NOPSEMA

Submission

December 2019

Environment and Communications References Committee

Inquiry into the impact of seismic testing on fisheries and the marine environment

Submission from the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA)

Introduction and structure of submission

The National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) welcomes the opportunity to make a submission to the inquiry into the impact of seismic testing on fisheries and the marine environment.

As the independent offshore regulator, NOPSEMA regulates resource and energy exploration and development operations in Commonwealth waters and coastal waters where a state or territory has conferred powers and functions for regulation to NOPSEMA.

This submission addresses all of the terms of reference, provides an overview of NOPSEMA's role in regulating seismic activities in Commonwealth waters with particular focus on the body of science and research into the use of seismic testing.

Questions from the Committee regarding the submission should be directed to:

Mr Nicholas Page

Manager – Legislative Change, Communications and Stakeholder Relations

Email – communications@nopsema.gov.au

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1. Executive summary

1. Offshore seismic surveying has been occurring off the coast of Australia since the 1960s and is needed to explore for oil and gas reserves under the seafloor. These surveys result in loud, low frequency, pulses of sound into the water often over large areas and sometimes for several months at a time. Seismic surveys have the potential to cause harm to the environment, including to protected marine fauna, when not managed appropriately. It is a technically complex industry, the regulation of which requires specialist knowledge and expertise.

2. The National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) is the single national regulator for health and safety, well integrity and environmental management for all offshore energy activities, including seismic surveys, in Commonwealth waters and in coastal waters where regulatory powers and functions have been conferred.

3. NOPSEMA is an independent statutory authority established under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act).

4. As the independent regulator of the offshore energy industry, NOPSEMA is not involved in Government policy decisions pertaining to whether fossil fuels should be exploited, the selection or release of areas for petroleum exploration and development or in the granting of petroleum titles.

5. NOPSEMA makes merits based decisions on specific seismic activities and their potential interactions with the local environment. Decisions focus exclusively on the technical and scientific merits of environmental impact and risk assessments and the accompanying proposed management plans and are independent of economic, commercial and political factors.

6. NOPSEMA maintains a core staff of highly trained and qualified technical experts with extensive experience in offshore environmental impact and risk management, marine ecology and environmental science. Where considered appropriate to inform its decision making, NOPSEMA can also access expertise from a range of external sources such as other international, federal and state government agencies or private sector entities which have roles and interests in areas including environmental protection and management, fisheries management, management of threatened and migratory species and scientific research.

7. In order to ensure that its decisions about seismic surveys are well informed and scientifically robust, NOPSEMA relies on a strong scientific evidence base by drawing from the published scientific literature. NOPSEMA actively seeks to remain informed of the latest research, both nationally and internationally. The authority actively participates in forums to influence the research agenda to ensure funding is directed towards addressing priority research questions related to potential impacts of seismic on the marine environment.

8. A significant body of scientific research into the effects of underwater noise on the marine environment has been undertaken and scientific knowledge in this area is continuing to improve. However, there are still many species for which the effects of underwater sound from seismic surveys are not fully understood, and may never be. This does not mean that NOPSEMA cannot make well informed decisions about seismic surveys and does not mean that seismic surveys cannot be conducted safely.

9. Environmental impact assessments are informed by complex underwater sound modelling, scientific research, regional and species-specific information and the results of consultation. The level of confidence in the impact predictions must be considered carefully when designing seismic surveys and applying management measures. In those circumstances where the level of scientific uncertainty about the potential environmental impacts from seismic surveys are higher, NOPSEMA applies greater precaution in decision-making and titleholders are required to apply greater precaution when predicting levels of harm and managing their activities.

10. For seismic surveys, the greater precaution is typically achieved by requiring more management controls during the seismic surveys or more stringent application of those controls to prevent acceptable levels of harm in locations where sensitive species are found. These requirements often include avoiding biologically sensitive times of the year for the potentially affected marine species, such as whales, using monitoring measures to test the effectiveness of controls and adapt them in response to results, or excising sensitive locations entirely from survey areas. If the predicted impacts to sensitive marine fauna cannot be managed to result in an acceptable environmental outcome, NOPSEMA will not allow the survey to proceed.

11. There are recognised effects from sound generated by seismic surveys, however by employing suitable environmental management measures, seismic activities can be carried out with acceptable levels of environmental impact and environmental risk.

12. Seismic surveys have attracted a lot of community, media and government interest recently and contributed to heightened tensions. This heightened tension is particularly true for fisheries stakeholders because of concerns about impacts to fish stocks and fishing activities. Interest from the general public has also increased, often due to concerns about potential impacts to sensitive marine fauna like whales and links between seismic activity and the continuation of the fossil fuel industry.

13. In some cases concern over seismic surveys has been heightened further when multi-client seismic companies and other operators prepare environment plans and consult with the local community for seismic surveys covering the same location. This duplication in consultation can be interpreted by stakeholders as meaning that multiple companies will undertake seismic surveys over the same area at the same time. In reality a petroleum company typically requires only one company to acquire the available seismic data over their title area and only one company is typically awarded the work and proceeds with the one survey.

14. Australia's marine management framework establishes that no single user has exclusive rights to the offshore area, and that all extractive and resource industries need to operate alongside each other cooperatively. Better recognition of the multiple use nature of the marine environment would assist in addressing conflicts.

15. NOPSEMA remains committed to fostering improved relationships between the offshore petroleum industry and fisheries stakeholders and will continue to progress initiatives that promote the sharing of perspectives, concerns, information and available research.

16. NOPSEMA makes several recommendations to improve the supporting science, regulation of the seismic industry and to help improve relationships between the seismic and fishing industries as summarised below, and in detail in Section 4.4.1:

- Collaborative petroleum focussed research framework – well funded and scoped research to address key priorities in relation to environmental impact assessment for seismic surveys.
- Best practice standards – in environmental impact assessment and seismic mitigation measures.
- Technological advancements – alternative technology for seismic surveys and mitigation measures.
- Guidance on implementation of policy – collaborative approach between government agencies.
- Marine spatial planning – consideration of all marine users and environmental sensitivities.
- Improved practices for industry cooperation – collaborative framework to address priority issues to support cooperation between the seismic and fishing industries.

17. NOPSEMA recognises that in many cases it will be the role of relevant policy agencies and industries to consider these recommendations and not NOPSEMA. NOPSEMA's role is to help identify issues and work with those other stakeholders to promote and collaboratively work on implementing the solutions as appropriate for the independent regulator.

2. Glossary of Key terms

µPa	micropascal = 10^{-6} pascals.
2D	Two dimensional
3D	Three dimensional
AA	Access Authority
AAD	Australian Antarctic Division
AFMA	Australian Fisheries Management Authority
ALARP	As Low As Reasonably Practicable
AMP	Australian Marine Park
APPEA	Australian Petroleum Production and Exploration Association
ASCOBANS	Agreement of the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas
BACI	Before After Control Impact
BIA	Biologically Important Area
BRAHSS	Behavioural Response of Australian Humpbacks to Seismic Sound
CMS	Convention on Migratory Species
CoAG	Council of Australian Governments
dB	decibel
DIIS	Department of Industry, Innovation and Science
DEWHA	Department of Environment, Water, Heritage and the Arts
DoEE	Department of the Environment and Energy
DOSITS	Discovery Of Sound In The Sea
DNP	Director of National Parks
EIA	Environmental Impact Assessment
EMS	Environmental Management System
Environment Regulations	*OPGGS (Environment) Regulations 2009*
EP	Environment Plan
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999*
EPBC PS2.1	*EPBC Act Policy Statement 2.1*
FRDC	Fisheries Research and Development Corporation
GAB	Great Australian Bight
HELCOM	Helsinki Commission
Hz	Hertz
IOGP	International Association of Oil and Gas Producers

IOPER	International Offshore Petroleum Environment Regulators
JNCC	Joint Nature Conservation Committee
kHz	kilohertz = 10^3 Hz
kPa	Kilopascal = 10^3 pascals
MMO	Marine Mammal Observer/Marine Fauna Observer
MSFD	Marine Strategy Framework Directive
NCVA	National Conservation Values Atlas
NOAA	National Oceanic and Atmospheric Administration (USA)
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
NOPTA	National Offshore Petroleum Titles Authority
NZ	New Zealand
OCS	Offshore Constitutional Settlement
OHS	Occupational Health and Safety
OPGGS Act	*Offshore Petroleum and Greenhouse Gas Storage Act 2006*
PSD	Power Spectral Density
PSL Act	*Petroleum (Submerged Lands) Act 1967*
PTS	Permanent Threshold Shift
re	relative
SBT	Southern Bluefin Tuna
SIA	Seafood Industry Australia
SoE	State of the Environment
SPA	Special Prospecting Authority
SPRAT	Species Profile and Threats Database
TTS	Temporary Threshold Shift
UK	United Kingdom
WAFIC	Western Australia Fishing Industry Council

3. Role of NOPSEMA

18. The National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) is the national regulator for health and safety, well integrity and environmental management for offshore energy activities in Commonwealth waters and in coastal waters where regulatory powers and functions have been conferred. At the time of writing only Victoria has conferred powers to NOPSEMA (for occupational health and safety and well integrity) for regulating offshore petroleum activities in State waters. NOPSEMA maintains close cooperation with relevant State and Northern Territory agencies via the Upstream Petroleum Resources working group under CoAG and through direct engagement.

19. NOPSEMA is not involved in Government policy decisions pertaining to whether fossil fuels should be extracted, the selection or release of areas for petroleum exploration and development or in the granting of petroleum titles. Once these decisions have been made, NOPSEMA plays an important role as an independent regulatory authority in assessing and making decisions about individual activity proposals to ensure that impacts and risks are reduced to as low as reasonably practicable and that environmental impacts and risks are acceptable.

20. Marine seismic surveys are among the offshore activities regulated by NOPSEMA.

21. By law, offshore energy activities cannot commence before NOPSEMA has assessed and accepted detailed environmental impact and risk assessment and accompanying management plans. NOPSEMA cannot approve an activity unless stringent requirements have been met, such as ensuring impacts and risks to the environment and other marine users will be properly managed by the company.

22. As an independent authority, NOPSEMA makes expert, impartial decisions based on merit and with regard to relevant science and facts.

23. NOPSEMA recognises that no offshore petroleum activity is without impact but is committed to ensuring that appropriate measures and controls are applied to reduce impacts to an acceptable level, in accordance with Commonwealth regulations.

4. Addressing the Terms of Reference

4.1. The body of science and research into the use of seismic testing

4.1.1. Seismic Exploration

24. Seismic exploration is necessary for oil and gas proponents to explore for deposits of oil and gas under the seafloor by imaging sub-bottom sediment layers with high intensity, low frequency sound. High-pressure airguns release highly compressed air in pulses approximately every 10 seconds that form air pockets that expand and compress rapidly to produce a pulse of sound. The sound is reflected back from the seafloor and subsea layers to a string of hydrophone receivers that form a picture of the formations that lay beneath the seafloor and determine whether oil and gas deposits are present in the layers below the sea floor (see Figure 2).

25. During a survey, data is acquired using a vessel towing an airgun array (the seismic source) and a series of cables or streamers (3D), or single cable (2D), behind it. The streamers are typically 5,000 metres long and 100 metres apart. The array is composed of several air-guns and this is typically towed 4-10 metres below the surface of the water. The characteristics of the seismic airgun array (i.e. volume, number of elements and firing pattern), and the survey design, vary depending on the focus and objectives of the seismic survey. Data for 2D is acquired along a single continuous line and results in a single cross-section image of the sub-surface; and 3D, which results in a cube of data allowing imaging of the subsurface from any angle.

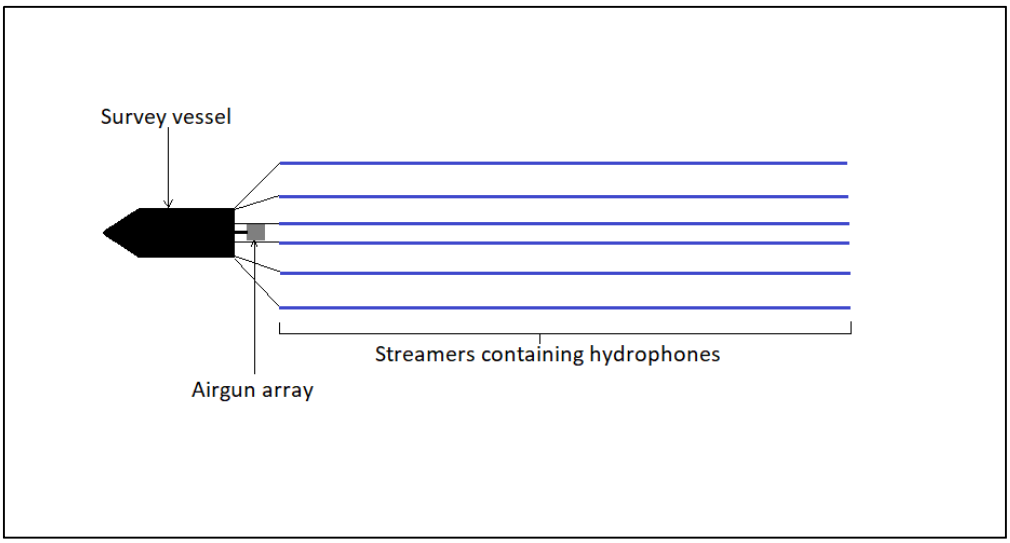


Figure 1: A typical seismic survey involves a vessel with airgun array and hydrophone streamers

26. 2D surveys are often used for larger regional surveys during early phases of oil and gas exploration and typically have a smaller sound source and fewer and more widely spaced sail lines that may cross each other. In comparison, a 3D survey uses a larger sound source and follows a design of closely spaced parallel sail lines, which is used to gain a finer level of detail and understanding of the subsurface geological features. Consequently, 3D surveys typically have a greater potential for impacts to marine fauna than 2D surveys.

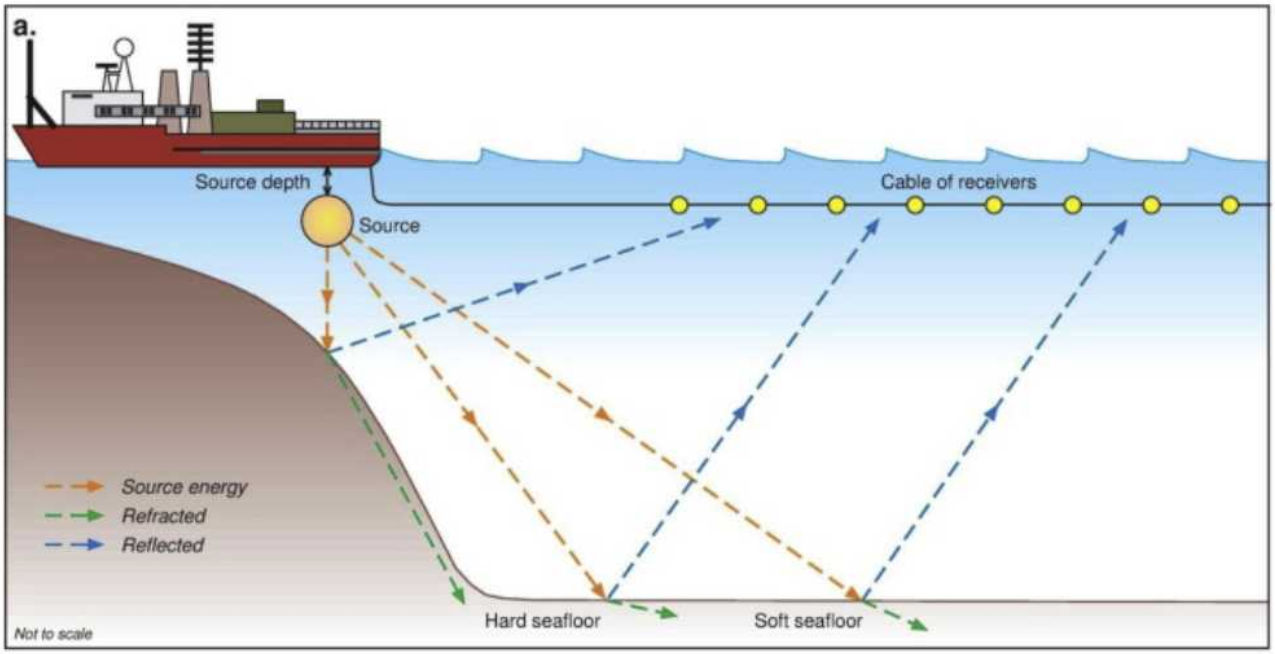


Figure 2: Illustrates how seismic sound is used for imaging beneath the seafloor (Source Carroll et al. 2017)

27. Anthropogenic noise is recognised by environmental protection agencies as a pressure for a number of protected marine species, and there is the real potential for serious impacts to marine fauna from intense sounds produced by seismic surveys and other anthropogenic sounds if those activities are not managed properly.

28. Sound from seismic surveys can impact marine species in a number of ways through physical, physiological and behavioural responses, as well as communication masking. These impacts will be described further in Section 4.1.6.

29. Seismic surveys can be managed and regulated to ensure that they do not have serious, unacceptable impacts on the marine environment or marine fauna.

There is a common misconception that seismic surveys are the only loud noise in the ocean and even when well managed are often perceived to have a far greater environmental impact than they actually do.

30. To manage surveys appropriately and prevent unacceptable impacts from occurring, there needs to be a thorough understanding of how seismic sound can affect local receptors and an understanding of how to prevent those impacts.

31. This part of the submission focuses on the body of science and research into the use of seismic surveys and includes an overview of the basics of seismic and sound to provide context regarding the marine soundscape. This section will also define the environments and biological receptors affected by seismic, describe specific sensitivities of the Australian environment, and the impact and effect pathways for these sensitivities. The focus of this section will be on providing a synopsis of information compiled from the body of contemporary scientific research into the potential effects of seismic on the marine environment.

4.1.2. History of offshore seismic surveys in Australia

32. There is a long history of seismic surveys being safely conducted in Australia and internationally. The first offshore seismic survey in Australia was undertaken in the Otway Basin in the early 1960s. Since that time, there have been more than 2,740 seismic surveys conducted across Australia (including gravity, magnetic and seismic surveys in both state and Commonwealth waters, see Figure 2). Of these, 1,660 seismic surveys were conducted between 1960 and 1999, before the introduction of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and were not subject to formal assessment.

33. Once the EPBC Act came into effect, it became a requirement that any action (including seismic surveys) with the potential for significant impacts on matters of national environmental significance be referred for formal assessment. For seismic surveys, this typically meant that only surveys proposed in sensitive areas with potential impacts for threatened and migratory species underwent formal environmental assessment by the Federal Government. Where no significant impact to an EPBC Act listed species was predicted no assessment was conducted, including for commercially important species not protected under the EPBC Act. There have been about 430 marine seismic surveys conducted in offshore Commonwealth waters since the establishment of the EPBC Act.

34. The Offshore Petroleum and Greenhouse Gas Storage (OPGGS) Environment Regulations (Environment Regulations) came into force in 2009, requiring environmental impact assessments, including details of control measures, to be undertaken for all seismic surveys and undergo independent assessment by the regulator. NOPSEMA has been responsible for the environmental regulation of offshore petroleum activities since 2012. Since then, and at the time of writing, there have been 123 seismic surveys conducted in Australian Commonwealth waters. Additional information about the regulation of seismic activities will be provided later in this submission.

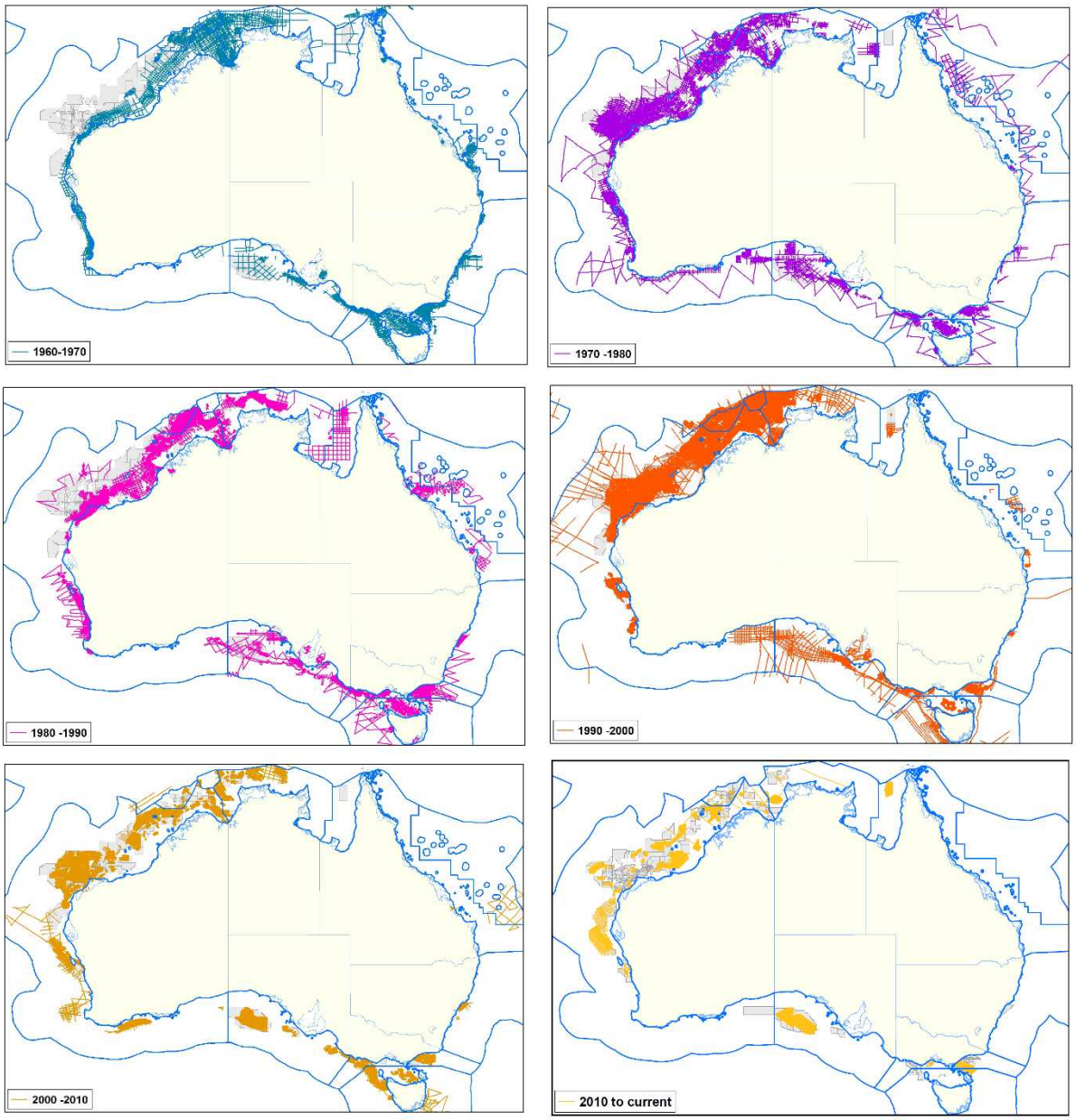


Figure 3: Seismic survey acquisition from 1960 onwards (Source: NOPTA).

35. High levels of seismic exploration activity has been occurring on the north-west shelf of Western Australia consistently over time, in conjunction with high levels of other marine based industrial activities. In contrast, of the 1660 marine seismic surveys conducted in Australian waters since 1960, only 29 have been in offshore sub-basins of the Great Australian Bight, and of these, 11 have occurred since 1999, following the requirement for formal assessment by government. Historically low levels of seismic activity in the Bight may contribute to the current negative public perceptions and concern about seismic exploration in this area.

36. Increasing levels of concern are being expressed by some members of the fishing industry about potential impacts from seismic surveys on commercially important fish species in the north and north-west regions. Despite the high level of seismic activity in the north-west, a healthy, sustainable fishing industry in the North West has been maintained, as well as the recovery of the western humpback whale population to pre-whaling exploitation levels. Since 2013, there has

been an increase in the observation of Killer Whale predation events on humpback whale calves (Pitman et al. 2014) and more recently blue whales, indicating the increasing health of Australian whale populations (Pitman et al. 2014). Recent research based on acoustic data collected between 2004 and 2017 indicates that both the Antarctic and pygmy blue whale populations within Australian waters continue to increase (McCauley et al. 2018), indicating the health of the marine ecosystem.

4.1.3. Basics of Seismic and Sound

37. The characteristics of sound influence the transmission and perception of that sound by receptors, so it is important to understand the characteristics in order to predict potential impacts to sensitive receptors.

38. Sound travels in longitudinal waves with sound energy causing particles to vibrate parallel to the direction in which the sound wave is travelling. These longitudinal waves have areas of compression and rarefaction, with compressions representing regions of high pressure causing particles to move closer together, and rarefactions representing regions of low pressure causing the particles to move further apart.

39. The transmission of sound requires particles to vibrate, hence sound can only travel through a medium and cannot exist in a vacuum. Sound travels much faster in denser, more elastic mediums, where the increased density is a result of compression, as the particles are closer together allowing for more rapid transmission of energy. Consequently, sound travels much faster in water (around 1,500 metres per second for seawater) than in air (around 340 metres per second).

40. Given that the speed of sound in a medium is influenced by the density, elasticity, and conductivity of a medium, oceanographic factors such as temperature, salinity and depth (pressure increases with depth) influence the speed of sound. The speed of sound increases with increasing temperature, salinity and elasticity, and decreases with increasing density.

41. Sound characteristics, including sound intensity, which is relative to pressure, and frequency, are important aspects to consider in the assessment of potential impacts of sound on underwater receptors. Frequency determines which receptors will be most likely to experience impacts from seismic sound and other underwater noise due to potential overlap with frequency specific hearing and communication ranges, as well as the distance to which the sound will transmit (see Figure 4). The received sound levels (pressure) determine the type and severity of effects that will be experienced by marine fauna. The sound produced by seismic airguns has the greatest sound energy in the low frequency bands, making it more likely to affect marine fauna with hearing and communication ranges overlapping low frequency bands. This would include species such as blue, humpback and southern right whales. Seismic sound however is less likely to affect species with high frequency hearing and communication ranges such as dolphins and small toothed whales.

42. Hearing perception is frequency specific, with humans having a hearing range of between 20 and 20,000 Hz. Many animals can hear sounds outside the human hearing range.

