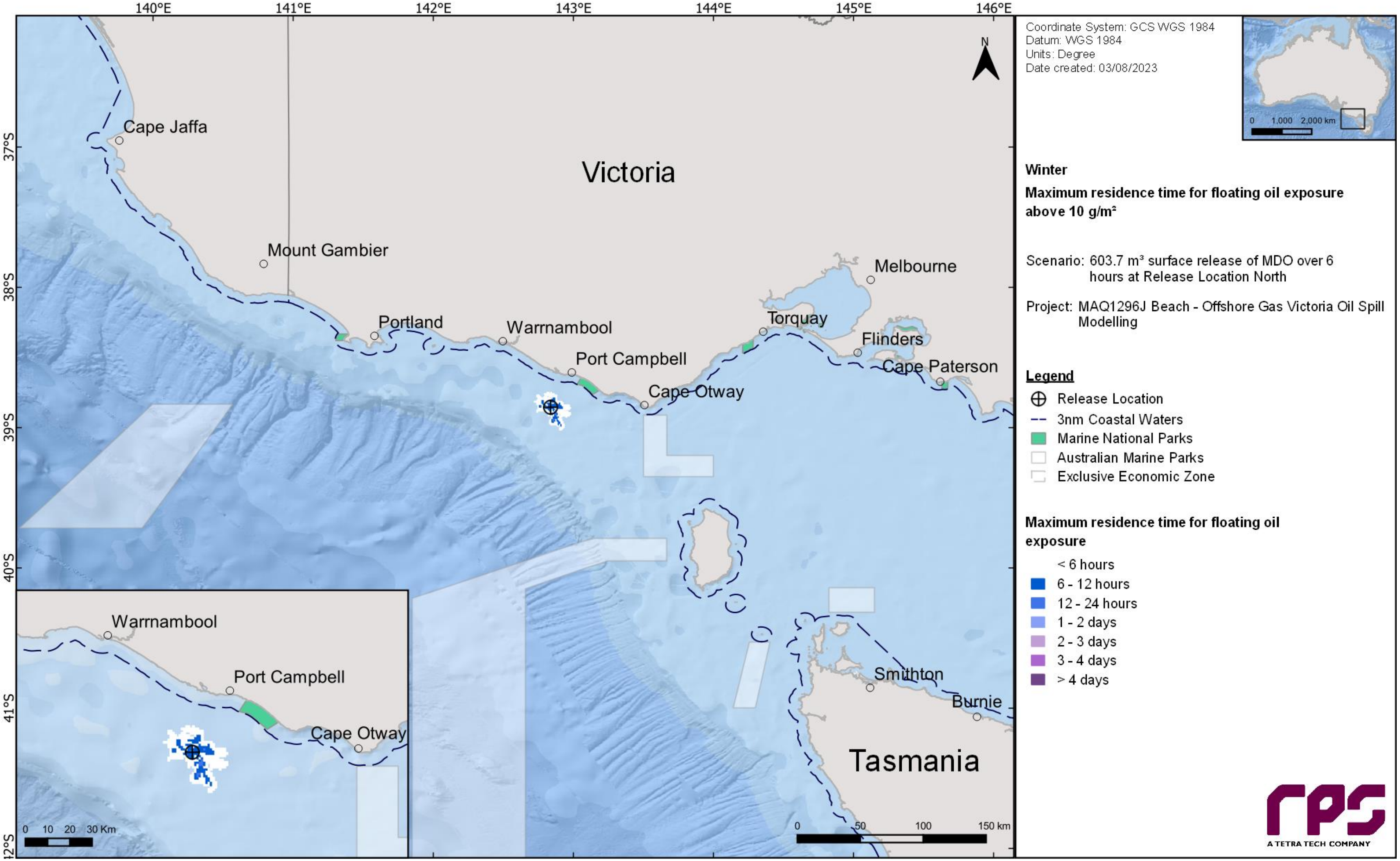


Figure 14-7 Maximum residence time of floating oil exposure above 10 g/m^2, in the event of 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during winter conditions.

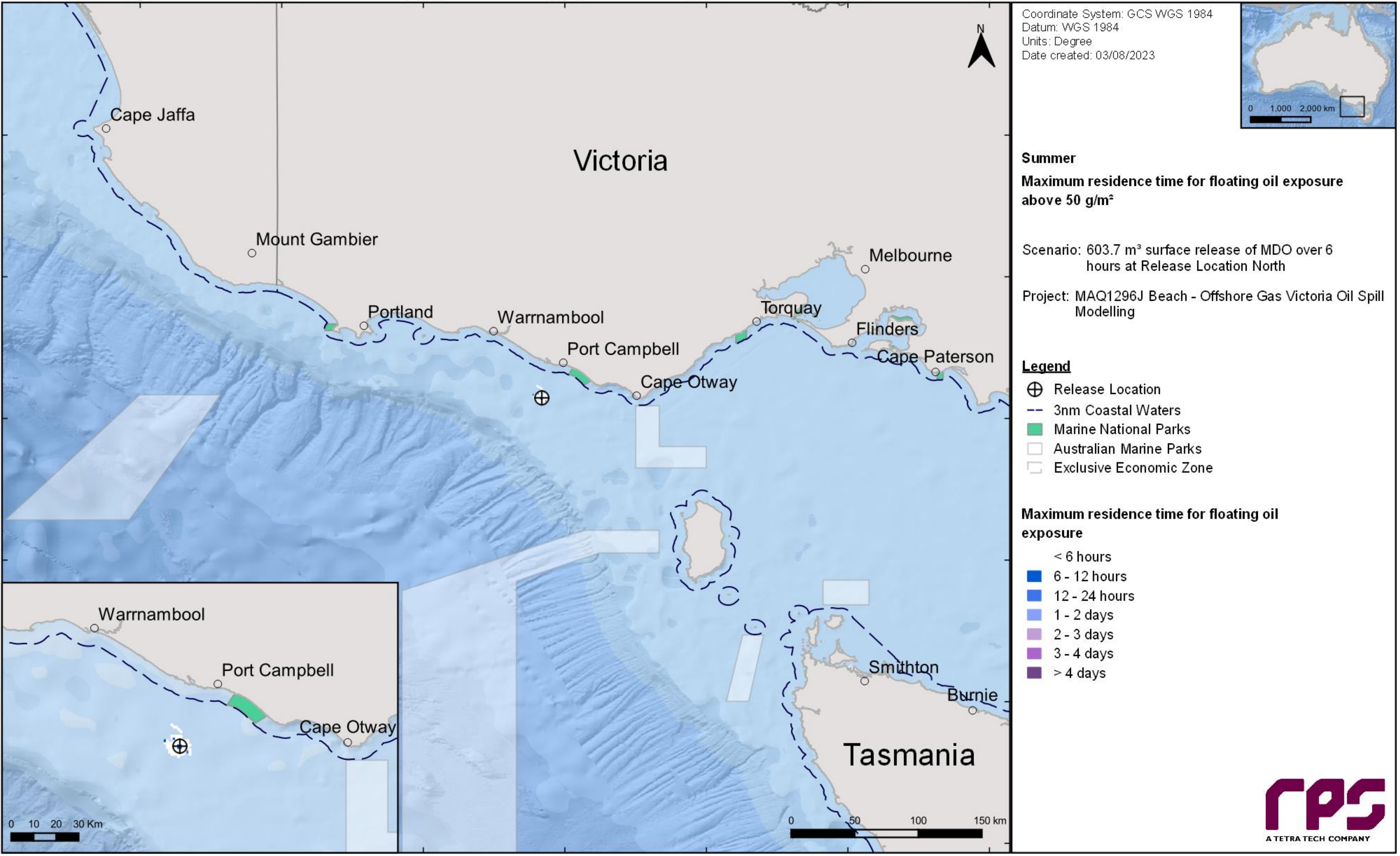


Figure 14-8 Maximum residence time of floating oil exposure above 50 g/m^2, in the event of 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during summer conditions.

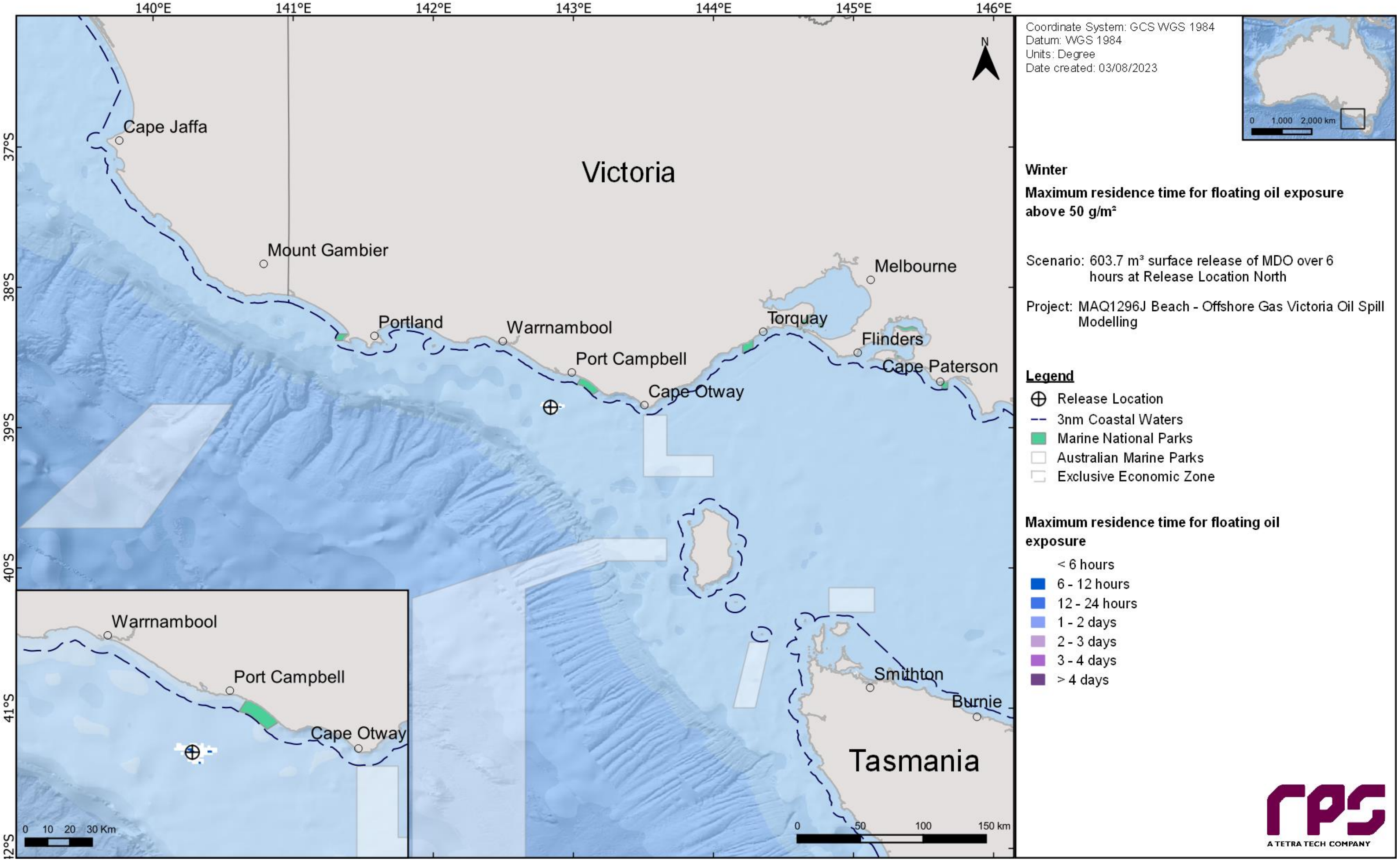


Figure 14-9 Maximum residence time of floating oil exposure above 50 g/m^2, in the event of 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during winter conditions.

14.1.3 Shoreline Accumulation

Table 14-4 presents a summary of the predicted potential shoreline accumulation during the summer and winter conditions. The probability of accumulation to any shoreline at, or above, the low level (10 g/m^2) threshold was 28% during summer conditions and 26% during winter conditions. The minimum time before oil accumulation at, or above, the low threshold was 4 days during summer conditions, and 2 days during winter conditions. The maximum volume ashore for a single spill trajectory during the summer and winter conditions was 25 m^3 and 35 m^3, respectively, whilst the maximum length of shoreline accumulation at the low threshold was 26 km and 30 km, respectively. For the moderate threshold (100 g/m^2), the maximum length of shoreline accumulation predicted was 9 km and 10 km during summer and winter respectively. No shoreline accumulation was predicted for the high (1,000 g/m^2) threshold.

Table 14-5 summarises the shoreline accumulation on individual receptors during the summer and winter conditions. Colac Otway recorded the highest probability of shoreline accumulation at the low threshold with 24% (summer) and 20% (winter) and the largest shoreline accumulation with 24 m^3 and 34 m^3, respectively.

The minimum time before shoreline accumulation above the low threshold was 4 days predicted for Colac Otway and Cape Patton during summer conditions and 2 days during the winter conditions for the same receptors.

The summer and winter conditions maximum potential shoreline loading above the low, moderate and high shoreline thresholds are presented in Figure 14-10 and Figure 14-11, respectively.

Table 14-4 Summary of oil accumulation across all shorelines. Results are based on a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations per season.

Shoreline Statistics	Summer	Winter
Probability of accumulation on any shoreline (%)	28	26
Absolute minimum time for visible oil to shore (days)	4	2
Maximum total volume of hydrocarbons ashore (m^3)	25	35
Average volume of hydrocarbons ashore (m^3)	2	3
Maximum length of the shoreline at **10 g/m^2** (km)	26	30
Average shoreline length (km) at **10 g/m^2** (km)	9	11
Maximum length of the shoreline at **100 g/m^2** (km)	9	10
Average shoreline length (km) at **100 g/m^2** (km)	4	3
Maximum length of the shoreline at **1,000 g/m^2** (km)	-	-
Average shoreline length (km) at **1,000 g/m^2** (km)	-	-

Table 14-5 Summary of oil accumulation on individual shoreline receptors. Results are based on a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations per season.

Shoreline Receptor		Summer																Winter															
		Maximum probability of shoreline loading (%)			Minimum time before shoreline accumulation (days)			Load on shoreline (g/m^2)		Volume on shoreline (m^3)		Mean length of shoreline accumulation (km)			Maximum length of shoreline accumulation (km)			Maximum probability of shoreline loading (%)			Minimum time before shoreline accumulation (days)			Load on shoreline (g/m^2)		Volume on shoreline (m^3)		Mean length of shoreline accumulation (km)			Maximum length of shoreline accumulation (km)		
		Low	Mod	High	Low	Mod	High	Mean	Peak	Mean	Peak	Low	Mod	High	Low	Mod	High	Low	Mod	High	Low	Mod	High	Mean	Peak	Mean	Peak	Low	Mod	High	Low	Mod	High
SHORE	Colac Otway	24	3	-	4	7	-	5	253	2	24	8	3	-	24	8	-	20	6	-	2	4	-	5	516	3	34	9	3	-	21	9	-
	Corangamite	8	-	-	6	-	-	2	37	<1	4	2	-	-	8	-	-	10	2	-	3	4	-	6	166	2	15	6	5	-	15	6	-
	King Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	20	30	-	2	106	1	3	2	1	-	4	1	-
	Moyne	2	-	-	13	-	-	2	94	<1	4	6	-	-	9	-	-	1	-	-	7	-	-	2	13	<1	1	1	-	-	1	-	-
	Phillip Island	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	13	18	-	2	119	<1	4	8	1	-	8	1	-
	Surf Coast	3	-	-	12	-	-	2	23	<1	2	2	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sub-LGA	Apollo Bay	9	-	-	5	-	-	3	47	1	3	5	-	-	9	-	-	11	1	-	3	4	-	4	195	1	5	4	1	-	11	1	-
	Bay of Islands	2	-	-	13	-	-	2	94	<1	4	6	-	-	9	-	-	1	-	-	7	-	-	2	13	<1	1	1	-	-	1	-	-
	Cape Otway West	17	3	-	4	7	-	5	253	1	22	6	3	-	15	8	-	18	5	-	2	4	-	9	516	3	32	7	4	-	19	9	-
	Cape Patton	8	-	-	8	-	-	4	76	1	7	6	-	-	14	-	-	4	-	-	10	-	-	3	45	<1	3	3	-	-	6	-	-
	Lorne	5	-	-	12	-	-	3	86	1	3	3	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Moonlight Head	6	-	-	6	-	-	2	37	<1	2	2	-	-	6	-	-	10	2	-	3	4	-	7	166	2	15	5	5	-	13	6	-
	Port Campbell	3	-	-	11	-	-	2	32	<1	1	2	-	-	3	-	-	2	-	-	7	-	-	2	30	<1	2	3	-	-	4	-	-

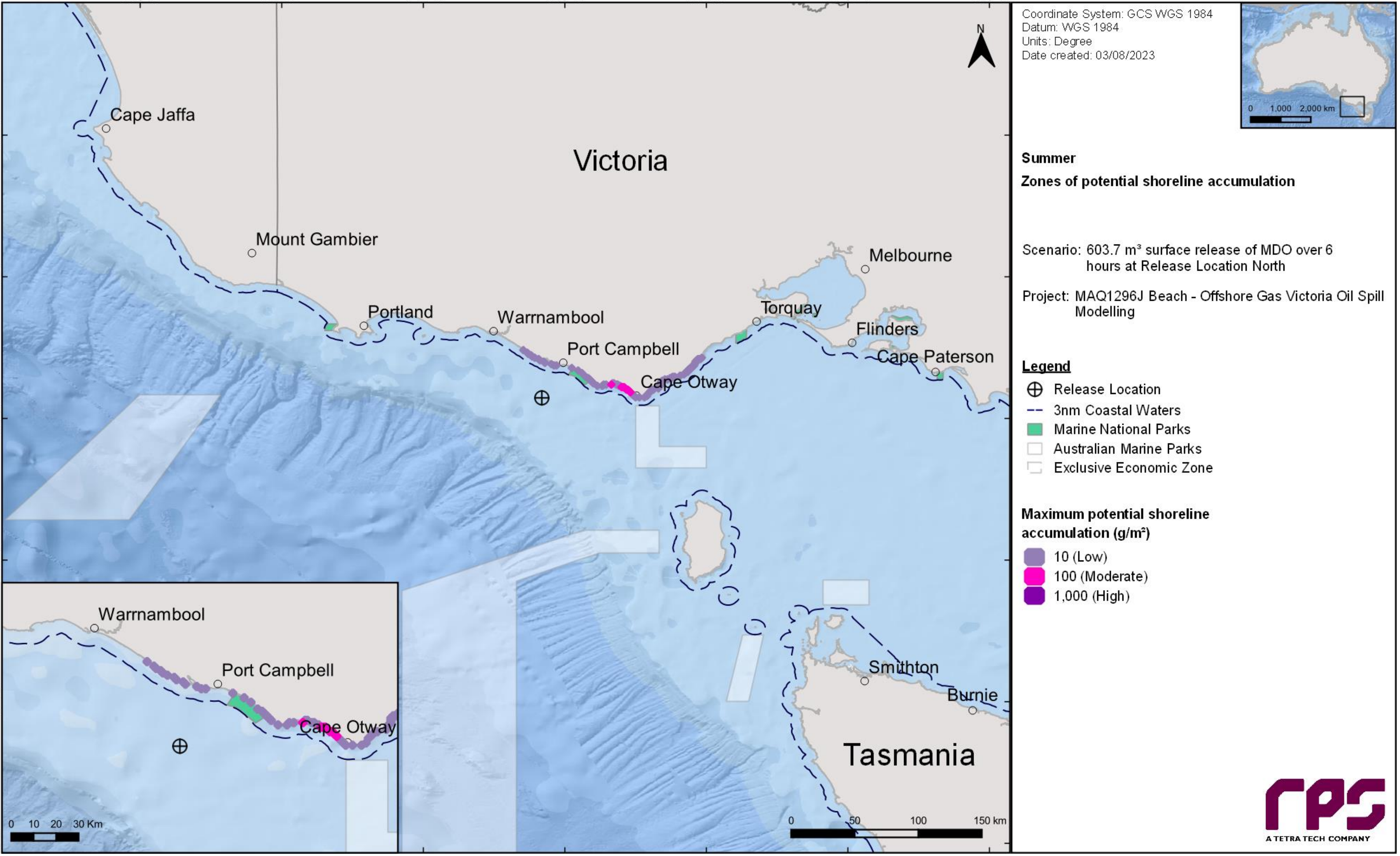


Figure 14-10 Maximum potential shoreline loading in the event of a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during summer conditions.

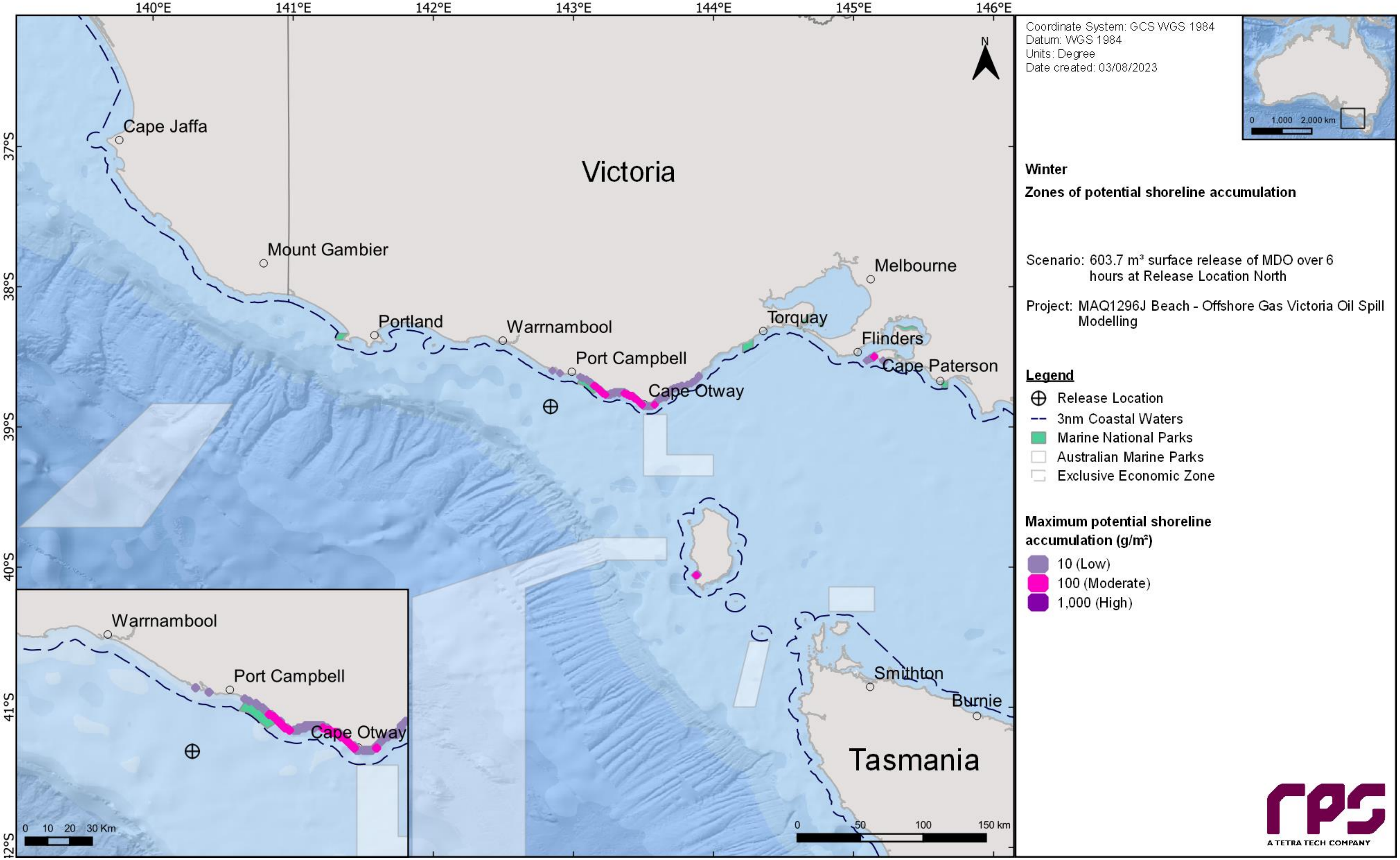


Figure 14-11 Maximum potential shoreline loading in the event of a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during winter conditions.

