From: Alan Noble
To: DPTI:State Commission Assessment Panel
Subject: Response to Addendum to the Smith Bay Wharf Draft EIS
Date: Friday, 20 December 2019 4:52:46 PM
Attachments: AusOcean_Addendum_to_the_Smith_Bay_Wharf_Draft_EIS_Response.pdf

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To the Minister for Planning,
Attention: Robert Kleeman, Unit Manager Policy and Strategic Assessment

I write to you on behalf of the Australian Ocean Lab (AusOcean). Please find attached our response to the Addendum to the Smith Bay Wharf Draft EIS.

This response brings new information that builds upon our initial EIS response (which can be found here) and our Smith Bay Marine Ecology Report (which can be found here).

All of this considered, we retain our earlier recommendation that Smith Bay is an inappropriate place for the KIPT, or any port.

Regards,
Alan Noble
Founder, AusOcean

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Addendum to the Smith Bay Wharf Draft EIS Response

Prepared by the Australian Ocean Lab (AusOcean)

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Acknowledgements

AusOcean would like to acknowledge all of its amazing employees, interns, volunteers and partners who made this report possible.

In particular, Catherine Larkin, Lachlan McLeod and Saxon Nelson-Milton deserve a special mention. Special thanks to Trek Hopton and Dave Muirhead for their amazing photos and videos.

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Purpose

This document has been prepared in response to the Kangaroo Island Plantation and Timber (KIPT) Addendum to the Smith Bay Wharf draft Environmental Impact Statement (EIS), dated October (2019).

This document seeks to remedy inaccurate and/or misleading statements presented in the Addendum through a scientific and evidence-based assessment of the impact of the proposed development, based both on first-hand observations and the best-available science.

This document was prepared by the Australian Ocean Lab (AusOcean). AusOcean is a South Australian-based non-profit organisation, registered on the Commonwealth's Register of Environmental Organisations (REO) and with the Australian Charities and Not-for-profits Commission (ACNC). AusOcean receives no public funding. AusOcean's ABN is 34617043722.

1.0 Introduction

Kangaroo Island Plantation Timber (KIPT) released the Addendum to the Smith Bay Wharf Draft Environmental impact statement (EIS) in October 2019. In response, AusOcean returned to Smith Bay in November 2019 to conduct further marine ecological surveys[1]. In previous assessments undertaken in December of 2018 and February of 2019 sites were selected to encompass both the eastern and western sides of the bay and deeper waters located more centrally (see Larkin, 2019). In doing so, a variety of locations were surveyed to assess the heterogeneity of habitats and species throughout the bay.

Sites surveyed in November were strategically selected to assess the potential implications of the revised design features put forward by KIPT on the marine ecology of Smith Bay (Table 1). Notably, the construction of a suspended deck jetty, connecting to a floating wharf approximately 650m offshore. Locations at the berthing area, approach, exit and jetty were subject to additional surveys to assess the potential consequences on marine communities by construction, as well as direct and indirect impacts from vessel movements. Of particular interest was a site identified by SEA Pty Ltd as an area of topographical interest located in the vessel approach trajectory identified in the Addendum as site S31 (Appendix C2). This site however, was only surveyed using camera drops, therefore it was included in our surveys to assess its ecological importance.

Smith Bay and indeed, the entire north cost of Kangaroo Island forms part of the wider Great Southern Reef (GSR) spanning the entire southern coastline of the Australian continent. Many of the species found within Smith Bay and the wider GSR utilise temperate reef habitat and adjoining inter-reef habitats such as seagrass meadows and sponge 'gardens'. These intermediary habitats facilitate connectivity among reefs and act as important nursery grounds for many species. Unfortunately, local stressors such as intense coastal developments are having profound effects on the health and resilience of habitats throughout the GSR.

Smith Bay's marine environment exhibits high species richness and endemism supporting an abundance of emblematic and threatened species with high conservation value. Six protected

[1] For detailed surveying methodologies see Smith Bay Marine Ecology Report prepared by AusOcean https://www.ausocean.org/s/doc/2019_AusOcean_Smith_Bay_Marine_Ecology_Report.pdf.

species from the Syngnathidae family have been noted in Smith Bay. Including both the Weedy sea dragons (*Phyllopteryx taeniolatus*) and Leafy sea dragons (*Phycodurus eques)* which were noted at a site located within the vessel approach. These species are susceptible to major sediment disturbance from propeller wash and the consequent increase in turbidity. Furthermore, two species of temperate coral namely, *Coscinaraea mcneilli* and *Plesiastrea versipora* were sited in numerous locations throughout the bay. These corals are rare in South Australian waters, with their relatively widespread presence on the island likely due to the undeveloped coastline which provides a refuge from threats such as water pollution.

This document describes how the proposed development would undeniably damage the marine environment of Smith Bay. Numerous evidence-based studies that demonstrate why species may lack the ability to simply 'move away' from a perceived threat, such as noise and/or turbidity, have been provided and analysed throughout the document. Hence, potential damage to marine fauna is likely, particularly for benthic invertebrates that are unable to move and species more susceptible to environmental perturbations, such as those from the Syngnathidae family. Anthropogenic noise generated during construction and ongoing port use is not only a threat to individuals but may have implications on the health and service functions of the entire ecosystem. We suggest that any potential damaging impacts to Smith Bay's ecosystem both ecologically and biologically should be assessed in its entirety and be encompassing of all resident species.

Furthermore, we raise numerous new concerns in relation to the water quality impacts assessment, in particular, the sediment sampling and operational propwash modelling of the revised design. Firstly, baseless assumptions that old sampling data would be sufficient to describe the new location, secondly, an overestimated median grain diameter to describe sediment over the entire location, thirdly, invalid justification for use of a large median grain diameter, and finally selected vessel characteristics used in modelling that are not conservative.

All of this considered, we retain our earlier recommendation that Smith Bay is an inappropriate place for the KIPT, or any, port.

2.0 Marine Ecology

Smith Bay and indeed, the entire north coast of Kangaroo Island forms part of the wider Great Southern Reef (GSR) spanning the entire southern coastline of the Australian continent (Bennett *et al.* 2015). The GSR is one of the most pristine and unique temperate reefs in the world and has been recognised as Mission Blue's newest Hope Spot in recognition of the reef's exquisite, raw beauty and immensely rich biodiversity (Mission Blue, 2019). Many of the species found on the GSR utilise temperate reef habitat and adjoining inter-reef habitats such as seagrass meadows and sponge 'gardens' (Bennett *et al.* 2015). These intermediary habitats facilitate connectivity among reefs (Vanderklift & Wernberg 2008) and act as important nursery grounds for many species (Jenkins & Wheatley 1998). Unfortunately, local stressors are having profound effects on the health and resilience of the GSR. For example, kelp forests have undergone widespread decline and loss adjacent to intense coastal developments as a result of localised pollution (Bennett *et al*. 2015). These losses are likely to continue over the next century with local declines accumulating to eventually coalesce as regional impacts (Bennett *et al*. 2015). The high diversity and endemism of the GSR make it globally unique.

According to the State of the Environment Report (EPA 2018) the South Australian marine environment is subject to a diverse range of anthropogenic influences. Human pressures, include, but are not limited to, coastal pollution, habitat modification, disturbance of native species and incursions of pests and diseases. These impacts coupled with the effects of climate change are exacerbating the pressures imposed on these fragile systems. Current population trends for coastal and marine native fauna are worsening with declines in parts of the state with the highest population and development (EPA 2018).

Smith Bay's marine environment exhibits high species richness and endemism supporting an abundance of emblematic and threatened species with high conservation value. This is due in part to the heterogeneous ecology that provides complex habitat for a myriad of species including fishes, sponges, bryozoans, echinoderms and molluscs. Over the course of our surveys, 60 species of fish and 35 species of invertebrates were noted within surveys, comprising 1778 individuals (1460 fish and 318 invertebrates) an additional 11 species of fish and 9 species of invertebrates were sited outside surveyed transects (see Appendix A for entire species inventory). Of these, five species noted by AusOcean and one by SEA Pty Ltd. are protected under the Australian Commonwealth *Environmental Protection and Biodiversity*

Conservation (EPBC) *Act* (1999). In addition, several species of conservation concern were noted as described by the Conservation Council, Reef Watch Feral or Imperil program (Reef watch 2019).

Due to the recent changes in wharf design, habitats of particular interest are those that will be either directly or indirectly impacted by jetty construction and ongoing wharf use located now 650m offshore. Therefore, sites surveyed in November 2019 were selected to reflect the amendments made to project design (Table 1). Of particular interest is the presence of reef habitat located in the vessel approach that is home to several species of protected Syngnathidae including Weedy sea dragons (*Phyllopteryx taeniolatus*) and Leafy sea dragons (*Phycodurus eques)*. This site was identified by SEA Pty Ltd as an area of 'topographical interest', however, was assessed using camera drops, as opposed to scuba surveys. We therefore included it in our surveys to assess its ecological importance. These unique pockets of varied reef topography provide necessary habitat and shelter for a myriad of fish and invertebrate species, including those that are protected (Figure 1). These species will be affected both during wharf construction and ongoing wharf use as a result of shipping movements. The full extent of this reef is unknown however we can confirm its presence in numerous locations (Figure 2).

Figure 1: Reef habitat located at site 4 (left) and site 16 (right).

Table 1: Sites, coordinates and number of transects for November 2019 dives sites.

Site no.	Site	Lat (deg)	Lng (deg)	No. Transects
11	Exit	-35.58423	137.424	1
12	Berthing Area West (BAW)	-35.58525	137.42563	1
13	Jetty	-35.58653	137.4261	1
14	Berthing Area East (BAE)	-35.58529	137.42772	2
15	Approach	-35.58385	137.4294	1
16	S31	-35.58478	137.43122	2

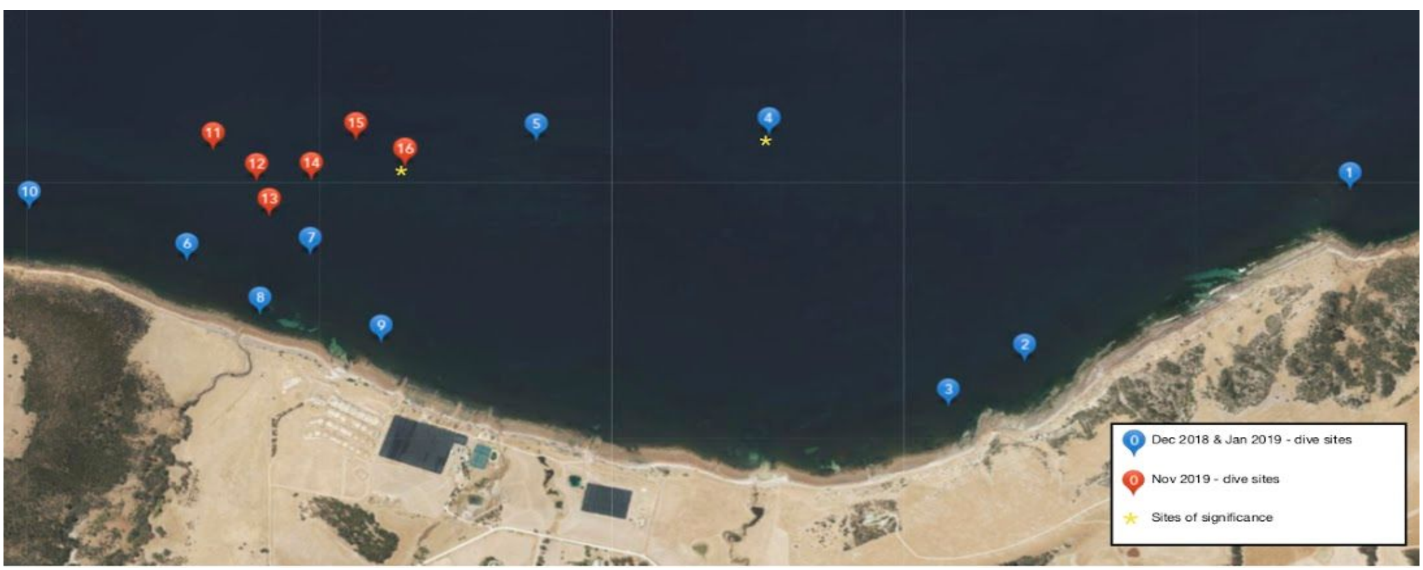

Figure 2: Map of survey locations.

2.1 Protected Species

Six protected species from the Syngnathidae family have been noted in Smith Bay. Namely, Wide bodied pipefish (*Stigmatopora nigra*), Spotted pipefish (*Stigmatopora argus*), Mother of pearl pipefish (*Vanacampus margaritifer*), Ringed back pipefish (*Stipecampus cristatus*), Weedy sea dragon (*Phyllopteryx taeniolatus*) and Leafy sea dragon (*Phycodurus eques).* These species are protected under the Australian Commonwealth *Environmental Protection and Biodiversity Conservation* (EPBC) *Act* (1999).

Smith Bay has the potential to be a Syngnathid hotspot for numerous reasons:

1. Six species have already been recorded which suggests that further taxa are likely to be present.
2. Habitat within Smith Bay is highly heterogeneous providing a range of seagrass, reef and sponge habitat which supports a diverse assemblage of fish species. Additionally, Smith Bay is located in close proximity to other known hotspots such as Pelican Lagoon.
3. Further species await discovery and a location such as Smith Bay which has never been trawled is a place where rare and potentially new species may have survived (D Muirhead, personal communication, 18 December).

Protected species of Smith Bay will be exposed to a myriad of risks stemming from the construction and ongoing use of the wharf, namely noise, turbidity and turbulence. These are discussed in further detail throughout the report. It is important to note the impacts addressed throughout this report are by no means exhaustive. There are a plethora of associated risks likely to impact these vulnerable species and surrounding environs, both known and unknown.

Figure 3: Leafy sea dragon (*Phyllopteryx taeniolatus*) (left) and Weedy sea dragon (*Phyllopteryx taeniolatus*) (right) noted at site 16.

2.2 Temperate Coral

Throughout AusOcean's surveys two species of colony forming corals, namely *Coscinaraea mcneilli,* and *Plesiastrea versipora* were sighted at several locations throughout Smith Bay, including site 16 of the most recent surveys by AusOcean (Figure 4). Numerous sightings suggest there may be additional colonies yet to be discovered within the bay.

Baker *et al.* (2013) has described the temperate coral *Plesiastrea versipora* as a species of conservation interest on northern Kangaroo Island. Although this species is not currently considered threatened on a global scale, there may be localised threats for populations residing in shallow water systems due to sedimentation of reefs, nutrient enrichment due to coastal developments and physical damage caused by destructive fishing practices (Baker *et al.* 2013). It has been suggested by Baker *et al.* (2013) that the undeveloped coastline of northern Kangaroo Island (as opposed to eastern coast of Gulf St. Vincent for example) provides a refuge for these species from threats such as water pollution. Hard corals such as *P. versipora* are very slow growing in temperate waters with rates of less than 1cm per year (Burgess et al. 2009). For example, research by Burgess *et al*. (2004) has dated the base of a 24cm *P.versipora* core in the Spencer Gulf to 151 years. Furthermore, an additional 6 colonies of coral in the South Australian gulfs with age estimates ranging from 90-320 years were dated using various methods of ageing (Burgess *et al.* 2004). Baker *et al.* (2013) suggest that large old colonies of *P. versipora* are rare and it is considered likely that such colonies below 10m deep have been removed in the gulfs region by trawling, which has occurred since the 1960's.

Figure 4: Green coral (*Plesiastrea versipora*) (left) noted at site 4 and McNeill's coral (*Coscinaraea mcneilli*) (right) noted at site 16.

3.0 Environmental Issues

This section raises direct concerns with the following statements contained within the Addendum to the Smith Bay Wharf Draft EIS.

3.1 Noise

1. As noted in the Draft EIS, damage to the hearing of marine fauna would be considered unlikely as the normal behavioural response to loud noise would be to move away. Behavioural changes in response to noise are expected to be temporary and ecologically inconsequential as Smith Bay is not known to provide important feeding or breeding habitat.
2. The Draft EIS assessment concluded that without mitigation, the overall risk of adverse noise effects on the relevant marine species is low.

According to the World Health Organisation (2011) human induced (anthropogenic) noise is recognised as a global pollutant and is characterised as one of the most harmful forms. Research surrounding the effects of noise pollution has primarily centered around marine mammals. In recent times however, the implications on fish and invertebrates are being increasingly recognised (Weilgart 2018). This is an important consideration because fishes and invertebrates underpin the food web for marine mammals, reptiles, seabirds and humans (Hawkins & Popper 2016). According to Slabberkoon *et al.* (2010) all fish studied to date are able to hear sounds and that increasing numbers of invertebrates are able to detect sound and/or vibration and respond to acoustic cues (Simpson *et al*. 2011). It has been suggested that fish and invertebrates use sound in numerous ways, comparable to marine mammals and terrestrial vertebrates (Hawkins & Popper 2017). This includes communication with conspecifics, avoiding predators, seeking prey, locating appropriate habitats, and orientating with respect to environmental features (Hawkins & popper 2017).

As outlined in the EIS (Appendix N p.34) fish with swim bladders (most teleost fish) are much more susceptible to trauma, compared to those without (chondrichthyes). However, underwater noise predictions and threshold distances were not included for either fish with swim bladders or invertebrates. Underwater pile driving and its impact on fish and invertebrates are adequately discussed in an assessment made by McAuley & Kent (2008) in response to a proposed wharf development. It therefore remains unclear as to why these assessments have not been included in either the EIS or Addendum. Although there are discussions surrounding the usefulness of behavioural audiograms in only a select number of fish species, these effects and risks should be adequately addressed. Even though many of the fishes and invertebrates present in a system may not be afforded special conservation designation as a species, they may be especially important components of local ecosystems (Hawkins & popper 2017). Any potentially damaging impacts to Smith Bay's ecosystem both ecologically and biologically should be assessed in its entirety and be encompassing of all residing species. Of particular importance are individuals that may be especially vulnerable to noise exposure and those that play an important ecological role within local biological communities (Hawkins & Popper 2017).

Noise is known to have wide ranging, adverse effects on an individuals behaviour, anatomy, physiology and development (Weilgart 2018). An organism's response to sound is dependent on a variety of factors such as tolerance, distance, degree of exposure and the nature of the source (Hawkins & Popper 2017). Figure 5 details a number of possible responses to sound. Furthermore, a detailed outline of the potential effects of anthropogenic noise is outlined in Table 2, as derived from Hawkins & Popper (2017).

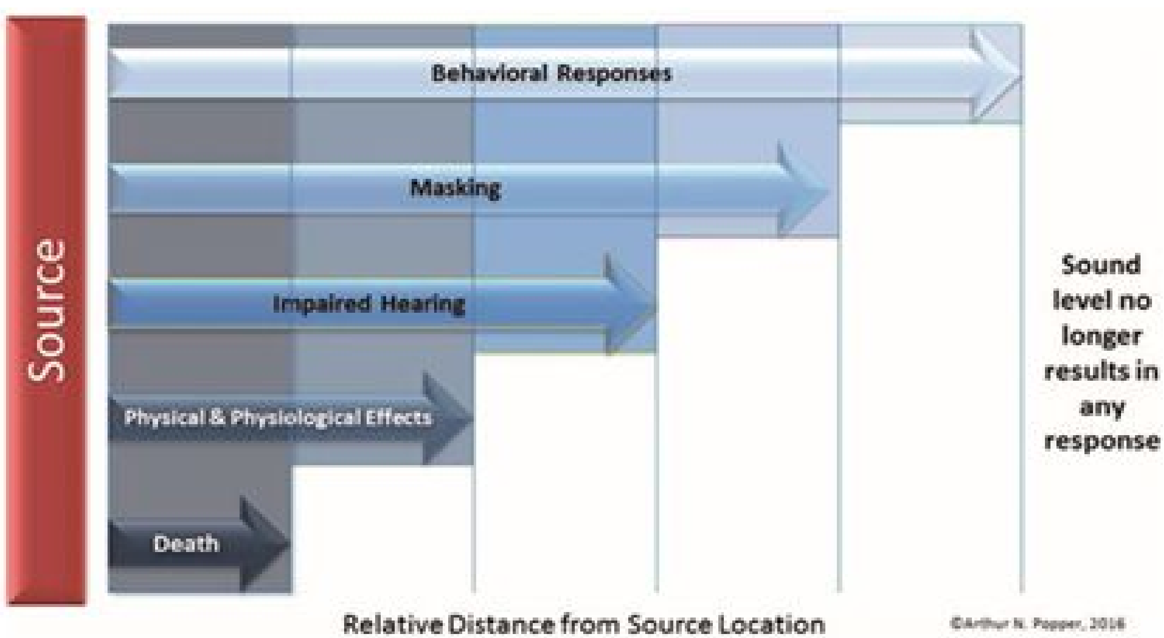

Figure 5: Potential effects of sound at different distances from a source (Hawkins & Popper 2017).

Table 2: Potential effects of anthropogenic sound on animals. From Hawkins & Popper (2017).

Death	Either immediate mortality or tissue and/or physiological damage that is sufficiently severe that death occurs some time later due to decreased fitness. Mortality has a direct effect upon animal populations, especially if it affects individuals close to maturity.
Physical and/or Physiological Effects	Tissue and other physical damage or physiological effects, that are recoverable but which may place animals at lower levels of fitness, may render them more open to predation, impaired feeding and growth, or lack of breeding success, until recovery takes place.
Impaired Hearing	Short - or long-term changes in hearing sensitivity (temporary threshold shift - TTS or permanent threshold shift - PTS) may, or may not, reduce fitness and survival. Impairment of hearing may affect the ability of animals to capture prey and avoid predators, and also cause deterioration in communication between individuals; affecting growth, survival, and reproductive success.
Masking	The presence of man-made sounds may make it difficult to detect biologically significant sounds against the noise background. Masking of sounds made by prey organisms may result in reduced feeding with effects on growth. Masking of sounds from predators may result in reduced survival. Masking of spawning signals may reduce spawning success and affect recruitment. Masking of sounds used for orientation and navigation may affect the ability of fish to find preferred habitats including spawning areas, affecting recruitment, growth, survival and reproduction.
Behavioural Responses	Changes in behaviour may take place in a large proportion of the animals exposed to the sound, as such responses may occur at relatively low sound levels. Some of these behavioural responses may have adverse effects. Displacement from preferred habitats may affect feeding, growth, predation, survival and reproductive success. Changes in movement patterns may affect energy budgets, diverting energy away from egg production and other vital functions. Migrations to spawning or feeding grounds may be delayed or prevented, with detrimental effects upon growth, survival and reproductive success. Prevention of recruitment and settlement in preferred habitats may affect colonization and population size in any area exposed to high levels of noise.

Kunc *et al*. (2016) showed that noise impacts on behaviour at the individual level such as compromised communication, feeding, orientation, parental care, prey detection and increased aggression can have implications at the community level through less group cohesion, avoidance of important habitat, fewer offspring and higher death rates (Figure 6). Similarly, noise impacts on physiology can cause poor growth rates, low reproductive rates and decreased immunity (Weilgart 2018). While some individuals may recover from physiological or behavioral impacts, other serious injuries such as changes to DNA or genetic material or injury to vital organs are irreversible (Kight & Swaddle 2011). These collective impacts, reversible or not, can have broad ramifications on ecosystem functioning, potentially altering the population biology (the health and resilience of various populations) and ecology (the interaction and coexistence of multiple species) (Kunc *et al*. 2016). Williams *et al.* (2015) suggest that non injurious effects can still accumulate to have population level impacts mediated by a range of factors including physiological. This is supported by Peng *et al.* (2015) who conclude that noise pollution is not only a threat to individuals, but may also have implications on the health and service functions of entire ecosystems.

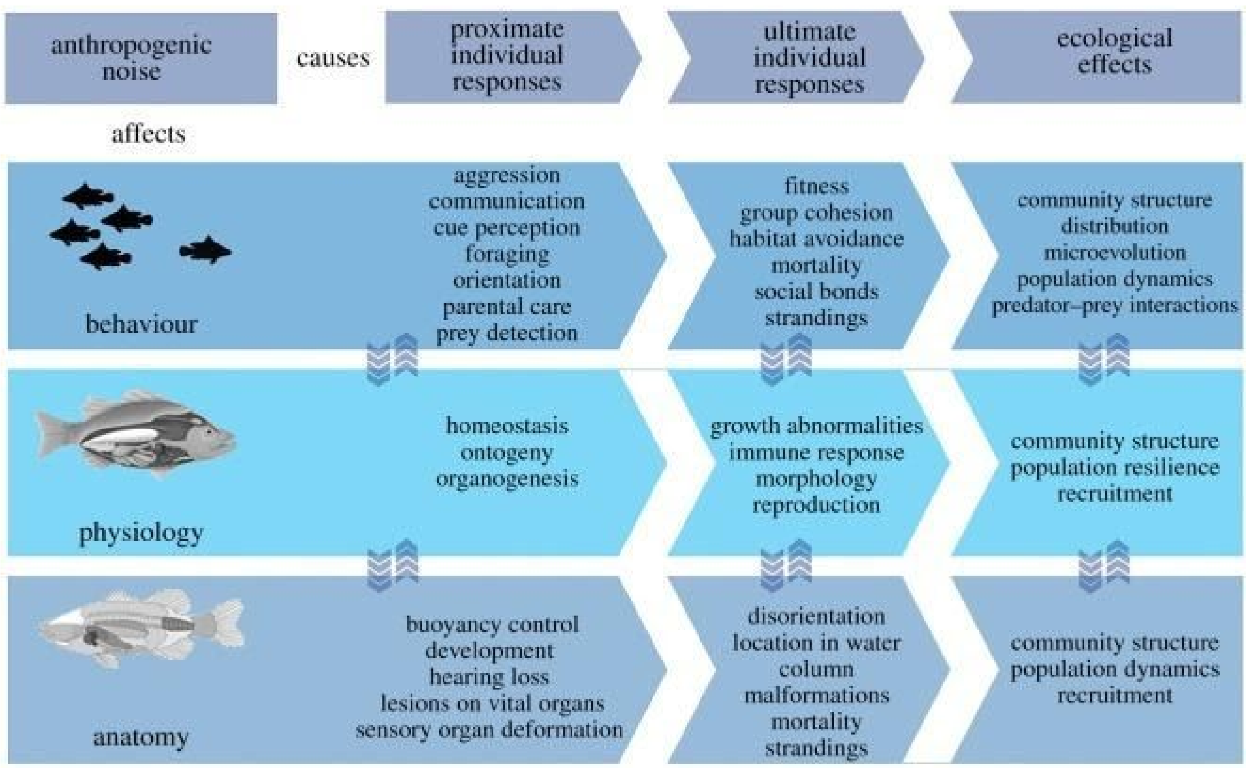

Figure 6: The effects of anthropogenic noise on individuals' anatomy, physiology and/or behaviour, resulting in effects at the ecological level (Kunc *et al.* 2017).

Often, the effects of noise have been oversimplified by suggesting that species are either sensitive and will abandon an area or are not and will remain (Francis & Barber 2013). Researchers advise that it should not be automatically assumed fish will leave a noisy area and thus avoid harmful exposures for several reasons (Aguilar de Soto 2016). It is not uncommon to observe a typical “fright” response or to freeze in place (Popper 2003), or individuals may not be able to escape because they are disoriented from the noise effects on their sensory systems (Aguilar de Soto 2016). Furthermore, some species are territorial and others have small home range sizes and cannot move quickly enough. For example, species from the Syngnathidae family (pipefish, seadragons and seahorses) have life history traits that make them particularly susceptible to decline (Foster & Vincent 2004; Martin-Smith & Vincent 2006). Studies show that most individuals in common with leafy seadragons, have limited home range sizes of <1 ha (Sanchez-Camara & Booth 2004). This may make it difficult to move away from a perceived threat, particularly if they are residing in areas of fragmented habitat. Furthermore, damage to hearing structures can worsen over time, even after the noise has ceased, sometimes becoming most pronounced after 96 hours post-noise exposure with temporary hearing loss lasting months (Weilgart 2018).

Human activities that involve direct contact with the sea bed such as pile driving, which produces radiating particle motion waves, can impact bottom dwelling animals (Roberts *et al.* 2015). Studies have shown ecological services such as water filtration, mixing sediment layers and bioirrigation (fundamental nutrient cycling processes on the seabed) can be negatively affected. Researchers utilised a semi-open field experiment to examine the effect of impact pile driving on clearance rates in mussels. Clearance rate, the rate at which filter feeders sift out suspended particles from the water, is a reliable indicator of feeding activity in mussels (Weilgart 2018). Hence, observed increased feeding rates may be a sign of mussels coping with stress and the higher metabolic demand this requires (Spiga *et al*. 2016). In addition Roberts *et al*. (2015) found clear behavioural changes in mussels, mainly valve closure. The results indicate that vibration through activities such as pile driving is likely to impact the overall fitness of individuals and mussel beds due to disruptions in valve periodicity which can have ecosystem and commercial implications.

In addition to sounds of relatively short exposure, such as those produced during pile driving, more moderate noises that occur over longer durations such as those produced by vessels have the potential to impact much larger areas and therefore have wider implications on inhabiting marine fauna (Slabberkoon *et al*. 2010). Studies that investigated boat noise and its effect on local fish species found that by raising ambient noise by 40dB, detection distance of other fish sounds can be reduced by 100-fold depending on the species (Codarin *et al*. 2009). Other effects include antipredator behaviour (La manna *et al*. 2016; Simpson *et al.* 2016; McCormick *et al*. 2018; Wale *et al.* 2013), foraging and feeding (Magnhagen *et al*. 2017; Bracciali *et al.* 2012; McLaughlin & Kunc 2015; Payne *et al.* 2014), attention (Purser & Radford 2011; Chan *et al.* 2010; Voellmy *et al.* 2014), schooling behaviour (Sarà *et al*. 2007; Mueller-Blenkle *et al.* 2010) and perhaps the most serious impact, survival and reproduction, which can have consequences at the population level (Nedelec *et al*. 2017; de Jong *et al.* 2018; Krahforst 2017). Wale *et al.* (2016) demonstrated the effects ship noise playbacks can have on mussels. Results showed significantly higher breaks in the DNA in cells of noise exposed mussels. Algal clearance rates were also lower and oxygen-consumption rates higher, indicating stress. These impacts can cause reduced growth, immune response and reproduction. Lower algal clearance rates imply that important ecological services such as water filtration could not be performed (Wales *et al.* 2016). Further research by André *et al*. (2011) found that experimental exposure to low sound frequencies of two species of squid, one species of cuttlefish, and one species of octopus resulted in massive acoustic trauma.

To oversimplify the ramifications of noise pollution and suggest that species have the ability to simply ‘move away’ is inadequate. We provide numerous evidenced-based studies that demonstrate why species may lack this ability. For this reason, potential damage to marine fauna is likely, particularly to benthic invertebrates that are unable to move. Moreover, proposing that noise-based behavioural changes are expected to be temporary and ecologically inconsequential contradicts relevant research. Numerous studies clearly outline the potential behavioural changes and significant implications at the population level.

3.2 Turbidity

Turbidity is the relative measure of clarity caused by suspended particles in the water column. It is known to affect key evolutionary processes related to visual stimuli and olfactory cues in many species of fish (Higham *et al.* 2015). Site 16, an ecologically diverse location containing species of high conservation significance, lies directly beneath the proposed trajectory of ships approaching the wharf. At a depth of 15m, the site is susceptible to major sediment disturbance from propeller wash (see section 3.5) and a consequent increase in turbidity.

5 species of Syngnathids, all of which are protected (EPBC *Act* 1999), have been sighted within Smith Bay. They are a family of highly visually oriented fish and as such their sexual selection is largely determined by visual cues (Rosenqvist and Berglund 2011). Adaptive mate choice requires these cues to be communicated clearly by both receiver and sender. Those organisms that rely solely on visual stimuli for mate choice can face decreased levels of fitness for both sexes, as a consequence of impaired signal transmission (Sundin *et al.* 2010). This in turn, can negatively affect population viability. Sundin *et al.* (2010) noted the effects of turbidity in a sex role-reversed broad-nosed pipefish, *Syngnathus typhle,* where male mate choice was indeed altered by turbid water. As with most species of fish, colours and markings are factors in mate choice, as is body size, an important trait in sexual selection which directly relates to fitness (Sundin *et al.* 2010). *S. typhle* males always chose larger females in clear water, however turbidity hindered their vision resulting in decreased time assessing potential mates and no preference in relation to quality/size of the females. Furthermore the pipefish did not appear to use olfactory cues for mate choice, making visual incentive the sole motivator for sexual selection. Similar results in other species of fish have been found (Moyaho *et al.* 2004; Heubel and Schlupp 2006; Engström-Öst and Candolin 2007).

The feeding behaviour of fish is another key process susceptible to change in turbid water (Kellog and Leipzig-Scott 2017). For many species of teleost fish, there is a strong correlation between visual predation and illuminance of the immediate underwater environment (Felício *et al.* 2006). The majority of syngnathids are diurnal feeders, with only two species of seahorse and one species of pipefish recorded as feeding nocturnally (Manning *et al.* 2019). Such a direct relationship between feeding and light availability suggests a drastic change in turbidity will result in drastically disturbed feeding regimes. While it is true some fish are able to use both visual and olfactory cues in their foraging efforts, this is not the case for the syngnathids, which are highly adapted visual hunters (Manning *et al.* 2019). Their specialised eyes are evolved to seek out live, mobile prey, rich in carotenoids (Collin and Collin 1999). Coupling the impacts of disturbed feeding regimes with reduced visibility for predation could have detrimental effects on survival and reproduction.

Two species of temperate coral identified in Smith Bay (see section 2.2) have the potential to be negatively affected by turbid water and resuspension of benthic sediment. Turbidity and suspended sediment concentrations (SCC) are known to limit ambient light availability, thereby hindering photosynthesis of the coral's endosymbiotic algae (Pollock *et al.* 2014; Macdonald 2015). Being heterotrophic feeders, excess sedimentation can clog feeding apparatus, inhibiting feeding efficiency and further contributing to a decrease in overall energy intake (Bessel-Browne *et al.* 2017). Furthermore there is evidence that suggests sediment and turbidity are directly related to disease prevalence in corals. Pathogens such as silt-associated bacteria can be carried by disturbed sediment onto nearby corals, contributing to necrosis and other health issues (Pollock *et al.* 2014). Temperate coral colonies are rare and of ecological interest. Those located within the vicinity of wharf construction and underlying vessel movements will be particularly susceptible to damage or destruction.

3.3 Turbulence

Panamax vessels with a draft of up to 11.75m can cause significant turbulence in the water column. Those organisms and surrounding habitat which are not immediately destroyed via contact with vessels and propellers, have the potential to become severely displaced or experience alterations in feeding and behavioural mechanisms (Higham *et al.* 2015)

Syngnathids are particularly susceptible to turbulence issues. Compared to most species of teleost fish, syngnathids are weak swimmers. They move delicately and stealthily through rapid oscillations of the pectoral and dorsal fins, rather than thrusting through water using muscular caudal fins (Consi *et al.* 2001; Ashley-Ross 2002; Neutens *et al.* 2017). It is a likely scenario that any syngnathid caught in turbulence from propeller wash will be destroyed due to their inabilityto swim away. Those syngnathids that are able to escape physically unscathed, still face danger from disorientation due to their limited home ranges (Sanchez-Camara and Booth 2004). Furthermore, bony fish have sensitive swim bladders that, when under stress, are susceptible to damage. Improperly functioning swim bladders fail to adequately maintain buoyancy, resulting in the eventual death of the fish.

Turbidity as a consequence of turbulence is well documented, however the effects of turbulence on the fitness of organisms through altered zooplanktonic interactions at the trophic level is less known (Iversen *et al.* 2009). Boat generated turbulence has a myriad of effects on copepods (Bickel *et al.* 2011), small crustaceans of extreme importance in many aspects of marine ecology, such as the food web. They are one of the key primary food sources for many species of fish, including seadragons and pipefish (Collin and Collin 1999). Bickel *et al.* (2011) describe changes in behaviour, physiology and most notably, the high mortality rates of copepods attributed to boat generated turbulence. Disruptions at any trophic level can lead to drastic alterations in the food chain, many of which are catastrophic or have largely unknown effects. As noted by KIPT in the addendum, up to 10 vessels per day may enter Smith Bay during construction, with the possibility of creating frequently turbulent conditions. The potential for negative impacts, either direct or indirect, affecting organisms and the ecosystem as a whole raises cause for concern.

3.5 Sediment Mobilisation and Seafloor Scour

From the Addendum to the Smith Bay Wharf Draft EIS, a comment is made based upon BMT's water quality impacts assessment of the revised design: *"The results also confirm that ship movements would result in only very minor effects on water quality in Smith Bay that would be confined to the immediate vicinity of the pontoon."* (Environmental Projects 2018, pg 15); it could be argued however that BMT's updated water quality assessment does not adequately adjust for the new design. BMT states that the *"operational propwash modelling assessment undertaken for the Draft EIS (BMT 2018a) was updated for the revised KI Seaport design"* (BMT 2019, pg4), however, there is no indication that new sediment samples have been collected to parameterize the updated location. It can only be assumed that the revised model has re-used sediment characteristics found from the original sampling sites.

Figure 7 outlines the sediment sampling locations relative to the old and new designs. It is clear that the original sampling sites do not extend adequately northward to describe the revised berthing and approach/departure locations. The assumption that sediment characteristics are consistent across the old and new areas is unfounded; suggested by Figure 8, showing median sediment diameters to be heterogeneous across sampling sites. Assuming this heterogeneity continues northward, it is possible that there are locations of particular susceptibility to suspension and mobilisation that have not been accounted for in modelling; one such location being Site 16, a site of ecological significance (see section 2.1).

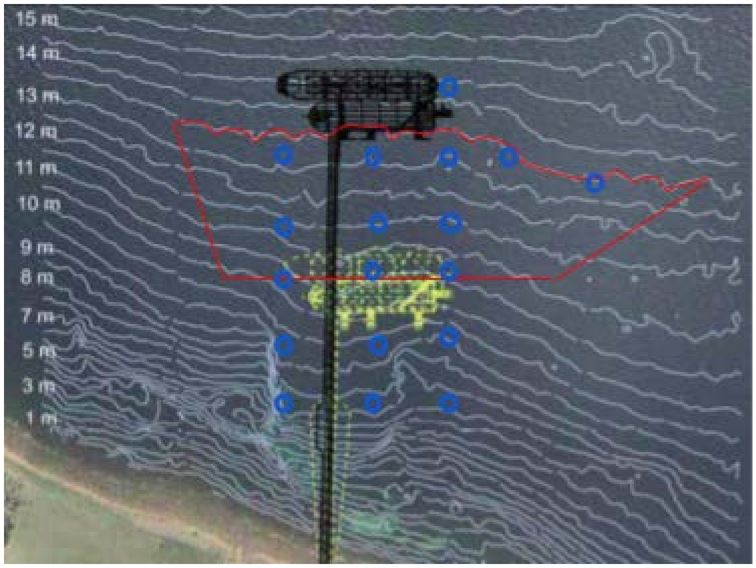

Figure 7: Comparison of old and new wharf design from (Environmental Projects 2019) with an overlay of approximate dredge area and sediment sample locations.

Not only do the original sampling sites fail to describe sediment characteristics of the new wharf area, it is also questionable as to how well the original model accounts for the clear diversity in sediment diameters as to be necessarily conservative within the analysis. While parameterisation of shipping to be involved is cautious i.e. adopting characteristics of Panamax Class (largest vessel to be used at the Wharf), full power over acceleration/deceleration and large acceleration/deceleration segments, the choice of median grain size and justification is unusual. BMT states that *"A median grain size* $D_{50} = 0.5mm$ *was applied, corresponding to the maximum value from the geotechnical assessment (COOE, 2017) which maximises the friction coefficient."* (BMT 2019, pg83), but according to the analysis documents made available from COOE (2018), the maximum grain size was not 0.5mm, as some diameters reported were up to 19mm. In any case, the justification provided is unusual. It's unclear why a maximum grain size was chosen in the first place; susceptibility to resuspension and transport is negatively correlated to grain size regardless of increased frictional coefficient, as demonstrated by equation 1 from Van Rijn (2013) giving critical suspension velocity.

$$U_{cr,susp} = 5.75log(\frac{12h}{6D_{50}})\sqrt{(\theta_{cr,susp}(s-1)gD_{50}} \qquad (1)$$

This equation provides critical suspension velocity (bed velocity at which particles become suspended) as a function of grain diameter, assuming relative density and water depth are constant. If this relationship is plotted, it is clear that the critical velocity decreases with a decrease in grain diameter, as shown by figure 9. Put simply, the smaller sediment grain size, the more readily it is suspended by bed velocities. It is therefore unexpected that a maximum grain size was chosen as a median if the intention was to be conservative.

Site	Median Grain (mm)	Site	Median Grain (mm)
SB1	0.464	SB10	0.823
SB2	0.14	SB11	?
SB3	?	SB12	0.146
SB4	?	ZZ3	0.195
SB5	0.118	ZZ4	0.285
SB6	0.129	ZZ5	0.257
SB7	0.162	ZZ6	0.265
SB8	0.376	ZZ7	0.314
SB9	?	ZZ9	0.279

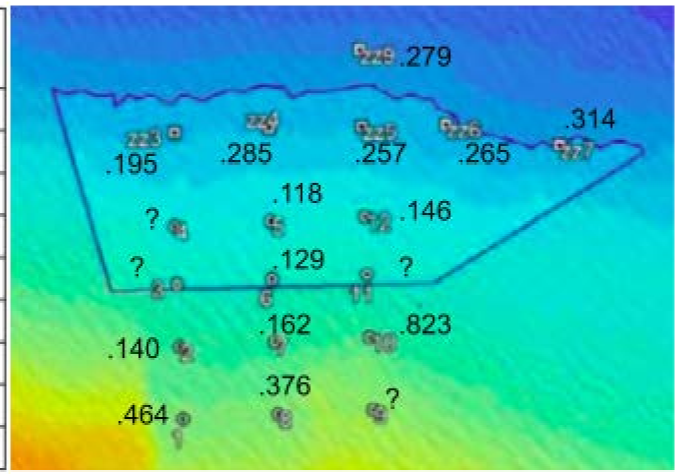

Figure 8: Sediment sampling locations with median particle size (mm) indicated (COOE 2017).

Median grain diameters for each site have been extracted from the ALS (2017-2018) analysis results, summarised and overlaid on the site map in Figure 8. Information on sites however is deficient, as the analysis results for 4 sites, namely, SB3, SB4, SB9 and SB11 have not been included in the COOE (2019) report. No explanation for their absence has been provided. Nonetheless, it is still obvious that median grain diameter varies significantly from site to site, and for the most part is much smaller than 0.5mm, with the minimum median diameter in the included data being .118mm (ALS 2017). A conservative analysis would have adopted the smallest found median diameter, or used the median sediment diameter over all sites, and then applied some factor of safety. Adopting a median grain diameter larger than the actual median would result in an analysis that would undoubtedly underestimate sediment mobilisation and transport.

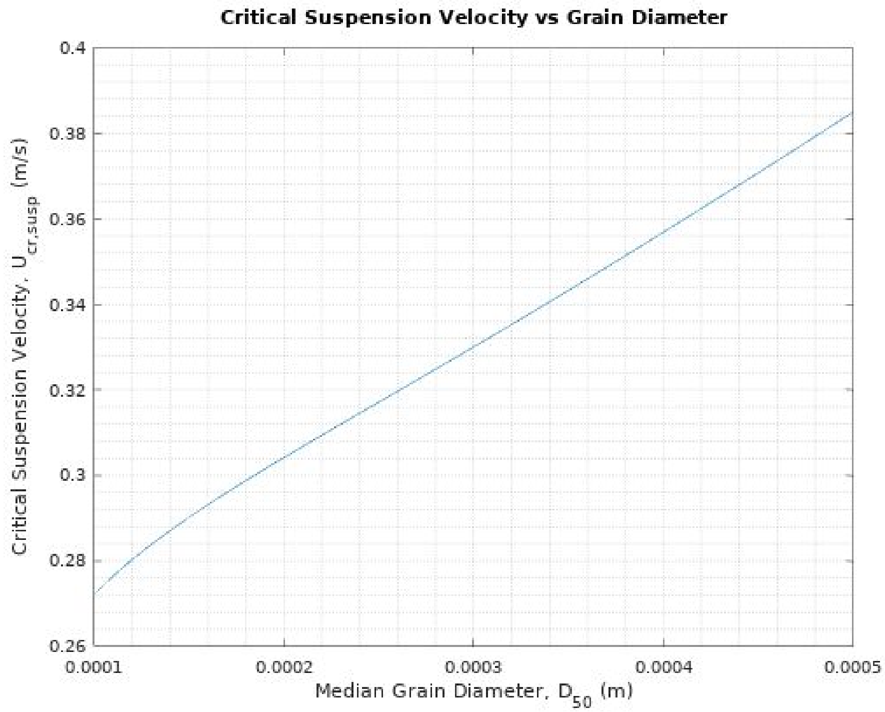

Figure 9: Plot of equation 1 (see Appendix B for plotting code).