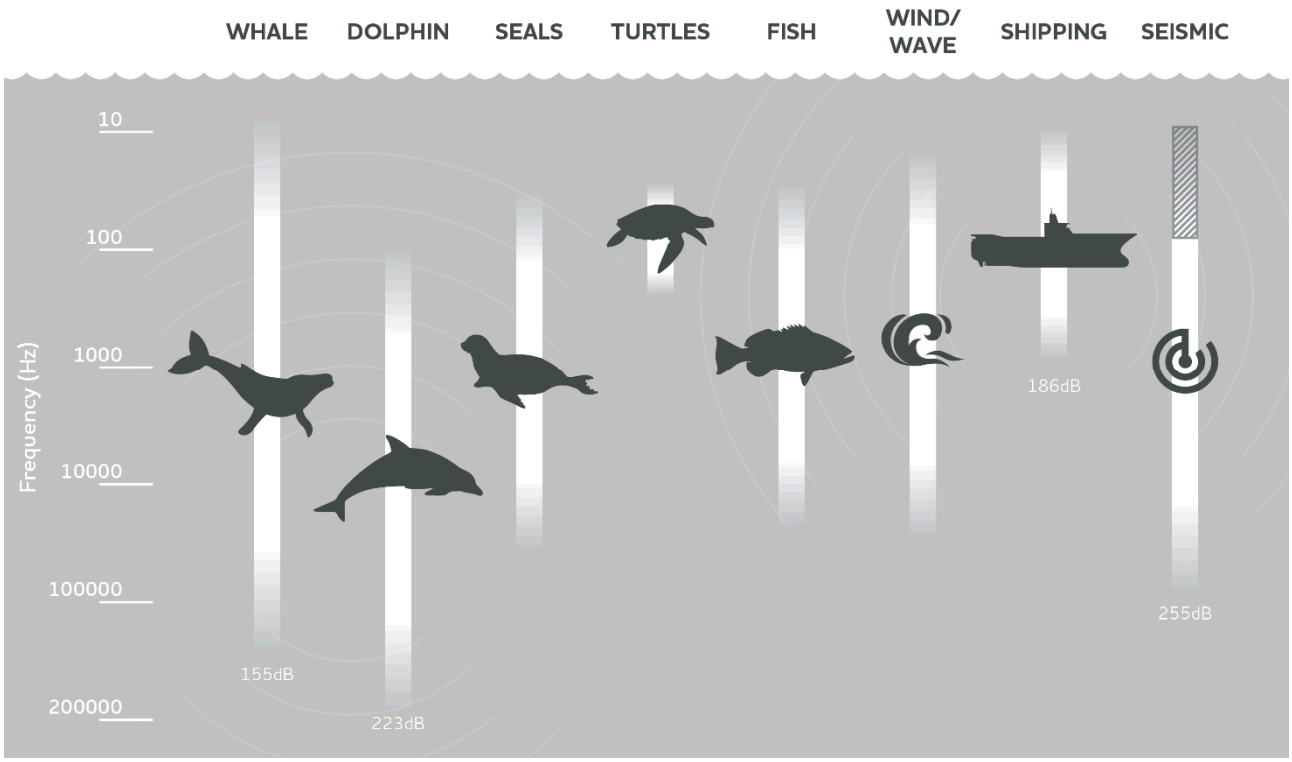


Figure 4: How hearing ranges of fauna compare with emitted sounds

43. Figure 4 compares the hearing ranges of a number of species groups of marine fauna with the frequency range of emitted sounds from natural sources, shipping and seismic. The shaded bar represents the frequency bands within which most of the sound energy is concentrated for seismic sound. The dB values at the bottom of the bars represents the maximum sound levels that can be emitted by each source.

44. The frequency of a sound measures the number of cycles per second and is influenced by wavelength and the speed at which the sound is travelling. Low frequency sounds have longer wavelengths, while high frequency sounds have shorter wavelengths (Figure 5).

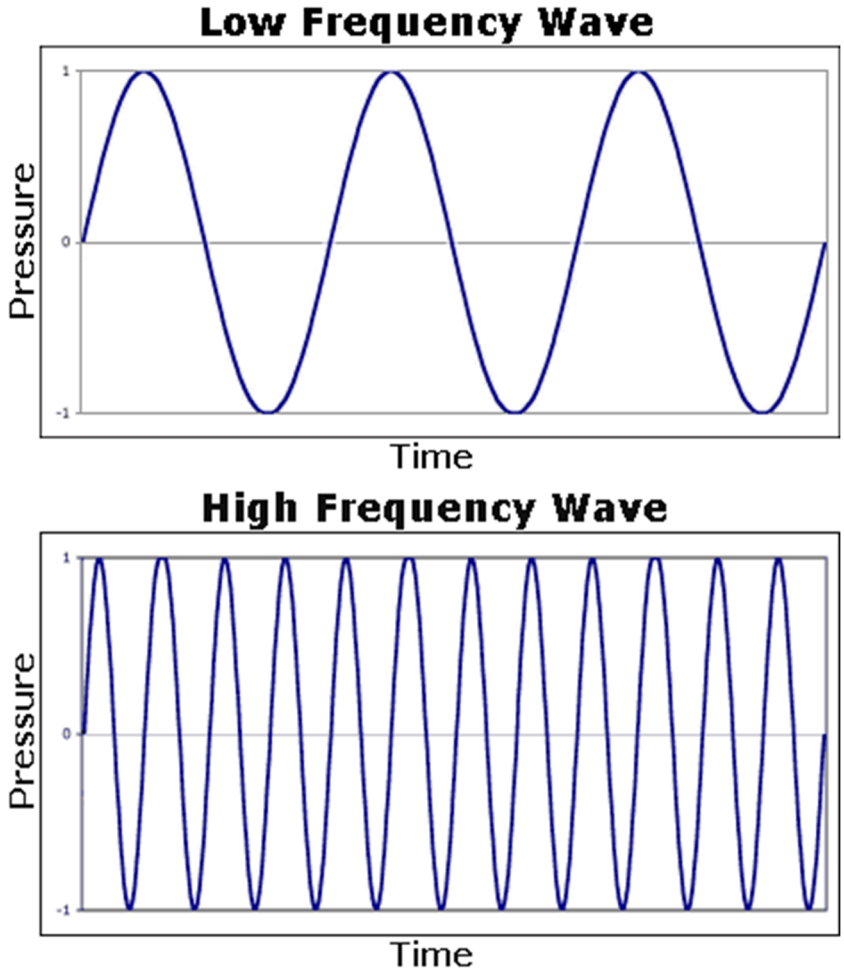


Figure 5: Long wavelength, low frequency sound (above) compared to a shorter wavelength, high frequency sound (below). Source: Discovery of Sound in the Sea (DOSITS 2019).

45. Frequency is an important consideration when using sound to image the seafloor as it determines how far the sound will travel and the size of the target that can be imaged under the seafloor. Frequency is measured in Hz or kHz (1 kHz = 1,000 Hz). A 1 Hz sound has one cycle or wavelength per second, while a 1 kHz sound has 1,000 cycles per second (Figure 5).

46. High frequencies (e.g. 1 kHz and above) are absorbed even more rapidly by the seafloor than by seawater and therefore do not penetrate the seafloor to a sufficient depth to assist in the identification of geological formations (see 5 above). Low frequencies travel further through both the water column and seafloor and are suitable for identifying large geological targets and are thus suitable for seismic surveys. Conversely, low frequency sounds are not suitable for use in echo sounders and sonars as the wavelength must be small in comparison to the target of the imaging.

47. Pressure is generally measured in micro pascals (µPa) with one micro pascal equivalent to 10^{-6} pascals. Pressure is an important component in the measure of sound intensity, as it is relative to a reference pressure depending on the medium within which it is being measured (i.e. air or water).

48. The intensity of sound is measured in decibels (dB). As sound travels in waves made up of compressions and rarefactions, the density of the medium it is travelling in influences the

perception of the intensity of the sound. Consequently intensity is a relative measurement with intensity in air being relative to 20 µPa, and intensity in water relative to 1 µPa. Because they use different reference pressures, sound intensity in air is not directly comparable to sound intensity in water.

49. Seismic airguns produce impulsive, broadband sound that is intense and of short duration, as opposed to continuous sound. Despite having a broad frequency range, the peak in sound energy occurs in the low frequency bands. At some point in the far field (at distance), impulsive sound characteristics become more similar to continuous sound, this results in a decrease in sound intensity but an increase in duration with increasing distance from the sound source. This, combined with the regular interval of seismic shots or pulses over prolonged periods of time means that it is important to consider not only the instantaneous sound levels but the accumulated sound levels that a receiver may be exposed to when assessing the potential for impacts.

4.1.4. Sounds in the Ocean

50. Beneath the surface, the ocean is filled with many very loud sounds that are generated by a variety of natural sources including seismic activity from earth movements, wind, rain, waves and marine life, as well as anthropogenic noise including shipping, military sonar and seismic. The natural and anthropogenic contributors to this ambient noise can be determined based on frequency spectra commonly called Wenz curves (Wenz 1962, Erbe et al. 2015, McCauley et al. 2015, Jolliffe 2019, Ward et al. 2019; Figure 6).

51. The main contributors to ambient noise levels in the low frequency bands include ship noise, marine mammal vocalisations and other natural sources such as ice breaking and earthquakes (Erbe et al. 2015, McCauley et al. 2015, Carrol et al. 2017, Jolliffe 2019, Ward et al. 2019; Figure 7).

52. Low frequency sound has little attenuation in deep water and hence travels very long distances. For this reason, the ambient noise level in the low frequency bands is higher, meaning that the source level of any sound must be higher in order to be detectable above ambient noise (McCauley et al. 2015, Erbe et al. 2015, Jolliffe 2019, Ward et al. 2019). For example, breaking sea ice and earthquakes produce low frequency sounds that can be heard thousands of kilometres away, with ice breaking sound levels recorded at up to 193 dB re 1 µPa at 1 m.

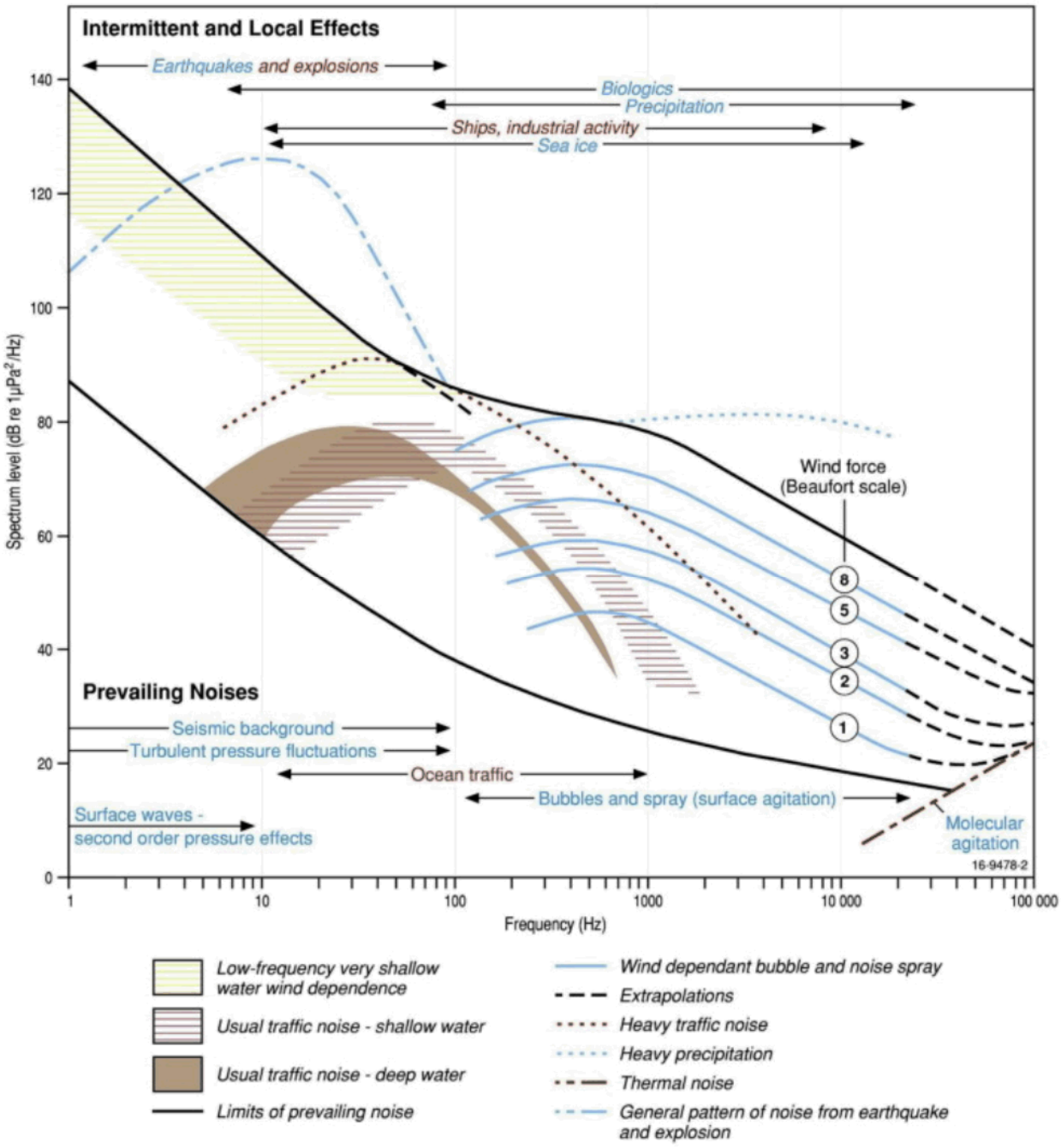


Figure 6: Wenz curves showing ambient noise spectra levels from natural and anthropogenic sources for the marine environment. The arrows show the approximate frequency ranges of influence of the various sources. Source: Carrol et al. (2017).

53. In the frequency bands of 20 to 500 Hz, background noise is heavily influenced by distant shipping. Ships produce continuous intense noise, with a large tankers producing sound at around 186 dB re 1 µPa at 1 m. The noise generated by vessels comes primarily from propeller cavitation with some contribution from engine noise. While noise contributed by shipping to the marine sound scape varies between locations and is generally lower in the southern hemisphere, resulting in ambient noise levels around 10 dB less, ship noise is increasing globally as ship traffic, imports and exports increase (DOSITS 2019).

54. Ambient noise levels between 500 Hz and 100 kHz are largely due to spray and bubbles from breaking waves and increase with increasing wind speed. While above 100,000 Hz, thermal noise caused by the motion of water molecules dominates. In shallow bays, inlets and coastal areas below 40° latitude, snapping shrimp dominate the marine soundscape between 2 – 5 kHz with individual snaps having source levels as high as 189 dB re 1 µPa at 1 m (Erbe et al. 2015, McCauley et al. 2015).

55. Marine animals also produce intense sounds with whale vocalisations ranging from around 155 dB re 1 µPa at 1m, to up to 223 dB re 1 µPa at 1m for sperm whale clicks. A humpback whale slapping its fluke or pectoral fin on the water can produce sounds of up to 192 dB at 1 m (DOSITS 2019).

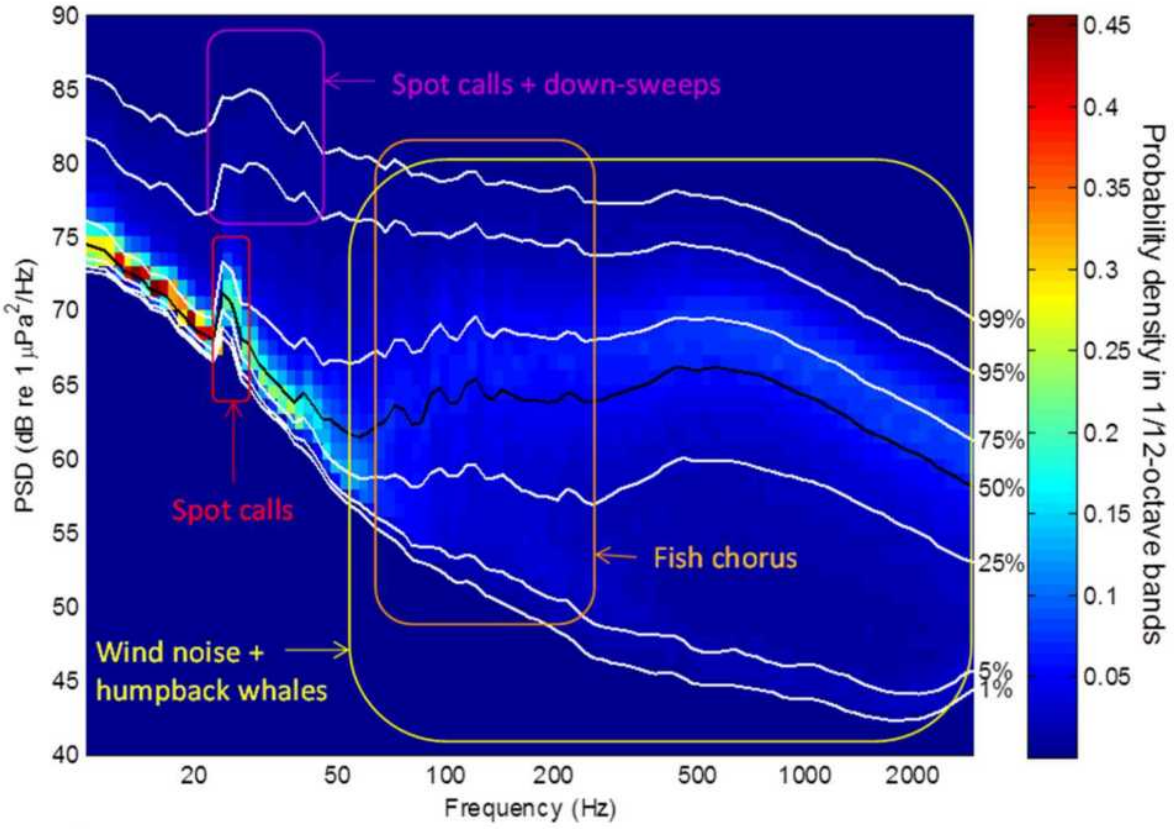


Figure 7: Wenz curves showing ambient noise spectra levels from natural and anthropogenic sources for the Great Australian Bight. Source: Ward et al. 2019

56. Figure 7 shows ambient noise levels recorded from the Great Australian Bight, with noise in the frequency bands of 20 to 75 Hz dominated by vocalisations from southern right whales and a detectable peak in noise levels corresponding to spot calls and another corresponding to down sweep vocalisations. The fish chorus is evident from 75 to 250 Hz, and humpback whale vocalisations and wind noise dominates from 50 to 2,000 Hz. Source: Ward et al. 2018.

57. The ocean is a noisy place and becoming increasingly so. Much of this noise can be attributed to natural sources, and increases in ambient noise levels in the frequency bands corresponding to low frequency cetaceans (whales) have been shown to be largely due to increases in the populations of these animals themselves, as populations of baleen whales continue to recover post whaling (Jolliffe et al. 2019). Peaks in power spectral density (PSD) curves often correspond to peaks in the presence of biological sound sources within an area. For example blue whales can

raise ambient noise levels by 10 to 20 dB during peak presence (Jolliffe 2019). Ambient noise levels in the frequency bands corresponding to whale vocalisations are likely to continue to increase in line with the increase in population numbers and whale caller density in Australian waters (Jolliffe 2019).

58. One of the loudest sources of anthropogenic noise is military sonar. The US Navy's AN/SQS-53C mid frequency sonar produces sound with a broadband source level of 235 dB re 1 µPa at 1 m (DOSITS 2019). Military sonar has been linked with indirect mortal impacts to mid frequency cetaceans in the canyons of the Bahamas and Canary Islands (Balcomb and Claridge, 2001; Martin et al. 2004). Mass stranding of beaked whales in the wake of US and NATO naval exercises are thought to be the result of acoustic trauma and behavioural disturbance, resulting in decompression sickness when the usual dive patterns of deep foraging cetaceans are disrupted by noise from military sonar (Parsons 2017).

59. Military sonar represents a short term activity with potential serious impacts due to the high intensity of the sound in the mid frequency bands. Ship noise on the other hand is a continuous contributor to the marine soundscape and continues to increase as the oceans become busier, representing one of the most pervasive and enduring sources of anthropogenic noise. Despite the noise contribution of shipping, ship strike remains the biggest threat to large cetaceans with direct mortal impacts (Thomas 2016).

60. When compared to shipping, seismic surveys represent a shorter term input to anthropogenic noise, and despite the sensitivity of many receptors to intense impulsive sounds, strict regulations are in place for the conduct of seismic surveys in Australian waters which prevent physical injury to marine fauna and disturbance to fauna during critical life stages.

4.1.5. Sensitivities of the Australian environment

61. The unique offshore environment of Australia encompasses a variety of habitats from tropical waters to temperate seas and the variety of ecosystems and species they support. The OPGGS (Environment) Regulations 2009 define the environment as:

a. Ecosystems and their constituent parts, including people and communities; and

b. Natural and physical resources; and

c. The qualities and characteristics of locations, places and areas; and

d. The heritage value of places; and includes

e. The social, economic and cultural features of the matters mentioned in paragraphs (a), (b), (c) and (d).

62. For the purpose of environmental impact assessments, it is important that the potential impacts and risks from seismic surveys are described in the context of the environment in its entirety. Thus it is not only the individual receptors that are of concern, but the habitats and resources that support them, their ecosystems, the people that use and rely on these, and the socioeconomic, cultural and heritage values of these ecosystems. Information about environmental sensitivities for the purposes of environmental impact assessments should be drawn from Bioregional Plans, Australian and State Marine Park Management plans, recovery plans, conservation management plans and other plans of management and data sourced from the Department of Environment

and Energy (DoEE) website in addition to the broader scientific knowledge base. Some of these sensitivities, and the habitats that support their critical life functions, have specific legislative requirements under the EPBC Act.

Threatened and migratory species

63. Australia is home to a number of listed threatened and migratory species including marine mammals, sharks, birds and reptiles. Australian waters are home to 45 species of whales, dolphins and porpoises, 11 listed shark species, and six species of marine turtle.

64. Listed threatened and migratory species are protected under the EPBC Act and seismic surveys must be conducted in a manner that will not result in unacceptable impacts to these species, consistent with species specific recovery plans and conservation advice. Anthropogenic noise is listed as a threat for marine mammals and marine turtles, and specific actions related to the conduct of seismic surveys are outlined in the respective recovery plans. Recovery plans exist for marine turtles, four species of shark and two whale species. Other relevant information about the protection status of marine fauna can be found on the Species Profile and Threats (SPRAT) database.

Biologically Important Areas

65. There are a number of Biologically Important Areas (BIAs) designated by the DoEE for marine species in Australian waters. BIAs are spatially defined areas of importance to regionally significant marine species. These areas are where biologically important behaviours, such as breeding, foraging, resting or migration are known to occur. BIA maps are available in relevant recovery plans, conservation management plans, the SPRAT database, and the National Conservation Values Atlas (NCVA) on the DoEE website.

66. The identification of BIAs is based on available scientific information and documented evidence of the species occurring in that area and particular behaviours occurring in that area. For many protected species, there are no defined BIAs as there is limited information on species distribution and habitat use. BIAs do not represent species' full ranges but rather identify areas of biological importance to the species.

67. While BIAs have not been designed to identify protected areas, and have no legal status of their own, they provide useful context in providing biological information to help inform environmental impact assessment and regulatory and management decisions. This includes actions and context contained in species specific recovery plans that may relate to BIAs and the management of human activities within them.

68. As the body of scientific knowledge grows, new and relevant species information may be used by the DoEE to update and improve existing BIAs, or create new ones.

The Commonwealth Marine Area

69. The Commonwealth marine area is broken into bio-regional areas, each with their own network of marine parks and management plans. Management plans set out the approach to managing Australian Marine Parks in Commonwealth waters. There are six marine park management plans in operation, one for each of the five marine park networks (North, North-west, South-west, South-east and Temperate East) and one for the Coral Sea Marine Park.

70. Environment plans for seismic activities must include relevant information and analysis that underpins a clear and well-founded case for why the activity will not be inconsistent with a management plan for an Australian Marine Park (AMP), and that the environmental risks and impacts of the activity are of an acceptable level. This includes taking into consideration the marine park values, including the representatives of relevant natural values, and demonstrating that the activity will not have unacceptable impacts on these values. Other relevant information may include marine park zoning and associated rules for activities, relevant management plan prescriptions and authorisations issues by the Director of National Parks (DNP).

71. Under the management plans, planned mining operations are generally allowable in Multiple Use Zones and Special Purpose Zones (IUCN category VI) or 'blue zones', with the exception of Special Purpose (Mining Exclusion) zones. Mining operations are not allowed to occur in any other zones of the parks. An exception to this general rule is where a titleholder is the holder of a prior usage right title, or has been granted a licence by the DNP to construct and operate a pipeline in a Category II or IV zone. Mining operations are prohibited in the Coral Sea Marine Park.

72. Mining operations include seismic surveys, and when assessing the potential impacts of these operations on the values of the marine park, proponents are required to do so in the context of the noise emissions that may extend further than the boundaries of the activity itself.

4.1.6. The types of impacts and impact pathways relevant to underwater noise

73. Impacts to marine fauna that could result from acoustic emissions in the marine environment include mortality, physical injury, hearing impairment (permanent or temporary threshold shifts), stress, diminished health, masking of communication, displacement from important habitats and behavioural disturbance. The extent, severity and duration of these impacts depends on the nature of the sound, the sensitivity of the receptor and its proximity to the sound source. For example, effects on marine mammals vary depending on their proximity to the source, with permanent threshold shifts in hearing only predicted to occur within very close proximity of the seismic source, while behavioural effects could occur out to 3 km from the source (Figure 8).

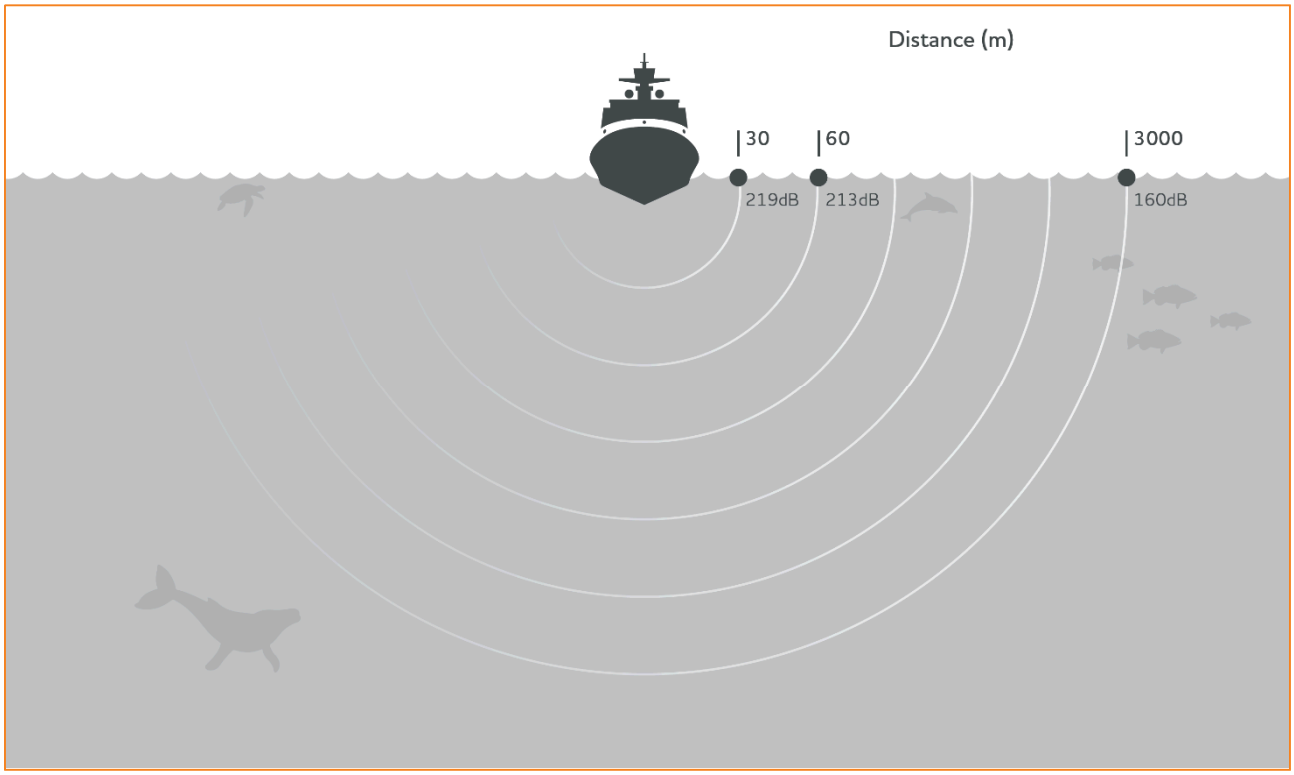


Figure 8: Noise ranges and effects in relation to source

74. Figure 8 provides an example of the ranges at which effects on marine mammals may occur for the operation of a 3150 cui seismic source. The permanent threshold shift (PTS) single shot threshold of 219 dB re 1 µPa is exceeded only within 30 m of the seismic source, while the temporary threshold shift (TTS) single shot threshold of 213 dB re 1 µPa is exceeded only within 60 m of the source. Behavioural disturbance may occur out to 3 km where single impulse received sound levels are 160 db re 1 µPa and above.