14.1.4 In-water exposure

14.1.4.1 Dissolved Hydrocarbons

Table 14-6 summarises the probability of exposure to individual receptors from dissolved hydrocarbons in the 0-10 m layer during the summer and winter conditions. No dissolved hydrocarbon exposure at the high (400 ppb) threshold was predicted,

Outside of the receptors that the Release Location North resides within (refer to Table 10-3), the highest concentration of dissolved hydrocarbon was predicted for the Southern Right Whale - Aggregation BIA in summer (45 ppb) and in Apollo AMP in winter (31 ppb). The highest probability of low dissolved hydrocarbon exposure was recorded for Pygmy Blue Whale - Foraging BIA (summer – 3%, winter – 8%) and Short-tailed Shearwater – Foraging (summer – 3%, winter – 9%).

Table 14-7 presents the predicted minimum time to dissolved hydrocarbon exposure and maximum residence time for dissolved hydrocarbon exposure to individual receptors, in the 0-10 m depth layer, for all seasonal conditions and all thresholds assessed. The maximum residence time of dissolved hydrocarbon exposure at the low threshold was 1 day both during summer and winter.

Figure 14-12 and Figure 14-13 presents the zones of potential dissolved hydrocarbon exposure for the 0-10 m depth layer, for each threshold assessed under summer and winter conditions, respectively.

Figure 14-14 to Figure 14.17 present the maximum residence time of dissolved hydrocarbon exposure for the NOPSEMA thresholds in summer and winter.

Table 14-6 **Probability of dissolved hydrocarbons exposure to marine based receptors in the 0–10 m dept. Results are based on a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations per season.**

Receptor		Summer (November through to March)				Winter (April to October)			
		Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure			Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure		
			Low	Moderate	High		Low	Moderate	High
AMP	Apollo	16	1	-	-	31	3	-	-
BIA	Antipodean Albatross - Foraging*	151	55	15	-	156	59	20	-
	Black-browed Albatross - Foraging*	151	55	15	-	156	59	20	-
	Bullers Albatross - Foraging*	151	55	15	-	156	59	20	-
	Campbell Albatross – Foraging*	151	55	15	-	156	59	20	-
	Common Diving-petrel – Foraging*	151	55	15	-	156	59	20	-
	Indian Yellow-nosed Albatross – Foraging*	151	55	15	-	156	59	20	-
	Pygmy Blue Whale – Distribution*	151	55	15	-	156	59	20	-
	Pygmy Blue Whale - Foraging	32	3	-	-	101	8	1	-
	Pygmy Blue Whale - Foraging (annual high use area)*	151	55	15	-	156	59	20	-
	Pygmy Blue Whale - Known Foraging Area	14	1	-	-	28	2	-	-
	Short-tailed Shearwater - Foraging	32	3	-	-	101	9	1	-
	Shy Albatross – Foraging*	151	55	15	-	156	59	20	-
	Southern Right Whale - Aggregation	45	2	-	-	25	2	-	-
	Southern Right Whale - Known Core Range*	151	55	15	-	156	59	20	-
	Wandering Albatross – Foraging*	151	55	15	-	156	59	20	-
	Wedge-tailed Shearwater – Foraging*	151	55	15	-	156	59	20	-
	White Shark – Distribution*	151	55	15	-	156	59	20	-
	White Shark - Foraging	12	1	-	-	3	-	-	-
	White-faced Storm-petrel - Foraging	10	1	-	-	20	2	-	-
EEZ	Australian*	151	55	15	-	156	59	20	-
IBRA	Otway Plain	2	-	-	-	19	1	-	-
IBRA	Otway Ranges	2	-	-	-	22	1	-	-
IMCRA	Central Bass Strait	8	-	-	-	20	2	-	-

Receptor		Summer (November through to March)				Winter (April to October)			
		Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure			Maximum dissolved hydrocarbon exposure	Probability of dissolved hydrocarbon exposure		
			Low	Moderate	High		Low	Moderate	High
IMCRA	Central Victoria	13	1	-	-	28	1	-	-
IMCRA	Otway*	151	55	15	-	156	59	20	-
SHORE	Colac Otway	2	-	-	-	22	1	-	-
State Waters	Victoria State Waters	9	-	-	-	41	2	-	-
Sub-LGA	Apollo Bay	2	-	-	-	22	1	-	-
	Cape Otway West	2	-	-	-	11	1	-	-

*The release location resides within the receptor boundaries.

Table 14-7 **Predicted minimum time to dissolved hydrocarbon exposure and maximum residence time for dissolved hydrocarbon exposure to individual receptors in the 0-10 m depth layer. Results are based on a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill trajectories per season.**

Receptor		Summer (November through to March)						Winter (April to October)					
		Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)			Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
AMP	Apollo	3	-	-	< 1	-	-	1	-	-	< 1	-	-
BIA	Antipodean Albatross - Foraging*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Black-browed Albatross - Foraging*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Bullers Albatross - Foraging*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Campbell Albatross – Foraging*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Common Diving-petrel – Foraging*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Indian Yellow-nosed Albatross – Foraging*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Pygmy Blue Whale – Distribution*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Pygmy Blue Whale - Foraging	1	2	-	< 1	< 1	-	1	1	-	< 1	< 1	-
	Pygmy Blue Whale - Foraging (annual high use area)*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Pygmy Blue Whale - Known Foraging Area	4	-	-	< 1	-	-	2	-	-	< 1	-	-
	Short-tailed Shearwater - Foraging	< 1	2	-	< 1	< 1	-	1	1	-	< 1	< 1	-
	Shy Albatross – Foraging*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Southern Right Whale - Aggregation	2	4	-	< 1	-	-	1	-	-	< 1	-	-
	Southern Right Whale - Known Core Range*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Wandering Albatross – Foraging*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	Wedge-tailed Shearwater – Foraging*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	White Shark – Distribution*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
	White Shark - Foraging	6	-	-	< 1	-	-	-	-	-	-	-	-
	White-faced Storm-petrel - Foraging	5	-	-	< 1	-	-	2	-	-	< 1	-	-
EEZ	Australian*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
IBRA	Otway Plain	-	-	-	-	-	-	2	-	-	< 1	-	-
	Otway Ranges	-	-	-	-	-	-	2	-	-	< 1	-	-

Receptor		Summer (November through to March)						Winter (April to October)					
		Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)			Minimum time before dissolved hydrocarbon exposure (days)			Maximum residence time for dissolved hydrocarbon exposure (days)		
		Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
IMCRA	Central Bass Strait	9	-	-	-	-	-	2	-	-	< 1	-	-
	Central Victoria	5	-	-	< 1	-	-	2	-	-	< 1	-	-
	Otway*	< 1	< 1	-	1	< 1	-	< 1	< 1	-	1	< 1	-
SHORE	Colac Otway	-	-	-	-	-	-	2	-	-	< 1	-	-
State Waters	Victoria State Waters	4	-	-	< 1	-	-	1	-	-	< 1	-	-
Sub-LGA	Apollo Bay	-	-	-	-	-	-	2	-	-	< 1	-	-
	Cape Otway West	-	-	-	-	-	-	2	-	-	< 1	-	-

*The release location resides within the receptor boundaries.

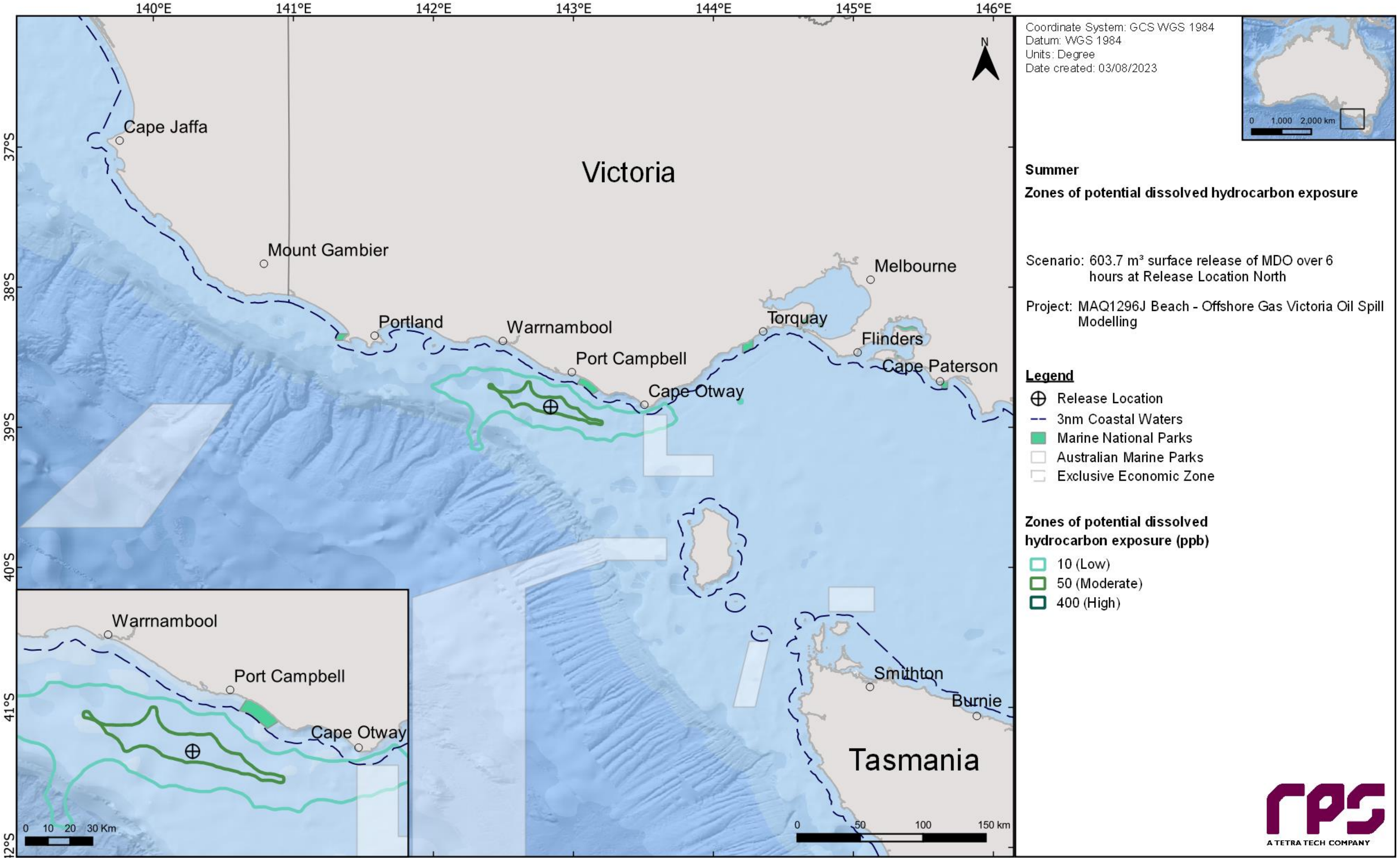


Figure 14-12 Zones of potential dissolved hydrocarbon exposure at 0-10 m below the sea in the event of a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during summer conditions.

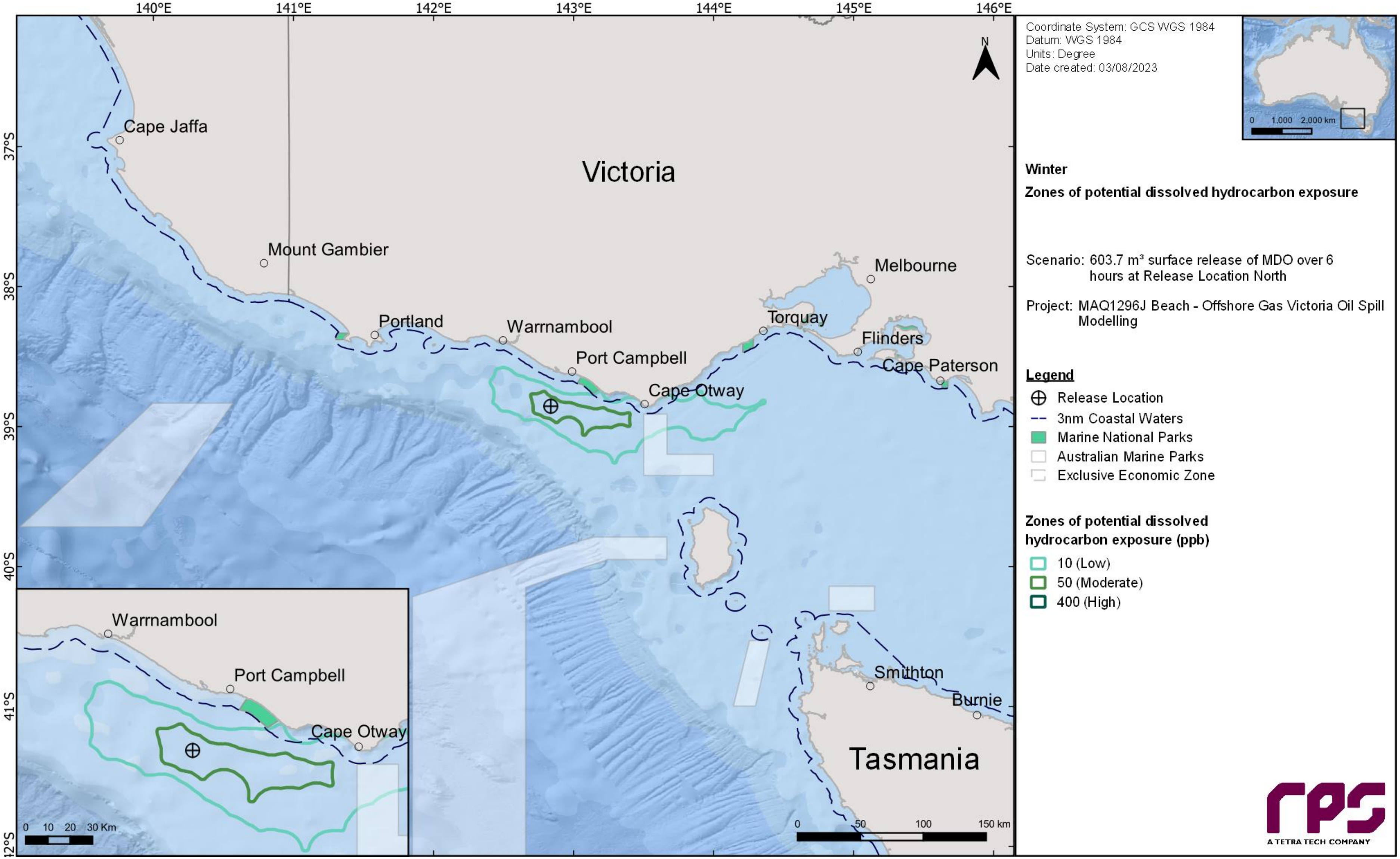


Figure 14-13 Zones of potential dissolved hydrocarbon exposure at 0-10 m below the sea in the event of a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during winter conditions.

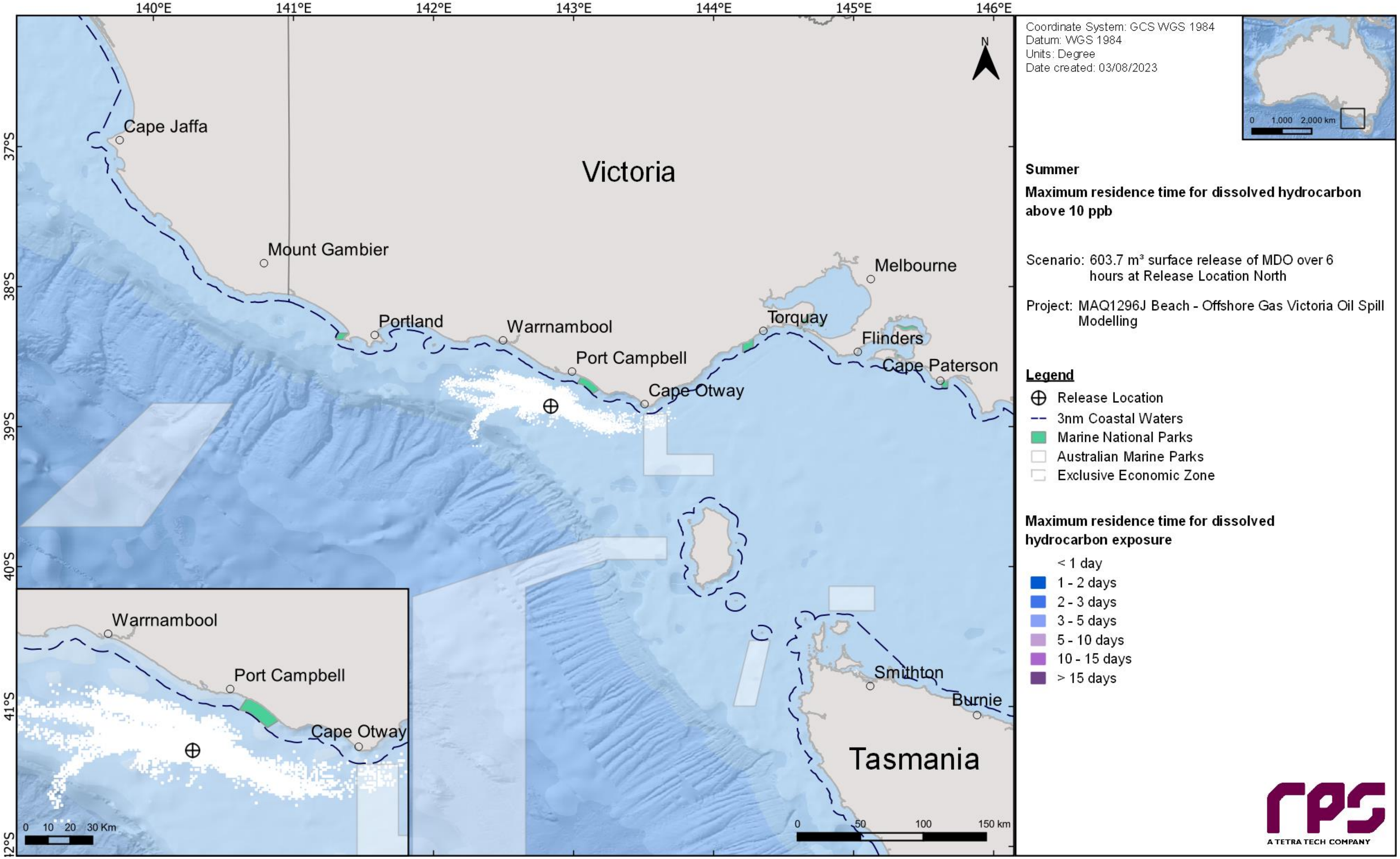


Figure 14-14 **Maximum residence time for dissolved hydrocarbon exposure above 10 ppb, at 0-10 m below the sea surface in the event of a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during summer conditions.**

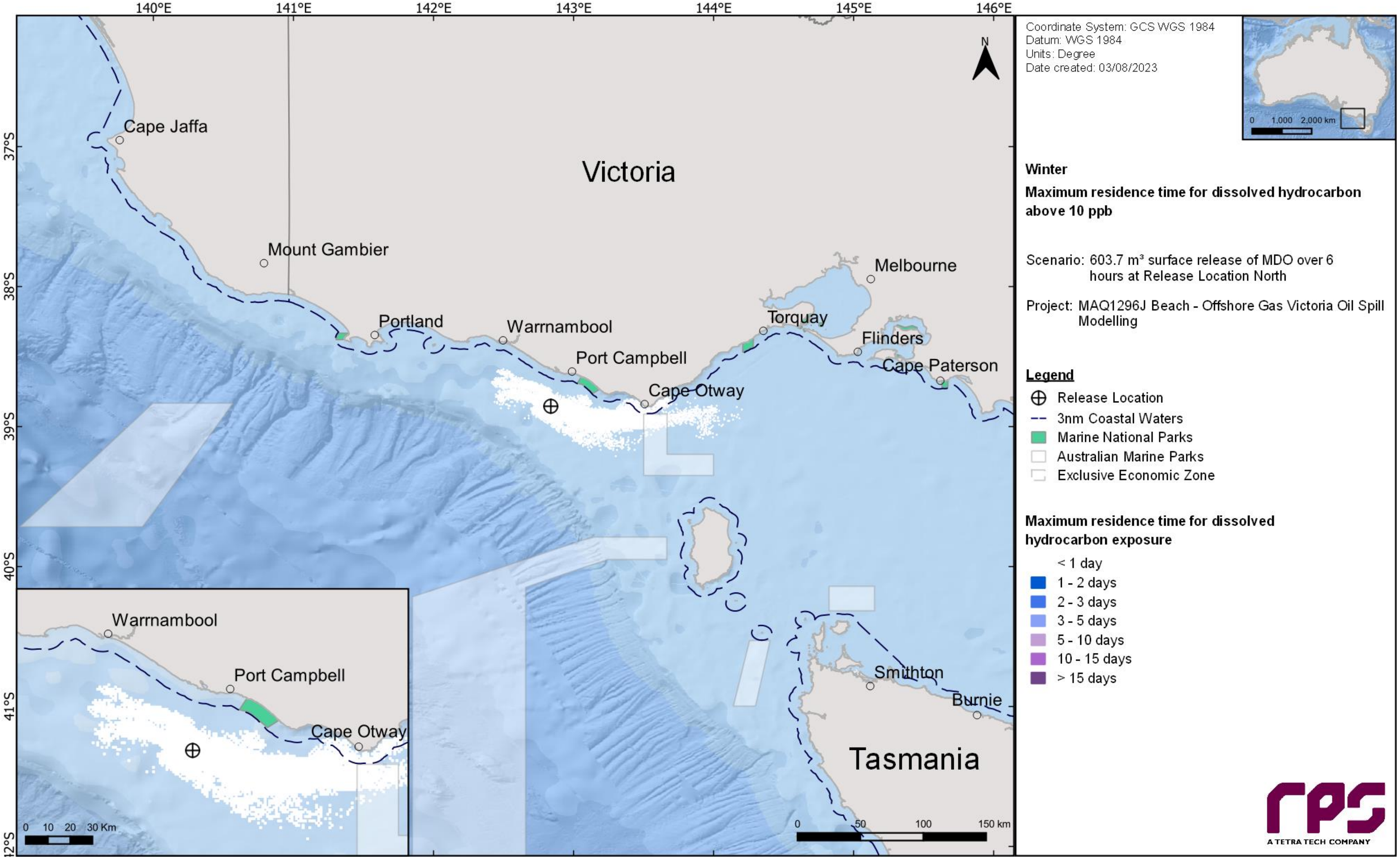


Figure 14.15 Maximum residence time for dissolved hydrocarbon exposure above 10 ppb, at 0-10 m below the sea surface in the event of a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during winter conditions.