A concern besides the aforementioned assumptions on sediment grain size is the chosen set of vessel characteristics used for modelling; the main factor in determining resulting bed velocities besides water depth. Table 3 summarises vessel characteristics from the BMT (2019) hydrodynamic analysis, for which no origin or justification of these values is provided. Interestingly, they do not align well with typical vessel characteristics provided by MAN Diesel & Turbo (2013) visible in Table 3; SMCR power for vessels of similar size is considerably larger than the adopted value. For the BMT analysis to be conservative, a vessel resulting in maximum bed velocity while satisfying the imposed dimensional limits should have been chosen, but the analysis performed (Appendix C) shows that this is not the case. Two typical panamax vessels satisfying the dimensional constraints have been found to impose higher maximum bed velocities than the vessel adopted by the BMT modelling. This indicates that the BMT modelling has not been sufficiently conservative; there are clearly other vessels that could be used with this wharf that will have a greater influence on sediment mobilisation. Proponents of the EIS may argue that vessels with greater SMCR power than that of the selected will not be used at the wharf, but the EIS clearly states that the wharf will accommodate *"Panamax vessel of up to 60,000 deadweight tonnes (DWT) and a draft of up to 11.75 metres."* (Environmental Projects

2019, pg51). Either the BMT analysis has not been sufficiently conservative, or statements regarding vessel limits are misleading.

Table 3: Vessel characteristics and resulting max seabed velocity at Depth 15m corresponding to Site 16 for vessels from BMT and AusOcean analysis' (vessel characteristics for AusOcean analysis are typical for vessels in this class (MAN 2013)).

Vessel	1, BMT	2, AusOcean	3, AusOcean
Class	Panamax	Panamax	Panamax
DWT (tonne)	63,000	38,100	30,800
Draft (m)	11.6	11.3	10.7
LOA (m)	200	246	211
Breadth (m)	32.3	32.2	32.2
SMCR Power (kW)	8,990	31,300	25,000
Cruise Speed (kts)	23[2]	23.5	22.5
Prop Diameter (m)	6.5	8.48	8.03
Prop Speed (Hz)	2.05	1.75	1.74
Max Seabed Velocity (m/s)	8.94	11.12	9.63

Not only does the BMT modelling appear flawed in itself, it also only addresses effects of sediment suspension and transport on general water quality throughout Smith Bay, and in particular the impact this may have on Yumbah's water intake, however, it does not address the extent of direct damage operational propwash may have on sites located in the berthing area and the approach/departure zones. Although substrate in the berthing area is rubbly, and less prone to resuspension, sites such as site 16 were observed to possess fine sandy substrate. It is said in the original BMT (2018, pg 83) modelling report: *"The approach and departure patterns of the vessel are operator influenced and subject to high variability."*. Based on previous marine surveys, there is in all likelihood, sites of similar ecological significance to Site 16. Any such site will be subject to detrimental effects, both direct and indirect, as a consequence of these highly variable vessel approach/exit trajectories. Calculated maximum seabed velocity (stationary to thrust required for cruise) of the BMT modelled vessel is 22 times

[2] Cruise velocity for vessel from BMT analysis has been estimated to that of similarly sized vessels.

the critical suspension velocity of grains with .5mm size at 15m depth; the same depth of site 16. There is no doubt substrate, vegetation and organisms would be ripped apart with velocities of this magnitude. There is clear evidence that turbulence and turbidity have detrimental effects on organisms, as explored by Sections 3.3 and 3.2 respectively.

To summarise, the revised BMT hydrodynamic analysis is problematic on multiple fronts:

- The assumption that the original sampling sites are sufficient to model the revised area is unfounded, as indicated by the sheer heterogeneity in substrate observed.
- The selected median grain diameter for modelling is far larger than the medians of the investigated sites and is therefore not conservative.
- The justification of use of large grain diameter for maximisation of friction coefficient is invalid as susceptibility to suspension is negatively correlated to grain size.
- Finally, the selected vessel characteristics do not result in maximum theoretical seabed velocity, as other vessels under the dimensional limits of the wharf were found to result in higher seabed velocities, with concomitant damage much higher.

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Appendices

Appendix A: Species Inventory

*Total and FOO includes North Central and North where no formal survey transects were undertaken.

Species	Common name	Feb 2018/Jan 2019 survey sites										November 2019 survey sites						Transect Total	FOO	Total*	FOO*
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16				
Atule mate	Yellowtail scad				30												166	166	1	196	2
Pseudocaranx dentex	Silver trevally																156	156	1	156	1
Enoplosus armatus	Old wife				3												144	144	1	147	2
Austrolabrus maculatus	Blackspotted wrasse		10		11	3	15	60	2	6	15						13	121	7	135	9
Trachinops noarlungae	Yellow-headed hula fish		4	30	100			60			2							96	4	196	5
Notolabrus tetricus	Bluethroat wrasse	5	4	25				4	26	2	2						5	73	8	73	8
Girella zebra	Zebra fish	2		60	2													62	2	64	3
Parequula melbournensis	Silverbelly			50											1			51	2	51	2
Pictilabrus laticlavius	Senator wrasse	1	4	3			1	4	5	3	5							26	8	26	8
Notolabrus parilus	Brownspotted wrasse	3	1							5				1			13	23	5	23	5
Omegophora armilla	Ringed toadfish						1	1	1	1		3	4		2	1	3	17	9	17	9
Cheilodactylus nigripes	Magpie perch			1	3			3	1		1						9	15	5	18	6
Parapercis haackei	Wavy grubfish				5		1	11				1						13	3	18	4
Siphonognathus beddomei	Pencil weed whiting					4	1	5		2	2		1		1			12	6	16	7
Dotalabrus aurantiacus	Castlenau wrasse	3	1	3		2			3		1							11	5	13	6
Dactylophora nigricans	Dusky morwong	2		1	2	1		5	1								2	11	5	14	7
Heteroscarus acroptilus	Rainbow cale							5	3									8	2	8	2
Parma victoriae	Scalyfin		2	3					3									8	3	8	3
Scorpis aequipinnis	Sea sweep	4		2				2										8	3	8	3
Upeneichthys vlamingii	Blue spotted goatfish		2	1	7	4	4										1	8	4	19	6
Haletta semifasciata	Blue weed whiting								1					1			6	8	3	8	3
Tilodon sexfasciatus	Moonlighter			3						1							1	5	3	5	3
Nesogobius greeni	Twinbar goby								2					2				4	2	4	2
Siphonognathus attenuatus	Slender weed whiting				1				2						2			4	2	5	3
Kyphosus sydneyanus	Silver drummer	1		2														3	2	3	2
Pempheris klunzingeri	Rough bullseye		3		1													3	1	4	2
Hypoplectrodes nigroruber	Banded seaperch							2									1	3	2	3	2
Siphonognathus caninis	Sharp-nosed weed whiting							2									1	3	2	3	2
Dinolestes lewini	Longfin pike				100												3	3	1	103	2
Phyllopteryx taeniolatus	Weedy seadragon				6												3	3	1	9	2
Brachaluteres jacksonianus	Southern pygmy leatherjacket											1	1			1		3	3	3	3
Acanthaluteres brownii	Spiny tailed leatherjacket								2									2	1	2	1
Achoerodus gouldii	Western blue groper	2																2	1	2	1
Helcogramma decurrens	Blackthroat threefin			1				1										2	2	2	2
Meuschenia hippocrepis	Horseshoe leatherjacket			2														2	1	2	1
Pempheris multiradiata	Common bullseye			2														2	1	2	1
Pentaceropsis recurvirostris	Longsnout boarfish					3	1	1										2	2	5	3
Sphyraena novaehollandiae	Snook			2														2	1	2	1
Diodon nicthemerus	Globefish							1									1	2	2	2	2
Chelmonops curiosus	Western talma				3	3											2	2	1	8	3
Heteroclinus perspicillatus	Common weedfish						1											1	1	1	1
Olisthops cyanomelas	Herring cale								1									1	1	1	1
Siphonognathus tanyourus	Longtail weed whiting						1											1	1	1	1
Aracana aurita	Shaw's cowfish																1	1	1	1	1
Cochleoceps bicolor	Western cleaner clingfish				1								1					1	1	2	2
Neosebastes pandus	Big head gunard perch					1									1			1	1	2	2
Phycodurus eques	Leafy seadragon																1	1	1	1	1
Scobinichthys granulatus	Rough leatherjacket																1	1	1	1	1
Anoplocapros lenticularis	Humpback boxfish				1													0	0	1	1
Aracana ornata	Ornate cowfish				2													0	0	2	1
Caesioperca lepidoptera	Butterfly perch				1													0	0	1	1
Caesioperca rasor	Barber perch				4													0	0	4	1
Centroberyx gerrardi	Bight redfish				2													0	0	2	1
Meuschenia freycineti	Sixspine leatherjacket				2													0	0	2	1
Paraplesiops meleagris	Southern blue devil				2													0	0	2	1
Parapriacanthus elongatus	Elongate Bullseye				20													0	0	20	1
Paristiopterus gallipavo	Brownspotted boarfish				1													0	0	1	1
Pempheris ornata	Orangelined bullseye				30													0	0	30	1
Stigmatopora nigra	Wide-bodied pipefish				1													0	0	1	1
Vanacampus margaritifer	Mother-of-pearl pipefish				1													0	0	1	1
	Total Fish	23	31	191	342	21	26	167	53	20	28	5	7	4	7	2	533	1097		**1460**	
	Total Fish Species	9	9	17	23	8	9	16	14	7	7	3	4	3	5	2	21	37		**60**	

Species	Common name	Feb 2018/Jan 2019 survey sites										November 2019 survey sites						Transect Total	FOO	Total*	FOO*
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16				
Invertebrates																					
Pentagonaster duebeni	Vermillion biscuit star				2		7			3	1		1	1	1	4	9	27	8	29	9
Phyllacanthus irregularis	Western slatepencil urchin		6	2	4	3		8	1	2	4						2	25	7	32	9
Phasianella australis	Painted lady	2	1					2		8	4				1			18	6	18	6
Tosia australis	Biscuit star	2		1	2		4			1	6				2			16	6	18	7
Australaria australasia	Australian Horse Conch												1	1	3	4	6	15	5	15	5
Jasus edwardsii	Southern rock lobster			5					4		2							11	3	11	3
Scallop spp.	Unidentified scallop					*	4	6							*			10	2	10	2
Echinaster glomeratus	Orange reef star		1					1		2			2	2	1			9	6	9	6
Paguroidea spp.	Unidentified hermit crab								4		4							8	2	8	2
Australostichopus mollis	Australasian brown sea cucumber											2	2	4				8	3	8	3
Australostichopus mollis	Southern sea cucumber				2			1		1	2						2	6	4	8	5
Plectaster decanus	Mosaic seastar						1			1	1	1			2			6	5	6	5
Coscinasterias muricata	Eleven armed seastar			1			1								2	2		6	4	6	4
Pinna bicolor	Pinna				20	17		1		1				2	1	1		6	5	43	7
Heliocidaris erythrogramma	Purple urchin																6	6	1	6	1
Doris chrysoderma	Lemon lolly doris				1								4		1			5	2	6	3
Leptomithrax gaimardii	Great spider crab											1			2	2		5	3	5	3
Haliotis spp.	Abalone									4								4	1	4	1
Uniophora granifera	Granular seastar								1		3							4	2	4	2
Pleuroploca australasia	Tulip shell					3	1			1		1				1		4	4	7	5
Ceto cuvieria	Curviers sea cucumber				10	2											4	4	1	16	3
Luidia australiae	Southern sandstar														3		1	4	2	4	2
Echinaster arcystatus	Pale mosaic sea star			1					1	1								3	3	3	3
Lunella undulata	Periwinkle	2		1														3	2	3	2
Nectria wilsoni	Wilsons Seastar											2				1		3	2	3	2
Anthaster valvulatus	Mottled seastar					1					2							2	1	3	2
Fusinus australis	Southern spindle							1			1							2	2	2	2
Paguristes frontalis	Southern hermit crab	1						1										2	2	2	2
Nectria pedicelligera	Multi spined seastar		1												1			2	2	2	2
Goniocidaris tubaria	Stumpy pencil urchin				1				1									1	1	2	2
Astroboa ernae	Basketstar				5									1				1	1	6	2
Meridiastra gunnii	Gunn's six armed seastar				2												1	1	1	3	2
Stichopus Ludwigi	Ludwig's sea cucumber												1					1	1	1	1
Ophiarachnella ramsayi	Brittle star														1			1	1	1	1
Thylacodes sipho	Worm snail				1													0	0	1	1
Austrofromia polypora	Many-spotted sea star				1													0	0	1	1
Conocladus australis	Southern basketstar				3													0	0	3	1
Holothuriid spp.	Sea cucumber				1	2												0	0	3	2
Cassis fimbriata	Snail				1													0	0	1	1
Nectria saoria	Saori's seastar				2													0	0	2	1
Petricia vernicina	Cushion seastar				1													0	0	1	1
Phasianotrochus eximius	Snail				1													0	0	1	1
Smilasterias irregularis	Seastar					1												0	0	1	1
Turbo torquatus	Turban shell																	0	0	0	0
	Total invertebrates	7	9	11	51	26	18	21	12	25	30	7	10	11	21	15	31	254		**305**	
	Total Invertebrate Species	4	4	6	12	5	6	8	6	11	11	7	6	11	13	7	31	29		**35**	
	Total Count of fish and invertebrates	30	40	202	393	47	44	188	65	45	58	12	17	15	28	17	564	1351		**1765**	
	Total number of fish and invertebrate species	13	13	23	35	13	15	24	20	18	18	10	10	14	18	9	52	66		**95**	

Fish sited outside transects		Invertebrates sited outside transects	
Scobinichthys granulatus	Rough leather Jacket	*Goniocidaris tubaria*	Stumpy pencil urchin
Neosebastes pandus	Big head gunard perch	*Octopus spp.*	Unidentified octopus
Anoplocapros lenticularis	Humpback boxfish	*Nectria saoria*	Saori's seastar
Pempheris ornata	Orangelined Bullseye	*Phasianotrochus eximius*	Snail
Parapriacanthus	Elongate Bullseye	*Austrofromia polypora*	Many-spotted sea star
Acanthaluteres briwnii	Spinytail Leatherjacket	*Smilasterias irregularis*	Seastar
Nemadactylus valenciennesi	Blue Morwong	*Bulla quoyii*	Bubble shell
Latropiscis purpurissatus	Sergeant Baker	*Meridiastra calcar*	Carpet seastar
Siphonognathus caninis	Sharpnose weed whiting	*Bellastraea Aurea*	Shell
Lepidotrigla papilio	Spiny Gurnard		
Upeneichthys vlamingii	Blue spotted goatfish		

Appendix B: Plotting Code

The following code was used to create the plot of equation 1 i.e. critical suspension velocity vs grain diameter.

```
# Clean up environment.
clear all
close all
clc

# Define some const parameters.
h = 15                # Water depth (m).
g = 9.81              # Acceleration due to gravity (m/s/s).
rho_w = 1000          # Water density (kg/m^3).
rho_s = 1602          # Sediment (sand) density (kg/m^3).
v = 1.3*(10^-6)       # Water kinematic viscosity coefficient (10degC) (m^2/s).
d = .0001:0.00001:0.0005; # Range of diameter values (m).
# Relative density
s = rho_s / rho_w

# Dimensionless sediment size
d_star = d.*(((s-1).*(g/(v.^2))).^(1/3));

# Critical dimensionless shear stress
theta_cr = .3./(1+d_star)+.1.*(1-exp(-.05.*d_star));

# Critical suspension velocity (m/s)
v_cr = 5.75.*log10((12.*h)./(6*d)).*((theta_cr.*(s-1).*g.*d).^.5);

# Create plot.
plot(d,v_cr)
title("Critical Suspension Velocity vs Grain Diameter")
xlabel("Median Grain Diameter, D_{50} (m)")
ylabel("Critical Suspension Velocity, U_{cr,susp} (m/s)")
grid minor on
```

Appendix C: Bed Velocity Analysis

The following analysis provides a comparison of seabed velocities as a result of shipping propwash for 3 sets of vessel characteristics. The first set of characteristics is that of the vessel used in the BMT (2019) modelling and the second and third set of characteristics are from typical shipping vessels that still satisfy the dimensional limits of the proposed wharf. Seabed velocities will be estimated for prop rotational frequencies equivalent to cruise speed, further, thrust coefficients will align with the scenario that the vessel is at rest, and is subjected to a sudden burst of thrust. Regardless, the comparison will reflect differences in magnitudes of these bed velocities between analysed vessels.

Nominal continuous rating is at 75% SMCR (MAN 2018) i.e. the design speed of the vessel, therefore operating engine power may be expressed as,

$$P_{engine} = .75P_{SMCR} \quad (1)$$

Thrust power can be expressed as a function of engine power assuming reduction by a total propulsive efficiency,

$$P_T = \eta P_{engine} \quad (2)$$

Substituting (1) into (2), an expression for net vessel power in terms of SMCR power results,

$$P_v = .75\eta \, P_{SMCR} \quad (3)$$

Vessel thrust can be expressed as a function of thrust power and vessel velocity,

$$T = \frac{P_V}{V} \quad (4)$$

Substituting (3) into (4), gives a function of SMCR power for thrust,

$$T = \frac{.75\eta P_{SMCR}}{V} \quad (5)$$

Thrust coefficient is expressed as follows (MIT 2006),

$$k_T = \frac{T}{\rho n^2 D^4} \quad (6)$$

Substituting (5) into (6),

$$k_T = \frac{.75\eta P_{SMCR}}{\rho V n^2 D^4} \quad (7)$$

Advance ratio is given by (MIT 2006),

$$J = \frac{V}{nD} \quad (8)$$

Using the plot of typical torque and thrust coefficients in Figure 1, an approximate linear function for thrust coefficient can be derived,

$$K_T = -0.364J + 0.4 \quad (9)$$

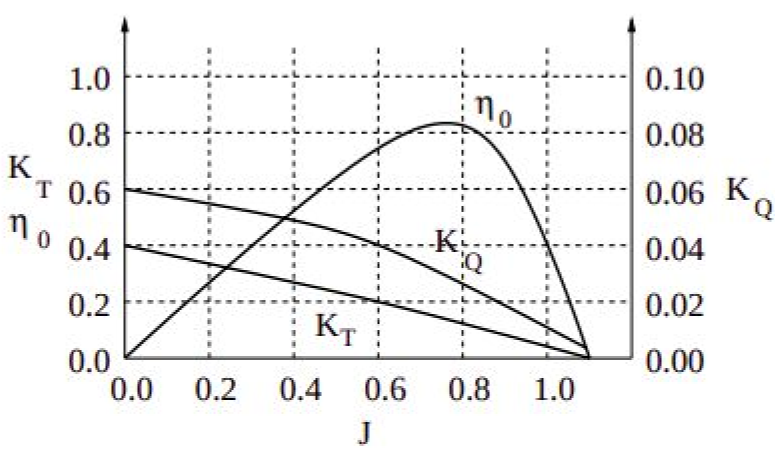

Figure 1: Typical thrust and torque coefficients (MIT 2004).

Substituting (7) and (8) into (9),

$$\frac{.75\eta P_{SMCR}}{\rho V n^2 D^4} = -0.364\frac{V}{nD} + 0.4 \quad (10)$$

Equation (10) can be solved for n, the propeller frequency. The vessel modelled in the BMT hydrodynamic simulations has a SMCR power of $P_{SMCR} = 8990\ kW$ and prop diameter of $D = 6.5m$ (2019). The total propulsive efficiency can be estimated at $\eta = 0.77$ (Valentine 2012) and design velocity is assumed to be approximate to other vessels of similar size, $V = 23\ knots = 11.8\ m/s$ (MAN 2013). Substituting in values and solving,

$$\frac{0.75(0.77)(8990\times10^3)}{(1000)(11.8)(6.5)^4 n^2} = -0.364\frac{11.8}{6.5n} + 0.4$$

$$\Rightarrow n = 1.97\ Hz = 118.2\ rpm$$

Efflux velocity is expressed as follows (Fuehrer and Römisch 1977, cited in Hamill *et al*. 2015),

$$V_0 = 1.59nD\sqrt{k_t} \quad (11)$$

Resultant maximal bed velocity from propwash can be estimated as (Fuehrer and Römisch 1987, cited in Stoschek *et al.* 2014),

$$V_{b,max} = V_0 E(\frac{h_p}{D_p})^{-1} \quad (12)$$

Substituting (11) into (12) gives an equation from which we can use to calculate potential bed velocities at a given depth,

$$V_{b,max} = 1.59nD\sqrt{k_t}\ E(\frac{h_p}{D_p})^{-1} \quad (13)$$

For maximum thrust coefficient, it is assumed the vessel is powered suddenly from rest to cruise, therefore, advance coefficient is $J \simeq 0$, and from figure 1, thrust coefficient is $k_t \simeq .4$. It's also assumed the vessel rudder is in central position, which results in $E = 0.71$ (Stoschek *et al.* 2014). As an arbitrary depth, let's use 15m; the same depth at the ecologically significant site 16 on the approach/departure trajectory. Using draft from the modelled vessel, vertical distance from prop axis to seabed may be calculated,

$$h_p = depth - draft + \frac{prop\ diameter}{2} = 15 - 11.6 + \frac{6.5}{2} = 6.65m$$

Substituting discussed values into (13), the maximum bed velocity results,

$$V_{b,max} = 1.59(1.97)(6.5)\sqrt{.4}\,(.71)(\tfrac{6.65}{6.5})^{-1} = 8.94\ m/s$$

For comparative purposes, maximum bed velocity will now be calculated for a vessel possessing a higher SMCR, but still satisfying the dimensional limits of the wharf, as described in table 1. Propeller diameter is not provided, but can be estimated from vessel draught using an upper limit of diameter to draft ratio of 0.75 (MAN Energy Solutions, 2018). Considering the preference towards a higher efficiency and lower fuel consumption, a larger propeller diameter is generally chosen (MAN Energy Solutions, 2018). Therefore, it is reasonable to use the upper limit of the diameter to draft ratio for calculation of a diameter,

$$D = 0.75T_d = 0.75(11.3) = 8.48\ m$$

Using equation (10) and solving, we can now find propeller frequency for the new vessel. All parameters besides SMCR power, propeller diameter and speed are consistent,

$$\frac{.75(.77)(31300\times10^3)}{(1000)(12.09)n^2(8.48)^4} = -0.364\frac{(12.09)}{n(8.48)} + 0.4$$

$$\Rightarrow n = 1.72\ Hz = 103.2\ rpm$$

Calculating vertical distance from prop axis to seabed,

$$h_p = depth - draft + \frac{prop\ diameter}{2} = 15 - 11.3 + \frac{8.48}{2} = 7.94\ m$$

Using equation (13) to calculate maximum bed velocity,

$$V_{b,max} = 1.59(1.72)(8.48)\sqrt{.4}\,(.71)(\tfrac{7.94}{8.48})^{-1} = 11.12\ m/s$$

Interestingly, this value is higher than the calculated bed velocity for the vessel modelled in the BMT hydrodynamic analysis, indicating either that simulations will have underestimated sediment mobilization, or statements suggesting the wharf can be used for vessel up to 11.75 m is misleading.

Table 1: Characteristics of a typical panamax vessel from MAN Diesel & Turbo (2013).

Container ship class	Panamax	**Length between pp (m)**	232
Ship size (TEU)	3500	**Breadth (m)**	32.2
Scantling draught (m)	12.7	**Sea margin (%)**	15
Deadweight (scantling) (dwt)	46700	**Engine margin (%)**	10
Design draught (m)	11.3	**Average design ship speed (kts)**	23.5
Deadweight (dwt)	38100	**SMCR Power (kW)**	31,300
Length overall (m)	246	**Engine Options**	6K90ME9/ME-C9 7K90MC-C6/ME-C6 7K80ME-C9 9K80MC-C6/ME-C6

It could be argued that the chosen prop diameter is too large, as such, maximum bed velocities have been calculated for varying prop diameters, and still, right down to 6m (below the prop diameter of the BMT modelled vessel) we still see higher maximum bed velocities.

Table 2: *Resultant maximum bed velocity for varying prop diameters.*

Prop Diameter (m)	n (Hz)	Maximum Bed Velocity (m/s)
8.48	1.72	11.12
8	1.87	11.10
7.5	2.05	11.05
7	2.26	10.98
6.5	2.53	10.98
6	2.85	10.93

A third and final analysis will be performed on a smaller panamax vessel still with SMCR power higher than that of the BMT modelled vessel. Characteristics of this vessel are described in Table 3.

Again using the prop diameter to draft ratio from MAN Energy Solutions (2018), we can find the upper limit prop diameter for this vessel,

$$D = 0.75T_d = 0.75(10.7) = 8.03\ m$$

Using equation (10) and solving, we can now find propeller frequency for the new vessel. All parameters besides SMCR power, propeller diameter and vessel velocity are consistent,

$$\frac{.75(.77)(25000\times10^3)}{(1000)(11.58)n^2(8.03)^4} =- 0.364\frac{(11.58)}{n(8.03)} + 0.4$$

$$\Rightarrow n = 1.74\ Hz = 104.4\ rpm$$

Calculating vertical distance from prop axis to seabed,

$$h_p = depth - draft + \frac{prop\ diameter}{2} = 15 - 10.7 + \frac{8.03}{2} = 8.32m$$

Using equation (13) to calculate maximum bed velocity,

$$V_{b,max} = 1.59(1.74)(8.03)\sqrt{.4}\,(.71)(\tfrac{8.32}{8.03})^{-1} = 9.63\ m/s$$

Again, the calculated value of maximum seabed velocity is higher than that of the vessel used in modelling.

Table 3: Characteristics of a typical panamax vessel with 2800 TEU from MAN Diesel & Turbo (2013).

Container ship class	Panamax	**Length between pp (m)**	196
Ship size (TEU)	2800	**Breadth (m)**	32.2
Scantling draught (m)	12.0	**Sea margin (%)**	15
Deadweight (scantling) (dwt)	38,500	**Engine margin (%)**	10
Design draught (m)	10.7	**Average design ship speed (kts)**	22.5

Deadweight (design) (dwt)	30,800	**SMCR Power (kW)**	25,000
Length overall (m)	211	**Engine Options**	6K80ME-C9 7K80MC-C6/ME-C6 8L70MC-C8/ME-C8 8S70MC-C8/ME-C8

Robert Kleeman,
Unit Manager Policy and Strategic Assessment
Planning and Development, Development Division
Dept of Planning, Transport and Infrastructure
GPO Box 1815
Adelaide SA 5000

December 16th, 2019

Dear Mr Kleeman,

I write to you regarding the Addendum to the Smith Bay Wharf Draft EIS for the proposed timber port at Smith Bay, Kangaroo Island.

I expressed my support for the port in the initial public consultation period as a new Australian citizen working in the timber industry in a professional capacity. I have now reviewed the Addendum to the Smith Bay Wharf Draft EIS. The addendum to the EIS shows that Kangaroo Island Plantation Timbers has taken any concerns raised in the public consultation period on board, and provided further information on the matters in question or made changes to their design to mitigate concerns where necessary.

In summary, there appears to be no item brought up in the consultation period that would illustrate that the proposed port should not go ahead. Hence my opinion remains as it did earlier this year, that the proposed port is a positive economic development and should be approved.

Yours sincerely,

Alazne Zubizarreta
Adelaide, SA

From:	Birubi Holiday Homes
To:	DPTI:State Commission Assessment Panel
Subject:	Smith Bay Wharf Proposal - EIS Addendum
Date:	Thursday, 5 December 2019 4:03:29 PM

Minister for Planning,
c/- Robert Kleeman
Unit Manager Policy and Strategic Assessment
Department of Planning, Transport and Infrastructure
GPO Box 1815, Adelaide. SA 5000

Dear Minister Kleeman,

The Smith Bay Wharf Proposal is a critical development which is crucial to the economic sustainability for Kangaroo Island and South Australia.

Kangaroo Island has struggled for years to attract enough interest and investment to provide an ongoing economic viability for our existing and future population. Without **sensible and viable Projects like this one**, the economy of the Island continues to decline and as a result, the population growth is also declining.

It is pleasing to note that the amended EIS has very clearly addressed any major concerns by way of replacing the solid causeway with a suspended piled jetty (removing the need for extensive water disturbance) and extending the jetty another 250m further out to the natural 13.8 depth contour (eliminating the need for dredging).

We firmly believe that all major concerns have now been addressed to the satisfaction of all Departments and the majority of general public and the design changes will also enable the Project to be completed in a timely and less disruptive manner.

Your urgent approval and support for the Smith Bay Wharf Proposal is requested, as this is a once in a lifetime opportunity for Kangaroo Island which we cannot ignore.

Yours sincerely,
Art and Marg Hay

Marg and Art Hay
Birubi Holiday Homes
[redacted] Kingscote. SA 5223
[redacted]
Multi Award Winning Kangaroo Island Accommodation

Robert Kleeman,
Unit Manager Policy and Strategic Assessment
Dept of Planning, Transport and Infrastructure
GPO Box 1815
Adelaide SA 5000

via email to: majordevadmin@sa.gov.au

December 16th, 2019

Re: Addendum to the EIS
Proposed timber port at Smith Bay, Kangaroo Island

Dear Mr Kleeman,

I write to you as a shareholder of Kangaroo Island Plantation Timbers Pty Limited (KIPT), in support of the Addendum to the Smith Bay Wharf Draft EIS for the proposed timber port at Smith Bay, Kangaroo Island.

I am impressed with KIPT's addendum as a response to public consultation submissions. The company has listened to the public and taken it upon themselves to address the concerns presented, including altering the design to ensure no risk to the water quality at Smith Bay and no material risk to Yumbah Aquaculture.

Although the design alterations will incur additional costs for KIPT, my confidence in the company and its integrity has grown. KIPT has modelled respect for all stakeholders, including the environment, and we feel strongly that these are the types of companies and projects that we, as a nation, should support.

We need to show Australia that it is companies who uphold the values of community and environment, as shown by KIPT, who progress; approval of the proposed Smith Bay wharf will do just this.

Yours sincerely,

Bella Esposito, *KPT investor and resident of South Australia*

Email for the Attention of Mr Robert Kleeman

Re: Kangaroo Island Seaport

Dear Sir,

I have sent this letter of support for the improved design for the Seaport at Smiths Bay by Kangaroo Island Plantations Timbers.

I have a vested interest being a Plantation owner at Triple Valley - Karatta.

I feel that the Abalone People have not been entirely upfront with their complaint, and that other voices in the debate against have not revealed vested interest.

I am impressed with KIPT for putting their heads down and spending the extra money to upgrade the design at the neighbour's request.

I don't believe KIPT needed to go this far with the Port …but they propose to do what is asked - and I hope they can be rewarded for their good work in good faith.

The Island desperately needs the jobs and KIPT have bent over backwards to get these jobs into work and pay.

In doing so, and in this new proposal they have my full support.

I find their determination to go the full distance remarkable.

Thank you for your time.

Brian Noble

Triple Valley Plantation

Karatta.

Flinders Ports Pty Ltd ABN 83 097 377 172
296 St. Vincent Street, Port Adelaide, South Australia, 5015
P.O. Box 19, Port Adelaide, South Australia, 5015
Tel +61 8 8447 0611 **Fax** +61 8 8447 0606

18 December 2019

Minister for Planning
c/- Mr Robert Kleeman
Unit Manager Policy and Strategic Assessment
Department of Planning, Transport and Infrastructure
GPO Box 1815
ADELAIDE SA 5000

majordevadmin@sa.gov.au

Dear Minister,

Letter of support: Smith Bay Port

Further to our original letter dated May 23, Flinders Ports would like to reiterate its support for the Smith Bay Port development. Flinders Ports has an MoU in place with Kangaroo Island Plantation Timber Ltd under which our company will provide port compliance and operations services at the proposed KI Seaport at Smith Bay, subject to final contractual arrangements.

We believe the proposed KI Seaport aligns closely with Government's policies and vision for infrastructure development in South Australia. As you are aware, the port's proponents have pledged to make the multi-user facility available for third party access on commercial terms. This presents opportunities for various commodity and product types as well as berthing intermediate size passenger vessels, subject in each case to regulatory consent.

We understand the KI Seaport project proponents have the funding and the construction contracts ready to start. Since our initial submission we also acknowledge the amendments to the port design by KIPT, particularly the new piled jetty which appears to represent a more environmentally friendly structure, further minimizing the impact on the local marine environment.

Flinders Ports acknowledges its commercial relationship with the proponents. The benefits to the community are wider than our interests. While the reason for building the facility relates to timber, the local community and economy benefits will flow much more widely once the KI Seaport is in place. This is the enabling effect of key infrastructure.

Flinders Ports stands ready to play its part, to ensure that the facility is operated safely, efficiently, environmentally resposibly and for the good of the State and the community.

Yours faithfully

C.B. Kavina

Carl Kavina
General Manager
Flinders Ports Pty Ltd

Robert Kleeman,
Unit Manager Policy and Strategic Assessment
Dept of Planning, Transport and Infrastructure
GPO Box 1815
Adelaide SA 5000

via email to: majordevadmin@sa.gov.au

December 16th, 2019

Dear Mr Kleeman,

Re: Addendum to the EIS, Proposed timber port at Smith Bay, Kangaroo Island

I wrote to you in May indicating my support for the proposed timber port at Smith Bay. I understand that there was much feedback from the public consultation period and that, in response to this, Kangaroo Island Plantation Timbers commissioned an engineering review to determine if there was an alternative design for the wharf that could assuage any concerns presented.

I feel the company's response to the public feedback shows their strong regard for the community of Kangaroo Island. Not only will the wharf resurrect a struggling economy on the island, it is being proposed by a company who demonstrates respect to all stakeholders. The addendum shows that Kangaroo Island Plantation Timbers has taken on concerns voiced by Yumbah, another business on the island, and has found a solution to address these concerns. I find it refreshing to see a company who works with its peers rather than against them.

Kangaroo Island needs a development such as the proposed Smith Bay timber port, you have a company who has proven itself to be honourable and diligent wanting to provide such a development, I urge you to accept their proposal.

Yours sincerely,

Caroline Simpson
Adelaide, SA

<u>Letter to the Islander 6/12/19</u>

<u>KIPT Forestry Day</u>

As an NRM Board member, I attended the KIPT Forestry Day recently and thought the information presented about the development at Smith's Bay showed it to be well researched and responsive to community concerns. Two points of particular interest were the increased length of the proposed jetty without a causeway to remove the need to do periodic dredging and the use of a covered conveyor belt to transport wood chips from shore to ship. This would eliminate the possibility of dust and woodchip contamination of seawater in the vicinity of the jetty. KIPT demonstrated a willingness to discuss problems and I would hope that those still opposed to the project will now discuss why in a more open manner. The project will provide significant benefits economically to KI and resolve the problem of what to do with plantation timber on the Island. As in the case of any developments on the Island there are always going to be negative responses but I believe that KIPT is addressing these appropriately. Unless further information is bought forward by those opposed for the community to consider as it stands I would support the KIPT proposal at Smith's Bay.

David Welford Stokes Bay

From:	Debbie Clarke
To:	DPTI:State Commission Assessment Panel
Subject:	Response to the Addendum to Environmental Impact Statement for Proposed timber port at Smith Bay, Kangaroo Island
Date:	Tuesday, 17 December 2019 1:20:59 PM

Deb Foster,
[redacted]
Kingscote, SA 5223.

Dear Mr Kleeman,

I am writing in support of the proposed design change to the Smith Bay Wharf Draft Environmental Impact Statement as detailed in the Addendum prepared for Kangaroo Island Plantation Timbers (KIPT).

I commend KIPT's decision to abandon the solid causeway in favour of an open-piled jetty and working with neighbours to address concerns about the potential negative environmental affects to coastal processes which dredging and solid causeway may have caused.

I think the proposed development Deep Water Port Facility, Smith Bay, will be very important to the economy of the island, very necessary and of huge benefit to the islands economic sustainable development.

I can understand that people who live, work and have other interests in Smith Bay are not happy about this development. But I agree that Smith Bay is the best site for the port.   I am bemused with the council rejecting Smith Bay but suggesting Cape Dutton for the port site which goes against all the science and studies covered in the EIS.

Deb Foster

From: Glenda Wilby
To: DPTI:State Commission Assessment Panel
Subject: KIPT Revised Jetty
Date: Wednesday, 11 December 2019 9:42:40 AM

Attention Robert Kleeman.

I wish to submit this letter of support regarding the new extended jetty at Smiths Bay. I feel that this new concept will eliminate any concerns regarding the sea floor disruption ie:dredging and proximity to the Abalone Farm.
I commend KIPT for their willingness to find the best solution to proceed forward in this major project.
Regards
Glenda Wilby
[redacted]
Kingscote
Kangaroo Island
SA 5223

From:	Harry Van Den Berg
To:	DPTI:State Commission Assessment Panel
Subject:	Revised jetty design of proposed timber port at Smith Bay , Kangaroo Island
Date:	Friday, 6 December 2019 4:19:26 PM

Dear Mr Kleeman,

In response to issues raised in the public consultation process Kangaroo Island Plantation Timbers has modified its design of its proposed seaport at Smith Bay.

I have reviewed the details of its modified design and I am of the opinion that the revised design is a definite improvement on the previous design for various reasons:

* eliminate the need for dredging
* increased benefits to the marine environment
* change to a full piled jetty structure instead of a solid causeway
* significant reduction of effects on natural coastal processes
* elimination of the concerns and objections of its neighbour Yumbah Aquaculture
* significant improved access for cruise ship passengers to Kangaroo island attractions

The overall benefits of the modified design are convincing and substantial and clearly address the concerns raised in the public consultation process.
I have therefore no hesitation in strongly supporting the revised design of the proposed development at Smith Bay as it will be a substantial contributor to the economic development of Kangaroo Island and its associated employment and social benefits.

Harry Van Den Berg
[redacted], Kingscote SA 5223
[redacted]

From:	Ian Drummond
To:	DPTI:State Commission Assessment Panel
Cc:	Ian Drummond
Subject:	Support letter for Smith Bay proposal
Date:	Tuesday, 17 December 2019 7:01:50 AM

Hon Stefan Knoll

Minister for Planning

c/o Robert Kleeman
Unit Manager Policy and Strategic Assessment
Department of Planning, Transport and Infrastructure
GPO Box 1815, ADELAIDE SA 5000

Dear Minister,

I remain strongly supportive of the KIPT proposal. It's got all the hallmarks of a great project for Kangaroo Island and SA. There's a lot of wealth sitting on KI waiting to be harvested. The industry can provide jobs into the future, just what KI needs.

The company is to be congratulated on additional safeguards for the environment, namely:

- **moving the berth face about 250m further offshore, to the natural -14m seabed contour to eliminate any need for dredging.**
- **utilising a fully piled jetty structure instead of a solid causeway, so that natural coastal processes will be uninterrupted.**

KIPT has strong leadership and good vision. They have identified the optimum location for a wharf and have the finance to pull it off.

More than ever I am satisfied that the project poses no threat to any other business or to the environment which is very important to me. It has strong green credentials. It seems to fit your Government's business growth policy and should be supported and assisted.

Regards,

Ian

Ian Drummond Chairman - APP Group of Companies

Australian Property Projects Pty Ltd

Ground Floor - 50 Hindmarsh Square - Adelaide South Australia 5000

e [redacted]

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From:	James Florance
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Friday, 20 December 2019 4:30:24 PM

None of the changes to KIPT submission for a massive seaport at Smith Bay have altered the astronomical damage this could cause to the ecology of the bay in regarding the whales, fish, sea dragons and coral. There is a massive threat to biosecurity with bilge water, if Australia is that concerned at the border of airports it should not change here either. It would not matter how far the port is extended out into this bay, the negative effects will still remain. I would also like to point out that Smith Bay is not a sheltered bay from the weather as they have maintained, as a resident myself I have seen the effects on the coastline of the weather with systems coming in from the Northwest, my father has even seen daylight under shipping container ships in rough weather out in the straight so how would any extension hinder this threat. I never got to put in a length submission last time but since we are talking about more noise pollution because of more piles I think it is valid that I mention I have 2 autistic children in my household, 1 of which is extremely sensitive to noises that do not seem to bother the rest of us. If you can imagine the impact on whales from deafening of pile driving under water, it is not too much of a stretch to consider what people on the Autism Spectrum can pick up. I am not against the removal of the trees and the money it can put into the economy of this country, state and the local island, but the correct placement has to be found and far away from the trees in a bay used for sustainable aquaculture, fishing, tours and environmental safe harbour is simply stupidity.

James Florance

Attention: Robert Kleeman

Unit Manager Policy and Strategic Assessment

Department of Planning, Transport and Infrastructure

GPO Box 1815

ADELAIDE SA 5000

or via email to: majordevadmin@sa.gov.au

18th December, 2019

Dear Sir,

I am writing to you in regards to the KIPT Smith Bay Development being an Islander of 4 generations.

I have looked at the changes that have been made from the original wharf design and the KIPT have my full support of this project.

I look forward to Kangaroo Island having economic growth for future generations of Islanders.

Thanking you

Jane Peckover

Submission on Addendum to the Smith Bay Environmental Impact Statement, related to the construction and operation of a deepwater port and associated infrastructure in Smith Bay on Kangaroo Island by Kangaroo Island Plantation Timbers Ltd.

Submission made by:

1. Donna Pillay

[redacted]

Emerald Beach NSW 2450

[redacted]

2. Kelly Tracey

[redacted]

Coogee NSW 2034

[redacted]

3. Celine Gunther

[redacted]

Valla Beach NSW 2448

[redacted]

4. Adrian Gunther

[redacted]

Hyland Park NSW 2448

[redacted]

5. Annabelle Wilson

[redacted]

Paddington NSW 2021

[redacted]

6. Cressida Wilson

[redacted]

Edgecliff NSW 2021

[redacted]

7. Alastair Donnelley

[redacted]

Darlington NSW 2008

[redacted]

8. Dolma Gunther

[redacted]

Darlington NSW 2008

[redacted]

9. Monique Howley

[redacted]

Dover Heights NSW 2030

[redacted]

10. Sarah Bock

[redacted]

Annerly QLD 4103

[redacted]

11. Jeannie Alamkara

[redacted]

Currumbin Waters QLD 4223

[redacted]

12. Kamala Hope-Campbell

[redacted]

Hyland Park NSW 2448

[redacted]

13. Jean-Baptiste Labbe

[redacted]

Randwick NSW 2031

[redacted]

14. Kirsten Berry

[redacted]

Randwick NSW 2031

[redacted]

15. Jemma Noble

[redacted]

Coogee NSW 2034

[redacted]

16. Grant Focas

[redacted]

Woy Woy NSW 2256

[redacted]

17. Brigette Fyfe

[redacted]

Woy Woy NSW 2256

[redacted]

18. Charlotte Davis

[redacted]

Nowra NSW 2541

[redacted]

19. Rowan Hardinge

[redacted]

Currumbin Waters QLD 4223

[redacted]

20. Tara Henderson

[redacted]

Bronte NSW 2024

[redacted]

21. Vanessa Fenton

[redacted]

Suffolk NSW 2481

[redacted]

22. Michele Sierra

[redacted]

Annandale NSW 2038

[redacted]

23. Belinda Heywood

[redacted] Vic 3079

[redacted]

24. Tracey Jones

[redacted] NSW 2055

[redacted]

25. Nancye Hughes

[redacted]

Port Macquarie NSW 2444

[redacted]

26. Jane Lyttleton

[redacted]

Tamarama NSW 2026

[redacted]

27. Genevieve Lancaster

[redacted]

Granville NSW 2142

[redacted]

28. Kathleen Chodron

[redacted]

Kyogle NSW 2474

[redacted]

29. Anne Higginson

[redacted]

Valla NSW 2448

[redacted]

30. Samuel Chambers

[redacted]

Valla NSW 2448

[redacted]

31. Jannie Higginson

[redacted]

Tennyson NSW 2111

[redacted]

32. Jodie Lyons

[redacted]

Craignish QLD 4223

[redacted]

33. Janice Baird

[redacted]

Turramurra NSW 2074

[redacted]

34. Pamela Sceats

[redacted] Mullumbimby NSW 2482

[redacted]

For any questions, please contact Janice Baird at [redacted].

Referrals Gateway
Assessment & Governance Branch
Department of the Environment and Energy
GPO Box 787
Canberra ACT 2601

Email: majordevadmin@sa.gov.au

20 December 2019

Dear Minister,

Re: Smith Bay, Kangaroo Island - Deep Water Port Facility

1. We would like to thank the Department of Planning, Transport and Infrastructure (**DPTI**) and the Department of Environment and Energy (**DoEE**) for consulting on the Addendum to the Smith Bay Environmental Impact Statement (**Addendum**). The Addendum relates to the construction and operation of a deepwater port and associated infrastructure in Smith Bay on Kangaroo Island (**Proposed Action**) by Kangaroo Island Plantation Timbers Ltd (**KIPT**).

2. We submit that the Commonwealth Minister for the Environment should not approve the Proposed Action under s 130(1) the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (**EPBC Act**) on grounds of unacceptable impacts to listed threatened species.

3. This submission makes the following key points in relation to the impacts of the Proposed Action on endangered Southern Right Whales:

    a. The Southern Right Whales that are likely to be affected by the Proposed Action are part of the south-eastern population of the species;

    b. Any significant disruption to biologically important areas (**BIAs**) for the south-eastern population has the potential to cause irreversible, long-term decline of the population;

    c. The extension of the suspended deck and berth face will significantly displace core coastal, breeding and calving habitat;

    d. The noise and timing of marine piling operations will severely disrupt calving and breeding behaviour; and

    e. The marine infrastructure will interfere with spatial recovery of the species as set out in the Conservation Management Plan for Southern Right Whales.

Background

4. On 30 January 2019 KIPT submitted its final Draft Environment Impact Statement (**Draft EIS**) to DPTI for public release. The Draft EIS set out details of the following key marine infrastructure components of the Proposed Action:

   a. a floating pontoon with a nominal displacement of 37,600t, a freeboard of approximately 3.5m and a length and beam of 168m and 41m;

   b. restraint dolphins at pontoon ends for vessel head and stern lines;

   c. bollards along the pontoon berthing face;

   d. a 420m approach to the pontoon consisting of a 250m rock-armoured causeway (to a depth of approximately 8 m), a 170m suspended deck jetty and a linkspan bridge; and

   e. a berth pocket dredged to a depth of 13.5m to allow access by Handymax and Panamax-class vessels.