75. There are also a number of indirect impacts that may occur, including for example:

- Impacts on other trophic levels, e.g. prey displacement or depletion.
- Temporary reductions in catchability or stock availability of commercially targeted fish species.
- Reduced reproductive success.

76. There are a number of mechanisms by which underwater noise may affect marine fauna and these can vary according to the component of sound and the nature of the receiving organism. The broadband nature of seismic pulses means the sound falls within the communication ranges of most species and could prevent marine animals from hearing important sounds by masking natural signals, or cause them to alter their behaviour. For example, marine mammals such as whales have highly developed hearing systems and are sensitive to the pressure component of sound, whereas marine invertebrates sense vibrations and movements associated with the particle motion component of sound. More severe impacts such as physical injury only occur if the animals are very close to the source and receive very intense levels of sound (Southall et al. 2007, Popper et al. 2005).

77. The major marine fauna groups with potential to interact with seismic surveys that may be impacted by noise emissions include marine mammals, turtles, fish and invertebrates (including benthic species such as rock lobster and pelagic species such as squid).

78. Sound has the potential to affect these fauna groups in different ways depending on their behaviour, life stage, ecology and physiology. Different life stages may have different vulnerabilities. For example, calving whales are generally more sensitive to sound than migrating adults, and the physiology of hearing and presence of gas filled organs will also influence sensitivity to sound.

79. The information below outlines sensitive receptors within the Australia marine environment and how they may be affected by underwater noise.

Marine mammals

80. Marine mammals, especially cetaceans (whales and dolphins) are considered to be the most sensitive to anthropogenic noise impacts, as sound plays a critical role in their lives, from locating and communicating with each other, to navigating and finding food. The sensitivity of different species of cetacean to different sources of anthropogenic noise depends largely on the source. The high frequency component of seismic sound attenuates very close to the source and consequently, effects on high and mid frequency cetaceans are generally only possible very close to the seismic source (Southall et al. 2007). For seismic surveys that produce broadband signals with the energy concentrated below 100 Hz, low frequency cetaceans, primarily baleen whales, are considered to be the most sensitive, as this is the range within which their hearing is most sensitive, and their primary communication signals fall (Southall et al. 2007).

81. The potential impacts of high intensity noise on cetaceans include hearing impairment, such as PTS, where the hearing of an animal is permanently impaired (Southall et al. 2007, Finneran 2016, Southall et al. 2019) and TTS where the hearing is temporarily impaired (Southall et al. 2007, Finneran 2016, Southall et al. 2019). There is also the potential for behavioural effects where animals may be displaced or disturbed from biologically important behaviour, and masking of biologically important sounds produced by conspecifics (other individuals of the same species), which may make it difficult to find prey or hear sounds made by other species, making them vulnerable to predators (Erbe et al. 2016). Anthropogenic noise from commercial vessels contributes most heavily to the loss of communication space for baleen whales as a result of masking (Erbe et al. 2016). Behavioural responses to seismic have been documented in several studies with effects including avoidance, changes in calling rate, ceasing of vocalisations, decreased swimming speeds and changes in diving behaviour (Di Iorio & Clark 2009; Pirotta et al. 2018, Dunlop et al. 2017).

82. Acoustic trauma is a severe traumatic injury from sound that occurs as a result of the tissues inability to tolerate very high, sudden pressures from impulsive sounds. Injuries to the auditory system from extreme events such as explosions, blows to the head or concussive forces are often mistaken as acoustic trauma but are not caused by sound (Ketten 1995).

83. NOPSEMA considers it necessary for environmental impact assessment to consider the behaviour, habitat use and distribution of species within the activity area, as well as the extent (both spatial and temporal) over which impacts may occur. This includes not only the activity itself but the ranges at which noise emissions from the activity could impact upon cetaceans. The proponent

must implement suitable environmental management measures to prevent unacceptable impacts on cetacean species, or the habitats and ecological functions they depend on. This includes an assessment of the potential for an animal to be experience cumulative sound exposure, and the ecological implications of causing behavioural disturbance. For a number of cetacean species, BIAs have been defined to protect important habitats and subsequently prevent disturbance of animals engaged in critical life behaviours such as resting, foraging and calving, as well as allow animals to continue to utilise their migration routes.

84. Pinnipeds, including seal and fur seals, are sensitive to sound both in air and water and can be broken into two hearing groups, Otariids and Phocids (Southall et al. 2019). Both sea lions and fur seals belong to the family Otariidae, species of which have less sensitive hearing underwater than those belonging to the Phocidae family (true seals; Southall et al. 2019). Behavioural responses to anthropogenic noise have been documented for a number of different pinnipeds and often include seals hauling out of the water to evade the sound. Seals and sea lions can experience threshold shifts in a similar way to cetaceans when exposed to intense impulsive sounds, however they are considered to be less sensitive to underwater sound than cetaceans with the hearing range of Otariid pinnipeds underwater believed to be between 60 Hz and 39 kHz (NOAA, 2016).

85. The threshold values for TTS and PTS effects in Otariid pinnipeds are 226 dB re 1 µPa (Pk), 188 dB re 1 µPa (cumulative) and 232 dB re 1 µPa (Pk), 203 dB re 1 µPa (cumulative) respectively (Southall et al. 2019). These values are higher than the thresholds for cetaceans (NOAA 2016, Southall et al. 2019), and noise levels generally dissipate to below these levels within 10's to 100 s of metres of the sound source. Behavioural responses may be possible at further distances from the sound source, and thus NOPSEMA considers it important that a proponent's environmental impact assessment take into consideration critical life stages and important behaviours and habitats for these species, and the mitigate any potential impacts from their activity in the context of these.

86. In areas where seals and sea lions are likely to occur, such as the Great Australian Bight and Bass Strait, proponents are required to demonstrate through their environmental impact assessment that there will not be unacceptable impacts to pinnipeds, and where necessary implement controls to mitigate the impact to individual animals. The controls required under EPBC PS2.1 (discussed in Section 2.1.13), including soft starts, low power zones and shut down zones are commonly implemented for pinnipeds as well as cetaceans.

Marine reptiles including sea turtles

87. Six of the world's seven species of marine turtles occur in Australian waters and are protected under the EPBC Act. These species are the EPBC Act listed threatened 'endangered' loggerhead (*Caretta caretta*), olive ridley (*Lepidochelys olivacea*), and leatherback (*Dermochelys coriacea*) turtles, and 'vulnerable' green (*Chelonia mydas*), flatback (*Natator depressus*) and hawksbill (*Eretmochelys imbricata*) turtles.

88. Marine turtles are found throughout Australia's marine environment and are most common across northern Australia. Australia has some of the largest marine turtle nesting rookeries in the Indo-Pacific region and is the only country where flatback turtles nest (DoEE 2017). Key pressures on marine turtles include terrestrial predation of nests, marine debris, expanding urbanisation and industrial development of coastal strips, deteriorating water quality, loss of nesting and foraging habitats and fisheries bycatch (DoEE 2017).

89. Marine turtles can hear low to mid frequency sounds, but with less sensitivity than marine mammals. They appear to hear best between 200 and 750 Hz. Most evidence indicates that illegal fishing, bycatch and climate change are far more significant threats to marine turtles than anthropogenic noise.

90. The opening to a sea turtle's ear is covered by thick skin and a thick subcutaneous fat layer. This makes it difficult for turtles to hear well in air but provides good conductivity for hearing in water (DOSITS 2019).

91. The impacts of anthropogenic noise on marine turtles have not been well studied compared to marine mammals. Though erratic behaviour has been observed in response to sounds of greater than 175 dB and behavioural avoidance, in the presence of a seismic survey (McCauley et al. 2000, Weir 2007), very few studies have focused on potential physiological impacts on marine turtles. The Recovery Plan for Marine Turtles (DoEE 2017) in Australian waters lists anthropogenic noise as a potential pressure and requires a precautionary approach to be taken such that seismic surveys that may overlap with biologically important habitat are scheduled to occur outside biologically important times.

92. NOPSEMA requires proponents to conduct thorough environmental impact assessment into the occurrence, habitat use and behaviour of turtles within the activity area and surrounding waters to establish whether there is any potential for impacts to marine turtles or their habitats. Where turtles are likely to be present within an activity area, or there is an overlap with important habitat for turtles, suitable environmental management measures will need to be implemented to prevent unacceptable impacts on marine turtles. This includes preventing injury to turtles, damage to their habitat, or disturbance of turtles engaged in critical life functions such as nesting or foraging.

93. Australia is also home to a number of listed sea snake species. In particular, northern and north Western Australia are important region of high diversity and density of sea snakes. North-west Western Australia harbours two critically endangered sea snake species, the Leaf-scaled, and Short-nosed Seasnake, and one endangered species, the Dusky Seasnake. Pressures affecting seasnakes include climate change, fishing and trawling, and habitat modification. Reefs off NW Australia such as Ashmore reef have suffered significant declines in seasnake abundance in recent years, from unknown causes but possibly changing predator dynamics or disease.

94. Very few studies have assessed the potential impacts of seismic sound on sea snakes. Studies of hearing morphology in sea snakes indicate that they may detect particle motion and hear low frequency sounds within 100 m of the sound source (Crowe-Riddell et al. 2016). Sea snakes have not been observed to exhibit a behavioural response to sound, and it is suggested that they are less sensitive to sound than bony fishes and sea turtles (Chapuis et al. 2019). Consequently, seismic surveys are unlikely to impact upon sea snake populations and are not likely to be responsible for the population decline of sea snakes at Ashmore Reef (Crowe-Riddel. 2016).

Fish and sharks

95. Australia is home to around 180 species of sharks and sawfish, of which a handful are listed as threatened. The Grey Nurse Shark (east coast population) and Speartooth Shark are both critically endangered, while the Northern River Shark is endangered. Six species are listed as vulnerable

including the Grey Nurse (west-coast population), Whale Shark, White Shark, Dwarf Sawfish, Freshwater Sawfish and Green Sawfish.

96. Australian waters are home to more than 4,000 species of fish, many of which are commercially important, or protected under the EPBC Act. Five species of fish are listed as critically endangered, 18 are listed as endangered, 18 are vulnerable and eight are listed as conservation dependent. Australia's commercial and recreational fisheries target 68 different species (SoE Report 2016).

97. The extent to which seismic sound may impact upon fish depends on their morphology and behaviour. The severity of impacts will also vary spatially and temporally depending on species distribution and timing of spawning.

98. There is a growing body of knowledge regarding the nature and extent of impacts to fish and the fisheries that target them, however there is more work to be done (Slabberkoorn 2016, Slabberkoorn et al. 2019). Physical harm to fish is only possible at very close ranges to typically brief but high powered sources (Slabbekoorn, 2016). Seismic sound has the potential for ecological impacts to fish through short and long term impacts on behaviour (Slabberkoorn 2016), damage to the otolith-macula system for hearing, balance and depth perception, reduction in egg viability, masking of communication or acoustic cues and potential mortality at all life stages (Carrol et al. 2017).

99. Although sound level thresholds have been proposed for mortality and potential mortal injury in fish (Popper 2003), there has been no scientific evidence of mortality to fish or observation of fish mortality as a result of marine seismic surveys. The proposed thresholds are based largely on studies of barotrauma in fish as a result of low frequency sound produced by pile driving (Casper et al. 2012b, Halvorsen et al. 2012, Casper et al. 2013a, Casper et al. 2013b, Halvorsen et al. 2013). A number of studies have exposed caged fish to seismic sources and observed no lethal impacts, or increased mortality levels as a result. Similarly, fish monitoring and abundance studies conducted at Scott Reef alongside a 3D seismic survey found that the actual effects of exposure to a seismic survey were less than predicted (Grebe, Smith & Reid, 2009). Specifically, there was found to be no detectable effect of the seismic survey on the overall species abundance and richness at six sites around Scott Reef (Miller & Cripps, 2013). In addition, although hearing loss has been documented in fish it has generally been found to recover rapidly (~24 hours; Popper et al. 2005). The most relevant considerations for fish are likely to be behavioural disturbance during biologically important life stages (e.g. spawning) or to fished populations that may become more difficult to capture during the disturbance period.

100. There are also potential economic impacts to fisheries as a result of ecological impacts to fish. For example, there is speculation that seismic surveys may result in a reduction in catch as a result of changed behaviour, disruption of fishing operations, long term impacts on spawning and recruitment, and cumulative impacts resulting in a decline in species abundance.

101. All fish studied to date can detect sound, although some are more susceptible to impacts from seismic sound than others. Many fish and invertebrate species spend part of their life in a planktonic phase. Larval fish have similar hearing thresholds to their adult counterparts and those with swim bladders may develop them in the planktonic phase which may render them susceptible to barotrauma. Fish with a gas filled swim bladder or specialised hearing structures are considered to be at greater potential to be affected by seismic sound and the thresholds for

injury and potential mortality are lower than that of fish without specialised hearing organs or swim bladders (Popper et al. 2005).

102. Teleost (bony) fishes possess an otolithic organ. Fish hear via inertial stimulation of the otolithic organs as a result of the particle motion component of sound. Cartilaginous fishes including sharks and rays possess similar structures with the addition of a macula neglecta. Fish with gas filled chambers such as swim bladders are more sensitive to sound pressure. Swim bladders can be connected to the ear and have a role in hearing, or can be close to the ear but not internally connected. Fish with a swim bladder connected to the ear have heightened hearing sensitivity as the sound pressure results in the gas filled chamber oscillating in volume which in turn stimulates the ear. Fish with a swim bladder not connected to the ear are susceptible to physical injury from rapid changes in pressure (i.e. barotrauma) however have less sensitive hearing and are only receptive to particle motion. Some species of fish, such as Southern Bluefin Tuna (SBT), are believed to have poor hearing sensitivity and be largely visual predators, as their inner ear morphology has a somewhat fortified structure with dense fatty material in place of fluid like matter in the inner ear, and a thick cartilaginous material in place of a membranous labyrinth. These are likely adaptations to protect the ear of the SBT from flow noise associated with swimming at great speed, and the pressure of diving to great depths (Popper 2003, Evans et al. 2018).

103. Impacts to fish can be classified as mortality and mortal injury, recoverable injury, permanent threshold shifts in hearing (PTS), temporary threshold shifts in hearing (TTS), communication masking and behavioural impacts. Behavioural impacts may result in disruption to biologically important behaviours such as spawning are of increasing concern given the potential to impact on the sustainability of fish stocks.

104. Studies of indicator species for Australian fisheries have found commercial fish stocks to be generally well distributed and well connected throughout their range based on the wide ranges of single biological stocks. This indicates that impacts associated with short term and localised disturbance to fish spawning behaviour from seismic surveys are likely to be lessened by recruitment from other parts of the range that will limit the potential for long term or stock level impacts (Status of Australian Fish Stocks Report, 2018).

105. Site attached fish are considered to be more likely to be impacted as they are unlikely or unable to avoid a seismic source given their limited home range. Impact assessments should consider the different behaviour of site attached fish when compared to non-site attached species that are more likely to swim away from the seismic source.

106. Of the fish in which TTS effects have been studied, recovery has been shown to occur within 24 hours (Popper et al. 2005) showing that impacts to hearing were mostly short term and recoverable.

107. The impacts of seismic surveys on fisheries are difficult to measure because annual catch and effort data for a fishery are likely to vary based on a number of different factors including natural variability in fish distribution and abundance and other natural and anthropogenic pressures on the fishery. NOPSEMA requires that seismic survey proponents conduct an analysis of the potential impact from their activity on fisheries by firstly quantifying the overlap in time and space of the seismic survey with the fishery and then evaluate the potential consequences of this interaction to the fishery. Proponents must reduce their impacts on the fishery to levels that are

acceptable and as low as reasonably practicable. They may do this by adjusting the survey design to avoid spawning times/areas and key habitats for site-attached fish or reducing the spatial overlap with the planned fishing activities. Titleholders are also required to consult with the relevant fisheries when preparing their environment plan and to inform the survey design.

108. Soft starts, where the level of sound from a seismic source is slowly increased over time, are designed to provide warning to cetaceans affording them opportunity to avoid the seismic source and likely provide similar opportunity to free-ranging fish species to avoid the area.

109. For fisheries such as the Southern Bluefin tuna fishery, where behavioural disturbance to schools of fish may disrupt ranching operations, additional mitigation measures may be necessary. For example aerial surveys to detect schools of tuna and continuous monitoring of schools to maintain a buffer between the seismic vessel and the tuna that would prevent behavioural disturbance may be required, in addition to shut downs and relocation of the vessel within the survey area if schools of tuna were to be in close proximity.

Marine invertebrates

110. Marine invertebrates represent the vast majority of marine biodiversity and include many different organisms from sponges and corals, to worms, sea urchins, nudibranchs, sea cucumbers and crustaceans. Marine invertebrates occur throughout the water column, from seafloor to sea surface and also within the substrate itself. Many species of marine invertebrate are commercially important such as crabs, crayfish, prawns, scallops and oysters, while others such as reef building corals and nudibranchs are important attractions for tourism. Marine invertebrates also play a vital role in the ecosystem, often providing essential habitats for other species.

111. There are a number of marine invertebrate species that are of commercial importance that could be affected by sound from seismic surveys. Concerns specifically exist regarding the potential impact of sound produced by seismic surveys on rock lobster, crab, octopus, scallops and pearl oysters. These species have flesh that is of similar density to the water and no specialised hearing organs meaning that the wave component of sound is unlikely to have any effect on them.

112. Invertebrates are generally considered to be less sensitive to sound impacts as they lack a gas-filled bladder and therefore unable to detect pressure changes associated with sound waves. Particle motion aspects of sound can be detected with sac like structures called statocycts that are present in all cephalopods, some bivalves, echinoderms and crustaceans. Cephalopods (squid, octopus etc.) have epidermal hair cells that allow them to detect particle motion similar to the lateral line in fish, while decapods (lobsters, crabs, prawns etc) have sensory setae (stiff hair-like structures) on their body which may be used to detect low frequency vibrations.

113. Marine invertebrates with sensory “hair” cells are likely to be sensitive to particle motion that results in water movements close to the sound source and may result in damage to these hair cells. The hair cells may allow for sensing of nearby prey or predators, and help with navigation and orientation.

114. No mortal effects have been observed for marine invertebrates from seismic surveys, however the particle motion aspect of sound has been found to result in damage to lobster statocysts (a sac-like structure containing sensory hairs which is involved in balance and orientation) which may impair the ability of the animal to right itself (Day et al. 2019, Day et al. 2016). Studies on the

larvae of commercially important invertebrate species have not observed any mortality above natural mortality levels, even when exposed within 10 m of an airgun array (Day et al. 2016).

115. Many marine invertebrates may have a noise resistant physiology which is exemplified by the snapping shrimp which represents possibly the most significant contribution to biological sound in shallow temperate and tropical waters.

116. Marine invertebrates generally have far lower mobility than other pelagic species which results in limited ability to move away from seismic sound. However, they are often restricted to the benthos and in deep water, the sound received at the seafloor is often less than that emitted from the sound source.

117. NOPSEMA requires titleholders to undertake a thorough assessment of the potential impacts on all fisheries that are overlapped spatially by a seismic survey. Of the studies conducted to date on invertebrates, there has been limited effect observed from seismic on crustaceans, molluscs and bivalves, or their spawn (Christian et al. 2003, Payne et al. 2007, Day et al. 2016b). Those studies that have observed effects, such as physiological trauma to cephalopods (Andre` et al. 2011, Sole´ et al. 2013), have involved unrealistic laboratory conditions where animals were exposed to much higher levels of sound energy than they would be from an actual seismic survey or exposed within glass tanks (Carroll et al. 2017). Similarly, the environment which the sample animals are taken from may influence their response to sound, with populations that are regularly exposed to high levels of ambient noise likely to be adapted to higher anthropogenic noise levels. A study by Regnault and Lagardere (1983) observed a change in the metabolic rate of shrimp when exposed to seismic sound in glass jars. These shrimp were not only exposed within a small glass container but were taken from a natural environment with little anthropogenic activity and ambient noise levels of around 50 dB.

Seabirds

118. Australia is home to a large number of listed migratory and marine seabirds. While there is very little information on the hearing abilities of aquatic birds, those species for which hearing sensitivity has been measured, have greatest sensitivity to sounds in air between 1000 and 3000 Hz (Crowell et al. 2015). Underwater hearing sensitivity, is difficult to study, though was measured in a male cormorant, with the greatest sensitivity occurring at 2000 Hz (Hansen et al. 2017). Studies of the auditory systems of aquatic birds indicate some species may possess special adaptations for underwater hearing, and the high pressures associated with diving to depth, and hitting the water at speed (Ketten 2008, Sade et al. 2008).

119. There is no research to suggest that anthropogenic noise causes mortality or injury to seabirds, however given their high frequency hearing ranges, any impacts are likely limited to behavioural responses.

120. Sound does not readily transmit between two mediums with the air-sea interface acting as a barrier that reflects most underwater sound back into the water column. Consequently, it is only whilst diving that seabirds may be exposed to underwater noise.

121. There is evidence to suggest that African penguins may alter their foraging behaviour in the presence of seismic activity, with penguins foraging further from the seismic vessel during seismic surveys. Foraging behaviour returned to normal at the cessation of the survey with no evidence of long term behavioural impacts (Pichegru et al. 2017). However, it is not clear whether the change

in penguin foraging behaviour is related to avoidance of seismic noise or in response to changes in the distribution of prey.

122. There is no evidence of long term impacts to penguins from seismic surveys. Where a seismic survey is proposed to overlap with important penguin or seabird habitat, NOPSEMA would expect a proponent to provide a scientifically supported evaluation of the risks and impacts of the activity on penguins and other listed seabirds. Where necessary, the proponent may be required to implement controls to temporally or spatially avoid important habitats, such as those used for nesting and foraging, during important times. In addition, should the survey be proposed to overlap an area that constitutes important foraging habitat, NOPSEMA would expect that the potential impacts to the prey species that support the seabirds and penguins also be evaluated.

Plankton

123. Zooplankton is the name given to the array of organisms that drift on ocean currents with weak or no swimming ability. Zooplankton are the animal component of plankton and feed on phytoplankton, detritus and other zooplankton. Zooplankton is made up of an assortment of species, from copepods and protozoa that spend their entire life in a planktonic phase to the larvae and juveniles of benthic invertebrates, fish and crustaceans that will spend a portion of their life cycle in a planktonic phase.

124. Zooplankton represent a secondary level of productivity and are often found in high abundance in areas where there have been blooms of phytoplankton, or primary productivity. Plankton form the foundation of the food web and are fundamental to life in the oceans. Certain regions of the marine environment have bathymetric and oceanographic properties that create conditions suitable for blooms of phytoplankton. This primary productivity supports zooplankton and the rest of the food web and is considered an important value of many marine parks and areas.

125. While zooplankton lack highly developed auditory systems that are sensitive to sound, the particle motion component of sound has been shown to have potential mortal and injurious impacts on zooplankton (McCauley et al. 2017).

126. Despite the potential for mortality to plankton from seismic sound, it is important to note that one of the primary values of zooplankton is as a food source for other species and as such they have a very high natural mortality rate and typically, high reproductive rates. The impacts of seismic sound on plankton do not remove them from the food web and as such the nutrients and energy they contain are retained within the ecosystem.

127. Zooplankton are sensitive to a variety of activities and any boating activity including fishing, shipping and recreation has the potential to cause mortality to plankton from the boat propeller and wash.

128. Mortal impacts to individual zooplankton, including fish eggs and larvae, have typically been documented within close range (< 10 m) to seismic airguns (Fields et al. 2019), with the exception of one recent study (McCauley et al. 2017). This study was of short duration with a low level of replication and should not be considered in isolation of other relevant research. The major considerations for impacts to zooplankton is the potential for indirect impacts up the food chain or implications for fisheries recruitment.

129. Following the McCauley et al. (2017) paper and the finding of potential impacts to zooplankton from seismic airguns at a greater range than previously documented, Richardson et al. (2017)

undertook modelling to put the results of this paper into a real world context. The modelling found that due to high natural replenishment rates of zooplankton and dynamic ocean conditions, effects from a real world seismic survey were likely to be short-term and relatively localised. The Richardson et al. (2017) report also included some recommendations for conducting seismic surveys in a manner that would lessen the impacts on the productivity values of marine areas.

130. Richardson et al. (2017) indicated that surveys conducted in regions with more dynamic ocean circulation are likely to have less net impact on zooplankton than surveys undertaken in less energetic environments. Additionally, surveys conducted off the shelf edge in deeper waters, or in seasons where there is typically lower biomass (i.e. outside upwelling periods) are likely to have less of an absolute impact despite the effect on individual zooplankton being the same. Surveys can also be designed to have less of an impact by orienting sail lines at a 45 degree angle to the prevailing current to prevent multiple exposures to the same patch of zooplankton.

131. When considering the potential impacts of seismic on zooplankton, NOPSEMA recognises the value of the zooplankton as the foundation of a productive ecosystem. Consequently it is not the impact on individual zooplankton that needs to be considered but the impact on the available biomass of zooplankton. Taking the Richardson et al. (2017) report into consideration, if impacts on zooplankton in regions of high productivity can be minimised by orientating survey lines across prevailing currents to maximise replenishment into the region and minimise exposure of individual zooplankton, then further surveys should be scheduled outside key upwelling areas at known upwelling times.

132. Many fish and invertebrate species spend part of their life in a planktonic phase. Larval fish have similar hearing thresholds to their adult counterparts and those with swim bladders may develop them in the planktonic phase which may render them susceptible to barotrauma.

133. Zooplankton have external sensory hairs that may vibrate with the particle motion aspect of sound to the point where damage to sensory hairs or tissue may occur. These hairs may be extremely sensitive to sound.

134. Peer reviewed thresholds for sound levels that may cause mortality and potential injury are relatively high and associated with relatively close-range exposure. Consequently, anthropogenic sound impacts range from no effect to mortality/tissue injury within close proximity of the array (e.g. tens of metres). Current evidence suggests that any impact from seismic sound is limited to close proximity to the array. In the context of recruitment into an area which is high in well mixed oceanographic environments, and limited exposure of individual planktonic animals to the array due to currents and water movement, impacts from seismic surveys on plankton are localised and recoverable and unlikely to result in changes to the availability of plankton to higher trophic order species.