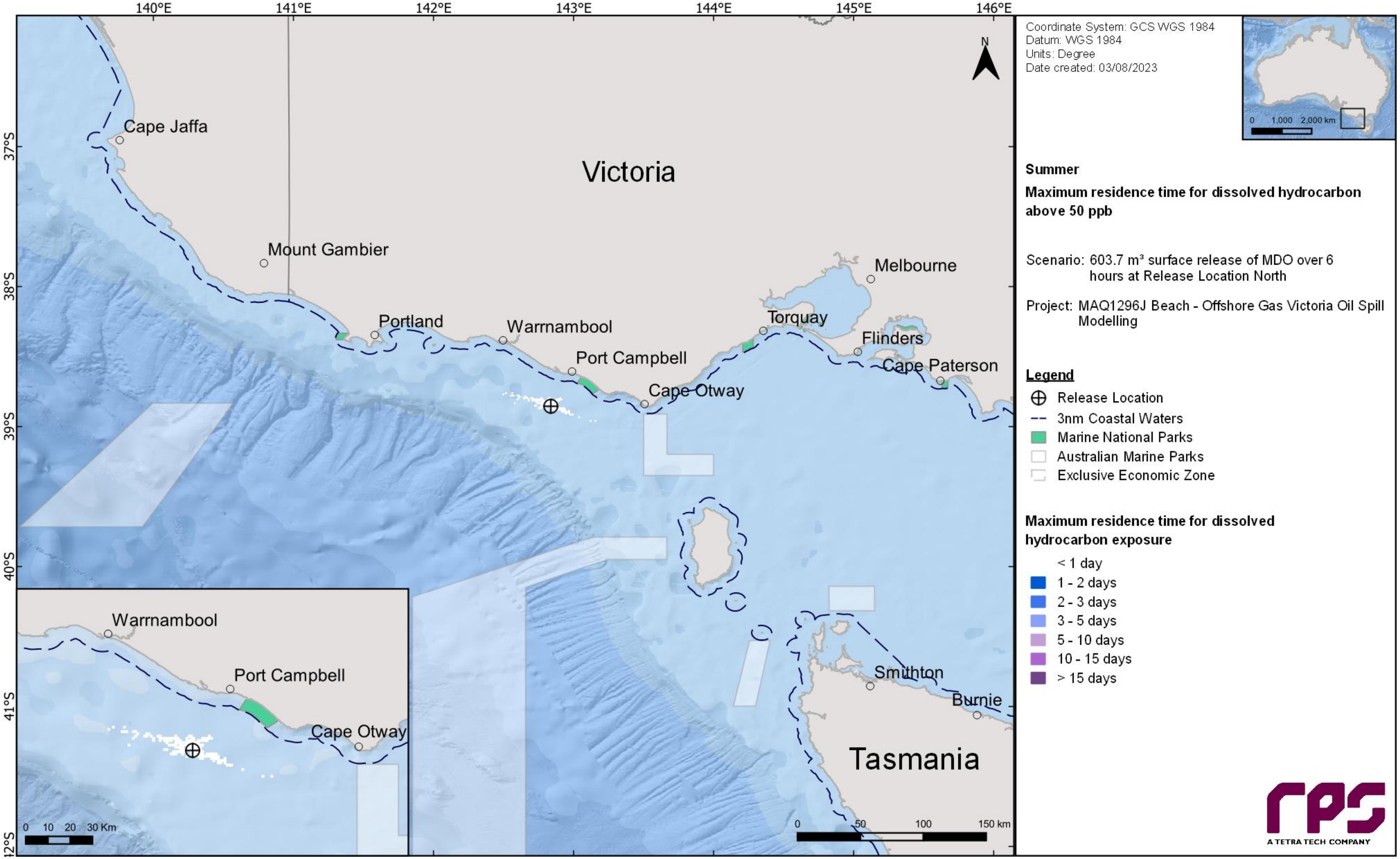


Figure 14.16 Maximum residence time for dissolved hydrocarbon exposure above 50 ppb, at 0-10 m below the sea surface in the event of a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during summer conditions.

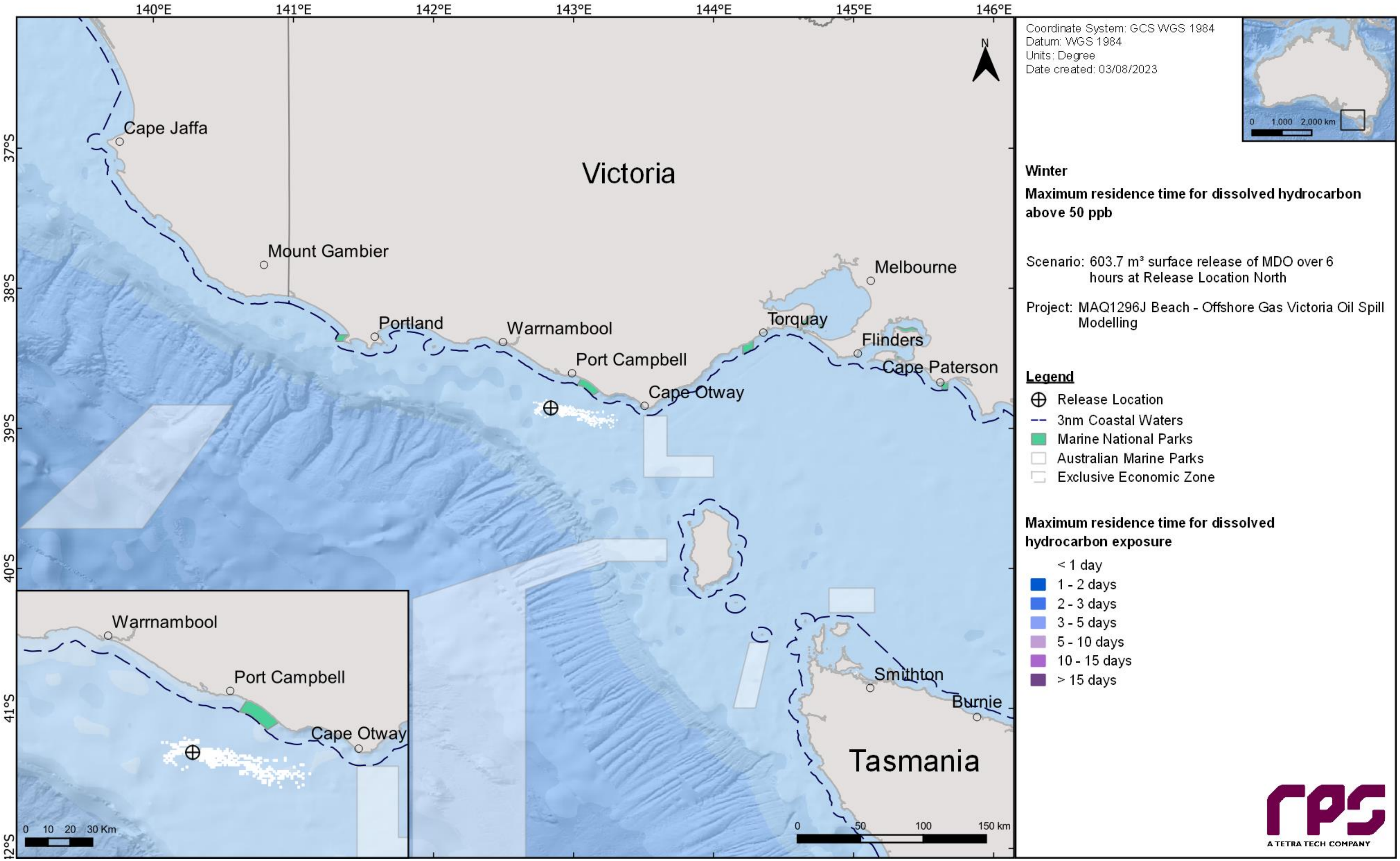


Figure 14.17 **Maximum residence time for dissolved hydrocarbon exposure above 50 ppb, at 0-10 m below the sea surface in the event of a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during winter conditions.**

14.1.4.2 Entrained Hydrocarbons

Table 14-8 presents the probability of exposure to individual receptors from entrained hydrocarbons in the 0-10 m depth layer for the summer and winter conditions.

Outside of the receptors that the Release Location North resides within (refer to Table 10-3), the highest concentration of entrained hydrocarbon was predicted for Short-tailed Shearwater - Foraging BIA (summer – 801 ppb, winter – 1,326ppb), which also presented the highest probability of low entrained hydrocarbon exposure (summer – 51%, winter – 81%).

Table 14-9 presents the predicted minimum time to entrained hydrocarbon exposure and maximum residence time for entrained hydrocarbon exposure to individual receptors in the 0-10 m depth layer, for all seasonal conditions and all thresholds assessed.

Figure 14-18 and Figure 14-19 present the zones of potential entrained hydrocarbon exposure for the 0-10 m depth layer, for each threshold assessed under summer and winter conditions, respectively.

Figure 14-20 to Figure 14-23 present the maximum residence time of entrained hydrocarbon exposure for the NOPSEMA thresholds in summer and winter.

Table 14-8 **Probability of entrained hydrocarbons exposure to marine based receptors in the 0–10 m depth layer. Results are based on a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations per season.**

Receptor		Summer (November through to March)			Winter (April to October)		
		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure	
			Low	High		Low	High
AMP	Apollo	139	29	2	392	63	9
BIA	Antipodean Albatross - Foraging*	13,567	97	89	12,277	97	92
	Australasian Gannet - Foraging	43	6	-	58	4	-
	Black-browed Albatross - Foraging*	13,567	97	89	12,277	97	92
	Bullers Albatross - Foraging*	13,567	97	89	12,277	97	92
	Campbell Albatross – Foraging*	13,567	97	89	12,277	97	92
	Common Diving-petrel – Foraging*	13,567	97	89	12,277	97	92
	Indian Yellow-nosed Albatross – Foraging*	13,567	97	89	12,277	97	92
	Little Penguin - Foraging	2	-	-	13	1	-
	Pygmy Blue Whale – Distribution*	13,567	97	89	12,277	97	92
	Pygmy Blue Whale - Foraging	665	49	19	1,146	78	34
	Pygmy Blue Whale - Foraging (annual high use area)*	13,567	97	89	12,277	97	92
	Pygmy Blue Whale - Known Foraging Area	102	27	1	370	60	6
	Short-tailed Shearwater - Foraging	801	51	21	1,326	81	37
	Shy Albatross – Foraging*	13,567	97	89	12,277	97	92
	Southern Right Whale - Aggregation	440	30	2	365	9	2
	Southern Right Whale - Known Core Range*	13,567	97	89	12,277	97	92
	Wandering Albatross – Foraging*	13,567	97	89	12,277	97	92
	Wedge-tailed Shearwater – Foraging*	13,567	97	89	12,277	97	92
	White Shark – Distribution*	13,567	97	89	12,277	97	92
	White Shark - Foraging	81	10	-	19	4	-
	White-faced Storm-petrel - Foraging	94	25	-	370	56	5
EEZ	Australian*	13,567	97	89	12,277	97	92
IBRA	Gippsland Plain	1	-	-	13	1	-

Receptor		Summer (November through to March)			Winter (April to October)		
		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure		Maximum entrained hydrocarbon exposure	Probability of entrained hydrocarbon exposure	
			Low	High		Low	High
	Otway Plain	84	12	-	224	19	3
	Otway Ranges	50	10	-	183	13	2
	Warrnambool Plain	40	7	-	173	11	1
IMCRA	Central Bass Strait	76	20	-	362	56	5
	Central Victoria	102	27	1	370	59	6
	Otway*	13,567	97	89	12,277	97	92
	Victorian Embayments	1	-	-	11	1	-
KEF	Bonney Coast Upwelling	18	1	-	1	-	-
	West Tasmania Canyons	31	1	-	10	1	-
MNP	Twelve Apostles	40	10	-	224	9	1
RSB	Bravenes Rock	70	16	-	134	25	1
SHORE	Colac Otway	84	12	-	224	19	3
	Corangamite	40	8	-	173	11	1
	Moyne	15	3	-	13	1	-
	Phillip Island	1	-	-	11	1	-
State Waters	Victoria State Waters	102	21	1	466	32	7
Sub-LGA	Apollo Bay	34	10	-	183	13	2
	Bay of Islands	15	3	-	13	1	-
	Cape Otway West	84	12	-	207	19	3
	Cape Patton	24	7	-	19	3	-
	Childers Cove	7	-	-	15	1	-
	Lorne	12	1	-	5	-	-
	Moonlight Head	40	8	-	173	11	1
	Port Campbell	15	3	-	42	3	-

*The release location resides within the receptor boundaries.

Table 14-9 **Predicted minimum time to entrained hydrocarbon exposure and maximum residence time for entrained hydrocarbon exposure to individual receptors in the 0-10 m depth layer. Results are based on a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill trajectories per season.**

Receptor		Summer (November through to March)				Winter (April to October)			
		Minimum time before entrained hydrocarbon exposure (days)		Maximum residence time for entrained hydrocarbon exposure (days)		Minimum time before entrained hydrocarbon exposure (days)		Maximum residence time for entrained hydrocarbon exposure (days)	
		Low	High	Low	High	Low	High	Low	High
AMP	Apollo	2	2	5	< 1	1	1	10	1
BIA	Antipodean Albatross – Foraging*	<1	<1	14	4	<1	<1	12	4
	Australasian Gannet – Foraging	4	-	3	-	4	-	4	-
	Black-browed Albatross – Foraging*	<1	<1	14	4	<1	<1	12	4
	Bullers Albatross – Foraging*	<1	<1	14	4	<1	<1	12	4
	Campbell Albatross – Foraging*	<1	<1	14	4	<1	<1	12	4
	Common Diving-petrel – Foraging*	<1	<1	14	4	<1	<1	13	4
	Indian Yellow-nosed Albatross – Foraging*	<1	<1	14	4	<1	<1	12	4
	Little Penguin – Foraging	-	-	-	-	13	-	< 1	-
	Pygmy Blue Whale – Distribution*	<1	<1	14	4	<1	<1	13	4
	Pygmy Blue Whale – Foraging	<1	<1	13	1	<1	<1	13	2
	Pygmy Blue Whale – Foraging (annual high use area)*	<1	<1	14	4	<1	<1	13	4
	Pygmy Blue Whale – Known Foraging Area	3	3	12	-	1	1	10	1
	Short-tailed Shearwater – Foraging	<1	<1	13	3	<1	<1	12	3
	Shy Albatross – Foraging*	<1	<1	14	4	<1	<1	13	4
	Southern Right Whale – Aggregation	1	1	8	1	1	1	8	2
	Southern Right Whale – Known Core Range*	<1	<1	14	4	<1	<1	13	4
	Wandering Albatross – Foraging*	<1	<1	14	4	<1	<1	12	4
	Wedge-tailed Shearwater – Foraging*	<1	<1	14	4	<1	<1	13	4
	White Shark – Distribution*	<1	<1	14	4	<1	<1	12	4
	White Shark – Foraging	3	-	4	-	7	-	4	-
	White-faced Storm-petrel - Foraging	3	-	12	-	1	1	9	1
EEZ	Australian*	<1	<1	14	4	<1	<1	13	4
IBRA	Gippsland Plain	-	-	-	-	13	-	< 1	-

Receptor		Summer (November through to March)				Winter (April to October)			
		Minimum time before entrained hydrocarbon exposure (days)		Maximum residence time for entrained hydrocarbon exposure (days)		Minimum time before entrained hydrocarbon exposure (days)		Maximum residence time for entrained hydrocarbon exposure (days)	
		Low	High	Low	High	Low	High	Low	High
	Otway Plain	3	-	12	-	1	1	11	3
	Otway Ranges	3	-	6	-	1	2	9	< 1
	Warrnambool Plain	3	-	3	-	2	2	13	1
IMCRA	Central Bass Strait	3	-	5	-	1	2	7	< 1
	Central Victoria	3	3	12	-	1	1	8	1
	Otway*	<1	<1	14	4	<1	<1	13	4
	Victorian Embayments	-	-	-	-	13	-	< 1	-
KEF	Bonney Coast Upwelling	9	-	2	-	-	-	-	-
	West Tasmania Canyons	6	-	3	-	15	-	< 1	-
MNP	Twelve Apostles	3	-	4	-	2	2	13	2
RSB	Bravenes Rock	2	-	4	-	2	3	2	< 1
SHORE	Colac Otway	3	-	12	-	1	1	11	3
	Corangamite	4	-	3	-	2	2	13	1
	Moyne	12	-	1	-	5	-	< 1	-
	Phillip Island	-	-	-	-	13	-	< 1	-
State Waters	Victoria State Waters	1	4	13	< 1	1	1	13	3
Sub-LGA	Apollo Bay	3	-	3	-	1	2	8	< 1
	Bay of Islands	12	-	1	-	5	-	< 1	-
	Cape Otway West	3	-	12	-	1	2	11	3
	Cape Patton	5	-	3	-	6	-	1	-
	Childers Cove	-	-	-	-	3	-	< 1	-
	Lorne	13	-	< 1	-	-	-	-	-
	Moonlight Head	3	-	3	-	2	2	13	1
	Port Campbell	5	-	1	-	3	-	2	-

*The release location resides within the receptor boundaries.

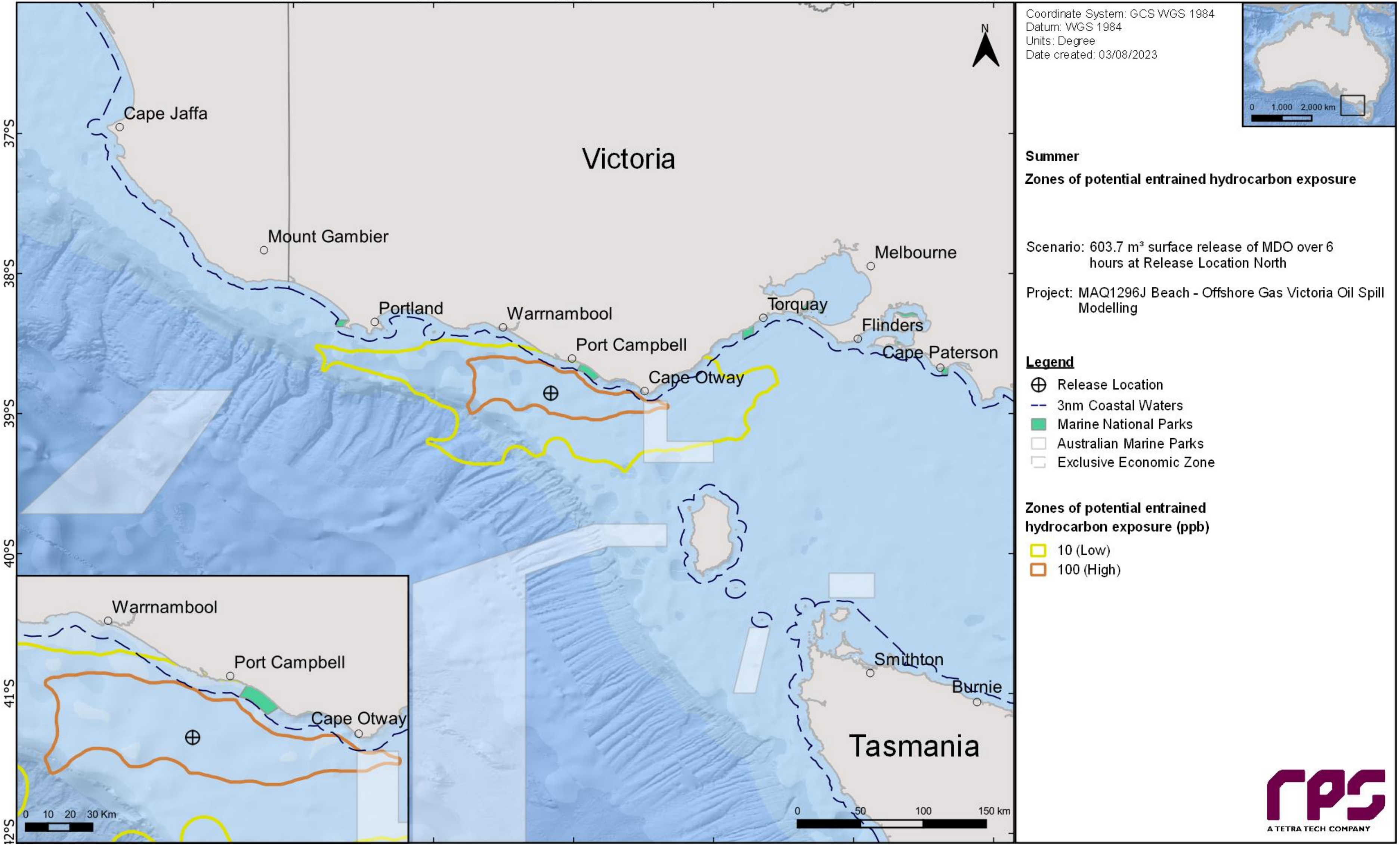


Figure 14-18 Zones of potential entrained hydrocarbon exposure at 0-10 m below the sea surface in the event of a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during summer conditions.

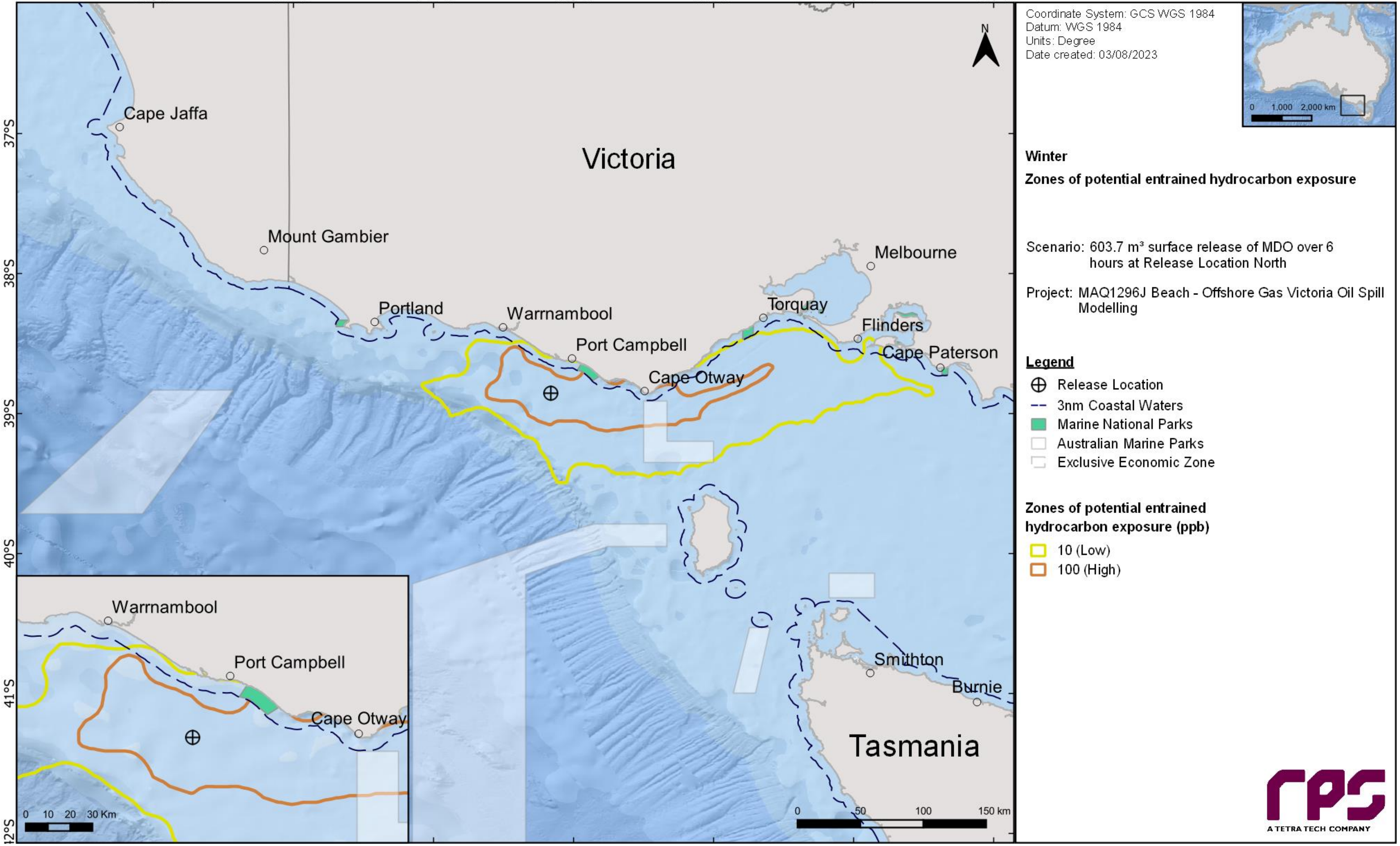


Figure 14-19 Zones of potential entrained hydrocarbon exposure at 0-10 m below the sea surface in the event of a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during winter conditions.