5. On 28 March 2019, DPTI released the Draft EIS for public comment. The period for public consultation was between 28 March 2019 – 28 May 2019. The submissions received by DPTI showed significant concern by stakeholders regarding the impacts of dredging on marine water quality. Of particular concern were the effects of the sediment plume affecting the abalone and oyster farming operations of local businesses such as Yumbah Aquaculture and KI Shellfish. The dredging also had the potential to cause serious, irreversible impacts to marine and algal and seagrass species in the direct path and within the vicinity of the dredging.

6. On 7 November 2019, DPTI released the Addendum for public comment. The Addendum amended the design of the Proposed Action by:

   a. removing plans for the berth pocket and, as such, the need for dredging;

   b. removing plans for the rock-armoured causeway and changing the approach to comprising fully of a suspended deck;

   c. moving the berth face approximately 250 metres further offshore, to the approximate -13.8 metres seabed contour; and

   d. moving the location of all ancillary marine infrastructure such as the floating pontoon, restraint dolphins and bollards to the new berth face location.

7. Figure 1 below shows the revised design. Figure 2 below shows the depth contour at which the new berth face will be located

Figure 1: Revised design showing the suspended deck, linkspan bridge, pontoon and ship[1]

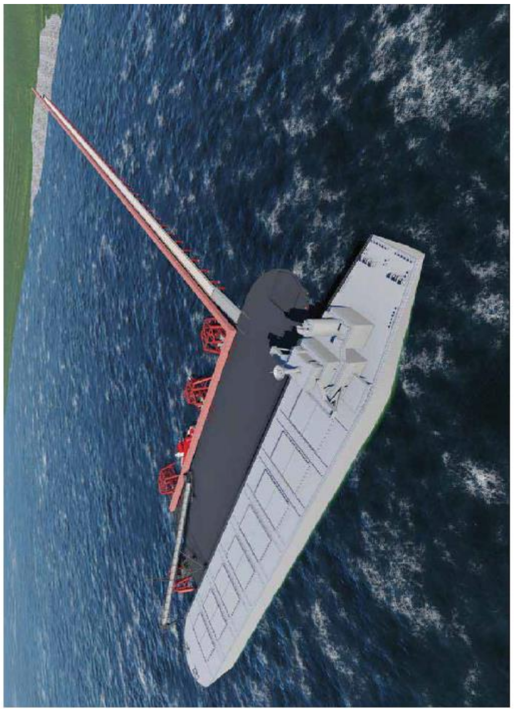
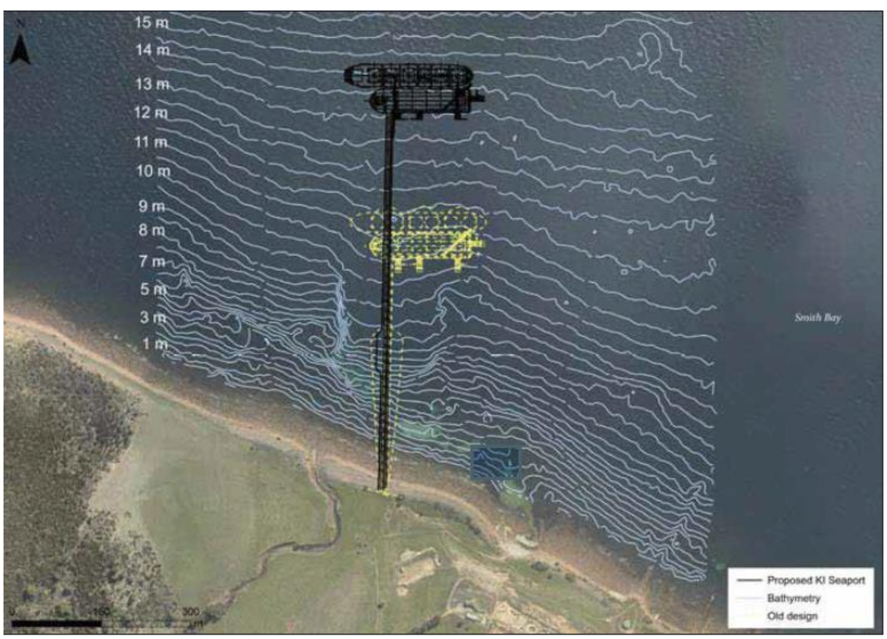


Figure 2: Conceptual layout of the KI seaport infrastructure (overlaying the previous design)[2]



[1] Environmental Projects, 'Addendum to the Smith Bay Draft EIS' (October 019) 7.
[2] Ibid 8.

Impacts to Southern Right Whales

Abundance and population trends

8. Southern Right Whales are listed as endangered under the EPBC Act. The term "endangered" is defined by the International Union of Concerned Scientists as a species "when there is very high risk of extinction in the wild in the immediate future."[3]

9. The population of Southern Right Whales was devastated by whaling in the nineteenth century. In the late 1700s, there were approximately 55,000-70,000 Southern Right Whales in the southern hemisphere. By the 1920s, fewer than 300 individuals remained. In 2012, scientists have estimated the Australian population to be approximately 3500.[4]

10. There are two genetically distinct Southern Right Whale populations in Australia based on mtDNA halotype, but not nuclear gene frequencies. These populations are the south-east population and the south-west population.[5] The Southern Right Whales that are likely to be affected by the Proposed Action are part of the south-east population.

11. According to a 2017 report to the Commonwealth Government, the south-east population is dangerously low and shows no sign of improvement:

    "The 'western' sub-population occurs predominantly between Cape Leeuwin, Western Australia (WA) and Ceduna, South Australia (SA). This sub-population comprises most of the Australian population and is estimated at around 2,200 individuals in 2016, increasing at an annual rate of approximately 5.5 % per annum (p.a.) (Bannister, 2017). The 'eastern' subpopulation can be found along the south-'eastern' coast, including the region from Tasmania to Sydney, with key aggregation areas in Portland and Warrnambool in Victoria. The 'eastern' sub-population is estimated at less than 300 individuals and is showing no signs of increase (Bannister, 2017)."[6]

12. The environment that may be affected (**EMBA**) by the Proposed Action is within the core coastal range of the species and within close vicinity of a historic high use area with evidence of current use (see Figure 3 below). "Coastal connecting habitat" is listed as BIA that is "necessary for southern right whales' essential life functions" under the Conservation Management Plan for Southern Right Whales[7].

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[3] < https://www.iucn.org/downloads/en_iucn__glossary_definitions.pdf>

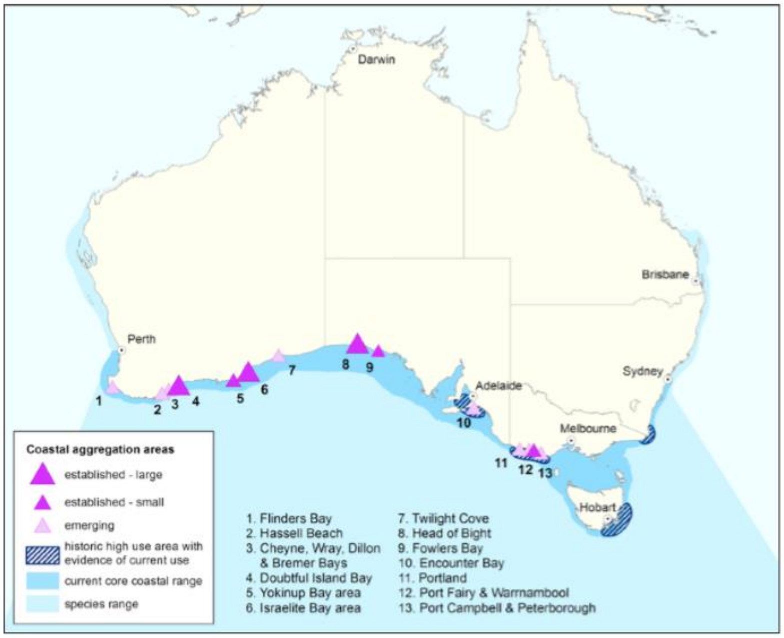
[4] Commonwealth of Australia, *Conservation Management Plan for the Southern Right Whale 2011-2021* (2012) 7.

[5] Ibid 25.

[6] Claire Marie Charlton, '*Southern Right Whale (Eubalaena australis) Population Demographics in Southern Australia'* (PhD Thesis, Curtin University, 2017) 18 <https://espace.curtin.edu.au/bitstream/handle/20.500.11937/59638/Charlton%20C%202017.pdf?sequence=1>, Ibid 18, J.L. Bannister, 'Project A7- Monitoring Population Dynamics of 'Western' Right Whales off Southern Australia 2015-2018' (Final report to National Environment Science Program, Australian Commonwealth Government, 2017).

[7] Ibid 28-29.

Figure 3: Species range and core aggregation areas of the Southern Right Whale



Reproduction

13. Southern Right Whales have an average of 1 calf every 3 years. Gestation time is ~ 12 months, lactation lasts at least 7–8 months and weaning occurs within 12 months.[8] Longer calving intervals are expected in the future because of rising tea temperatures resulting from climate change. The species' low and slow reproductive rate is the main contributor to its gradual recovery from whaling and reduces its resilience and capacity to withstand impacts.[9]

14. Female Southern Right Whales have high site fidelity to calving and nursing grounds.[10] This means that they often return to the same areas to give birth and nurse offspring. Recent population studies at Head of Bight found that:

    "A total of 67% of the breeding population identified between 1991 and 2016 (n=459) were sighted more than once and displayed a degree of fidelity to the site. Similarly, site fidelity was recorded for 69% of the breeding females identified between 1991 and 1995 (n=81) (Burnell, 2001)."[11]

15. Southern Right Whale calves also show high fidelity to natal grounds. Recent population studies at the Head of Bight found that:

    "Of the 69 calves that were resighted at HoB since the year of birth, 23 individuals displayed natal site fidelity and were sighted at HoB at least once with their own calves...The probability

[8] Ibid 22.
[9] Ibid 22.
[10] Charlton, above n6, 66.
[11] Ibid 81.

of calves being resighted at HoB increased six years after their birth. Overall, the proportion of calves that returned to HoB within the first six years was 10% of resights. This data supports that calves may disperse to other areas and return to their site of birth once they reach sexual maturity. Age of first parturition for the Australian population of SRW is a minimum of six years and a mean of 9.3 years (Charlton, 2017 – Chapter 3). Of the calves that displayed natal site fidelity (n=23), 60%"[12]

16. The protection of calving and nursing grounds is critical for the recovery of the species. This is because "their strong site fidelity and social cues are likely to constrain their capacity to establish regular aggregations in new or previously used locations, even where apparently suitable habitat is available".[13] Therefore, Southern Right Whales that are displaced from calving and nursing habitat may find it difficult to establish calving and nursing grounds in new or alternative locations.

17. The importance of existing calving and nursing habitat is recognised by the Conservation Management Plan for Southern Right Whales, which lists the following areas as BIAs:

    "Large established aggregation areas used for calving and nursing - These are important for recovery as they currently contribute most to overall abundance increases by being the sites of highest calf production.

    Small and potentially emerging aggregation areas used for calving and nursing - These are important for recovery in terms of expanding the habitat occupancy of southern right whales and contributing to the maintenance of genetic diversity as site fidelity may lead to small scale genetic differences. These areas will contribute to overall population increases and enable calf production to regularly occur at a greater number of sites as recovery progresses."[14]

18. <u>The DoEE's National Conservation Values Atlas provides that the entire coastline of Kangaroo Island, to a distance of 1.5 km offshore, is used as seasonal calving habitat for the Southern Right Whale. Further, the Protected Matters Search Tool also provides that the breeding is known to occur within the area. As such, any major offshore infrastructure project located within 1.5 km of the island's shoreline must consider potential impacts on calving and nursing grounds for the species.</u>

19. Local sightings of Southern Right Whales in Smith Bay include:

    a. September 2017 – A mother and calf were spotted in nursing in Smith Bay.[15]
    b. 30 July 2018 –A Southern Right Whale breaching in the bay.[16]
    c. 27 August 2018 – A mother, calf and sub-adult were observed in Smith Bay. A photograph of the whales was published in the KI Islander.[17]

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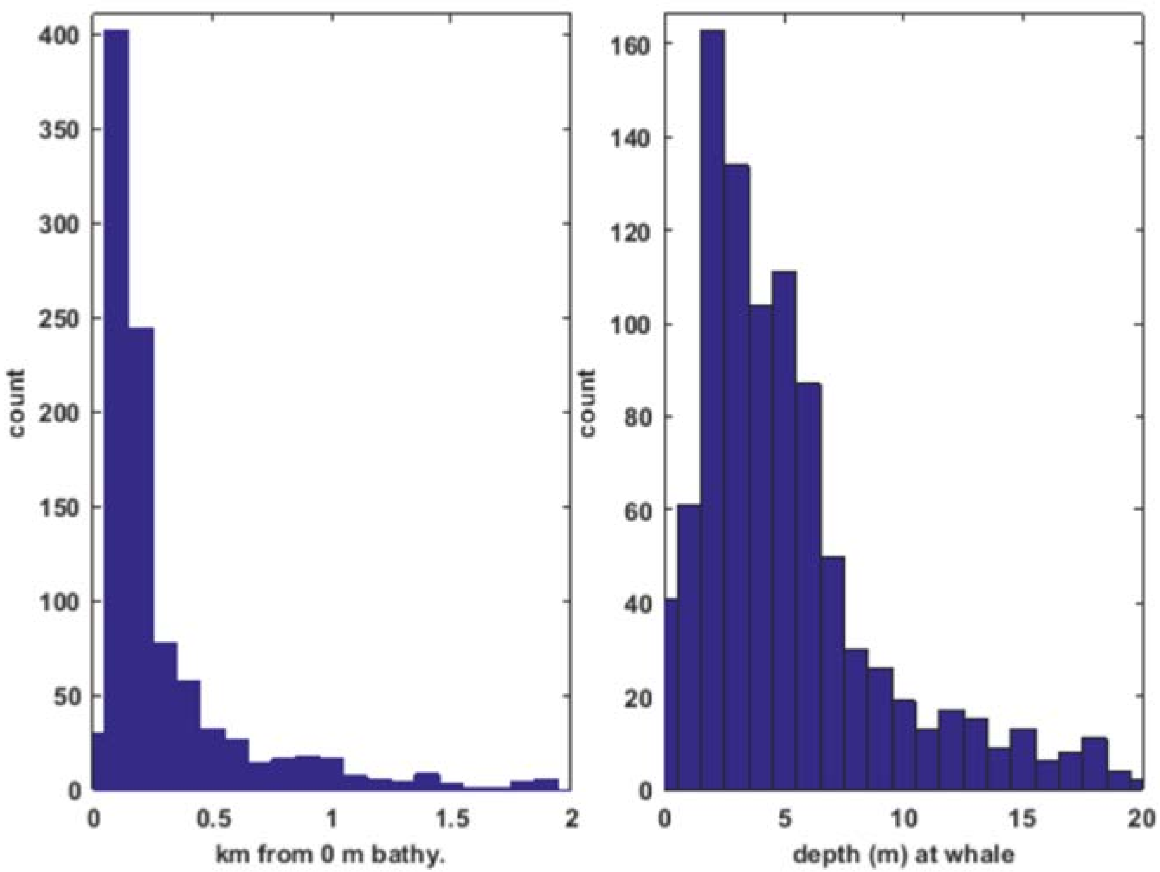
[12] Ibid 83.
[13] Commonwealth of Australia, above n4, 27.
[14] Commonwealth of Australia, above n4, 29.
[15] Stan Gorton, 'Smith Bay identified as vital whale, dolphin area', *The KI Islander*, 31 July 2018 < https://www.theislanderonline.com.au/story/5557480/smith-bay-identified-as-vital-whale-dolphin-area/>.
[16] Ibid.
[17] Stan Gorton, 'Whales hanging out at Smith Bay, Kangaroo Island', *The KI Islander*, 28 August 2018 < https://www.theislanderonline.com.au/story/5612054/whales-hanging-out-at-smith-bay-kangaroo-island/>.

Displacement of core coastal, nursing and breeding habitat

20. The extension of the berthing face a further 250 m offshore, which would extend the marine infrastructure to a total distance of 670 m offshore at the 13.8m bathymetric contour will significantly displace core coastal habitat of the south east population of Southern Right Whales. In particular, the extension is likely to displace most of the species' core coastal range off the coast of Smith Bay.

21. A study of Southern Right Whale populations in the Head of Bight from 1992-2016 found that 95% of Southern Right Whale distribution was within 1 km of shore, with most of the distribution less than 500 m from shore. The same study found that the distribution of most whales was in less than 10m o depth (see Figure 4 below).

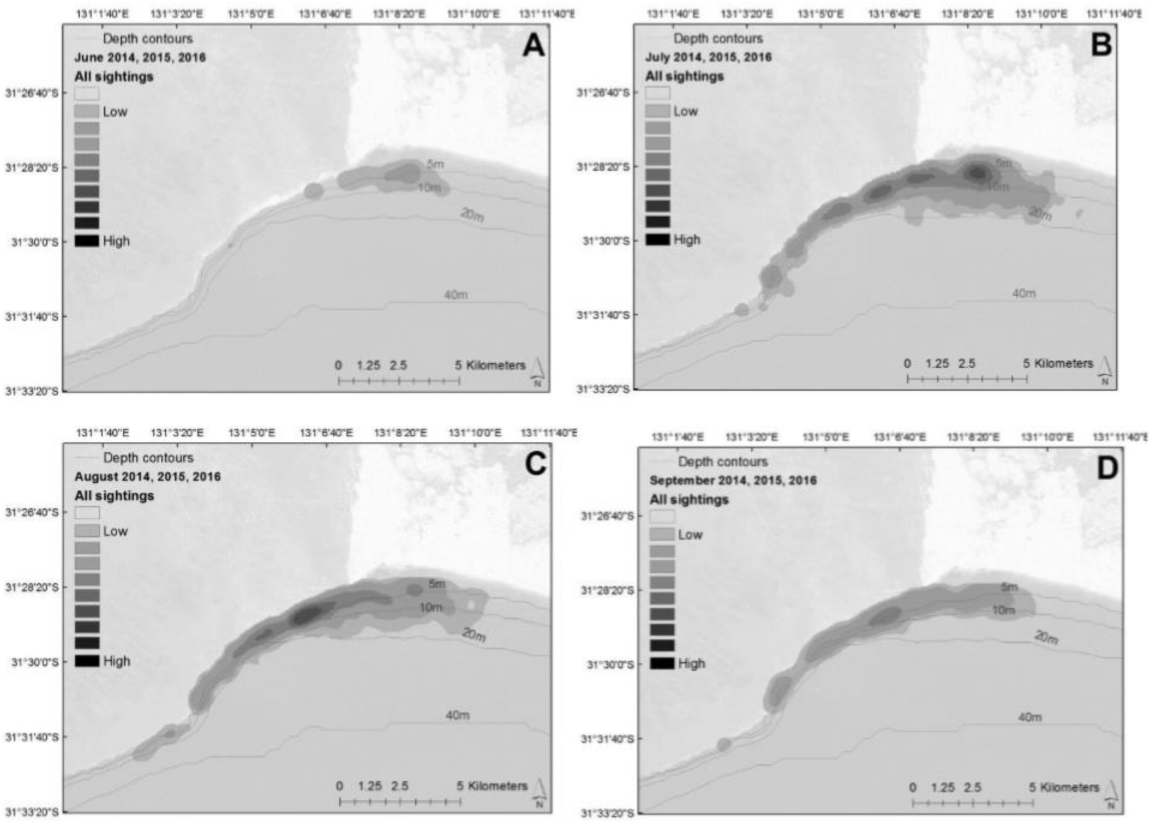
Figure 4: Distributions of Southern right whale distance from 0 bathymetry contour (left) and depth (right), for sightings at Head of Bight recorded between June and September, 2014-2016. [18]



22. Depth contours at which Southern Right Whales were recorded at various seasons are shown in Figure 5 below.

[18] Charlton, above n 6, 28.

Figure 5: Within season distribution of Southern right whales at the Head of Bight, South Australia using pooled data 2014-2016: A) June; B) July; C) August; D) September[19]



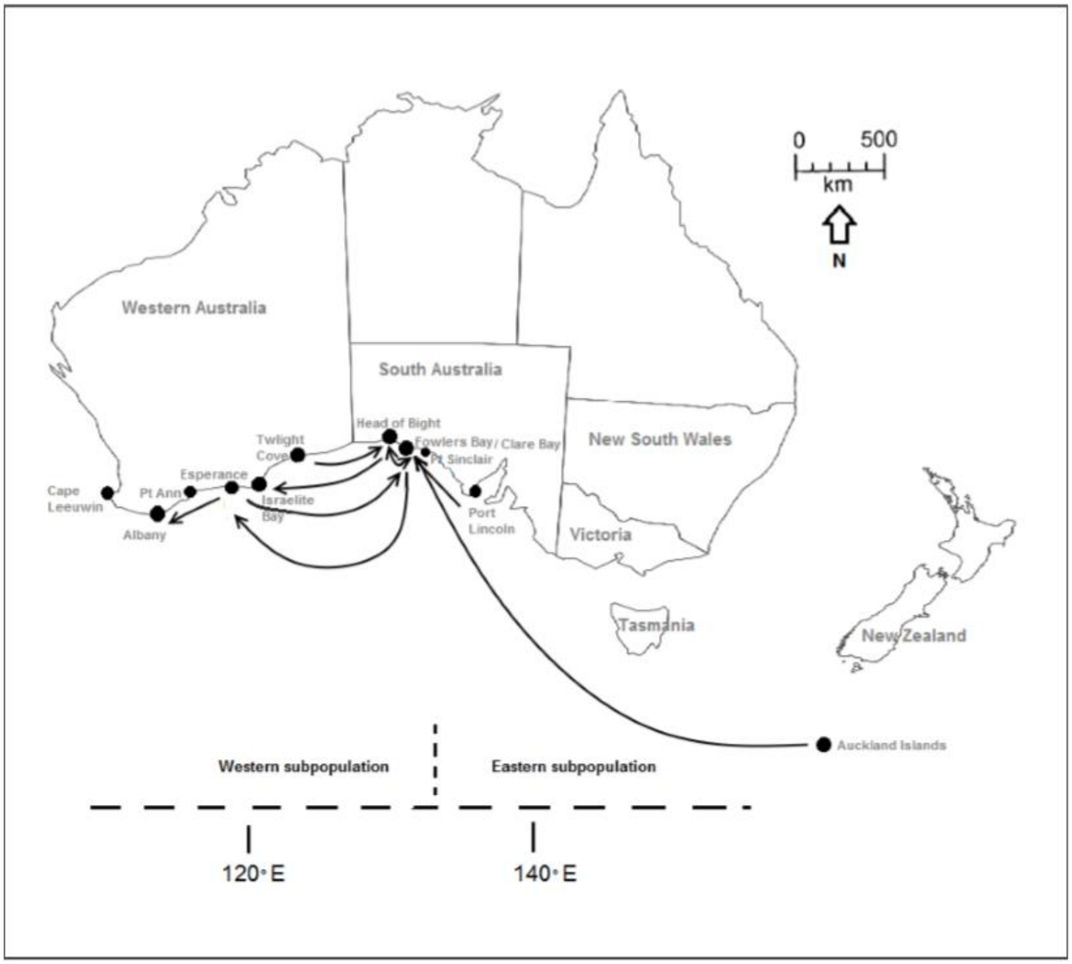
23. Core coastal habitat is a critical part of the behavioural patterns of Southern Right Whales. The long migration distances of the species are described as follows:

"Within and between season movements of SRWs on the southern Australian coastline were documented by Burnell (2001). Within year movements averaged 730 km, over 34 days. The maximum reported within season movement of an individual SRW across coastal southern Australia is 1,490 km. Of the calving females photo-ID'd at FB, one individual moved approximately 910 km within a season. Reported between year movements of SRWs were an average of 1,036 km, and up to 2,287 km (Burnell, 2001). The maximum between season movement of an individual whale photo-ID'd at FB was approximately 3,410 km between Auckland Islands and FB. Long-range movements of SRWs between Australia and subantarctic NZ aggregation areas of approximately 3,600 km across years have also been documented (Pirzl et al., 2009)."[20]

[19] Charlton, above n 6, 32.
[20] Charlton, above n6, 132.

24. Figure 6 below shows migration patterns of the south-west and south-east population.

Figure 6: Example of movements within and across season for southern right whales from Fowlers Bay, South Australia to other coastal aggregation areas on the southern coast of Australia and the Auckland Islands, New Zealand.[21]



25. The long distances between aggregation and resting areas (200-1500 km) for the Southern Right Whales means that connectivity of coastal habitat is critical for the species.[22] The Conservation Management Plan relevantly states that:

"Connectivity may be disrupted temporarily or permanently by human activities and as functional connections between habitat areas are essential, conservation planning should consider the importance of connecting habitat as well as aggregation areas."[23]

[21] Charlton, above n6, 127.
[22] Commonwealth of Australia, above n4, 28.
[23] Commonwealth of Australia, above n4, 28.

26. Habitat modification and displacement of connecting habitat is recognised as one of the key threats to the species because it can disrupt movements, thereby increasing the whales' exposure to other risks such as entanglement, predation, vessel disturbance and pollution[24].

27. The low numbers of the south-eastern population of the Southern Right Whale make it vulnerable to disruption from the death or injury of a even a single individual. It is submitted that significantly modifying or displacing core connecting habitat is likely to significantly interfere with the recovery of the species.[25].

Disruption of calving and breeding habitat from marine piling noise

28. Southern Right Whales they live in an environment where vision is not their primary sense because light does not penetrate far beneath the ocean surface. They rely upon sound as their primary sense for communication and awareness of their surroundings.

29. Their communication is important for intra-sexual selection, mother/calf cohesion, group cohesion, individual recognition and danger avoidance[26]. As such, disruption to the acoustic environment that they live in can have severe consequences for their survival.

30. KIPT's Environmental Noise Impact Assessment (**ENIA**) states the primary method of piling for infrastructure construction is expected to be impact piling. The ENIA provides:

"For the purposes of this assessment it is assumed that the primary piling methodology is impact piling. On average around one pile will be installed per day, with a total of approximately 140 piles to be installed. Up to 1,800 impacts per day may be expected during piling.

Based on a steel pile diameter of approximately 0.9m, a source level of SEL 198 dB re 1 μPa2 ·s per impact and a peak level of 225 dB re 1 μPa@ 1m have been determined from (Rodkin et. al.)."

31. Based on current interim criteria adopted by the US National Oceanic and Atmospheric Administration and applied by the South Australian Government in its current Underwater Piling Noise Guidelines (**SA Piling Noise Guidelines**), the level of noise from impact piling will cause behavioural disturbance at the very least, and at worst, may cause permanent injury or death (see Table 1 below). It is submitted that even at the lower end of the spectrum, the piling will disrupt calving and breeding habitat in close proximity to Smith Bay.

32. KIPT proposed the following measures to mitigate impacts from piling noise:

    a. piling to occur during daylight hours between 7 am and 7 pm;

[24] Commonwealth of Australia, above n4, 38.
[25] Best PB (2000) Coastal distribution, movements and site fidelity of right whales Eubalaena australis off South Africa, 1969–1998 South African Journal of Marine Science 22: 43–55.
[26] Ibid.

b. the duration of hammering to be around 20 minutes per pile installed, with up to two piles installed per day; and

c. all piles installed beyond the low-water mark to be installed from a marine plant (i.e. there would be no piling in-water from plant located onshore).

33. The mitigation measures proposed by KIPT are unlikely to be effective because they fail to meet industry and government standards, such as the SA Piling Noise Guidelines. Of significance is the failure of KIPT's plans to include qualified marine fauna observers and stop-start procedures to mitigate impacts.

34. In particular, there has been a complete absence of basic measures such as:

a. In the period 30 minutes before piling commences; marine fauna observers to monitor for a 2000 m radius from piling activities whether whales are present;

b. Piling only to commence if, for 30 continuous minutes, no whale has been observed by a marine fauna observer within 1300 metres of the piling location;

c. Soft start-up procedures to be implemented for all piling activities, for the first 30 minutes of piling;

d. Immediate shut-down procedures if a whale is spotted within 1300 m of piling activities;

e. Piling activities not to recommence until a sighted whale has moved beyond 1300 metres of piling activities of its own accord, or the whale has not been seen within 30 minutes; and

f. Piling activities that have been ceased for more than 15 minutes may only recommence in accordance with soft start procedures.[27]

35. Mitigation measures such as those listed above were required by the DoEE in Referral 2018/8362, which involved marine construction activities in Dampier Marine Park.

[27] See for example DoEE, 'Notification of REFERRAL DECISION - not controlled action if undertaken in a particular manner Scarborough Development Nearshore Component, Pilbara Region, WA (2018/8362)'.

Table 1: Comparison between Operational Noise from Piling and Accoustic Thresholds for the Southern Right Whale

	Operational Activity	Noise level	Behavioral Disturbance[28]	Injury (PTS)	TTS
1	Impact Piling	Peak 190-245 dB re 1 μPa. Single Pulse SEL 170-225 dB re 1 μPa2 ·s	**SPL 160 dB re 1 μPa**	**Peak 230 dB re 1 μPa** **SEL 198 dB(Mlf) re 1 μPa ·s**	**Peak 224 dB re 1 μPa** **SEL 183 dB(Mlf) re 1 μPa ·s**
2	Vibro Driving	160–200 dB re 1 μPa	**SPL 120 dB re 1 μPa**	**Peak 230 dB re 1 μPa** **SEL 215 dB(Mlf) re 1 μPa ·s**	**SPL 180 dB re 1 μPa**

[28] Department of Transport, Planning and Infrastructure, *Underwater Piling Noise Guidelines* (November 2012) 16.

36. KIPT has failed to make provision in its construction plans for the times of year females and calves are likely to be present in the calving/breeding habitat. The Addendum sets out the following indicative construction timeframe, which provides for 309 days of "construction of the suspended piled jetty including the deck and piling".

Table 2 Indicative Construction Timeframe[29]

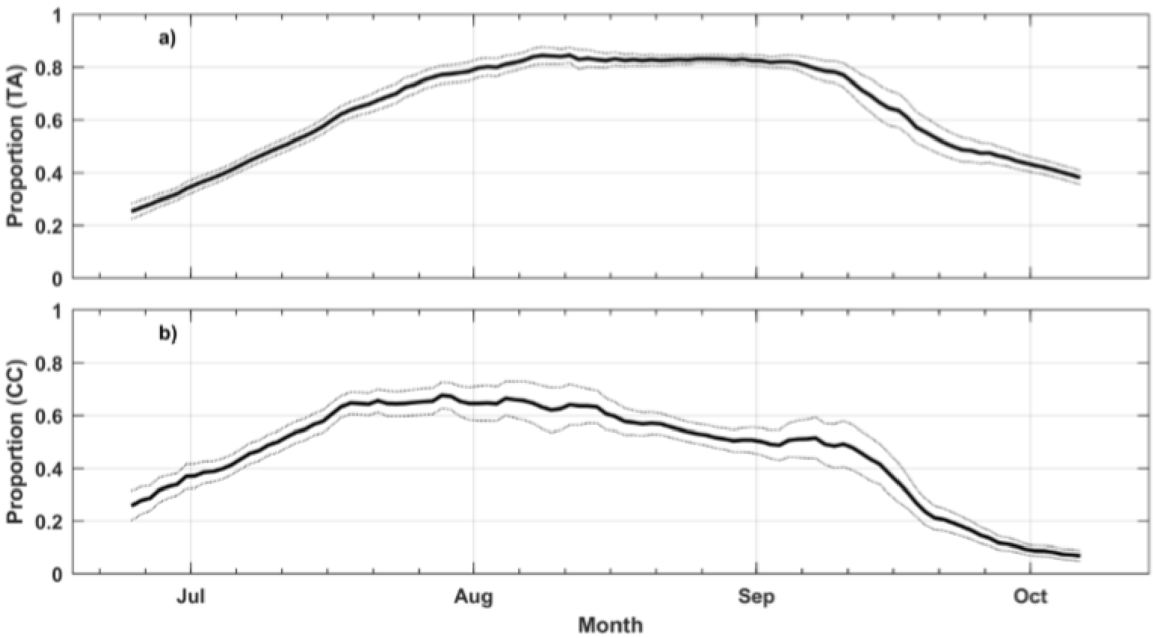
Commencement day	Activity	Expected duration (approximate number of days)
Day 1	Construction of suspended piled jetty, including the deck and piling	309
Day 48	Onshore civil works (roads, pavements, services, offices, materials handling conveyors and commissioning)	364
Day 178	Marine construction works (i.e. installing restraint dolphins, mooring dolphins, etc.)	120
Day 298	Installation of pontoon and final pontoon finishing works including weather and/or interruption contingency	108
Day 406	Marine works completed	
Day 412	All construction completed	

37. A recent study of the Great Australian Bight show that female Southern Right Whales are likely to use calving and nursing grounds between the months of May-October (see Figure 5 below):

"Results here provide information on timing of arrival and departure of SRWs to the HoB coastal aggregation area, which is required for species management in Australian waters and risk minimisation. Considering the proportion of the breeding population recorded at HoB from midJune to late-September, and the maximum percentage of breeding females at HoB remaining at the end of the study period (61%), SRWs and their newborn calves may be sensitive to potential impacts in the broader GAB area between May and October or beyond. The number of breeding females present at the start of the season is an underestimate because pregnant females are not recorded as part of that season's breeding cohort until they are sighted with a calf. For example, of the five unaccompanied adults photo-identified between 16 and 19 June 2016, three were sighted later in the season with a calf."[30]

[29] Environmental Projects, above n1, 10 .
[30] Charlton, above n6, 36.

Figure 5: Abundance of (a) the total southern right whales and (b) females accompanied by a calf sighted at the Head of Bight Study area between 1992 and 2016 using a 14-day moving average with 12 day overlap (presented as a proportion of overall sightings). The dotted lines represent the 95% confidence limits.[31]



38. The long duration of construction (309 days) makes it inevitable that construction will be taking place during calving season. No attempts have been made to mitigate impacts by to Southern Right Whales during calving season.

39. Given that there are less than 300 individuals left in the Southern Right Whale eastern population and that calving only happens once every three years, any disruption to calving habitat at Smith Bay could lead to an irreversible, long term decline of the species.

Conclusion

40. For the reasons above, we submit that the Minister should not approve the Proposed Action because of unacceptable impacts to the Southern Right Whale.

[31] Charlton, above n6, 34.

From: Jayne Bates [redacted]>
Sent: Friday, 20 December 2019 7:48 PM
To: DPTI:State Commission Assessment Panel
Subject: KIPT Smith Bay development EIS Comment

Categories: Green Category

Attention: Robert Kleeman
Unit Manager Policy and Strategic Assessment
Department of Planning, Transport and Infrastructure
GPO Box 1815
ADELAIDE SA 5000

Dear Mr Kleeman,

Having read the Kangaroo Island Plantation Timber's addendum to the EIS for the Smith Bay development I would like to express my full support for the project.
In particular, I am pleased that the concerns of the neighbouring aquaculture enterprise have been address through the redesign of the wharf infrastructure.

The decision to redesign the solid causeway in lieu of a longer open-piled jetty has addressed the concerns suggesting that the infrastructure would adversely affect coastal processes in Smith Bay and subsequently lowers the risks to adjoining land-based aquaculture.
The report(s) also significantly address the issue of both businesses co-existing within the Smith Bay area .

I am a strong supporter of the long held ambition of the Island Community to see both a social and economic gain from the forestry on the Island. This opportunity before us gives the strongest and most credible opportunity to achieve that aim.

Cheers
Jayne Bates

Jayne Bates
Cape View Cottage Holiday Accommodation
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w. capeviewcottage.com.au e.[redacted]
a. PO Box 245, Penneshaw SA 5222


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Your FREE Guide to Kangaroo Island
KANGAROO ISLAND
TOURISM, FOOD, WINE & BEVERAGE ASSOCIATION

From:	Joele Moodie
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Friday, 6 December 2019 5:06:25 PM

I’m concerned with the new design proposals size , The impact on flora, fauna and marine life generated by the light and on going operational noise and vibration along with pile driving and construction. The lack of adequate studies performed for all these issues. The absence of appropriate management plans also makes it impossible to understand and assess how they intend to mitigate the impacts. Bio security regarding international shipping has not been properly addressed and poses extreme risk to kangaroo Island.

ANDROMEDA PARTNERS
CORPORATE ADVISORY

3rd December 2019

Attention: Robert Kleeman
Unit Manager Policy and Strategic Assessment
Department of Planning, Transport and Infrastructure
GPO Box 1815
ADELAIDE SA 5001

Dear Mr Kleeman,

Re: KIPT Port at Smith Bay – Submission on revision to jetty structure

I wrote to the Minister of Planning on 29th March 2019 in support of the proposed KIPT Port at Smith Bay. In light of the proposed revision to the jetty structure, which makes a substantial further reduction in the project's environmental impact, this project in the revised form should be supported and promptly approved by the South Australia government.

At a time when economic growth is stagnating it is important that the South Australian government demonstrates to the business community that large economically-viable, environmentally-responsible projects are supported and dealt with in an efficient and timely manner. Delays and uncertainty have substantial adverse impacts on businesses' willingness to invest capital and resources. Lengthy delays can have the effect of destroying value. This value destruction can be quantified, and it is lost permanently both to the state of South Australia and the country.

It has now been over 31 months since the previous Minister for Planning declared that the proposal would be considered as a 'major development' pursuant to s.46(1) of the Development Act 1993. While companies recognise that due process needs to occur such an elongated timeframe appears excessive given that the approval process for the Tesla battery storage project at Jamestown was nowhere near as arduous or lengthy.

I wish to reiterate our support for the wharf proposal for the reasons stated below:

- Affirmation by South Australia that the government is supportive of investment by private enterprise;
- Delivery of a key infrastructure project to Kangaroo Island;
- Creation of long-term skilled jobs in a regional community;
- Generating substantial and sustainable economic growth; and
- Diversifying South Australia's revenue sources, and in doing so generating considerable foreign exchange income.

I appreciate your consideration of this submission.

Yours sincerely,

John Hobson
Partner

KANGAROO ISLAND COUNCIL

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abn 93 741 277 391

Ref. No: L2019/
Cross Ref. No: L2019/
File No: 3.12.111

State Commission Assessment Panel
Attn: Robert Kleeman, Unit Manager Policy and Strategic Assessment
Department of Planning, Transport and Infrastructure
GPO Box 1815
Adelaide SA 5000

Via email: majordevadmin@sa.gov.au

19 December 2019

Dear Mr Kleeman

Referral Response – KI Plantation Timbers, Addendum EIS

Major Development Proposal – Timber Port Facility – Allotment Comprising Pieces Q51* & Q52* DP92343 Hundred of Menzies and Coastal Waters North Coast Kangaroo Island, Smith Bay

Thank you for the opportunity to comment on the abovementioned Addendum EIS produced by Kangaroo Island Plantation Timbers (KIPT), in respect of the development of its proposed timber port at Smith Bay on the North Coast of Kangaroo Island.

Council acknowledges and welcomes the amendments made to the proposal in terms of the port facilities responding to the concerns of Yumbah Aquaculture represented in the initial consultation process. This is considered to be a positive step in attending to environmental impacts in the area.

However, it is greatly disappointing to Kangaroo Island Council that our concerns previously submitted to the Commission in May 2019, regarding road transport impacts to Kangaroo Island, biosecurity concerns (for the Kangaroo Island coastline and marine environment), and our fundamental concern about the location of the port facility have not been addressed at all.

Council would, therefore again, implore the Commission to turn its attention to these fundamental factors which affect the proponent company's operational impacts upon Kangaroo Island. Council further implores the Commission, as part of its assessment, to identify the State Government DPTI/Transport Minister's strategies intended to secure major forestry haulage routes/high productivity vehicles (B / A Doubles combinations) and the penultimate yet unanswered question on costs and accountability of upgrades and maintenance to the transport route roads.

KIPT has indicated its Board / Directorship's position that the company would not contemplate any consideration of a port site located further west and therefore located within the Southern Spencer Gulf Marine Park. Council would also implore the Commission and Minister to establish whether the marine park can be adjusted to accommodate a port facility which is not within the marine park boundaries.

Council is unequivocal in its view that the forestry product on Kangaroo Island must establish its end use/export and it is fundamentally essential to move the forestry

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product from Kangaroo Island economically – in this respect Council supports the need for a port facility, however, Council continues to vehemently contend that the location of the proposed development at Smith Bay remains inappropriate.

Council maintains its view that a location further west on the Kangaroo Island coastline, nominally west of Stokes Bay, would accommodate an adequate deep water port appropriate for the envisaged Panamax sized vessels' operational draught, without such extensive wharf infrastructure, and would site the port facility substantially closer to the forestry operations resulting in substantially reduced haulage distances to port, and therefore, substantially reduced impacts to road infrastructure and residents.

Should you wish to further discuss any matters associated with this proposal, please do not hesitate to contact me on 8553 4500.

Yours sincerely

Greg Georgopoulos
Chief Executive Officer

From:	Florance Karin
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Wednesday, 18 December 2019 3:53:41 PM

KPT's New Smith Bay (650metre) "Wharf ". does in NO way alter the IMPACT on the ALREADY EXISTING PRISTINE WATERS of the Very Valuable BAY , SMITH BAY....
No matter what size "they" propose for their "jetty".... it will be the SAME result !!!!!
Signifiigant studies by many scientists have already identified the AMAZING MARINE LIFE NOW PRESENT IN THIS BAY.
EG, ...Seadragons, seahorses , amazing corals and grasses.
Together with abundant fish life, dolphins and magnificent migrating whales.!!!!!!
"HOW " could ANYONE give KPT a green light to destroy or even endanger what we already HAVE ? Once gone , it's gone.
Notably, permanent hearing loss may also result for our beautiful creatures.
KANGAROO ISLAND IS A NOTABLE TOURIST DESTINATION...
How can any Australian Government give its "0K " to such a proposal..
How will we , as Austalians, come across World Wide ?
The World is watching.
We are a small island, and every part of our land and seas is IMPORTANT!
Neither will our roads be safe. They are narrow dirt/gravel roads. Deaths will occur.
Residential homes will be effected. ....families/ children.
Please say NO to KPT.'s plans. And block all further requests from them.
Sincerely,
Karin Florance.

Attention; Robert Kleeman.

Dear Sir,

I send this letter of support for the changes made to the export port at Smiths Bay by KIPT.

As a tree-owner I am impressed with the way KIPT have moved forward and addressed the concerns of the neighbour.

My trees are ready for harvest, and it has always been important to me through my long life here on Kangaroo Island to be courteous to my neighbours, but I have also always respected the right of my neighbour to get on with his business in a way that is legal, professional and fits within good conduct on both sides of the fence.

Thank you for your attention.

Andrew Noble.

Karatta

From: Kirsty Buick
Sent: Wednesday, 18 December 2019 3:21 PM
To: DPTI:State Commission Assessment Panel
Subject: KIPT Super Jetty Objection

Categories: Green Category

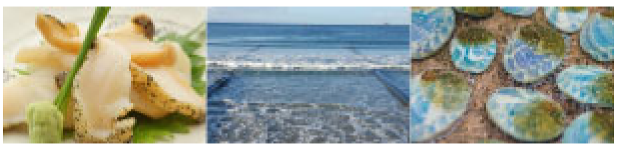
To the Department of Planning Transport and Infrastructure Minister

Please see below for my Objection to KIPT's Super Jetty proposal. Smith Bay is not the place for this to get the go ahead.

Smith Bay is currently marine pest free. Can KIPT guarantee it will stay that way with the introduction of panama ships coming in from international waters where pests have been introduced from ships and destroyed ocean habitats?
How can KIPT prove that with the new design being a jetty 650metres long that it will not affect the ocean currents in Smith Bay, and therefore increasing the water temperature during the warmer months?
How does KIPT plan on putting the pile ons of this new jetty in? Hammering them will no doubt cause all sorts of noise and vibrations in the ocean affecting all the local marine life, including the seasonal whales and resident dolphin pods. How does KIPT plan on making sure the ocean floor is not stirred up during this whole process and installing this super jetty, so the Abalone Farm intakes suck this in and suffocate the abalone? How far are the jetty piles going to be apart? Can the existing marine life pass under the jetty, and, if the conveyor is operating, causing constant vibrations protruding down the jetty piles to the ocean floor, how is this going to be managed or proven to have no effect on the marine life?
How can KIPT prove that during wind events, that the neighboring Abalone farm will not get covered in dust and wood chips?
How does KIPT plan to source their water from? There is no mains water supplied to Smith Bay, and I do believe that to KIPT will need to use a lot of water for a vast majority of their wood chipping operations and dust control?

Thankyou

Kirsty Buick
Processing Manager



Yumbah Kangaroo Island
1884 North Coast Road
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T: +61 8 8553 5322

E: [redacted]
W: www.yumbah.com

From: Lester Noble
To: DPTI:State Commission Assessment Panel
Subject: Attention Robert Kleeman
Date: Monday, 9 December 2019 9:14:07 PM

Dear Sir,As Blue gum plantation growers we support KIPT in their changes to the design of their proposed new sea port at Smith Bay Kangaroo Island.Moving from a solid causeway
to an open pile jetty will allow free movement of the sea water,which in turn will be much better
for the marine environment.KIPT have been prepared to make these design changes in working
with the community and neighboring industries to bring about the best out come,creating a new
industry and jobs for the island.The trees are ready, the markets available,its time to start.
Thank you
Regards Lester & Erika Noble

From:	Linda Briere
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Thursday, 19 December 2019 11:36:34 PM

Smith Bay is a unique marine environment that would be destroyed by KPT's new Smith Bay mega-wharf. The new plans do not mitigate the damage to this very special marine environment. Other locations on Kangaroo Island are better options for KPT to build a wharf.