135. Laboratory experiments that exposed larvae to intense, long duration sounds that are not representative of real world conditions, have resulted in observable impacts on snow crab eggs (Christian et al. 2003). However work building on this study (DFO 2004) has found no effects on crab and lobster larvae even within close proximity of a seismic array (Pearson et al. 1994; Day et al., 2016).

136. Despite potential mortality impacts on zooplankton, it is noted that for significant impacts at the ecological scale to occur, the temporal or spatial scale of the seismic survey would have to be very

large in comparison to the ecosystem concerned. Richardson et al. (2017) concluded that the area of impact was greatest within the survey area (+2.5 km) buffer and that zooplankton biomass in a well-mixed environment can return to normal within three days of the survey concluding. While there may be substantial impacts to zooplankton on the local scale within and close to the survey area, the effects at a regional scale were negligible and consequently unlikely to have wider ecological effects.

137. Key findings from these studies are used in NOPSEMA assessments noting that while impacts of seismic on zooplankton have been reported, these need to manifest at the population level to have an impact within the marine ecosystem. NOPSEMA requires impact assessment to consider the impact on plankton and the ecological value it represents as a resource for higher trophic levels. This includes considering the extent of the impact and the likely recovery time in the context of the spatial and temporal extent of the survey. Specific actions can be included to minimise impacts such as orientating survey lines across prevailing currents to maximise zooplankton and minimise exposure and scheduling surveys outside key upwelling areas at known upwelling times.

4.1.7. Other pressures on marine fauna

138. While seismic surveys do contribute to pressure on marine fauna by introducing underwater sound, it is a non-extractive activity that does not aim to have mortal effects. Marine fauna are subject to numerous other anthropogenic pressures which, unlike seismic surveys, have commonly been associated with reported mortal effects on marine fauna, e.g. commercial fishing and shipping. In order to properly manage the range of marine activities that may occur across a region in a sustainable way, it is important to consider all of the pressures on marine fauna from the various different sources of anthropogenic noise and other impacts, and not simply consider individual pressures in isolation.

Unlike other marine activities such as fishing, there is no allowable incidental take of protected species during the conduct of seismic activities. In particular all mortality of EPBC listed species from seismic surveys is prohibited and could result in enforcement action under the EPBC Act or OPPGS Act.

139. Marine mammals in particular face threats from many different human activities. Fisheries bycatch is responsible for killing more marine mammals than any other anthropogenic activity with a global estimate of more than 650,000 marine mammals killed annually (NRDC, 2014). Shipping is recognised as the leading cause of mortality for whales with an estimated 80 whales per year killed by ships off the coast of California alone. Whaling and dolphin hunts kill thousands of cetaceans a year, with Japan recently joining Iceland and Norway as the only countries to continue commercial whaling. While the drive hunts of the Faroe Islands and Taiji kill hundreds of pilot whales and dolphins per year (Vail et al. 2019; Singleton & Fielding 2017). Killer whales and dolphins are also hunted by subsistence fishers in parts of Indonesia.

140. Fishing is an extractive industry with a take of over 160,000 tonnes per annum (2014-2015 data). Of 294 fish stocks assessed in the Status of Australian fish stocks reports 2016, 175 were assessed as sustainable with a take of over 115,000 tonnes. Twenty-six stocks were assessed as transitional depleting, with a take of 4,000 tonnes, nine were transitional recovering with take of 1,000

tonnes and 17 were overfished with a take of 9,000 tonnes. Forty-nine stocks were undefined with a take of 6,000 tonnes while five stocks were listed as environmentally limited with no take (ABARES 2018). Of the commercial fish catch within Australia, Western Australia contributes 24 per cent of the value of wild-caught fisheries production, while South Australia contributes the highest catch with over 44,000 tonnes per annum. Commonwealth managed fisheries catch over 39,000 tonnes per annum representing 23 per cent of the value of wild-caught fisheries (Evans, Bax & Smith 2016). In contrast, seismic surveys are designed with a precautionary approach to address scientific uncertainty about the impacts of sound to fisheries to avoid mortal impacts to all commercially important fish species and avoid disturbances to these species during sensitive time periods that may impact significantly on the commercial fishery.

141. In addition to target species, nearly all commercial fisheries catch other species, while these are mostly other fish or invertebrate species, they can also include protected species. In Australia interactions with EPBC Act listed species are reported under all state and territory legislation however this information is not always readily available to the public in order to understand the impact of these activities. Impacts such as injury or death of protected species as a result of petroleum activities must be reported under the EPBC Act but also to NOPSEMA. There have been no incidences of protected fauna species injury or death reported to NOPSEMA as a result of seismic survey interactions. In addition, NOPSEMA inspections of seismic activities have not revealed evidence of impacts of this nature.

142. Interactions with listed species for Commonwealth managed fisheries are reported by the Australian Fisheries Management Authority (AFMA) on behalf of the fishers. Between 2012 and 2015, reported interactions for AFMA managed fisheries included 330 turtles, 32,214 sea snakes, 93 dolphins, 3 whales, 753 fur seals/sea lions, 399 seabirds, 1,636 sawfish, 899 seahorses or pipefish and 9,146 sharks. Reported interactions include those where the animal is alive, dead or unknown. Outside of regulated fishing, illegal fishing represents a considerable threat to the marine environment and is recognised as the greatest threat to the sustainability of fisheries. Between 1980 and 2003, illegal fishing increased from 24 per cent of the catch of commercial fisheries to 32 per cent in the eastern Indian Ocean (Evans, Bax & Smith 2016).

143. Interactions with protected species by fisheries is allowed under the EPBC Act as long as they are in accordance with accredited management plans or regimes. Some migratory species of shark, such as Mako and Porbeagle sharks, can be kept and traded if brought up dead. However, any listed shark species that are caught alive must be returned to the ocean unharmed. Generally, the number of protected species interactions reported by fisheries accounts for less than 10 per cent of the total catch (Evans, Bax & Smith 2016).

144. Underwater explosions used for construction purposes, military actions and fishing in some parts of the world are known to cause mortality in fish and mortal injuries in sea turtles and cetaceans. For example, humpback whales exposed to TOVEX explosives (detonation velocity of 4,500 m/s), had severe blast injuries and died within three days as a result. Similar injuries to that observed in human blast victims with massive cerebrospinal fluid pressure and brain trauma (Ketten 1995).There is a common misconception that seismic airguns produce ‘sonic booms’ that are similar to explosions and have similar impacts on marine fauna. Explosions result in an immediate pressurisation of the surrounding medium which allows for compressional waves to travel faster than the medium’s usual speed of sound. While both seismic airguns and underwater explosions

produce intense compressional waves of energy, seismic airguns produce sound waves while explosions result in shock waves. Sound waves are small-amplitude compressional waves that propagate at the local sound speed and leave the state of the medium unchanged once they have passed through. Shock waves by comparison carry much more energy and are non-linear waves, these waves travel with increasing speeds and 'catch up to one another' rapidly building up into a shock front. The shock front travels at supersonic speeds and abruptly changes the properties of the medium it passes through, generally leaving it at a higher temperature and pressure. Unlike sound waves where the peak pressure occurs in the middle of the wave, the peak pressure of a shock wave occurs at the leading front. Seismic air guns have a moderate pressure rise time that is much slower than that of high and moderate velocity explosives. It is the fast rise time of explosives that is believed to be the cause of mortal impacts. Studies have shown low velocity explosives with peak pressures much higher than 70 psi result in no harm to fish, while high velocity explosives with peak pressures of 40 psi result in mortal impacts (NOAA 1985). For this reason, it is not specifically the relative change in pressure caused by the wave but the rapid onset of that pressure change that results in concussive forces that can result in concussive brain damage, cranial fractures and haemorrhage.

4.1.8. Modelling: Understanding seismic sound emissions and potential impacts

145. In order to properly predict the potential impacts to marine fauna from a seismic survey, as part of the environmental impact assessment process, seismic survey proponents need to use robust methods to predict received sound levels from the seismic source proposed for use. This typically involves a combination of source and propagation modelling that takes into account the local environmental variables. The modelling outputs are then compared with receptor specific sound exposure thresholds (presented in peer reviewed scientific literature) to determine the ranges at which different effects on marine life are expected to occur.

146. While the requirement for noise modelling is not explicitly stated within the regulations, it is considered to be an important step to demonstrate that the impacts and risks of the activity are suitably understood. NOPSEMA does not prescribe how modelling must be conducted or by whom, however it is expected that the modelling consider site specific environmental, bathymetric and oceanographic variables, and place the modelled noise emissions in the context of sensitive receptors and important habitats. NOPSEMA employs staff who are suitably qualified and experienced to independently review the validity of modelling inputs and outputs, and their application to environmental impact assessment.

147. Effectively modelling sound propagation requires detailed environmental information on the sound transmission medium (e.g. temperature, salinity and density that inform sound speed profiles), seabed composition (e.g. particle size and material), and the bathymetry of the seabed. It is important that noise modelling takes these factors in to consideration and that modelling is undertaken at representative locations within the proposed survey area.

148. Oceanographic properties that contribute to sound speed profiles of the water column vary daily and seasonally. Seismic survey modelling inputs need to be reliable and have some level of conservatism built into them to provide confidence in the modelling outputs. For example, proponents should use the sound speed profile that would result in the worst case scenario for sound propagation in their models (i.e. received levels at sensitive receptors would be the highest).

149. One of the important factors that can affect the received levels of sound by receptors in the marine environment is the interaction of sound with the surface of the water and with surface ducts that can form between the water surface and other layers in the water column caused by differences in temperature, salinity and/or density. Surface ducts only form under certain conditions and are more common in low energy environments where the mixing of water due to wind, wave and current action is reduced.

150. Despite all attempts to design air guns so that sound propagates towards the sea floor, the omni-directional spread of sound in water means that there will still be some interaction of sound waves with the surface and this is described as a surface ghost. This 'ghost' reflection is modelled with a ray tracing model and is used to inform the worst case received sound levels. In general, oceanic conditions preclude low frequency sound from being trapped in the surface duct as the wavelength of the sound is too long compared to the depth of the sound channel and consequently the sound passes through and is not ducted. When sound passes between mediums of different sound speeds the 'ray' will be refracted upwards or downwards depending on if the sound speed of the medium it is entering is faster or slower than that it is coming from. Surface ducts occur as a result of stratification in the water column causing sound speed gradients that result in sound being reflected at the boundary of the two layers of water rather than refracted. If a sound wave is reflected at the boundary towards the surface it will then be reflected back from the surface and become trapped in the duct. Sounds that are trapped in the surface duct can travel for very long distances as opposed to those that are transmitted normally through the water column. Whether a sound can be trapped in the surface duct depends on the properties of the water column, the angle of incidence of the sound wave and the wavelength of the sound. The depth of the surface layer determines the frequencies of sound that can be trapped within the duct as the wavelength must be shorter than the depth of the surface layer in order for the sound to be trapped. For this reason, surface ducts, where they exist, generally can only trap high frequency sounds as the wavelength of low frequency sounds is too long.

151. With respect to the modelled potential for impact on marine fauna, both the peak and cumulative sound exposure needs to be considered, to assess the potential for impact on marine life. A precautionary approach should be taken to inform impact assessment and mitigation and to demonstrate that activities will not result in unacceptable impacts, particularly when there are high levels of scientific uncertainty around model inputs and predicted impacts.

152. Thresholds for behavioural impacts, and temporary and permanent hearing loss should be based on the most relevant and up to date peer-reviewed scientific literature. Examples of some of the most contemporary sources for threshold criteria that are commonly applied to the assessment of impacts on marine life include:

- Cetaceans/Pinnipeds– NMFS 2018 & Southall et al. 2019
- Fish/Turtle Injury/Larvae and Eggs – Popper et al. 2014
- Crustaceans and Bivalves – Payne et al. 2007, Day et al. 2016a
- Plankton – McCauley et al. 2017, Richardson et al. 2017
- Sirenians – Southall et al. 2019.

153. Where operations are proposed to occur within or adjacent to biologically important areas for critical life stages of a species, seismic survey operators must assess the potential for behavioural disturbance, displacement, communication masking as well as temporary and/or permanent

hearing impairment and mitigate for these impacts. For cetaceans, the appropriate behavioural disturbance thresholds are influenced by the biological and life stage context with more sensitive thresholds applied for cows with calves than to migrating adults.

154. In some cases, acoustic modelling is combined with animal movement modelling to determine the potential impacts of seismic sound on marine life. This form of modelling takes into consideration population density, distribution and likely behaviour of animals within the seismic survey area to provide predictions of the number of animals exposed to sound, the intensity of the exposure and likely effects. When considering the suitability of this modelling approach for assessing potential impacts on marine life, the inputs to the modelling should be carefully reviewed to ensure they are based on contemporary scientific evidence for behaviour, density and distribution appropriate to the environment in which the survey is proposed to occur.

155. The auditory thresholds of many species, particularly large whales, are based on extrapolation from observed effects on a limited number of species of captive odontocetes (toothed whales). These extrapolations have been improved through the use of auditory weighting functions, based on the auditory range of species as well as an assessment of hearing organ morphology (Southall et al. 2019).

156. Given the inherent difficulty in conducting experiments involving the controlled observation of large baleen whales, there are no direct measurements of potential threshold shifts in these species, only modelled thresholds. In light of this scientific uncertainty, a precautionary approach is needed and mitigation measures applied to seismic surveys to reduce the potential for temporary threshold shifts (TTS). This in turn will prevent permanent threshold shifts or more serious acoustic trauma from occurring, in accordance with the current Australian national guidelines for the management of interactions between seismic surveys and whales (EPBC Act Policy Statement 2.1).

4.1.9. The body of scientific research and how it is applied to environmental impact assessment

157. Environmental impact assessment (EIA) is the process by which the potential environmental impacts from an activity are identified, analysed and evaluated in terms of their extent, severity and duration against pre-determined criteria informing an 'acceptable level' of impact. Management and mitigation measures are then applied to the activity to prevent unacceptable impacts from occurring and ensure that species and environments are protected.

When environmental impact assessment is informed by outcomes of the latest research, relevant scientific evidence and use of verified models, confidence in the predictions of the EIA process is improved.

158. It is important to recognise when the EIA supporting science may be incomplete or insufficient resulting in high levels of scientific uncertainty by applying greater levels of precaution when interpreting the EIA outputs and applying mitigation measures.

159. In Australia, EIA for seismic activities is the responsibility of the proponent and the outputs are then assessed by the regulator during the environment plan assessment. The high level process for EIA is built into the content requirements of the Environment Regulations. This process is

modelled on the Australian Standard for Risk Management (AS ISO 31000:2018). The EIA process, the requirements under the Environment Regulations and advice for titleholders on how to improve their management of seismic surveys is explained in more detail in NOPSEMA's Information Paper on Acoustic Impact Evaluation and Management in Appendix B of this document. The Information Paper also sets out some examples of measures to address predictive uncertainty and decision guidance on when they should be implemented.

160. In summary, there are three key steps in the EIA process that rely on supporting science; establishing the context for a proposed activity; the process of evaluating the predicted potential impacts on the environment in which the survey is proposed to occur; and deciding how the activity should be managed to ensure acceptable environmental outcomes are achieved.

161. Important internal and external context that needs to be considered when assessing the potential impacts of sound generating activities such as seismic surveys in order to decide if the predicted impacts will be acceptable includes:

- The nature of the activity itself, e.g. spatial and temporal extent and types of sound sources.
- The sensitivity of the receiving environment, e.g. what are the sound sensitive fauna groups that may be present at the activity location at the time the activity is proposed and any biological and physical sensitivities, as well as the nature of the physical environment itself in terms of sound propagation characteristics.
- The legislative requirements, guidelines and plans of management that are relevant to the activity and protection of species and places, e.g. Australian Marine Park Management Plans, bioregional plans, recovery plans for threatened whale species, National Water Quality Management Strategy etc.
- Input from and expectations of stakeholders or relevant persons that may be affected by the activity.
- The environmental policy of the company proposing to conduct the survey.

162. The process for evaluating and managing impacts typically entails:

- Identifying and detailing potential impacts
- Detailing the sound exposure regime and predicting underwater sound levels
- Defining the acceptable levels of impact and levels of protection required for specific places and species within them (using the context above).
- Evaluating the predicted impacts against the pre-defined acceptable levels and required levels of protection.
- Applying mitigation measures to reduce the predicted impacts down to acceptable levels and levels that are as low as reasonably practicable (ALARP).

163. Seismic mitigation measures and how science is applied to inform these are described in greater detail in section 4.1.13.

164. In cases where the science is incomplete or uncertain, a precautionary approach needs to be taken and additional management measures or changes to the location and/or timing of seismic surveys may be required to prevent environmental harm.

The science regarding the impacts of noise on marine life is not complete and will never be for all fauna groups. However the scientific knowledge base is rapidly evolving and the need to improve scientific understanding does not automatically mean that seismic surveys cannot be undertaken safely and without significant environmental harm.

165. Addressing the scientific uncertainty for seismic survey EIA and reducing the application of potentially overly precautionary mitigation measures can be done in a number of ways, including:

- Improving the understanding of the cause-effect pathway for marine sound impacts on sensitive and commercially important marine fauna.
- Enhancing the confidence in the effectiveness of control measures.
- In-situ measurement of received sound levels to validate sound level predictions.
- In-situ field studies to determine presence, abundance and behaviour of biota or validate predictions of impact on biota.
- Implementing adaptive management measures in response to information collected during activity implementation.
- Implementing strict control measures that exclude areas or time of particular biological sensitivity to prevent unacceptable impacts to marine fauna from occurring.

166. Some examples of how precautionary activity management and decision making has been applied to seismic surveys in order to address scientific uncertainty are provided in Table 1. This includes the management measure that was required by the regulator to address the scientific uncertainty.

Table 1: Examples of where a precautionary approach is needed

Area of scientific uncertainty	Measure to address
High levels of uncertainty exist as to effects of underwater sound from seismic surveys on pearl oysters within close proximity of the source.	Exclusion of seismic surveys in water depths less than 50m where suitable pearl oyster habitat exists. Large scale research program commissioned to investigate the effects of sound on pearl oysters – North West Shoals to Shore Program.
Underwater sound levels within a sensitive whale habitat are predicted to be close to levels of concern for particular species and life stage and there is uncertainty as to whether this level will be exceeded.	In-situ measurement of received sound levels at boundary of whale habitat during activity implementation to inform required buffer distance between survey and whale habitat during sensitive period.
Absence of or conflicting scientific studies to inform impact predictions for commercially targeted marine invertebrates.	Before After Control Impact (BACI) field study to determine impacts on target species and validate predictions of impact.
Uncertainty about the timing and distribution of whale movements and potential for interaction with the seismic survey.	An adaptive management process that involves collecting data on whale observations during the survey and using this data to inform decisions on management measures, e.g. moving to a different area or increasing the size of precaution zones.
Uncertainty about the effects of sound on fish spawning activity.	Exclusion of seismic acquisition in important fish habitat during the spawning period.

167. NOPSEMA does not undertake marine environmental research but does ensure that the best available science and appropriate seismic mitigation measures are applied by proponents to the EIA process and management of offshore activities and used to inform regulatory decision making. As an end user of the science to inform regulatory decision making, NOPSEMA takes an active role in promoting collaborative research efforts to answer high priority questions relevant to environmental impact assessment, environmental management of offshore activities and decision making.

168. There is no single repository or source of scientific research related to impacts from underwater sound. This can make it challenging and time consuming for petroleum companies, consultancies, management agencies and regulators to keep abreast of the latest research and what it means in the EIA context.

169. NOPSEMA maintains awareness of the latest science through subscriptions to scientific journals, participation in national and international regulatory forums, engagement with relevant industry bodies such as the International Association of Oil and Gas Producers (IOGP), the International Association of Geophysical Contractors (IAGC) and the Sound and Marine Life Joint Industry Programme, participation at relevant conferences and workshops and direct engagement with scientific experts nationally and internationally.

170. A number of scientific literature reviews (e.g. Carroll et al. 2017) have been undertaken in recent years on the topic of the effects of sound on marine life and these reviews assist with highlighting

available science as well as limitations in the scientific knowledge base that need to be accounted for in decision making and addressed by further research efforts.

171. An example of current research effort that once complete will provide a valuable contribution to understanding the impact from seismic surveys on marine fauna is the Australian Institute of Marine Science's North West Shoals to Shore Research Program. This collaborative research program is investigating the effects of seismic sound on demersal fish and pearl oysters to enhance the understanding of the impacts of seismic surveys on marine biota using a commercial scale seismic array in a real world setting. It is also noteworthy as an excellent example of collaboration between the research community, petroleum industry and the pearl fishing industry to address key science questions.

172. A further example of collaborative research effort that has been used to better inform EIA and the management of seismic surveys is the Behavioural Response of Australian Humpback Whales to Seismic Surveys study or the BRAHSS study. This study investigated the behavioural reactions of humpback whales to seismic air guns to determine if these have longer-term biological effects and also looked at the effectiveness of soft-starts as a mitigation measure.

173. There are also examples of studies that have been undertaken in parallel to a real world seismic survey. For example, the Gippsland marine environmental monitoring program undertaken by Geoscience Australia investigating potential impacts on scallops and demersal fish in order to prevent unacceptable impacts to these receptors. A number of papers were published as a result of this work. Studies such as this can assist with alleviating stakeholder concerns and contribute to the broader understanding of the impacts of seismic surveys on marine life.

174. Another large-scale study seeking to test the effects of a real-world seismic survey on a fishery is proposed for 2020 off the Gippsland coast. This study is funded in part by a seismic company with co-contributions from the Fisheries Research and Development Corporation (FRDC).

175. The FRDC awarded funding in June 2018 to the Western Australia Fishing Industry Council (WAFIC) for a three year national seismic research coordination project. The 'Seismic Response Project - Oil and Gas: National coordination - seismic and other issues' was to deliver; a publicly accessible research portal; reference cases (summaries of research); supported research applications; a 'best practice' document for commercial fishing representative bodies to use for EP submissions; and a 'best practice' document for commercial fishing bodies to use for fee-for-service EP consultation. In the roughly one and a half years since the project was announced, it appears that the output delivered is an excel spreadsheet (found linked on the FRDC website) containing a mixed collection of published literature, industry reports and media articles related to seismic (and other underwater noise) impacts. A summary of the 'research' is provided but is not peer reviewed, doesn't appear to have been developed collaboratively with other key stakeholders, has not had input or review by NOPSEMA and in NOPSEMA's view does not provide a balanced or reasonable reflection of the outcomes of many of the papers. See also Section 4.2.16 for information on the role of fisheries advocacy groups and contribution to conflict between fishing and petroleum industries.

176. The body of relevant science is considered by titleholders when considering the potential impacts to marine fauna from their survey and this is typically done for each of the fauna groups that have potential to interact with the survey. For fauna groups that have had limited scientific attention, it's important that all relevant science is considered, rather than only applying the latest science

or the science that supports the desired outcome and assuming the findings apply in all circumstances.

177. Science is important to inform a number of aspects of EIA for underwater noise, from describing the environment to understanding the potential impacts on different fauna groups (including the potential for cumulative impacts), understanding the resilience of those fauna groups to impacts and then evaluating the expected effectiveness of control measures. In order to continue informing EIA and best practice management of seismic surveys with contemporary science, it is important that research is designed with EIA questions in mind, outcomes are published in a timely manner and papers are preferably peer reviewed.

178. Availability of other data is also critical in producing well-informed impact assessments. For example, in order for proponents to adequately evaluate the potential for impacts on fisheries stocks and the ability of commercial fishers to catch their target species contemporary data on fish stock status, catch-effort data and biologically sensitive areas and times such as spawning areas/periods must be available. However, this information is often withheld from publication or not readily shared due to fishers concerns regarding identification of key fishing or spawning locations and mistrust of the use of data by the seismic industry.

4.1.10. Research challenges – application of science to EIA

179. There is a common concern that there is not enough research into the impacts of seismic or that this research is inadequate. While there will always be limitations in scientific knowledge, including coverage across specific locations, populations, species and life stages, there is a growing body of research nationally and internationally into the impact of anthropogenic sound on various marine fauna groups with increasing focus on seismic sound in particular. It is very important to apply the science appropriately to environmental impact assessment, recognise the limitations of the science and take a precautionary approach when there is scientific uncertainty in order to build confidence in management and regulatory outcomes.

180. Research focussed on underwater sound may be designed to observe specific effects and may be conducted in laboratory conditions, which may not be representative of real world conditions. Research that does not reflect real world conditions must be treated with caution and does not necessarily provide useful outputs to inform impact predictions or evaluation of seismic survey management effectiveness – two fundamental elements of EIA.

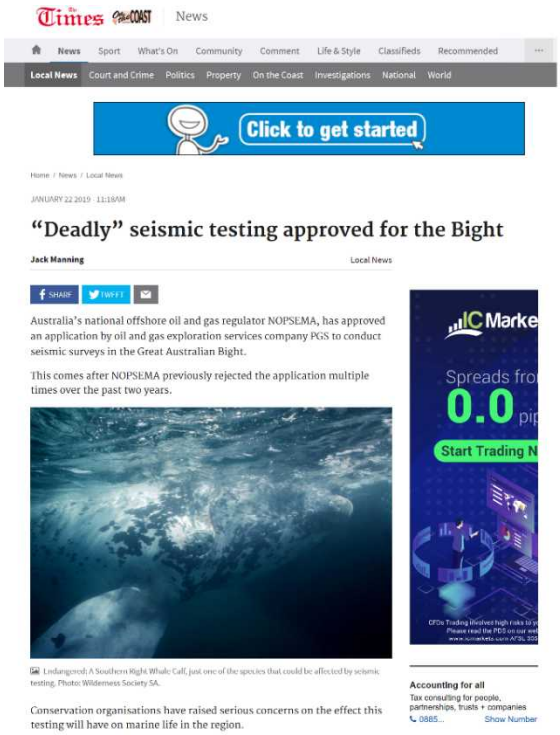
181. A big challenge for EIA, industry social licence, regulation of the industry and meeting community expectations is the misinterpretation and misuse of research. The outputs of research publications can be taken out of context, misinterpreted, selectively used to support a desired outcome, misapplied or inappropriately extrapolated to other species and locations when conducting EIA.

182. Misunderstandings of the nature of sound or seismic, and the misrepresentations of seismic impacts and research outcomes in the media also contribute to the gap between perception and reality. Unfortunately, the media is often not focussed on the scientific evidence and misrepresents or exaggerates the risks, impacts and residual uncertainty using emotive and extreme language to prompt an emotional response. This misrepresentation in turn can lead to high levels of public concern regarding the perceived extent and severity of impacts from seismic surveys (see Figure 3 below for some recent examples).

183. Unfortunately the oil and gas industry has also contributed to the misunderstandings about seismic survey impacts by underplaying the potential impacts. Seismic surveys have been described by the leading seismic industry representative body as "similar to an ultrasound imaging a human body" and having 'environmental benefit' because they reduce the number of wells that need to be drilled. There are also claims by industry that "currently there is no scientific evidence demonstrating biologically significant negative impacts on marine mammal populations" from seismic surveys without explaining that no scientific studies have been designed for this purpose. Industry representatives also state in website content that "seismic surveys are generally considered not to be harmful or damaging to the marine environment" without clarifying the circumstances where this may be true such as a well-managed seismic survey in a non-sensitive environment.