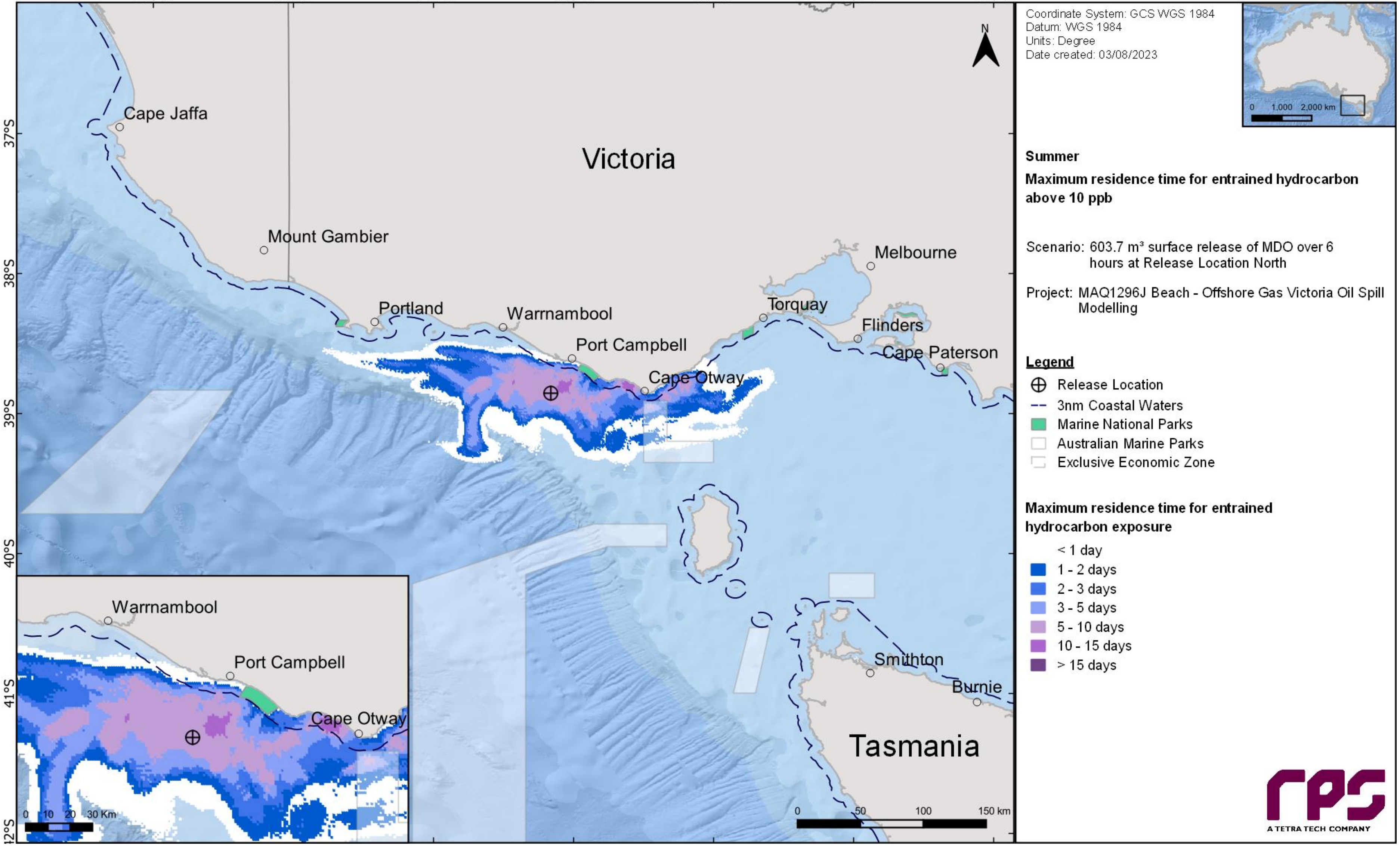


Figure 14-20 Maximum residence time for entrained hydrocarbon exposure above 10 ppb, at 0-10 m below the sea surface in the event of a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during summer conditions.

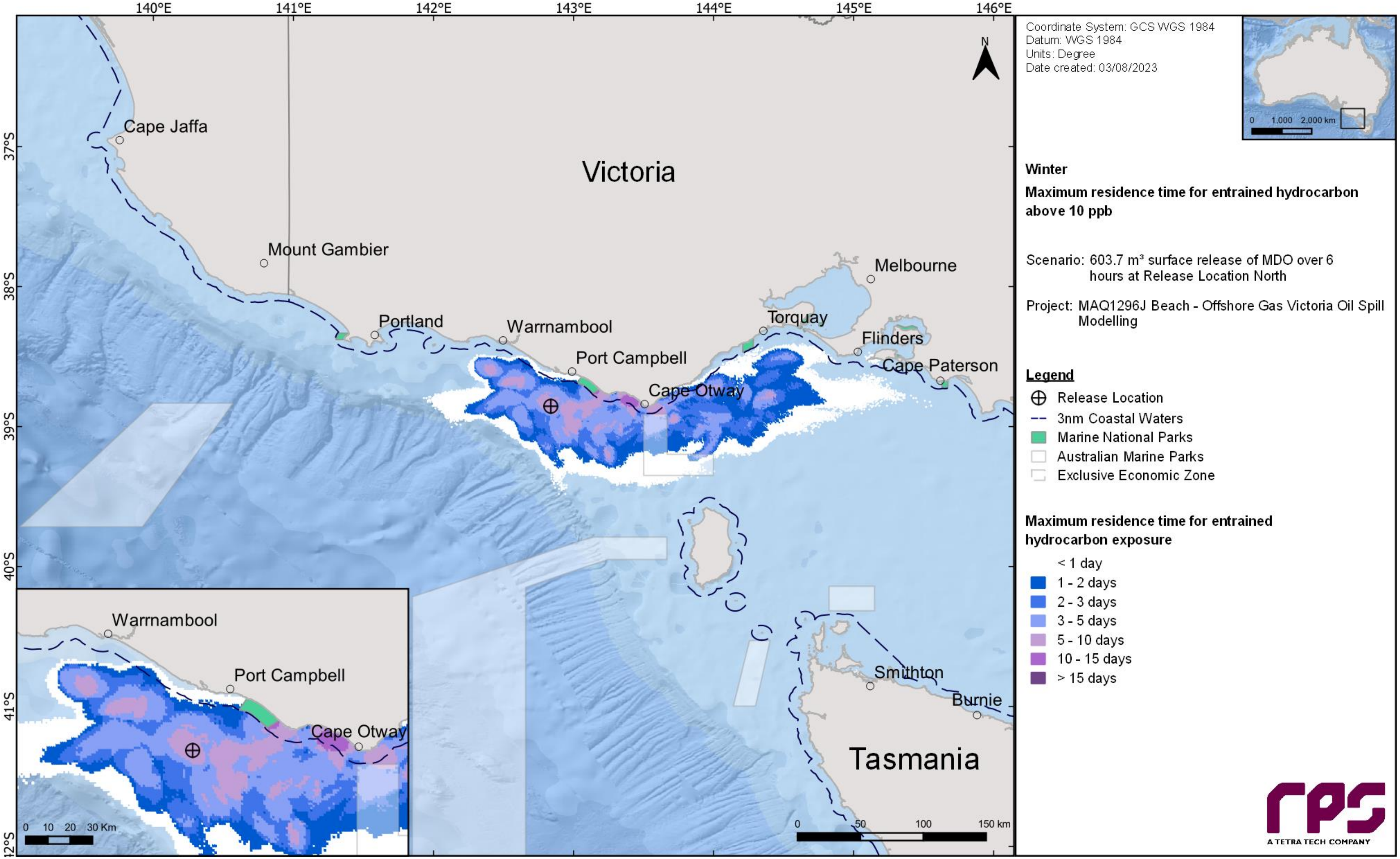


Figure 14-21 Maximum residence time for entrained hydrocarbon exposure above 10 ppb, at 0-10 m below the sea surface in the event of a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during winter conditions.

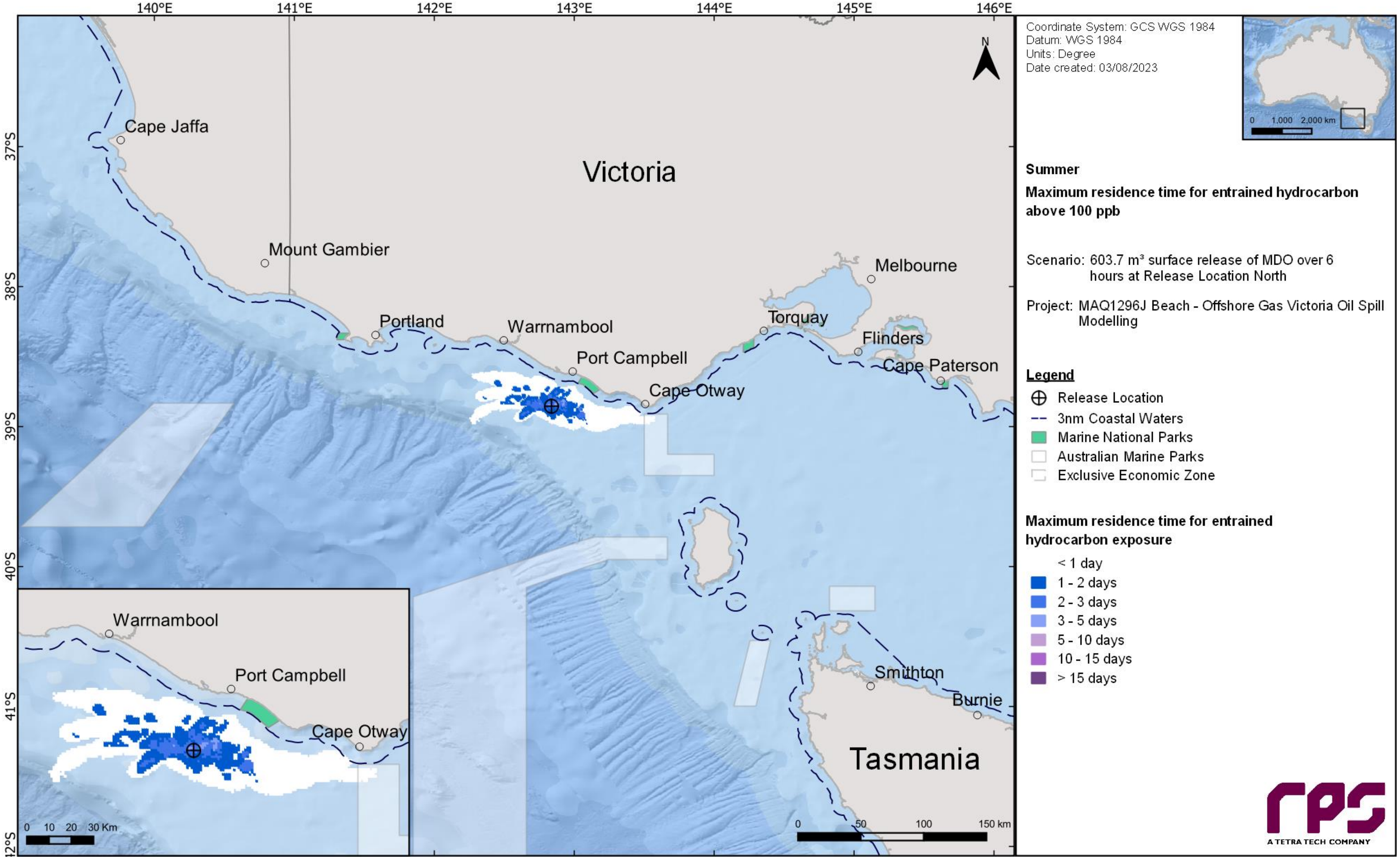


Figure 14-22 Maximum residence time for entrained hydrocarbon exposure above 100 ppb, at 0-10 m below the sea surface in the event of a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during summer conditions.

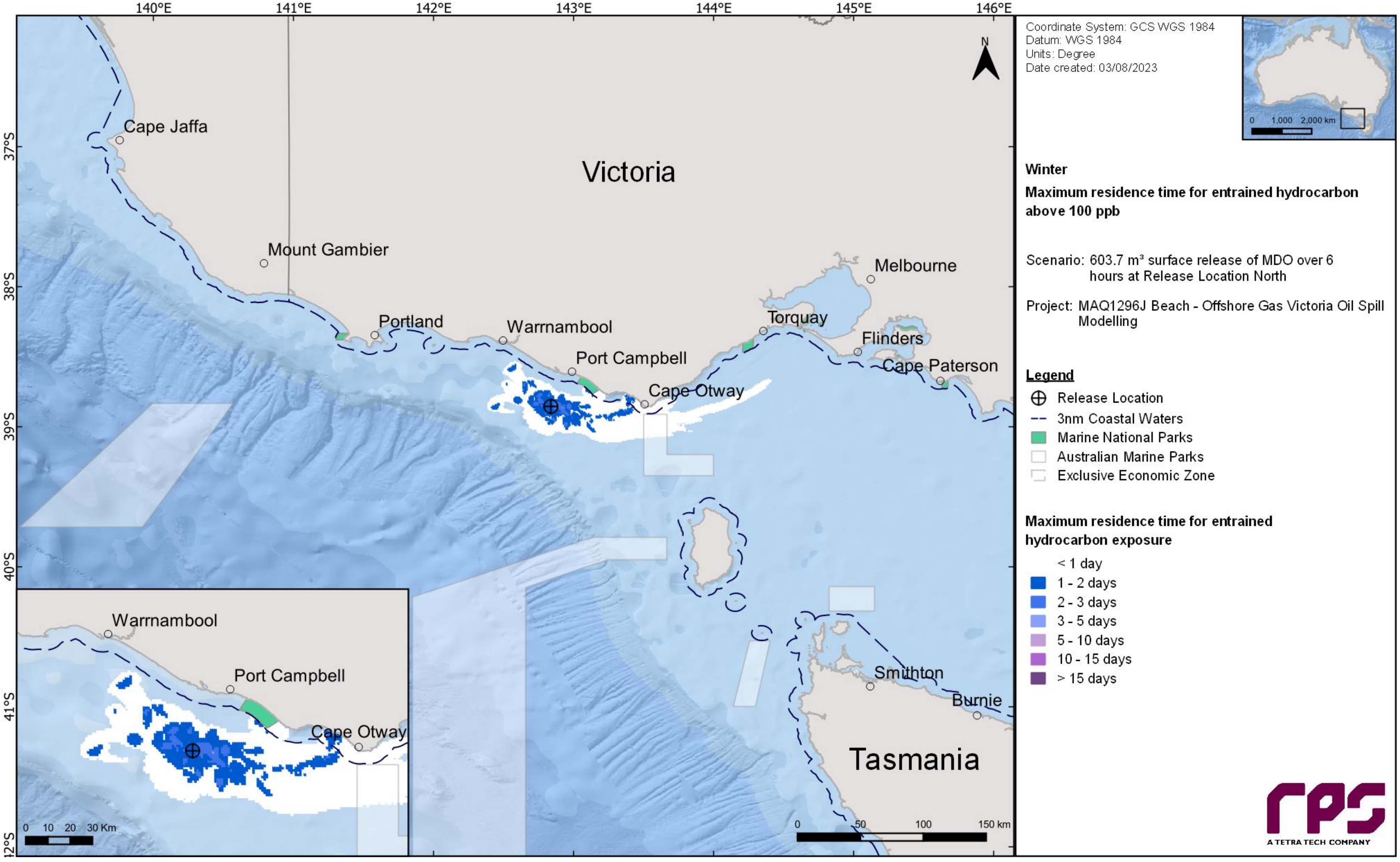


Figure 14-23 Maximum residence time for entrained hydrocarbon exposure above 100 ppb, at 0-10 m below the sea surface in the event of a 603.7 m^3 surface release of marine diesel for a loss of containment from vessel collision at the Release Location North field. The results were calculated from 100 spill simulations during winter conditions.

15 REFERENCES

American Society for Testing and Materials (ASTM) 2013, 'F2067-13 Standard Practice for Development and Use of Oil-Spill Trajectory Models', ASTM International, West Conshohocken (PA).

Andersen, OB 1995, 'Global ocean tides from ERS 1 and TOPEX/POSEIDON altimetry', Journal of Geophysical Research: Oceans, vol. 100, no. C12, pp. 25249–25259.

Anderson JW, Neff JM, Cox BA, Tatem HE & Hightower GM 1974, 'Characteristics of dispersions and water-soluble extracts of crude and refined oils and their toxicity to estuarine crustaceans and fish', Marine Biology, vol. 27, no. 1, pp. 75–88.

Anderson JW, Riley R, Kiesser S & Gurtisen J 1987, 'Toxicity of dispersed and undispersed Prudhoe Bay crude oil fractions to shrimp and fish', Proceedings of the 1987 International Oil Spill Conference, American Petroleum Institute, pp. 235–240.

Applied Science Associates (ASA) 2011, OILMAP-DEEP: Blowout Plume Model Technical Manual, Applied Science Associates Inc, South Kingstown, USA.

Asia-Pacific ASA 2010, 'Montara well release monitoring study S7.2 Oil fate and effects assessment: modelling of chemical dispersant operation', Prepared for PTTEP Australasia.

Australian Maritime Safety Authority (AMSA) 2014, 'Identification of oil on water: Aerial observations and identification guide', viewed 4 June 2020, https://www.amsa.gov.au/sites/default/files/2014-01-mp-amsa22-identification-oil-on-water.pdf

Australian Maritime Safety Authority (AMSA) 2015, 'Australian Maritime Safety Authority Technical Guideline for the Preparation of Marine Pollution Contingency Plans for Marine and Coastal Facilities Australian Maritime Safety Authority', viewed 20 June 2017, https://www.amsa.gov.au/forms-and-publications/Publications/AMSA413_Contingency_Planning_Guidelines.pdf

Australian and New Zealand Environment and Conservation Council (ANZECC) & Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) 2000, 'Australian and New Zealand guidelines for fresh and marine water quality Volume 1, The guidelines (National water quality management strategy; no.4)', Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand. Brandvik, PJ, Johansen, O, Leirvik, F, Farooq, U & Daling PS 2013, 'Droplet Breakup in subsurface oil releases – Part 1: Experimental study of droplet breakup and effectiveness of dispersant injection', Marine Pollution Bulletin, vol. 73, no. 1, pp 319–326.

Becker, JJ, Sandwell, DT, Smith, WHF, Braud, J, Binder, B, Depner, J, Fabre, D, Factor, J, Ingalls, S, Kim, S-H, Ladner, R, Marks, K, Nelson, S, Pharaoh, A, Trimmer, R, Von Rosenberg, J, Wallace, G & Weatherall, P 2009, 'Global bathymetry and evaluation data at 30 arc seconds resolution: SRTM30_PLUS', Marine Geodesy, vol. 32, no. 4, pp. 355–371.

Belore, UC 2014, 'Subsea chemical dispersant research', Proceedings of the 37th AMOP Technical Seminar on Environmental Contamination and Response, Environmental Canada, Canmore, Alberta, Canada pp. 618–650.

Blum DJ & Speece RE 1990, 'Determining chemical toxicity to aquatic species', Environmental Science & Technology, vol. 24, no. 3, pp. 284–293.

Bonn Agreement 2009, 'Bonn Agreement aerial operations handbook, 2009 - Publication of the Bonn Agreement', viewed 13 January 2015, http://www.bonnagreement.org/site/assets/files/3947/ba-aoh_revision_2_april_2012.pdf

Brandvik, PJ, Johansen, O, Farooq, U, Angell, G & Leirvik F 2014, 'Sub-surface oil releases – Experimental study of droplet distributions and different dispersant injection techniques- version 2', A scaled experimental approach using the SINTEF Tower basin. SINTEF report no: A25122. Trondheim Norway 2014. ISBN: 9788214057393

Carls, MG, Holland, L, Larsen, M, Collier, TK, Scholz, NL & Incardona, JP 2008, 'Fish embryos are damaged by dissolved PAHs, not oil particles', Aquatic Toxicology vol. 88, no. 2, pp.121–127.

Chassignet, EP, Hurlburt, HE, Smedstad, OM, Halliwell, GR, Hogan, PJ, Wallcraft, AJ, Baraille, R & Bleck, R 2007, 'The HYCOM (hybrid coordinate ocean model) data assimilative system', Journal of Marine Systems, vol. 65, no. 1, pp. 60–83.

Chassignet, E, Hurlburt, H, Metzger, E, Smedstad, O, Cummings, J & Halliwell, G 2009, ‘U.S. GODAE: Global Ocean Prediction with the HYbrid Coordinate Ocean Model (HYCOM)’, Oceanography, vol. 22, no. 2, pp. 64–75.

Davies, AM 1977a, ‘The numerical solutions of the three-dimensional hydrodynamic equations using a B-spline representation of the vertical current profile’, in JC Nihoul (ed), Bottom Turbulence: Proceedings of the 8th Liège Colloquium on Ocean Hydrodynamics, Elsevier Scientific, Amsterdam, pp. 1–25.

Davies, AM 1977b, ‘Three-dimensional model with depth-varying eddy viscosity’, in JC Nihoul (ed), Bottom Turbulence: Proceedings of the 8th Liège Colloquium on Ocean Hydrodynamics, Elsevier Scientific, Amsterdam, pp. 27–48.

French, D, Reed, M, Jayko, K, Feng, S, Rines, H, Pavignano, S, Isaji, T, Puckett, S, Keller, A, French III, FW, Gifford, D, McCue, J, Brown, G, MacDonald, E, Quirk, J, Natzke, S, Bishop, R, Welsh, M, Phillips, M & Ingram, BS 1996, ‘The CERCLA Type A natural resource damage assessment model for coastal and marine environments (NRDAM/CME), Technical Documentation, Volume I - Model Description, Final Report,’ Office of Environmental Policy and Compliance, U.S. Department of the Interior, Washington DC.

French, D, Schuttenberg, H & Isaji, T 1999, ‘Probabilities of oil exceeding thresholds of concern: examples from an evaluation for Florida Power and Light’, Proceedings of the 22nd Arctic and Marine Oil Spill Program (AMOP) Technical Seminar, Environment Canada, Alberta, pp. 243–270.

French-McCay, DP 2002, ‘Development and application of an oil toxicity and exposure model, OilToxEx’, Environmental Toxicology and Chemistry, vol. 21, no. 10, pp. 2080–2094.

French-McCay, DP 2003, ‘Development and application of damage assessment modelling: example assessment for the North Cape oil spill’, Marine Pollution Bulletin, vol. 47, no. 9, pp. 9–12.

French-McCay, DP 2004, ‘Spill impact modelling: development and validation’, Environmental Toxicology and Chemistry, vol. 23, no.10, pp. 2441–2456.

French-McCay, DP 2009, ‘State-of-the-art and research needs for oil spill impact assessment modelling’, Proceedings of the 32nd Arctic and Marine Oil Spill Program (AMOP) Technical Seminar, Environment Canada, Ottawa, pp. 601–653.

French-McCay, D, Rowe, JJ, Whittier, N, Sankaranarayanan, S, & Etkin, DS 2004, ‘Estimate of potential impacts and natural resource damages of oil’, Journal of Hazardous Materials, vol. 107, no. 1, pp. 11–25.

French-McCay, D, Whittier, N, Dalton, C, Rowe, J, Sankaranarayanan, S & Aurand, D 2005a, ‘Modeling the fates of hypothetical oil spills in Delaware, Florida, Texas, California, and Alaska waters, varying response options including use of dispersants’, Proceedings of the International Oil Spill Conference 2005, American Petroleum Institute, Washington DC, paper 399.

French-McCay, D, Whittier, N, Rowe, J, Sankaranarayanan, S, Kim, H-S & Aurand, D 2005b, ‘Use of probabilistic trajectory and impact modeling to assess consequences of oil spills with various response strategies,’ Proceedings of the 28th Arctic and Marine Oil Spill Program (AMOP) Technical Seminar, Environment Canada, Ottawa, pp. 253–271.