From:	Maggie Welz
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Thursday, 19 December 2019 8:28:11 PM

650 metres is a mega wharf and will have a mega impact on the pristine ecosystem of Smith Bay. It will destroy the aesthetics of the area while introduction of pests and exotic species will have a devastating effect on the rare and valuable ecosystem. A 650 metre structure and ship activity will impact and disturb the routes taken by whales and dolphins who use this area as a resting and recovery site. I am not sure if I can express my concern of the impact on the whole area that will be experienced here as mega trucks carry wood chips every few minutes for many kilometres of this up til now quiet wildlife area to a 650 metre wharf. This will impact on tourism a major industry of the island. It will impact in so many ways on the Abalone farm with an even longer structure with increase lights noise etc. But most importantly it will threaten the pristine waters and species of this unique area.

DEEP WATER PORT FACILITY
Smith Bay, Kangaroo Island

The Addendum to the EIS is currently on public consultation
TELL US WHAT YOU THINK

All submissions will be made publicly available and will be included in the proponent's consolidated Response Document (that will be released for public information at a later date).

Name: Malcolm Boxall *Address:* ...
Telephone: ... *Email:* ...

Overall, what do you think about the proposed changes?

I Feel the changes are an improvement, probably more costly. No need for dredging is certainly an improvement
Removing the Causeway is also a good idea. When Breakwaters are constructed they tend to muck up the normal sand flow.

Do you have any specific comments on the following?

Extension of the jetty further offshore

A couple of other areas to coment on, I cannot remember what I put in my first Submission.
It is very disappointing that Council and Yumbah will not speak to KIPT. If we could have some constructive conversations it would help the process considerably.
KIPT needs to be able to negotiate with Council, State and

Further information
Call – 1800 PLANNING – press option 1
Visit – sa.gov.au/planning/majordevelopments
Email – majordevadmin@sa.gov.au

Government of South Australia
Department of Planning, Transport and Infrastructure

DEEP WATER PORT FACILITY

Smith Bay, Kangaroo Island

Removal of the causeway (and the removal of the need to dredge)

Federal governments to plan road infrastucture.

For economics of operation I still believe Cape Dutton would be a better port proposition. I know there is a couple of serious hurdles for this to happen. One the Landowner does not want to sell, and two it is located in in the edge of a marine park protection Zone.

The two main advantages is 18 metre of water right next to the Coast and shorter trucking distance thus less road building costs. From the Playford Hyway - Stokes Bay Rd Junction it is 23 km to Cape Dutton and 46 km to Smith Bay & 60 km to Ballast Hd

Written submissions commenting on the Addendum are invited until 20 December 2019

Minister for Planning c/- Robert Kleeman Unit Manager, Policy and Strategic Assessment Department of Planning, Transport and Infrastructure GPO Box 1815 ADELAIDE SA 5000	email to: majordevadmin@sa.gov.au Further information: www.saplanningportal.sa.gov.au www.saplanningcommission.sa.gov.au

I agree the changes are an improvement, probably more costly. No need for dredging is certainly an improvement. Removing the causeway is also a good idea. When breakwaters are constructed they tend to muck up normal sand flow.

I can not remember what I put in my first submission but I would like to make a couple of comments. It is very disappointing that Council and Yumbah will not speak to KIPT. If we could have some constructive conversations it would help the process considerably. KIPT needs to be able to negotiate with Council, State and federal governments to plan road infrastructure.

For economics of operations, I still believe Cape Dutton would be a better port proposition. I know there is a couple of serious hurdles for this to happen. One the landowner does not want to sell, and two the site us located in the edge of a marine park protection zone. The two main advantages is 15 meters of water right next to the coast and shorter trucking distance thus less road building costs. From the Playford Highway – Stokes Bay Road intersection it is 23km to Cape Dutton, 46km to Smith Bay and 60km to Ballast Head

MARITIME CONSTRUCTIONS PTY LTD
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MARITIME CONSTRUCTIONS

9 December 2019

Minister for Planning
Department of Planning, Transport & Infrastructure
GPO Box 1815
Adelaide SA 5000

Attn: Robert Kleeman, Unit Manager Policy & Strategic Assessment

Sub: Maritime Constructions Support for Marine Infrastructure for KIPT
Deep Water Port Facility, Smith Bay, Kangaroo Island

Dear Minister,

Maritime Constructions (MC), a family owned SME in Port Adelaide employing over 140 staff, have been assisting Kangaroo Island Plantation Timbers (KIPT) for over 5 years in the development and planning of a port/export facility for Kangaroo Island's forestry resource.

As a local business, we are extremely excited and proud to be involved with this project. It will provide significant increased employment opportunities for our current and new/additional staff including significant upskilling of staff both on and off the island.

MC have been involved in the planning stages of quite a number of regional/resource projects in South Australia (none of which ever made it this far) and I can categorically state that we have never seen the level of personal investment, tenacity and determination to find the right solution for the island as we have done from KIPT.

KIPT have taken any and all concerns raised extremely seriously and have invested heavily in designing and adopting measures to mitigate any impacts both real and perceived; I know this because despite the economic impacts of some of the decision junctures, KIPT has maintained a steadfast guiding principle that they would navigate the development pathway in such a way as to accommodate, placate and mitigate concerns and any areas of possible harm early and from the outset. To be completely frank, at times we worried whether such a pathway was ever possible as there are inevitably always objectors to any development, large or small, and broadening the scope of the EIS and field studies early on whilst altruistic, seemed risky.

With the deletion of any seabed disturbance by way of the removal of all dredging works, moving further out to sea and the replacement of the entire rock armoured earthen causeway with a piled jetty, the construction of the facility will have minimal impact, if any at all, to neighbours and the environment. This cannot be overstated and KIPT should be commended for this as the alternatives certainly would have been more cost effective.

Our company has been operating for over 25 years providing marine services to this state. We represent the single best source for advice and guidance for the expected outcomes of any chosen methodology or approach to this type of work. It is the unwavering opinion of our company that the final design that KIPT have arrived at is the most environmentally friendly and will have by far the least impact on neighbours and Smith Bay generally. After having priced and assessed the suitability of all other locations on the island, I can also categorically say that Smith Bay is by far the most appropriate site for this well overdue infrastructure.

This project will be very important to our company and our suppliers and will provide for significant investment decisions and massive spending in South Australia. Again, I point to all the proposed marine/port infrastructure projects that never went ahead in South Australia and the missed opportunities for local business and the local economy as a result.

Thank you for your time minister.

Yours sincerely

Shane Fiedler
Chief Executive Officer

PF OLSEN AUSTRALIA

PF OLSEN (AUS) PTY LTD
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20 December 2019

By Email
majordevadmin@sa.gov.au

Minister for Planning
C/- Robert Kleeman
Unit Manager Policy and Strategic Assessment
Department of Planning, Transport and Infrastructure
GPO BOX 1815
ADELAIDE SA 5000

Dear Minister

ADDENDUM TO THE SMITH BAY WHARF EIS

I wish to register PF Olsen (Aus) Pty Ltd's (PF Olsen Australia) support for the modifications that Kangaroo Island Plantation Timbers Ltd (KIPT) have made to the design of the jetty for the KI Seaport.

The changes represent a considered and proactive approach to effectively address concerns expressed by stakeholders relating to the initial plan's potential impact on coastal processes and the impact of dredging.

It is PF Olsen Australia's view that the KI Seaport should be approved as a matter of urgency. Once the port is approved, plantation harvesting can commence and generate several hundred direct and indirect regional jobs, and significant economic growth for the Kangaroo Island community and South Australia more broadly.

In approving the KI Seaport, the government will ensure that the residents of Kangaroo Island and South Australia can realise the potential this development has to offer.

Yours sincerely,

PF OLSEN (AUS) PTY LTD

Martin Crevatin
Acting Managing Director

December 2019

MITSUI&CO.

Submission regarding the addendum to the draft EIS for the proposed Kangaroo Island Plantation Timber seaport at Smith Bay

Mitsui & Co. (Australia) Ltd. (Mitsui) welcomes the opportunity to make a submission regarding the addendum to the draft Environmental Impact Statement for the proposed Kangaroo Island Plantation Timber Ltd (KIPT) seaport at Smith Bay.

The South Australian Government's rigorous assessment process, including the requisite Environmental Impact Statement (EIS) provides a valuable opportunity for constructive community, industry and regulatory consultation on the proposed development.

Mitsui in Australia

Mitsui is a global trading and investment enterprise, and a long-term partner of Australia.

As Australia's fourth largest exporter with $8 billion in total exports annually, we are helping deliver lasting benefits for the nation's future.

We have invested more than $15 billion in Australia over the last decade alone, including in significant renewable power infrastructure in South Australia. We continue to work as a trusted partner with local businesses to identify new opportunities and create new trade flows that strengthen the national economy.

Mitsui is proud of our history in Australia and the work we do. Our investment in Australia extends to contributing to the community through activities outside our core business, specifically in the areas of international exchange, education, environment and sustainability.

Mitsui Bussan Woodchip Oceania

Mitsui Bussan Woodchip Oceania Pty Ltd (MWO) is a wholly owned Australian based subsidiary of Mitsui & Co. Ltd.

Over several decades, MWO have heavily invested in Australia's forest products industry. MWO's involvement in the forest industry spans the entire supply chain - from planting seedlings, to processing timber, to delivering wood products to customers throughout Asia.

Mitsui's woodchip export joint venture in the Portland region recently celebrated 10 years of operation. Mitsui was proud to celebrate the contribution to the community and economy, noting that we have exported over AU$1 billion worth of woodchips since 2007.

MWO is a valued partner in and trusted operator of sustainable forestry resources across Australia. These investments include timber plantations and processing and exporting operations in South Australia, Victoria and Western Australia.

MWO's partnership with KIPT

MWO and KIPT have executed long-term offtake agreements for the timber products growing on Kangaroo Island (KI). The arrangement gives MWO exclusive access to a valuable resource during a period of anticipated scarcity, while giving KIPT the security of dealing with a highly regarded and reliable trader, marketer and offtake partner.

MITSUI&CO.

Submission regarding the addendum to the draft EIS for the proposed Kangaroo Island Plantation Timber seaport at Smith Bay

MWO is also the exclusive developer and operator of the proposed woodchip handling facility. Plans for the facility include infrastructure capable of receiving, screening, stockpiling, sampling, and loading woodchips into bulk vessels for export. MWO operates similar facilities at Bunbury, in Western Australia and in Portland, Victoria.

Through its ongoing investments and activities, MWO is a significant contributor to the local economies and communities of Portland, Myamyn, Collie and Bunbury, in addition to the benefits flowing to the wider regions. KIPT will work closely with MWO and draw on their extensive experience managing woodchip-handling facilities to ensure the operations are efficient, safe and integrated into the local KI community.

Addendum to the Smith Bay Wharf Draft Environmental Impact Statement

Mitsui considers KIPT's Addendum to the Smith Bay Wharf EIS to be a considered response to feedback received during the public consultation period, making particular effort to accommodate the neighbouring Yumbah abalone farm.

Mitsui and our partners have operated our Portland woodchip export operation in proximity to Yumbah Narrawong abalone farm for many years. The two operations have successfully coexisted during that time and delivered lasting benefits to the Portland community. Mitsui hopes the two companies can coexist at Smith Bay so we may deliver similar benefits to the Kangaroo Island community.

Support for a sustainable Australian forest industry

Mitsui and MWO are proud supporters of a sustainable Australian forest industry. Sustainably produced wood and timber products offer a suite of benefits – being renewable, reusable, recyclable, and biodegradable. Sustainably managed forests and plantations absorb immense volumes of CO_2 every day, storing that carbon in our homes and household products.

KIPT have achieved Forest Stewardship Council (FSC) and Program for the Endorsement of Certification (PEFC) certification for the hardwood plantations growing on KI, making them among the most sustainably managed forests in the world.

From:	Paul Turnbull
To:	DPTI:State Commission Assessment Panel
Subject:	Smiths Bay Development - change to EIS
Date:	Tuesday, 3 December 2019 4:57:27 PM

Attention: Robert Kleeman
Unit Manager Policy and Strategic Assessment
Department of Planning, Transport and Infrastructure
GPO Box 1815
ADELAIDE SA 5000

Dear Mr Kleeman,
I am a shareholder of kpt and visited the site of the development in November 2019.

The changed design for the jetty is a step change improvement for the natural water flow in Smith's Bay. I commend the board and management of kpt for this change as it shows sensitivity to the environment and community at the cost of delaying a decision on the eis, increasing the cost of the development and delaying jobs and wealth that the project provides for all.

I am impressed by the professionalism.

I support the project and the modified design.

Kind Regards

Paul Turnbull

Sent from Mail for Windows 10

Robert Kleeman,
Unit Manager Policy and Strategic Assessment
Planning and Development, Development Division
Dept of Planning, Transport and Infrastructure
GPO Box 1815
Adelaide SA 5000

majordevadmin@sa.gov.au

Re: Proposed timber port at Smith Bay, Kangaroo Island

Dear Minister Knoll,

It would appear that Kangaroo Island Plantation Timbers has now suffered a prolonged and costly project EIS to which there appears no end. It is time for your government to make a decision in the interests of allowing future sustainable and economically desirable projects for South Australia.

My concerns have always been for the collateral damage potential to our fisheries, wildlife and other commercial ventures such as Yumbah aquaculture. It is now clear to me that the floating wharf design and its additional length addresses the main concerns stated by Yumbah in previous correspondence. The recent amendment to the EIS is not only a valid and fair compromise to Yumbah's concerns but it is also an indication of the commitment by KIPT to adhere to their environmental concerns in support of their social license.

I have every confidence that KIPT will stand by its promises to protect the environment on Kangaroo Island while adding a further layer of responsible industry to the island's economy.

I would be pleased to be interviewed separately in this matter if this would be helpful.

Yours sincerely

Peter Clements

Former Mayor of Kangaroo Island

Tuesday, 3 December 2019

Peter Wales
[redacted]
American River
SA 5221

Mr Robert Kleeman,
Unit Manager Policy and Strategic Assessment
Planning and Development, Development Division
Dept of Planning, Transport and Infrastructure
GPO Box 1815
Adelaide SA 5000

Dear Sir,

KIPT – PROPOSED JETTY AT SMITH BAY, KANGAROO ISLAND

In April of this year (2019) I wrote to you to express my support for Kangaroo Island Plantation Timbers' Smith Bay Jetty project.

The plan as it stood at that time was an exceptionally positive, transformative project for Kangaroo Island, with flow-on benefits to the whole of South Australia.

Objections to the jetty had primarily been made by, or at the urging of, staff at Yumbah's abalone farm at Smith Bay. The principle objection was purported negative impacts on the viability of farmed abalone during construction, and claimed possible issues with water quality when the jetty was in use.

Yumbah noted at the time of the release of the EIS: "The causeway is the most concerning physical feature of the seaport for Yumbah." and "The only option to protect coastal currents is an open-piled jetty with the berth pocket extended further offshore."

Maintaining coastal currents appeared to be important to Yumbah because the 200 megalitre per day waste outflow from their facility, if not adequately dispersed by ocean currents, has the potential to raise ambient water temperatures in the bay to the point where marine wildlife is endangered, and intake temperatures are too high for their own equipment to moderate to ensure the viability of farmed abalone.

One would have thought that since this issue existed because of high temperatures in Yumbah's waste outflow, this was Yumbah's problem to resolve, rather than KIPT's and the community's.

Nonetheless, although considerable additional costs will be incurred in construction, KIPT acted to resolve both of Yumbah's key complaints. The proposed change to the design of the jetty removes the solid causeway, replacing it with an open-piled jetty and extending the berth pocket further off-shore, exactly as Yumbah requested. This change reduces the need for dredging, and allows flow through of ocean currents with minimal disruption, ensuring Yumbah's waste outflow has minimal opportunity to interfere with wildlife and their own operations.

KIPT and community members who attended information sessions believed on the basis of advice given by marine biologists and engineers that any environmental and water quality issues with the initial proposal could be mitigated to ensure the safety of marine wildlife, and no disruption to Yumbah's Smith Bay operations.

The proposed change even further reduces the environmental impact of the project, and ensures water quality in the bay is maintained.

Objections offered to Kangaroo Island Plantation Timbers' Smith Bay Jetty proposal have no basis in real world evidence and experience, or in the case of temporary changes in water quality during construction, can be mitigated to ensure minimal environmental impact, and continued safe operation of the abalone farm.

The development of a jetty at Smith Bay offers substantial ongoing social and financial benefits to the residents of Kangaroo Island and should proceed.

Yours sincerely,

Peter Wales

B.Th, MCTS, MCITP, A+ IT Tech, CTT, Project+

06/12/2019

RJ & VJ Ordway
Lemon Tree Cottage
[redacted]
Kingscote SA 5223

27th May 2019

Attention: Robert Kleeman,
Unit Manager Policy and Strategic Assessment
Planning and Development, Development Division
Dept of Planning, Transport and Infrastructure
GPO Box 1815
Adelaide SA 5000
via email to: majordevadmin@sa.gov.au

Re: Smith Bay development proposal by Kangaroo Island Plantation Timbers

I wish to provide a letter of support for the proposed design change to the Smith Bay Wharf Draft Environmental Impact Statement as detailed in the Addendum prepared for Kangaroo Island Plantation Timbers (KIPT).

I commend KIPT's decision to abandon the solid causeway in favour of an open-piled jetty and working with neighbours to address concerns about the potential negative environmental affects to coastal processes which dredging and solid causeway may have caused.

I believe the forestry industry has the potential to stimulate the economy and improve the number of people living on the island. If the population of the Island can increase by 400-500 people because of the 200+ jobs on offer, that will not only benefit small business here but will also provide more people for our sports, community and service groups, such as CFS. Our volunteers are an integral part of our rural community and we need more of them, these new people will become a part of our communities and support our volunteers, as well shows, field days, markets and much much more.

With these design changes, there will be no harm to water quality in Smith Bay and no material risk to Yumbah providing the best environment for both operations are in the best co-exist

The Island relies so much on seasonal business – both in tourism and in agriculture. The all-year-round forestry industry will bring much-needed, well-paying jobs and allow all businesses on the Island to prosper.

Yours sincerely,

Valerie J Ordway

Dick & Val Ordway

Penneshaw Fuel and Hardware
[redacted]
Penneshaw 5222

Robert Kleeman,
Unit Manager Policy and Strategic Assessment
Planning and Development, Development Division
Dept of Planning, Transport and Infrastructure
GPO Box 1815
Adelaide SA 5000

via email to: majordevadmin@sa.gov.au

19th December 2019

Re: Addendum to Environmental Impact Statement for Proposed timber port at Smith Bay, Kangaroo Island

Dear Mr Kleeman,

I wish to provide a letter of support for the proposed design change to the Smith Bay Wharf Draft Environmental Impact Statement as detailed in the Addendum prepared for Kangaroo Island Plantation Timbers (KIPT).

I commend KIPT's decision to abandon the solid causeway in favour of an open-piled jetty and working with neighbours to address concerns about the potential negative environmental affects to coastal processes which dredging and solid causeway may have caused.

This project has the potential to be the biggest full-time employers on the island which is much needed in the Kangaroo Island community. Business confidence is currently low; with a council reducing its operational and infrastructure budget, limited government commercial construction work forecast for KI in the coming years and locked up economic potential of the forested lands – business owners like ourselves have considered and will consider if we can afford to remain on KI.

With these design changes, there will be no harm to water quality in Smith Bay and no material risk to Yumbah providing the best environment for both operations are in the best co-exist

I urge you to approve the export facility development by Kangaroo Island Plantation Timbers, which will enable the establishment of the forestry business - a new, sustainable and profitable industry for Kangaroo Island.

Yours sincerely,

Richard Ordway

Penneshaw Fuel and Hardware

From:	Ros Morgan
To:	DPTI:State Commission Assessment Panel
Subject:	Submission
Date:	Tuesday, 10 December 2019 9:53:27 AM

Attention: Robert Kleeman, Unit Manager Policy and Strategic Assessment Department of Planning,Transport and Infrastructure
GPO Box 1815 ADELAIDE SA 5000

Dear Sir,

I write in support of KIPT'S addendum to the EIS for a deep sea port at Smiths Bay.
In response to Yumbah the change to an open pile jetty of 650 metres in length and the use of Worlds Best Practice construction methods should negate any objections to the port being approved.

Brian L Morgan
PMB15 Flinders Chase Service
Via Kingscote Kangaroo Island SA 5223

From: S Petit
To: DPTI:State Commission Assessment Panel
Date: Friday, 20 December 2019 12:22:31 AM

Attention: Robert Kleeman, Unit Manager Policy and Strategic Assessment

Re: Submission regarding the amended proposed Smith Bay Wharf development on Kangaroo Island

From: Dr. S. Petit, Associate Professor in Wildlife Ecology

20 December 2019

To: majordevadmin@sa.gov.au

Thank you for the opportunity to provide comments on the Smith Bay Wharf amendment.

1. Although it is positive that the proponents have abandoned the idea of major dredging, it is inconceivable that the proposed development and associated activities would not have a dramatic impact on the Bay and coastal processes. The timber plantations were established without planning for the future, resulting in the situation we are in now. With great sympathy for shareholders, we must be realistic and at last decide that proper **planning** must be undertaken for any activity with potentially serious impacts, and it is time that long-term planning be conducted. The following questions must be asked from both the proponents and our planning minister:
- Considering the proposed continued activity and spread of the blue gum industry on Kangaroo Island, what is the impact of the industry on the water table and recharge requirements (blue gums consume a considerable amount of water)?
- What is the impact of the industry on biodiversity?
- Would other agricultural activities be more suitable for Kangaroo Island?
- Have other avenues (with local benefits) be sought for the woodchips?
- In view of the extraordinary cost of running an international seaport that is expected to run in total from 1 to 2 months per year or so, who is going to pay for its maintenance?
- It is obviously impossible for an international seaport not to be plagued by biosecurity issues; a location that accepts an international seaport has to accept the introduction of highly damaging marine and terrestrial pests. What will be the social and environmental impacts of these new pests?
- Prices of woodchips vary dramatically; what will happen when prices drop and other, more competitive markets develop elsewhere?
- If the port is used 30-75 d per year, who are the other potential users? What is their activity and how is their activity going to affect Kangaroo Island? Will "they" pay for the maintenance of an international seaport? What would fees have to be to cover the costs without taxing the community?
- If KIPT goes out of business, what will happen to the seaport?
- Who would own the seaport located in State (public) waters?
- How is KIPT going to deal with the koala issue in its KI plantations?

No one is against progress, but progress is planning appropriately (with the future in mind!), not necessarily building constructions that have significant social, economic, and environmental legacies.

2. It appears that one of the major issues raised by the community and not presented in the amendment is road traffic. It is not appropriate to say that no matter of national environmental significance is concerned, when threatened species occur in the area (e.g.

how does one offset dead echidnas?). The noise and disturbances created by truck traffic have not been considered. The planning minister should also advise whether the state will be paying for the ongoing additional maintenance of the roads.

3. Similarly nothing has been said about minimising the effect of road dust (extraordinarily large volume of truck traffic) and sawdust on both terrestrial and marine environments. Added to diesel, wood leaching, fungicides, and sediment pollution, these impacts could be significant on residents and local ecosystems.

4. Although the public hopes that concerns will be addressed by the proponents, it appears that this activity will take place "in due course" – and there is no indication that these numerous concerns will be taken into account before a decision is made. "*KIPT and the EIS study team are currently reviewing, assessing and considering the submissions. A formal Response Document, which will summarise KIPT's responses, will be submitted to the Minister for Planning ('the Minister') in due course*." (p. 1).

5. No additional information is available concerning the previous cost/benefit analysis, which did not include true costs.

In conclusion, the amendment is disappointing in that its only contribution to addressing public comments is a reduction of dredging (any reduction goes in the right direction), when many other extremely important issues exist. The Department of Planning needs to examine costs to the State, the local community, and biodiversity. Kangaroo Island thrives on its wilderness and the green image of agriculture – the island's environment is unique Australia; any decision to destroy wilderness will have serious consequences to long-term social, economic, and environmental viability.

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PROUDLY KANGAROO ISLAND

E| kihire@kauppila.com.au P| 08 8553 2808 M| 0439 687 155 (Sharon) M| 0438 806 889 (Luke)

Robert Kleeman,
Unit Manager Policy and Strategic Assessment
Planning and Development, Development Division
Dept of Planning, Transport and Infrastructure
GPO Box 1815
Adelaide SA 5000

via email to: majordevadmin@sa.gov.au

4th December 2019

Re: Addendum to Environmental Impact Statement for Proposed timber port at Smith Bay, Kangaroo Island

Dear Mr Kleeman,

I wish to provide a letter of support for the proposed design change to the Smith Bay Wharf Draft Environmental Impact Statement as detailed in the Addendum prepared for Kangaroo Island Plantation Timbers (KIPT).

I commend KIPT's decision to abandon the solid causeway in favour of an open-piled jetty and working with neighbours to address concerns about the potential negative environmental affects to coastal processes which dredging and solid causeway may have caused.

As a significant contributor to the construction industry on KI, Kauppila Builders sees the Smith Bay Wharf as a massive opportunity as well as an absolute necessity. Business confidence is currently low; with a council reducing its operational and infrastructure budget, limited government commercial construction work forecast for KI in the coming years and locked up economic potential of the forested lands – business owners like ourselves have considered and will consider if we can afford to remain on KI. This is a massive decision for us, but if we don't see a future here, we will need to look elsewhere for our family's future.

With these design changes, there will be no harm to water quality in Smith Bay and no material risk to Yumbah providing the best environment for both operations are in the best co-exist

I urge you to approve the export facility development by Kangaroo Island Plantation Timbers, which will enable the establishment of the forestry business - a new, sustainable and profitable industry for Kangaroo Island.

Yours sincerely,

LB & SK Kauppila

Kauppila Pty Ltd

LB & SK Kauppila | 62 Lovers Lane (PO Box 602), Kingscote SA 5223
www.kauppila.com.au | Like us on Facebook
BLD 244321 | ABN 80 155 073 868

From:	Ibudaric Ibudaric
To:	DPTI:State Commission Assessment Panel
Subject:	Smiths Bay Development
Date:	Monday, 9 December 2019 8:21:02 PM

I would like to take the opportunity to express my overall support for the proposed jetty at Smiths Bay. It would appear the major concerns have been addressed, and while I still have reservations about maintenance to existing roadworks with the hugely increased truck traffic, I believe the benefits to the Island's economy and infrastructure make it worthwhile. Smiths Bay to look at is a sea of black shadecloth, not a pristine jewel and already exploited. Meanwhile a great deal of the Island is under forestry, which simply must be harvested.

Regards, Steve Budarick, Kingscote.

From:	Sue Holman
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Wednesday, 4 December 2019 1:13:50 PM

I am even more concerned about the mega-wharf plans as, not only will it cause seriously high levels of noise in the ocean, but it will also drive Dolphins and their calves even further out to sea and therefore they would be in far greater danger of being predated upon further off shore and, the calves would be in further danger as the water temperature would be significantly colder than what they require while so tiny. That is why the females stay inshore - so their babies are safe and kept at the right temperature. We have photographic evidence that the Dolphins breed all year round and, also, back up photographic evidence that there are a significant number of breeding Dolphins that regularly travel via Smith Bay from Dashwood Bay to Emu Bay & North Cape and back.

The on-land issues and concerns I had with the previous EIS have not been addressed at all so my concerns regarding roads being unable to cope with the truck traffic, and all that ensues, remain unchanged ie. noise and dust pollution, wildlife and their habitat being destroyed along any route the trucks would take, danger to other road users - especially overseas tourists that are not familiar with Australian dirt road driving.
The Koalas being evacuated from where they've been settled for so long then having to migrate into other Koala territories with the ensuing trouble that would cause to already stretched Wildlife Vets/carers resources - besides the extra road carnage. Light pollution at Smith Bay 24/7 is yet another to keep on the list.

As for using it as a 'multi-user' facility - that is impossible as the amount of infrastructure needed for cruise ships to use it for their passengers prohibitive, as they would need far more facilities than is practically possible to be built at that site.

From: [redacted]
To: DPTI:State Commission Assessment Panel
Subject: KIPT Smith Bay Development
Date: Tuesday, 10 December 2019 8:04:42 PM

Attention: Robert Kleeman
Unit Manager Policy and Strategic Assessment
Department of Planning, Transport and Infrastructure
GPO Box 1815
ADELAIDE SA 5000

Dear Robert
I wish to show my support for the new design of the KIPT Smith Bay extension of the jetty/wharf.
This would have to be a huge plus for the ab farm, noting that there won't be as much dredging required.
I am very impressed with the changes and sacrifice that KIPT are prepared to make for this development to go ahead.

Yours sincerely

Tom Fryar
[redacted]
Emu Bay SA 5223
Kangaroo Island

Kangaroo Island / Victor Harbor Dolphin Watch

in partnership with

Whale and Dolphin Conservation

www.kangarooislanddolphinwatch.com.au www.islandmind.com

Facebook Twitter & Instagram: @KIVHDolphinWatch

PO Box 30 American River, Kangaroo Island, SA 5221

[redacted] [redacted]

Dec 18th 2019

Kangaroo Island Plantation Timbers Addendum Response

PREAMBLE

Ever since the research findings of the **Rolland Study** following 9/11 were published it has been acknowledged as fact that anthropogenic sound has enormous impacts upon the lives of cetaceans.

These marine mammals use sound as their major sense for meeting their lifestyle needs and our interference with this element of their lives is of extreme concern to scientists around the globe.

We can no longer claim we act with impunity and in light of our expressed desire to maintain biological diversity, we must do everything we can to mitigate the impacts of human induced noise on the marine environment.

- ## Sound Propagation Modelling:

The proponents have stated their sound propagation modelling is adequate to cater for the changes outlined in the addendum document. They make consistent statements that the mitigation measures described in the EIS are considered adequate to cater for the amended design.

An example below is drawn from their conclusion to Appendix D of the Addendum:

"The changes to the design do not change the risk profile of the development as described in the Draft EIS. No additional MNES would be triggered by the changes to the proposal. Mitigation measures as described in the Draft EIS and in Table 1-2 are considered effective to manage any direct or indirect

impacts to the southern right whale. The revised proposal would not generate any residual significant impacts on the southern right whale."

In keeping with the scant regard for MNES demonstrated in the EIS, KIPT have asserted throughout the Addendum in **Sections 4.6 Matters of National Environmental Significance** and **4.8 Noise and Light**, that there is no need to change anything in their mitigation measures.

4.6.2 ASSESSMENT OF LIKELY DIRECT AND INDIRECT IMPACTS

"Table 14-2 of the Draft EIS identifies the development's potential impacts on the southern right whale. The impact assessments (direct and indirect) for the southern right whale have been reviewed (see Appendix D).

The increased length of jetty substructure and increased piling activity (number of piles to be installed, and the distance the activity would occur further out to sea) would have a negligible impact on southern right whales.

Noise modelling (Resonate 2018) undertaken on piling for the original design in the Draft EIS considered two scenarios which are consistent with the redesign: a duration of 30 minutes per day, assuming 60 blows per minute; and a duration of 15 minutes per day, assuming 120 blows per minute.

The revised impact assessment considers the revised construction program that plans for the installation of one pile at a time, but with the possibility of piling in two locations simultaneously.

Piling in two places simultaneously would effectively double the number of blows per minute per day, which would have the effect of increasing the cumulative sound exposure level (SEL) by 3 dB, and increasing the 'threshold distances' for temporary threshold shift (TTS) and permanent threshold shift (PTS) onset by approximately 1.6 times the values in Table 18.11 of the Draft EIS, assuming the exposure time is the same.

It is important to note that with the extended piled jetty substructure, the duration per day of the impact pilling is consistent with the assumptions used for the original modelling, and would occur for a total period of up to 20 minutes per pile installed, with up to two piles being installed per day."

4.8 NOISE AND LIGHT

4.8.1 ASSESSMENT OF POTENTIAL IMPACTS

"The Draft EIS assessed potential noise and vibration impacts which may have resulted from constructing a shorter section of suspended piled jetty. (This was incorporated into the original design). The approach would now be a full length suspended piled jetty and the impact assessments have been reviewed in that context. The onshore components of the KI Seaport have not changed."

Underwater Noise – Construction

"The suspended piled jetty requires the installation of approximately 156 tubular steel piles using a jack-up (piling) barge and impact hammer (refer Section 3.2.1). Increasing the number of pile installations to construct a longer jetty would also potentially extend the duration of the impact (noise source).

The baseline underwater noise environment at Smith Bay was described in Section 18.4.2 of the Draft EIS, and the effects of piling activities on the underwater noise environment were described in Section 18.4.4 of the Draft EIS. The revised design uses the same construction methodology described in the Draft EIS, which is summarised in Section 3.2 of the Addendum.

Underwater environmental impacts were assessed based on the:

- *existing conditions (such as ambient noise environment, local bathymetry, wave and wind climate)*
- *significant marine species in the study area*
- *significance of the area as a habitat for marine species*

- *species' sensitivity to sound*
- *characteristics of the identified noise sources in terms of duration, source level and frequency*
- *sound propagation characteristics of the marine study area.*

The potential impacts that were considered in the assessment are, in increasing order of severity:

- *behavioural change*
- *temporary threshold shift (TSS) in marine species' hearing*
- *permanent threshold shift (PTS) in hearing*
- *organ damage (possibly leading to death).*

To assess the impacts of the construction and operational sources, noise criteria were established for each of the considered impact levels. The underwater noise criteria adopted are based on National Oceanic and Atmospheric Administration (NOAA) Marine Mammal Acoustic Technical Guidance and the Sound Exposure Guidelines for Fishes and Sea Turtles. These represent the most up-to-date research and approach for the species considered in this assessment and are generally more stringent than the DPTI Underwater Piling Noise Guidelines.

As noted in the Draft EIS, damage to the hearing of marine fauna would be considered unlikely as the normal behavioural response to loud noise would be to move away.

Behavioural changes in response to noise are expected to be temporary and ecologically inconsequential as Smith Bay is not known to provide important feeding or breeding habitat.

The management and mitigation measures described in the Draft EIS include using a soft start, establishing a 1 km shutdown zone around the site (i.e. beyond the predicted PTS distance, see Table 21 of Resonate 2018 of the Draft EIS), and monitoring by marine mammal observers. The use of two piling rigs would reduce the total duration of piling, which would also be a consideration for planning the construction program.

Operationally, it is considered that the suspended piled jetty and reduced in-waterfootprint would have a negligible impact on whale behaviour. The design changes would remove the solid causeway from the design (which may be considered a potential barrier to movement) and any future maintenance dredging activity would no longer be required.

The proposed management measures for identified potential impacts to the southern right whale (see Appendix D Table 1-1), are consistent with the principles described in the EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales (DEWHA 2008) and are considered effective.

The assessment of the revised design against the 'significant impact criteria' is provided in Appendix D (Table 1-2)."

4.6.3 ASSESSMENT OF RESIDUAL IMPACTS

"Based on the above assessment, there would be no residual significant impacts on the southern right whale as a result of the revised design for the KI Seaport."

4.6.4 CONCLUSIONS

"The changes to the design do not change the risk profile of the development as described in the Draft EIS.

No additional MNES would be triggered by the changes to the proposal.

Existing mitigation measures as described in the Draft EIS are considered effective to manage any direct or indirect impacts to the southern right whale. The revised proposal would not generate any residual significant impacts on the southern right whale."

<u>This is a completely false assumption and assertion.</u>

It is based on **convenience, not Science**.

In **Section 2.2 Government Agency Consultations on the Design Change** in specific discussions with the Department of the Environment and Energy (Commonwealth) the following is stated:

"Underwater noise baseline data collection and predictive modeling assessment review in relation to the design change".

We are obviously not the only people concerned about the lack of adequate sound modeling in light of the changes to the design of the wharf.

Their response is simply to suggest what was in place was good enough previously so it's good enough now, albeit 250 metres further out to sea.

This is extremely unscientific and shows a complete **lack of understanding of sound propagation in the marine environment**.

- Potential Impacts:

Sound propagation properties change markedly in different situations as described in the **EIA Guidelines** attached. Also attached are the **CMS Technical Studies** for the guidelines.

Australia is a signatory to the CMS documentation provided and due consideration needs to be taken of the principles and findings of this world leading research.

The **EIA Guidelines** and accompanying **CMS Technical Details** were presented and adopted at the *CMS CoP 12, 2017* in the Philippines. They describe the possible impacts of all known forms of anthropogenic sound introduced to the marine environment and include information regarding construction noise production relevant to this submission.

**Reference 1 - Attachment 1*: EIA Guidelines*

**Reference 2 - Attachment 2*: CMS Guidelines: EIA Marine Noise Technical Support Information*

The following tracts from Page 9 from these extremely comprehensive documents make salutary reading.

They are an excellent starting point in any consideration of anthropogenic sound in the marine environment.

8. The propagation of sound in water is complex and requires many variables to be carefully considered before it can be known if a noise-generating activity is appropriate or not.
It is inappropriate to generalize sound transmission without fully investigating propagation

(Prideaux, 2017a). Often, statements are made in Environmental Impact Assessments that a noise-generating activity is 'X' distance from 'Y' species or habitat and therefore, will have no impact. In these cases, distance is used as a basic proxy for impact but is rarely backed with scientifically modelled information. (Wright et.al. 2013; Prideaux and Prideaux 2015)

9. To present a defensible Environmental Impact Assessment for any noise-generating activity proposal, proponents need to have expertly modelled the noise of the proposed activity in the region and under the conditions they plan to operate. Regulators should have an understanding of the ambient or natural sound in the proposed area. This might require CMS Parties or jurisdictions to develop a metric or method for defining this, by drawing on the range of resources available worldwide. (Prideaux, 2017a)

10. All EIAs should include operational procedures to mitigate impact effectively during activities, and there should be proof of the mitigation's efficacy. These are the operational mitigation procedures that should be detailed in the national or regional regulations of the jurisdictions where the activity is proposed. Operational monitoring and mitigation procedures differ around the world, and may include industry/company best practices.

Monitoring often includes, inter alia:

- *a. periods of visual and other observation before a noise-generating activity commences*
- *b. passive acoustic monitoring*
- *c. marine mammal observers*
- *d. aerial surveys*

Primary mitigation often includes, inter alia:

- *e. delay to start, soft start and shut-down procedures*
- *f. sound dampers, including bubble curtains and cofferdams; sheathing and jacket tubes*
- *g. alternative low-noise or noise-free options (such as compiled in the OSPAR inventory of measures to mitigate the emission and environmental impact of underwater noise)*

Secondary mitigation, where the aim is to prevent encounters of marine life with noise sources, includes inter alia:

- *h. spatial & temporal exclusion of activities*

11. Approaches to mitigate the impact of particle motion (e.g. reducing substrate or sea ice vibration) should also be investigated. Assessment of the appropriateness and efficacy of all operational procedures should be the responsibility of the government agency assessing Environmental Impact Assessments (EIA).

Given the plethora of studies completed, some of which are noted here, and the data acquired regarding the impacts of construction noise upon the marine environment, it is timely for the government to consider the situation in light of **potential economic**, **social** and **environmental** implications.

**Reference 3 - Attachment 3: Environmental Impact Assessment Guidelines Prideaux_Prideaux2015*

From pages 11 and 12 of the EIA guidelines the following points are worthy of note:

23. Many propagation models have been developed such as ray theory, normal modes, multipath expansion, fast field, wavenumber integration or parabolic equation. However, no single model accounts for all frequencies and environments. Factors that influence which propagation model/s should be used include the activity noise frequencies, water depth, seabed topography, temperature and salinity, and spatial variations in the environment.
(Urick, 1983, Etter, 2013; Prideaux, 2017a)

<u>The information provided below in **Sections 25 and 28** is especially relevant in consideration of impacts upon resident marine fauna, particularly Sygnathids, which include a number of endangered species.</u>

25. Commonly missing in EIAs is the modelling of particle motion propagation. Invertebrates, and some fish, detect sound through particle motion to identify predator and prey. Like sound intensity, particle motion varies significantly close to noise sources and in shallow water. Excessive levels of ensonification of these animal groups may lead to injury (barotrauma). Specific modelling techniques are required to predict the impact on these species.

28. Sound exposure levels works well for marine mammals but not well for a number of other marine species, including crustaceans, bivalves and cephalopods, because these species are thought to mainly detect sound through particle motion. Particle motion or particle displacement is the displacement of a material element caused by the action of sound. For these Guidelines the motion concerned is the organism resonating in sympathy with the surrounding sound waves, oscillating back and forth in a particular direction, rather than through the tympanic mechanism of marine mammals or swim-bladders of some fish species.
(Mooney, et.al., 2010; André, et.al., 2011; Hawkins and Popper, 2016; NOAA, 2016)

- <u>Inadequate Sound Propagation Modelling:</u>

As the water properties modelled in the original EIS are significantly different from those now involved in the amended plan, **further, more comprehensive modelling should be undertaken**.

It is not conceivable to make decisions based on the previously provided modelling which is no longer relevant.

To suggest otherwise is irresponsible in the extreme and in keeping with KIPT's previous performance with respect to MNES.

- <u>Questionable "Benefits" of Movement Offshore:</u>

The proponents have been at pains to explain the "benefits" of the movement further offshore by 250 metres.

They have described the benefits in detail without any consideration of the difficulties this creates for marine fauna and cetaceans in particular. This is particularly so for impacts which will *"disrupt the breeding cycle of a population"* as specified under MNES/EPBC documentation.

In their documentation KIPT state the following:

*"**The National Conservation Values Atlas** identifies the entire coastline of Kangaroo Island as a biologically important area that is used for seasonal calving by the southern right whale (DoEE 2015), and there are no records of breeding in this area. The presence of the port is unlikely to impact breeding at other sites, such as Encounter Bay and Fowlers Bay, as they are too far away to be affected."*

- No Understanding of the Conservation Management Plan:

There has been no understanding of the **Conservation Management Plan** as demonstrated, and the need to protect areas of possible recolonisation.

Nor is there any upgrading of their understanding related to data provided regarding **breeding observed in Smith Bay and adjacent areas**.

The Addendum is therefore extremely limited in scope and designed for a single purpose only ….. an attempt to appease Yumbah Aquaculture.

There is a **Conservation Management Plan** for this species due to their endangered status under the provisions of the EPBC Act. This plan covers the period from 2011 to 2021.

**Reference 4: Conservation Management Plan for the Southern Right Whale - A Recovery Plan under the Environment Protection and Biodiversity Conservation Act 1999 2011–2021*

The movement further out to sea compounds the situations described in our previous submission in response to the EIS.

As they describe in their addendum documentation, in **Sections 4.6 and 4.8**, sound propagated by piling is now at a magnitude 1.6 times that previously considered as part of their mitigation strategies. That effectively moves the **potential for TTS impacts** from 6.5 metres to 10kms, or possibly greater, under new modelling.

This means the sound impacts will be affecting sensitive receptors in the middle of **Investigator Strait**. It is worth noting this is an extremely busy shipway and the potential for vessel strike situations is therefore heightened.

The following tract from Sharon Livermore of IFAW explains some of the difficulties:

Ship strikes and whales: Preventing a collision course

4 November 2019

*"Today, many species of whale around the world are threatened by collisions with vessels, known as ship strikes, and unfortunately, these collisions often result in severe injury or death. **Both ship numbers and the speeds at which ships are able to travel have increased globally in the last few decades and this means a***

greater risk of ship strikes and injuries to whales, particularly where shipping activities overlap with critical whale habitat.

For those whales that are not killed immediately, a collision can result in horrific and serious injuries; blunt trauma resulting in major internal injury, deep propeller scars, and severed spines, tail flukes and fins, are just some of the injuries recorded in live and stranded animals that have been victims of collisions. ***A whale that has sustained a serious injury from a ship strike will often suffer a slow, painful death.***

Certain whale populations are more vulnerable to ship strikes, particularly those found close to developed coastal areas or those found in high numbers in areas with large volumes of shipping traffic. ***Consequently, ship strikes are recognized as a serious conservation and welfare problem for many whale populations throughout the global ocean.***

Worryingly, the risk of ship strike is largely unrecognised and reports of ship strikes likely under represent actual incidents. Many mariners do not know about reporting requirements for ship strikes and in many cases collisions go unnoticed; even an animal as large as a whale pales into insignificance against a 300-metre cargo vessel.

IFAW is working hard to help reduce ship strikes in several regions, with a specific focus on areas where ship strikes are known to negatively impact endangered whale populations. The solutions that exist to prevent ship strike vary depending on many factors, including whale distribution, behaviour, habitat use, and ship routing options and limitations. ***Separating shipping lanes and whale habitat*** *is the most effective option, but where this is not possible,* ***slowing vessel speeds*** *can also help protect whales from strikes. Ensuring* ***mariners are aware*** *of ship strike risk is also key to reducing the problem.*

For example, our work in the Hellenic Trench, Greece, focuses on a small change in shipping routes, which is required to dramatically reduce risk to endangered Mediterranean sperm whales. This is also the case for blue whales off southern Sri Lanka. However in New Zealand, Bryde's whale distribution across the Hauraki Gulf means that vessel speed limits offer the most straightforward solution to reduce risk. Slower speeds also reduce the levels of underwater noise from ships, resulting in further benefits for whales. In the USA, IFAW and partners pioneered the Whale Alert app to help protect the North Atlantic right whale from ship strikes. This technology offers a tool for mariners, advising them of measures to reduce collision risk and the presence of seasonal management zones, where the U.S. government has put ship speed reduction measures in place in the areas most important to these critically endangered whales.