Neither the extreme position of 'terrible harm', nor the extreme position of 'no harm' from seismic surveys is accurate. The true environmental impact from well managed seismic surveys lies somewhere in between. Making extreme and inaccurate claims creates a challenge for establishing a consistent, evidence-based understanding of the impacts from seismic surveys on the marine environment across a broad audience.

184. This situation is further exacerbated because it is generally not well understood how precautionary approaches and existing research is applied in the environmental impact assessment process, management of seismic surveys nor regulatory decision making to ensure that unacceptable impacts to the marine environment will not occur.



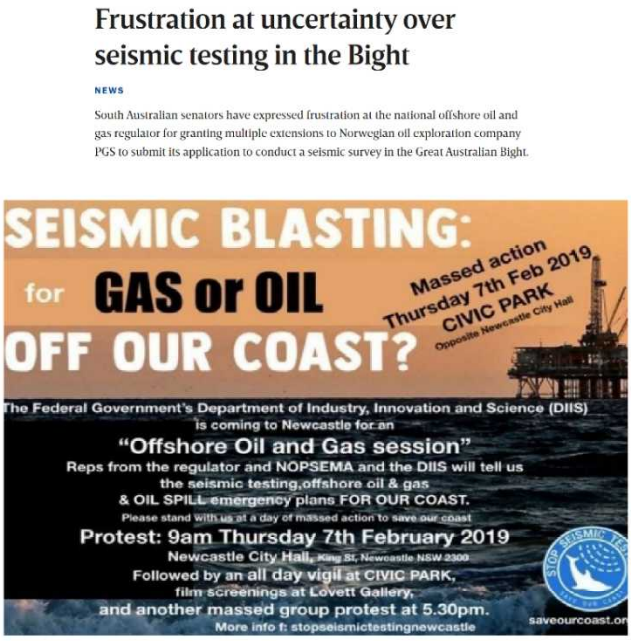


Figure 9: Examples of media interest in seismic activity around the world

4.1.11. Research application - case studies

185. While an internet search of the impacts of seismic surveying on the environment will bring up a lot of hits, a deeper dive into the literature shows that the majority of papers, even those whose titles contain words to the effect of 'Seismic Impacts on…' generally conclude that there are no clear impacts to environmental receptors from seismic exposure. Where physiological effects have been observed, implications at an ecologically meaningful level are unknown or untested, or the experimental design is not representative of real world exposures. While a number of studies have found lower level impacts in specific receptors, there is often no link with long term impacts on survivability and no clear ecological consequences from these impacts.

186. To demonstrate some recent examples where important research has been interpreted in various ways and reported incorrectly, some case studies are presented below.

- The Fisheries Research and Development Corporation (FRDC) funded research into the effects of seismic surveys on rock lobsters. One of the experiments involved exposing lobsters to sound from seismic surveys, flipping them onto their back and recording how long it took for exposed lobsters to right themselves, relative to non-exposed lobsters. The results showed that exposed lobsters took longer to right themselves. However, these results were characterised in the media as meaning that seismic surveys result in lobsters flipping onto their backs and being unable to right themselves. This interpretation was then perpetuated by stakeholders potentially affected by seismic surveys which led to concern although the ecological consequences of lobsters taking a longer time to right themselves was not investigated.
- The FRDC funded research into the impacts of seismic on both the rock lobster and scallop fisheries. The published results indicated that there was no direct mortality to scallops from seismic exposure. Increased scallop mortality in the experimental group was within natural ranges and thus was concluded to not represent a threat to the stock or fishery. Short term differences in the tail gape of berried lobster females was also observed, though these differences did not persist 120 days post exposure (Day et al. 2016). A decrease in the nutritional index of exposed lobster was also observed post exposure. However this was in response to chronic noise exposure (i.e. Repeated exposure to the air gun) and could not be replicated in other sample groups (Day et al. 2016). Consequently it was not clear whether the change in nutritional index was due to seismic airgun exposure or some other environmental driver. The physiological impairments observed throughout the study were deemed to be minor and did not result on an impact to lobster survivability (Day et al. 2016). Consequently there is no evidence that seismic airgun exposure has the potential to impact the stock or fisheries for lobster or scallops.
- A mass mortality event of scallops in 2010 nearby a seismic survey prompted an investigation that could not find any causal links between the seismic survey and the scallop deaths. This prompted a seismic exposure experiment seeking to investigate the effects on scallops. It was hypothesised that seismic may increase mortality in scallops by driving them to engage in more energetically costly behaviour, however the observed effect from seismic response was actually a decrease in activity. While the experimental group suffered a higher mortality rate throughout the experiment to the control group, the mortality rates that were recorded in the experiment were within the natural mortality range (Day et al. 2017) and therefore

could not be attributed to the seismic exposure. In addition, both the control and experimental groups suffered analogous 100% mortality 120 days post exposure (Day et al. 2017).

- A case of mass stranding of marine turtles on the coast of Israel, with significant physiological trauma resulting in the deaths of many turtles, was initially attributed by the local and international media to a seismic survey being conducted in offshore waters. The media reports were accompanied by graphic images of dead turtles washed up on beaches. However, following a very extensive investigation by the relevant Israeli authorities, it was later demonstrated that the timing and location of the seismic survey could not have caused the turtle mortality, nor were the injuries sustained by the turtles consistent with seismic activity. The claims made in the media that seismic activity was the cause of the deaths was also contrary to the results of studies that have deliberately exposed marine turtles to close range seismic sound which showed no effects of this nature. The turtles' injuries were more likely to have been caused by explosions of some kind.

187. There are also examples where experimental designs have included unrealistic sound exposure regimes and the negative impacts as a result of this exposure have been directly compared to real world seismic surveys incorrectly. For example:

- Studies on the impacts of seismic on fish often involve caging animals and exposing them to unrealistic levels of sound by restricting their ability to move away from the sound. One such study by McCauley et al. (2003b) found that hair cell damage in caged pink snapper exposed to seismic pulses showed increasing levels of damage for at least 54 days post exposure with no evidence of recovery within 58 days. While the effects did occur, the caged fish were unable to swim away from the noise as they would be able to in a natural setting and thus this experiment does not represent real world exposure.

- Another study reported malformations in scallop larvae after exposure to seismic sound but the sound exposure regime consisted of sound playbacks for up to 90 hours from a speaker 9 cm from the larvae (Anguilar de Soto 2013). This sound exposure regime significantly exceeds that which would be associated with a seismic survey in real world conditions.

188. Impacts from other sound sources have resulted in negative claims about the impacts from seismic surveys despite differences in the sound sources. For example:

- The mass stranding of beaked whales in the Bahamas in 2000 resulted in a temporary ban on naval sonar and seismic while the incident was being investigated. Both a seismic survey being conducted in the area and Naval exercises were suspected to have caused the mass stranding. It was concluded that the intense mid frequency sound produced by naval sonar was responsible for the injuries sustained by the beaked whales that ultimately led to their stranding. This example is often used to support arguments that seismic surveys may cause stranding as they too produce high intensity sounds.

189. Mass stranding of whales is an unfortunate event with a multitude of possible causes. While there is currently no clear understanding of why whales strand, some locations are more susceptible to stranding than others, such as Cape Cod and Farewell Spit. While individual baleen whales may strand, or wash up dead on beaches, smaller odontocetes such as pilot whales tend to strand en masse. The reason for this is the tight knit social bonds these species share with their pod that

result in all the animals within a group stranding, sometimes as a result of one sick or injured animal. Where necropsies can be performed, a cause may be possible to define, such as toxicity from algal blooms that caused a mass stranding of sei whales in Chile, malnourishment from plastic ingestion or lack of natural resources that is observed in increasing number of whale stranding globally, or chasing prey into unfamiliar dangerous waters such was the case for a sperm whale mass stranding in the North Sea in 2016 (Ijsseldijk et al. 2018).

190. Analysis of whale stranding occurrences around Australia was compared with the timing and location of seismic surveys and no causal links were found, rather a correlation between large-scale climatic events and significant stranding events was observed (Evans et al. 2005). While mass stranding has been observed in response to the use of naval sonar by the USA and NATO, there is no evidence that seismic causes whales to strand. Evidence of mass whale stranding exists from six to seven million years ago, long before anthropogenic sound became a factor and it is likely that any observable increase in occurrence is due to greater visibility of previously inaccessible coastline.

4.1.12. Research opportunities – reducing scientific uncertainty

191. Recognising that the science around the potential impacts of seismic sound on marine fauna is improving rapidly, there are still some key data gathering and collaborative research opportunities to further improve our understanding and potentially reduce the levels of the precautionary activity management and decision-making currently occurring.

192. Some of the opportunities for further development and improved levels of confidence in the existing body of research into the effects of anthropogenic sound, particularly noise emissions from seismic surveys are outlined below;

- Long term repeated experiments in space and time to secure confidence in current results, particularly for controversial studies (e.g. McCauley et al, 2017).
- Long term or cumulative effects of noise disturbance on animals, for example, in terms of the long term fitness impact from causing animals to deviate from their migratory pathway.
- Ecological consequences of impacts to larval stages of commercially important species.
- Threshold shifts in hearing – exposure and recovery times for various species and potential for threshold shifts to result in secondary consequences such as missed feeding periods or predator detection.
- Robust baseline data to enable effective post survey monitoring to allow assessment of management effectiveness for species where the potential for impact from underwater noise is high.
- Studies on the response of elasmobranchs (sharks and rays) to sound.
- Thresholds for auditory impacts for baleen whales which are currently based on extrapolation of a small number of studies on toothed whales which have a different auditory structure to baleen whales and use sound differently (i.e. echolocation).
- Implications of high levels of disturbance from underwater noise to marine turtles during critical life stages including physiological stress and impacts on nesting success.

- Research conducted in natural settings repeated over a sufficient timescale to account for natural variability. Similarly, tagging studies often used to inform movement patterns and distribution needs to reflect differences in the ecological context of the animal, such as gender, life stage etc.
- Greater understanding of the cause and effect relationships and the threshold levels for causing different effects on commercially important invertebrates such as scallops and rock lobster and the implications of these effects to relevant fisheries.
- Collaborative, inter-disciplinary research to investigate population level impacts of anthropogenic noise on fish and fisheries (Slabberkoorn et al. 2019).

4.1.13. Seismic Mitigation measures

193. Underwater sound from seismic surveys is capable of harming a range of biological receptors if not managed appropriately. Once the potential impacts to marine fauna are clearly understood by using science to inform the impact assessment process, appropriate seismic mitigation measures must be applied to reduce the potential impact. Many of these mitigation measures are commonly applied in other jurisdictions around the world and when applied with additional control measures such as avoiding particularly sensitive locations and biologically important time periods if necessary, seismic surveys can be conducted safely and without serious harm to marine faun, or ecological consequences. In situations where the impacts cannot be reduced to acceptable levels through the application of controls, the survey design may need to be altered significantly or the survey may not be permitted to occur.

194. If the evaluation of predicted impacts from seismic surveys demonstrates that acceptable levels of impact cannot initially be achieved, then additional management control measures need to be implemented to reduce those impacts down to levels that are both as low as reasonably practicable and acceptable.

195. Control measures that are commonly applied to seismic surveys in Australia and elsewhere around the world to reduce the potential for impacts to marine fauna such as fish, commercially important species and turtles typically include:

- Eliminating the impact by using temporal and spatial limitations in the survey design to avoid overlap with important areas at biologically sensitive time periods;
- Applying engineering controls by changing the survey configuration or array size to reduce the levels of sound being produced;
- Applying administrative controls such as adaptive management/mitigation procedures e.g. powering down to a lower level, shutting down the seismic source completely when marine fauna are observed within close proximity of the seismic vessel where impacts could occur, or moving to a different part of a survey area if high numbers of marine fauna are encountered.

196. The minimum standard for mitigation measures relevant to cetaceans in Australia is *EPBC Act Policy Statement 2.1* (EPBC PS2.1) developed in 2008 by the Department of Environment and Energy (formerly DEWHA). The guidance set out in the Policy Statement is broadly consistent with the International Joint Nature Conservation Committee (JNCC) guidelines for seismic survey mitigation, adopted in several countries around the world, with the exception that shut downs as additional precautionary measures are required under the EPBC Policy Statement and are not a feature in the JNCC guidelines.

197. EPBC PS2.1 applies a 'common sense' approach to mitigation such that shutting down the source when animals are within range of potential mortal and injurious effects will prevent serious impacts. The Policy Statement aims to 'provide practical standards to minimise the risk of acoustic injury to whales' in the vicinity of seismic survey operations, though is often applicable to other sensitive marine fauna as well. The Policy Statement provides a framework that minimises the risk of biological consequences from acoustic disturbance to whales in biologically important areas or during critical behaviours, as well as providing guidance to proponents and operators about their legal responsibilities under the EPBC Act (DoEE 2008). The Policy Statement focuses on baleen whales and large toothed whales (odontocetes) as they have hearing sensitivities that overlap with the frequency bands of seismic sound that contain the most energy. The management measures outlined in EPBC PS2.1 are divided into two areas, precaution zones and management procedures.

198. Precaution zones are based on the received sound levels an animal is likely to receive and refer to the observation, low power, and shut down zones that must be applied to seismic surveys. All seismic vessels must have marine mammal observers (MMO) on board to watch for whales in the vicinity of the vessel and seismic source and direct the seismic source operators to take the appropriate actions when whales are observed in order to prevent injury and disturbance. For surveys where the sound exposure level for one shot of the seismic source will not exceed 160 dB re 1 µPa at 1 m, the following precaution zones are recommended and applied at horizontal radius from the source:

- 3+ km observation zone
- 1 km low power zone
- 500 m shut down zone
- For all other surveys the following precaution zones are recommended:
- 3+ km observation zone
- 2 km low power zone
- 500 m shut down zone

199. The second area of EPBC PS2.1 refers to management measures and includes both standard management measures that must be applied to all surveys and additional measures to be implemented during more sensitive time periods for whales. The PS recommends where possible, that seismic surveys should not be programmed in areas where whales are likely to be breeding, calving, resting or feeding. However in reality, surveys in these areas are generally not permissible because they would be inconsistent with relevant Recovery Plans and other plans of management made under the EPBC Act and predicted impacts to protected species would likely be unacceptable.

200. The following measures must be implemented as standard mitigation for all seismic surveys, and appropriately trained crew must be available to ensure their effective implementation.

- Pre-start up visual observations (30 minutes minimum), out to and exceeding 3 km radius where possible.
- Soft starts (slow ramp up of the seismic array over a 30 min period)

- Operations procedure which includes continuous visual observations during daylight hours and power down when not collecting data.
- Stop work procedure where animals within the observation zone are continually monitored, if an animal enters low power zone the airgun array must be powered down to the lowest possible setting and if an animal enters the shutdown zone the airgun array must be shut down completely. Power up cannot occur until the animal moves outside low power zone or 30 minutes has elapsed since the last sighting.
- Night time and low visibility procedures that require there to have been less than three whale instigated power or shut downs within the preceding 24 hours for operations to be conducted at night or in low visibility conditions. During low visibility continual observation should be maintained where possible with a focus on the shut down and low power zones.
- All sightings, power downs and shut downs must be recorded and a report provided to DoEE within two months of survey completion.

201. PS 2.1 also advises that additional management procedures may be necessary where the likelihood of encountering whales is moderate to high and depending on the context including;

- The use of qualified MMOs with experience in whale identification and observation within Australian waters.
- Daylight spotter planes or vessels to search night time survey areas for whales or pre-survey research to provide higher confidence in the presence and timing of animals.
- Increased precaution and buffer zones to prevent displacement or disturbance of whales during critical behaviours, e.g. feeding.
- Passive acoustic monitoring to detect whales in real time.
- Adaptive management to deal with the encounter of higher than expected numbers of whales such as relocation within the survey area, ceasing of night time operations, increased buffer zones, etc.

202. While PS2.1 applies to whales specifically, the application of these guidelines affords a level of protection to other species as well. Shut downs are commonly implemented for other marine mammals including seals and dugongs, as well as turtles and whale sharks where there are expected to be high numbers of these animals. The distances to injury and mortality effects for these species are within close proximity of the source (generally less than 100 m) and consequently shut downs for animals within 500 m will dramatically reduce any chance of these impacts being realised. Soft starts are believed to provide a level of protection for most species, including turtles and demersal and pelagic fish species by eliciting an avoidance response in animals in the area (McCauley et al. 2000).

203. Studies into the response of humpback whales to seismic surveys in Australian waters (Behavioural Response of Australian Humpbacks to Seismic Surveys) have found that whales generally avoid the seismic vessel and source at distances greater than the standard precaution zones, indicating that soft starts are likely effective for humpback whales (Dunlop et al. 2017). In addition, a number of studies globally have tested the effectiveness of seismic mitigation

measures with a general consensus that soft starts can be an effective mitigation measure to reduce the risk of physiological harm to a range of species (Stone et al. 2017).

204. Statement 2.1 is considered the minimum standard for the management of seismic survey interactions with whales. In many cases, it is determined by the titleholder and/or NOPSEMA that this is insufficient to protect species during particularly sensitive time periods or particular locations. In those instances, the survey is either not permitted to proceed in its planned format or additional mitigation measures or exclusions must be applied to ensure that the survey does not result in unacceptable impacts to the environment.

205. The regulation of seismic in Commonwealth waters is discussed in further detail in Section 4.2. Under NOPSEMA's objective based regulation, it is the responsibility of the titleholder to demonstrate how control measures will be applied to manage the impacts of the activity to an acceptable level. Where an environment plan cannot demonstrate that a specific aspect of the activity will be managed such that it will not result in unacceptable impacts, the activity may be accepted in part or with limitations imposed by NOPSEMA.

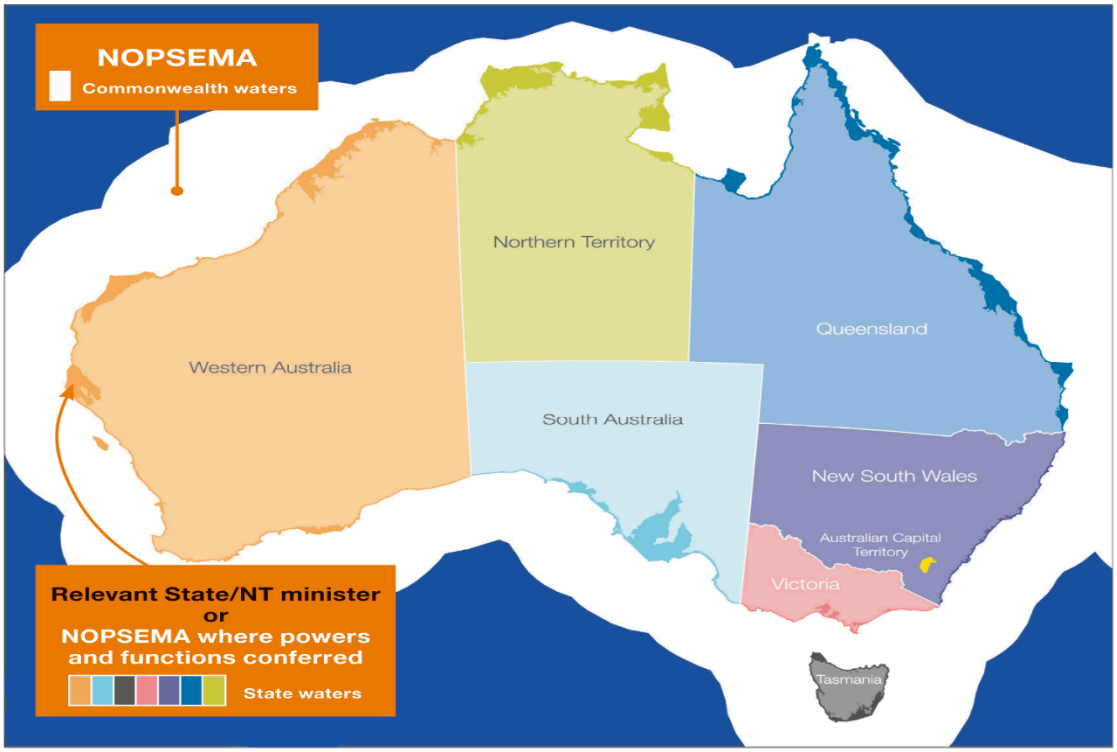
4.2. The Regulation of Seismic Testing in Commonwealth and State Waters

206. This part of the submission focusses on the regulation of seismic surveys in both Commonwealth and state waters and includes an overview of the approach NOPSEMA takes to assessing environment plans and ensuring compliance during seismic surveys.

207. NOPSEMA regulates all offshore petroleum activities in Commonwealth waters, which comprise those areas beyond the first three nautical miles of the territorial sea. Seismic surveys used for petroleum exploration purposes cannot proceed without an appropriate title issued by the National Offshore Petroleum Titles Authority (NOPTA) and an accepted environment plan (EP) which has been assessed by NOPSEMA. The EP sets out the environmental impact assessment that has been conducted by the titleholder and the management arrangements that they intend to implement for the ongoing conduct of the activity to ensure that good environmental outcomes are achieved. NOPSEMA assesses the EP and then if the activity is approved, inspects against it to ensure that companies are doing what they said they would do. If non-compliances are detected, enforcement action may be taken.

208. A large proportion of the seismic surveys conducted in commonwealth waters are conducted to inform exploration for potential petroleum reservoirs or greenhouse gas storage opportunities. These seismic surveys are regulated by NOPSEMA. A smaller number of seismic surveys are conducted in state and commonwealth waters for other purposes such as geological research, seabed surveys, other geophysical studies and for scientific purposes. These surveys are regulated by the Department of Environment and Energy and (if within state or Northern Territory waters) the relevant state/territory agency if triggers for assessment are met.

209. There are various state and territory agencies that regulate seismic activity in state/territorial waters within the first three nautical miles of the coast. The approach to regulation of seismic surveys will vary across the Australian marine area due to these jurisdictional delineations. An explanation of how each state or territory agency regulates seismic activities within their jurisdiction is the responsibility of that agency and will not be addressed further in this submission.



Note: State and Northern Territory coastal waters conform more or less to the Australian continent and associated islands. Commonwealth waters extend seaward from the edge of the three nautical mile limit of designated coastal waters, to the outer extent of the Australian Exclusive Economic Zone at 200 nautical miles.

Figure 10: Illustrates jurisdiction boundaries in Australian waters

210. In instances where companies are operating in multiple jurisdictions or across boundaries, this can create challenges for proponents, due to potential for inconsistency between jurisdictions (refer to figure below for an example of complex jurisdictional boundaries in Western Australia). It is the responsibility of each company to be aware of the legal requirements within each jurisdiction and comply with them.

211. For seismic surveys proposed to be conducted in Commonwealth waters but may impact values in adjacent state waters, NOPSEMA ensures that the consideration and protection of state values is appropriate and that state agencies have been consulted. NOPSEMA undertakes regular engagement with relevant state and territory agencies to promote consistency, however without a nationally harmonised approach to the regulation of petroleum activities, the risk of inconsistency in requirements and approach across jurisdictions will continue. A nationally consistent approach to regulation of petroleum agencies by an independent, well-resourced expert regulator has been recommended in several government reviews and NOPSEMA continues discussions with relevant agencies to progress this agenda. At the time of writing this submission, conferral of powers for safety regulation but not environmental regulation, has only occurred in Victoria.

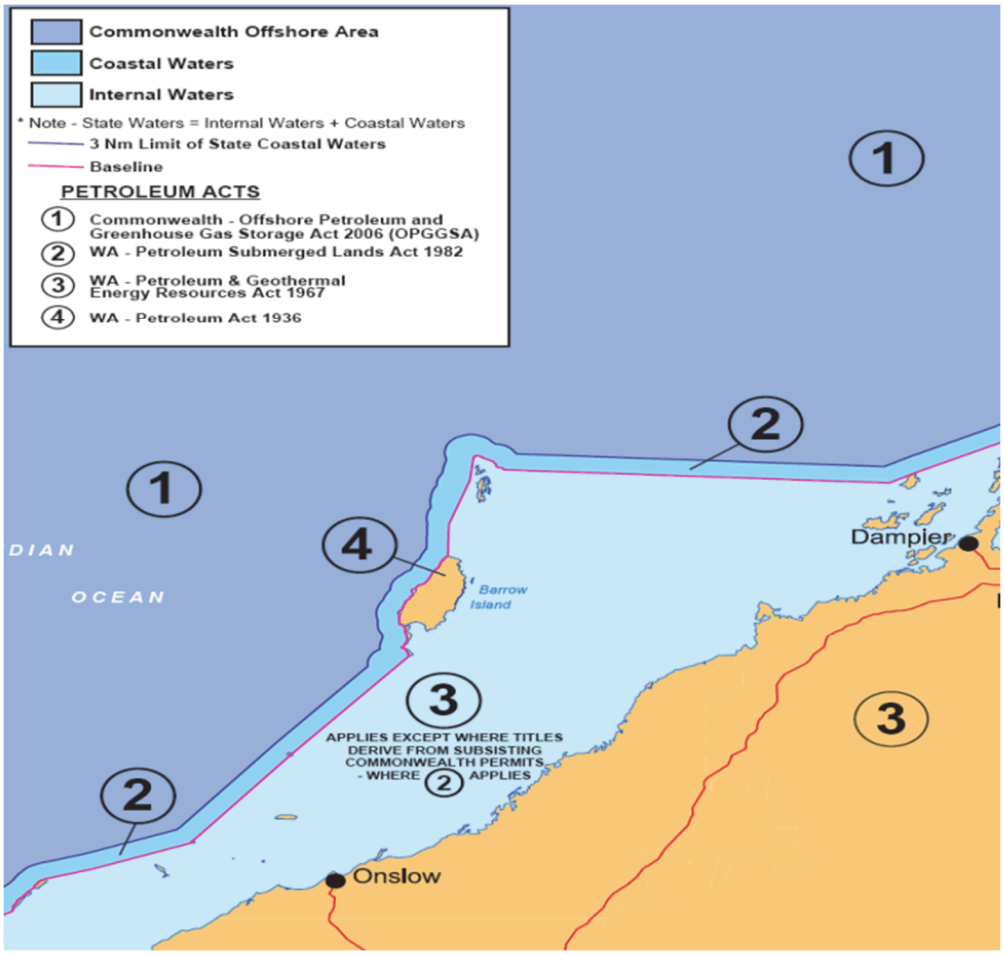


Figure 11: Delineation of the Commonwealth and state offshore areas with Western Australia as an example

4.2.1. Overview of the titling regime for offshore seismic surveys

212. Seismic surveys in the Commonwealth offshore area can be authorised under a number of different title types. These include long-term titles such as exploration permits and production licences as well as short-term titles such as special prospecting authorities (SPA) and access authorities (AA) and this process is managed by NOPTA. The titling process is completely independent of NOPSEMA's regulatory processes.

213. Long-term exploration permits are granted through a competitive acreage release process which involves nomination of areas for release, a public consultation process led by the Government through the Department of Industry, Innovation and Science (DIIS), final determination of successful work program bids and grant of an exploration permit by the responsible Commonwealth Minister or delegate. Exploration permits granted through this process have an initial term of six years and may be extended for two further five-year periods. These types of titles are ordinarily held by petroleum companies (titleholders) that have an enduring interest in a particular area and will be present in that area for an extended period of time undertaking operations and works to explore and potentially develop petroleum resources in accordance with their work program. These titleholders have an interest in ensuring that a social licence to operate is established and maintained with other marine users and communities proximate to the title

area for the duration of their operations. Please refer to the Senate Inquiry Submission made by DIIS for a further explanation of the titling process.