French-McCay, D, Reich, D, Rowe, J, Schroeder, M & Graham, E 2011, ‘Oil spill modeling input to the offshore environmental cost model (OECM) for US-BOEMRE's spill risk and costs evaluations’, Proceedings of the 34th Arctic and Marine Oil Spill Program (AMOP) Technical Siminar, Environment Canada, Ottawa.

French-McCay, D, Reich, D, Michel, J, Etkin, DS, Symons, L, Helton, D, & Wagner J 2012, ‘Oil spill consequence analysis of potentially-polluting shipwrecks’, Proceedings of the 35th Arctic and Marine Oil Spill Program (AMOP) Technical Seminar, Environment Canada, Ottawa.

French-McCay, D, Jayko, K, Li, Z, Horn, M, Kim, Y, Isaji, T, Crowley, D, Spaulding, M, Decker, L, Turner, C, Zamorski, S, Fontenault, J, Schmmkler, R & Rowe, J 2015, ’Technical Reports for Deepwater Horizon Water Column Injury Assessment: WC_TR.14: Modeling Oil Fate and Exposure Concentrations in the Deepwater Plume and Rising Oil Resulting from the Deepwater Horizon Oil Spill’ RPS ASA, South Kingston, Rhode Island.

Gordon, R 1982, ‘Wind driven circulation in Narragansett Bay’ PhD thesis, Department of Ocean Engineering, University of Rhode Island.

Grant, DL, Clarke, PJ & Allaway, WG 1993, ‘The response of grey mangrove (*Avicennia marina* (Forsk.) Vierh) seedlings to spills of crude oil,’ The Journal of Experimental Marine Biological Ecology, vol. 171, no. 2, pp. 273–295.

International Tankers Owners Pollution Federation (ITOPF) 2020, ‘Handbook 2020/21’, International Tankers Owners Pollution Federation Ltd, UK.

Isaji, T & Spaulding, M 1984, ‘A model of the tidally induced residual circulation in the Gulf of Maine and Georges Bank’, Journal of Physical Oceanography, vol. 14, no. 6, pp. 1119–1126.

Isaji, T, Howlett, E, Dalton C, & Anderson, E 2001, ‘Stepwise-continuous-variable-rectangular grid hydrodynamics model’, Proceedings of the 24th Arctic and Marine Oil spill Program (AMOP) Technical Seminar (including 18th TSOCS and 3rd PHYTO), Environment Canada, Edmonton, pp. 597–610.

Jones, ISF 1980, ‘Tidal and wind driven currents in Bass Strait’, Australian Journal of Marine and Freshwater Research vol. 31, no. 2, pp. 109–117.

Koops, W, Jak, RG & van der Veen, DPC 2004, ‘Use of dispersants in oil spill response to minimise environmental damage to birds and aquatic organisms’, Proceedings of the Interspill 2004: Conference and Exhibition on Oil Spill Technology, Trondheim, presentation 429.

Kostianoy, AG, Ginzburg, AI, Lebedev, SA, Frankignoulle, M & Delille, B 2003, ‘Fronts and mesoscale variability in the southern Indian Ocean as inferred from the TOPEX/POSEIDON and ERS-2 Altimetry data’, Oceanology, vol. 43, no. 5, pp. 632–642.

Levitus, S, Antonov, JI, Baranova, OK, Boyer, TP, Coleman, CL, Garcia, HE, Grodsky, AI, Johnson, DR, Locarnini, RA, Mishonov, AV, Reagan, JR, Sazama, CL, Seidov, D, Smolyar, I, Yarosh, ES & Zweng, MM 2013, ‘The World Ocean Database’, Data Science Journal, vol.12, no. 0, pp. WDS229–WDS234.

Li, Z, Spaulding, M, French-McCay, D, Crowley, D & Payne JR 2017, ‘Development of a unified oil droplet size distribution model with application to surface breaking waves and subsea blowout releases considering dispersant effects’, Marine Pollution Bulletin, vol. 114, no. 1, pp 247–257.

Lin, Q & Mendelssohn, IA 1996, ‘A comparative investigation of the effects of south Louisiana crude oil on the vegetation of fresh, brackish and Salt Marshes’, Marine Pollution Bulletin, vol. 32, no. 2, pp. 202–209.

Ludicone, D, Santoleri, R, Marullo, S & Gerosa, P 1998, ‘Sea level variability and surface eddy statistics in the Mediterranean Sea from TOPEX/POSEIDON data’, Journal of Geophysical Research, vol. 103, no. C2, pp. 2995–3011.

Malins DC & Hodgins HO 1981, ‘Petroleum and marine fishes: a review of uptake, disposition, and effects’, Environmental Science & Technology, vol. 15, no. 11, pp.1272–1280.

Matsumoto, K, Takanezawa, T & Ooe, M 2000, ‘Ocean tide models developed by assimilating TOPEX/POSEIDON altimeter data into hydrodynamical model: A global model and a regional model around Japan’, Journal of Oceanography, vol. 56, no.5, pp. 567–581.

McAuliffe CD 1987, ‘Organism exposure to volatile/soluble hydrocarbons from crude oil spills – a field and laboratory comparison’, Proceedings of the 1987 International Oil Spill Conference, American Petroleum Institute, pp. 275–288.

McCarty LS 1986, ‘The relationship between aquatic toxicity QSARs and bioconcentration for some organic chemicals’, Environmental Toxicology and Chemistry, vol. 5, no. 12, pp. 1071–1080.

McCarty LS, Dixon DG, MacKay D, Smith AD & Ozburn GW 1992a, ‘Residue-based interpretation of toxicity and bioconcentration QSARs from aquatic bioassays: Neutral narcotic organics’, Environmental Toxicology and Chemistry, vol. 11, no. 7, pp.917–930.

McCarty LP, Flannagan DC, Randall SA & Johnson KA 1992b, ‘Acute toxicity in rats of chlorinated hydrocarbons given via the intratracheal route’, Human & Experimental Toxicology, vol. 11, no. 3, pp.173–117.

McCarty LS & Mackay D 1993, ‘Enhancing ecotoxicological modelling and assessment. Body residues and modes of toxic action’, Environmental Science & Technology, vol. 27, no. 9, pp. 1718–1728.

McGrath JA, & Di Toro DM 2009, ‘Validation of the target lipid model for toxicity assessment of residual petroleum constituents: monocyclic and polycyclic aromatic hydrocarbons’, Environmental Toxicology and Chemistry, vol. 28, no. 6, pp. 1130–1148.

Middleton, JF & Bye AT 2007, ‘A review of shelf-slope circulation along Australia’s southern shelves: Cape Leeuwin to Portland’, Progress in Oceanography vol. 75, pp. 1–41.

National Centers for Environmental Information (NCEI) 2021, ‘World Ocean Atlas’ viewed 20 July 2021, https://www.ncei.noaa.gov/products/world-ocean-atlas

National Oceanic and Atmospheric Administration (NOAA) 2013, Screening level risk assessment package Gulf state, Office of National Marine Sanctuaries & Office of Response and Restoration, Washington DC.

National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) 2018, ‘At a glance: Oil spill modelling’, viewed 15 November 2018, https://www.nopsema.gov.au/assets/Publications/A626200.pdf

National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) 2019, ‘Environment bulletin: Oil spill modelling’, viewed 4 February 2020, https://www.nopsema.gov.au/assets/Bulletins/A652993.pdf

National Research Council (NRC) 2003, ‘Oil in the sea III: Inputs, fates and effects’, National Research Council, The National Academic Press, Washington DC.

National Research Council (NRC) 2005, ‘Oil Spill Dispersants Efficacy and Effects. Committee on Oil Spill Dispersants: Efficacy and Effects’, National Research Council, The National Academies Press, Washington DC.

Neff JM & Anderson JW 1981, ‘Response of marine animals to petroleum and specific petroleum hydrocarbons’ United States Department of Energy, United States.

Nirmalakhandan N & Speece RE 1988, ‘Quantitative techniques for predicting the behaviour of chemicals in the ecosystem’, Environmental Science & Technology, vol. 22, no. 6, pp. 606–615.

Nordtug, T., Olsen, A.J., Altin, D., Overrein, I., Storøy, W., Hansen, B.H. and De Laender, F., 2011. Oil droplets do not affect assimilation and survival probability of first feeding larvae of North-East Arctic cod. Science of the Total Environment, 412, pp.148–153.

Oil Spill Solutions 2015, ‘Evaluation - The Theory of Oil Slick Appearances’, viewed 6 January 2015, http://www.oilspillsolutions.org/evaluation.htm

Owen, A 1980, ‘A three-dimensional model of the Bristol Channel’, Journal of Physical Oceanography, vol. 10, pp. 1290–1302.

Qiu, B & Chen, S 2010, ‘Eddy-mean flow interaction in the decadally modulating Kuroshio Extension system’, Deep-Sea Research II, vol. 57, no. 13, pp. 1098–1110.

Redman AD 2015, ‘Role of entrained droplet oil on the bioavailability of petroleum substances in aqueous exposures’, Marine Pollution Bulletin, vol. 97, no. 1–2, pp. 342–348.

Saha, S, Moorthi, S, Pan, H-L, Wu, X, Wang, J & Nadiga, S 2010, ‘The NCEP Climate Forecast System Reanalysis’, Bulletin of the American Meteorological Society, vol. 91, no. 8, pp. 1015–1057.

Sandery, P & Kämpf, J 2007, ‘Transport timescales for identifying seasonal variation in Bass Strait, south-eastern Australia’, Estuarine, Coastal and Shelf Science, vol. 74, no. 4, pp. 684-696.

Scholten, MCTh, Kaag, NHBM, Dokkum, HP van, Jak, R.G., Schobben, HPM & Slob, W 1996, Toxische effecten van olie in het aquatische milieu, TNO report TNO-MEP – R96/230, Den Helder.

Spaulding, ML, Kolluru, VS, Anderson, E & Howlett, E 1994, ‘Application of three-dimensional oil spill model (WOSM/OILMAP) to hindcast the Braer Spill’, Spill Science and Technology Bulletin, vol. 1, no. 1, pp. 23–35.

Spaulding, ML, Bishnoi, PR, Anderson, E & Isaji, T 2000, ‘An integrated model for prediction of oil transport from a deep water blowout’, Proceedings of the 23rd Arctic and Marine Oilspill Program (AMOP) Technical Seminar, Environment Canada, Vancouver, BC, pp. 2611–2635.

Spaulding, ML, Mendelsohn, D, Crowley, D, Li, Z, and Bird A, 2015. Technical Reports for Deepwater Horizon Water Column Injury Assessment- WC_TR.13: Application of OILMAP DEEP to the Deepwater Horizon Blowout. RPS APASA, 55 Village Square Drive, South Kingstown, RE 02879.

Suprayogi, B & Murray, F 1999, ‘A field experiment of the physical and chemical effects of two oils on mangroves’, Environmental and Experimental Botany, vol. 42, no. 3, pp. 221–229.

Swartz RC, Schults DW, Ozretich RJ, Lamberson JO, Cole FA, Ferraro SP, Dewitt TH & Redmond MS 1995, ‘ΣPAH: A Model to predict the toxicity of polynuclear aromatic hydrocarbon mixtures in field-collected sediments’, Environmental Toxicology and Chemistry, vol. 14, no. 11, pp. 1977–1187.

Verhaar, HJ, Van Leeuwen, CJ & Hermens, JL 1992, ‘Classifying environmental pollutants’, Chemosphere, vol. 25, no. 4, pp. 471-491.

Verhaar, HJ, de Wolf, W, Dyer, S, Legierse, KC, Seinen, W & Hermens, JL 1999, ‘An LC_{50} vs time model for the aquatic toxicity of reactive and receptor-mediated compounds. Consequences for bioconcentration kinetics and risk assessment’, Environmental Science & Technology, vol. 33, no. 5, pp.758–763.

Willmott, CJ 1981, ‘On the validation of models’, Physical Geography, vol. 2, no. 2, pp.184–194.

Willmott, CJ 1982, ‘Some comments on the evaluation of model performance’, Bulletin of the American Meteorological Society, vol. 63, no. 11, pp.1309–1313.

Willmott CJ, Ackleson SG, Davis RE, Feddema JJ, Klink, KM, Legates, DR, O’Donnell, J & Rowe, CM 1985, ‘Statistics for the evaluation of model performance’, Journal of Geophysical Research, vol. I 90, no. C5, pp. 8995–9005.

Willmott, CJ & Matsuura, K 2005, ‘Advantages of the mean absolute error (MAE) over the root mean square error (RMSE) in assessing average model performance’, Journal of Climate Research, vol. 30, no. 1, pp. 79–82.

Yaremchuk, M & Tangdong, Q 2004, ‘Seasonal variability of the large-scale currents near the coast of the Philippines’, Journal of Physical Oceanography, vol. 34, no., 4, pp. 844–855.

Zigic, S, Zapata, M, Isaji, T, King, B, & Lemckert, C 2003, ‘Modelling of Moreton Bay using an ocean/coastal circulation model’, Proceedings of the 16th Australasian Coastal and Ocean Engineering Conference, the 9th Australasian Port and Harbour Conference and the Annual New Zealand Coastal Society Conference, Institution of Engineers Australia, Auckland, paper 170.

Appendix N: Stakeholder Consultation Information Sheets

Offshore Gas Victoria Project

Drilling Activities

Drilling activities | July 2023

Project overview

Beach Energy supplies the ongoing natural gas needs of Victorian homes, business and industry, through production at the Otway Gas Plant near Port Campbell and the Lang Lang Gas Plant, 80kms south-east of Melbourne CBD.

Beach is continuing its commitment to supply natural gas to the east coast domestic market and has commenced planning for the *Offshore Gas Victoria* (OGV) Project to deliver the next phases of exploration and development in the Otway and Bass projects.

The OGV Project is considering a range of activity across several phases. Confirmation of project timings and scope is subject to internal and external project approvals, confirmation of contractor vessels and rig availability

This information sheet focuses on drilling activities.

Seabed Assessments

Assessment of suitable locations for drill rig and new seabed infrastructure to connect wells

earliest start Jan 24

Removal of Wells

Removal of five suspended wells through a formal procedure called ‘plug and abandonment’

earliest start Jan 2025

Drilling of Wells

Up to eleven exploration / appraisal wells

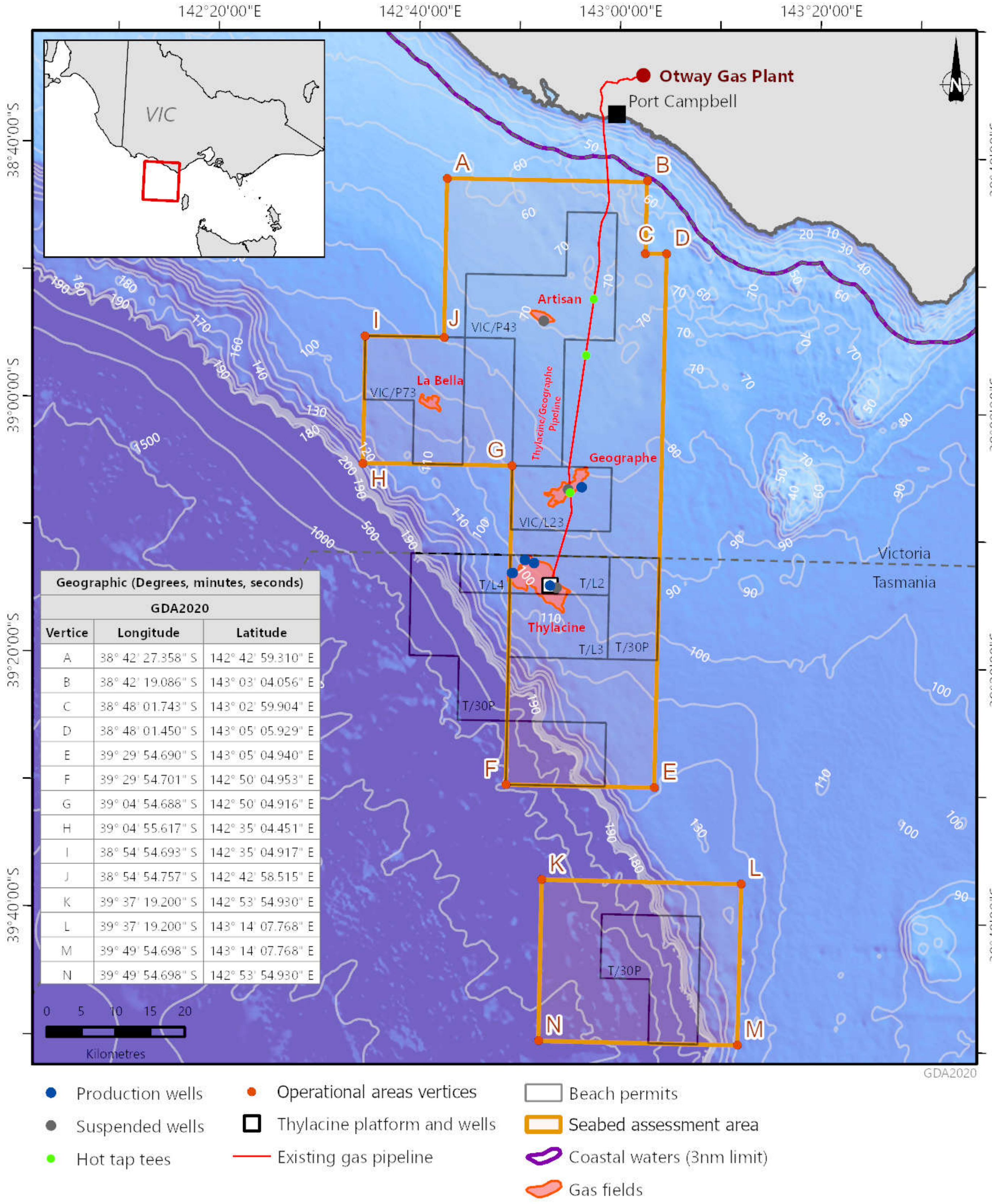
earliest start Feb 2025

Completing & Connecting of Wells

Completing successful wells, installing infrastructure, and connecting wells to existing pipelines

earliest start mid-2025

Otway Basin



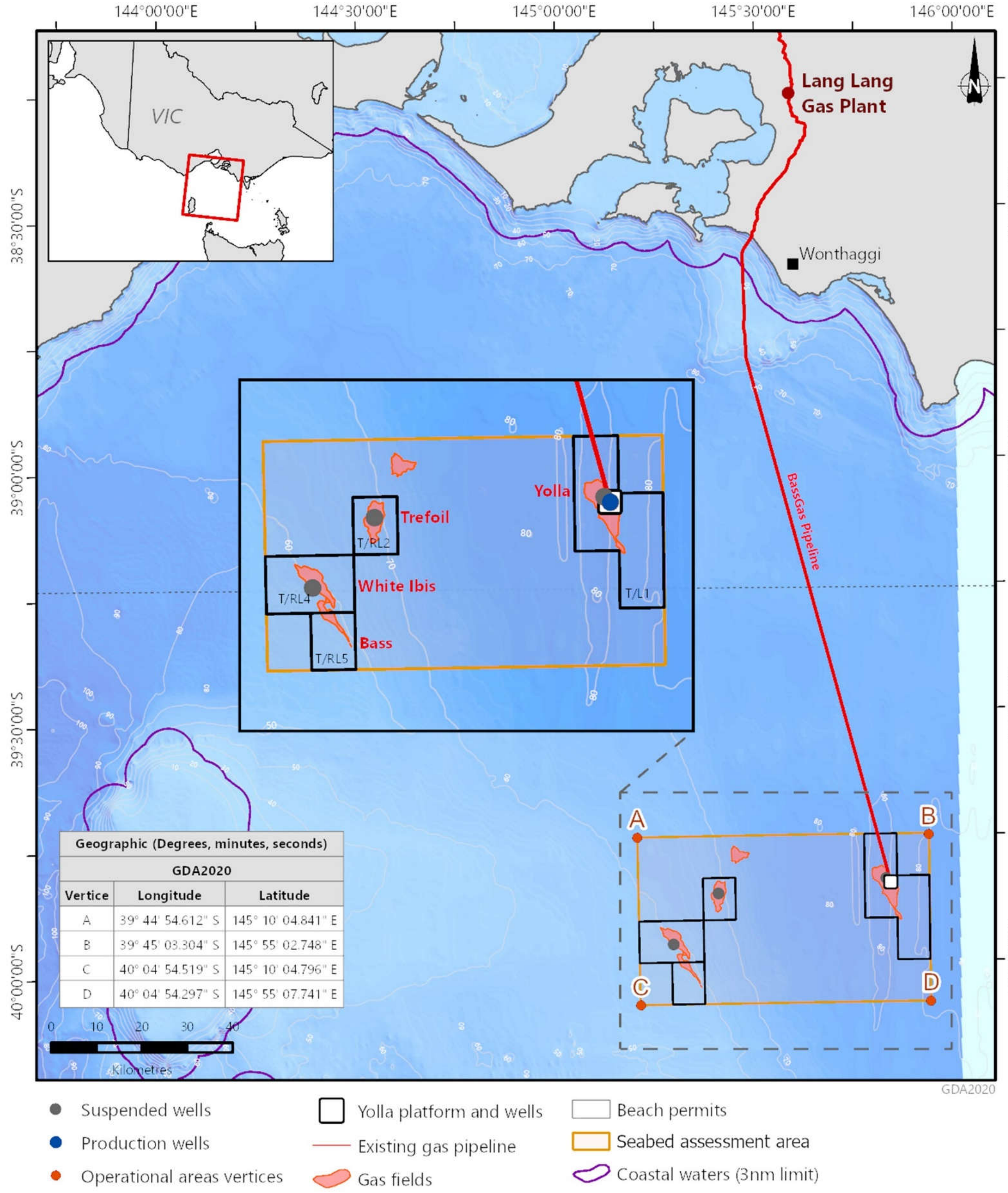
Geographic (Degrees, minutes, seconds)		
GDA2020		
Vertice	Longitude	Latitude
A	38° 42' 27.358" S	142° 42' 59.310" E
B	38° 42' 19.086" S	143° 03' 04.056" E
C	38° 48' 01.743" S	143° 02' 59.904" E
D	38° 48' 01.450" S	143° 05' 05.929" E
E	39° 29' 54.690" S	143° 05' 04.940" E
F	39° 29' 54.701" S	142° 50' 04.953" E
G	39° 04' 54.688" S	142° 50' 04.916" E
H	39° 04' 55.617" S	142° 35' 04.451" E
I	38° 54' 54.693" S	142° 35' 04.917" E
J	38° 54' 54.757" S	142° 42' 58.515" E
K	39° 37' 19.200" S	142° 53' 54.930" E
L	39° 37' 19.200" S	143° 14' 07.768" E
M	39° 49' 54.698" S	143° 14' 07.768" E
N	39° 49' 54.698" S	142° 53' 54.930" E

25/05/2023

The locations on this map are accurate at the time of publication and are subject to change

OT23-0015C

Bass Basin



Geographic (Degrees, minutes, seconds)		
GDA2020		
Vertice	Longitude	Latitude
A	39° 44' 54.612" S	145° 10' 04.841" E
B	39° 45' 03.304" S	145° 55' 02.748" E
C	40° 04' 54.519" S	145° 10' 04.796" E
D	40° 04' 54.297" S	145° 55' 07.741" E

31/05/2023

The locations on this map are accurate at the time of publication and are subject to change

OT23-0015D

Offshore Drilling

The OGV Project is a continuation of Beach's previous Phase 4 and 5 projects and may contain up to 11 wells to be drilled over approximately two years. Beach's program of work has been optimised in well design and equipment so that exploration wells can be completed where successful or 'plugged and abandoned (P&A) where unsuccessful.

Part of the drilling program is the re-entry and completion of the Artisan exploration which was drilled in March 2021.

The drilling program is subject to regulatory approval and rig availability and is not expected to commence until at least mid-2024.