Slowing down helps to save the lives of whales because, in a similar way to the injuries sustained by a pedestrian hit by a vehicle on our roads, the speed at which a ship is travelling has a strong bearing on the likelihood of a fatal injury occurring to a whale. On roads, we use 'school zones' to control speed and reduce the risk of fatal injuries to children. In our oceans, the concept of 'whale zones,' or areas where ships need to slow down, could also be used in the areas of highest risk where separating whales and shipping is not an option.

These practical solutions that exist to reduce the risk of ship strikes to whales are already being used elsewhere around the world. All that is required is the political will to make the changes needed on the water. Critically, a lack of action puts both individual whales and their populations in danger, which is why at IFAW, we are working on practical, science-based solutions to protect whales from ship strikes in the places they call home."

Sharon Livermore: Program Officer, Marine Conservation November 4th 2019

**Reference 5: IFAW - Sharon Livermore Article*

Under **MNES provisions** there are a greater number of species likely to be impacted upon by the construction / piling noise, including:

- **Sperm whales** - *Physeter macrocephalus*
- **Blue whales** - *Balaenoptera musculus*
- **Humpback whales** - *Megaptera novaeangliae*
- **Beaked whales** - *Ziphiidae* etc

Some of these species are endangered, some vulnerable, others threatened and **ALL** migratory.

All are known to frequent Investigator Strait.

Also by pushing further out into deeper water the chances of impacting upon **Shortbeaked Common dolphins** *Delphinus delphis* are exacerbated.

The proponents imply that the **longer piling jetty will be less of a barrier to movement** than the solid causeway.

This supposition is **not** borne out by Science. It is purely convenient conjecture.

The paper by Heithaus et al referenced in our previous submission clearly indicates the impacts on inshore cetacean species of having to travel further offshore.

**Reference 6: "Spatial variations of shark-inflicted injuries to insular Indo-Pacific bottlenose dolphins (Tursiops aduncus) of the SW Indian Ocean."*

Heithaus et al   Marine Mammal Science 33(1) January 2017

https://www.researchgate.net/publication/304778135_Spatial_variations_of_shark-inflicted_injuries_to_insular_IndoPacific_bottlenose_dolphins_Tursiops_aduncus_of_the_SW_Indian_Ocean

Given KIPT's demonstrated disregard for environmental concerns, public perceptions and lack of trust, it would be best if MMO's, upon which so much of the mitigation strategies rely, were **independent**, albeit at KIPT's expense.

In light of the potential impacts upon deep diving species it should be required that the MMO's observations be supplemented with **Passive Acoustic Monitoring** techniques, preferably boat based and mobile, rather than fixed.

This is a base level for ensuring proper safety for marine fauna and for mitigating possible impacts upon threatened, vulnerable and migratory species.

KIPT themselves have signaled the possibility of **usage of acoustic monitoring in Section 4.8**

Noise and Light:

"Using marine mammal observers to monitor this zone with an additional perhaps complemented by acoustic equipment to detect mammals; pile driving would stop if a marine mammal was sighted in the zone."

This rather strangely worded statement seems to indicate they would only stop if a mammal was seen, not necessarily if it was heard.

Very strange indeed?????

**Reference 7: KIPT Addendum Page 22*

- Dolphin "Breeding Season" ?

In the State Government agencies response to the EIS in Section 36 concern was raised about **dolphins as well as whales during breeding season**.

While whales do have a discrete breeding season, this is not the case for Bottlenose dolphins - resident on the North Coast of Kangaroo Island.

Newborn calves have been observed in all months of the year. As the dolphins travel through Smith Bay on an almost daily basis this will mean enormous disruptions to construction through "shut down" mitigative practices.

This makes the situation almost untenable in terms of the timelines promoted in the Addendum document.

It is easy to consider the **potential impacts of this proposal**, particularly in light of the changes outlined in the Addendum, in isolation, rather than considering their impacts in light of likely cumulative impacts - a more important metric.

One relevant paper attached which deals with **matters of cetacean welfare** talks about cumulative impacts, including sound, and how it cannot simply be viewed in isolation.

This approach is worthy of consideration in the assessment/approval process.

**Reference 8 - Attachment 4*: Marine Mammals and Multiple Stressors: Implications for Conservation and Policy Mark P. Simmonds1,2 1Humane Society International, London, United Kingdom; 2University of Bristol, School of Veterinary Sciences, Bristol, United Kingdom*

Following are some tracts particularly relevant to sound impacts:

"Simmonds and Brakes (2011) compared a review of threats to cetaceans made in 1996, with their understanding in 2011, and suggested the following key developments: (There had been a general acceptance of noise pollution as a substantive threat and some movement to address this.)

It is also now much more clearly recognized that intense sounds from human activities—such as seismic air guns—can have direct physiologic effects on marine mammals and that naval sonar triggers behavioral reactions that can lead to death by stranding (NAS, 2016).

Factors impacting marine mammals populations can be lethal (e.g., a ship strike or a launched harpoon) or sublethal, and when describing "stressors" here, it is a sublethal impact that is being primarily considered. For example, while loud noise can be lethal, the most common effect of noise on marine mammals is behavioral disturbance. From a population perspective, rather subtle behavioral changes affecting very large numbers of marine mammals may have greater consequences than occasional lethal events affecting a few (NAS, 2016).

A good example is exposure to a loud noise, and multiple, frequent exposures might be more significant than rare exposures over a longer time. "Cumulative effect" has been defined as the combined effect of exposures to multiple stressors integrated over a defined relevant period: a day, a season, year, or lifetime (NAS, 2016)."

The following passage, again from **Simmonds 2017** explores and defines this approach:

"Claudio Campagna, in an inspiring keynote address at the 2015 Conference of the Society for Marine Mammalogy, challenged his audience with a bleak but well-informed view of modern conservation (Campagna, 2015). He opined that the continuing crisis of imminent extinctions is being driven by a paradigm that he summarized as

"provide me with a good economic reason or I do nothing… or I will make small adjustments of no consequence". He argued that the current approach to species conservation is flawed as it is based on the notion that science informs policy and policy informs conservation and sustainable economic growth. However, in practice, he argued new information is used to intervene only when it is no more costly than doing nothing! Valuing nature only in economic terms avoids recognizing the disastrous consequences of what Campagna called "the species crisis."   "

**Reference 9 - Attachment 4*: Marine Mammals and Multiple Stressors: Implications for Conservation and Policy Mark P. Simmonds1,2 1Humane Society International, London, United Kingdom; 2University of Bristol, School of Veterinary Sciences, Bristol, United Kingdom*

The fundamental questions therefore become:

What price true marine fauna safety? What price extinction?

- Biologically Important Area For Southern Right Whales

In relation to the mitigations described in the EIS and the Addendum, in can be argued that mitigative practises, for example *"soft start"* and *"ramping up"* procedures, while presumably protecting whales from **Temporary Threshold Shift** and **Permanent Threshold Shift** can actively impact in deleterious ways by driving them out of critical habitat.

Smith Bay is emerging as a Biologically Important Area for Southern right whales.

If true mitigations come down to temporal and spatial, it could well be argued that in light of the flexibility of timings of migrations, especially in light of climate change impacts and the like, it would be not too extreme to suggest that some **important areas should be out of bounds for development activities as described in the EIS and Addendum**.

As temporal mitigation is problematic, spatial mitigation is the only reasonable solution and this is easily employed by moving the proposed development away from sensitive receptors.

Please do not hesitate to contact me for further information or clarification.

Thank you for your consideration of this submission with respect to the Addendum to the EIS prepared for KIPT with regard to the Smith Bay Wharf proposal.

Yours sincerely,

Tony Bartram

Tony Bartram

Kangaroo Island / Victor Harbor Dolphin Watch Coordinator

Please find attached the following documents:

**Reference 1 - Attachment 1*: EIA Guidelines*

**Reference 2 - Attachment 2*: CMS Guidelines: EIA Marine Noise Technical Support Information*

**Reference 3 - Attachment 3*: Environmental Impact Assessment Guidelines Prideaux_Prideaux2015*

**Reference 8 & 9 - Attachment 4*: Marine Mammals and Multiple Stressors: Implications for Conservation and Policy Mark P. Simmonds1,2 1Humane Society International, London, United Kingdom; 2University of Bristol, School of Veterinary Sciences, Bristol, United Kingdom*

CONVENTION ON MIGRATORY SPECIES

Distribution: General
UNEP/CMS/Resolution 12.14
Original: English

ADVERSE IMPACTS OF ANTHROPOGENIC NOISE ON CETACEANS AND OTHER MIGRATORY SPECIES

Adopted by the Conference of the Parties at its 12th Meeting (Manila, October 2017)

Recalling that in Resolution 9.19 and Resolution 10.24[1] the CMS Parties expressed concern about possible "adverse anthropogenic marine/ocean noise impacts on cetaceans and other biota",

Recognizing that anthropogenic marine noise, depending on source and intensity, is a form of pollution, composed of energy, that may degrade habitat and have adverse effects on marine life ranging from disturbance of communication or group cohesion to injury and mortality,

Aware that, over the last century, anthropogenic noise levels in the world's oceans have significantly increased as a result of multiple human activities,

Recalling the obligations of Parties to the United Nations Convention on the Law of the Sea (UNCLOS) to protect and preserve the marine environment and to cooperate on a global and regional basis concerning marine mammals, paying special attention to highly migratory species, including cetaceans listed in Annex I of UNCLOS,

Recalling that the United Nations General Assembly Resolution A/RES/71/257 on *Oceans and the Law of the Sea* adopted in 2016 "[n]otes with concern that human-related threats, such as marine debris, ship strikes, underwater noise, persistent contaminants, coastal development activities, oil spills and discarded fishing gear, together may severely impact marine life, including its higher trophic levels, and calls upon States and competent international organizations to cooperate and coordinate their research efforts in this regard so as to reduce these impacts and preserve the integrity of the whole marine ecosystem while fully respecting the mandates of relevant international organizations",

Recalling CMS Resolution 10.15 on *Global Programme of Work for Cetaceans*, which urges Parties and non-Parties to promote the integration of cetacean conservation into all relevant sectors by coordinating their national positions among various conventions, agreements and other international fora and instructs the Aquatic Mammals Working Group of the Scientific Council to develop advisory positions for use in Environmental Impact Assessments at the regional level and to provide support to governments and regional bodies for assessing and defining appropriate standards for noise pollution,

[1] Both now consolidated as Resolution 12.14

Recalling that other international fora recognize anthropogenic marine noise as a potential threat to marine species conservation and welfare, and have adopted related decisions and resolutions or issued guidance, including:

a) the Convention on Biological Diversity (CBD) through Decision X.29 concerning marine and coastal biodiversity and in particular its paragraph 12 relating to anthropogenic underwater noise and Decision XIII.10 addressing impacts of anthropogenic underwater noise on marine and coastal biodiversity and in particular paragraphs 1-2 relating to anthropogenic underwater noise,

b) the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) through Resolution 2.16 on *Impact Assessment of Man-Made Noise*, Resolution 3.10 on *Guidelines to Address the Impact of Anthropogenic Noise on Marine Mammals in the ACCOBAMS Area*, Resolution 4.17 on *Guidelines to address the impact of anthropogenic noise on cetaceans in the ACCOBAMS area*, Resolution 5.15 on *Addressing the Impact of Anthropogenic Noise* and Resolution 6.17 on *Anthropogenic Noise*,

c) the Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) through Resolution 5.4 on *Adverse Effects of Sound, Vessels and other Forms of Disturbance on Small Cetaceans*, Resolution 6.2 on *Adverse Effects of Underwater Noise on Marine Mammals during Offshore Construction Activities for Renewable Energy Production* and Resolution 8.11 on *CMS Family Guidelines on Environmental Impact Assessments for Marine Noise-generating Activities*,

d) the International Maritime Organization (IMO), which in 2008 established in its Marine Environmental Protection Committee a high priority programme of work on minimizing the introduction of incidental noise from commercial shipping operations into the marine environment, and which in 2014 issued MEPC.1/Circ.833 *Guidelines for the Reduction of Underwater Noise from Commercial Shipping to Address Adverse Impacts on Marine Life*,

e) the Convention for the Protection of the Marine Environment of the North-East-Atlantic (OSPAR) Guidance on environmental considerations for offshore wind farm development,

f) the International Union for Conservation of Nature (IUCN) Resolution 3.068 concerning undersea noise pollution (World Conservation Congress at its 3rd Session in Bangkok, Thailand, 17–25 November 2004),

g) following International Whaling Commission (IWC) Resolution 1998-6, the IWC Scientific Committee has investigated the impacts of military sonar, seismic surveys, masking and shipping noise; it has concluded that, in addition to some instances of severe acute effects (e.g. from military sonar and similar noise sources), existing levels of ocean noise can have a chronic effect, and agreed that action should be taken to reduce noise in parallel with efforts to quantify these effects; and the IWC has identified the importance of continued and increased collaboration on this issue with other organizations including ACCOBAMS, ASCOBANS, IMO and IUCN,

Recalling that according to Article 236 of UNCLOS, that Convention's provisions regarding the protection and preservation of the marine environment do not apply to warships, naval auxiliary and other vessels or aircraft owned or operated by a State and used, for the time being, only on governmental non-commercial service; and that each State is required to ensure, by the adoption of appropriate measures not impairing operations or operational capabilities of such vessels or aircraft owned or operated by it, that such vessels or aircraft act in a manner consistent, so far as is reasonable and practicable, with UNCLOS,

Noting that the Convention on Biological Diversity (CBD) decision VI/20 recognized CMS as the lead partner in the conservation and sustainable use of migratory species over their entire range,

Acknowledging the ongoing activities in other fora to reduce underwater noise such as the activities within NATO to avoid negative effects of sonar use,

Noting Directive 2014/52/EU of the European Parliament and of the Council, amending Directive 2011/92/EU on the *Assessment of the Effects of Certain Public and Private Projects on the Environment*,

Noting the EU Marine Strategy Framework Directive and its implementing act, where Member States in European Union marine waters shall take necessary measures by 2020 to achieve or maintain their determined good environmental status, including on underwater noise, established by each of them and in coordination at Union, regional and sub-regional levels,

Grateful for the invitation of ACCOBAMS and ASCOBANS, accepted in 2014, that CMS participate in the Joint Noise Working Group, which provides detailed and precautionary advice to Parties, particularly on available mitigation measures, alternative technologies and standards required for achieving the conservation goals of the treaties,

Aware that some types of marine noise can travel faster than other forms of pollution over more than hundreds of kilometres underwater unrestricted by national boundaries and that these are ongoing and increasing,

Taking into account the lack of data on the distribution and migration of some populations of marine species and on the adverse human-induced impacts on CMS-listed marine species and their prey,

Aware that incidents of stranding and deaths of some cetacean species have coincided with and may be due to the use of high-intensity mid-frequency active sonar,

Reaffirming that the difficulty of proving possible negative impacts of acoustic disturbance on CMS-listed marine species and their prey necessitates a precautionary approach in cases where such an impact is likely,

Noting the draft research strategy developed by the European Science Foundation on "*the effects of anthropogenic sound on marine mammals",* which is based on a risk assessment framework,

Noting the OSPAR *Code of Conduct for Responsible Marine Research in the Deep Seas and High Seas of the OSPAR Marine Area* and the ISOM *Code of Conduct for Marine Scientific Research Vessels*, providing that marine scientific research is carried out in an environmentally friendly way using appropriate study methods reasonably available,

Aware of the calls on the IUCN constituency to recognize that, when there is reason to expect that harmful effects on biota may be caused by anthropogenic marine noise, lack of full scientific certainty should not be used as a reason for postponing measures to prevent or minimize such effects,

Recognizing with concern that cetaceans and other marine mammals, reptiles and fish species, and their prey, are vulnerable to noise disturbance and subject to a range of human impacts,

The Conference of the Parties to the
Convention on the Conservation of Migratory Species of Wild Animals

1. *Reaffirms* that there is a need for ongoing and further internationally coordinated research on the impact of underwater noise (including inter alia from offshore wind farms and associated shipping) on CMS-listed marine species and their prey, their migration routes and ecological coherence, in order to give adequate protection to cetaceans and other marine migratory species;

2. *Confirms* the need for international, national and regional limitation of harmful anthropogenic marine noise through management (including, where necessary, regulation), and that this Resolution remains a key instrument in this regard;

3. *Urges* Parties and invites non-Parties that exercise jurisdiction over any part of the range of marine species listed on the appendices of CMS, or over flag vessels that are engaged within or beyond national jurisdictional limits, to take special care and, where appropriate and practical, to endeavour to control the impact of anthropogenic marine noise pollution in habitats of vulnerable species and in areas where marine species that are vulnerable to the impact of anthropogenic marine noise may be concentrated, to undertake relevant environmental assessments on the introduction of activities that may lead to noise-associated risks for CMS-listed marine species and their prey;

4. *Strongly urges* Parties to prevent adverse effects on CMS-listed marine species and their prey by restricting the emission of underwater noise; and where noise cannot be avoided, *further urges* Parties to develop an appropriate regulatory framework or implement relevant measures to ensure a reduction or mitigation of anthropogenic marine noise;

5. *Calls* on Parties and *invites* non-Parties to adopt whenever possible mitigation measures on the use of high intensity active naval sonars until a transparent assessment of their environmental impact on marine mammals, fish and other marine life has been completed and as far as possible aim to prevent impacts from the use of such sonars, especially in areas known or suspected to be important habitat to species particularly sensitive to active sonars (e.g. beaked whales) and in particular where risks to marine species cannot be excluded, taking account of existing national measures and related research in this field;

6. *Urges* Parties to ensure that Environmental Impact Assessments take 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;

7. *Endorses* the “CMS Family Guidelines on Environmental Impact Assessments for Marine Noise-generating Activities” attached as Annex and *welcomes* the Technical Support Information contained in UNEP/CMS/COP12/Inf.11[2];

8. *Invites* Parties to ACCOBAMS and ASCOBANS to consider adopting these Guidelines, in the elaboration of which they were fully involved, at their next Meetings of the Parties;

9. *Further invites* Signatories to relevant Memoranda of Understanding concluded under CMS to consider using these Guidelines as guiding documents;

10. *Recognizes* that the work done in relation to marine noise is rapidly evolving, and *requests* the Scientific Council, in collaboration with the Joint Noise Working Group of CMS, ACCOBAMS and ASCOBANS, to review and update these Guidelines regularly;

[2] also provided online at http://www.cms.int/guidelines/cms-family-guidelines-EIAs-marine-noise

11. *Urges* Parties and *encourages* non-Parties to disseminate these Guidelines, where necessary translating the Guidelines into different languages for their wider dissemination and use;

12. *Invites* the private sector and other stakeholders to make full use of these Guidelines in order to assess, mitigate and minimize negative effects of anthropogenic marine noise on marine biota;

13. *Welcomes* the efforts of the private sector and other stakeholders to reduce their environmental impact and *strongly encourages* them to continue making this a priority;

14. *Recommends* that Parties, the private sector and other stakeholders apply Best Available Techniques (BAT) and Best Environmental Practice (BEP) including, where appropriate, clean technology, in their efforts to reduce or mitigate marine noise pollution;

15. *Further recommends* that Parties, the private sector and other stakeholders use, as appropriate, noise reduction techniques for offshore activities such as: air-filled coffer dams, bubble curtains or hydro-sound dampers, or different foundation types (such as floating platforms, gravity foundations or pile drilling instead of pile driving);

16. *Stresses* the need of Parties to consult with any stakeholder conducting activities known to produce anthropogenic marine noise with the potential to cause adverse effects on CMS-listed marine species and their prey, such as the oil and gas industry, shoreline developers, offshore extractors, marine renewable energy companies, other industrial activities and oceanographic and geophysical researchers recommending, how best practice of avoidance, diminution or mitigation of risk should be implemented. This also applies to military authorities to the extent that this is possible without endangering national security interests. In any case of doubt the precautionary approach should be applied;

17. *Encourages* Parties to integrate the issue of anthropogenic noise into the management plans of marine protected areas (MPAs) where appropriate, in accordance with international law, including UNCLOS;

18. *Invites* the private sector to assist in developing mitigation measures and/or alternative techniques and technologies for coastal, offshore and maritime activities in order to minimize anthropogenic noise pollution of the marine environment to the highest extent possible;

19. *Encourages* Parties to facilitate:

- regular collaborative and coordinated temporal and geographic monitoring and assessment of local ambient noise (both of anthropogenic and biological origin);
- further understanding of the potential for sources of noise to interfere with long-range movements and migration;
- the compilation of a reference signature database, to be made publicly available, to assist in identifying the source of potentially damaging sounds;
- characterization of sources of anthropogenic noise and sound propagation to enable an assessment of the potential acoustic risk for individual species in consideration of their auditory sensitivities;
- studies on the extent and potential impact on the marine environment of high- intensity active naval sonars and seismic surveys in the marine environment; and the extent of noise inputs into the marine environment from shipping and to provide an assessment, on the basis of information to be provided by the Parties, of the impact of current practices; and
- studies reviewing the potential benefits of “noise protection areas”, where the emission of underwater noise can be controlled and minimized for the protection of cetaceans and other biota;

whilst recognizing that some information on the extent of the use of military sonars (e.g. frequencies used) will be classified and would not be available for use in the proposed studies or databases;

20. *Recommends* that Parties that have not yet done so establish national noise registries to collect and display data on noise-generating activities in the marine area to help assess exposure levels and the likely impacts on the marine environment, and that data standards are made compatible with regional noise registries, such as the ones developed by the International Council for the Exploration of the Sea (ICES) and ACCOBAMS;

21. *Urges* all Parties to endeavour to develop provisions for the effective management of anthropogenic marine noise in CMS daughter agreements and other relevant bodies and Conventions;

22. *Invites* the Parties to strive, wherever possible, to ensure that their activities falling within the scope of this Resolution avoid harm to CMS-listed marine species and their prey;

23. *Requests* the Scientific Council, supported by the Joint Noise Working Group of CMS, ACCOBAMS and ASCOBANS, to continue monitoring new available information on the effects of underwater noise on marine species, as well as the effective assessment and management of this threat, and to make recommendations to Parties as appropriate;

24. *Requests* the Secretariat and *calls upon* Parties to contribute to the work of the IMO MEPC on noise from commercial shipping;

25. *Invites* Parties to provide the CMS Secretariat, for transmission to the Scientific Council, with copies of relevant protocols/guidelines and provisions for the effective management of anthropogenic noise, taking security needs into account, such as those of relevant CMS daughter agreements, OSPAR, IWC, IMO, NATO and other fora, thereby avoiding duplication of work; and

26. *Repeals*

a) Resolution 9.19, *Adverse Anthropogenic Marine/Ocean Noise Impacts on Cetaceans and Other Biota*; and

b) Resolution 10.24, *Further Steps to Abate Underwater Noise Pollution for the Protection of Cetaceans and Other Migratory Species*.

Annex to Resolution 12.14

CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities

These **CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities** have been developed to present the Best Available Techniques (BAT) and Best Environmental Practice (BEP), as called for in CMS Resolutions 9.19, 10.24 and 10.15, ACCOBAMS Resolution 5.15 and ASCOBANS Resolutions 6.2 and 8.11. In addition to the parent convention, CMS, these guidelines are relevant to:

- Agreement on the Conservation of Cetaceans of the Black Seas Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS)
- Agreement on the Conservation of Seals in the Wadden Sea (Wadden Sea Seals)
- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)
- MOU Concerning Conservation Measures for the Eastern Atlantic Populations of the Mediterranean Monk Seal (*Monachus monachus*) (Atlantic Monk Seals)
- MOU Concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa (Atlantic Marine Turtles)
- MOU Concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia (Western African Aquatic Mammals)
- MOU for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (Pacific Islands Cetaceans)
- MOU on the Conservation and Management of Dugongs (*Dugong dugon*) and their Habitats throughout their Range (Dugong)
- MOU on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (IOSEA)
- MOU on the Conservation of Migratory Sharks (Sharks)

Contents

I. Introduction

1. These **CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities** are designed to provide regulators with tailored advice to apply in domestic jurisdictions, as appropriate, to create EIA standards between jurisdictions seeking to manage marine noise-generating activities. The requirements within each of the modules are designed to ensure that the information being provided by proponents will provide decision-makers with sufficient information to make an informed decision about impacts. The modules should be read in tandem with the **Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessments for Marine Noise-generating Activities** (available at www.cms.int/guidelines/cms-family-guidelines-EIAs-marine-noise). They are structured to stand as one complete unit or to be used as discrete modules, tailored for national and agreement approaches.

2. The sea is the interconnected system of all the Earth's oceanic waters, including the five named ‘oceans’ - the Atlantic, Pacific, Indian, Southern and Arctic Oceans - a continuous body of salty water that covers over 70 per cent of the Earth's surface. This vast aquatic environment is home to a wider range of higher animal taxa than exists on land. Many marine species have yet to be discovered and the number known to science is expanding annually.

3. The sea also provides people with food—mainly fish, shellfish and seaweed—as well as other marine resources. It is a shared resource for us all.

4. Marine wildlife relies on sound for vital life functions, including communication, prey and predator detection, orientation and for sensing surroundings. The ocean environment is filled with natural sound (ambient noise) from biological (marine animals) and physical processes (earthquakes, wind, ice and rain) (Urick, 1983). Species living in this environment are adapted to these sounds.

5. Over the past century many anthropogenic marine activities have increased levels of noise (Hildebrand 2009; André et.al. 2010; Miksis-Olds and Nichols 2016) These modern anthropogenic noises have the potential for physical, physiological and behavioural impacts (Southall et.al. 2007).

6. Parties to CMS, ACCOBAMS and ASCOBANS have in several resolutions recognized underwater noise as a major threat to many marine species. These resolutions also call for noise-related considerations to be taken into account as early as the planning stages of activities, especially by making effective use of Environmental Impact Assessments (EIAs). The Convention on Biological Diversity Decision XII/23 also encourages governments to require EIAs for noise-generating offshore activities, and to combine acoustic mapping with habitat mapping to identify areas where these species may be exposed to noise impacts. (Prideaux, 2017b)

7. Wildlife exposed to elevated or prolonged anthropogenic noise can suffer direct injury and/or temporary or permanent auditory threshold shifts. Noise can mask important natural sounds, such as the call of a mate, or the sound made by prey or predator. Anthropogenic noise can also displace wildlife from important habitats. These impacts are experienced by a wide range of species including fish, crustaceans, cephalopods, pinnipeds (seals, sea lions and walrus), sirenians (dugong and manatee), sea turtles, the polar bear, marine otters and cetaceans (whales, dolphins and porpoises) (Southall et.al. 2007; Aguilar de Soto, 2017a; 2017b; Castellote, 2017a; 2017b; Frey, 2017; Hooker, 2017; McCauley, 2017; Marsh, 2017; Notarbartolo di Sciara, 2017a; 2017b; 2017c; Parks, 2017; Truda Palazzo, 2017; Vongraven, 2017). Where there is risk, full assessment of impact should be conducted.

8. The propagation of sound in water is complex and requires many variables to be carefully considered before it can be known if a noise-generating activity is appropriate or not. It is inappropriate to generalize sound transmission without fully investigating propagation (Prideaux, 2017a). Often, statements are made in Environmental Impact Assessments that a noise-generating activity is 'X' distance from 'Y' species or habitat and therefore, will have no impact. In these cases, distance is used as a basic proxy for impact but is rarely backed with scientifically modelled information. (Wright et.al. 2013; Prideaux and Prideaux 2015)

9. To present a defensible Environmental Impact Assessment for any noise-generating activity proposal, proponents need to have expertly modelled the noise of the proposed activity in the region and under the conditions they plan to operate. Regulators should have an understanding of the ambient or natural sound in the proposed area. This might require CMS Parties or jurisdictions to develop a metric or method for defining this, by drawing on the range of resources available worldwide. (Prideaux, 2017a)

10. All EIAs should include operational procedures to mitigate impact effectively during activities, and there should be proof of the mitigation's efficacy. These are the operational mitigation procedures that should be detailed in the national or regional regulations of the jurisdictions where the activity is proposed. Operational monitoring and mitigation procedures differ around the world, and may include industry/company best practices. Monitoring often includes, *inter alia*:

a. periods of visual and other observation before a noise-generating activity commences
b. passive acoustic monitoring
c. marine mammal observers
d. aerial surveys

Primary mitigation often includes, *inter alia*:

e. delay to start, soft start and shut-down procedures
f. sound dampers, including bubble curtains and cofferdams; sheathing and jacket tubes
g. alternative low-noise or noise-free options (such as compiled in the OSPAR inventory of measures to mitigate the emission and environmental impact of underwater noise)

Secondary mitigation, where the aim is to prevent encounters of marine life with noise sources, includes *inter alia*:

h. spatial & temporal exclusion of activities

11. Approaches to mitigate the impact of particle motion (e.g. reducing substrate or sea ice vibration) should also be investigated. Assessment of the appropriateness and efficacy of all operational procedures should be the responsibility of the government agency assessing Environmental Impact Assessments (EIA).

II. Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities

12. **Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessments for Marine Noise-generating Activities** is provided as a full document and as stand-alone modules at: www.cms.int/guidelines/cms-family-guidelines-EIAs-marine-noise.

13. This **Technical Support Information** has been specifically designed to provide clarity and certainty for regulators, when deciding to approve or restrict proposed activities. The document provides detailed information about species' vulnerabilities, habitat considerations, impact of exposure levels and proposed assessment criteria for all of the CMS-listed species groups and their prey.

14. The document is structured to cover specific areas, as follows:

- ‘Module A: Sound in Water is Complex’ provides an insight into the characteristics of sound propagation and dispersal. This module is designed to provide decision-makers with necessary foundation knowledge to interpret the other modules in these guidelines and any impact assessments that are presented to them for consideration.
- ‘Module B: Expert Advice on Specific Species Groups’ presents twelve separate detailed sub-modules covering each of the CMS species groups, focusing on species' vulnerabilities, habitat considerations, impact of exposure levels and assessment criteria.
- ‘Module C: Decompression Stress’ provides important information on bubble formation in marine mammals, source of decompression stress, source frequency, level and duration, and assessment criteria.
- ‘Module D: Exposure Levels’ presents a summary of the current state of knowledge about general exposure levels.
- ‘Module E: Marine Noise-generating Activities’ provides a brief summary of military sonar, seismic surveys, civil high-powered sonar, coastal and offshore construction works, offshore platforms, playback and sound exposure experiments, shipping and vessel traffic, pingers and other noise-generating activities. Each section presents current knowledge about sound intensity level, frequency range and the activities’ general characteristics. The information is summarized in a table within the module.
- ‘Module F: Related Intergovernmental or Regional Economic Organization Decisions’ presents the series of intergovernmental decisions that have determined the direction for regulation of anthropogenic marine noise.
- ‘Module G: Principles of EIAs’ establishes basic principles including strategic environmental assessments, transparency, natural justice, independent peer review, consultation and burden of proof.
- ‘Module H: CMS-Listed Species Potentially Impacted by Anthropogenic Marine Noise’

15. The evidence presented in the **Technical Support Information** Modules B, C and D establishes that the effective use of EIA for all marine noise-generating activities is in line with CMS Resolutions 9.19, 10.24 and 10.15, ACCOBAMS Resolution 5.15 and ASCOBANS Resolutions 6.2 and 8.11.

16. The **Technical Support Information** was developed before the release of ISO 18405: Underwater acoustics – Terminology that provides valuable consistency to language used. The Guidelines have been slightly adapted to reflect this new ISO standard, without losing the vital connection to the **Technical Support Information**. Decision-makers should refer to both documents wherever possible.

III. Technical Advisory Notes

17. The following advisory notes should be considered in conjunction with the individual EIA Guideline tables, as presented in Modules IV through XI.

III.1. Ambient Sound

18. ISO 18405 refers to ambient sound as “*sound that would be present in the absence of a specified activity*” and “*is location-specific and time-specific*”. These Guidelines more specifically define it as the average ambient (non-anthropogenic) sound levels from biological (marine animals) and physical processes (earthquakes, wind, ice and rain etc) of a given area. It should be measured (including daily and seasonal variations of frequency bands), for each component of an activity, prior to an EIA being developed and presented.

III.2 Sound Intensity

19. ISO 18405 defines sound intensity as "the product of the sound pressure", which is the contribution to total pressure caused by the action of sound, "and sound particle velocity", which is the contribution to velocity of a material element caused by the action of sound.

III.3. Exclusion Zones

20. Where exclusion zones are referred to in these Guidelines, these are areas that are designed for the protection of specific species and/or populations. Activities, and noise generated by activities, should not propagate into these areas.

III.4. Independent, Scientific Modelling of Noise Propagation

21. The objective of noise modelling for EIAs is to predict how much noise a particular activity will generate and how it will disperse. The aim is to model the received sound levels at given distances from the noise source. The amount of sound lost at the receiver from the sound source is propagation loss.

22. The intention of EIAs is to assess the impact of proposed activities on marine species and the environment. EIAs should not only present the main output of interest to the activity proponent, but should fully disclose the full frequency bandwidth of a proposed anthropogenic noise source, the intensity/pressure/energy output within that full range, and the principal or mean/median operating frequency of the source(s). (Urick, 1983, Etter, 2013; Prideaux, 2017a)

23. Many propagation models have been developed such as ray theory, normal modes, multipath expansion, fast field, wavenumber integration or parabolic equation. However, no single model accounts for all frequencies and environments. Factors that influence which propagation model/s should be used include the activity noise frequencies, water depth, seabed topography, temperature and salinity, and spatial variations in the environment. (Urick, 1983, Etter, 2013; Prideaux, 2017a)

24. The accuracy (i.e. bias) of sound propagation models depends heavily on the accuracy of their input data.

25. Commonly missing in EIAs is the modelling of particle motion propagation. Invertebrates, and some fish, detect sound through particle motion to identify predator and prey. Like sound intensity, particle motion varies significantly close to noise sources and in shallow water. Excessive levels of ensonification of these animal groups may lead to injury (barotrauma). Specific modelling techniques are required to predict the impact on these species.

III.5. Sound Exposure Level cumulative (SEL_{cum})

26. Sound Exposure Level (SEL) is generally referred to as dB 0 to peak or peak to peak (dB 0 to peak or dB p to p) for impulsive noise like air guns or pile driving, and dB Root Mean Squared (dB_{rms}) for non-impulsive noise such as ship noise, dredging or a wind farm's constant drone. Often this metric is normalized to a single sound exposure of one second (NOAA, 2016). The SEL cumulative (SEL_{cum}) metric allows the cumulative exposure of an animal to a sound field for an extended period (often 24 hours) to be assessed against a predefined threshold for injury. (Southall, 2007; NOAA, 2016)

27. NOAA recommends a baseline accumulation period of 24 hours, but acknowledges that there may be specific exposure situations where this accumulation period requires adjustment (e.g., if activity lasts less than 24 hours or for situations where receivers are predicted to experience unusually long exposure durations). (NOAA, 2016) The limit value for pile driving in Germany is a sound exposure level of SEL_{05} and the sound pressure level L_{peak} at a distance of 750 metres.

III.6. Particle Motion/Displacement

28. Sound exposure levels works well for marine mammals but not well for a number of other marine species, including crustaceans, bivalves and cephalopods, because these species are thought to mainly detect sound through particle motion. Particle motion or particle displacement is the displacement of a material element caused by the action of sound. For these Guidelines the motion concerned is the organism resonating in sympathy with the surrounding sound waves, oscillating back and forth in a particular direction, rather than through the tympanic mechanism of marine mammals or swim-bladders of some fish species. (Mooney, et.al., 2010; André, et.al., 2011; Hawkins and Popper, 2016; NOAA, 2016)

29. The detection of particle motion or particle displacement requires different types of sensors than those utilized by a conventional hydrophone. These sensors must specify the particle motion in terms of the particle displacement, or its time derivatives (particle velocity or particle acceleration).

IV. EIA Guideline for Military and Civil High-powered Sonar

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances.

The EIA Guideline for Shipping and Vessels Traffic (V) should be used when the vessel is underway/making way with sonar off.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the activity – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed activity, above natural ambient sound levels • Detail of the typical weather conditions and day length for the area during the proposed activity period • Identification of previous and simultaneous activities, their seasons and duration in the same or adjoining areas, existence and location of any marine protected areas, and a review of activity findings and implications

Component	Detail
Description of the equipment and activity	• Explanation of all activity technologies available and why each proposed technology is chosen • Description of the activity technology including: a. name and description of the vessel/s to be used (except where details would risk national security) b. total duration of the proposed activity c. proposed timing of operations – season/time of day/during all weather conditions d. signal duration and sound intensity level (dB peak to peak) in water @ 1 metre, frequency ranges and ping rate • Specification of the activity including anticipated nautical miles to be covered, track-lines, speed of vessels and sonar power setting changes • Identification of other activities having an impact in the region during and after the planned activity, if there is information, accompanied by the analysis and review of potential cumulative or synergistic impacts
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in the same season/weather conditions as the proposed activity accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed exclusion zones for species and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels; and calculated from this, the extent of the impact zones b. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts on prey species c. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summaries): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions. • Quantification of the effectiveness of proposed mitigation methods

Component	Detail
Mitigation and monitoring plans	• Detail of: a. Scientific monitoring programmes before the survey to assess species distribution and behaviour, to facilitate the incorporation of monitoring results into the impact assessment. b. Scientific monitoring programmes, conducted during and after the activity, to assess impact c. Transparent processes for regular real-time public reporting of activity progress and all impacts encountered d. Most appropriate methods of species detection (e.g. visual/acoustic) and the range of available methods, and their advantages and limitations, as well their practical application during the activity. e. Impact mitigation proposals: i. 24-hour visual or other means of detection, especially under conditions of poor visibility (including high winds, night conditions, sea spray or fog) ii. establishing exclusion zones to protect specific species, accompanied by scientific and precautionary justification for these zones iii. soft start and shut-down protocols iv. spatio-temporal restrictions
Reporting plans	• Detail of post operation reporting plans including verification of the effectiveness of mitigation
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

V. EIA Guideline for Shipping and Vessels Traffic

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances.

This EIA Guideline is directed to shipping regulators, including port and harbour authorities. Cumulative impact of shipping, identifying appropriate exclusion zones and shipping lanes should be the focus.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the activity – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed shipping, above natural ambient sound levels • Detail of the typical weather conditions and day length for the area during the proposed activity period • Existence and location of any marine protected areas
Description of vessels and equipment	• Description of vessel/s (tonnage, propulsion and displacement) and equipment activity • Detail of all activities including sound intensity levels (dB_{rms}) @ 1 metre and frequency ranges (all frequencies to encompass, *inter alia*, propeller resonance, harmonics, cavitations, engine and hull noise) • Identification of other activities having an impact in the region accompanied by the analysis and review of potential cumulative or synergistic impacts
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in confined areas (harbours and channels) and accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed species exclusion zones and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features

Component	Detail
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels. Calculated from this, the extent of the impact zones, and the number of animals affected by the activity. b. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts on prey species c. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summary): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions
Monitoring plans	• Explanation of access to the evaluation of ongoing scientific monitoring data to assess impacts • Quantification of the effectiveness of proposed mitigation methods • Spatio-temporal restrictions
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

VI. EIA Guideline for Seismic Surveys (Air Gun and Alternative Technologies)

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the survey – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed survey, above natural ambient sound levels • Detail of the typical weather conditions and day length for the area during the proposed activity period • Identification of previous and simultaneous activities, their seasons and duration in the same or adjoining areas, existence and location of any marine protected areas, and a review of activity findings and implications
Description of the equipment and activity	• Explanation of all survey technologies available (including low-noise or noise-free options) and why the proposed technology has been chosen. If low-noise options have not been chosen, an explanation should be provided about why these technologies are not preferred • Description of the survey technology including: a. name and description of the vessel/s to be used b. total duration of the proposed survey, date, timeframe c. proposed timing of operations – season/time of day/during all weather conditions d. sound intensity level (dB peak to peak) in water @ 1 metre and all frequency ranges and discharge rate e. if an air gun technology is proposed: i. number of arrays ii. number of air guns within each array iii. air gun charge pressure to be used iv. volume of each air gun in cubic inches v. official calibration figures supplied by the survey vessel to be charted, for noise modelling vi. depth the air guns to be set vii. number and length of streamers, distance set apart and depth the hydrophones are set • Specification of the survey including anticipated nautical miles to be covered, track-lines, speed of vessels, start-up and shut-down procedures, distance and procedures for vessel turns including any planned air gun power setting changes • Identification of other activities having an impact in the region during the planned survey, accompanied by the analysis and review of potential cumulative or synergistic impacts

Component	Detail
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in the same season/weather conditions as the proposed activity accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed species exclusion zones and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels. Calculated from this, the extent of the impact zones, and the number of animals affected by the activity. a. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts to prey species b. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summary): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions

Component	Detail
Mitigation and monitoring plans	• Detail of: a. Scientific monitoring before the survey to assess baselines, species distribution and behaviour to facilitate the incorporation of monitoring results into the impact assessment b. Scientific monitoring programmes, conducted during and after the survey, to assess impact, including noise monitoring stations placed at specified distances c. Transparent processes for regular real-time public reporting of survey progress and all impacts encountered d. Most appropriate methods of species detection (e.g. visual/acoustic) and the range of available methods, and their advantages and limitations, as well their practical application during the activity. e. Impact mitigation proposals: i. 24-hour visual or other means of detection, especially under conditions of poor visibility (including high winds, night conditions, sea spray or fog) ii. establishing exclusion zones to protect specific species, including scientific and precautionary justification for these zones iii. soft start and shut-down protocols iv. protocols in place for consistent and detailed data recording (observer/PAM sightings and effort logs, survey tracks and operations) v. detailed, clear, chain of command for implementing shut-down mitigation protocols vi. spatio-temporal restrictions • Quantification of the effectiveness of proposed mitigation methods
Reporting plans	• Detail of post operation reporting plans including verification of the effectiveness of mitigation, and any shut-down procedures occurring and reasons why
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed survey in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed survey in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

VII. EIA Guideline for Construction Works

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances. This guideline should be applied to all forms of marine construction, including dredging and similar vessel based activities where ships may be stationary, but under way. All commissioning and decommissioning activities should also follow these guidelines.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the activity – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed activity, above natural ambient sound levels • Detail of the typical weather conditions and day length for the area during the proposed activity period • Identification of previous and simultaneous activities, their seasons and duration in the same or adjoining areas, existence and location of any marine protected areas, and a review of activity findings and implications
Description of the equipment and activity	• Explanation of all activity technologies available and why each proposed technology is chosen, including consideration of noise-free installation methods • Specification of: a. total duration of the proposed activity b. proposed timing of operations – season/time of day/during all weather conditions c. sound intensity level (dB peak to peak) in water @ 1 metre and frequency ranges d. If explosives are proposed: i. what type of explosive and what charge weight is proposed, also whether the explosive is going to be used on the seabed or subsurface ii. specification of sound intensity level (dB 0 to peak) in water @ 1 metre, frequency range and number of detonations and interval time • Description of noise counter measures e.g.: bubble curtains, noise dampers and cofferdams, including a description of state-of-the-art technology, Best Environmental Practice (BEP) or Best Available Technology (BAT) • Identification of other activities having an impact in the region during the planned activity, accompanied by the analysis and review of potential cumulative or synergistic impacts
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in the same season/weather conditions as the proposed activity accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed exclusion zones for species and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features

Component	Detail
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels; and calculated from this, the extent of the impact zones b. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts to prey species c. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summary): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions
Mitigation and monitoring plans	• Detail of: a. Scientific monitoring programmes, conducted before, during and after the activity, to assess impact, including noise monitoring stations placed at specified distances b. Transparent processes for regular real-time public reporting of activity progress and all impacts encountered c. Most appropriate methods of species detection (e.g. visual/acoustic) and the range of available methods, and their advantages and limitations, as well their practical application during the activity. d. Impact mitigation proposals: i. 24-hour visual or other means of detection, especially under conditions of poor visibility (including high winds, night conditions, sea spray or fog) ii. establishing exclusion zones to protect specific species, including scientific and precautionary justification for these zones iii. soft start and shut-down protocols iv. spatio-temporal restrictions • Quantification of the effectiveness of proposed mitigation methods
Reporting plans	• Detail of post operation reporting plans including verification of the effectiveness of mitigation, and any shut-down procedures occurring and reasons why

Component	Detail
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why e. If it is decided that BEP or BAT is not used, this should be justified • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

VIII. EIA Guideline for Offshore Platforms

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances.