214. Short-term titles such as SPAs and AAs are granted by NOPTA through an application process. SPAs are most commonly applied for by multi-client seismic survey companies (multi-client companies) whose business model is based on the acquisition of 3D geological data for on-selling to third party oil and gas companies at a profit given that they are entitled to retain data on a confidential basis for 15 years. These titles last for a maximum of 180 days during which proposed operations must be undertaken. Multi-client companies can submit an environment plan for a seismic survey without the AA or SPA being granted as long as they are an applicant for a title. The survey cannot proceed however until the title has also been granted.

215. There is no requirement for government to consult prior to granting an SPA by NOPTA. Consultation is generally limited to that which is undertaken by a company in order to prepare an environment plan for activities that are proposed to be undertaken under an SPA. In some cases, usually on the basis of industry demand or the prospect that funding may be available, different multi-client companies will compete for work in a similar region over a similar time period by each applying for a title and each company submitting an environment plan. In most cases however, only one company wins the work and only one survey will proceed.

216. Seismic surveys for petroleum exploration purposes are allowed in AMP special purpose zones and all multi-use zones subject to a class approval. Mining (including seismic surveys) is not allowed in Sanctuary, National Park, Recreational Use, Habitat Protection and Special Purpose (Mining exclusion) zones or the Coral Sea Marine Park. Petroleum titles cannot be released for those areas where mining is not allowed.

217. Being awarded a petroleum title does not guarantee that a petroleum activity will proceed. It simply allows a titleholder to then proceed to apply for environmental approval for their activity through the environment plan submission process.

4.2.2. Regulatory approach under the OPGGS Act

218. NOPSEMA is an independent statutory authority established under the OPGGS Act and is fully cost-recovered through industry levies. The functions of NOPSEMA are completely independent of political influence and government funding processes.

219. The OPGGS Act and Environment Regulations establish an objective based environmental management regime that is administered by NOPSEMA. The object of the Environment Regulations is to ensure that any petroleum activity or greenhouse gas activity carried out in an offshore area is:

a) Carried out in a manner consistent with the principles of ecologically sustainable development set out in section 3A of the EPBC Act; and
b) Carried out in a manner by which the environmental impacts and risks of the activity will be reduced to as low as reasonably practicable; and
c) Carried out in a manner by which the environmental impacts and risks of the activity will be of an acceptable level.

220. The objective based approach to regulation is supported internationally by regulatory authorities, risk management professionals and academics, as being the most appropriate regulatory

framework for major hazard industries. For example, Hopkins (2012) identifies the four basic features of a successful regulatory regime for oil and gas as:

- impact management and risk management frameworks;
- a requirement to "make a case" to the regulator that the specific controls to manage impacts and risks are sufficient for the unique circumstances of the particular activity and location proposed;
- a competent and independent regulator; and
- a general duty of care being placed on the operator (in this case the titleholder).

221. The OPGGS objective based environmental management regime:

- establishes a framework based on specified objectives and requires titleholders to demonstrate how they will achieve those objectives
- provides an independent assessment of the impact evaluation and challenges the efficacy of the proposed management controls to manage and reduce impacts and risks
- ensures that once an EP is accepted, all requirements are implemented and complied with
- ensures that those who create risk are responsible for identifying and managing that risk
- is adaptable, flexible and scalable to the particular circumstances of individual petroleum activities and the environments in which they take place
- provides the opportunity for the offshore oil and gas industry to adopt advances in technology and apply control measures that are best suited to the individual circumstances of the activity
- encourages adoption of best practice environmental management systems and continuous improvement in all aspects of a titleholder's environmental performance
- is recognised as international regulatory best practice for major hazard industries such as offshore oil and gas and the nuclear industry.

222. The regulatory regime under which NOPSEMA operates provides all of these features and the Environment Plan is where the titleholder makes 'the case' that the way they will manage the activity is sufficient by using scientific evidence to support the conclusions that they make and management actions they propose.

4.2.3. Streamlining under the Environment Protection and Biodiversity Conservation Act 1999

223. In February 2014, the Commonwealth Minister for the Environment endorsed NOPSEMA's environmental management authorisation process[1] (the Program) as meeting the requirement of Part 10, section 146, of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Subsequently the Minister for the Environment approved a class of actions which, if

[1] Program Report – Strategic Assessment of the environmental management authorisation process for the petroleum and greenhouse gas storage activities administered by the National Offshore Petroleum Safety and Environmental Management Authority under the Offshore Petroleum Greenhouse Gas Storage Act 2006.

undertaken in accordance with the endorsed Program, will not require referral, assessment and approval under the EPBC Act.

224. This endorsement was the mechanism that resulted in making NOPSEMA the sole environment regulator for all oil and gas activities in Commonwealth waters, including seismic surveys.

225. NOPSEMA's assessment process explicitly takes into consideration potential impacts on the following matters protected under Part 3 of the EPBC Act, as well as the broader marine environment within the Commonwealth marine area:

- world heritage properties;
- national heritage places;
- wetlands of international importance;
- listed threatened species and ecological communities;
- listed migratory species; and
- the Commonwealth marine area.

226. The Environment Regulations specifically require matters protected under the EPBC Act to be described in an Environment Plan and any impacts and risks to these matters must be detailed and evaluated.

227. The Program commitments places obligations on NOPSEMA to ensure that activities are not undertaken within World Heritage properties and that activities are managed so that there are no unacceptable impacts on matters protected and environment plans are consistent with relevant plans of management, e.g. recovery plans for listed threatened species. For more information on the Program and NOPSEMA's commitments refer to the Information Paper on Streamlining environmental regulations of petroleum activities in Commonwealth Waters: https://www.nopsema.gov.au/assets/Information-papers/A341856.pdf

228. As a result, titleholders and NOPSEMA must have regard to relevant EPBC Act context such as recovery plans, marine bioregional plans and Australian Marine Park Management Plans to ensure that environment plans and NOPSEMA's regulatory decisions are not inconsistent with key objectives and actions. The EPBC Act policy documents may also provide important context on acceptable levels of impact or the control measures that should be implemented. For further information about the implementation of the Program during the EP assessment process see Section 4.2.13.

229. Successful implementation of the Program relies on clear environmental EPBC Act policies (supported by guidance for implementation in EIA), which has a basis in contemporary science and/or mechanisms to ensure implementation can be underpinned by up to date information.

230. The streamlining of environmental approvals processes reduced duplication in environmental regulation while ensuring that strong environmental safeguards are maintained so that unacceptable impacts to protected matters and the broader marine environment are not permitted.

231. NOPSEMA and the Department of the Environment and Energy (DoEE) continue to operate under agreed administrative arrangements for the transfer of relevant information in relation to matters

protected under the EPBC Act and the general administration of the Program. This includes periodic review of NOPSEMA's implementation of the Program.

232. In 2015, following the first 12 months of the Program coming into effect, NOPSEMA was subject to an independent review. The review examined the performance of NOPSEMA's environmental authorisation process in ensuring that impacts on matters protected under Part 3 of the EPBC Act are acceptable.

233. The review found NOPSEMA is delivering the levels of environmental protection required under the EPBC Act, and processes and procedures are in place to continue to do so in the future.

234. The first five yearly Program review will be undertaken as part of the NOPSEMA Operational Review and is due to be reported in 2020.

235. NOPSEMA also maintains a strong relationship and very regular communication with Parks Australia and the Director of National Parks to ensure that petroleum activities that are conducted in close proximity or within the Australian Marine Parks multi-use zones (where mining activities are allowable) do not compromise park values or objectives.

236. An independent audit of NOPSEMA's assessment of drilling in the Great Australian Bight was completed by Dr Alan Finkel in September 2019. The audit focussed on the adequacy of NOPSEMA's processes and found NOPSEMA to be a highly skilled, professional and competent regulator. NOPSEMA was found 'to have appropriate processes, guidance material and practices to ensure environment plans are assessed against relevant, sufficient and complete scientific and technical information referenced by titleholders' (for the full report see Appendix A).

237. The environmental assessment and approval processes of NOPSEMA under the OPGGS Act and the Department of the Environment under the EPBC Act contain many of the same essential elements but with some important differences. Both processes require impacts to protected matters under Part 3 of the EPBC Act to be assessed and managed in accordance with published policies and plans of management under the EPBC Act. The main difference between the two processes is that the Environment Regulations administered by NOPSEMA require the titleholder to complete a full evaluation of all environmental impacts and risks not just those to matters protected under the EPBC Act. The titleholders then need to identify appropriate control measures to manage and monitor those impacts and risks to be included in a consolidated package in an environment plan submitted to NOPSEMA for assessment and acceptance.

4.2.4. Overview of how NOPSEMA fulfils its environmental management functions

238. NOPSEMA delivers its environmental management functions through five core regulatory activities which are interlinked and provide an integrated and comprehensive regulatory framework.

239. Put simply, NOPSEMA:

- **assesses** how a titleholder proposes to manage the environmental impacts and risks of their activity through an EP submission and determines whether the proposal is appropriate;
- **inspects** the titleholder to determine whether the activity is being managed in accordance with the accepted EP and other legislative requirements;

- **investigates** where an incident occurs or where a potential non-compliance with the legislation is suspected;
- takes **enforcement** action where this is required to rectify non-compliance or to ensure that non-compliance does not reoccur; and
- provides **advice** to the industry on learnings from assessments, inspections, investigations and enforcements and promotes good environmental management practice.

Further information on each of these functions is provided throughout the following sections.

4.2.5. Environment plan assessment process

240. For all petroleum activities, including seismic surveys, titleholders are required to submit an environment plan (EP) to NOPSEMA. It is an offence to undertake an offshore petroleum activity without an accepted EP for that activity.

241. NOPSEMA policies and processes ensure that dedicated assessment teams comprising highly qualified and experienced technical experts are assigned to assess each EP in line with their area of expertise. The cost recovery mechanism ensures that NOPSEMA is well resourced and capable of attracting and retaining highly qualified and experienced staff. There are currently about 30 staff allocated to four teams within the Environment Division, many with Doctorate and Masters level post-graduate qualifications. All staff are highly qualified in terms of their technical and regulatory qualifications and experience across a wide variety of disciplines such as coral ecology, benthic ecology, bioacoustics, water and sediment quality, marine mammal ecology, seabird biology, fish biology, marine turtles, fisheries and aquaculture, oceanography, chemistry, physics and environmental management of offshore petroleum activities. Many staff have first-hand experience working in the petroleum industry. In instances where the relevant technical skills cannot be sourced within NOPSEMA, contract arrangements are in place with external service providers such as the Marine Mammal Centre within the Australian Antarctic Division to provide support as required.

242. When an EP is submitted to NOPSEMA for assessment, a multidisciplinary team is formed based on the activity type, location and relevant environmental sensitivities and risk and impact profile. The team is supervised by a member of the Environment Division Leadership Team, who is delegated by the NOPSEMA Chief Executive Officer, to make decisions regarding acceptability of the EP. The assessment team undertakes a general assessment of the whole EP against the regulatory requirements in all cases. In addition, relevant qualified staff are assigned to undertake one or more detailed technical assessments focussing on the highest impact and risk aspects of the activity to ensure that the activity will not have unacceptable impacts on the environment. Throughout assessment, the environmental impact assessment conclusions and predicted environmental outcomes are thoroughly tested by the assessment team using available research, published literature, industry reports and of course the extensive experience of the assessment team.

243. An initial completeness check of all exploration EPs is done by NOPSEMA to determine if they meet the regulatory requirements for publication. This is not a full assessment of the acceptability of the proposed activity. Once the completeness check is passed, the EP is published on the NOPSEMA website (with the sensitive information part removed) and the public is invited to make comment within a 30 day public comment period. NOPSEMA facilitates the public comment process by hosting a public comment portal on its website, receiving and recording submitted comments and providing public comments to titleholders. Once the public comment period is complete, the titleholder must consider public comments prior to resubmitting the EP to NOPSEMA for further publication and full assessment.

244. NOPSEMA has a 30 day statutory timeframe in which to make an initial decision about the submitted EP. If it is found that the EP does not meet the requirements of the Environment Regulations, NOPSEMA is required to provide titleholders with the opportunity to improve the environment plan and case being made to the regulator that the activity can be conducted without unacceptable environmental impacts. NOPSEMA provides detailed feedback to the titleholder where a submission fails to meet regulatory requirements and does not present a case for acceptable impacts but does not prescribe how a titleholder should manage their activities. A summary of the EP preparation and assessment process can be found in Figure 12.

Figure 12: Simplified assessment and approval process for exploration environment plans

245. The assessment timeframes, between the first submission by a titleholder and the final acceptance or refusal decision of an EP by NOPSEMA has fluctuated over the years with a median of 73 days in 2012 to upwards of 250 days in some years. Currently in 2019, the mean assessment timeframe is 98 days for seismic survey environment plans. However, assessment timeframes can be influenced by a number of factors including the quality of the submission or sensitivity of the location in which the survey is proposed to occur, the total number of resubmissions and the length of time in between submissions, which is often driven by a range of company/activity specific factors external to NOPSEMA. The combination of these factors results in assessment timeframes not being a meaningful indicator of neither NOPSEMA nor titleholder performance.

246. NOPSEMA's assessment process is iterative and more than 90 per cent of EPs have at least one interim decision made before a final decision to accept or refuse the EP is made. Interim decisions can include a request by NOPSEMA for further written information or, as mentioned above, provision of an opportunity for the titleholder to modify and resubmit the EP. The assessment process may involve several rounds of feedback from NOPSEMA about the content of the EP and

the proposed survey management arrangements. Titleholders respond to the feedback by making changes to the proposed management of the activity, survey timing or locations, in order to reduce the environmental impacts to acceptable levels.

247. As an indication of the degree to which seismic survey EPs (including changes to the survey design) are required to be amended throughout the assessment process, through multiple iterations, 38 plans (29 per cent) have been accepted on their second submission while 33 per cent required two resubmissions to NOPSEMA before the EPs could be accepted. Only 16 per cent of plans required three or more resubmissions to be accepted. Those plans that undergo several resubmissions are those that have required the greatest levels of change before they can be approved, either because they were poor quality submissions, or the EP authors were unable to demonstrate that the survey could be conducted safely and therefore changes to the survey design were required to ensure the environmental outcomes were acceptable. NOPSEMA has refused four seismic survey EPs since 2012, however many more assessments were stopped or withdrawn by companies before a final decision could be made by NOPSEMA.

248. At the completion of the assessment process, if the environment plan still doesn't meet the requirements of the Regulations or the Act and it cannot be demonstrated that the survey cannot be conducted without unacceptable environmental impacts, it will be refused by NOPSEMA. In rare circumstances, NOPSEMA will accept an EP in part or apply conditions to an EP allowing it to proceed under specific circumstances, such as not allowing the part of the survey plan that carries unacceptable levels of environmental risk. Accepting EPs in part or applying conditions is an option provided to the Regulator under Regulation 10(6).

249. One example of a seismic survey environment plan that was accepted by NOPSEMA with conditions is the Duntroon multi-client 3D and 2D Marine Seismic Survey. The published NOPSEMA Key Matters Report for this survey is included at Appendix C. Summary information about the proposed survey, key decisions and the full environment plan can be found on the NOPSEMA website https://info.nopsema.gov.au/activities/319/show_public

250. If NOPSEMA is reasonably satisfied that the environment plan meets the acceptance criteria set out in the regulations and the survey can be managed with good environmental outcomes, the EP must be accepted. NOPSEMA will also publish the accepted EP on the NOPSEMA website.

251. An accepted EP establishes the legally binding environmental management conditions that must be met by the titleholder and against which NOPSEMA can secure compliance. Failure to comply with an accepted EP is an offence, and grounds for NOPSEMA to withdraw its acceptance of an EP.

252. The Environment Regulations set out very clear environment plan content requirements, which effectively mirror standard environmental impact assessment (EIA) processes and are consistent with Australian Standard Risk Management Guidelines AS ISO 31000:2018. However, the regulations do not prescribe the way in which those content requirements should be met, for example, what impacts should be evaluated against (e.g. biological effect thresholds are not defined in regulations) or managed (e.g. specific control measures are not defined in regulations). Where national or international standards for environmental impact assessment and management controls are available, titleholders are expected to follow these approaches as appropriate to the context of their activity or demonstrate why alternative approaches are acceptable.

253. The regulations require an EIA for all impacts and risks, including underwater noise for seismic surveys, which requires careful analysis of the potential interactions between the activity and its noise emissions with the biota in the receiving environment, see section 4.1.9 for further details. An EIA may include reference to environmental baseline data, marine monitoring reports and published research to support the conclusions drawn about the consequences of potential impacts and explanations of why the impacts are acceptable. This ensures that impact predictions and control measures are tailored to the particular activity circumstances, location in which they will occur and will be effective in managing impacts to acceptable levels. This regulatory approach allows for advances in science and technology to be taken into account for each new project and activity without the need to revise the regulations. The EIA information presented in environment plans is what is assessed and tested by the NOPSEMA assessment teams.

254. There are eight acceptance criteria outlined in the Environment Regulations that NOPSEMA must assess each EP against. The assessment teams record findings, in a bespoke Regulatory Management System, about the environment plan against these criteria in preparation for the decision maker. The criteria are that the EP:

- is appropriate for the nature and scale of the activity;
- demonstrates that the environmental impacts and risks of the activity will be reduced to as low as reasonably practicable;
- demonstrates that the environmental impacts and risks of the activity will be of an acceptable level;
- provides for appropriate environmental performance outcomes, environmental performance standards and measurement criteria;
- includes an appropriate implementation strategy and monitoring, recording and reporting arrangements;
- does not occur in a World Heritage Property (with the exception of environmental monitoring or responding to an emergency);
- demonstrates that appropriate consultation has been carried out; and
- complies with the OPGGS Act and its associated regulations.

255. Inherent within the acceptance criteria and explicit in the Environment Regulations is the requirement for titleholders to address (and for NOPSEMA to assess) impacts and risks to matters protected under Part 3 of the EPBC Act.

256. During an assessment, and when making decisions about a titleholder's case for acceptability of impacts, the assessment teams and the decision maker will follow principles of good decision making and have regard to the following information to inform the findings about the degree to which the EP meets the criteria listed above:

- reputable, publicly available scientific and other literature relevant to the assessment
- the Department of the Environment and Energy policies, guidelines, plans of management and any other material relating to matters protected under Part 3 of the EPBC Act relevant to the activity;

- relevant state and territory information for instance where activities in Commonwealth waters may impact the environment in state or territory waters;
- relevant information, including comments received during the public comment period and correspondence from relevant person consultation; and
- the compliance record of the titleholder, where it relates to matters considered in the EP.

257. All EPs must demonstrate that appropriate consultation with relevant state, territory and Commonwealth agencies and persons or organisations whose functions, interests or activities could be affected by the proposed activity has been undertaken by the titleholder. Further detail about the consultation process can be found in Section 4.2.14.

258. This demonstration must include:

- provision of a report on consultation between the titleholder and relevant persons;
- an assessment of the merits of any objection or claim about the adverse impact of each activity to which the EP relates;
- a statement of the titleholder's response or proposed response to each objection and claim; and
- a copy of the full text of any response by a relevant person.

259. The EP must also include provisions for ongoing consultation with affected persons.

260. NOPSEMA prepares and regularly updates published policies, guidance, Environment Bulletins, Environment Alerts and articles in 'The Regulator' magazine to highlight common industry challenges and to provide advice to titleholders and their consultants on how to meet the requirements of the Environment Regulations. NOPSEMA has published good practice guidance on the EIA of noise generating offshore petroleum activities in an Information Paper on Acoustic Impact Evaluation and Management (Appendix B).

261. As an independent statutory authority, NOPSEMA makes assessment decisions based on the requirements of the Environment Regulations, the scientific and technical merits of proposed impact and risk management measures and whether the activity can be carried out in a manner consistent with the object of the regulations.

262. With the exception of potential detrimental impacts and risks to socioeconomic aspects of the receiving environment, NOPSEMA does not consider economic, commercial or political factors in its decision making processes.

4.2.6. Assessment decision making and the principles of ESD

263. The science on the impacts of noise on marine life is not complete and will never be for all fauna groups and the scientific knowledge base is rapidly evolving. However, this does not mean that NOPSEMA cannot make decisions on noise generating activities such as seismic surveys. It does mean that where there is insufficient science to demonstrate an acceptable environmental outcome can be achieved, seismic surveys may not be able to proceed or may not be able to proceed in the desired location or time.

264. A key aspect of any environmental impact assessment process includes identifying and addressing areas of scientific uncertainty by completing additional studies/research, or removing the threat

of serious impact through additional control measures or changes to the survey plan. In addition, proponents are required to demonstrate that levels of environmental performance will be met. Where there is uncertainty around the performance of a control measure, the implementation strategy should include measures to verify the effectiveness of control measures in achieving the desired level of environmental performance.

265. During the assessment process NOPSEMA gauges the level of scientific uncertainty in a titleholder's environmental impact assessment and decides whether this has been appropriately managed by the titleholder. Consistent with the precautionary principle when there is a threat of serious or irreversible environmental damage and scientific uncertainty as to the environmental damage, NOPSEMA will consider how the EP removes at least one of these two conditions. This could be through further study, modification to the proposed activity, and/or adoption of previously rejected control measures. In cases where levels of scientific uncertainty are high, more precautionary approaches to impact prediction and mitigation will need to be taken by titleholders.

266. The control measures are incorporated by titleholders into an environmental management system (EMS) as per Australian/NEW Zealand Standard ISO 14001:2016 to ensure areas of uncertainty are addressed and environmental management continues to be effective throughout the activity. An EMS is an important part of the implementation strategy in an environment plan and includes measures to ensure impacts and risks continue to be identified and managed, control measures are effective and defined levels of performance for environmental management are achieved.

267. The precautionary principle is enshrined within the principles of ecologically sustainable development (ESD) which are set out in the EPBC Act and a key element within the objects of the Environment Regulations. The following are principles of ESD;

- Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations.
- 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 (the 'precautionary principle').
- The principle of inter-generational equity – that 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 conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making.
- Improved valuation, pricing and incentive mechanisms should be promoted.

268. NOPSEMA gives careful consideration to the principles of ESD during its assessment processes and ensures that any petroleum or greenhouse gas activity is carried out in a manner consistent with the principles of ESD. The principles of ESD are integral to defining acceptable levels of impact and risk.

269. When assessing an EP and making a decision about that activity, NOPSEMA must be reasonably satisfied that the available evidence presented in the EP, and the conclusions that are made are

objectively reasonable and the regulatory requirements are met. Further information about how NOPSEMA makes decision on EPs can be found in the Environment Plan Decision Making Guideline: https://www.nopsema.gov.au/assets/Guidelines/A524696.pdf

4.2.7. Environmental Inspections

270. Once an EP is accepted by NOPSEMA and a petroleum activity is scheduled to occur, NOPSEMA inspections of those activities can be scheduled. NOPSEMA conducts inspections to monitor compliance with the law including ongoing implementation and compliance with accepted EPs. Not all seismic surveys will be inspected, but many of them are, particularly those proposed to occur near sensitive locations or during biologically sensitive time periods.

271. NOPSEMA undertakes approximately 60 environmental management inspections per year which focus on specific aspects of titleholders' environmental impact and risk management. These inspections are scoped and scheduled using a risk-based methodology that considers relevant risk factors, previous company performance and compliance history, current industry incident trends, and responses to recommendations from any previous inspections. Inspections are conducted either offshore on the facility or at the titleholder's business premises depending on the scope of the inspection by the same team of people that assess the EPs ensuring continuity through the process. Titleholders are required to provide reasonable assistance and facilities to NOPSEMA inspectors to allow them to conduct inspections. This includes transport out to offshore facilities including seismic vessels. It is an offence for a person to obstruct or hinder a NOPSEMA inspector or to not provide reasonable assistance in the conduct of an inspection. These requirements provide NOPSEMA inspectors access to all of the relevant facilities and documents, records and relevant staff during an inspection to inform the inspection findings and any necessary follow up actions.

272. Upon completion of an inspection, NOPSEMA provides a detailed report of inspection findings, conclusions and any recommendations for improvement to the titleholder. NOPSEMA may also request a titleholder to provide proposed corrective actions to be taken with respect to the conclusions and recommendations arising from an inspection for the purpose of improving environmental management of that activity.

273. Where an inspection finds non-compliance (actual or potential) with legislative requirements including the accepted EP, NOPSEMA may take enforcement action.

274. NOPSEMA also publishes on its website a suite of industry performance data, policy and guidance material, latest news, reports and a quarterly magazine[2].

4.2.8. Investigations

275. NOPSEMA may commence an investigation where it suspects or becomes aware of a potential non-compliance with the legislation. Investigations may be instigated following an inspection of a petroleum activity, a report of non-compliance by the titleholder, a complaint from a third party or an incident.

[2] http://www.nopsema.gov.au/resources/

276. Investigations are conducted to seek information that may then be utilised as a basis for enforcement, prosecution and/or advice and promotion purposes.

277. Major investigations are led by an independent specialist team of experienced and highly trained investigators supported by subject matter experts from within the environment division where required.

278. NOPSEMA shares lessons learnt from the investigation of incidents with the industry where these learnings will contribute to continuous improvement in risk management performance.

4.2.9. Enforcement

279. Where NOPSEMA determines a breach of the EP or the legislation has occurred it may take enforcement action requiring the titleholder to rectify the breach, take steps to prevent a recurrence and to act as a deterrent to future non-compliance.

280. Typically, enforcement action is taken based on information discovered during an inspection or following an investigation into a reported notifiable incident, complaint or information provided by a third-party. NOPSEMA inspectors have extensive powers to make decisions and issue enforcement notices as required, including issuing “on the spot” notices during an inspection where there is a serious and immediate threat to the environment.

281. There are a range of enforcement actions available to NOPSEMA enabling it to select an appropriately proportionate, targeted and effective measure to address the non-compliance. The selection of the relevant enforcement action is based on a consideration of factors such as the outcome that is to be achieved, the gravity of impact or risk to the environment, the responsiveness required to address the non-compliance and the compliance history of the titleholder.

282. Enforcement actions under the legislation include:

- Improvement notices – allow NOPSEMA inspectors to specify the actions that must be taken to remove an environmental threat. It is an offence for a person to breach a requirement of the notice.
- Prohibition notices – allow NOPSEMA inspectors to stop an activity from being conducted, or being conducted in a particular way that involves an immediate and significant environmental threat. It is an offence to not comply with this notice.
- General Directions – NOPSEMA can issue directions to a titleholder to conduct their activity in a particular way. It is an offence to engage in conduct that breaches a Direction.
- Prosecution - depending on the nature of identified non-compliance with environmental law identified through investigations, NOPSEMA may proceed to prosecution.

283. In circumstances where NOPSEMA determines that an EP does not provide appropriate arrangements to manage a titleholder’s activity, NOPSEMA has power under the Environment Regulations to request a revision to that EP or under relevant circumstances (outlined in the Regulations) may withdraw acceptance of an EP meaning that the activity can no-longer be conducted.

284. Between 2013 and 2019, 11 enforcement actions were taken by NOPSEMA relating to seismic survey activities. These enforcements include six written warnings, one prohibition notice, two improvement notices and two general directions. The enforcement actions prevented unacceptable impacts to the environment from occurring.