Three different types of wells are proposed as part of the drilling program:

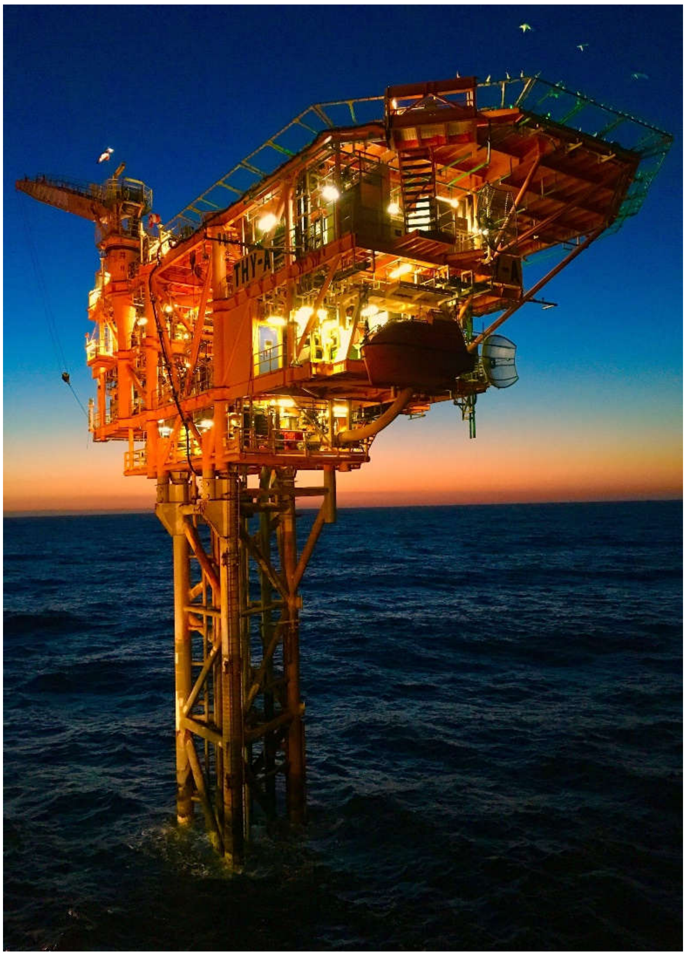
- An **exploration well** is a well drilled to establish the existence of a possible hydrocarbon accumulation in an unproven area. Location of exploration wells typically driven by results of previous seismic surveys that show geological features that strongly indicate the potential for hydrocarbons. Prior to drilling there is a large degree of uncertainty as to whether commercial quantities of hydrocarbon exist.
- **Appraisal wells** are typically drilled once a hydrocarbon accumulation has been discovered by an exploration well. The purpose of appraisal wells is to establish the extent and size of the hydrocarbon accumulation as well as the characteristics of the reservoir. The design, planning and construction of appraisal wells are usually identical to exploration wells.
- A **production well** that has successfully reached a proven reserve and will be tied into seabed infrastructure to supply raw gas for processing.

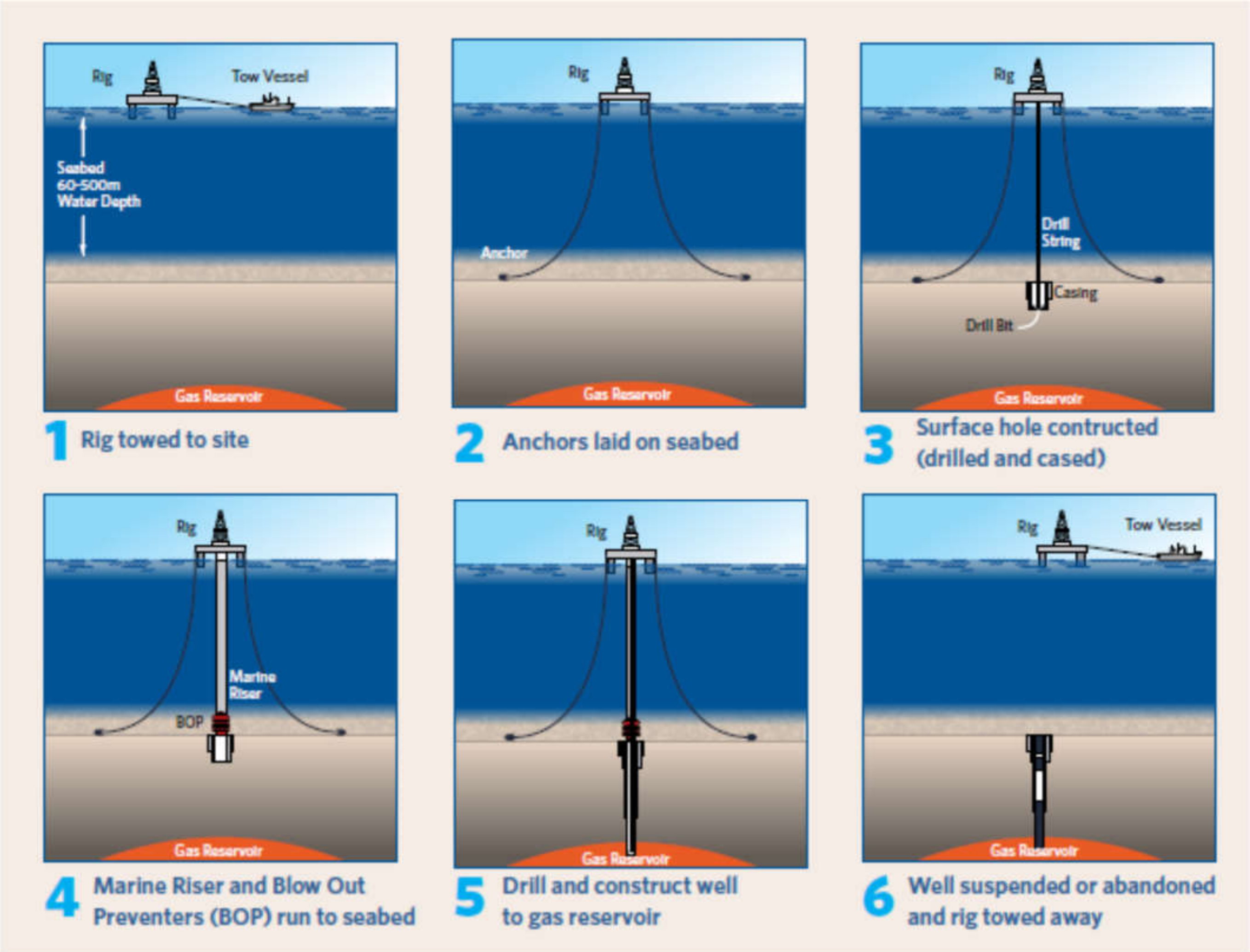
Approach and equipment

Beach will contract a semi-submersible drill rig for the OGV project.

The approach to drilling is summarised in the following steps.

- Using an approved shipping route, tow vessels will manoeuvre the drilling rig into place
- Anchors will be pre-laid by specialist anchor handling vessels and the rig will be anchored at sites determined as suitable by the seabed assessments
- A surface hole will be drilled and cased, then a marine riser and Blow-out Preventer (BOP) installed
- The well will be drilled to reach the gas reservoir beneath the seabed
- The rig will be moved from one well to the next, repeating the anchoring and drilling process
- After all wells are completed, the drilling rig will be towed to an agreed demobilisation point
- Production wells will be completed with a wellhead remaining above the seabed ready for connection to the existing pipeline
- Exploration wells may be completed, suspended for future completion, or formally abandoned (dry hole).





An outline of the drilling process that will be used in the offshore Otway Basin drilling program

Drilling Methodology

Beach will use a typical semi-submersible drilling rig commonly used in Australian waters. It can operate in waters up to 3,000m deep, drill for gas at up to 10,000m deep and accommodate around 150 crew.

Once the drilling rig is in position and anchored at the well site, a surface hole will be drilled and cased, followed by installation of a marine riser and BOP. Weighing approximately 244 tonnes and measuring 14 m high, the BOP is a highly specialised valve unit used in all offshore drilling. The BOP is used to shut-in and seal off a well for planned operations such as pressure testing and in the event of a pressure build up or ‘kick’. It ensures well integrity throughout the drilling process, ongoing safety of personnel and prevention of any environmental incidents.

The drilling process will typically have 4-5 stages, starting with a 42-inch drill head. Drilling will then reduce in diameter to consecutively smaller sizes until it reaches the end target depth. For each section, a casing (steel pipe) will be placed in the hole and cemented, then a smaller drill will be run through the casing to drill a smaller hole to the next target depth and the process repeated to reach the final target.

Drilling muds

Offshore drilling operations typically use both water based, and synthetic based fluids called ‘muds’ to lubricate and stabilise the wellbores in each section and remove drilling cuttings. Drill cuttings are rock chips from the sedimentary layers that emerge from the drilling process and will range from very fine to coarse in size.

Water based mud will be used in the upper and lower parts of the well to remove the cuttings. Water based muds are recycled as much as possible during the drilling process. Cuttings will not require any treatment and will be deposited onto the seabed.

Synthetic based muds are not planned to be used. Typically, synthetic based muds will require treatment to recover the fluid from the cuttings. The cuttings will be processed on the drilling rig before they are discharged overboard, where they will settle rapidly on the seafloor around the well site. The cuttings will contain small levels of base fluid, which will quickly biodegrade. This is standard industry practice in Australia.

Marine mammals and fish may transit through these areas but will usually avoid the temporary disturbance. Any exposure to suspended sediment before it settles on the seabed will be highly localised and temporary due to high dilution and fast dispersal in the water column.

Production well connections

When the production wells have been completed, they will be ready to connect to seabed infrastructure and the existing offshore to onshore pipeline.

Some seabed infrastructure for tying in the new wells is already in place and connected to the existing pipelines. Additional infrastructure for any new production wells will also be installed to tie-in to the existing pipeline. New infrastructure will include:

- An Artisan Diving Integration Skid (ADIS) will be installed and connected to the Hot Tap Tee X location on the Otway Gas Production Pipeline at KP33.9
- The A-SVS (Artisan Subsea Valve Skid) will be installed next to and connected to the ADIS
- Flowlines and umbilicals will connect the production wells to the existing A-SVS
- The umbilicals and flying leads will enable remote monitoring and control of the production wells from the Otway Gas Plant via the Thylacine Platform.
- Concrete mattresses will be installed over the flowlines and/or umbilicals for stabilisation and protection as required

A subsea construction support vessel equipped with 2 work-class WROV will install the subsea equipment and pre-commission the production wells after connection. Only the ADIS will be installed using divers from a dive support vessel.

Exploration well completions

Successful exploration wells will either be suspended for future completions, by placing a standard wellhead of around one to two metres in height from the seabed or completed. Positions of wellheads will be notified to the AHO and recorded on nautical charts.

If a well is commercially unviable due to limited gas prospectivity, multiple cement plugs will be installed within the well to permanently seal the well and isolate it from formations. A cement plug will be installed at the seabed and all casings will be cut at least 2 m below the mudline to ensure that the seabed is returned to the same condition prior to drilling (P&A).

Questions and Answers

How long will drilling take?

Each exploration well will take between 35 to 55 days and each production well, between 70 to 90 days. Each P&A well will take approximately 15 days. The entire drilling program can take up to 24 months. Drilling will commence no earlier than mid-2024 and will continue to approximately the end of 2026. Timings will depend on final project planning, regulatory approvals, and fair sea states.

How is the drilling rig secured?

Once the drilling rig has been towed to the well site, supported by an 'anchor handling vessel', the tugboats will run out eight to twelve anchoring lines which may extend to a kilometre and a half. Specifically designed marine anchors, around 15 – 20 tonnes each, will be used to moor the drilling rig. Positioning of the anchors will be determined by a mooring analysis, based on the results of the seabed site assessment and year-round weather data for the area.

Will the drilling rig be visible from land?

The drilling rig at the Artisan well location (Beach previous Phase 4 project) was visible from some shore locations. However, given the distance from the shore of the OGV wells from Artisan and the shore, the drilling rig and support vessels will have low visibility from onshore and may appear similar to other shipping activity.

How many people will work on the drilling rig?

There will be around 150 personnel onboard the drilling rig at any one time. The crew will be transported to and from the rig via helicopter.

How is safety managed on the drilling rig?

At Beach, safety is our first priority. Offshore drilling activities are highly regulated to stringent safety standards. All drilling rig operations will be managed in accordance with the dedicated Safety Case for the drilling rig, to be accepted by the regulator NOPSEMA. For more information see: https://www.nopsema.gov.au/safety/safety-case/

How will Beach manage maritime safety?

The support vessels involved in the activities will operate in accordance with Australian maritime standards and ensure safe operations by:

- Having operational and navigation lighting on all vessels
- Maintaining a 24-hour shipping radar watch
- Monitoring and managing safety and exclusion zones

What will happen to any discharges from the borehole drilling?

Seawater and/or bentonite will be used to lubricate the drill bit and stabilise the borehole, as well as remove seabed material produced through drilling, called cuttings. As the fluids and cuttings come out of the borehole they will be deposited onto the seabed. Bentonite is an inert material that is classed as posing little or no risk to the environment.

Will an exclusion zone exist?

The work will occur among commercial shipping routes and designated Commonwealth and State fisheries. There will be a 2-3 km radius cautionary zone around the drilling rig for avoidance of mooring chains and anchors. There will also be a temporary PSZ in place, which is a safety exclusion zone of 500 m around the drilling rig for each well (new wells or P&A well) location while the rig on location. Formal safety exclusion zones will be communicated via a ‘Notice to Mariners’ by the AHO. The PSZs will be monitored by support vessels once the drilling rig is anchored into position.

PSZs of approximately 13.5 km^2 already exist for the Thylacine and Yolla platforms, existing wells and infrastructure. New PSZs not exceeding 500m radius will be created for new production well locations and the ADIS structure next to the Otway Gas Production Pipeline.

What about impacts on commercial fishing?

The Project is located within existing designated Commonwealth and State fisheries. Each fishery covers a vast area, whereas the drilling and installation activities require access to relatively small areas. Beach will complete seabed assessments before any drilling activities can commence. Beach will engage closely with the commercial fishing industry to identify any commercial fishers that may operate in the area and to assess any potential impacts. Beach will provide regular updates on its operations to fishing associations throughout the duration of the activities.

Beach has a *Fair Ocean Access* procedure which sets out Beach’s commitment to consultation, minimising impacts of its activities, the circumstances in which a fisher may claim compensation, the evidence required and the claim process.

Will the activities affect whales and dolphins?

Vessels within the permit area will move slowly. Each vessel will have a trained marine mammal observer whose specific task is to notify the vessel master of any whale or dolphin and advise them of suitable protocols to avoid potential impact. Avoidance of whales and dolphins will be undertaken in accordance with the Environment Protection and Biodiversity Conservation (EPBC) Regulations (2000), including adherence to required speed and distances. All whale sightings will be recorded along with the actions taken to avoid potential impacts.

Will the drilling impact shipwrecks?

The drilling program will not impact any known shipwrecks. Prior to any drilling commencing, the completed seabed assessments ensure a detailed understanding of the marine environment of each well site. Any new information discovered from these assessments, such as the presence of shipwrecks, will be reported to relevant authorities.

What is ALARP?

ALARP stands for “As Low As Reasonably Practicable”. It is an assessment principle commonly used in the oil and gas industry to assess and reduce potential impacts and risks that cannot be completely eliminated. For information on how NOPSEMA assesses ALARP see: ALARP Guidance Note (nopsema.gov.au)

Consultation and Feedback

Consultation and feedback is an important part of developing Environmental Plans and Offshore Project Proposals.

This information sheet has been prepared to provide a summary of proposed activities and commence consultation with relevant persons whose functions, interests or activities may be affected by the activities to be carried out under the environment plan.

Please contact us if you would like further information or to consult with us about how this project may impact your functions, interests or activities.each will consider all feedback, including any concerns or objections and will explore measures to reduce any impacts and risks.

Relevant persons may request that the information they provide not be published, and it will be identified as sensitive information and not published in the EP.

If there is someone you believe may be affected by the proposed activities, please have them contact us.

P: 1800 797011

E: community@beachenergy.com.au

beachenergy.com

Offshore Gas Victoria Project

Program Summary

Information Sheet | September 2023

Project Overview

Beach Energy supplies the ongoing natural gas needs of Victorian homes, business and industry, through production at the Otway Gas Plant near Port Campbell and the Lang Lang Gas Plant, 80kms south-east of Melbourne CBD.

As part of the most recent phase of development of the Otway Basin, Beach successfully drilled one exploration well and six production wells in offshore Commonwealth permits over the past four years. Four production wells have been connected and are now producing gas for the east coast market, with the two remaining wells still to be connected.

Beach is continuing its commitment to supply natural gas to the east coast domestic market and has commenced planning for the *Offshore Gas Victoria* (OGV) Project to deliver the next phases of exploration and development in the Otway and Bass projects (see maps).

The OGV Project is considering a range of activity across several phases (summarised below). Confirmation of project timings and number of wells to be drilled is subject to internal and external project approvals, confirmation of contractor vessels and drill rig availability.

Environment protection regulations

The National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA), regulates activities in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations (2009)* (Environment Regulations). The OGV Project will require Environment Plans to be accepted by NOPSEMA before commencement of activities.

Environment Plans must include a description of the existing environment and the proposed activities, an evaluation of the impacts and risks, environmental performance outcomes and controls, implementation strategy, and reporting requirements. They must also demonstrate that consultations with persons or organisations whose functions, interests and activities may be affected by the activities in the Environment Plan ("*relevant persons*"), have been carried out in accordance with the regulations.

For successful gas discoveries that will proceed to development, an Offshore Project Proposal (OPP) will be required and will undergo a public consultation phase. Once an OPP is accepted, further Environment Plans will be required for construction activities and commissioning the new wells.

Seabed Assessments →

Assessment of suitable locations for drill rig and new seabed infrastructure to connect wells

earliest start Jan 24

Removal of Wells ↔

Removal of five suspended wells through a formal procedure called 'plug and abandonment'

earliest start mid-2024

Drilling of Wells →

Up to eleven exploration / appraisal wells

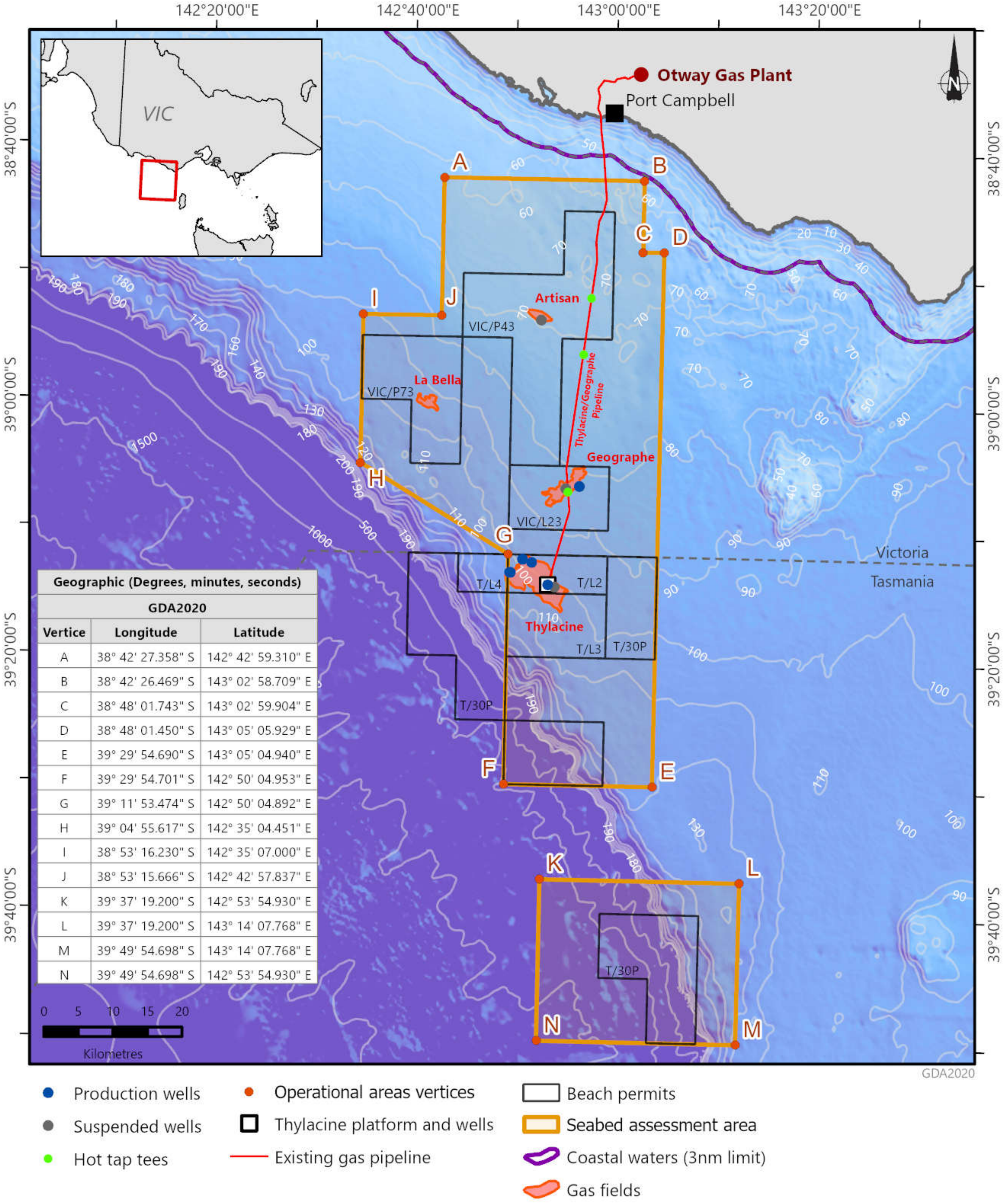
earliest start mid-2024

Completing & Connecting of Wells

Completing successful wells, installing infrastructure, and connecting wells to existing pipelines

earliest start mid-2025

Otway Basin



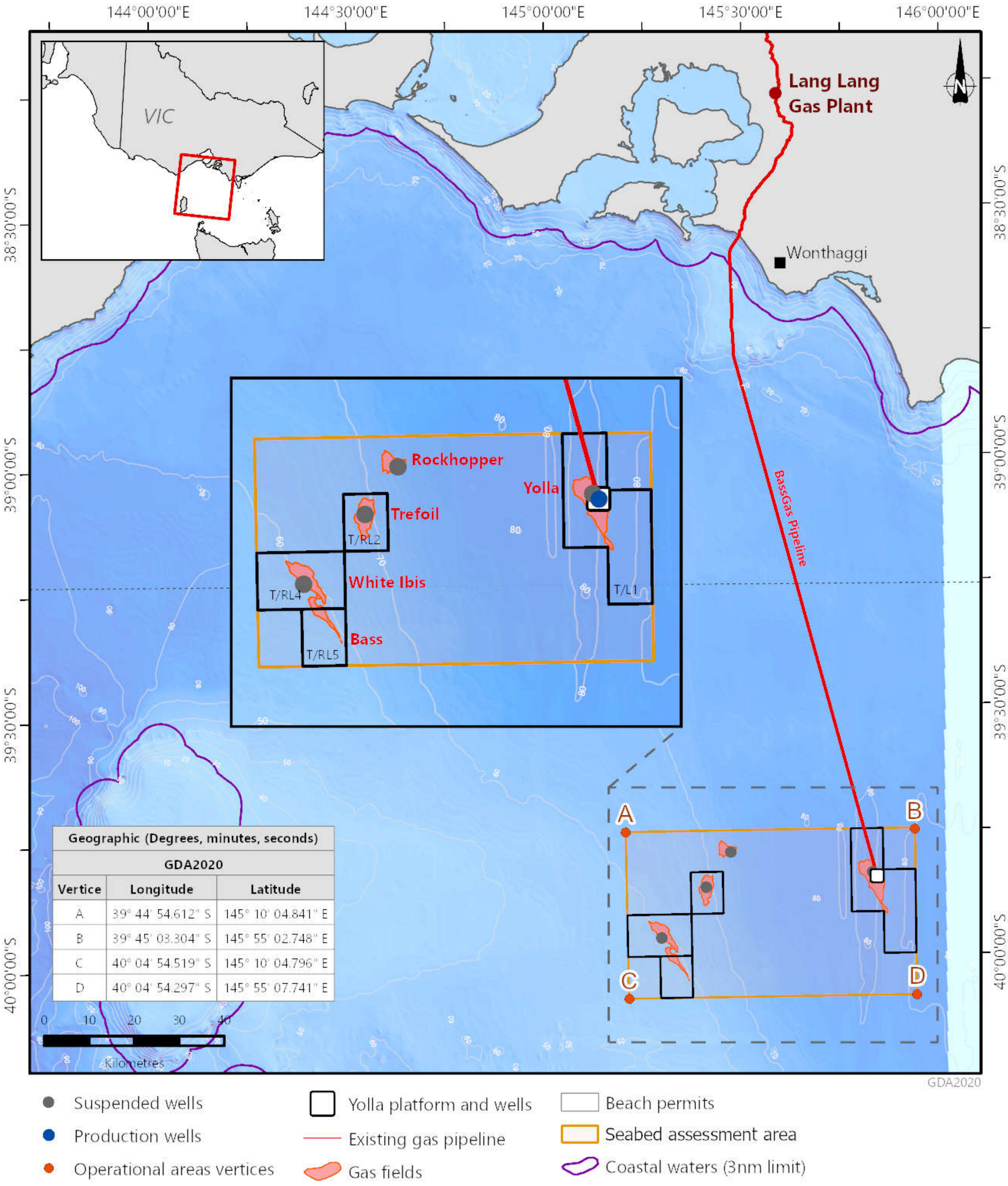
Geographic (Degrees, minutes, seconds)		
GDA2020		
Vertice	Longitude	Latitude
A	38° 42' 27.358" S	142° 42' 59.310" E
B	38° 42' 26.469" S	143° 02' 58.709" E
C	38° 48' 01.743" S	143° 02' 59.904" E
D	38° 48' 01.450" S	143° 05' 05.929" E
E	39° 29' 54.690" S	143° 05' 04.940" E
F	39° 29' 54.701" S	142° 50' 04.953" E
G	39° 11' 53.474" S	142° 50' 04.892" E
H	39° 04' 55.617" S	142° 35' 04.451" E
I	38° 53' 16.230" S	142° 35' 07.000" E
J	38° 53' 15.666" S	142° 42' 57.837" E
K	39° 37' 19.200" S	142° 53' 54.930" E
L	39° 37' 19.200" S	143° 14' 07.768" E
M	39° 49' 54.698" S	143° 14' 07.768" E
N	39° 49' 54.698" S	142° 53' 54.930" E

21/08/2023

The locations on this map are accurate at the time of publication and are subject to change

OT23-0015E

Bass Basin



Geographic (Degrees, minutes, seconds)		
GDA2020		
Vertice	Longitude	Latitude
A	39° 44' 54.612" S	145° 10' 04.841" E
B	39° 45' 03.304" S	145° 55' 02.748" E
C	40° 04' 54.519" S	145° 10' 04.796" E
D	40° 04' 54.297" S	145° 55' 07.741" E

25/05/2023

The locations on this map are accurate at the time of publication and are subject to change

OT23-0015D

Questions and Answers

What's Beach's approach to climate change?