All commissioning and decommissioning activities should also follow these guidelines. Where impulsive activities, such as offshore platforms being constructed through impact driven piles, the guidelines for VII: Construction Works should also be applied.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the activity – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed activity, above natural ambient sound levels • Detail of the typical weather conditions and day length for the area during the proposed activity period • Identification of previous and simultaneous activities, their seasons and duration in the same or adjoining areas, existence and location of any marine protected areas, and a review of activity findings and implications

Component	Detail
Description of the equipment and activity	• Explanation of all activity technologies available and why each proposed technology is chosen, including consideration of alternatives • Description of the activity technology including name and description of the vessel/s and sea floor equipment to be used • Specification of: a. total duration of the proposed activity b. sound intensity level (dB_{rms}) in water @ 1 metre (from noise source e.g.: platform caissons or drill ship's hull etc.) and frequency ranges c. sound intensity levels (peak and rms) during planned maintenance schedules • Identification of other activities having an impact in the region during the planned activity, accompanied by the analysis and review of potential cumulative or synergistic impacts
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in the same season/weather conditions as the proposed activity accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed exclusion zones for species and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels; and calculated from this, the extent of the impact zones b. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts to prey species c. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summary): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration: iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions

Component	Detail
Mitigation and monitoring plans	• Detail of: a. Scientific monitoring programmes, conducted before, during and after the activity, to assess impact, including noise monitoring stations placed at specified distances b. Transparent processes for regular real-time public reporting of activity progress and all impacts encountered c. Most appropriate methods of species detection (e.g. visual/acoustic) and the range of available methods, and their advantages and limitations, as well their practical application during the activity. d. Impact mitigation proposals e. 24-hour visual or other means of detection, especially under conditions of poor visibility (including high winds, night conditions, sea spray or fog) f. Spatio-temporal restrictions • Quantification of the effectiveness of proposed mitigation methods
Reporting plans	• Detail of post operation reporting plans including verification of the effectiveness of mitigation
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

IX. EIA Guideline for Playback and Sound Exposure Experiments

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the activity – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed activity, above natural ambient sound levels • Detail of the typical weather conditions and day length for the area during the proposed activity period • Identification of previous and simultaneous activities, their seasons and duration in the same or adjoining areas, existence and location of any marine protected areas, and a review of activity findings and implications
Description of the equipment and activity	• Noting that the scale of the noise needed to elicit a response (with respect to level and duration) may be much lower than in industry activities; and that noise can be controlled in order to affect only a small area or small number of individuals, the noise control measures of the experimental design should be described in detail. • Explanation of all technologies available for the activity and why each proposed technology is chosen • Description of the chosen technology including name and description of the vessel/s to be used • Specification of: a. lowest practicable sound intensity level required b. total duration of the proposed activity c. proposed timing of operations – season/time of day/during all weather conditions d. sound intensity level (dB peak to peak) in water @ 1 metre and all frequency ranges and discharge rate e. if an air gun technology is proposed refer to VI f. if explosives are proposed refer to VII • Specification of the activity including anticipated nautical miles to be covered, track-lines, speed of vessels, start-up and shut-down procedures, distance and procedures for vessel turns including any planned air gun power setting changes • Identification of other activities having an impact in the region during the planned activity, accompanied by the analysis and review of potential cumulative or synergistic impacts
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in the same season/weather conditions as the proposed activity accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed exclusion zones for species and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features

Component	Detail
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels; and calculated from this, the extent of the impact zones b. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts to prey species c. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summary): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions iv. how the experiment design will monitor target and non-target species and the steps that will be taken to halt sound emission if adverse response or behavioural changes are observed v. how exposures that are expected to elicit particular behavioural responses (e.g. responses elicited by predator sounds, conspecific signals) will inform specific mitigation and monitoring protocols. In such cases, impact assessment should also articulate what responses may not be related to the loudness of the exposure but to the behavioural significance of the signal/noise used.

Component	Detail
Mitigation and monitoring plans	• Detail of: a. Scientific monitoring programmes, conducted before, during and after the activity, to assess impact b. Transparent processes for regular real-time public reporting of activity progress and all impacts encountered c. Most appropriate methods of species detection (e.g. visual/acoustic) and the range of available methods, and their advantages and limitations, as well their practical application during the activity. d. Impact mitigation proposals: i. 24-hour visual or other means of detection, especially under conditions of poor visibility (including high winds, night conditions, sea spray or fog) ii. establishing exclusion zones to protect specific species, including scientific and precautionary justification for these zones iii. soft start and shut-down protocols iv. spatio-temporal restrictions • Quantification of the effectiveness of proposed mitigation methods
Reporting plans	• Detail of post operation reporting plans including verification of the effectiveness of mitigation
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

X. EIA Guideline for Pingers (Acoustic Deterrent/Harassment Devices, Navigation)

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the activity – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed activity, above natural ambient sound levels. • Detail of the typical weather conditions and day length for the area during the proposed activity period • Identification of previous and simultaneous activities, their seasons and duration in the same or adjoining areas, existence and location of any marine protected areas, and a review of activity findings and implications
Description of the equipment and activity	• Explanation of all technologies available for the activity and why the proposed technology is chosen, including the description should also contain the consideration of alternatives • Specification of sound intensity level (dB peak to peak) in water @ 1 metre, frequency ranges and ping rate, sound exposure level (SEL), as well as proposed spacing of pingers • Identification of other activities having an impact in the region accompanied by the analysis and review of potential cumulative or synergistic impacts
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in the same season/weather conditions as the proposed activity accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed exclusion zones for species and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features

Component	Detail
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels; and calculated from this, the extent of the impact zones a. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts to prey species b. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summary): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions
Monitoring plans	• Detail of scientific monitoring programmes, conducted before, during and after the activity, to assess impact • Spatio-temporal restrictions • Quantification of the effectiveness of proposed mitigation methods
Reporting plans	• Detail of post operation reporting plans including verification of the effectiveness of mitigation
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

XI. EIA Guideline for Other Noise-generating Activities (Acoustic Data Transmission, Wind, Tidal and Wave Turbines and Future Technologies)

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances.

All commissioning and decommissioning activities should also follow these guidelines.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the activity – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed activity, above natural ambient sound levels • Detail of the typical weather conditions and day length for the area during the proposed activity period • Identification of previous and simultaneous activities, their seasons and duration in the same or adjoining areas, existence and location of any marine protected areas, and a review of activity findings and implications
Description of the equipment and activity	• Explanation of all technologies available for the activity • Specification of sound intensity level (dB) in water @ 1 metre, and frequency ranges. This should include dB peak to peak for acoustic data transmission for example, dB_{rms} for wind, tidal and wave turbines and future technologies categorized accordingly • Identification of other activities having an impact in the region during the planned activity, accompanied by the analysis and review of potential cumulative or synergistic impacts
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in the same season/weather conditions as the proposed activity accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed exclusion zones for species and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features

Component	Detail
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels; and calculated from this, the extent of the impact zones b. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts to prey species c. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summary): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions • Quantification of the effectiveness of proposed mitigation methods
Monitoring plans	• Explanation of ongoing scientific monitoring programmes to assess impact • Most appropriate methods of species detection (e.g. visual/acoustic) and the range of available methods, and their advantages and limitations, as well their practical application during the activity. • Spatio-temporal restrictions
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

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Additional references are detailed in the Technical Support Information at www.cms.int/guidelines/cms-family-guidelines-EIAs-marine-noise.

Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities

Parties to the Convention on Migratory Species (CMS), the Agreement on the Conservation of Cetaceans in the Black Sea Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) and the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) have recognized underwater noise as a major threat to many marine species. Several resolutions have been passed calling for effective measures to mitigate and minimize the impact of noise pollution on marine life.

CMS, ACCOBAMS and ASCOBANS decisions also recognize that addressing this issue effectively requires that noise-related considerations should be taken into account starting with the planning stage of activities, especially by making effective use of Environmental Impact Assessments (EIA). The Convention on Biological Diversity Decision XII/23 encourages governments to require EIAs for noise-generating offshore activities and to combine acoustic mapping with habitat mapping to identify areas where these species may be exposed to noise impacts.

A considerable number of national and regional operational guidelines detail the impacts to be avoided and mitigation measures to be taken during proposed operations. For the most part these focus on cetaceans. Few guidelines cover other species and almost none has been developed about the specific content that should be provided in EIAs before approvals and permits are granted.

Thanks to a voluntary contribution from the Principality of Monaco under the Migratory Species Champions programme, and an additional contribution from OceanCare, the CMS, ASCOBANS and ACCOBAMS Secretariats are pleased to have developed guidelines for Environmental Impact Assessments for noise-generating offshore industries, providing a clear pathway to implementing the Best Available Techniques (BAT) and Best Environmental Practice (BEP).

This Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities is structured to stand as one complete unit or to be used as discrete modules, tailored for national and agreement approaches.

The full document and the stand-alone modules are online at: cms.int/guidelines/cms-family-guidelines-EIAs-marine-noise

Development of this Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities has been possible with the generous funding of Principality of Monaco and OceanCare.

Table of Contents

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Acronyms

ACCOBAMS	Agreement on the Conservation of Cetaceans in the Black Sea Mediterranean Sea and Contiguous Atlantic Area
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas
BAT	Best Available Techniques
BEP	Best Environmental Practice
CBD	Convention on Biological Diversity
CMS	Convention on the Conservation of Migratory Species of Wild Animals or Convention on Migratory Species
dB	decibels
DSC	deep sound channel
EEH	Equal Energy Hypothesis
EIA	Environmental Impact Assessment
IMO	International Maritime Organization
IWC	International Whaling Commission
NOAA	National Oceanic and Atmospheric Administration (US)
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PTS	permanent threshold shift
RMS	root mean squared
SEA	Strategic Environmental Assessment
SEL	sound exposure level
SELcum	cumulative sound exposure level
SIL	Sound Intensity Level
SOCAL-BRS	Biological and Behavioural Response Studies of Marine Mammals in Southern California
SOFAR	Sound Fixing and Ranging Channels
SPL	Sound Pressure Level
TTS	temporary threshold shift
UK	United Kingdom of Great Britain and Northern Ireland
US	United States of America

Tables

Executive Summary

The sea is the interconnected system of all the Earth's oceanic waters, including the five named 'oceans' - the Atlantic, Pacific, Indian, Southern and Arctic Oceans - a connected body of salty water that covers over 70 percent of the Earth's surface.

This vast environment is home to a broader spectrum of higher animal taxa than exists on land. Many marine species have yet to be discovered and the number known to science is expanding annually. The sea also provides people with substantial supplies of food, mainly fish, shellfish and seaweed, in addition to marine resource extraction. It is a shared resource for us all.

Levels of anthropogenic marine noise have doubled in some areas of the world, every decade, for the past 60 years. When considered in addition to the number other anthropogenic threats in the marine environment, noise can be a life-threatening trend for many marine species.

Marine wildlife rely on sound for vital life functions, including communication, prey and predator detection, orientation and for sensing surroundings. While the ocean is certainly a sound-filled environment and many natural (or biological) sounds are very loud, wildlife is not adapted to anthropogenic noise.

Animals exposed to elevated or prolonged anthropogenic noise can suffer direct injury and temporary or permanent auditory threshold shifts. Noise can mask important natural sounds, such as the call of a mate, the sound made by prey or a predator. These impacts are experienced by a wide range of species including fish, crustaceans and cephalopods, pinnipeds (seals, sea lions and walrus), sirenians (dugong and manatee), sea turtles, the polar bear, marine otters and cetaceans (whales, dolphins and porpoises).

The Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities has been developed to present the Best Available Techniques (BAT) and Best Environmental Practice (BEP). The document is structured to stand as one complete unit or to be used as discrete modules, tailored for national and agreement approaches.

The modules that follow are structured to cover species area, as follows:

'**Module A: Sound in Water is Complex**' provides an insight into the characteristics of sound propagation and dispersal. This module is designed to provide decisions-makers with necessary foundation knowledge to interpret the other modules in these guidelines and any impact assessments that are presented to them for consideration.

'**Module B: Expert Advice on Specific Species Groups**' presents 12 separate detailed sub-modules covering each of the CMS species groups, focusing on species' vulnerabilities, habitat considerations, impact of exposure levels and assessment criteria.

'**Module C: Decompression Stress**' provides important information on bubble formation in marine mammals, source of decompression stress, source frequency, level and duration, and assessment criteria.

'**Module D: Exposure Levels**' presents a summary of the current state of knowledge about general exposure levels.

'**Module E: Marine Noise-generating Activities**' provides a brief summary of military sonar, seismic surveys, civil high powered sonar, coastal and offshore construction works, offshore platforms, playback and sound exposure experiments, shipping and vessel traffic, pingers and other noise-generating activities. Each section presents current knowledge about sound intensity level, frequency range and the

activities general characteristics. The information is summarized in a table within the module.

'**Module F: Related Intergovernmental or Regional Economic Organisation Decisions**' presents the series of intergovernmental decisions that have determined the direction for regulation of anthropogenic marine noise.

'**Module G: Principles of EIAs**' establishes basic principles including strategic environmental assessments, transparency, natural justice, independent peer review, consultation and burden of proof.

The Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities is structured to stand as one complete unit or to be used as discrete modules, tailored for national and agreement approaches.

The complete document and the discrete modules are online at: cms.int/guidelines/cms-family-guidelines-EIAs-marine-noise

A. Sound in Water is Complex

Geoff Prideaux
Wild Migration

The ocean environment is filled with natural sound from animals and physical processes. Species living in this environment are adapted to these sounds. Over the past century many anthropogenic marine activities have increased levels of noise. (André *et al* 2010, Hildebrand 2009) These modern anthropogenic noises have the potential for physical, physiological and behavioural impacts on marine fauna–mammals, reptiles, fish and invertebrates. (Southall *et al* 2007)

The propagation of sound in water is complex and requires many variables to be carefully considered before it can be known if a noise-generating activity is appropriate or not. It is inappropriate to generalize sound transmission without fully investigating propagation.

Often, statements are made in Environmental Impact Assessments that a noise-generating activity is 'X' distance from 'Y' species or habitat and therefore, will have no impact. In these cases distance is used as a basic proxy for impact but is rarely backed with scientifically modelled information. (Wright *et al* 2013, Prideaux and Prideaux 2015)

The behaviour of sound in the marine environment is different from sound in air. The extent and way that sound travels (propagation) is affected by many factors, including the frequency of the sound, water depth and density differences within the water column that vary with temperature, salinity and pressure. (Clay and Medwin 1997, Etter 2013, Lurton 2010, Wagstaff 1981) Seawater is roughly 800–1,500 times denser than air and sound travels around five times faster in this medium. (Lurton 2010) Consequently, a sound arriving at an animal is subject to propagation conditions that are complex. (Calambokidis *et al* 2002, Hildebrand 2009, Lurton 2010, McCauley *et al* 2000)

To present a defensible Environmental Impact Assessment for any noise-generating activity proposal, proponents need to have expertly modelled the noise of the proposed activity in the region and under the conditions they plan to operate.

Understanding the basic concepts that should be presented is important to assess if the Environmental Impact Assessment is defensible and sufficient.

A.1. Basic concepts

The study of acoustics is a specialized and technical field. Professional acousticians will consider many more complexities beyond the scope of this paper.

The basic concepts that decision-makers may need to understand are outlined in a very simplified form, specifically to be accessible to a lay-audience.

A.1.1. Elasticity

The speed of sound is not a fixed numerical value. Sound wave speed varies widely and depends on the medium, or material, it is transmitted through, such as solids, gas or liquids. Sound waves move through a medium by transferring kinetic energy from one molecule to the next. (Lurton 2010) Each medium has its own elasticity (or resistance to molecular deformity). This elasticity factor affects the sound wave's movement significantly. Solid mediums, such as metal, transmit sound waves extremely fast because the solid molecules are tightly packed together, providing only tiny spaces for vibration. Through this high-elasticity medium, solid molecules act like small springs aiding the wave's movement. The speed of sound through aluminium, for example, is around 6,319ms^{-1}. Gas, such as air, vibrates at a slower speed because of larger spaces between each molecule. This allows greater deformation and results in lower elasticity. Sound waves moving through air at a temperature of 20°C will only travel around 342ms^{-1}. Liquid molecules, such as seawater, bond together in a tighter formation compared with gas molecules. This results in less

deformation, creating a higher elasticity than gas. Sound waves moving through water at 22°C travel at around 1,484ms^{-1}. (Brekhovskikh and Lysanov 2006, Au and Hastings 2009, Ross 2013) Temperature also has an effect on molecules. Molecules move faster under higher temperatures, transmitting sound waves more rapidly across the medium. Conversely, decreasing temperatures cause the molecules to vibrate at a slower pace, hindering the sound wave's movement. (Brekhovskikh and Lysanov 2006, Au and Hastings 2009, Ross 2013) The temperature of seawater at different depths is therefore of importance to modelling.

A.1.2. Spherical Spreading, Cylindrical Spreading and Transmission Loss

The way sound propagates is also important. Spherical spreading is simply sound leaving a point source in an expanding spherical shape. As sound waves reach the sea surface and sea floor, they can no longer maintain their spherical shape and they begin to resemble the shape of an expanding cheese wheel. This is called cylindrical spreading.

The transmission loss, or the decrease in the sound intensity levels, happens uniformly in all directions during spherical transmission. However, when sound is in a state of cylindrical transmission, it cannot propagate uniformly. The sound is effectively contained between the sea surface and the sea floor, while the radius still expands uniformly (the sides of the cheese wheel). The height is now fixed and so the sound intensity level decreases more slowly. (Urick 1983, Au and Hastings 2009, Lurton 2010, Jensen *et al* 2011)

In actuality, the seabed is rarely, if ever, flat and parallel to the sea surface. These natural variations add extra complexities to modelling cylindrical spreading. However, these characteristics must be known to model spreading accurately, as should the water depth and the rise and fall of the seabed surrounding it. (Lurton 2010, Jensen *et al* 2011)

A.1.3. Sound Fixing and Ranging Channels (SOFAR)

As well as spherical and cylindrical spreading, another variable can impact how far sound will be transmitted. This is usually called a Sound Fixing and Ranging Channel (SOFAR) and is a horizontal layer of water in the ocean at which depth, the speed of sound is at its minimum.

The SOFAR channel is created through the interactive effect of temperature and water pressure (and, to a smaller extent, salinity). This occurs because pressure in the ocean increases with depth, but temperature is more variable, generally falling rapidly in the main thermocline from the surface to around a thousand metres deep and then remaining almost unchanged from there to the ocean floor. Near the surface, the rapidly falling temperature causes a decrease in sound speed (or a negative sound speed gradient). With increasing depth, the increasing pressure causes an increase in sound speed (or a positive sound speed gradient). The depth where the sound speed is at a minimum is called the sound channel axis. The speed gradient above and below the sound channel axis acts like a lens, bending sound towards the depth of minimum speed. The portion of sound that remains within the sound channel encounters no acoustic loss from reflection of the sea surface and sea floor. Because of this low transmission loss, very long distances can be obtained from moderate acoustic power. (Urick 1983, Brekhovskikh and Lysanov 2006, Lurton 2010, Jensen *et al* 2011)

A.1.4. Decibels dB

The decibel (dB), 1/10th of a Bel, is used to measure sound level. It is the unit that will be presented in documentation.

The dB is a logarithmic unit used to describe a ratio. The ratio may be power, sound pressure or intensity.

The logarithm of a number is the exponent to which another fixed value, the base, must be raised to produce that number. For example, the logarithm of 1,000 to base 10 is 3, because 1,000 is 10 to the power 3:

$$1{,}000 = 10 \times 10 \times 10 = 10^3.$$

More generally, if $x = b^y$, then y is the logarithm of x to base b, and is written y = logb(x), so log10 (1,000) = 3. (Au and Hastings 2009, Jensen *et al* 2011, Ross, 2013)

A common mistake is to assume that 10dB is half as loud as 20dB and a third of 30dB.

To disprove this false assumption, suppose there are two loudspeakers, the first playing a sound with power P1, and another playing a louder version of the same sound with power P2, but everything else (distance and frequency) remains the same.

The difference in decibels between the two is defined as:

10 log (P2/P1) dB where the log is to base 10.

If the second produces twice as much power as the first, the difference in dB is:

10 log (P2/P1) = 10 log 2 = 3 dB.

To continue the example, if the second has 10 times the power of the first, the difference in dB is:

10 log (P2/P1) = 10 log 10 = 10 dB.

If the second has a million times the power of the first, the difference in dB is:

10 log (P2/P1) = 10 log 1,000,000 = 60 dB.

This example shows one feature of decibel scales that is useful in discussing sound: they can describe very big ratios using manageable numbers.

A.1.5. Peak and RMS values

Peak value, as the term implies, is the point of a sound wave with the greatest amplitude. Peak values are associated with plosive sounds like seismic air guns, pile driving, low frequency sonar and explosives. (Au and Hastings 2009)

RMS (root mean squared) is the formula used to calculate the mean of a sound wave over time. RMS values are associated with constant non-plosive sounds like shipping propeller and engine noise, oil rig operations, some mid to high frequency sonar and water based wind turbines. (Au and Hastings 2009)

A.1.6. Phase

Phase can be best described as the relational alignment with two or more sound waves over time. Very simplistically, waves with the same phase will constructively interfere to produce a wave whose amplitude is the sum of the two interfering waves, while two waves which are 180 degrees out of phase will destructively interfere to cancel each other out. (Rossing and Fletcher 2013)

A.2. Understanding Sound Exposure Levels

A.2.1. Sound Exposure Level cumulative (SELcum)

Sound Exposure level (SEL) is generally referred to as dB 0 to peak or peak to peak (dB 0 to peak or dB p to p) for plosive or pulsive noise like air guns, military sonar etc and dB Root Mean Squared (dB rms) for non-plosive or non-pulsive noise such as ship noise, dredging, wind farms, constant drone (Au and Hastings 2009). These measurements are generally of a one second duration only. The question arises, is this a realistic measurement metric for understanding the effects on all marine species?

According to NOAA's paper, Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing, (NOAA, 2016) sound exposure level works well for marine mammals but not well for other marine species (crustaceans, bivalves, cephalopods, finned fish, etc) because non-mammal marine species detect sound through particle motion (the organism resonating in sympathy with the surrounding sound waves) rather than through a tympanic mechanism as with marine mammals. A more informed measurement introduced to modelling is sound exposure level cumulative (SELcum) by which a time component is added into SEL enabling it to encompass all marine species.

While SEL has been acceptable in the past, with the use of SELcum modelling, species experts have documented noticeable impacts on species' welfare that have otherwise gone unnoticed.

NOAA has set a default time of 24 hours for SELcum. An alternate prescribed time can be applied to SELcum if stated. Within the SELcum metric, reference to sound intensity level (0 to peak, peak to peak or rms) is not appropriate due to the extended time parameter. It may be displayed as 190 dB SELcum *re* 1µPa @ 1m pulsive or non-pulsive depending.

A.2.2. Equal Energy Hypothesis

NOAA also mentions the Equal Energy Hypothesis (EEH) which discusses the basic impact trends on marine species. They also comment that the EEH is pretty loose due to the complexity of all the potential factors, but it serves as a reasonable rule of thumb.
It states:

- Growth rate of threshold shift (TS) is higher for frequencies where hearing is more sensitive
- Non-impulsive intermittent exposures require higher SELcum to induce a TS compared to continuous exposures of the same duration
- Exposures for longer durations and lower levels induce TTS at a lower level than those exposed to a higher level and a shorter duration with the same duration SELcum
- With the same SELcum, longer exposures require longer recovery time.
- Intermittent exposures recover faster compared to continuous exposures of the same duration
- Animals may be exposed to multiple sound sources and stressors beyond acoustics during an activity. This also

may have a cumulative effect.

Also, pulsive/plosive SELcum noise will induce TS more quickly than a non-pulsive noise with the same SELcum due to the fast rise time characteristics of pulsive/plosive noise.

A.3. Necessity of Modelling

These complexities illustrate the necessity for expert modelling of sound propagation from noise-generating activities. (Urick 1983, Etter 2013) While noise modelling is common for land-based anthropogenic noise-producing activities, it is less common for proposals in the marine environment. The lack of rigorous noise modelling in the marine setting needs to be urgently addressed. (Prideaux and Prideaux 2015)

Modelling of each noise-generating activity proposal should be expertly and impartially conducted to provide decision-makers with credible and defensible information. The modelling should provide a clear indication of sound dispersal characteristics, informed by local propagation features. (Urick 1983, Etter 2013)

With this information, the acoustic footprint of the noise-generating activity can be identified and informed decisions about levels of noise propagation can be made. (Prideaux and Prideaux 2015)

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B. Expert Advice on Specific Species Groups

The sea is the interconnected system of all the Earth's oceanic waters, including the five named 'oceans' - the Atlantic, Pacific, Indian, Southern and Arctic Oceans - a connected body of salty water that covers over 70 percent of the Earth's surface.

This vast environment is home to a broader spectrum of higher animal taxa than exists on land. Many marine species have yet to be discovered and the number known to science is expanding annually. The sea also provides people with substantial supplies of food, mainly fish, shellfish and seaweed. It is a shared resource for us all.

Levels of anthropogenic marine noise have doubled in some areas of the world, every decade, for the past 60 years. (McDonald, Hildebrand *et al* 2006, Weilgart 2007) When considered in addition to the number other anthropogenic threats in the marine environment, noise can be a life-threatening trend for many marine species.

Marine wildlife rely on sound for its vital life functions, including communication, prey and predator detection, orientation and for sensing surroundings. (Hawkins and Popper 2014, Simmonds, Dolman *et al* 2014) While the ocean is certainly a sound-filled environment and many natural (or biological) sounds are very loud, wildlife is not adapted to anthropogenic noise.

The species groups covered in the following sub-modules are:

- Inshore Odontocetes
- Offshore Odontocetes
- Beaked Whales
- Mysticetes
- Pinnipeds
- Polar Bears
- Sirenians
- Marine and Sea Otters
- Marine Turtles
- Fin-fish
- Elasmobranchs
- Marine Invertebrates

General principles

Building on the information from module section B.1, sound waves move through a medium by transferring kinetic energy from one molecule to the next. Animals that are exposed to elevated or prolonged anthropogenic noise may experience passive resonance (particle motion) resulting in direct injury ranging from bruising to organ rupture and death (barotrauma). This damage can also include permanent or temporary auditory threshold shifts, compromising the animal's communication and ability to detect threats. Finally, noise can mask important natural sounds, such as the call of a mate, the sound made by prey or a predator.

Table 1: Potential results of sound exposure (from Hawkins and Popper 2016)

Impact	Effects on animal
Mortality	Death from damage sustained during sound exposure
Injury to tissues; disruption of physiology	Damage to body tissue, e.g internal haemorrhaging, disruption of gas-filled organs like the swim bladder, consequent damage to surrounding tissues
Damage to the auditory system	Rupture of accessory hearing organs, damage to hair cells, permanent threshold shift, temporary threshold shift
Masking	Masking of biologically important sounds including sounds from conspecifics
Behavioural changes	Interruption of normal activities including feeding, schooling, spawning, migration, and displacement from favoured areas
These effects will vary depending on the sound level and distance	

These mechanisms, as well as factors such as stress, distraction, confusion and panic, can affect reproduction, death and growth rates, in turn affecting the long-term welfare of the population. (Southall, Schusterman *et al*, 2000, Southall, Bowles *et al*, 2007, Clark,

Ellison *et al*, 2009, Popper *et al*, 2014, Hawkins and Popper 2016)

These impacts are experienced by a wide range of species including fish, crustaceans and cephalopods, pinnipeds (seals, sea lions and walrus), sirenians (dugong and manatee), sea turtles, the polar bear, marine otters and cetaceans (whales, dolphins and porpoises)–the most studied group of marine species when considering the impact of marine noise.

The current knowledge base is summarized in the following module.

This important volume of information should guide the assessment of Environmental Impact Assessment proposals.

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B.1. Inshore Odontocetes

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Odontocetes close to shore or in shallow waters

Consider when assessing

- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- Agreement on the Conservation of Cetaceans of the Black Seas Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS)
- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)
- MOU for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (Pacific Islands Cetaceans)
- MOU Concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia (West African Aquatic Mammals)

Related modules

- Refer also to modules B.10, B.12 and C when assessing impact to inshore odontocetes

B.1.1. Species Vulnerabilities

Close-range, acute noise exposure is known to generate spatial displacement, often extended over the duration of the noise exposure (Anderwald *et al* 2013, Pirotta *et al* 2013), temporary hearing impairment (temporary threshold shifts or TTS)(e.g. Kastelein *et al* 2015, Lucke *et al* 2009) reduction in both occurrence and efficiency, or even cessation, of foraging behaviour (e.g. Pirotta *et al* 2014).

Permanent hearing impairment (permanent threshold shifts or PTS) has not been documented empirically (unethical) but is expected to occur and exposure thresholds have been predicted (e.g. Southall *et al* 2007, NOAA 2016).

Long-range (and therefore of wider spatial magnitude), chronic noise exposure is also known to generate spatial displacement, often extended over the duration of the noise exposure (Campana *et al* 2015). Masking of communication and other biologically important acoustic signals also occurs (e.g. Gervaise *et al* 2012).

Spatial displacement can cause the temporary loss of important habitat, such as prime feeding ground, forcing individuals to exploit suboptimal foraging areas. This effect is of significant concern if foraging behaviour is seasonal and/or if foraging habitat is limited or patched. Similarly, displacement can reduce breeding opportunities if it occurs during the mating season. Therefore, foraging habitat and breeding season are particularly sensitive components to noise impact.

B.1.2. Habitat Considerations

Inshore odontocetes often feed on opportunistic, seasonally abundant prey (e.g. Shane *et al* 1986). Habitat is often degraded due to proximity to highly populated coastal areas. Thus, populations have been fragmented or are in the process of being fragmented. For these reasons, suboptimal habitat should be available to perform the biological tasks that will be disturbed by the introduction of noise. Population structure should be known in enough detail to allow evaluation of the population's resilience to the disturbance. Some odontocetes show diel (24 hour cycle) movement patterns from offshore to inshore regions for resting (Thorne *et al* 2012), or prey accessibility (Goodwin 2008). Similarly, seasonal patterns have been described for inshore odontocetes mainly driven by their prey's life cycle (Pirotta *et al* 2014) or seasonality in human disturbance (Castellote *et al* 2015). These movement patterns and co-occurring disturbances should be considered to minimize odontocetes' exposure to noise or reduce cumulative impact. Some species have small home ranges or show high site fidelity with low connectivity. They therefore may be more vulnerable to population level impacts, particularly in areas of repeated anthropogenic activity. Caution should be taken to minimise overlaps with such areas. Appropriate scheduling of noise-generating activities at periods with the lowest presence of odontocetes should be prioritized. Feeding can be concentrated in habitat specific features such as river mouths (Goetz *et al* 2007) or canyons (Moors-Murphy 2014). These spatial

particularities of habitat should also be considered and their disturbance minimized.

B.1.3. Impact of Exposure Levels

The harbour porpoise has been described as the inshore odontocete most sensitive to noise exposure among the species of which we have data (Lucke *et al* 2009, Dekeling *et al* 2014, but see Popov *et al* 2011).

Based on the NOAA acoustic guidelines (NOAA 2016), which imply the most up-to-date scientific information on the effects of noise on marine mammals, onset of physiological effects, that is TTS and PTS, for impulsive and non-impulsive noise sources is based on a dual metric (dB peak for instantaneous sound pressure and SEL accumulated over 24 h for both impulsive and non-impulsive, whichever is reached first) and is summarized in the table (over) for high frequency hearing specialists, which includes the harbour porpoise.

These thresholds are based on weighted measurements, which take into consideration hearing sensitivity across frequencies for each hearing functional group. For more details please see NOAA (2016).

A more restrictive decision from the German Federal Maritime and Hydrographic Agency on the onset for physiological effects on harbour porpoises must also be considered in this context. This Agency has implemented a different threshold since 2003, specifically for pile driving operations. Criteria consist of a dual metric, SEL = 160dB re 1 mPa^2/s and SPL(peak-peak) = 190 dB re 1µPa. Both measures should not be exceeded at a distance of 750 m from the piling site.

Table 2: TTS and PTS from impulsive and non-impulsive noise sources for inshore odontocetes (from NOAA 2015)

Metric	TTS onset		PTS onset	
	Impulsive	Non-impulsive	Impulsive	Non-impulsive
SEL cum 24h	140 dB	153 dB	155 dB	173 dB
dB peak	196 dB	n/a	202 dB	202 dB

Regarding onset of behavioural disruption, NOAA has not yet updated its guidelines, and a threshold of 120 dB RMS for non-impulsive and 160 dB RMS for impulsive noise remain as the onset thresholds for all cetacean species. New information obtained through controlled noise exposure studies on offshore cetacean species (e.g. SOCAL-BRS, 3S), suggests that onset of behavioural disruption is context dependent, and not only received levels but also distance to the source might play an important role in triggering a reaction. Few studies have been focused on behavioural reaction to noise on inshore odontocetes. These show how the onset of a response is triggered by the perceived loudness of the sound, not just received levels (Dyndo *et al* 2015). At least for harbour porpoises, this finding lends weight to the recent proposal by Tougaard *et al* (2015) that behavioural responses can be predicted from a certain level above their threshold at any given frequency (e.g. in the range of 40–50 dB above the hearing threshold for harbour porpoise).

For loud noise sources such as large diameter pile driving or seismic surveys commonly found in inshore odontocete habitat, the onset for behavioural response can occur at very substantial distances (e.g. Tougaard *et al* 2009, Thompson *et al* 2013).

B.1.4. Assessment Criteria

Several key characteristics on the biology of a species should be adequately assessed in an EIA. Population stock structure is a critical element to allow evaluating potential negative effects outside the scope of the individual level. This information is often unavailable for inshore odontocetes, and regulators or decision makers should adopt a much stricter position regarding this criterion for impact assessment decisions. Correct impact evaluation cannot be accomplished without understanding the extent of a potentially impacted population. Because spatial displacement is by far the most prominent effect to occur in noisy activities occurring in inshore odontocete habitat, sufficient information on habitat use and the availability of unaffected suboptimal habitat should be addressed in the evaluation. Other more general points should not be forgotten when determining if this species group has been adequately considered by an EIA, such as the correct relationship between the spectral content of the noise source and hearing information for the affected species, and the integration of both behavioural and physiological effects for the estimated proportion of the population to be affected by the activity.

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B.2. Offshore Odontocetes

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Odontocetes in deeper waters

Consider when assessing

- Military sonar
- Seismic surveys
- Civil high power sonar
- Offshore platforms
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons

Related CMS agreements

- Agreement on the Conservation of Cetaceans of the Black Seas Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS)
- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)
- MOU for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (Pacific Islands Cetaceans)
- MOU Concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia (West African Aquatic Mammals)

Related modules

- Beaked whales are considered separately in module B.3.
- Refer also to modules B.10, B.12 and C when assessing impact to offshore odontocetes

B.2.1. Species Vulnerabilities

While spatial displacement has been well documented in several inshore odontocetes species, little data is available for offshore odontocetes (other than beaked whale species), but similar behavioural responses are expected. Few direct measures of displacement are available (e.g. Goold 1996, Bowles *et al* 1994), and some indirect measures of disturbance exist, such as changes in vocal behaviour in short beaked common dolphins, Atlantic spotted dolphins and striped dolphins in the presence of anthropogenic noise (Papale *et al* 2015). Sperm whales exposed to tactical active sonar reduced energy intake or showed significant displacement with no immediate compensation (Isojunno *et al* 2016, Miller *et al* 2012). However, sperm whales chronically exposed to seismic airgun survey noise in the Gulf of Mexico did not appear to avoid a seismic airgun survey, though they significantly reduced their swimming effort during noise exposure along with a tendency toward reduced foraging (Miller *et al* 2009). Changes in vocal behaviour are normally associated with displacement in other odontocetes (e.g. Holt *et al* 2009, Lesage 1999).

Physiological impact by close-range, acute noise exposure, such as temporary threshold shift, has never been described in offshore odontocetes due to the difficulty to maintain these species in captivity. There is just one anecdotic description of physiological injury due to airgun noise exposure on a pantropical spotted dolphin (Graya and Van Waerebeek, 2011).

This lack of evidence should not be considered conclusive but rather as reflecting the absence of studies. Furthermore, due to similarities in sound functionality, hearing anatomy and physiology between offshore and inshore odontocetes, the vulnerabilities described for inshore species are expected to be very similar for offshore species.

Because of the lack of knowledge on offshore odontocete habitat seasonal preferences (e.g. it is not known whether reproduction occurs in similar habitats as where foraging occurs), noise impact on these species cannot be broken into lifecycle components.

B.2.2. Habitat Considerations

Little survey effort has been dedicated to offshore waters in most exclusive economic offshore zones and even less in international waters. As a consequence, data on offshore odontocete occurrence, distribution and habitat preferences is scarce for most species. However, some generalizations can be highlighted: Sperm whales do not use offshore regions uniformly, topography plays a key role in shaping their distribution (e.g Pirotta *et al* 2011). Moreover, solitary individuals use the habitat differently from groups (Whitehead 2003).

The occurrence of eddies, often associated with numerous seafloor topographic structures (canyons and seamounts), are known to favour ecosystem richness and consequently, cetacean occurrence (Ballance *et al* 2006, Hoyt 2011, Redfern *et al* 2006, Correia *et al* 2015). Therefore, areas were eddies are known to occur, particularly those related to underwater topography features,

should be taken into special consideration when assessing impact to offshore odontocetes, even if no knowledge on cetacean occurrence is available.

B.2.3. Impact of Exposure Levels

Offshore odontocetes fall in their majority into the mid frequency hearing specialists. This group was considered for noise impact assessments during an international panel review (Southall *et al* 2007). This review has been updated in recent efforts by the U.S. Navy and NOAA. NOAA's most updated draft on acoustic guidelines (NOAA 2016) considers TTS and PTS, for impulsive and non-impulsive noise sources is based on a dual metric (dB peak for instantaneous sound pressure and SEL accumulated over 24 h for both impulsive and non-impulsive, whichever is reached first) and is summarized in the table below for mid frequency hearing specialists (Table 3).

Table 3: TTS and PTS from impulsive and non-impulsive noise sources for offshore odontocetes, excluding beaked whales (from NOAA 2015)

Metric	TTS onset		PTS onset	
	Impulsive	Non-impulsive	Impulsive	Non-impulsive
SEL cum 24h	170 dB	178 dB	185 dB	198 dB
dB peak	224 dB	n/a	230 dB	230 dB

Please note these thresholds are based on weighted measurements, which take into consideration hearing sensitivity across frequencies for each hearing functional group. For more details please see NOAA (2016).

Regarding onset of behavioural disruption, NOAA has not yet updated its guidelines, and a threshold of 120 dB RMS for non-impulsive and 160 dB RMS for impulsive noise remains as the onset thresholds for all cetacean species. Recent results from one of the few behavioural response studies where offshore odontocetes, other than beaked whales, are targeted identified higher thresholds than expected for avoidance of military tactic sonar by free-ranging long-finned pilot whales (Antunes *et al* 2015). The US Navy currently uses a generic dose–response relationship to predict the responses of cetaceans to naval active sonar (US Navy 2008), which has been found to underestimate behavioural impacts on killer whales and beaked whales in multiple studies (Tyack *et al* 2011, DeRuiter *et al* 2013, Miller *et al* 2012 and 2014, Kuningas *et al* 2013). The navy curve appears to match more closely results with long-finned pilot whales, though the authors of this study suggest that the probability of avoidance for pilot whales at long distances from sonar sources could well be underestimated. These results highlight how functional hearing grouping, particularly for offshore odontocete species, might not be the most conservative approach for noise mitigation purposes. Behavioural responses of cetaceans to sound stimuli often are strongly affected by the context of the exposure, which implies that species and the received sound level alone is not enough to predict type and strength of a response. Although limited in sample size, this new information has not yet been profiled in EIA procedures. Contextual variables are important and should be included in the assessment of the effects of noise on cetaceans (see Ellison *et al* 2012 for a context-based proposed approach).

B.2.4. Assessment Criteria

Because our limited knowledge on offshore odontocete ecology and their seasonal habitat preferences, common sense mitigation procedures such as avoiding the season of higher odontocete occurrence might be difficult to implement. However, habitat predictive modelling is often applicable with limited data (Redfern *et al* 2006), and should be encouraged in situations where impact assessments suffer from odontocete data deficit.

It should also be noted that in some particular cases, spatial displacement has generated drastic indirect effects at the population level. Good examples are the several episodes of large numbers of narwhals entrapped in ice in Canada and West Greenland attributed to displacement caused by seismic surveys (Heide –Jørgensen *et al* 2013). Displacement in offshore areas could drive odontocetes towards fishing grounds, increasing the risk of entanglement. In cases where planned offshore disturbance is proposed near potential risk areas for odontocetes, this indirect impact mechanism must be evaluated. In the case of sperm whales, regulations tend to be made assuming that animals avoid areas with high sound levels. Thus some policies assume benefits of avoidance in terms of reduced sound exposure, even in the absence of evidence that it occurs for some noise sources (Madsen *et al* 2006). Avoidance can also have adverse effects, with the biological significance depending upon whether important activities are affected by

animal movement away from an aversive sound.

Other more general points should not be forgotten when determining if this species group has been adequately considered by an EIA, such as the correct relationship between the spectral content of the noise source and hearing information for the affected species, and the integration of both behavioural and physiological effects for the estimated proportion of the population to be affected by the activity.

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B.3. Beaked Whales

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Consider when assessing

- Military sonar
- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- Agreement on the Conservation of Cetaceans of the Black Seas Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS)
- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)
- MOU for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (Pacific Islands Cetaceans)

Related modules

- Refer also to modules B.10, B.12 and C when assessing impact to beaked whales

B.3.1. Species Vulnerabilities

Beaked whales (Ziphiids) became widely known to the public due to mass mortalities of whales stranded with gas/fat emboli when exposed to submarine-detection naval sonar or underwater explosions (Jepson *et al*, 2003, Fernández *et al*, 2005). Most researchers agree that a ‘fight or flight’ stress response is responsible for the deaths of whales following noise disturbances (Cox *et al*, 2006). Interruption of foraging and avoidance at high speed have been found in different species of beaked whales subject to playbacks of naval sonar at 1/3rd octave RMS received levels as low as 89–127 dB re 1 µPa (Tyack *et al*, 2011, DeRuiter *et al*, 2013, Miller *et al*, 2015). Beaked whales may also be sensitive to other sources of anthropogenic noise, as suggested by the effectiveness of acoustic pingers in reducing the bycatch of beaked whales in deep-water fisheries, much higher than for other species (Carretta *et al* 2011), and by their apparent response to low levels of ship noise (Aguilar de Soto *et al* 2006). There has been a number of mass-strandings of beaked whales coincident in time and space with seismic activities (Malakof 2001, Castellote and Llorens 2016), but the lack of adequate post-mortem examinations has prevented assessing possible cause-effects relationships in these cases. This means that any intense underwater anthropogenic noise can be considered as of concern for beaked whales: blasting, intense naval and scientific sonar, seismics, pingers, etc.

It is still unknown why beaked whales are more sensitive to noise than many other marine mammal species. The reasons may lie in their specialized way of life. Ziphiids stretch their physiological capabilities to perform dives comparable to sperm whales, but with a much smaller body size (Tyack *et al* 2006). Their poor social defences from predators such as highly vocal killer whales may explain why beaked whales limit their vocal output (Aguilar de Soto *et al* 2012) and respond behaviourally to sound at relatively low received levels. The combination of a low threshold of response and a potentially delicate physiological balance may explain why behavioural responses can cause mortalities (Cox *et al* 2006).

Population data for beaked whales are scarce offshore, but long-term monitoring shows that local populations in nearshore deep-waters are small (<100-150 individuals), have high site-fidelity and apparently low connectivity and calving rate (Claridge, 2013, Reyes *et al* 2015). These characteristics generally reduce animal resilience to population-level impacts. Differences in population structure, with a reduced number of young, have been found between beaked whales inhabiting a naval training range and a semi-pristine neighbouring area in the Bahamas (Claridge, 2013). In summary, while discrete noise activities are of concern due to potential acute exposures/responses, there is a risk for population-level effects of noise on beaked whales inhabiting areas where impacts are repetitive.

B.3.2. Habitat Considerations

Some of the 22 species of the Ziphiidae family can be found in the deep waters of all oceans. However, beaked whales have a low probability of visual and acoustic detection (Barlow *et al* 2006, Barlow *et al* 2013) and knowledge about their distribution and abundance is poor, preventing identification of hot-spots offshore. Until more data exist, the assumption is that any area with deep waters is potential beaked whale habitat year-round.

Most mass-strandings related to naval sonar or underwater explosives have been recorded when the activities occurred in nearshore areas of steep bathymetry, suggesting that whales might die due to the stranding process. However, there is at least one mass-stranding case indicating that animals can die offshore before stranding: the naval exercise “Majestic Eagle”. This exercise occurred > 100 km offshore from the Canary Islands and dead whales were carried to the shore by the current and winds. The whales showed the same pathological findings identified previously as symptomatic of whales stranded alive in coincidence to naval exposure (Fernández *et al* 2012).

Thus, the vulnerability of beaked whales and their wide distribution make EIA relevant whenever human activities emitting intense sound occur near the slope or in abyssal waters offshore.

B.3.3. Impact of Exposure Levels

Beaked whales show strong avoidance reactions to a variety of anthropogenic sounds with the most sensitive fraction of the population responding at received levels of naval sonar below 100 dB re 1 μPa, and most of the animals tested responding at received levels of 140 dB re 1 μPa. This corresponds to ranges of several km from the ship operating the sonar (Miller *et al* 2015, Tyack *et al*, 2011).

There are no data for thresholds of response for other noise sources. The range at which beaked whales may be expected to be at risk of disturbance from a given anthropogenic noise can be estimated from the characteristics of the sound source, acoustic propagation modelling and the dose: response data provided by behavioural response studies. For example, Tolstoy *et al* (2009) present broadband calibrated acoustic data on a seismic survey performed in shallow waters and received at deep (1600 m) and shallow water (50 m) sites. The line fit to have 95% of the received levels falling below a given received level (RL) was RL = 175.64 – 29.21 $\log_{10}$(range in km) for the deep water site and RL = 183.62 – 19 $\log_{10}$(range in km) at the shallow site. Solving the equation for shallow water and a RL of 140 dB at which beaked whales may be expected to be disturbed, the potential disturbance range would be range = $10^{43.62/19}$ = 197 km. The range predicted to disturb more sensitive individuals within the population would be greater.