285. All decisions relating to enforcement action are conducted in accordance with established policies and procedures, following a graduated enforcement management model and with the involvement of the NOPSEMA Compliance Committee. This Committee consists of the NOPSEMA senior leadership team, General Counsel and the Chief Executive Officer.

286. If non-compliances relate to EPBC Act protected matters, NOPSEMA cooperates with the DoEE to allow that agency to take enforcement action under the EPBC Act if necessary.

4.2.10. Promotion and advice

287. Effective regulation benefits from meaningful communication and engagement. To ensure industry performance continuously improves, NOPSEMA has a legislative function to promote and advise on environmental management matters. NOPSEMA proactively seeks to engage with stakeholders including international regulatory counterparts through liaison meetings, information sessions, presentations and participating in conferences and forums. NOPSEMA also publishes on its website a suite of performance data, policy and guidance material, latest news, reports and a quarterly magazine.

288. NOPSEMA averages 700 liaison meetings per year with duty holders, related government agencies and departments, peak industry bodies, non-governmental environmental organisations and other stakeholders. For example, NOPSEMA meets with Seafood Industry Australia, Seafood Industry Victoria, the Tasmanian Seafood Industry Council, the Western Australian Fishing Industry Council, and the South East Trawl Fishing Industry Association at least twice per year.

289. NOPSEMA's Community and Environment Reference Group meets also meets twice per year to provide NOPSEMA with perspectives broadly reflective of the community, including: commercial and recreational fishing, conservation advocacy, public policy and government functioning, small business and tourism, cultural heritage and Indigenous communities; as well as regional perspectives from the north-west, south-east and northern regions of Australia. Records of these meetings and their discussions are published on NOPSEMA's website.

290. NOPSEMA frequently participates and/or presents at domestic and international conferences and forums and working groups focused on offshore environmental management. This has included the Effect of Sound on Marine Mammals Conference, the Australian Marine Science Association Annual Conference, the Effect of Noise on Aquatic Life Conference, Spillcon, Interspill, the International Oil Spill Conference, the APPEA conference and exhibition.

291. Presentations at these events and more are published on NOPSEMA's website and include topics such as, the importance of science for evidence-based decision making, implications of scientific uncertainty in seismic environmental impact assessments, using science and collaboration to improve environmental impact assessment and management of sound generating activities.

292. Since 2013, NOPSEMA has been an active member of the International Offshore Petroleum Environment Regulator's group. The group, comprising NOPSEMA's international regulatory counterparts, seeks to improve offshore petroleum environmental management performance.

The group's Marine Sound Working Group is currently working to ensure the recognition of priority research needs, the promotion of best practice guidance, and identification of collaborative research initiatives.

293. NOPSEMA also publishes a quarterly magazine, *the Regulator*, to approximately 2500 subscribers. E-campaigns to communicate environmental management alerts, bulletins and news are sent to approximately 1500 subscribers and email updates to subscribers on the status of environment plan assessments average 25,000 emails per year. A variety of brochures, factsheets and videos are made available on NOPSEMA's website and at various events to improve understanding of NOPSEMA's role, environmental approvals, marine seismic surveys, consultation with relevant persons, public comment, decommissioning, oil spill modelling, oil spill preparedness and response amongst other things.

4.2.11. Communication of regulatory decisions to affected persons

294. NOPSEMA is proactive in communicating decisions regarding the regulation of offshore petroleum activities to the public. Assessment decisions are published on the NOPSEMA website to keep the public updated on the status of submissions. In addition, upon acceptance of an environment plan, NOPSEMA publishes a key matters report that identifies common concerns raised by the public through the public comment process and how these concerns have been addressed by the proponent. NOPSEMA also identifies in the key matters report how they have taken the proponents' responses to these concerns into consideration in making a decision to accept the plan. An example of a key matters report for an accepted seismic survey EP is included in Appendix C.

295. Where petroleum activities that have received considerable public concern have been approved and conducted, NOPSEMA encourages proponents to publish their environmental performance reports (not a requirement). The environmental performance report documents that mitigation measures were implemented effectively and that the activity was conducted in a manner that was consistent with the accepted environment plan. The PEP11 Baleen 2D survey conducted off the coast of NSW received considerable public attention, with concerns over the potential impacts. Asset energy published the environmental performance report for the activity post-completion to demonstrate that the mitigation measures in the accepted environment plan were effectively implemented and the survey was conducted in a manner that did not result in unacceptable impacts on the marine environment. The environmental performance report for the Baleen 2D Seismic Survey is attached in Appendix D.

296. NOPSEMA also publishes information on the website about major incidents and all regulatory decisions in relation to enforcement notices and Directions https://www.nopsema.gov.au/resources/published-directions-and-notices/.

4.2.12. Seismic survey activity in Australia

297. Since NOPSEMA became the offshore petroleum environment regulator in Commonwealth waters in 2012, NOPSEMA has assessed 133 environment plans for seismic survey activities associated with offshore petroleum or greenhouse gas storage activities. Of these, 111 were accepted and 123 seismic surveys have taken place.

There is not a one to one relationship between the number of environment plans and the number of seismic surveys - in some cases no survey will actually be conducted even with an accepted EP and in other cases one EP may cover multiple seismic surveys.

298. In general, titleholder companies submit fewer seismic survey environment plans, when compared to multi-client companies, but the titleholder driven surveys are generally more likely to proceed. This may be a reflection of why the different surveys are being conducted, but also a general trend in recent years for titleholder companies to outsource their seismic surveys to multi-client companies. There was an overall downtrend in recent years in the annual number of seismic survey environment plans submitted for assessment from 33 in 2012, to 22 in 2014, 11 in 2016 and four in 2018. In 2019 that trend appears reversed with 10 seismic environment plans submitted for assessment to date.

299. Between 2012 and 2017 an average of 74 per cent of seismic surveys for which an environment plan was accepted actually proceeded. The number of multi-client seismic environment plans submitted for assessment has decreased in recent years from between nine and 12 submitted environment plans between 2012 and 2015, to five in both 2016 and 2017. Of these, an average of less than 60 per cent of surveys actually went ahead. By contrast the average number of seismic surveys with accepted environment plans submitted by titleholders that proceeded was 87 per cent. See Table 2 below for the number and percentage of surveys that proceeded by year and type.

Table 2: Number of completed seismic surveys by year for multi-client companies vs. petroleum companies.

	2012	2013	2014	2015	2016	2017	2018	Total	Total proportion of surveys that proceeded following assessment
Multi-client	7	6	6	8	1	3	0	31	58.5%
Petroleum Company	17	10	4	5	4	5	2	47	87%

300. Of the plans that have been submitted for assessment by NOPSEMA since 2012, 54 per cent were proposed for North West WA (including the Pilbara region). A further 6 per cent of surveys were proposed for waters off the Northern Territory. Only 16 per cent of proposed surveys were for southern Australia, including 7 per cent in the Otway region, 4.5 per cent in the Gippsland region and 4.5 per cent off South Australia.

301. Of the 123 seismic surveys that have been conducted in Australian waters, NOPSEMA inspected 41 of these between 2012 and 2019.

302. The majority of these surveys have been undertaken in areas that may also be utilised by other industries including fisheries, shipping, tourism operations and areas used for recreation.

4.2.13. How EPBC Act and other requirements are applied to seismic surveys

303. The Environment Regulations are objective based, which ensures that the latest requirements, guidance and good practices can be adopted through NOPSEMA's regulation of seismic surveys and as a result, implemented into management and control of seismic survey activities undertaken by industry.

NOPSEMA applies good practice approaches developed internationally in the absence of international conventions or recognised standards developed specifically for regulation and/or management of seismic survey environmental impact.

304. In addition to NOPSEMA ensuring EPBC Act requirements are met through the Environment Regulations, a range of other sources of good practice and standardised approaches are continually evolving and are applied in a manner relevant to the offshore petroleum regulatory regime. More information about how NOPSEMA engages internationally to keep abreast of research and other jurisdictions approaches to regulating and managing environmental impacts of seismic surveys is captured in Section 4.3.

EPBC Requirements

305. The Environment Regulations require that titleholders describe the legislative and other requirements that apply to their activity and then demonstrate how they will be met. For seismic surveys this includes (among other considerations) the key requirement in the Australian jurisdiction for managing impacts of underwater acoustic emissions which is the EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales (DEWHA 2008a). The EPBC Policy Statement 2.1 is supported by a Background Paper (DEWHA 2008b) and is discussed in detail earlier in Section 4.1.13.

306. It is recognised that the EPBC Policy Statement 2.1 is more than 10 years old, however during the assessment process, NOPSEMA ensures that titleholders consider more contemporary science, most current published thresholds for hearing and technology advancements in whale detection in their environment plans to ensure that mitigation reflects the best available science and technology, where relevant. In addition to the Part A Standard Management Procedures outlined in the Policy Statement, Part B Additional Management Procedures are often required where the likelihood of encountering whales is moderate to high. The Policy Statement was written with the goal of minimising the likelihood of injury or hearing impairment of whales and was not intended to prevent all behavioural changes. NOPSEMA ensures that titleholders address the potential for behavioural impacts to protected species in their environment plans, especially during biologically important times such as breeding, feeding and calving or in important areas such as narrow migratory corridors.

307. The EPBC Policy Statement 2.1 is also specific to whales and large odontocetes and does not address all protected matters. As a result, NOPSEMA frequently requires adaptations of the

controls set out in the policy statement to be applied to other marine fauna such as whale sharks and turtles. EPBC Policy Statement 2.1 is proposed for review in the near future.

308. In addition to meeting the requirements of the Environment Regulations and EPBC Policy Statement 2.1, titleholders must demonstrate that their activity can be conducted in a manner that is consistent with the objectives and actions of management plans for protected matters that may occur within the area. These include species specific Recovery Plans and Conservation Management Plans, Australian Marine Park Management Plans, Bioregional Plans, Ramsar Wetland management plans and any other relevant plans of management made under the EPBC Act.

309. When conducting assessments and making decisions, NOPSEMA must have regard to relevant policy documents, recovery plans, threat abatement plans, conservation advice, bioregional plan and guidelines on the DoEE website. In addition, NOPSEMA must not accept an environment plan that is inconsistent with a species recovery plan or threat abatement plan nor plans of management for Australian Marine Parks. NOPSEMA maintains close and regular communication with the DoEE to ensure that any new or updated relevant DoEE documents are provided to NOPSEMA in a timely way to inform assessments and decision making.

310. Many of the DoEE documents are statutory instruments and are subject to extensive government process prior to being published for the first time and for subsequent reviews. They often cover extensive periods of time (5-10 years) and consequently may not contain the most contemporary science. The National Conservation Values Atlas (NCVA) is an interactive web-based tool maintained by the DoEE. While not a statutory instrument, the NCVA contains a range of national data on Australia's marine environment as well as specific information on the location and area of important marine habitats, ecological features, known breeding and feeding areas for protected species and other conservation values in the marine regions. The NCVA is not constrained by statutory processes for review and update, however sometimes contains information that contradicts management/recovery plan information and doesn't reflect the most contemporary science.

A collaborative research framework that directs funding toward priority research projects would allow data gaps to be filled in a more timely and effective way.

311. The NCVA is regularly used by titleholders when preparing their environment plans and by NOPSEMA during assessment of those plans, however both titleholders and NOPSEMA are often having to rely on the more contemporary research outside the NCVA to inform EIA and regulatory assessments. When more contemporary research exists outside of the NCVA, NOPSEMA regularly alerts the DoEE to the contemporary data that should be considered for inclusion in the NCVA and encourages industry to do the same.

OPGGS Act and other requirements

312. There are other legislated requirements that must be considered by titleholders when planning seismic surveys. It is a requirement under s280 of the OPGGS Act that a person carrying out activities in an offshore area under a petroleum activity must do so in a manner that does not interfere with navigation, fishing, the conservation of resources of the sea and seabed, enjoyment

of native title rights and interests, or any other activity being lawfully carried out by way of exploration, recovery or conveyance of a mineral, or the construction of a pipeline. An understanding and application of these requirements must be included in the environment plan and can be a measure to ensure that titleholders can ensure compliance with the requirement is maintained. Additional legislated requirements relevant to seismic surveys that must be considered and incorporated into environment plans includes, for example, relevant requirements of the *Biosecurity Act 2015* and *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*.

4.2.14. Consultation with communities on seismic survey environment plans

313. NOPSEMA recognises that community consultation is an important part of both commercial enterprise and government decision making.

The public comment process affords the opportunity for all members of the community to make input to assessment of seismic survey environmental approvals, however only a specific set of community stakeholders are identified in the regulations for direct consultation by titleholders.

314. NOPSEMA has recently clarified via an Environment Bulletin how community consultation features in the regulatory system it administers (statutory consultation) and how companies planning to conduct seismic surveys should consider consulting with the wider community. The regulatory system was amended following a policy review in 2017-2018. The revised system comprises two mechanisms with respect to required consultation prior to NOPSEMA making a decision:

a) Statutory 'Relevant Person' consultation that the titleholder is required to undertake in the course of preparing an environment plan (Regulation 11A).
b) Public comment on environment plans on first submission to NOPSEMA for activities that include exploration, including seismic surveys.

315. NOPSEMA has also recognised that community expectations may differ in relation to how consultation is undertaken by companies planning to conduct seismic surveys. To this end, NOPSEMA has highlighted good practice in consulting interested stakeholders in published guidance, industry workshops and through interactions with companies, however NOPSEMA does not have any role or powers to enforce compliance for these aspects.

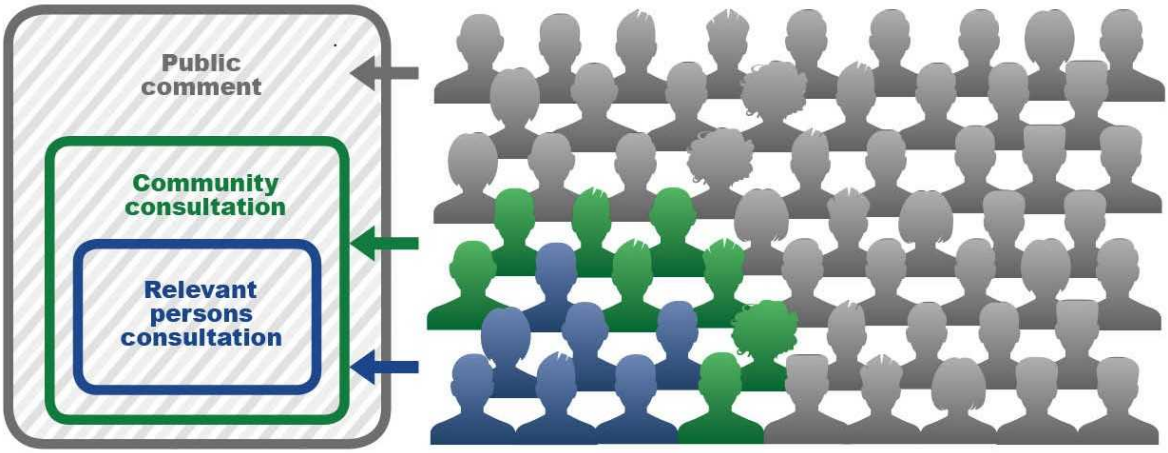


Figure 13: Illustrates the three avenues for engagement with stakeholders

316. NOPSEMA has published a suite of documents that provide information and advice in relation to engagement with stakeholders. This includes:

- Guidance Note on Environment Plan Content Requirements (GN1344)
- Guideline on Environment Plan Decision Making (GL1721)
- NOPSEMA Bulletin 2 – Clarifying statutory requirements and good practice consultation, November 2019
- Guidance Note on Petroleum Activities and Australian Marine Parks (GN1785) [for guidance on consulting with Director of National Parks]
- Public comment on environment plans brochure (March 2019)
- Requirements for consultation and public comment on petroleum activities in Commonwealth waters brochure (August 2018).

A. Statutory consultation by titleholders with 'relevant persons'

317. The Regulations specify that a particular group of stakeholders, termed 'relevant persons', are required to be appropriately consulted by the titleholder before NOPSEMA can approve an environment plan for a specific petroleum or greenhouse gas activity.

318. During the preparation of an environment plan, the Regulations specify that relevant persons must be consulted by the titleholder before the EP is submitted to NOPSEMA.

319. The provisions for statutory relevant person consultation by titleholders are provided for in the Environment Regulations:

- Regulation 11A which imposes the pre-conditional requirement for a titleholder to consult with 'relevant persons'; and

A rigorous iterative process is required to complete relevant person consultation. Where there is a good relationship and objective consideration of facts and evidence, good outcomes are achieved.

- Regulation 16(b) which stipulates the content requirements for the titleholder report on consultation with relevant persons that must be included in an EP; and
- Regulation 10A which establishes the criteria by which NOPSEMA must use when considering to approve or refuse to approve an environment plan.

320. The requirements are included in full below.

Division 2.2A—Consultation in preparing an environment plan

11A Consultation with relevant authorities, persons and organisations, etc

(1) In the course of preparing an environment plan, or a revision of an environment plan, a titleholder must consult each of the following (a ***relevant person***):

(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;

(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;

(c) the Department of the responsible State Minister, or the responsible Northern Territory Minister;

(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;

(e) any other person or organisation that the titleholder considers relevant.

(2) For the purpose of the consultation, the titleholder must give each relevant person sufficient information to allow the relevant person to make an informed assessment of the possible consequences of the activity on the functions, interests or activities of the relevant person.

(3) The titleholder must allow a relevant person a reasonable period for the consultation.

(4) The titleholder must tell each relevant person the titleholder consults that:

(a) the relevant person may request that particular information the relevant person provides in the consultation not be published; and

(b) information subject to such a request is not to be published under this Part.

16 Other information in the environment plan

The environment plan must contain the following:

(a) a statement of the titleholder's corporate environmental policy;

(b) a report on all consultations under regulation 11A of any relevant person by the titleholder, that contains:

(i) a summary of each response made by a relevant person; and

(ii) an assessment of the merits of any objection or claim about the adverse impact of each activity to which the environment plan relates; and

(iii) a statement of the titleholder's response, or proposed response, if any, to each objection or claim; and

(iv) a copy of the full text of any response by a relevant person;

10A Criteria for acceptance of environment plan

For regulation 10, the criteria for acceptance of an environment plan are that the plan:

(g) demonstrates that:

(i) the titleholder has carried out the consultations required by Division 2.2A; and

(ii) the measures (if any) that the titleholder has adopted, or proposes to adopt, because of the consultations are appropriate; and

321. In order to be considered a relevant person for this targeted consultation, the individual or group must meet specific categories in the regulations. Relevant persons are divided in the Regulations into categories [subregulations 11A(1)(a), (b), (c), (d) and (e)]. Fishing licence holders, for example, are considered to be relevant persons under category 11A(1)(d). The Director of National Parks is considered a relevant persons under category 11A(1)(a).

322. Titleholders have a responsibility to ensure that relevant persons are provided with enough information about the proposed activity so that they can evaluate how it might impact on their functions, interests and activities. The purpose of this consultation is to identify environmental values, including social, economic and cultural features, which could be affected by the activity. The titleholder must then ensure that impacts and risks to these values are addressed in their environment plan. This generally involves an iterative consultation process using a variety of methods such as face to face meetings, telephone, email and mail communication.

323. Relevant persons must be given adequate opportunity to convey to the titleholder how they may be affected. The titleholder must then assess the merits of any objections and claims raised by the relevant person, provide a response on how they propose to address these objections and claims and include this information, along with details of the consultation undertaken in a report that forms part of the EP. All copies of written correspondence from relevant persons must also be provided in the EP in order for NOPSEMA to impartially assess the suitability of the consultation undertaken by the titleholder.

324. As part of its decision making on an EP, NOPSEMA determines whether the titleholder has carried out consultation as per the regulations and whether control measures adopted in response to consultation are appropriate. NOPSEMA assesses:

- methodology adopted by the titleholder to identify and determine which individuals and groups are relevant persons;
- the approach to conducting consultation including the information provided, communication methods and time provided to undertake the consultation; and
- the outcomes of the consultation and whether objections and claims from relevant persons have been resolved as far as possible.

325. While NOPSEMA recognises that titleholders and relevant persons may not be able to reach agreement on all aspects of an activity proceeding as proposed, NOPSEMA expects that reasonable attempts have been made by the titleholder to resolve any objections and claims. This includes exploring options for resolving or mitigating the degree with which a person may be affected, particularly through adopting control measures. Where control measures are proposed to address objections and claims, NOPSEMA requires that these are adopted in the relevant section of the EP.

B. Public comment to NOPSEMA on environment plans on first submission to NOPSEMA

326. The Regulations provide an opportunity for any stakeholder or member of the public to have their say about the environmental management of the activity during a 30 day public comment period for environment plans in the case of exploration activities including seismic surveys. NOPSEMA identifies the requirement for titleholders to promote the public comment period, by publishing advertisements in relevant local, state and national newspapers as well as on their website.

327. Comments received during the public comment period may be from any member of the public, which may include individuals and groups who are also engaged through community and relevant persons' consultation. However, comments must relate to the information contained in the EP to be considered relevant. Commenters are encouraged to include supporting documents where there is new information so the titleholder and NOPSEMA can adequately consider the information.

328. Following the close of the public comment period, titleholders must provide a report to NOPSEMA outlining how they have considered the matters raised during the public comment period and where they have modified the environment plan in response these matters. NOPSEMA publishes this report on its website. NOPSEMA must also consider the matters raised during the public comment process in its assessment of the EP.

C. Stakeholder consultation

329. Stakeholders, including members of the public and community, may also be engaged through broader engagement by the titleholder about the proposed activity. This engagement is not a regulatory requirement and is therefore not enforceable by NOPSEMA, however NOPSEMA recognises the value in obtaining broader community and stakeholder input to environmental assessment and therefore encourages titleholders to engage stakeholders more broadly than the Regulations require.

330. A growing number of community organisations and individuals believe they should be consulted by petroleum titleholders in their preparations for planning and conducting petroleum activities. While this is recognised as a valid expectation, the regulations do not require a titleholder, or NOPSEMA, to consult with any individual or group who expresses an expectation to be consulted.

331. Australia's Chief Scientist (Finkel, 2019) also recognised that there is an opportunity for titleholders to consider further community engagement, in particular, where individuals or groups hold special interest or concern but are not 'relevant persons' for the purposes of the Regulations. NOPSEMA recognised this a worthy initiative however notes that while NOPSEMA can promote this as a good practice, NOPSEMA cannot enforce compliance with consultation outside the requirements of the Environment Regulations.

Issues arising from stakeholder expectations regarding consultation

332. The Regulations do not prescribe a method or approach to conducting statutory consultation with relevant persons. Titleholders use a wide range of approaches to consult with stakeholders across relevant person consultation and broader stakeholder engagement is undertaken as part of general business activities. These differences and in some cases, poor practices, create uncertainty, confusion and can generate unmet expectations among stakeholders. NOPSEMA has observed a loss of trust and frustration for an increasing number of stakeholders in some regions. Titleholders and seismic survey proponents are also reporting dissatisfaction with issues arising during consultation as well as the quality of outcomes achieved.

Challenges with relationships between seismic survey proponents and their stakeholders, as well as access to and misalignment on relevant facts and evidence, are the root cause of increasing dissatisfaction with consultation efforts, not the consultation requirements themselves.

333. Specifically, NOPSEMA is aware that titleholders and the fishing industry have expressed concerns regarding consultation practices adopted by both parties as part of titleholders' progressing relevant person consultation. Specifically:

- Consultation with relevant persons is sometimes viewed as incomplete prior to submission of an EP resulting in lack of trust and generating a perception that titleholders are not genuinely engaging in the process;
- Consultation is often inadequate as there is not enough information, inappropriate information, or insufficient time to deal with it;
- There is a heavy burden on the fishing industry, in terms of effort and cost, in dealing with the large volume of correspondence and communications;
- Titleholders sometimes perceive the fishing industry to be conflicted where industry representative organisations with lobby functions are also establishing 'fee for service' arrangements to act on behalf of titleholders;
- In some cases the exchange of information between fishing interests and a titleholder illustrates that information outside the public domain, such as low levels of fishing effort within a fishery area that may be affected by a seismic survey, is being withheld by fishing interests. This appears to be generating a strong perception that fishing interests are using the confidentiality of the information as a negotiation tactic to secure better outcomes in compensation; and
- Systemic issues such as those above have failed to be rigorously and diligently pursued through cooperative action between peak industry associations, such as APPEA. Occasional activity has generated some hope among stakeholders, however these have repeatedly stalled after promising first stages, which has sometimes served to undermine efforts to improve the relationships.

334. However, certain good practice principles should be evident in all processes to provide open and effective engagement between the titleholder and the relevant person. The model for

engagement utilised for any given activity may vary depending on a range of factors such as the type and size of the activity, the number of relevant persons and the extent to which they are affected by the activity.

335. Consultation provides an important avenue for early identification of potential impacts that require evaluation and management and may also inform the acceptability of impacts in relation to biological, social, economic and/or cultural values of the marine environment. In addition, it can facilitate the provision of information to address knowledge gaps in relation to the environment that may be affected.

4.2.15. Regulation of the fishing industry

336. There are a number of key differences in the regulatory models applied to fisheries and petroleum regulation that may contribute to misunderstanding and misalignment between the two industries. The regulation of the petroleum industry requires proponents to be responsible for undertaking consultation, completing environmental impact assessments based on baseline information that they are responsible for securing, and if proposals are approved, managing their activities to achieve an acceptable environmental outcome. The regulator is responsible for then monitoring compliance against the approved plans.

337. In comparison, the regulator of the fishing industry is responsible for undertaking the consultation, establishing baselines and defining acceptable levels of impacts. The regulator is also responsible for monitoring compliance and taking enforcement action.

338. Under the Environment Regulations, seismic titleholders are required to consult with commercial fishers when their seismic activities are likely to affect the interests or activity of the fishing industry to ensure that their activity does not interfere with fishing or navigation and to inform assessments and management of impacts and risks. This requirement for consultation is sometimes misunderstood to mean the fishers have greater rights over the use of the marine area than petroleum companies when in reality both industries have equal usage rights.

339. Commonwealth fisheries are managed by the Australian Fisheries Management Authority (AFMA) that regulates the total allowable catches, individual transferrable quotas, fishing gear types, and spatial/temporal closures. Fisheries activities are approved under the EPBC Act Parts 10, 13 and 13A and several fisheries have Marine Stewardship Council certification.

340. Like petroleum activities, fisheries often cross state and Commonwealth boundaries. In general, the Australian Government is responsible for the management of fisheries from 3 nm to the 200 nm jurisdictional boundary. State responsibilities extend to 3 nm from the low water mark. There are, however several cases where through agreement under the Offshore Constitutional Settlement (OCS), the management of fisheries is transferred to a single jurisdiction or managed under a joint authority arrangement.

341. While fisheries have statutory consultation requirements under the *Fisheries Management Act 1991*, consultation is in relation to processes associated with the management of fisheries and aquatic resources. This consultation is conducted through working groups, stakeholder input on draft documents and publication of decisions/policies. However consultation is only conducted with fisheries operators, and others with a direct interest in the fishery/s such as traditional fishers and conservation parties. See Table 3 below for a comparison of the roles and responsibilities of the fishing and petroleum industries.