Beach recognises that climate change is one of the global challenges of this century and understands the role we must play in managing our carbon emissions.

Beach has an aspiration to reach net zero Scope 1 and 2 emissions by 2050 and a target to reduce emissions intensity by 35% from its entire portfolio by 2030. See further information in Beach's Sustainability Report.

What role is natural gas playing as Australia transitions to renewable energy?

Carbon emissions of natural gas are significantly lower than coal. As old coal fired power stations are removed from Australia's energy mix, electricity powered from natural gas ensures a stable energy supply as our economy transitions to a different mix of energy sources for electricity generation.

The Australian Energy Market Operator (AEMO | 2022 Integrated System Plan (ISP) has forecast more gas-fired generation is required to reach Net Zero by 2050. In its "Step Change" scenario which achieves that objective, 40% more gas-fired generation capacity is required to enable energy from wind and solar to increase nine-fold, and battery storage to increase by a factor of 30.

Beach is committed to reducing emissions from its operations and has targets that are consistent with the changes to the Safeguard Mechanism, introduced from 1 July 2023.

Why do we still need natural gas?

Natural gas has a wide variety of uses in our daily lives. These include generating electricity, residential heating, hot water and cooking. In the industrial sector, gas is a primary heat source for manufacturing glass, steel, cement, bricks, wood, ceramics, tiles, paper and in producing food. Gas is a common ingredient in the manufacturing of fertilisers, plastics, pharmaceuticals and fabrics. The Australian Energy Market Operator's latest Victorian Gas Planning Report in March 2022 forecasts demand shortfall risks as soon as 2023.

Is Beach Energy increasing retail gas prices?

No. Beach Energy is a gas wholesaler and supplies the majority of its gas under contract to energy retailers in Australia. Beach does not set retail prices.

Is Beach exporting gas from the Otway and Bass basins? No. Beach does not export gas from the Otway or Bass basins. The gas processed at the Otway Gas Plant and Lang Lang Gas Plant in Victoria is supplied to the local gas market via an existing pipeline to meet residential, business and industry demand

Consultation and Feedback

Consultation and feedback is an important part of developing Environmental Plans and Offshore Project Proposals.

This information sheet has been prepared to provide a summary of proposed activities and commence consultation with relevant persons whose functions, interests or activities may be affected by the activities to be carried out under the Environment Plan.

Please contact us if you would like further information or to consult with us about how this project may impact your functions, interests or activities.

Beach will consider all feedback, including any concerns or objections and will explore measures to reduce any impacts and risks.

Relevant persons may request that the information they provide not be published, and it will be identified as sensitive information and not published in the Environment Plan.

If there is someone you believe may be affected by the proposed activities, please have them contact us.

P: 1800 797011

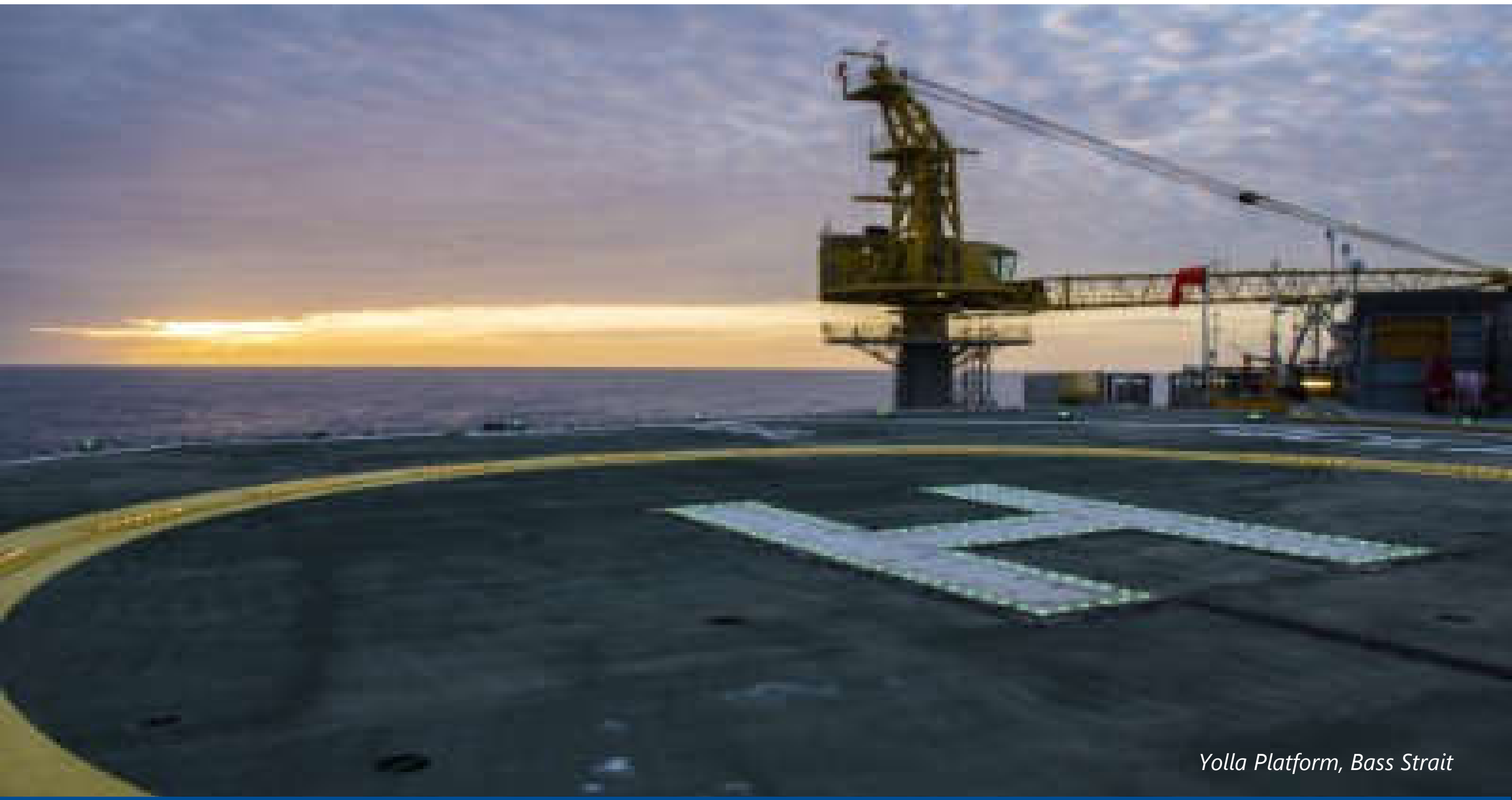
E: community@beachenergy.com.au

beachenergy.com

beach

Offshore Gas Victoria Project

Plug and Abandonment Activities



Yolla Platform, Bass Strait

Plug and Abandonment activities | July 2023

Project overview

Beach Energy supplies the ongoing natural gas needs of Victorian homes, business and industry, through production at the Otway Gas Plant near Port Campbell and the Lang Lang Gas Plant, 80kms south-east of Melbourne CBD.

Beach is continuing its commitment to supply natural gas to the east coast domestic market and has commenced planning for the *Offshore Gas Victoria* (OGV) Project to deliver the next phases of exploration and development in the Otway and Bass projects.

As part of the OGV Project Beach is planning for the 'plug and abandonment' (P&A) five suspended wells. Confirmation of project timings and scope is subject to internal and external project approvals, confirmation of contractor vessels and rig availability

This information sheet focuses on the P&A activities.

Seabed Assessments

Assessment of suitable locations for drill rig and new seabed infrastructure to connect wells

earliest start Jan 24

Removal of Wells

Removal of five suspended wells through a formal procedure called 'plug and abandonment'

earliest start Jan 2025

Drilling of Wells

Up to eleven exploration / appraisal wells

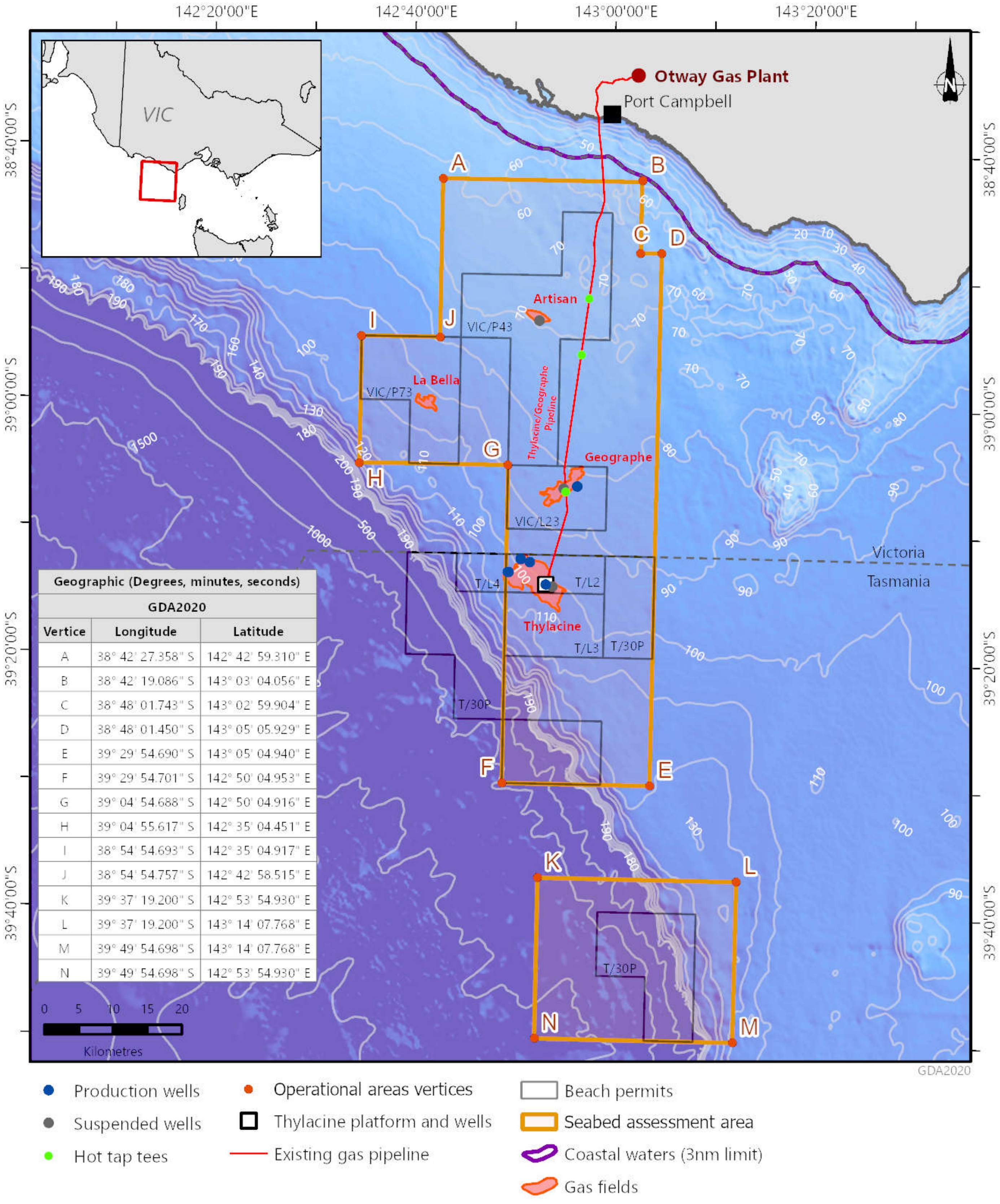
earliest start Feb 2025

Completing & Connecting of Wells

Completing successful wells, installing infrastructure, and connecting wells to existing pipelines

earliest start mid-2025

Otway Basin



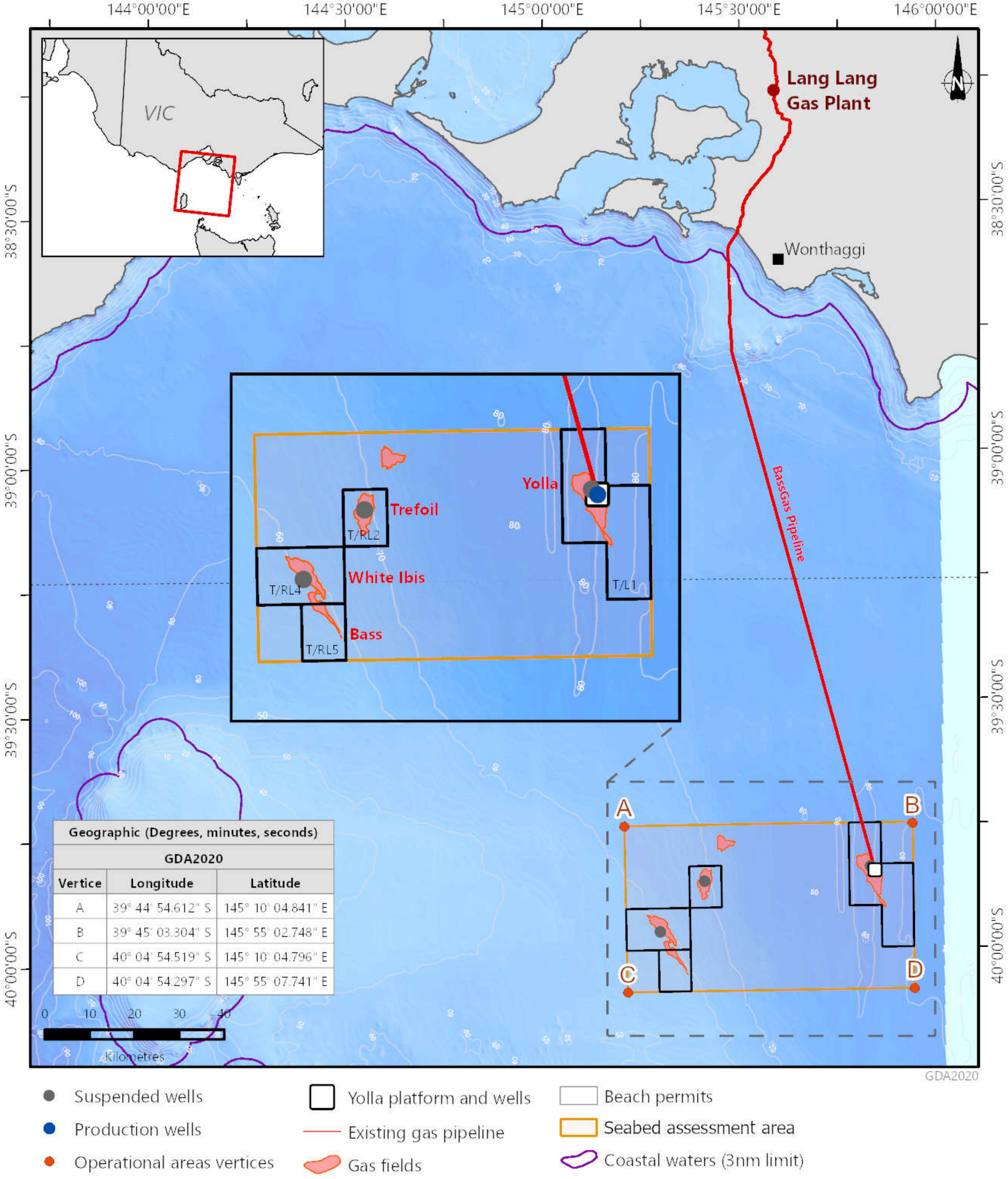
Geographic (Degrees, minutes, seconds)		
GDA2020		
Vertice	Longitude	Latitude
A	38° 42' 27.358" S	142° 42' 59.310" E
B	38° 42' 19.086" S	143° 03' 04.056" E
C	38° 48' 01.743" S	143° 02' 59.904" E
D	38° 48' 01.450" S	143° 05' 05.929" E
E	39° 29' 54.690" S	143° 05' 04.940" E
F	39° 29' 54.701" S	142° 50' 04.953" E
G	39° 04' 54.688" S	142° 50' 04.916" E
H	39° 04' 55.617" S	142° 35' 04.451" E
I	38° 54' 54.693" S	142° 35' 04.917" E
J	38° 54' 54.757" S	142° 42' 58.515" E
K	39° 37' 19.200" S	142° 53' 54.930" E
L	39° 37' 19.200" S	143° 14' 07.768" E
M	39° 49' 54.698" S	143° 14' 07.768" E
N	39° 49' 54.698" S	142° 53' 54.930" E

25/05/2023

The locations on this map are accurate at the time of publication and are subject to change

OT23-0015C

Bass Basin



Geographic (Degrees, minutes, seconds)		
GDA2020		
Vertice	Longitude	Latitude
A	39° 44' 54.612" S	145° 10' 04.841" E
B	39° 45' 03.304" S	145° 55' 02.748" E
C	40° 04' 54.519" S	145° 10' 04.796" E
D	40° 04' 54.297" S	145° 55' 07.741" E

31/05/2023

The locations on this map are accurate at the time of publication and are subject to change

OT23-0015D

Plug and abandonment

The OGV Project is a continuation of Beach's previous Phase 4 and 5 projects and may contain up to 11 wells to be drilled over approximately two years. Beach's program of work has been optimised to allow for the permanent P&A of five suspended wells. These wells are isolated from hydrocarbon zones and are managed in accordance with a Wells Operation Management Plan to ensure well integrity.

Suspended exploration wells are P&A when they are not suitable as future production wells due to limited gas prospectivity. Cement plugs will be installed within the well to permanently seal the well and isolate it from formations. A cement plug will be installed at or close to the seabed and all casings will be cut at least 2 m below the mudline to ensure that the seabed is returned to the same condition prior to drilling (P&A). Debris in vicinity will also be surveyed and retrieved where feasible to do so.

The P&A of wells is often planned to coincide with the drilling of new exploration or production wells using the same drilling rig which is the case with the OGV Project.

Questions and Answers

When were the wells drilled?

The wells were drilled by previous lease titleholders, from 1985 through to the most recent well being drilled by Origin Energy in 2004. Beach and its joint venture partners acquired the retention leases and production licence, the wells and associated production assets from Origin Energy in 2018.

Why are you decommissioning the suspended wells?

Although Beach is continuing development of natural gas in the Otway and Bass Basins, the suspended exploration wells are not suitable as future production wells. In addition, new exploration wells will be P&A shortly after drilling should results show limited prospectivity.

Are the suspended wells monitored for leaks?

Cement plugs were installed to suspend and seal the wells. Since then, the wells have undergone routine monitoring and have met inspection criteria.

Although unlikely given the well construction method, if a leak was found during an inspection, the hydrocarbon volume and composition would be assessed in order to determine the required maintenance response or 'plug and abandonment' action.

No leaks have been observed from all suspended wells inspections to date.

Consultation and Feedback

Consultation and feedback is an important part of developing Environmental Plans and Offshore Project Proposals.

This information sheet has been prepared to provide a summary of proposed activities and commence consultation with relevant persons whose functions, interests or activities may be affected by the activities to be carried out under the environment plan.

Please contact us if you would like further information or to consult with us about how this project may impact your functions, interests or activities.

Beach will consider all feedback, including any concerns or objections and will explore measures to reduce any impacts and risks.

Relevant persons may request that the information they provide not be published, and it will be identified as sensitive information and not published in the EP.

If there is someone you believe may be affected by the proposed activities, please have them contact us.

P: 1800 797011

E: community@beachenergy.com.au

beachenergy.com

beach

Offshore Gas Victoria Project

Seabed Assessment

Seabed assessment | August 2023

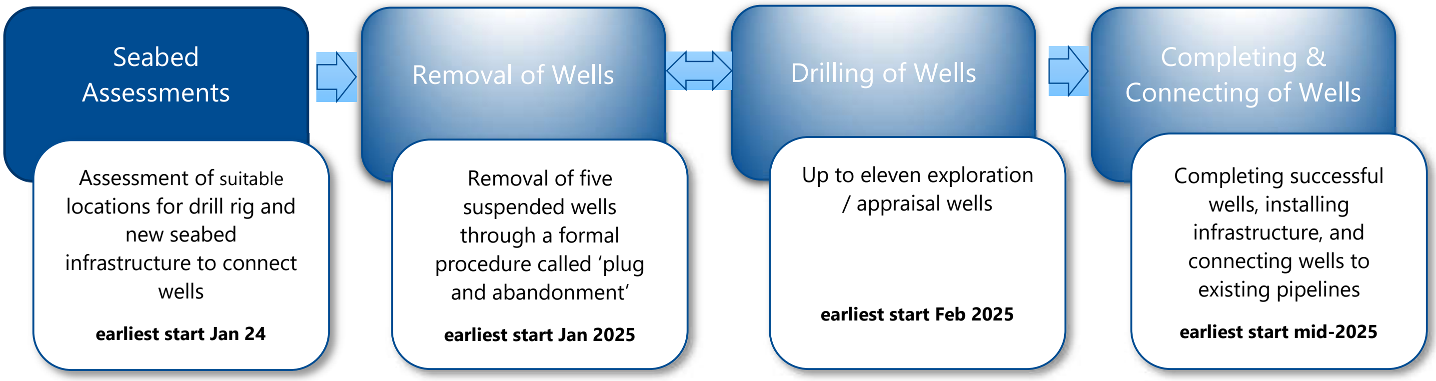
Project overview

Beach Energy supplies the ongoing natural gas needs of Victorian homes, business and industry, through production at the Otway Gas Plant near Port Campbell and the Lang Lang Gas Plant, 80kms south-east of Melbourne CBD.