The spectrum of the air gun sounds reported by Tolstoy *et al* (2009) is highest below 80 Hz, well below the naval sonars whose effects have been studied for dose-response curves, and in a frequency range where beaked whales are expected to have less sensitive hearing. It is difficult to weight the level of air guns by the hearing of beaked whale given the data available, but it is possible to make a rough estimate of the energy from air guns in the third octave band (which roughly match the frequency bands over which the mammalian ear integrates energy) of the naval sonars whose effects have been measured. The broadband SEL measured at 1 km for shallow water was 175 dB re 1 $\mu Pa^2 s$. Third octave levels were also reported for a shot recorded in shallow water at 1 km range. The third octave level for this shot at the 3 kHz sonar frequency was about 130 dB re1 $\mu Pa^2 s$, suggesting that this frequency band was about 45 dB lower than the broadband source level (SL). This suggests using a sound pressure level of 183.62 - 45 dB to estimate received level in this frequency band at 1 km range. In addition, seawater absorbs sound at about 0.18 dB/km at the 3 kHz sonar frequencies, and this absorption must be accounted for in the transmission loss. Therefore Transmission Loss (TL)= 19 $\log_{10}$(range) + 0.18*range. The range at which sensitive beaked whales, which respond at 100 dB re 1 μPa may respond, given that TL = SL – RL, i.e. 19 $\log_{10}$(range) + 0.18*range = 183.62-45-100 = 38.62, is estimated at 43 km.

These rough calculations show that beaked whales could be expected to be disturbed by exposure to airguns at ranges of 43-197+ km, assuming conditions as found by Tolstoy *et al* (2009). The actual values will depend upon the actual signature of the air gun array to be used, and the propagation conditions in the area. This guidance coupled with current data on beaked whale responses to anthropogenic noise suggests that each proposer should assess how sound is expected to propagate from the survey site to any beaked whale habitat with hundreds of km. If any of this habitat is expected to be exposed to levels of sound above those shown to disturb beaked whales (i.e. 100 dB re 1 μPa for the most sensitive individuals tested), then a further assessment should be made of the number of animals likely to be disturbed.

B.3.4. Assessment Criteria

EIA should consider different types of impacts, ranging from exposure of whales to intense received levels causing hearing damage to behavioural reactions with potential physiological consequences in some cases, to displacement and ecological effects (e.g. reduction in feeding rates or displacement

from preferred habitat due to avoidance behaviour resulting in lower fitness).

A framework for mitigation targeted to reduce risk of the different impacts above needs to be included in the EIA, including actions during the planning-phase, real-time mitigation protocols and post-activity reporting to inform future planning and mitigation (e.g. Aguilar de Soto *et al* 2015). An effective mitigation method is spatio-temporal avoidance of high density areas (Dolman *et al* 2011). This is informed by surveys and habitat modelling and can be aided by simulation engines. However, the scarcity of data supporting density maps for beaked whales increases uncertainty about the number of whales to be expected in a given area and the identification of high density areas. Thus, planning-phase mitigation is essential but it does not eliminate the possibility of encountering and affecting/harming beaked whales. Another aspect of planning-phase mitigation is the choice of acoustic devices to be used during the activity, as well as the source levels required to achieve the objectives of the activity. *In situ* measurements of sound transmission loss shortly before the activity may allow adjustment of source level to below the maximum, so that the maximum is not used by default. A protocol towards reducing total acoustic energy and peak source levels transmitted to the environment should be defined before the activity, for any activity, within workable limits.

Depending on the activity, EIA may require updated information of the density of beaked whales and other vulnerable species, before the activity, in order to allow current data to be compared with existing density maps and to improve their accuracy. Also, if a choice of locations is evaluated, it would be possible to decide locating the activity in the place with lower concentration of vulnerable species.

A powerful and cost-effective way to monitor the effects would be to moor passive acoustic recorders in the beaked whale habitats exposed to sound levels above 100 dB re 1 μPa and to monitor both the actual levels of anthropogenic sound and also to monitor for the rates at which beaked whale echolocation clicks are detected. In the case of seismic, modern seismic surveys often include the deployment of cabled geophones at the seabed. These could be easily equipped with high frequency hydrophones to record beaked whales and other marine fauna.

Given the low probability of visual detection of beaked whales even in good sea conditions, real-time mitigation methods proposed in the EIA require increasing probability of detection by using passive acoustic monitoring systems with detectors programmed for automated classification of beaked whale vocalizations. Automatic detections can then be checked by trained personnel to take decisions about initiation of mitigation protocols.

B.3.5. Species not listed on the CMS Appendices that should also be considered during assessments

All beaked whales not currently listed by CMS seem to be particularly vulnerable to anthropogenic marine noise.

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B.4. Mysticetes

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Consider when assessing

- Military sonar
- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Playback and Sound Exposure Experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- Agreement on the Conservation of Cetaceans of the Black Seas Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS)
- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)
- MOU for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (Pacific Islands Cetaceans)

Related modules

- Refer also to modules B.12 and C when assessing impact to mysticetes

B.4.1. Species Vulnerabilities

Mysticete whales are all known to rely upon acoustic communication to mediate critical life history activities, including social interactions associated with breeding, raising young, migration and foraging (Edds-Walton 1997, Clark 1990). Research into the hearing capabilities of mysticetes, based primarily on anatomical modelling indicate that mysticetes, as a group, are possibly capable of hearing signals from a minimum of approximately 7 Hz ~ 22 kHz (Southall *et al* 2007). This range of frequencies spans many sources of anthropogenic noise in the ocean, excluding only the highest frequency sonar systems and pinger systems > 25 kHz (Hildebrand *et al* 2009). Previous research has documented impacts of noise exposure to physiology, behaviour, and habitat usage in mysticetes (Richardson *et al* 1995, Nowacek *et al* 2007, Tyack 2008).

Physiological impacts have been documented in mysticetes in response to noise exposure. This includes strong evidence of a decrease in physiological stress levels in North Atlantic right whale associated with a reduction in shipping noise (Rolland *et al* 2012). Techniques are currently under development to allow testing of acute stress responses to short-term high amplitude noise exposure (Hunt *et al* 2013).

Behavioral impacts have been documented in mysticetes in response to a variety of noise sources over the past three decades. This includes evidence of military sonar affecting movement, foraging and acoustic behaviour (Miller et a. 2000, Tyack 2009, Goldbogen *et al* 2013), Seismic survey and air guns affecting movement and acoustic behaviour (Malme *et al* 1988, Di Iorio and Clark 2010, Castellote *et al* 2012), Vessel noise affecting foraging, social and acoustic behaviour (Melcon *et al* 2012), and response to playback of predator and/or alarm stimuli (Cummings and Thompson 1971, Dunlop *et al* 2013, Nowacek *et al* 2004)

Habitat impacts have been documented in a number of cases. Previous studies have documented abandonment of habitat areas during periods of intense noise. One of the earliest documented cases occurred when commercial dredging and shipping activities resulted in abandonment of a critical calving ground in gray whales for the duration of human activities in an enclosed shallow water bay (Bryant *et al* 1984). Seismic surveys have resulted in large-scale, temporary, displacements of mysticete whales away from regions of seismic exploration in the Mediterranean (Castellote *et al* 2012). A further concern, of long-standing (Payne and Webb 1971), is the potential for even relatively low amplitude anthropogenic noise raising the background noise to a degree that it significantly reduces the range of communication for mysticetes. Recent studies have demonstrated the potential degree of masking experienced by mysticetes in urbanized habitat areas due to vessel traffic (Clark *et al* 2009, Hatch *et al* 2012). This is a major concern to result in chronic erosion of suitable habitat conditions through raising the baseline background noise levels.

B.4.2. Habitat Considerations

Based on previous studies, mysticetes show variable response to noise exposures in different habitat areas, possibly linked to differences in the behavioural states and/or the availability of suitable alternative habitats (Nowacek *et al* 2007). Most mysticete whales

show some level of seasonal migratory behaviours (Corkeron and Connor 1999), therefore many habitats may seasonably pose relatively higher or lower risk depending on presence or absence of particular species. Calving grounds, breeding grounds, and foraging grounds are seasonally vulnerable areas for which there may not be suitable alternate habitat for many species, and would be of particular concern to highly endangered populations with limited available critical habitat areas.

Studies of responsiveness to noise exposure have been conducted on calving and breeding grounds (Miller *et al* 2000), on migratory corridors (e.g. Malme *et al* 1988, Tyack 2009, Dunlop *et al* 2013), and on foraging grounds for a variety of species (Di Iorio and Clark 2010, Parks *et al* 2011, Goldbogen *et al* 2013). Studies of migrating whales indicate that individuals may be highly responsive to noise exposure during migration, but may be able to deviate around acoustic disturbance without significant changes to the migratory distance (Malme *et al* 1988, Tyack 2009, Dunlop *et al* 2013).

The greatest data gaps regarding relative risk by habitat and season come from the facts that a) many species only have been tested in one type of habitat area and b) detection of an overt behavioural response may not truly indicate disturbance if animals are unable or unwilling to leave the habitat for foraging or breeding purposes. Also, for several species there is little known on the location of biologically important habitats (breeding, calving and fishing grounds).Future research to assess physiological responses to the same acoustic disturbance in multiple habitat areas are needed to have a high level of confidence regarding the actual impacts of noise exposure to mysticetes.

B.4.3. Impact of Exposure Levels

Relatively little data are available regarding the hearing abilities of mysticetes. Much of the current level of understanding comes from either anatomical modelling studies (Ketten 2000) or indirectly through interpretation of behavioural responses of mysticetes to controlled exposure experiments (Mooney *et al* 2012). A thorough review of exposure criteria for behavioural responses for mysticetes is summarized in Southall *et al* (2007). The thresholds for detectable behavioural responses to noise exposure varied by species, location and time of year, giving a wide range of thresholds for responses to multiple pulses and non-pulse signals.

Table 4: TTS and PTS from impulsive and non-impulsive noise sources for mysticetes (NOAA 2016)

Metric	TTS onset		PTS onset	
	Impulsive	Non-impulsive	Impulsive	Non-impulsive
SEL cum 24h	n/a	179 dB	183 dB	199 dB
dB peak	224 dB	n/a	219 dB	n/a

B.4.4. Assessment Criteria

Based on an extensive body of literature on the effects of noise on mysticetes (including physiology, behaviour and temporary habitat abandonment), a number of detailed criteria should be considered to assess potential risk of an signal generating activity. These include:

- Amplitudes, signal structure (pulse, multi-pulse, non-pulse), and anticipated cumulative time of exposure.
- Vulnerability of the species or sustainable 'take' – Some mysticete species and stocks are highly endangered, and warrant additional consideration if proposed activities have any potential to cause impacts at any level.
- Seasonal variability in the potential risk due to migratory timing of occupancy (can activities be seasonally shifted to minimize overlap with mysticete presence in critical habitat areas?).
- Data on noise exposure studies of target species, or closely related species, with similar signal type
- Comparison of the proposed acoustic exposure relative to the ambient, background levels and spectra of environmental noise (i.e. relatively low level noise exposure may be more significant in acoustically 'pristine' habitats).
- Consideration of potential cumulative effects of an additional introduction of sound into the environment (i.e. increase in potential for masking, increase in duration of exposure on daily and/or seasonal scales).

B.4.5. Species not listed on the CMS Appendices that should also be considered during assessments

Several of the CMS Appendix I and II species have not previously been studied regarding responses to noise exposure.

In particular, relatively little is known regarding the acoustic behaviours of sei whale, *Balaenoptera borealis*, Antarctic minke whale, *Balaenoptera bonaerensis*, Bryde's whale, *Balaenoptera edeni* and Omura's whale, *Balaenoptera omurai*.

In addition to the species listed in CMS Appendix I and II gray whale, *Eschrichtius robustus*, should be considered, due to recent documentation of individuals in 'novel' habitats including multiple confirmed sightings in the Atlantic Ocean (McKeon *et al* 2016) and severely threatened stocks in the Eastern Pacific (Rugh 2005).

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B.5. Pinnipeds

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Consider when assessing

- Military sonar
- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- Agreement on the Conservation of Seals in the Wadden Sea (Wadden Sea seals)
- MOU Concerning Conservation Measures for the Eastern Atlantic Populations of the Mediterranean Monk Seal (*Monachus monachus*) (Atlantic monk seals)

Related modules

- Refer also to modules B.10, B.12 and C when assessing impact to pinnipeds

B.5.1. Species Vulnerabilities

Pinnipeds are sensitive to sound in both air and under water, therefore, they are likely to be susceptible to the harmful effects of loud noise in both media. Recent research has revealed that many pinnipeds have a better hearing sensitivity in water than was previously believed. (Southall *et al*, 2000, 2008, Reichmuth *et al*, 2013)

In developing guidelines for underwater acoustic threshold levels for the onset of permanent and temporary threshold shifts in marine mammals, NOAA has been considering two pinniped families: Phocidae and Otariidae. Phocid species have consistently been found to have a more acute underwater acoustic sensitivity than otariids, especially in the higher frequency range. This reflects the fact that phocid ears are better adapted underwater for hearing than those of otariids, with larger, more dense middle ear ossicles. (NOAA, 2016) The effective auditory bandwidth in water of typical Phocid pinnipeds (underwater) is thought to be 50 Hz to 86 kHz while for Otariid pinnipeds (underwater) it is 60 Hz to 39 kHz (NOAA, 2016). The draft NOAA guidelines do not pertain to marine mammal species under the U.S. Fish and Wildlife Service's jurisdiction, including the third family of pinnipeds: Odobenidae (walrus), which means there is no update on the auditory bandwidth of walrus.

Behavioural responses to anthropogenic noise have been documented in a number of different pinnipeds at considerable ranges indicating the need for precautionary mitigation (Kelly *et al*, 1988) In addition to noise-induced threshold shifts, behavioural responses have included seals hauling out (possibly to avoid the noise) (Bohne *et al*, 1985, 1986, Kastak *et al* 1999) and cessation of feeding (Harris *et al*, 2001).

It is likely that pinniped foraging strategies also place them at risk from anthropogenic noise. Some pinnipeds forage at night, others transit to foraging locations by swimming along the bottom, and many dive to significant depths or forage over significant distances (Fowler *et al*, 2007, Villegas-Amtmann *et al*, 2013, Cronin *et al*, 2013) with Australian sea lions foraging offshore out to 189 km (Lowther *et al*, 2011).

In most respects, noise-induced threshold shifts in pinnipeds follow trends similar to those observed in odontocete cetaceans. Unique to pinnipeds are their vibrissae (whiskers), which are well supplied with nerves, blood vessels and muscles, functioning as a highly sensitive hydrodynamic receptor system (Miersch *et al*, 2011). Vibrissae have been shown to be sufficiently sensitive to low frequency waterborne vibrations to be able to detect even the subtle movements of fish and other aquatic organisms (Renouf, 1979, Hanke *et al*, 2012, Shatz and Groot, 2013). Ongoing masking through ensonification may impede the sensitivity of vibrissae and the animal's ability to forage.

It is possible that even if no behavioural reaction to anthropogenic noise is evident, masking of intraspecific signals may occur. (Kastak and Schusterman, 1998)

B.5.2. Habitat Considerations

Spatial displacement of pinnipeds by noise has been observed (e.g Harris *et al*, 2001), however observations are too sparse and definitely require greater attention to be understood in ways that can inform management. Such displacement is likely to have serious consequences if affecting endangered species in their critical habitats, such as Mediterranean monk seals in Greece or Turkey. Displacement can cause the temporary loss of important habitat, such as feeding grounds, forcing individuals to either move to

sub-optimal feeding location, or to abandon feeding altogether. Noise can also reduce the abundance of prey (refer to modules on fin-fish and cephalopods in these guidelines).

Displacement can also reduce breeding opportunities, especially during mating seasons. Foraging habitat and breeding seasons are therefore important lifecycle components of pinniped vulnerabilities. In particular, the periods of suckling and weaning are vulnerable times for both mothers and pups.

Many pinnipeds species exhibit high site fidelity. For some there is little or no interchange of females between breeding colonies, even between those separated by short distances, such as in Australian sea lions, *Neophoca cinerea* (Campbell *et al*, 2008). Site fidelity has implications to the risk of local extinction, especially at sites with low population numbers (e.g monk seals).

Some species of pinnipeds can range far offshore and because they are difficult to sight and identify at sea their offshore foraging may only be revealed by telemetry studies. These studies usually involve tagging individuals that might come ashore hundreds or even thousands of miles from offshore foraging habitats.

B.5.3. Impact of Exposure Levels

Onset of temporary threshold shift (TTS) and permanent threshold shift (PTS) for impulsive and non-impulsive noise, and at peak levels (for instantaneous impact) as well as sound exposure levels (SEL) accumulated over a 24 hour period based on the latest updates of the NOAA acoustic guidelines (NOAA, 2016), are summarized in the tables that follow (right).

Walrus, *Odobenus rosmarus*, hearing is relatively sensitive to low frequency sound, thus the species is likely to be susceptible to anthropogenic noise. (Kastelein *et al*, 2002) TTS and PTS levels can be inferred from Southall *et al*, (2007) for Odobenidae.

Kastelein *et al*, 2002 has drawn useful general observations by comparing hearing studies of the California sea lion, *Zalophus californianus*, harbour seal, *Phoca vitulina*, ringed seal, *Pusa hispida*, harp seal, *Pagophilus groenlandicus*, northern fur seal, *Callorhinus ursinus*, gray seal, *Halichoerus grypus*, Hawaiian monk seal, *Monachus schauinslandi* and northern elephant seal, *Mirounga angustirostris* to those of walrus. The high frequency cut-off of walrus hearing is much lower than other pinnipeds tested so far. The hearing sensitivity of the walrus *Odobenus rosmarus*, between 500 Hz and 12 kHz is similar to that of some phocids. The walrus, is much more sensitive to frequencies below 1 kHz than sea lion species tested. (Kastelein *et al*, 2002) Other sensitive pinnipeds such as harbour seals (about 20 dB more sensitive to signals at 100 Hz than California sea lions) and elephant seal, *Mirounga angustirostris* and *Mirounga leonine*, are also more likely to hear low-frequency anthropogenic noise. (Kastak and Schusterman, 1998)

Assessment should consider that routine deep-divers, that dive to or below the deep sound channels, may be exposed to higher sound levels than would be predicted based on simple propagation models. Assessment should also consider convergence zones which may result in areas with higher sound levels at greater ranges.

Table 5: TTS and PTS from impulsive and non-impulsive noise sources for phocidae (from NOAA 2016)

Metric	TTS onset		PTS onset	
	Impulsive	Non-impulsive	Impulsive	Non-impulsive
SEL cum 24h	170dB	181dB	185dB	201dB
dB peak	212dB	n/a	218dB	218dB

Table 6: TTS and PTS from impulsive and non-impulsive noise sources for otariidae (from NOAA 2016)

Metric	TTS onset		PTS onset	
	Impulsive	Non-impulsive	Impulsive	Non-impulsive
SEL cum 24h	188dB	199dB	203dB	219dB
dB peak	226dB	n/a	232dB	232dB

Table 7: TTS and PTS from impulsive and non-impulsive noise sources for odobenidae (from Southall *et al* 2007)

Metric	TTS onset		PTS onset	
	Impulsive	Non-impulsive	Impulsive	Non-impulsive
SEL cum 24h	171dB	171dB	186dB	203dB
dB peak	212dB	212dB	218dB	218dB

B.5.4. Assessment Criteria

There have been surprisingly few studies of the effects of anthropogenic noise, particularly from seismic surveys, on pinnipeds (Gordon *et al*, 2003).

The lack of evidence of dramatic effects of anthropogenic noise on pinnipeds, in contrast to the well-known mortality incidents with some cetaceans, does not necessarily mean that noise has negligible consequences on pinniped conservation, and more attention should be dedicated to achieving a better understanding of possible impacts. For instance, some pinnipeds may not appear to have been physically displaced by loud noise, moving instead to the sea surface, but these animals may be effectively prevented from foraging, due to an ensonified foraging environment.

It is important that assessment of impact for pinnipeds considers both the physiological impact (TTS and PTS) as well as the very real possibility of masking, causing both behavioural responses and making prey less available.

B.5.5. Species not listed on the CMS Appendices that should also be considered during assessments

The following species are also sensitive to anthropogenic marine noise:

- walrus, *Odobenus rosmarus*
- harbour seal, *Phoca vitulina*
- northern elephant seal, *Mirounga angustirostris*
- southern elephant seal, *Mirounga leonine*
- Caspian seal, *Phoca caspica*
- Australian sea lion, *Neophoca cinerea*
- Hawaiian monk seal, *Neomonachus schauinslandi*

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B.6. Polar Bears

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Consider when assessing

- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Playback and sound exposure experiments
- Pingers and other noise-generating activities

Related modules

- Refer also to modules B.1 and B.5 when assessing impact to polar bears

B.6.1. Species Vulnerabilities

There are two studies of polar bear hearing, showing that polar bears have hearing similar to humans, and that best sensitivity was shown between 11.2 – 22.5 kHz (Nachtigall *et al* 2007), and 8 – 14 kHz (Owen and Bowles 2011).

There have not been many specific studies of polar bears and noise. It has been shown that polar bears in Spitsbergen are disturbed by snowmobiles and can show strong behavioural reactions on a distance of 2-3 km, females with cubs showing stronger reactions at longer distance than adult males (Andersen and Aars 2008).

Polar bear would be highly vulnerable when hunting, as they are hunting for seals and depend on stealth, either by sneaking up on seals or by waiting at seal breathing holes in the ice (Stirling 1974, Stirling and Latour 1978). Studies indicate that denning females could be somewhat protected from noise from seismic air guns, although they could be vulnerable if sound sources are within close proximity of the den (less than 100 m) (Blix and Lentfer 1992).

B.6.2. Habitat Considerations

Polar bear's essential habitat is sea ice. Polar bears would prefer to stay on sea ice covering shallow and productive shelf areas (Durner *et al* 2009, Schliebe *et al* 2006). There would be particular concerns associated with all activities that have an impact in areas which resource selection functions have shown are preferred sea ice habitat for polar bears (Durner *et al* 2009).

Some models project an ice-free Arctic Basin in summer in just a few years from now, before 2020 (Maslowski *et al* 2012), and modelling studies have shown that most subpopulations will be reduced and experience large environmental stress (Amstrup *et al* 2008, Hamilton *et al* 2014).

Although not exclusively associated with specific habitats, there are certain activities that might be a concern. Some industrial activities are located in important habitat, of special concern is oil drilling activities on sea ice in productive sea areas, and the prospect of new developments of petroleum exploration in critical habitat, especially in North America. It must be noted that there are little or no specific studies of the effect of noise or manmade sound on polar bears, thus the level of impact is to a large degree inferred from general expert knowledge of the effect of disturbance on these animals.

Future impact from disturbance from sound exposure needs to be focused on denning areas in spring, and areas of sea ice and glacier fronts that are used by females with cubs-of-the-year to find food immediately after den emergence. Arctic areas in northern Canada, bordering to the Arctic Basin are generally the areas where one expects sea ice habitat to persist for the longest period (Amstrup *et al* 2007).

B.6.3. Impact of Exposure Levels

Given the specific vulnerability of polar bears to habitat loss, the exposure level of polar bears, especially in denning areas in spring, and areas of sea ice and glacier fronts that are used by females with cubs-of-the-year to find food immediately after den emergence should be prioritized.

B.6.4. Assessment Criteria

An assessment of the future impact of noise would have to take into account the dramatically decreasing area of critical sea ice habitat, in some areas the length of the ice-free period from ice melt in spring till ice freeze-up in fall, has increased by more than 140 days in the period 1979-2015 (Laidre *et al* 2015).

A minimum would be that EIAs on impact of sound would assess to what extent sound exposure would be detrimental to reproductive success by directly considering the effect of sound in denning areas and productive sea ice areas in the vicinity of denning areas, and also areas of sea ice over productive shelf areas.

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B.7. Sirenians

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Consider when assessing

- Military sonar
- Seismic surveys
- Civil high power sonar
- Coastal construction works
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- MOU Concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia (West African Aquatic Mammals)
- MOU on the Conservation and Management of Dugongs (*Dugong dugon*) and their Habitats throughout their Range (Dugong)

B.7.1. Species Vulnerabilities

Even though traditional ecological knowledge and field observations (Marsh *et al* 1978, Hartman 1979) suggest that sirenians (manatees and dugongs) have 'exceptional acoustic sensitivity', scientific research on their hearing and reactions to marine noise is relatively sparse. Published hearing studies are based on the Florida manatee, *Trichechus manatus latirostis*, while behavioural studies on reactions to noise are limited to the Florida manatee, the Antillean manatee, *Trichechus manatus*, and the dugong, *Dugong dugon*. Although most of this research is limited to sounds in water, behavioural observations indicate that sirenians are capable of detecting some sounds in air above the surface (Hartman 1979).

Evoked potentials recorded for Florida manatees (Bullock *et al* 1982, Mann *et al* 2005) demonstrated variable sensitivity over a range of frequencies from about 200Hz to 35–40 kHz with greatest sensitivity in the lower range at 1–1.5 kHz. In-water behavioural audiograms of four captive Florida manatees identified the frequency range of best hearing as 6 to 32 kHz (Gerstein *et al* 1999, Gerstein 2002, Gaspard *et al* 2012), with individual variation within this range. Peak hearing sensitivity has been variously reported as 16-18 kHz (Gerstein *et al* 1999, Gerstein 2002) and 8 kHz (Gaspard *et al* 2012). Gaspard *et al* (2012) also reported that one of their test animals appeared to be able to hear loud sounds as low as 0.25 kHz and ultrasonic frequencies as high as 90.5 kHz. Gerstein *et al* (1999) speculated that the greater sensitivity to higher frequencies observed in their audiogram research may be an adaptation that enabled manatees to avoid the complications associated with perceiving sound reflections propagated from the water–air interface (Lloyd mirror effect) in the shallow depths typical of their habitats, raising the interesting question of what these animals can hear when at the surface.

Both Gerstein (1999) and Gaspard *et al* (2012) conducted in-water behavioural experiments on captive Florida manatees to measure critical ratios. The differences in their results likely reflect both their different experimental protocols and individual differences in the manatees' responses. Gaspard *et al* (2012) found that the manatees have relatively narrow auditory filters and struggle to hear lower and higher pitched sounds above background noise. However, manatee hearing was much sharper at 8 kHz – the frequency at which manatees communicate – where they could still distinguish tones that were only 18.3 dB louder than the background. This estimate of the manatee's critical ratio (8 kHz) is among the lowest measured in mammals (Gaspard *et al* 2012) suggesting that generic marine mammal impact guidelines may not be appropriate for sirenians.

Field studies show that both the Florida manatee (Miksis-Olds *et al* 2007) and the dugong (Hodgson and Marsh 2007) exhibit short-term behavioural responses to noise. Miksis-Olds and Wagner (2010) showed that elevated sound levels affect the patterns of behaviour of the Florida manatee and that the response is a function of the manatee's behavioural state. When ambient sounds were highest, the manatees spent more time feeding and less time milling. In contrast, Hodgson and Marsh's (2007) experimental and behavioural studies showed that the time that dugongs spent feeding and travelling was unaffected by boat presence, the number of boat passes and whether a pass included a stop and restart. However, focal dugongs were less likely to continue feeding if the boat passed within 50 m, than if the boat passed at a greater distance. Boats passing at a range of speeds, and at distances of less than 50 m to over 500 m evoked mass movements of dugong feeding herds, but such movements only lasted a

couple of minutes. Castelblanco-Martínez and Arévalo-González (2015) experimentally studied the effects of side-scan sonar operating 455 kHz on the behaviour of 12 captive Antillean manatees. All the observed manatees variously showed behavioural changes including stopping foraging and feeding, significantly reducing displacement and remaining still at the bottom or at the surface, and increasing displacement behaviour. One male displayed continuous spinning movements for almost the entire experimental session. Most animals avoided the area nearest to the transducer.

Sirenians are not wilderness animals (Marsh *et al* 2011). Manatees occur in the inshore waters of Florida and have continued to use the intra-coastal waterway and residential canal estates, despite a high level of vessel activity (for references see Marsh *et al* 2011). Dugongs continue to use Johore Strait between Singapore and Peninsula area, one of the most heavily-used coastal waterways in the world, and are often detected in ports and military training areas along the Queensland east coast on the basis of their feeding trails and satellite tracking (Marsh *et al* 2011, Cleguer *et al* 2016). Hodgson *et al* (2007) experimentally tested the behavioural responses of dugongs to 4 and 10 kHz acoustic alarms (pingers). The rate of decline of the number of dugongs within the focal arena did not change significantly while pingers were activated. Dugongs passed between the pingers irrespective of whether the alarms were active or inactive, fed throughout the experiments and did not change their orientation to investigate pinger noise, or their likelihood of vocalizing. Thus despite the short-term behavioural responses noted above, there is no evidence that wild dugongs or Florida manatees are displaced by underwater noise, including side scan sonar (Gonzalez-Socoloske *et al* 2009). The reaction of dugongs and manatees to plosive sounds does not appear to have been formally tested.

Both manatees and dugongs use underwater sound for communication. There have been numerous studies of sirenian communication sounds (see Marsh *et al* 2011) Characteristics of individual call notes seem fairly similar among the species of sirenians. Frequency ranges are typically from 1 to 18 kHz, often with harmonics and non-harmonically related overtones (e.g Anderson and Barclay 1995, Sousa-Lima *et al* 2002, O'Shea and Poche 2006).

Adults of both sexes produce vocalizations, but exchanges of communication calls are most common between cows and their nursing calves. Florida manatee calves vocalize at much greater rates than adults (Sousa-Lima *et al* 2002, O'Shea and Poche 2006). Manatees other than cows and calves vocalize at rates that vary with activity and behavioural context, and are lowest during resting, intermediate while travelling, and highest at nursing and other social situations (Reynolds 1981, Bengtson and Fitzgerald 1985, Williams 2005, O'Shea and Poche 2006, Miksis-Olds and Tyack 2009). Dugongs seem to vocalize more often during dark, early morning hours (Ichikawa *et al* 2006). No data are available on vocal communication in African manatees, *Trichechus senegalensis*, although recordings and sound spectrograms of calls of an isolated captive calf in Cote d'Ivoire were similar to those of some Florida and Amazonian manatee calves (TJ O'Shea unpublished). Florida manatees may alter vocalization parameters in response to environmental noise levels (Miksis-Olds and Tyack 2009). Sakamoto *et al* (2006) attempted to quantify the effect of vessel noise on the vocal characteristics of dugongs (number of call per minute, dominant frequency and call duration). None of the changes was significant.

We know of no information regarding PTS, TTS or noise-induced auditory damage in sirenians.

B.7.2. Habitat Considerations

In the marine environment, both manatees and dugongs mostly occur in shallow waters because of their dependence of seagrass communities (Marsh *et al* 2011). Antillean and African manatees are both riverine and estuarine and in the marine environment mainly occur in water less than 5 m deep. Dugongs are strictly marine, feeding in waters up to about 35 m deep. They may occasionally cross ocean trenches (see Marsh *et al* 2011), but typically spend most of their lives in much shallower inshore coastal and island waters often commuting with the tide to or from intertidal seagrass meadows (Marsh *et al* 2011). There is increasing evidence that dugong migration corridors follow topographic features such as coastlines (Zeh *et al* 2016 in press) or reef crests (Cleguer 2015).

B.7.3. Impact of Exposure Levels

Given that the available evidence suggests that manatees and dugongs are unlikely to be displaced by noise, the most practical approach to reducing the risk of impacts is avoidance of the overlap of acute sound impacts with seasonal aggregation sites

and periods when the animals are likely to be under stress. Seasonal aggregation sites are most likely at the high latitude limits of the ranges of dugongs and manatees and typically occur as a behavioural repose to thermal conditions or prolonged periods of rough weather (see Marsh *et al*, 2002 and 2011 for details of some well-known sites in Florida, Australia and the Arabian region). Site-specific information on this topic should be a focus of the Environmental Impact Assessment process. Extreme weather events such as cyclones or prolonged cold fronts can cause substantial increases in mortality (Marsh *et al* 2011, Meager and Limpus 2013) and noisy construction impacts should be planned to avoid times of likely environmental stress.

B.7.4. Assessment Criteria

We know of no field studies on the effects of anthropogenic noise, other than vessel noise on sirenians. The effect of vessel noise *per se* seems much less than that of vessel collisions. This lack of evidence does not prove that noise has negligible consequences for sirenian conservation, and more attention should be dedicated to a better understanding of possible impacts and ways to ameliorate them. A precautionary approach to the exposure of manatees and dugongs to noise, especially at key habitats and aggregation sites, is warranted.

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B.8. Marine and Sea Otters

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Consider when assessing

- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related modules

- Refer also to modules B.10, B.12 and C when assessing impact to marine and sea otters

B.8.1. Species Vulnerabilities

The marine otter, *Lontra feline*, and sea otter, *Enhydra lutris*, are amphibious marine mammals that may be vulnerable to coastal anthropogenic disturbance. Auditory thresholds for sea otters have been measured in air and underwater from 125 Hz to 40 kHz. Critical ratios data indicate that although sea otters can detect underwater sounds, their hearing appears to be primarily air adapted and not specialized for detecting signals in background noise. (Ghoul and Reichmuth 2012, 2014, 2016)

B.8.2. Habitat Considerations

There is little definitive research available about the specific anthropogenic noise vulnerabilities of this species group, but given the frequency range of hearing and the knowledge that these animals are social communicators and benthic foragers, (McShane *et al*, 1995, Leuchtenberger *et al*, 2014, Lemasson *et al*, 2014, Thometz *et al*, 2015) this species group should be considered. Their dependence on restricted nearshore habitats puts sea otters at risk from acoustic disturbance and activities occurring both on land and at sea. (Ghoul and Reichmuth 2016)

B.8.3. Impact of Exposure Levels

Ghoul and Reichmuth (2016) have conducted the only known assessment of sea otter hearing sensitivity. They found that hearing was most sensitive at 8 and 16 kHz, where measured thresholds were the lowest at 69 dB re 1 μPa. The range of best sensitivity in water spanned ~4.5 octaves, from 4 to 22.6 kHz. The roll-off in high-frequency hearing was typically steep and had a 28-dB increase within a half-octave frequency step. Low-frequency hearing (0.125–1 kHz) was notably poor. The sea otter was unable to detect signals below 100 dB re 1 μPa within this frequency range. Noise spectral density levels in the underwater testing enclosure were sufficiently low to ensure that the measured thresholds were not influenced by background noise, especially at frequencies above 0.5 kHz, where noise levels were below 60 dB re 1 μPa/√Hz. (Ghoul and Reichmuth 2016)

B.8.4. Assessment Criteria

Regulators estimating zones of auditory masking for sea otters should follow the guidance given for other marine mammals and opt for conservative estimates until additional data are available. (Southall *et al*, 2000)

B.8.5. Species not listed on the CMS Appendices that should also be considered during assessments

Sea otters, *Enhydra lutris*, are classified by IUCN as Endangered, and should also be considered during assessments.

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B.9. Marine Turtles

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Consider when assessing

- Military sonar
- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- MOU Concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa (Atlantic marine turtles)
- MOU on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (IOSEA)

Related modules

- Refer also to modules B.12 and C when assessing impact to marine turtles

B.9.1. Species Vulnerabilities

Although the ecological role of hearing has not been well studied for sea turtles, hearing capacity has been inferred from morphological and electrophysiological studies. (Southwood *et al*, 2008)

Sea turtles do not have an external ear, in fact, the tympanum is simply a continuation of the facial tissue. Researchers have speculated that the cochlea and saccule are not optimized for hearing in air, but rather are adapted for sound conduction through two media, bone and water. Recent imaging data strongly suggest that the fats adjacent to the tympanal plates in at least three sea turtle species are highly specialized for underwater sound conduction. (Moein Bartol and Musick, 2003)

Hearing range (50-1200 Hz: Viada *et al*, 2008, Martin *et al*, 2012, Popper *et al*, 2014) coincides with the predominant frequencies of anthropogenic noise, increasing the likelihood that sea turtles might experience negative effects from noise exposure.

At present, sea turtles are known to sense low frequency sound, however, little is known about the extent of noise exposure from anthropogenic sources in their natural habitats, or the potential impacts of increased anthropogenic noise exposure on sea turtle biology. Behaviour responses have been clearly demonstrated. (Samuel *et al*, 2005)

Prolonged exposure could be highly disruptive to the health and ecology of the animals, encouraging avoidance behaviour, increasing stress and aggression levels, causing physiological damage through either temporary or even permanent threshold shifts, altering surfacing and diving rates, or masking orientation cues. (Samuel *et al*, 2005)

B.9.2. Habitat Considerations

Sea turtles have been shown to exhibit strong fidelity to fixed migratory corridors, habitual foraging grounds, and nesting areas (Avens *et al*, 2003), and such apparent inflexibility could prevent sea turtles from selecting alternate, quieter habitats.

The potential of noise for displacing turtles from their favoured or optimal habitat is unknown, but if it were to occur it could have negative consequences on growth, orientation, etc.

B.9.3. Impact of Exposure Levels

Sea turtles are low frequency specialists, but their range appears to differ between populations. Animals belonging to one population of subadult green turtles have been shown to detect frequencies between 100-500 Hz with their most sensitive hearing between 200-400Hz. Another responded to sounds from 100-800 Hz, with their most sensitive range being 600-700Hz. Juvenile Kemp's ridley turtles had a range of 100-500Hz, with their most sensitive hearing been 110-200Hz. (Moein Bartol and Ketten, 2006)

B.9.4. Assessment Criteria

It is important that assessment of impact for sea turtles both considers the physiological impact (TTS and PTS) as well as the very real possibility of masking prey movements. Some sea turtles may not appear to noise-generating industries to have been physically displaced by loud noise but these animals may be effectively prevented from foraging, due to an ensonified foraging environment. Possible effects of distribution (avoidance behaviour) orientation, and even communication (e.g in the hatching phase) cannot be discounted.

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B.10. Fin-fish

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Consider when assessing

- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons

Related CMS agreements

- Agreement on the Conservation of Cetaceans of the Black Seas Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS)
- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)
- MOU for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (Pacific Islands Cetaceans)
- MOU Concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia (West African Aquatic Mammals)
- Agreement on the Conservation of Seals in the Wadden Sea (Wadden Sea seals)
- MOU Concerning Conservation Measures for the Eastern Atlantic Populations of the Mediterranean Monk Seal (*Monachus monachus*) (Atlantic monk seals)
- MOU Concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa (Atlantic marine turtles)
- MOU on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (IOSEA)
- MOU on the Conservation of Migratory Sharks (Sharks)

Related modules

- Refer also to modules B.12 when assessing impact to fish

B.10.1. Species Vulnerabilities

The use of explosives will kill fin-fish inside a certain range (Yelverton *et al* 1975), with impact zones given in Popper *et al* (2014). Intense non-explosive, impulse noise such as pile driving or seismic surveys may impact adult fin-fish by: a) creating physiological damage such as rupturing gas spaces (ie. Halverson *et al* 2012), b) damaging sensory systems (McCauley *et al* 2003), c) creating adverse behavioural responses (e.g. Pearson *et al* 1996, McCauley *et al* 2003, Slotte *et al* 2004, Fewtrell and McCauley 2012, Hawkings *et al* 2014), d) masking the reception of signals of interest, or e) disrupting prey physiology, behaviour or abundance. For fin-fish the sustained but less intense noise from vessels or offshore construction activities may commonly produce behavioural impacts or masking of communication signals as indicated above. Fin-fish exposed to lower level, man-made noise for suitable time periods may receive damage to hearing systems and so suffer a loss of fitness.

There is an enormous amount of variability in the degree of sophistication of fin-fish hearing systems and habits which may pre-dispose or protect them from impacts of man-made noise sources, thus it is difficult to generalize known impacts across all fin-fish species with a high degree of confidence. In general terms: explosives routinely cause fin-fish deaths out to some range and sub-lethal injuries beyond this, pile driving is known to produce serious physiological and organ damage to fin-fish at short range, in some cases marine seismic surveys with air guns have produced hearing damage to fin-fish while in other cases such damage has not been observed, and most man-made noise sources are capable of producing fin-fish behavioural or masking impacts to some degree. Behavioural response to an approaching noise source by fin-fish seems to be reasonably generic, pelagic fin-fish tend to move downwards to eventually lie close to the seabed or flee laterally while site-attached fish may initially seek shelter in refuges or flee. At least some species of fin-fish do habituate to continual and stationary low level noise as they readily colonize man-made offshore facilities. The longer-term implications of consistent behaviour changes or slight physiological impairment from intense signals produced by seismic surveys are not well understood.

Many fin-fish form aggregations at specific times and places to spawn and produce fertilized eggs. Such aggregations may be spaced across several months or may occur only on few occasions per season. Many fin-fish species produce communication sounds as part of such aggregations (ie. McCauley 2001). Disruptions to such fin-fish spawning aggregations by excessive noise causing physiological or behavioural changes and which overlaps a large fraction of the species' seasonal spawning period will have deleterious

impacts on the following years reproductive output.

All fin-fish are dependent on smaller prey species which may be impacted by man-made noise sources. Prey may include fin-fish or invertebrates. In general terms small, common, fin-fish prey species, such as sardines, herring or pilchards, have well developed sensory systems thus may be equally or more vulnerable to exposure to intense man-mad noise than the larger fin-fish which prey on them. The response of marine invertebrates to intense signals such as seismic survey noise, are poorly known so it is difficult to draw conclusions or comparisons on how invertebrate prey fields will be impacted by noise exposure. Any changes to prey fields induced by a man-made noise source will impact fauna, possibly negatively, higher up the food chain.

All impacts of man-made noise sources on fin-fish need to be gauged at the population level. Noise sources which produce short term impacts, localized impacts compared with a species range, or which do not overlap well with habitats or time and spatial overlap of spawning periods would be expected to be of low severity form a population perspective, and vice versa.

B.10.2. Habitat Considerations

Fin-fish occupy an enormous variety of habitats, from deep ocean depths, pelagic systems, reefs and shoals, estuarine waters to inland waterways. Some fish may utilize multiple habitats on a seasonal or life cycle basis. In general terms habitats which are enclosed, such as estuaries, bays or reefs for site attached fin-fish, may be more susceptible to exposure by intense sound sources as the fin-fish have little options to escape the source. By contrast fin-fish that occupy physically larger spaces, such as oceanic species, have more options of where to flee and may be less constrained by the implications of moving geographical regions to avoid a noise source.

B.10.3. Impact of Exposure Levels

Known impacts of intense impulse noise exposure on fin-fish include consistencies in fish behavioural response to sound, but many anomalies. For high-energy impulse signals, such as seismic survey signals, the following can be said:

Fish behaviour most often changes at some range near to an approaching seismic vessel and generalized changes include diving, lateral spread or fleeing an area (e.g. Pearson *et al* 1996, McCauley *et al* 2003, Slotte *et al* 2004, Fewtrell and McCauley 2012, Hawkings *et al* 2014).

Fish behaviour is strongly impacted by an approaching seismic source above received levels of 145–150 dB re 1 μPa^2.s (SEL) (McCauley *et al* 2003), which equates to around 2–10 km using measured air gun arrays > 2000 cui.

Avoidance to an approaching seismic vessel by fish may be partly driven by the fish behavioural state, with feeding fishes appearing to be more tolerant and in one instance not showing avoidance to an approaching seismic survey vessel (Penä *et al* 2013).

Catch rates in some fisheries are altered during and after seismic operations, prolonged seismic can cause large-scale displacement of fish resulting in decreased fish abundance in and near a seismic operations area and increased fish abundance at long range (tens of km) from the seismic operations area (Engås *et al* 1996, Slotte *et al* 2004),

Long-term monitoring of reef fish community structure before and after a seismic survey programme showed no large-scale change in community structure (Miller and Cripps 2013) and fish sound production behaviour (chorusing) continued after a seismic programme with no apparent long-term change (McCauley 2011),

Exposure to accurately emulated repeated pile driving signals suggest physical injury (organ damage) arises at levels equivalent to 1920 strikes at 179 dB re 1 μPa^2.s or 960 strikes at 182 dB re 1 μPa^2.s, or an equivalent single strike SEL of 210–211 dB re 1 μPa^2.s (Halvorsen *et al* 2012).

In a review of experimental findings of sound on fishes Popper *et al* (2014) present sound exposure guidelines for fin-fish in the form of estimated levels at which the following occur: 1) mortality and potential mortal injury, 2) impairment – recoverable injury, 3) impairment – TTS, 4) impairment – masking, and 5) behavioural changes. They present these impacts for three categories of fin-fish, 1) no swim bladder, 2) swim bladder present but no links to otolith system, or 3) swim bladder present with links to otolith system, plus sea turtles and eggs/larvae. Popper *et al* (2014) present this data for sources of explosives, pile driving, air gun arrays, sonar and shipping. Given the lack of experimental evidence for most of these categories they were forced to: 1) either extrapolate from another exposure type, animal group or both, and 2) rather than presenting threshold levels often present the subjectively evaluated likelihood of an impact type occurring at 'near' (tens of m),

'intermediate' (hundreds of m) and 'far' (thousands of m) ranges. The thresholds listed for physical injury (mortality and impairment-recoverable injury) for pile driving and seismic air gun signals are the same, being primarily based on the pile driving work of Halverson *et al* (2012). Readers are referred to Popper *et al* (2014) for the particular thresholds for a fin-fish and sound exposure type as the reader should see their text for the reasoning and caveats behind the values presented.

B.10.4. Assessment Criteria

In assessing impacts of a noise source on fin-fish any EIA document should consider species which:

- are important for commercial fisheries,
- are listed as threatened, vulnerable or are endemic to an area,
- can be considered as important 'bait fish' or are important as prey species for higher order fauna,
- have limited ability to flee an intense noise source,
- utilize a noise impacted area for specific purposes such as feeding or spawning events.

In considering impacts of underwater noise on a species of fin-fish, factors which must be taken into account include:

- hearing capabilities of the species in question including knowledge of morphological adaptations to increase hearing capability, noting fin-fish primarily respond to motion of the water particles and less to measures of sound pressure. Fin-fish have a diverse range of morphological adaptations to improve hearing capability,
- studies of known impacts on this species,
- studies of known impacts on related species either taxonomically, morphologically or in general terms if no other comparison is available (ie. pelagic fishes, benthic fishes etc),
- particular spatial and temporal features which are critical to that fin-fish population's survival (ie. specific feeding areas or prey types, spawning locations and periods).