Table 3: Outlines roles of the petroleum versus fisheries sectors

Task	Petroleum sector	Fisheries sector
Consultation with stakeholders	Titleholder	Regulator
Establish an environmental baseline	Titleholder	Regulator
Propose acceptable level of impact	Titleholder	Regulator
Monitor compliance	Regulator	Regulator
Enforcement	Regulator	Regulator

342. Fisheries are considered to be a community owned resource. While access rights may be privately owned, they are not exclusive and marine resources remain community property. Statutory fishing rights provide the right to a specified quantity or proportion of fish; a right to use a specified type or quantity of fishing boats or equipment. These rights include fish quotas as well as boat/gear quotas. Fishing permits on the other hand are used where no plan of management for a fishery exists and allow access to specific fisheries in specific areas subject to certain conditions such as species and equipment limitations. State managed fisheries are generally managed using a variety of input controls though there are quotas in place for a small number of fisheries. There are varying levels of community involvement between State management processes.

4.2.16. Conflict between seismic operators and other users of the marine environment

343. Seismic surveys often overlap in space and time with areas that are also important for commercial fishing. Each group of marine users has a legislated right to utilise the marine environment, through licencing and titling processes, however when it is left up to competing industries to manage competing interests it can lead to conflict. NOPSEMA has observed significant and increasing levels of conflict increasing between fisheries groups and titleholders in relation to seismic surveys over time.

Conflict often arises as a result of competition for access to the same offshore resources in time and or space, without prior arrangements for priority of access or resolving competing interests.

344. These challenges are often simplified as problems with the environment plan consultation process. However, NOPSEMA's observation is that the root causes lie elsewhere and stakeholder commentary that the consultation process or regulatory requirements are inadequate is just identifying the symptom of these underlying root causes.

345. The root cause likely stems from the way in which rights are separately managed and issued for fisheries and for petroleum resources. Neither rights holder is given a priority use over the other. Both are expected to carry out their operations within the relevant legislation that applies.

346. Visible signs or symptoms that are usually identified as the cause of conflict between fisheries and petroleum industries fall into three broad categories: information, communication and management.

347. Reliable information is lacking across both sectors including lack of available and evidence-based fisheries data to allow seismic companies to better plan around fishing activity. Seismic companies don't always provide clear and simple descriptions of their activities and proposed survey designs together with an explanation of what the likely impacts to fisheries might be and how these will be managed. Gaps in the science regarding the impacts of seismic to commercially important species and the consequence of these impacts at a level that might affect a fishery, can ultimately erode confidence that these surveys can be managed without unacceptable impacts.

348. This combined with poor communication can lead to a lack of clarity, different and unmet expectations, and lack of understanding by both sectors. In addition, a lack of coordination and collaboration between companies wanting to operate in the same areas, and the difference in the management of consultation between fisheries and petroleum industries results in management inconsistencies between the two sectors.

349. Additional challenges are arising because of multiple roles for fishing industry advocacy groups where they are also providing fee for service consultation for the petroleum industry.

350. Attempts have been made by these industries to work collaboratively to develop a standard method of consultation but progress has been slow. In order to address the causes of the conflict, there is a need for:

- Comprehensive, quality information made available to those who need it in a timely manner
- Effective and open communication between parties to build trust
- Clear assignment of management responsibilities and implementation of processes to promote cooperation and consistently deliver acceptable levels of environmental performance.

351. In order to address the science needs of both industries, there have been calls for the seismic industry to invest in research designed to answer key questions relating to the impact of underwater sound on commercially important species and at levels that will result in consequences for the fisheries. This cannot be done effectively by any single company or fishery and will require a collaborative approach.

4.3. The Approach Taken to Seismic Surveys Internationally

352. Marine seismic surveys are conducted in oceans all around the world using much the same techniques. How they are regulated however varies and is dependent on the relevant legislation and policies of those countries and the environmental sensitivities of those places. More than 50 countries worldwide allow marine seismic surveys to be conducted, and Australia is one of only a small number countries that has baseline legislated controls in place for the conduct of seismic (Nelms et al. 2016; Weir & Dolman, 2007).

353. Low frequency sound, in particular, can travel large distances and in the case of European countries, can cross marine jurisdictions. This has resulted in the need for international agreements for the management of marine pollution including underwater noise, particularly in relation to the protection of migratory species. For example in Europe the Marine Strategy Framework Directive (MSFD) encourages member states to develop an ecosystem based approach to the management of human activities, enabling a sustainable use of marine goods and services (Erbe, 2013).

354. The Helsinki Commission (HELCOM) aims to protect the marine environment of the Baltic Sea from pollution through intergovernmental cooperation and use of indicators related to underwater noise and impacts on marine mammals to assess the effectiveness of action plans and the MSFD. The Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) focuses on bycatch rates, habitat deterioration and anthropogenic disturbance to small cetaceans and specifically requires that all parties address underwater noise (Erbe, 2013).

355. The Convention on the Conservation of Migratory Species of Wild Animals (CMS) is an environmental treaty under the aegis of the United Nations Environment Programme and lays the legal foundation for internationally coordinated conservation measures throughout a migratory range. CMS is a framework convention and includes a collection of Agreements and Memoranda of Understanding that have been concluded under it. Australia has been a party to the CMS since 1991.

356. In 2016, at the 12th meeting of the Conference of the Parties to CMS Resolution 12.14 on the Adverse Impacts of Anthropogenic Noise on Cetaceans and Other Migratory species was adopted. In its Annex, it contains CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities (CMS Guidelines) (Prideaux 2016). The Resolution urges Parties to ensure that environmental impact assessment takes full account of the effects of activities on CMS-listed marine species and their prey and consider a more holistic ecological approach at a strategic planning stage. The CMS Guidelines were endorsed and Parties to the CMS urged to disseminate them. The CMS Guidelines represent contemporary good practice guidance for environmental impact assessment.

357. NOPSEMA has regard to the CMS Guidelines and considers that the relevant guidance within the CMS Guideline is implemented in Australia under the Environment Regulations and NOPSEMA's administration of assessment and decision-making on environment plans. Implementation of the CMS Guidelines in Australia is explained further below. NOPSEMA ensures that elements of other examples of international best practice for EIA and management of offshore activities are also considered and adopted in the Australian context where appropriate. NOPSEMA keeps abreast of recent innovations and developments in international regulatory practices through engagement

with the International Offshore Petroleum Environment Regulators Forum (IOPER). This information exchange and learning forum has a working sub-group on offshore petroleum industry issues that relate to marine sound. A recent focus of this group has been on environmental impact assessment practices, research related to the effects of seismic sound on marine fauna and seismic mitigation procedures.

358. All environmental impact assessments should include operational procedures (controls) to mitigate impact to marine fauna effectively during seismic surveys. These monitoring and mitigation procedures are detailed by the national or regional jurisdictions where the activities are proposed and often required to be applied as part of licencing arrangements. There are three main methods currently used around the world to mitigate the potential impacts on marine mammals during seismic surveys: (1) implementation of operational procedures; (2) detection of animals close to airguns and implementation of real-time mitigation measures, and (3) time/area planning of surveys to avoid marine mammals (Weir and Dolman 2007). While the mitigation procedures appear broadly quite similar around the world, there are variations in most parameters of the procedures and there is currently no international standard for seismic monitoring or mitigation. It may be completely appropriate for mitigation procedures to vary depending on the local species, environment, policy and cultural context of the country in which they are applied, however there may also be benefit in standardising procedures where appropriate.

359. It is important to note that legislated control measures for the conduct of seismic surveys apply generally to marine mammals, specifically baleen whales and large toothed whales which are at most risk of impacts from seismic noise due to their hearing anatomy and auditory range coinciding with the high energy component of seismic noise emissions. While some countries extend mitigation measures to turtles, in most countries there are no legislated and prescribed controls in place for seals, polar bears, seabirds, fish or invertebrates. Consideration and management of seismic impacts to these receptors generally falls to consideration during the environmental impact assessment process and compliance with individual jurisdictional requirements. In Australia, all impacts and risks from seismic surveys have to be reduced to levels that are acceptable and as low as reasonably practicable. In the absence of a standard approach to this for species other than marine mammals, a bespoke approach is necessary for each seismic survey, providing a high level of environmental protection.

360. One country that does require mitigation measures for seismic in relation to fisheries is Norway. Seismic activity interactions with fisheries activities are managed in accordance with guidelines published by the Norwegian Ministry of Petroleum and Energy and the Ministry of Fisheries and Coastal Affairs[3] (included in full in Appendix E). The guidelines are designed to facilitate the coexistence of the seismic and fishing industries and to manage impacts to fishing activities. There are no legislated requirements for managing seismic surveys in relation to impacts on marine mammals in Norway.

361. The Norwegian guidelines consider direct and indirect impacts to fish and the fishing industry. There are no restrictions on seismic surveys with consideration to fish eggs, larvae and fry as

[3] Implementation of seismic surveys on the Norwegian Continental Shelf. Ministry of Fisheries and Coastal Affairs and Ministry of Petroleum and Energy.

these impacts are considered small and the consequences at the population level insignificant. Other than metres away from the source, adult fish are not considered to be directly impacted by seismic surveys because they will attempt to swim away from the source. To manage impacts to fisheries from behavioural reactions in fish such as startle responses to seismic sound and potential disruptions to fish spawning migration patterns, restrictions on seismic have been implemented in areas with important spawning grounds and in areas where concentrated spawning migrations take place.

362. Many aspects of the Norwegian guidelines are similar to the requirements for seismic surveys under the Environment Regulations in Australia such as: understanding the fishing activities in the proposed area of seismic operation; consulting with fisheries organisations; considering other seismic acquisition in the same area at the same time; conducting seismic activities so that they don't unnecessarily impede or obstruct fishing. There are however also some key differences between industry regulation in Norway and Australia. In Norway, a qualified fisheries expert must be on board the seismic vessel when fishing operations are occurring in the area to aid in communication between the activity operators. Another key difference between the regulation of seismic surveys in Norway compared to Australia is the convening of an annual meeting by the relevant government authorities to inform companies about time and areas where fish stocks and/or fisheries can be especially affected by seismic surveys. This meeting has a direct bearing on the planning of seismic surveys. The Norwegian Petroleum Act also has special rules regarding compensation for Norwegian fishermen for financial loss resulting from seismic activities in occupied fishing grounds. For compensation to be paid, the fishing activity must be impossible or significantly impeded due to the seismic activity, not just inconvenient. Claims for compensation made by fishermen are reviewed by a commission and if successful are paid by the State (see Appendix E for the full report).

363. Many of the countries with legislated controls to protect marine mammals have developed their seismic mitigation requirements from the guidelines prepared by the Joint Nature Conservation Committee (JNCC) for the first time in 1998 for UK regulators and republished most recently in 2017 (JNCC 2017). These guidelines have been implemented successfully for a number of years throughout the UK and have been subject to review and monitoring in terms of their effectiveness (Wright and Cosentino 2015, Weir and Dolman 2007, Stone 2015).

364. Australia was the next country to develop seismic guidelines in 2001 (Environment Australia 2001). These guidelines were then updated in 2008 with the publication of EPBC Policy Statement 2.1. NOPSEMA frequently requires adaptations of the controls set out in the policy statement to be applied to other marine fauna such as whale sharks and turtles and to ensure the most contemporary science is being considered in the application of mitigation procedures. It is important to note that the legislated controls applied to seismic surveys contained within Policy Statement 2.1 are the minimum controls required to be adopted in Australia and in most cases additional controls are required to demonstrate acceptability. Through the EIA process and application of controls, titleholders must demonstrate that their activity can be conducted in a manner that is not inconsistent with the objectives and actions of management plans for protected matters that may occur within the area.

365. The CMS Family Guidelines (Prideaux 2016) are not legislative requirements that must be applied in Australian waters as they have not been formally ratified and adopted by the Australian

Government, nor are they mandated through Australia's ratification of the relevant Convention itself. However, as mentioned, NOPSEMA has regard to the guidelines and many of the key elements of the CMS Guidelines are incorporated within the requirements of the Environment Regulations in Australia and published NOPSEMA advice. How the elements of the CMS Guidelines are implemented in Australia is presented in Table 4.

Table 4: Illustrates the relevant implementation in Australia under NOPSEMA's jurisdiction

Aspect of CMS Guidelines	Relevant implementation in Australia
Detailed descriptions of activity, equipment, environment, species impacts, etc.	Regulation 10A(a) requires that an environment plan is appropriate to the nature and scale of the activity. NOPSEMA's decision making guidelines require that for this regulation to be met that the activity must to adequately described, the environment that may be affected, and the risks and impacts from the activity must be suitably understood, and there must be analysis of how the activity and the environment interact. For all of these criteria to be met there needs to be detailed descriptions of the environment, the activity and the impact of the activity upon the environment.
Independent review of environmental impact assessment (EIA) by experts.	In Australia, EIA is the responsibility of the proponent under the Environment Regulations, and the EPBC Act. EIA is part of the EP process and is independently reviewed by NOPSEMA as part of its assessment and decision-making under the Environment Regulations. NOPSEMA retains staff to support assessments and can source external expertise where it is required (for example contact with the Department of Environment and Energy's Marine Mammal Centre, part of the Australian Antarctic Division).
Independent, scientific modelling of noise propagation should be impartially conducted	NOPSEMA's Information Paper on Acoustic Impact Evaluation and Management, includes reference to the Technical Support Information to these guidelines and identifies that noise modelling must be conducted by suitably experienced providers. In order to provide an analysis of how the activity and environment interact there is a need for noise modelling to be conducted. Understanding the geo-acoustic seabed properties, bathymetry and sound velocity profiles are inherent components of any noise modelling, that are required to inform frequency specific propagation losses. It is the responsibility of the proponent to contract a modelling expert, and NOPSEMA, as an objective based regulator, does not prescribe the way in which this must be conducted. Given the complexity of the models required to effectively model sound propagation, modelling is generally contracted to an experienced third party provider. NOPSEMA provides an independent review of the independent modelling report. NOPSEMA staff are suitably qualified and experienced, with a thorough understanding of sound modelling and underwater noise, to assess the validity of the noise modelling that has been conducted.

Aspect of CMS Guidelines	Relevant implementation in Australia
	In order for noise modelling to be appropriate, it must be site specific and utilise appropriate sound speed profiles, geo-acoustic properties, bathymetry, and take into account the full frequency spectrum of the airgun noise emissions. These elements are all vital to modelling propagation loss and received levels in the context of sensitive environmental receptors. Where peer-reviewed scientific source models have not been used, NOPSEMA would expect that models be validated prior to the commencement of the survey.
Consultation	A range of mechanisms (see Section 2.2.14) are in place to implement the guideline for community consultation through the Environment Regulations : - Consultation with "relevant persons" for environment plans - Public comment for all stakeholders. Further, the potential for anthropogenic noise to affect marine life is considered in EPBC Act species recovery plans, such as the Blue Whale Recovery Plan, among other matters. These plans are developed and maintained by the Commonwealth Department of Environment and Energy. The Department consults with the community on their development.
Mitigation and Monitoring Plans, and Reporting Plans	Regulation 10A(b) requires that environmental impacts and risks be reduced to as low as reasonably practicable while 10A(c) requires that the environment impacts and risks of the activity be of an acceptable level. In order to achieve this the environment plan must include all mitigation and monitoring measures necessary to reduce the risks and impacts of an activity to acceptable levels and ALARP. Mitigation and monitoring should consider the species and local environment in which the survey will be conducted. NOPSEMA inspects activities to ensure compliance with the accepted environment plan. The environment plan must also contain the details of the environmental performance outcomes, environmental performance standards and measurement criteria that will form the records and standards against which NOPSEMA can inspect the activity to ensure compliance (Regulation 10A(d)). NOPSEMA also requires under Regulation 10A(e) that the environment plan includes an appropriate implementation strategy and monitoring, recording and reporting arrangements. Greater transparency around the publication of environmental performance reports is being sought.
Species Impact	In order to meet the requirements of Regulation 10A (a), (b) and (c), NOPSEMA requires proponents to demonstrate an understanding of the environment including receptors to the species level. Where it is identified that a protected species or important habitat may occur within the area, the proponent must assess the impact on that specific receptor as well as how the activity will be mitigated to prevent impacts. This includes consideration of the activity and it's risks and impacts in the context of species specific sensitivities, behaviour, habitat and life stage.

366. The control measures of eight countries with legislated control measures that are publicly available were compared to determine similarities and differences. All require a minimum pre-start observation time of 30 minutes, during which no marine fauna must be observed in order to start the survey. In areas where there are potentially deep diving cetaceans such as beaked, sperm and blue whales, this pre-start observation time is generally extended to 60 minutes.

367. All eight countries require soft starts to be conducted. In poor visibility conditions, three countries have no additional controls, three require passive acoustic monitoring during the soft start prior to commencement, New Zealand requires passive acoustic monitoring during the soft start or for there to have been low sightings in the area prior to start up. Australia requires, as a minimum, less than four cetacean sightings prior to starting up in low visibility conditions. Soft starts are also applied to turtles in four jurisdictions, however in the USA (Gulf of Mexico) these apply to waters deeper than 200 m.

Community confidence in the seismic industry and ease of operation for seismic operators could be achieved through the collaborative development of a single good practice international standard for seismic mitigation measures.

368. Australia is one of five countries that requires the seismic equipment to be shut down if marine fauna enter the minimum 500 m mitigation zone, and is also one of six countries that requires a power down if marine fauna enter the low power zone of between 1 and 2 km. The UK does not require a shut down or power down, Ireland and Greenland do not require shut downs and NZ does not require power downs.

369. While Greenland is the only country to require noise propagation modelling, both Australia and NZ recommend it and NOPSEMA considers that for seismic surveys in proximity or overlapping with environmental sensitivities, it is a necessary tool to demonstrate that risks and impacts can be managed effectively.

370. Australia is one of five countries that requires marine mammal observers to be on lookout during all daylight hours, while the UK, Ireland and Canada only require marine mammal observers during pre-start observation periods and not during the conduct of the survey itself.

Table 5: Outline of survey soft start requirements in ten countries

Country	Species covered	Soft starts	Pre start obs	Shut downs	MMO
United Kingdom	Marine mammals	Yes	30-60 min	None	2 x trained MMO
Ireland	Marine mammals	Yes	30-60 min	None	Trained MMO
Denmark	Marine mammals and fisheries	Yes	30-60 min	Low power	Trained MMO
Spain	Marine mammals and turtles	Yes	30-60 min	Yes	Experienced MMO
Netherlands	Marine mammals	Yes	30 min	Yes	1 x MMO
USA (GoM)	Marine mammals and turtles	Yes	30 min	Yes	2 x trained MMO
Canada	Marine mammals, turtles, listed species	Yes	30 min	Yes	Trained MMO
Australia	Whales (baleen and large toothed whales)	Yes	30 min	Yes	Trained crew
New Zealand	Marine mammals – encouraged to adopt for turtles, penguins and seabird	Yes	30 min PAM 30 min visual	Yes	2 x trained MMO
Brazil	Marine mammals and fisheries	Yes	30 min	Yes	3 x trained MMO

371. All eight countries require the minimum size airgun array possible to achieve survey objectives to be used.

372. Australia requires that biologically important areas be avoided at biologically important times where possible, and if not possible, that additional mitigation measures be implemented which are consistent across all eight countries.

373. Prior to commencement, all seismic surveys must have an accepted environment plan that will detail all the adopted controls for the activity, which are generally above and beyond those required by Policy Statement 2.1. NOPSEMA requires additional controls to be implemented where there is a potential for impact to environmental sensitivities that requires further mitigation. In order for an environment plan to be accepted, NOPSEMA requires the environmental impacts and environmental risks to all environmental sensitivities to be of an acceptable level and managed to as low as reasonably practicable.

4.4. Any other related matters

374. This section will provide an overview of the some recommendations to address the current challenges in the regulation of seismic, including gaps in existing knowledge and shortfalls in the applicability of scientific studies to EIA. This section will highlight opportunities to improve the conduct and management of seismic into the future. NOPSEMA recognises that in many cases it will be the role of relevant policy agencies and industries to consider these recommendations and not NOPSEMA. NOPSEMA's role is to help identify issues and work with those other stakeholders to promote and collaboratively work on implementing the solutions as appropriate for the independent regulator.

4.4.1. Recommendations

Collaborative research framework

375. In order to bridge the gap between research and its application, there is a need for the questions and outputs of research to be driven by needs of EIA. A focus on real world scenarios, greater understanding of mechanisms for effect and natural levels of variability will all contribute to research that is more applicable to EIA.

376. There have been numerous literature reviews and workshops in the Australian context that have articulated the research priorities that relate to sound and marine life. However, there is no established pathway for these research priorities to be addressed in a standard, coordinated and collaborative manner, supported by sufficient funding and multi-disciplinary expertise.

377. There is an opportunity to develop an agreed framework for research priority setting that is driven by end user needs, underpinned by an overarching goal or outcome and specific to the petroleum industry. Such a framework would enable funding to be directed to priority research and greater coordination to avoid overlap and duplication. There is additional benefit from research to be gained through greater transparency and use of a science/industry research database.

378. Better scoping of research would ensure useable end products and this will require end users to identify clear pathways for the adoption of research outputs. Knowing how research outputs will be used in EIA will help research to be scoped to achieve the desired outcome.

379. Significant research effort is underway on the topic of sound and marine life around the world, but there is limited opportunity to influence research directions and ensure that there is a focus on areas of importance for environmental management decision making and an ability to deliver outputs that can be applied to environmental impact assessment. This is a significant limiting factor in advancing the ability to predict and manage the effects of noise on marine life.

380. The development of a process that facilitates the funding of research efforts that are specifically planned and designed to produce outputs that meet the needs of environmental impact assessment and environmental management of the petroleum industry has the potential to significantly improve efficiency and effectiveness of environmental management and improve stakeholder confidence.

381. There should be increased focus on population level impacts and secondary impacts is needed. Research to date largely focuses on the direct impact of noise on specific receptors. There is a

need for greater focus on the potential fitness impacts to individuals and populations from noise disturbance. For example, focus areas could include long term impacts of temporary displacement from migratory routes or foraging areas on the energy budget of the animal, impacts to spawning should aggregations of fish be disturbed, potential consequences of increased physiological stress in fish, marine mammals and marine turtles as a result of seismic noise, potential exclusion from habitat as a result of repeated surveys in one area.

382. In addition, species specific recovery plans and biologically important areas should reflect contemporary literature and be adaptable based on new information, or variability in species habitat use and behaviour. This is particularly important for those species for which a paucity of information exists, or population numbers are increasing which may lead to utilisation of previously unused habitat. Similarly, new information may lead to a better understanding of habitat use and distribution of suitable habitats for some species leading to smaller but more realistic biologically important areas. The management of recovery plans and the databases that assist in their implementation (e.g. The National Conservation Values Atlas and the Species Profile and Threats Database) should be dynamic and adaptable in response to new information. There may be an opportunity for NOPSEMA to play a role in the update of these materials to increase the usability and applicability of end products to environmental management decision making.

Best practice standards

383. There is opportunity to drive international best practice by standardising mitigation measures and EIA approach for seismic within Australia. Currently while Australia has stringent assessment processes for the approval of environmental plans for seismic surveys, the approach to the EIA process and particularly demonstrating acceptable levels of impact varies between companies. Seismic mitigation measures vary between international jurisdictions and some of this variation is not necessary or useful in maintaining community confidence.

384. EPBC Policy Statement 2.1 is now more than 10 years old and is due for review. While it provides an adequate level of protection for marine mammals as a minimum standard used in partnership with more stringent controls as required by NOPSEMA, it would benefit from an update using more contemporary science and incorporation of measures to reduce behavioural impacts.

Technological advancements

385. There are a number of technological advances in the development of sound sources for geophysical surveys, e.g. marine vibroseis, and the likelihood of alternative technologies with lower environmental impact or greater mitigation benefits becoming affordable and available is increasing.

386. Already a number of alternative approaches to mitigation exist that may have significant environmental benefit, including the use of drones for more effective marine fauna observation, bubble curtains to lessen the sound footprint of the airguns which may lessen sound transmission by up to 50 dB and more effective real time passive acoustic monitoring.

Guidance on implementation of policy

387. There is opportunity to publish guidance in collaboration with other agencies on the interpretation of recovery plans and conservation management plans that inform acceptable levels and the application of these acceptable level thresholds in the assessment of environment

plans. This guidance can extend to summarising current science and knowledge gaps and how the precautionary principle could be applied to account for these gaps.

Marine spatial planning

388. The process for releasing new acreage/titles for petroleum exploration is currently not informed by a strategic marine spatial planning process that considers potential conflicts with other marine users. It does consider environmental sensitivities but only to the degree that titles are not overlaid with areas where oil and gas activities are not permitted. A marine spatial planning process that considers all marine users and environmental sensitivities could assist with early identification of environmental management challenges and the setting of conditions or other requirements on titles to ensure they are effectively managed and conflict is minimised.

Improved practices for industry cooperation

389. Is it evident that good practice consultation by both seismic survey proponents and fishing stakeholders is essential. This leads to greater understanding, cooperation and constructive relationships. When either party engages in bad practices such as exaggerating, altering or withholding information, under or overvaluing impacts based on their interests, it is likely that relationships will be damaged and trust eroded between parties and ultimately industries.

390. While it is up to each individual proponent to ensure they carry out appropriate consultation for each activity with relevant persons, NOPSEMA believes there is an opportunity for the seismic and fishing industries to proactively share, exchange information, and address points of difference via collaborative forums rather than during consultation specific to an individual environment plan.

391. To achieve a more constructive and strategic means for addressing issues, NOPSEMA fully supports the establishment of a collaborative initiative between APPEA, fisheries and relevant government departments, to identify issues and collaborate on finding opportunities for how these can be resolved. The ‘Seafood and Petroleum Industries Regional Workshop’ held in Melbourne last year was a good model for this type of engagement and NOPSEMA would support it continuing, and its possible expansion to other regions. NOPSEMA has recently written to APPEA and SIA to discuss how this can be achieved.

392. For these collaborative initiatives to be successful, NOPSEMA believes that a framework is required that involves all relevant parties working cooperatively to ensure that priority actions are agreed, assigned and implemented. The framework could be structured around the following three themes:

- Relationships – with an aim of building trust, honesty and respect between all stakeholders
- Substance – fostering a better understanding of the issues, knowledge and associated gaps among stakeholders
- Process – improving processes to ensure they are efficient and effective, fair and transparent

393. In 2018, NOPSEMA commissioned a report to investigate what could be done to address conflict between users – Mitigating Fisheries and Seismic Conflict: A strategy for NOPSEMA, Watson 2018. This report identified a number of specific actions that could improve cooperation between the petroleum and fisheries industries including:

- developing better guidance on consultation that includes a template of expectations to assist those people who are frequently consulted on petroleum activities;
- annual regional stakeholder meetings to discuss future planning and issues may help alleviate concerns over duplicative surveys and de-conflict fishing and petroleum activities; and
- a greater use of industry liaison people and the potential to use 'fisheries experts' on board seismic vessels may assist in bridging communication gaps, resulting in more effective consultation (Watson 2018).

394. NOPSEMA is charged under the OPGGS Act with promoting and ensuring titleholders provide the right information to the right people through consultation, and also plays a role in raising awareness, promoting research and educating to build community trust in offshore petroleum management. Consequently, NOPSEMA may play a role in establishing the overarching framework and working group for improved cooperation between petroleum and fishing industries.

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