Beach is continuing its commitment to supply natural gas to the east coast domestic market and has commenced planning for the *Offshore Gas Victoria* (OGV) Project to deliver the next phases of exploration and development in the Otway and Bass projects.

The OGV Project is considering a range of activities across several phases. Confirmation of project timings and scope is subject to internal and external project approvals, confirmation of contractor vessels and rig availability

This information sheet focuses on seabed assessments which are an essential safety and environmental measure.



Seabed Assessments →

Assessment of suitable locations for drill rig and new seabed infrastructure to connect wells

earliest start Jan 24

Removal of Wells ↔

Removal of five suspended wells through a formal procedure called 'plug and abandonment'

earliest start Jan 2025

Drilling of Wells →

Up to eleven exploration / appraisal wells

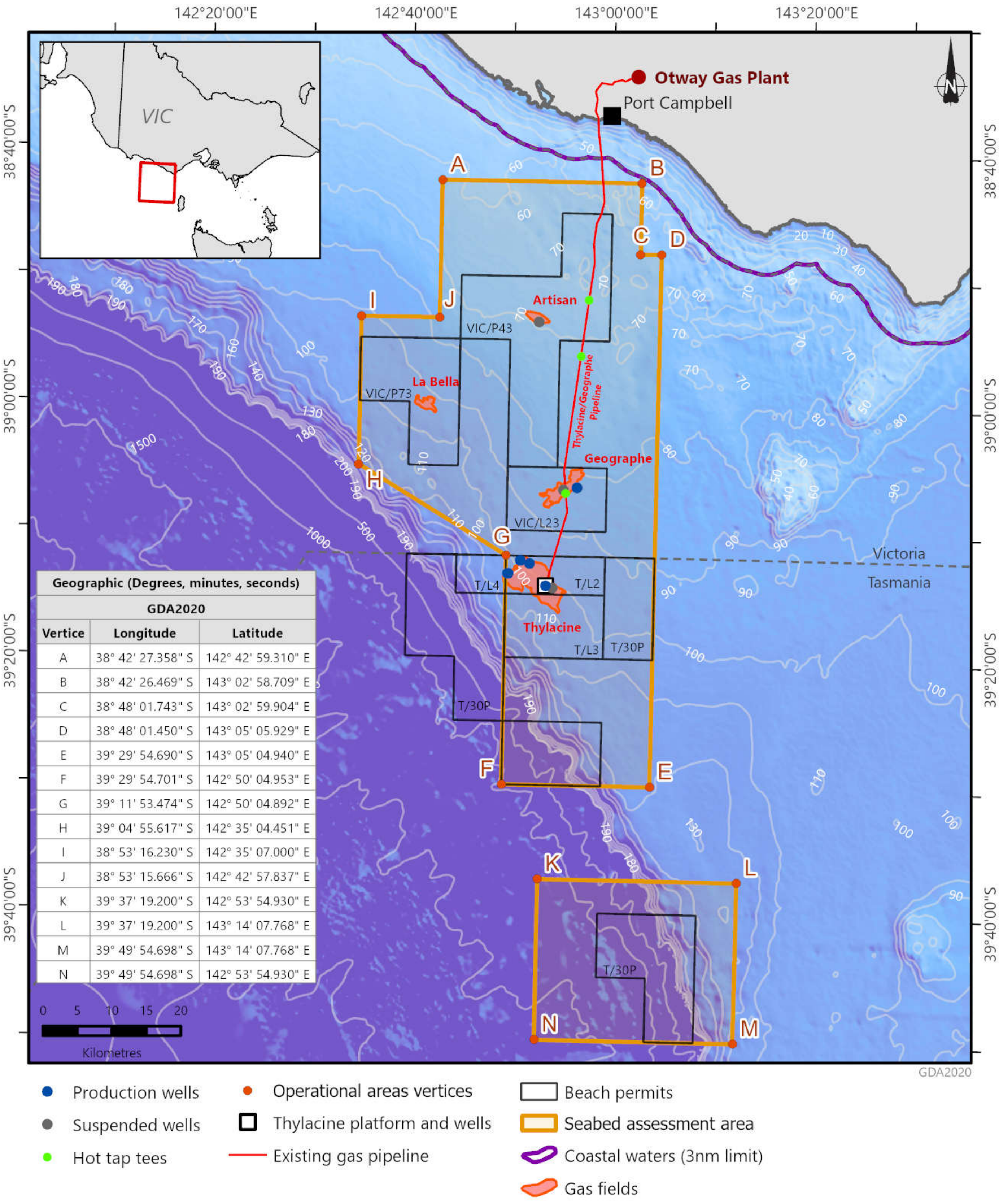
earliest start Feb 2025

Completing & Connecting of Wells

Completing successful wells, installing infrastructure, and connecting wells to existing pipelines

earliest start mid-2025

Otway Basin



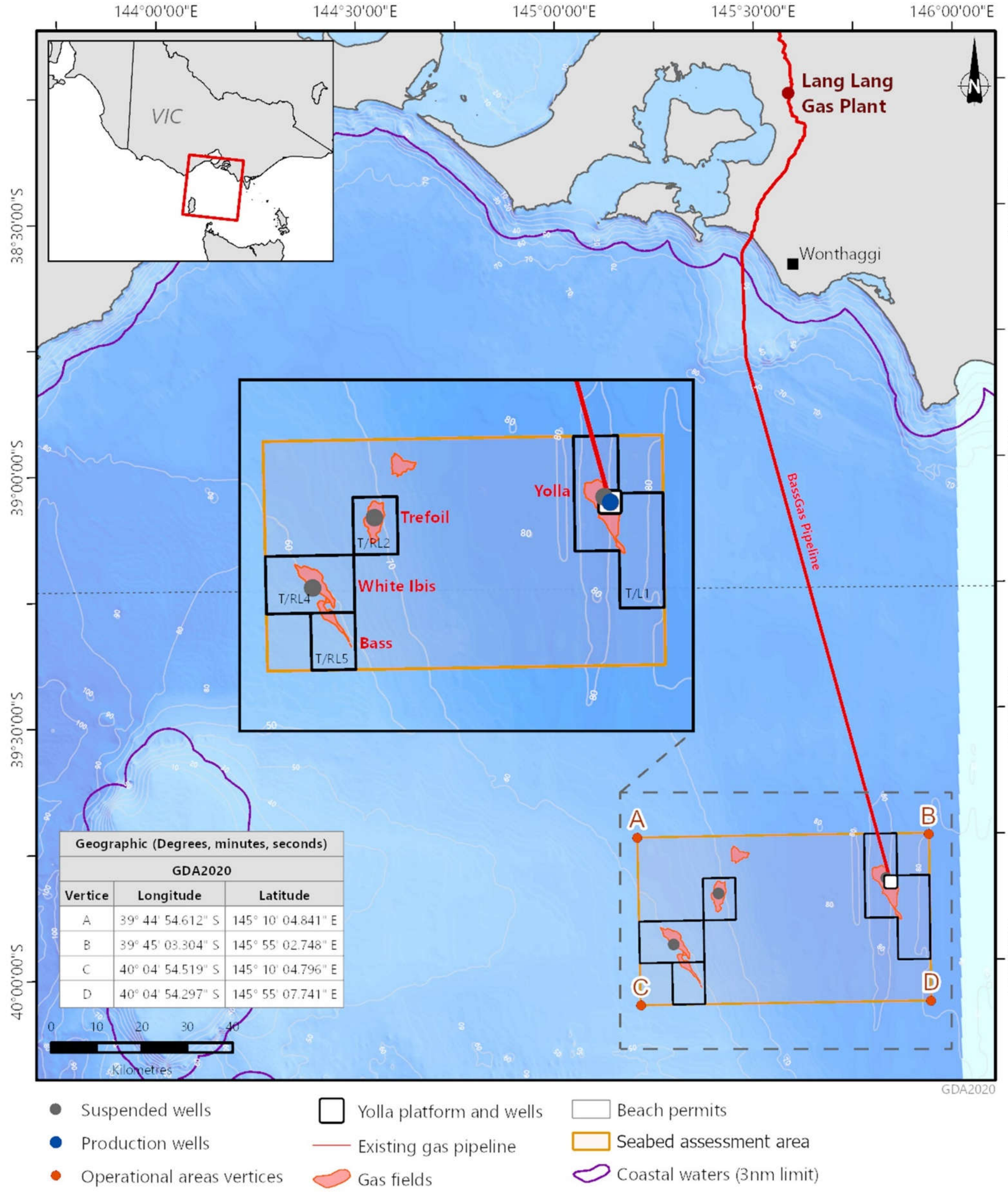
Geographic (Degrees, minutes, seconds)		
GDA2020		
Vertice	Longitude	Latitude
A	38° 42' 27.358" S	142° 42' 59.310" E
B	38° 42' 26.469" S	143° 02' 58.709" E
C	38° 48' 01.743" S	143° 02' 59.904" E
D	38° 48' 01.450" S	143° 05' 05.929" E
E	39° 29' 54.690" S	143° 05' 04.940" E
F	39° 29' 54.701" S	142° 50' 04.953" E
G	39° 11' 53.474" S	142° 50' 04.892" E
H	39° 04' 55.617" S	142° 35' 04.451" E
I	38° 53' 16.230" S	142° 35' 07.000" E
J	38° 53' 15.666" S	142° 42' 57.837" E
K	39° 37' 19.200" S	142° 53' 54.930" E
L	39° 37' 19.200" S	143° 14' 07.768" E
M	39° 49' 54.698" S	143° 14' 07.768" E
N	39° 49' 54.698" S	142° 53' 54.930" E

21/08/2023

The locations on this map are accurate at the time of publication and are subject to change

OT23-0015E

Bass Basin



Geographic (Degrees, minutes, seconds)		
GDA2020		
Vertice	Longitude	Latitude
A	39° 44' 54.612" S	145° 10' 04.841" E
B	39° 45' 03.304" S	145° 55' 02.748" E
C	40° 04' 54.519" S	145° 10' 04.796" E
D	40° 04' 54.297" S	145° 55' 07.741" E

31/05/2023

The locations on this map are accurate at the time of publication and are subject to change

OT23-0015D

Locations

The seabed assessment involves two different activities; geotechnical and geophysical. They will take place in Commonwealth waters of the Otway and Bass Basins (see maps).

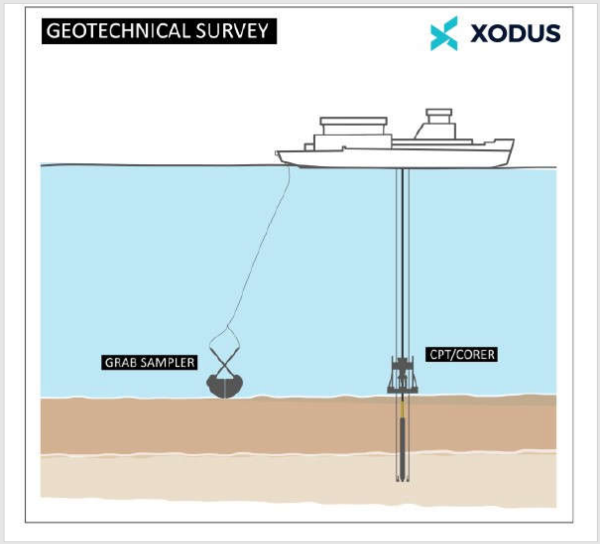
Timing

The seabed surveys are estimated to take on average around 20 days for each required well site location within the Operational Area. The surveys are subject to weather conditions and will be carried out no earlier than the 1sJJanuary 2024 and no later than the 31st December 2029. All relevant stakeholders will be notified at least two weeks in advance.

Geotechnical activity description

The geotechnical activities will be undertaken by a vessel with specialised equipment to carry out the following activities:

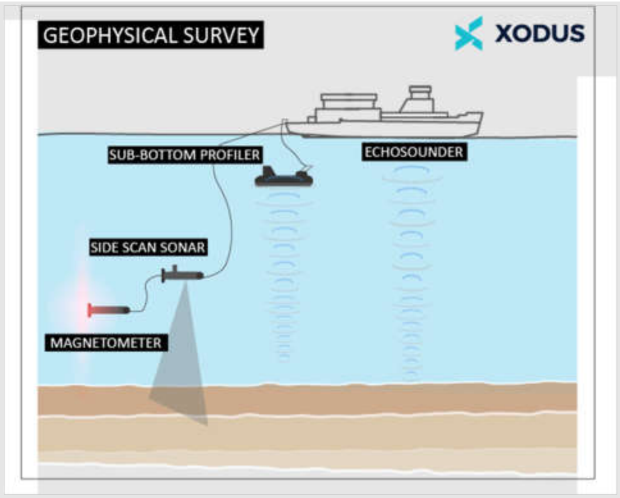
- Either a remotely operated vehicle (ROV) or unmanned aerial vehicle (UAV) could be used
- Obtaining core samples for geological analysis of formations below the seabed, from boreholes up to 150m deep, drilled using seawater or or bentonite
- Determining soil strenth and delineating soil stratigraphy using Piezo Cone Penetration Test (PCPT) to a maximum of 30 m depth
- Collecting core samples to a depth of 4 m for geological analysis
- Collecting small samples of surface sediments from the seafloor
- Using drop and tow cameras to visually observe the physical and biological environment.



Geophysical activity description

Activities and equipment included:

- Multibeam echosounder for bathymetry mapping
- Side-scan sonar for identifying seabed features
- Magnetometer to detect metallic objects on or below the seabed
- Sub-bottom profiler (SBP) to identify shallow formation structures below seafloor.



Marine Environment

Beach recognises the environmental, heritage, social and economic value in the areas in which we operate. The environment within the project area is characterised by:

- Water depths will be on average 100 m but can range up to 1500 m
- Hard sandy seabed consisting of sparsely scattered clumps of solitary sponges, polychaete worms, cone shells and featherstars

A variety of marine fauna occur in the project area including the potential presence of:

- Blue, humpback and fin whales, particularly during the summer months
- Southern right and minke whales, particularly during the winter months
- Common dolphin and shark species throughout the year
- New Zealand and Australian fur seals throughout the year
- Limited numbers of Loggerhead, green and leatherback turtles throughout the year.

Economic value within the project area include:

- Commercial fishing activity
- Commercial shipping activity.

Social and heritage values within the project area include:

- Multiple Use Zone of the Zeehan Australian Marine Park
- Two shipwrecks
- West Tasmania Canyons key ecological feature

Maritime safety

At Beach, safety is our number one priority. The marine vessels contracted by Beach will operate in accordance with Australian Maritime Standards, regulated by the Australian Maritime Safety Authority (AMSA). Notices to Mariners (NTM) will be issued by the Australian Hydrographic Office requesting that vessels do not approach closer than 2 nautical miles of the assessment vessel.

Regulatory approvals – Seabed assessments

Activities are regulated under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act) which requires an Environment Plan for the seabed assessment. Environment Plans are assessed by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) who regulates activities under the OPGGS Act.

Further regulatory approvals

For further development of the gas fields, including drilling production wells, installing seabed insfrastructure to tie the wells back to the existing platforms, Beach will be submitting an Offshore Project Proposal (OPP) to NOPSEMA.

Development of an OPP requires Beach to identify impacts and risks of the activities conducted over the life of the project and to demonstrate to NOPSEMA that the impacts and risks will be managed to acceptable levels. The OPP process involves a completeness assessment by NOPSEMA, followed by a public comment period, before final acceptance of the OPP by NOPSEMA.

Following OPP acceptance, Beach would then develop Environment Plans for specific activities which will be submitted to NOPSEMA for assessment before each activity can commence.

Questions and Answers

Why are seabed assessments needed?

The seabed assessments are required to obtain detailed information on the bathymetry, seabed features and shallow geology at potential well locations, as well as between the well locations and the Thylacine and Yolla platforms. This information will be used to determine future drilling and infrastructure opportunities for the OGV project.

Is Beach conducting seismic surveys for its new drilling program?

No, the range of different well types that are being planned for the OGV project are in areas that have previously been assessed with a seismic survey.

What will happen to any discharges from the borehole drilling?

Seawater and/or bentonite will be used to lubricate the drill bit and stabilise the borehole, as well as remove seabed material produced through drilling, called cuttings. As the fluids and cuttings come out of the borehole they will be deposited onto the seabed. Bentonite is an inert material that is classed as posing little or no risk to the environment.

Will the site assessments impact upon commercial fishing?

The seabed assessment area is located within existing designated Commonwealth and State fisheries. Engagement with fisheries has identified a low level of activity in the area. Each fishery covers a vast area, whereas the seabed assessments will only require access to a relatively small area for a very short period of time.

Beach is committed to minimising the impact of its activities and will consult with commercial fishers on arrangements to ensure each other's operational plans are understood, helping to minimise any impacts to fishing activities.

To avoid entanglement and safety risks, fishing nets, lines or pots should not be placed in the seabed assessment area during the activities.

Will the activities affect whales?

Based on the low intensity sound generated from the equipment, any impact to whales will be low and temporary based on the short duration of the activities. Shutdown and exclusion zones will be used to manage any impacts to whales that may be in the area during the seabed assessment. Avoidance of whales and dolphins will be undertaken in accordance with the EPBC Regulations (2000) including adherence to distance and speed requirements

Will an exclusion zone exist?

Exclusion zones will not be in place during the seabed assessment and normal navigational requirements will be followed.

Why can seabed assessments be undertaken within the Zeehan Australian Marine Park?

The seabed assessment area overlaps a small area of the Zeehan Australian Marine Park Multiple Purpose and Special Purpose Zones which allow for seabed assessments as long as they are undertaken as per the accepted Environment Plan. No geotechnical samples will be taken within the Zeehan Australian Marine Park so there will be no impacts to the seabed and associated values. Geophysical surveys, which are non-intrusive, will potentially be undertaken within the marine park to obtain information in relation to the seabed bathymetry and structure. If feasible, drop camera images will be obtained to gain information on the seabed habitat within the marine park. All information collected within the marine parks will be shared with the parks authority.

Will the seabed assessments impact shipwrecks within the Zeehan Australian Marine Park?

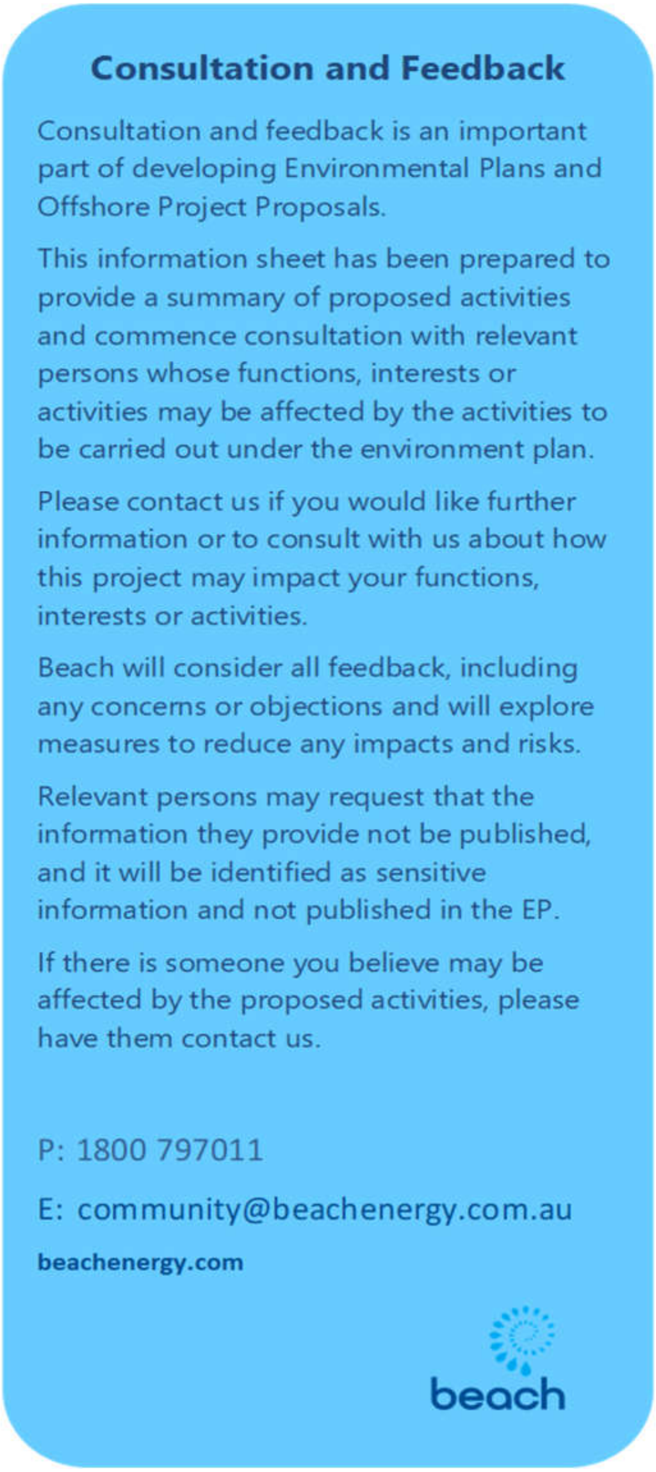
Though two shipwrecks have been identified within the seabed assessment areas there is the possibility that unknown shipwrecks could also be present. The aim of the geophysical survey is to identify any seabed obstructions such as shipwrecks. This will allow any geotechnical samples to be taken outside of the area of any obstructions, including shipwrecks. Where a shipwreck is identified from the seabed surveys it will be reported to the Department of Climate Change, Energy, the Environment and Water as per the requirements of the Underwater Cultural Heritage Act 2018._

Will there be impacts to the West Tasmania Canyons Key Ecological Feature?

The West Tasmania Canyons are an area of high productivity and aggregations of marine life with sponges concentrated near the canyon heads, with the greatest diversity between 200 m and 350 m depth. The aim of undertaking the geophysical and drop camera surveys is to identify any key features that should be avoided for well and anchor locations and future infrastructure.

How much seabed will be disturbed by the seabed assessments?

The geophysical surveys will not disturb the seabed. To take a core seabed sample a coring frame ~ 5 m x 5 m (footprint of ~25 m^2) is placed on the seabed to allow a core of ~15 cm diameter to be taken. The PCPT is taken within the coring frame area. Thus, each sample may disturb an area up to 25 m^2. Up to 150 core samples may be taken within the seabed assessment areas which is ~3,750 m^2. Due to the small area of disturbance at each location there is no impediment to the disturbed areas recolonising from the undisturbed surrounding areas.



Consultation and Feedback

Consultation and feedback is an important part of developing Environmental Plans and Offshore Project Proposals.

This information sheet has been prepared to provide a summary of proposed activities and commence consultation with relevant persons whose functions, interests or activities may be affected by the activities to be carried out under the environment plan.

Please contact us if you would like further information or to consult with us about how this project may impact your functions, interests or activities.

Beach will consider all feedback, including any concerns or objections and will explore measures to reduce any impacts and risks.

Relevant persons may request that the information they provide not be published, and it will be identified as sensitive information and not published in the EP.

If there is someone you believe may be affected by the proposed activities, please have them contact us.

P: 1800 797011

E: community@beachenergy.com.au

beachenergy.com

beach