For migratory fin-fish impact assessment must consider if a noise producing action may cause a species to leave an area and if so, the consequences of this to the species in question, for other fauna and for commercial fisheries which target that species.

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B.11. Elasmobranchs

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Consider when assessing

- Military sonar
- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- MOU on the Conservation of Migratory Sharks (Sharks)

Related modules

- Refer also to modules B.10 and B.12 when assessing impact to elasmobranchs

B.11.1. Species Vulnerabilities

Elasmobranchs as a group are poorly studied in relation to the potential impact of anthropogenic sounds, although several studies over time have been directed at particular species of shark to improve knowledge of their hearing mechanisms, abilities and implications for management. From as early as the 1960s (e.g. Nelson and Gruber, 1963), studies have shown that large sharks (*Carcharhinidae*, *Sphyrnidae*), in their natural environment, were attracted to low-frequency (predominantly 20 to 60 Hz) pulsed sounds, but apparently not to higher frequency (400 to 600 Hz) pulsed sounds, or to low-frequency continuous sounds. More recent research has established the hearing range of sharks to be between 40 Hz to approximately 800 Hz (Myrberg 2001), with possible limits for elasmobranchs in general at 20–1000 Hz (Casper and Mann, 2006, 2010).

Noise within the sharks' audible range may be produced by several anthropogenic sources such as shipping, underwater construction, pile driving, dredging, power stations and sonic surveys. It has been suggested that loud sounds in their audible range may repel sharks whereas low sounds may attract them (Francis and Lyon, 2013), probably as these latter mimics sounds emitted by struggling prey. Response likely depends on its distance from the source and the volume of the source.

Although more recent research in elasmobranch hearing and impacts in the wild have been sparse at best, and nonexistent for most species, there is evidence of habituation or at least no negative reaction to noise levels and frequencies from small boats operating recreational diving or from SCUBA divers' noises, even when these are regularly present and arising from many sources (Lobel, 2009 and personal observations by the author of this summary).

It is likely that elasmobranchs might suffer more impacts from noise through the effects it has on its prey species (Popper and Hastings, 2009, Carlson, 2012), and perhaps through acute events that impact concentration sites such as social groupings of hammerhead sharks, *Sphyrna* spp., and white sharks, *Carcharodon carcharias*, around offshore islands, as well as those gathering at coral reef habitats, in these cases, displacement may occur, either temporary or permanent, although again lack of adequate field research prevents any definitive conclusions. Several studies (eg Klimley and Myrberg 1979, Banner 1972, Myrberg *et al* 1978) indicate that elasmobranchs show consistent withdrawal from sources that are at close range and when confronted with sudden onset of transmissions. However they may habituate to these too if events become frequent (Myrberg, 2001). Seismic activities, pylon-driving operations, explosive construction work and activities involving similar pulsed sound emissions are likely therefore to have the most impact on elasmobranch species directly.

B.11.2. Habitat Considerations

Several species of elasmobranchs exhibit some type of site-fidelity, either permanent or seasonal. This has been observed in particular regarding species of interest to the dive industry. Some species of shark (eg whitetip, *Triaenodon obesus*, blacktip, *Carcharinus melanopterus*, and grey reef, *Carcharhinus amblyrhynchos*) and the reef manta, *Manta alfredi*, are particularly attached to coral reef environments, while others exhibit seasonal concentration around offshore islands (eg hammerheads, *Sphyrna lewini*, at Galápagos, Cocos and Malpelo Islands, white sharks, *Carcharodon carcharias*, at Guadalupe and Farallon Islands, whale sharks, *Rhincodon typus*, at Holbox, Mexico, and several other sites). Giant mantas *Manta birostris* also can be found in seasonal concentrations such as in Revillagigedo Islands in Mexico, Laje de Santos in Brazil and La Plata in Ecuador.

Seasons for these aggregations vary from site to site and by species and need to be assessed on a case by case basis.

Acoustic impacts which might severely affect vulnerable or complex habitats such as coral reefs or mangrove forests (essential nursery areas for some shark and ray species) are certain to have an effect on its elasmobranch fauna if it includes displacement or damage to prey species and any physical disruption of the habitat. Seasonal concentration areas for sharks and rays can be particularly vulnerable to acute acoustic disturbance, which may result in abandonment of the area or disruption of gregarious behaviour whose implications are yet not fully understood. Acute acoustic disturbances such as seismic or sonic surveys and any activity involving explosives in or around these critical habitats (coral reefs, offshore islands and other known seasonal concentration sites, key feeding grounds) are likely to have serious impacts on elasmobranch populations.

Although migration paths are still poorly understood for most species, recent satellite tagging research (e.g. Domeier and Nasby-Lucas, 2008) has begun to reveal some consistent patterns and as yet unknown concentration areas away from above-water topographic features. These areas likely represent additional vulnerability corridors where protection from acute acoustic disturbance should be incorporated into management actions.

B.11.3. Impact of Exposure Levels

As a group, elasmobranchs have been poorly represented in field studies on acoustics, with most knowledge available for more “visible” species such as large sharks. For these, observed impacts refer mostly to short-term avoidance responses to loud, sudden bursts of sound in their audible range, although there´s evidence that the regularity of such sounds might lead to habituation (see references above).

Given that bony fish, which make the majority of prey species for most sharks, may be severely impacted by sound, especially in loud bursts (eg Carlson, op. cit.), it is perhaps this indirect effect on prey that holds the most severe potential for generating impacts on shark populations.

There is insufficient information to assess long-term impacts or behavioral changes in elasmobranchs from anthropogenic noise that might affect survivability of species. Existing studies indicate that the most direct negative impact on the animals seems to be displacement by sonic outbursts, while longer-term exposure often seems to lead to habituation.

B.11.4. Assessment Criteria

From available data it seems that there are two main aspects of potential impacts on elasmobranchs that merit particular consideration: displacement or elimination of prey species and displacement or disruption of behaviour associated with specific sites by sound bursts. Given that detailed studies are mostly lacking, a precautionary approach to the exposure of elasmobranchs to noise, especially at key habitats and aggregation sites, is warranted. In particular activities involving the use of equipment or methods that generate loud sonic outbursts near known or estimated aggregation areas, or which might physically injure or displace prey, need to be carried out with adequate assessment (including baseline surveys for elasmobranch species and their prey) and mitigation measures as feasible and appropriate. Also, proposed activities that alter or impact keys habitats such as coral reefs, mangroves or offshore islands with known aggregations of elasmobranch species should be carried out with extreme caution and this group of species should be explicitly considered in studies and proposed management measures to reduce potential impacts.

B.11.5. Species not listed on the CMS Appendices that should also be considered during assessments

In general, listed species include those for which several acoustic and hearing studies exist, but as for the entire group detailed acoustic impact studies are lacking. The development and collation of more detailed data on a species by species basis could greatly help improve our understanding of the impacts of anthropogenic noise on their physiology and life cycles. Lack of information on most elasmobranch species is an impediment to the provision of any meaningful advice on species not listed on the CMS Appendices,

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B.12. Marine Invertebrates

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Consider when assessing

- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- Agreement on the Conservation of Cetaceans of the Black Seas Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS)
- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)
- MOU for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (Pacific Islands Cetaceans)
- MOU Concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia (West African Aquatic Mammals)
- Agreement on the Conservation of Seals in the Wadden Sea (Wadden Sea seals)
- MOU Concerning Conservation Measures for the Eastern Atlantic Populations of the Mediterranean Monk Seal (*Monachus monachus*) (Atlantic monk seals)
- MOU Concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa (Atlantic marine turtles)
- MOU on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (IOSEA)
- MOU on the Conservation of Migratory Sharks (Sharks)

Related modules

- Refer also to modules B.10 when assessing impact to marine invertebrates

B.12.1. Species Vulnerabilities

Very little is known about effects of anthropogenic noise on invertebrates (Morley *et al*, 2014). This includes more than 170,000 described species of multicellular marine invertebrates in spite of their ecological and economic importance worldwide (Anderson *et al*, 2011). Most research targets molluscs (e.g. cephalopods, shellfish) and crustaceans (e.g. crabs, shrimps, barnacles) (reviewed in Aguilar de Soto, 2016).

Molluscs:

Two atypical mass-strandings involving nine giant squids, *Architeuthis dux*, were associated with seismic surveys co-occurring in nearby underwater canyons where this species concentrates (Guerra *et al*, 2004, 2011). Two specimens suffered extensive multiorganic damage to internal muscle fibres, gills, ovaries, stomach and digestive tract. Other squids were probably disoriented due to extensive damage in their statocysts. Damage to the sensory epithelium was also observed in four species of coastal cephalopods (*Sepia officinalis*, *Loligo vulgaris*, *Illex coindetii* and *Octopus vulgaris*) by exposure to two hours of low-frequency sweeps at 100 per cent duty cycle (André *et al*, 2011, Solé, 2012, Solé *et al*, 2013). Fewtrell and McCauley (2012) reported that squid, *Sepioteuthis australis*, exposed to seismic pulses from a single air gun showed signs of stress such as significant increases in the number of startle and alarm responses, with ink ejection in many cases, increased activity and changing position in the water column.

Delayed and abnormal development as well as an increase in mortality rates in eggs and larvae of shellfish exposed to noise have been recorded in two species. New Zealand scallop larvae, *Pecten novaezelandiae*, exposed to playbacks of low frequency pulses in the laboratory showed significant developmental delays and developed body abnormalities (Aguilar de Soto *et al*, 2013). The number of eggs of sea hares, *Stylocheilus striatus*, that failed to develop at the cleavage stage, as well as the number that died shortly after hatching, were significantly higher in a group exposed to boat noise playback at sea compared with playback of ambient noise (Nedelec *et al*, 2014). In contrast, playbacks of ship-noise enhanced larval settlement in the mussel, *Perna canaliculus* (Wilkens *et al* 2012) while seemed to increase biochemical indicators of stress in adult mussels (*Mytilus edulis*) (Wale *et al* 2016).

Crustaceans:

Stress responses were observed in aquarium-dwelling brown shrimp, *Crangon crangon*, exposed to ambient noise of some 30 dB higher than normal at 25–400 Hz (Lagardere, 1982, Regnault and Lagardere,

1983). Shrimps did not seem to habituate throughout the experiment. Similarly, shore crabs, *Carcinus maenas*, increased metabolic consumption and showed signals of stress when exposed to playbacks of ship noise in the laboratory. Crustacean larvae seem to differ in their sensitivity to noise: larval dungeness crabs, *Metacarcinus magister*, did not show significant differences in survival nor in time-to-moult when exposed to a single pulse from a seven air gun array, even at the higher received level of 231 dB re 1µPa (Pearson *et al*, 1994). In contrast, larvae of other crab species, *Austrohelice crassa* and *Hemigrapsus crenulatus* megalopae, exposed to playbacks of noise from tidal turbines tended to suffer significant delays in time-to-moult (Pine *et al*, 2012) and low-frequency noise exposure inhibited settlement of early larvae of barnacle, *Balanus amphitrite* (Branscomb and Rittschof, 1984). The apparent contradiction in the larval responses from different species of crustaceans may be due, among other things, to the experimental set-up (wild versus laboratory, one pulse versus a continuous exposure), the biology of the species, or the characteristics of the sound treatment. Cellular and humoral immune responses of marine invertebrates to noise have also been examined. In the European spiny lobster, *Palinurus elephas*, exposure to sounds resembling shipping noise in the laboratory affected various haematological and immunological parameters considered to be potential health or disease markers in crustaceans (Celi *et al*, 2014).

B.12.2. Habitat Considerations

Marine invertebrates inhabit a range of habitats. Mainly, they may live associated to the seafloor (benthic or bentho-pelagic species) or free in the water column (pelagic). Many species have an initial pelagic phase as larvae, useful for dispersion, before finding suitable habitat for settling into their adult life. Sound from preferred habitats is one of the cues used by larvae to find a suitable location to settle (Stanley *et al* 2012). Once they settle, many species have limited capabilities to move fast enough at distances required to avoid noise exposure, due to morphological constrains or to territorial behaviour.

Species associated to the seafloor will be more exposed to ground-transmission of noise. This is especially relevant for intense low frequency sounds directed towards the seafloor, typical of seismic surveys. Seismic pulses coupled with the seafloor and low frequency vibrations can travel long distances through the ground and can re-radiate to the water depending on the structure and composition of the seafloor. Marine invertebrates are sensitive to the particle motion component of sound, more than to the pressure wave, they are well suited to detect low frequency vibrations because these are used, for example, to identify predators and prey.

The variability in the extent of barotrauma experienced by different giant squid stranding at the same time, in coincidence with the same seismic survey (Guerra *et al* 2004, 2011), underlines the difficulties inherent in predicting noise-induced damage to animals in the wild. Here, some giant squid suffered direct mortality from barotrauma, while the death of others seemed to be caused by indirect effects of physiological and behavioural responses to noise exposure. Direct injury (barotrauma) can be explained by some animals being exposed to higher sound levels due to complex patterns of sound radiation creating zones of convergence (Urick, 1983) of the seismic sound waves reflected by the sea surface/sea floor, and possibly by the walls of the steep underwater canyons in the area where the seismic survey took place.

Marine invertebrates often have discrete spawning periods. It is unknown if eggs/larvae have a greater vulnerability to sound-mediated physiological or mechanical stress, or even particular phases of larval development when larvae undergo metamorphosis.

Metamorphosis involves selective expression of genes mediating changes in body arrangement, gene expression is susceptible to stress, including from noise. Spawning periods are key for the recruitment of marine invertebrates and thus should be considered when planning activities.

B.12.3. Impact of Exposure Levels

There are no data about thresholds of pressure or particle motion initiating noise impacts on marine invertebrates. Studies have found a range of physiological effects (reviewed in Aguilar de Soto and Kight 2016) but there are no dose-response curves identifying levels of impact onset. Moreover, most studies report only sound pressure level, while particle motion is relevant for the effects of noise on these species. At a distance from an acoustic source (in the far-field) the pressure and particle motion components of sound are easily predicted in a free homogeneous environment such as the water column. In contrast, in the near-field animals may experience higher particle motions than would be expected for the same pressure level in the far-field. Intense underwater sound

sources such as air guns, pile driving, sonar and blasting have back-calculated peak source levels ranging from 230 to, in the case of blasting, >300 dB re 1 µPa at 1m. These activities routinely ensonify large areas with sound pressure levels higher than the thresholds of response observed in different studies of noise-impacts on marine invertebrates. For example, a seismic array with an equivalent source level of 260 dB pk-p re 1 µPa at 1m will produce levels in excess of 160 dB_{rms} over hundreds of km-squared. This level was measured in an experiment reporting noise-induced developmental delays and malformations in scallop larvae (Aguilar de Soto *et al* 2013). But the particle velocities experienced by the larvae in the experiment (about 4-6 mm s^{-1} RMS) imply higher far-field pressure levels of some 195-200 dB_{rms} re 1 µPa, reducing the potential impact zone to only short ranges from the source. However, there are several reasons why larvae in the wild may be impacted over larger distances than these approximate levels suggest. Given the strong disruption of larval development reported, weaker but still significant effects can be expected at lower exposure levels and shorter exposure durations. Moreover, low frequency sounds propagate in complex sound fields in which convergence zones and re-radiation of sound transmitted through the sea-floor can create regions with high sound levels far from the source (Madsen *et al* 2006). The sound field experienced by an organism is a complex function of its location with respect to the sound source and acoustic boundaries in the ocean necessitating *in situ* measurements to establish the precise exposure level.

B.12.4. Assessment Criteria

Benthic marine invertebrates often have little movement capabilities further than a few metres, limiting their options to avoid exposure to anthropogenic noise. In the case of intense low frequency noise, e.g. seismic or pile driving, it is essential to consider ground-transmission. For example, during a seismic survey animals will be exposed to sound received from the air gun array passing over the location of the animals, but these invertebrates will be receiving at the same time ground-transmitted vibrations originated by previous seismic pulses. Thus, animals will experience waves arising from the water and from the ground, differing in phase and other parameters. Complex patterns of wave addition mean that in some cases vibrations will sum, increasing the levels of sound exposure to the animals. Because ground vibrations may travel tens of kilometres or more, the time that benthic invertebrates will be exposed to a given threshold of pressure or particle motion will be increased when we consider seafloor transmission. An alternative source for seismic surveys (©Vibroseis) is currently being tested. In contrast to usual seismic surveys transmitting pulses every 6 to 15 s from an air gun array towed by a ship near the sea-surface, Vibroseis is towed near the seafloor and emits continuously, but at lower peak level. Thus, duty cycle increases to 100 per cent. EIA of Vibroseis and other low frequency sound sources should include modelling particle motion in the target area and consider exposures to benthic fauna.

Results of experiments about effects of noise on catch rates of marine invertebrates have not shown significant effects: Andriguetto-Filho *et al* (2005) did not find changes on catches of shrimps after the passage of a small air gun array. No effects of seismic activities on catches of rock-lobsters were found either by Parry *et al* (2006) performing a long-term analysis of commercial data. In contrast, fishermen have blamed seismic sources for mortalities of scallops and economic losses due to reduced catch rates.

Despite uncertainties about how noise may affect marine fauna and fisheries, several countries have already implemented regulations that reduce overlap between seismic surveys and fishing activities (mainly of fin-fish). However, these regulations do not address concerns of noise effects on eggs and larvae, i.e. that noise might affect stock recruitment and thereby cause delayed reductions in catch rates.

Marine invertebrates form the base of the trophic-web in the oceans, providing an important food source for fish, marine mammals and humans. In addition to direct effects to adults, noise exposure during critical growth intervals may contribute to stock vulnerability, underlining the urgency to investigate potential effects of acoustic pollution on marine invertebrates at different ontogenetic stages. Moreover, recent results investigating the effects of noise on a range of marine invertebrate species call for applying the precautionary principle when planning activities involving high-intensity sound sources, such as explosions, construction, pile driving or seismic exploration, in spawning areas/times of marine invertebrates with high natural and economic value.

B.12.5. Species not listed on the CMS Appendices that should also be considered during assessments

Some large cephalopods are migratory, including the giant squid, *Architeuthis sp* (Winkelmann *et al* 2013). Given the vulnerability of this species to acoustic sources, it should also be considered during assessments.

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C. Decompression Stress

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Decompression sickness (DCS, 'the bends') is a disease associated with gas uptake at pressure. As hydrostatic pressure increases with depth, the amount of nitrogen (N_2) that is absorbed by the blood and tissues increases, resulting in higher dissolved gas tensions that could at maximum reach equilibrium with the partial pressure of N_2 in the lungs. This is a long-known problem for human divers breathing pressurized air, but has often been discounted as a problem for breath-hold divers since they dive on only a single inhalation (Scholander 1940). However, for free-diving humans and other air-breathing animals, tissues can become highly saturated under certain circumstances depending on the iterative process of loading during diving and washout at the surface (Paulev 1967, Lemaitre *et al* 2009). During decompression, if the dissolved gas tension in the tissues cannot equilibrate fast enough with the reducing partial pressure of N_2 in the lungs, tissues will become supersaturated, with the potential for gas-bubble formation (Francis and Mitchell 2003).

Breath-hold diving vertebrates were previously thought to be relatively immune to DCS due to their multiple anatomical, physiological and behavioural adaptations (Fahlman *et al* 2006, Fahlman *et al* 2009, Hooker *et al* 2012). However, recent observations have shown that marine mammals and turtles may be affected by decompression sickness under certain circumstances (Jepson *et al* 2005, Dennison *et al* 2012, Van Bonn *et al* 2013, Garcia-Parraga *et al* 2014). Of most concern, however, are the beaked whales, which appear to be particularly vulnerable to anthropogenic stressors that may cause decompression sickness (Jepson *et al* 2003, Cox *et al* 2006, D'Amico *et al* 2009, Hooker *et al* 2009, Hooker *et al* 2012).

C.1.1. Bubble Formation

Among marine mammals, both acute and chronic gas emboli have been observed. The formation of bubbles has been suggested as a potential explanation for lesions coincident with intravascular and major organ gas emboli in beaked whales that mass stranded in conjunction with military exercises deploying sonar (Jepson *et al* 2003, Fernandez *et al* 2005). There is some controversy about the proximate cause of the gas emboli (Hooker *et al* 2012) although it is widely agreed that it appeared to be linked to man-made acoustic disturbance. However, these types of lesions have also been reported in some single-stranded cetaceans for which they do not appear to have been immediately fatal (Jepson *et al* 2005, Bernaldo de Quirós *et al* 2012, Bernaldo de Quirós *et al* 2013). Looking at species-specific variability in bubble presence among stranded animals, the deeper divers (Kogia, Physeter, Ziphius, Mesoplodon, Globicephala, and Grampus) appeared to have higher abundances of bubbles, suggesting that deep-diving behaviour may lead to a higher likelihood of decompression stress (Bernaldo de Quirós *et al* 2012).

In addition, osteonecrosis-type surface lesions have been reported in sperm whales (Moore and Early 2004). These were hypothesized to have been caused by repetitive formation of asymptomatic N_2 emboli over time and suggest that sperm whales live with sub-lethal decompression induced bubbles on a regular basis, but with long-term impacts on bone health. Bubbles have also been observed from marine mammals bycaught in fishing nets, which died at depth (Moore *et al* 2009, Bernaldo de Quirós *et al* 2013). These bubbles suggested the animals' tissues were supersaturated sufficiently to cause bubble formation when depressurized (as nets were hauled). B-mode ultrasound has also shown bubbles in stranded (common and white-sided) dolphins, which showed normal behaviour after release and did not re-strand, and so appeared to tolerate this bubble formation (Dennison *et al* 2012). Cerebral gas lesions have also been observed using Magnetic Resonance Imaging in California sea lions,

Zalophus californianus, admitted to a rehabilitation facility (Van Bonn *et al* 2011, Van Bonn *et al* 2013).

It therefore appears that gas supersaturation and bubble formation may occur more routinely than previously thought. These cases highlight a growing body of evidence that marine mammals are living with blood and tissue N_2 tensions that exceed ambient levels (Moore *et al* 2009, Bernaldo de Quirós *et al* 2013). However, our understanding of how marine mammals manage their blood gases during diving, and the mechanism causing these levels to become dangerous is very rudimentary (Hooker *et al* 2012). Some perceived threats appear to cause a behavioural response that may override normal N_2 management, resulting in decompression sickness, stranding and death.

C.1.2. Sources of Decompression Stress

There is a documented association between naval active sonar exercises and beaked whale mass strandings (Frantzis 1998, Evans and England 2001, Jepson *et al* 2003). However, a comprehensive review of beaked whale mass strandings (D'Amico *et al* 2009) suggests that some strandings may be associated with other events. It therefore seems likely that other high-intensity underwater sounds may also present conservation concerns for these species (Taylor *et al* 2004). Indeed, ship-noise also appears to cause a behavioural response disrupting foraging behaviour in Cuvier's beaked whales, *Ziphius cavirostris* (Soto *et al* 2006).

The process of diving causes oxidative stress (Hermes-Lima and Zenteno-Savin 2002). Episodic regional lack of oxygen and abrupt reperfusion upon re-surfacing creates a situation where post-ischemic reactive oxygen species (ROS) and physiological oxidative stress are likely to occur. However, a link between oxidative stress and DCS has not yet been confirmed (Wang *et al* 2015).

C.1.3. Source Frequency, Level and Duration

Understanding the responses of cetaceans to noise is a two-stage process: (1) understanding the noise required to cause the behavioural modification and (2) understanding the physiological mechanism by which that behavioural modification causes harm to the animal. At present, almost all research has focussed on the first of these, i.e. work evaluating playback and response, and almost nothing is known about how this response then leads to decompression stress.

Several recent studies have found similar behavioural responses of a small number of beaked whales to sonar signals (Tyack *et al* 2011, DeRuiter *et al* 2013, Stimpert *et al* 2014, Miller *et al* 2015). These studies have shown that beaked whales respond behaviourally to sonar and other human and natural stimuli, typically showing a combination of avoidance and cessation of noise-production associated with foraging (Table 8). Responses to simulated sonar have started at low received levels. These types of behavioural changes were also documented in work monitoring vocal activity using Navy range hydrophones (Tyack *et al* 2011, Moretti *et al* 2014). This type of 'flight' response could, if catastrophic, disrupt the normal physiological mechanisms of these animals, leading to DCS.

C.1.4. Assessment Criteria

At the planning stage, the primary mitigation method to reduce issues of decompression stress would be to reduce the interactions of stressor and animals (i.e. to reduce the number of "takes"). This can be done by placing any high-intensity noise into areas without high densities of species of concern. Thus proposals should take account of all survey and modelling information sources to predict areas of likelihood of high/low species density, and attempt to reduce the number of impacted animals by designing operations only for areas of low animal density.

To supplement this, or in areas in which such species densities are unknown, baseline studies should be conducted. Beaked whales are particularly difficult to monitor visually (surfacing for as little as 8 per cent of the time), but have more reliable detection acoustically (vocalising for 20 per cent of the time, de Soto *et al* 2012). Hydrophone arrays can detect animals at 2-6km distances (Moretti *et al* 2010, Von Benda-Beckmann *et al* 2010).

During the activity, real-time monitoring of animal presence should be conducted. This can be done using visual and acoustic monitoring, with detections within a specified range of the activity resulting in cessation of the sound source. On-board visual or towed hydrophone monitoring allows only limited detection distance and thus limits mitigation effectiveness.

Monitoring over a wider area can be achieved using hydrophone arrays placed on the seafloor (Moretti *et al* 2010). Such hydrophone arrays allow detection over a wide

but static area. Dynamic monitoring over a wide area could potentially be achieved using acoustic drones, allowing near real-time hydrophone arrays to be placed over a greater area to ensure more effective assessment of species presence prior to any disturbance event.

Modelling of animal likelihood and distance from the source should be carried out in order to aim to minimize received levels (Table 1), thus reducing the risk of animals receiving too high a dose which might incur DCS/death.

C.1.5. Species not listed on the CMS Appendices that should also be considered during assessments

Beaked whales, *Ziphius cavirostris* (Appendix I) and *Hyperoodon* spp and *Berardius* spp (Appendix II) require additional consideration. These species appear particularly vulnerable to noise impacts. 20 species of *Mesoplodon* are currently missing from the CMS Appendices and yet are likely to also be vulnerable to noise impacts. All of these species are likely to be particularly sensitive to decompression stress.

Of other deep diving species which may potentially be at increased risk of decompression stress, *Kogia* are currently not listed on either of the CMS Appendices, *Physeter* is listed on Appendices I and II, *Globicephala* on Appendix II, and Grampus should also be considered during assessments.

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Table 8: Responses of beaked whales to sound sources

Species	Sound source	Response observed as received level (dB re. 1µPa)
Cuvier's beaked whale, *Ziphius cavirostris* (DeRuiter *et al* 2013)	30 min playback of 1.6s MFA sonar signal repeated every 25 sec. Initial source level of 160 dB re 1 mPa-m was increased ('ramped up') by 3 dB per transmission to a maximum of 210 dB re 1 mPa-m.	89-127
Cuvier's beaked whale, *Ziphius cavirostris* (Soto *et al* 2006)	Maximum broadband (356 Hz–44.8 kHz) level received during the ship passage was 136 dB rms re 1 µPa, approx. 700m away.	106 (in click frequency range)
Northern bottlenose whale, *Hyperoodon ampullatus* (Miller *et al* 2015)	104 1-s duration 1–2 kHz upsweep pulses (naval sonar signals) at 20s intervals. The source level of the sonar pulses increased by 1 dB per pulse from 152 to 214 dB re 1 µPam over 20min (61 pulses), and the remaining pulses were transmitted for 15min at a source level of 214 dB re 1 µPa m.	107
Baird's beaked whale, *Berardius bairdii* (Stimpert *et al* 2014)	Simulated mid-frequency active (MFA) military sonar signal at 3.5-4 kHz, transmitting 1.6 s signal every 25 s. The initial source level of 160 dB re: 1 mPa was increased by 3 dB per transmission for the first 8 minutes to a maximum of 210 dB for 22 additional minutes (72 transmissions total over 30 minutes).	127
Blainville's beaked whale, *Mesoplodon densirostris* (Tyack *et al* 2011)	Simulated 1.4 s MFA sonar, killer whale and noise signals. MFA sonar had both constant frequency and frequency modulated tonal components in the 3–4 kHz band repeated every 25 s. Initial source level of 160 dB re 1 mPa-m was increased ('ramped up') by 3 dB per transmission to a maximum of 210 dB re 1 mPa-m.	138

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D. Exposure Levels

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D.1. Impact of Exposure Levels and Exposure Duration

One of the first comprehensive definitions of exposure criteria for noise impact on marine mammals considering two types of impacts, namely auditory injury and behavioural disturbances by three sound types (single pulse, multiple pulse and nonpulse) has been published by Southall *et al* (2007). Just recently, the National Oceanic and Atmospheric Administration (NOAA) compiled and synthesized best available science to guide the assessment of effects of anthropogenic noise on marine mammals (NOAA, 2016). Both guidance documents consider cetaceans and pinnipeds assigned to five functional hearing groups (i.e. low-frequency cetaceans, mid-frequency cetaceans, high-frequency cetaceans, pinniped in water, pinnipeds in air and low-frequency cetaceans, mid-frequency cetaceans, high-frequency cetaceans, phocid pinnipeds underwater, otariid pinnipeds underwater respectively). The assignment to functional hearing groups was based on functional hearing characteristics of the species (e.g. frequency range of hearing, auditory morphology) and with reference to Southall *et al* as well the medium in which the amphibious living pinnipeds were exposed to sound. The developed noise exposure criteria do not address polar bears, sirenians, and sea otters due to the absence of necessary data in these species. To account for different hearing bandwidths and thus differences in impacts of identical noise exposure frequency-weighting functions were developed for each functional hearing group and considered in the formulation of the noise exposure criteria. Southall *et al* and NOAA applied dual criteria for noise exposure using peak sound pressure level (SPL) and sound exposure level (SEL) in each of the considered functional hearing groups in order to account for all relevant acoustic features such as sound level, sound energy, and exposure duration that influence the impacts of noise on marine mammals.

The onset of a permanent threshold shift (PTS-onset) has been considered as the onset of auditory injury (Southall *et al* 2007, NOAA 2016, Finneran 2015). PTS-onset estimates are applied in order to formulate dual noise exposure levels. The PTS-onset thresholds were estimated from measured TTS-onset thresholds (=threshold where temporary change in auditory sensitivity occurs without tissue damage) in very few mid-frequency odontocetes (i.e. bottlenose dolphin and beluga) and pinnipeds (i.e. California sea lion, northern elephant seal, and harbour seal) and extrapolated to other marine mammals due to the scarcity of available TTS data. It has been noted, that this extrapolation from mid-frequency cetaceans and the subsequent formulation of exposure criteria may be delicate in particular for high-frequency cetaceans due to their generally lower hearing threshold as compared to other cetaceans. The growth rates of TTS were estimated based on data in terrestrial and marine mammals exposed to increasing noise levels. Noise exposure levels for single pulse, multipulse and nonpulse sounds were expressed for SPL and SEL whereby the latter has been frequency weighted to compensate for the differential frequency sensitivity in each functional marine mammal hearing group as described above. No noise exposure criteria were developed by Southall *et al* (2007) or NOAA (2016) for the occurrence of non-auditory injuries (e.g. altered immune response, energy reserves, reproductive efforts due to stress, tissue injury by gas and fat emboli), due to a lack of conclusive scientific data to formulate quantitative criteria for any other than auditory injuries caused by noise.

Additionally to auditory injuries Southall *et al* (2007) presented also explicit sound exposure levels for noise impacts on behaviour resulting in significant biological responses (e.g. altered survival, growth, reproduction) for single pulse noise. For the latter it has been assumed that given the nature

(high peak and short duration) of a single pulse behavioural disturbance may result from transient effects on hearing (i.e. TTS). Therefore, TTS values for SPL and SEL were proposed as noise exposure levels. In contrast, for multiple and nonpulse sounds it has been taken into account that behavioural reactions to sounds are highly context-dependent (e.g. activity animals are engaged at the time of noise exposure, habituation to sound) and depending also among others on environmental conditions and physiological characteristics such as age and sex. Thus noise impact on behaviour is less predictable and quantifiable than effects of noise on hearing. Moreover, adverse behavioural effects are expected to occur below noise exposure levels causing temporary loss of hearing sensitivity. Therefore, a descriptive method has been developed by the authors to assess the severity of behavioural responses to multipulse and nonpulse sound. A quantitative scoring paradigm has been developed by Southall *et al* (2007) which numerically ranks (scores) the severity of behavioural responses. Noise exposure levels have been identified in a scoring analysis based on a thorough review of empirical studies on behavioural responses of marine mammals to noise. Reviewed cases with adequate information on measured noise levels and behavioural effects were then considered in a severity scoring table with the two dimensions, severity score and received SPL.

In contrast to former sound exposure assessment attempts Southall *et al* (2007) and NOAA (2016) account for differences in functional hearing bandwidth between marine mammal groups through the developed frequency-weighting functions. Thus, this approach allows to assess the effects of intense sounds on marine mammals under the consideration of existing differences in auditory capabilities across species and groups respectively. Furthermore, as compared to the widely used RMS sound pressure Southall *et al* (2007) and NOAA (2016) propose dual criteria sound metrics (SPL and SEL) to assess the impact of noise on marine mammals, accounting not only for sound pressure but also for sound energy, duration and high-energy transients.

All these aspects are certainly major accomplishment as compared to earlier attempts to assess noise effects on marine mammals. However, it has also to be noted that due to the absence of data noise exposure criteria had to be based on extrapolations and assumptions and therefore, as Southall *et al* (2007) and Finneran (2015) pointed out, caution is needed regarding the direct application of the criteria presented and that it is expected that criteria would change as better data basis becomes available.

D.2. Species Vulnerabilities

The best documented vulnerabilities to noise in marine mammals in terms of number of studies and species involved are certainly behavioural responses to noise. Only a few studies considering a few species exist regarding noise impacts on hearing and hearing sensitivity and physiology in marine mammals and therefore the respective knowledge on specific vulnerabilities of noise is rather scarce.

Auditory effects resulting from intense noise exposure comprise temporary threshold shift (TTS) and permanent threshold shift (PTS) in hearing sensitivity. For marine mammals TTS measurements exist for only a few species and individuals whereas for PTS no such data exist (Southall *et al* 2007, Finneran 2015). Furthermore, noise may cause auditory masking, the reduction in audibility of biological important signals, as has been shown for pinniped species in air and water (Southall *et al* 2000, 2003) and in killer whales (Foote *et al* 2004) for example.

Physiological stress reactions induced by noise may occur in cetaceans as has been shown for few odontocete species where altered neuro-endocrine and cardiovascular functions occurred after high level noise exposure (Romano *et al* 2004, Thomas *et al* 1990c). Furthermore, regarding noise-related physiological effects it has to be noted that scientific evidence indicates that in particular beaked whales experience physiological trauma after military sonar exposure (Jepson *et al* 2003, Fernandez *et al* 2004, 2005) due to in vivo nitrogen gas bubble formation.

The magnitude of the effects of noise on behaviour may differ from biological insignificant to significant (= potential to affect vital rates such as foraging, reproduction, or survival). Noise-induced behaviour response may not only vary between individuals but also intra-individually and depends on a great variety of contextual (e.g. biological activity animals are engaged in such as feeding, mating), physiological (e.g. fitness, age, sex), sensory (e.g. hearing sensitivity), psychological (e.g. motivation, previous history with the sound) environmental (e.g. season, habitat type, sound transmission characteristics) and operational (e.g. sound type, sound source is moving / stationary, sound level, duration of exposure) variables

(Wartzok *et al* 2004).

Observable behavioural responses to noise include orientation reaction, change in vocal behaviour or respiration rates, changes in locomotion (speed, direction, dive profile), changes in group composition (aggregation, separation), aggressive behaviour related to noise exposure and/or towards conspecifics, cessation of reproductive behaviour, feeding or social interaction, startle response, separation of females and offspring, anti-predator response, avoidance of sound source, attraction by sound source, panic, flight, stampede, stranding, long term avoidance of area, habituation, sensitization, and tolerance (Richardson *et al* 1995, Gordon *et al* 2004, Nowacek *et al* 2007, Wartzok *et al* 2004).

Studies have shown that in mysticetes the reaction to the same received level of noise depends on the activity in which whales are engaged in at the time of exposure. For migrating bowhead whales strong avoidance behaviour to seismic air gun noise has been observed at received levels of noise around 120 dB re 1 µPa while engaged in migration. In contrast, strong behavioural disturbance in other mysticetes such as gray and humpback whales as well as feeding bowhead whales has been observed at higher received levels around 150-160 dB re 1 µPa (Richardson *et al* 1985, 1999, Malme *et al* 1983, 1984, Ljungblad *et al* 1988, Todd *et al* 1996, McCauley *et al* 1998, Miller *et al* 2005). Furthermore, in different dolphin species reactions to boat noise varied from avoidance, ignorance and attraction dependant on the activity state during exposure (Richardson *et al* 1995).

Noise-induced vocal modulation may include cessation of vocalization as observed in right whales (Watkins 1986), sperm whales and pilot whales (Watkins and Schevill 1975, Bowles *et al* 1994) for example. Furthermore, vocal response may include changes in output frequency and sound level as well as in signal duration (Au *et al* 1985, Miller *et al* 2000, Biassoni *et al* 2000).

Noise-induced behaviour depends on the characteristics of the area where animals are during exposure and/or of prior history with that sound. In belugas for example a series of strong responses to ship noise such as flight, abandonment of pod structure and vocal modifications, changes in surfacing, diving and respiration patterns has been observed at relatively low received sound levels of 94-105 dB re 1 µPa in a partially confined area but the animals returned after some days while ship noise was higher than before (LGL and Greeneridge 1986, Finley *et al* 1990).

The distance of a noise source or its movement pattern influences the nature of behavioural responses. For instance, in sperm whales, changes in respiration and surfacing rates has been observed in the vicinity of ships (Gordon *et al* 1992) and dependant on whether a ship is moving or not different reactions of bowhead whales and other cetaceans have been observed (Richardson *et al* 1995, Wartzok *et al*, 2004)

D.2.1. Species not listed on the CMS Appendices that should also be considered during assessments

- Deep-diving cetaceans, in particular beaked whales need special consideration regarding noise exposure levels due to the risk for tissue trauma due to gas and fat emboli under certain noise conditions.
- Due to their lower overall hearing thresholds, high-frequency hearing cetaceans (true porpoises, river dolphins, *Pontoporia blainvillei, Kogia breviceps, Kogia sima, cephalorhynchids*) may need additional consideration as their sensitivity to absolute levels of noise exposure may be higher than other cetacean hearing groups.
- Southall *et al* pointed out that due to a lack of data they could not formulate noise exposure levels for polar bears, sea otters, and sirenians. Certainly a point which needs consideration when dealing with areas where these marine mammal taxa occur.

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E. Marine Noise-generating Activities

Geoff Prideaux
Wild Migration

E.1. Military Sonar

E.1.1. Low Frequency Active Sonar

The evolution of lower frequency active (LFA) sonar came from two needs. First, to increase detection ranges to overcome passive sonar systems and second, to compensate for the improvements of stealth designs in submarine hulls, part of which was an anechoic coating that absorbed incident waves. It was discovered this coating was less efficient when exposed to longer wave lengths.

LFA sonars work below the 1KHz range. For transmitting long distances efficiently, high powered modulated signals, typically 240 dB in water at 1m, peak value, (240 dB re 1µPa @ 1m peak) are produced lasting from tens of seconds to sometimes minutes. An example of this technology is the SURTASS-LFA of the US navy that operates within 100-500Hz range. (Lurton, 2010)

E.1.2. Mid Frequency Active Sonar

Mid frequency active (MFA) sonar is used for detecting submarines at moderate range, typically less than 10km.

MFA operates between 1-5 KHz range, with a sound intensity levels typically 235 dB in water at 1m, peak value, (235 dB re 1µPa @ 1m peak) with pulse duration of 1-2 seconds. (Hildebrand, 2009, Fildelfo *et al*, 2009)

E.1.3. Continuous Active Sonar

The concept of continuous active sonar (CAS) is generating interest in the anti-submarine warfare community, largely due to it's 100 per cent duty cycle offering the potential for rapid, continuous detection updates. CAS operates between 500Hz to 3KHz range with sound intensity levels typically 182 dB in water at 1m, peak value, (182 dB re 1µPa @ 1m peak) with a signal duration of 18 seconds (Murphy and Hines, 2015)

E.1.4. Mine Counter Measures Sonar

Underwater mines have proven, over time, to be very affective. There prevalence led to the development of the Mine Counter Measures (MCM) sonar. This system works at very high frequency, usually between 100-500KHz, to achieve high quality acoustic imaging of the sea floor and water column. Targets, semi-buried or suspended from the sea floor, are easily identified. (Lurton, 2010)

E.1.5. Acoustic Minesweeping Systems

Acoustic Minesweeping Systems are another mine counter-measure that produces a low frequency broadband transmission, mimicking the sound produced by certain vessels whereby detonating the mine. (Lurton, 2010)

E.2. Seismic Surveys

The commonly used surveying method for offshore petroleum exploration is 'seismic reflection'. This is simply sound energy discharged from a sound source (air gun array) at the sea surface that penetrates subsurface layers of the seabed and is reflected to the surface where it is detected by acoustic receivers (hydrophones).

These surveys are typically conducted using specially equipped vessels that tow one or more cables (streamers) with hydrophones at constant intervals. Air guns vary in size and in conjunction with the charge pressure, determine the sound intensity level and frequency.

Frequencies used for seismic surveys are between 10-200Hz and down to 4-5Hz for the larger air guns. However, there are unused high frequency components up to 150KHz, with a very high discharge at the onset of the pulse. Sound intensity levels of 170dB in water at 1m, peak to peak value, (170 dB re 1µPa @

1m p-p) at 10KHz down to 120dB in water at 1m, peak to peak value, (120 dB re 1μPa @ 1m p-p) at 100KHz respectively. (Goold and Coates, 2006)

The typical discharge of each pulse of an air gun array is around 260-262 dB in water at 1m, peak to peak value, (260-262 dB re 1μPa @ 1m p-p) (OSPAR, 2009) every 10-15 seconds, and surveys typically run more or less continuously over many weeks. (Urick, 1983, Clay and Medwin, 1997, Caldwell and Dragoset, 2000, Dragoset, 2000, Lurton, 2010, Prideaux and Prideaux, 2015)

E.3. Civil High Power Sonar

Seafloor mapping sonar systems are probably one of the most prolific forms of underwater noise generation. The main application is coastal navigation for the production of bathymetric charts. Other applications include geology, geophysics, underwater cables and oil industry exploration and exploitation. Three examples are Single Beam Sounders (SBES), Sidescan Sonas and Multibeam Echo Sounders (MBES).

E.3.1. Single Beam Sounders

Single beam sounders point vertically below the vessel and transmit a short signal, typically 0.1ms. The frequencies vary on their application. For deep water, the frequency would be around 12KHz and increase to 200, 400 and even 700KHz for shallow water. The sound intensity level is usually around 240 dB in water at 1m, peak value (240 dB *re* 1μPa @ 1m peak). (Lurton, 2010)

E.3.2. Sidescan Sonar

Sidescan sonar system structures are similar to single-beam sonars. This sonar differs as it is installed on a platform or "towfish" and towed behind a vessel close to the seabed. Two antennae are placed perpendicularly to the body of the towfish, pointing fractionally to the sea floor. The transmission of the sidescan sonar insonifies the sea floor with a very narrow perpendicular band. The echo received along time, reflects the irregularities of the sea floor. A simple analogy is the scan mechanism of a photo copier. The operating frequency is usually in the range of many hundreds of KHz with the pulse duration 0.1ms or less. (Lurton, 2010)

E.3.3. Multibeam Echosounder

Multibeam echosounders are the major tool for seafloor mapping, for hydrography and offshore industry applications. The transmission and receiving arrays are mounted on the vessel to create a narrow beam, fan-like 150º spread, perpendicular to the keel.

Multibeam sounders can be put into three main catagories depending on their system structure and varied uses:

- Deep water systems, designed for regional mapping, 12Khz for deep ocean, 30Khz for continental slopes.
- Shallow water systems designed for mapping continental shelves, 70-200KHz and
- High-resolution systems for hydrography, shipwreck location and underwater structural inspection, 300-500Khz.

The attraction for multibeam systems is the scale of area that can be covered over time. For instance, a deep water configured multibeam sounder with a 20km fan/spread can cover 10,000km² per day. (Lurton, 2010)

E.3.4. Boomers, Sparkers and Chirps

Sparkers and boomers are high frequency devices which are generally used to determine shallow features in sediments. These devices may also be towed behind a survey vessel, with their signals penetrating several tens (boomer) or hundred (sparker) of metres of sediments. Typical sound intensity levels of sparkers are approximately 204-210 dB in water at 1m, rms value (204-210 dB re 1 μPa @ 1 m). Deep-tow boomer sound intensity levels are approximately 220 dB in water at 1m, rms value (220 dB re 1 μPa @ 1 m). The frequency range of both is 80Hz-10kHz and the pulse length is 0.2 ms. (Aiello *et al*, 2012, OSPAR, 2009)

Chirps produce sound in the upper frequency range around 20Hz-20 kHz. (Mosher and Simpkin, 1999) The sound intensity level for these devices is about 210-230 dB in water at 1m, peak value, (210-230 dB re 1 μPa @ 1 m) and the pulse length is 250ms. (Dybedal and Boe, 1994, Lee *et al*, 2008, OSPAR, 2009)

E.4. Coastal and Offshore Construction Works

E.4.1. Explosions

Explosions are used in construction and for the removal of unwanted seabed structures. Underwater explosions are one the strongest anthropogenic sound sources and can travel great distances. (Richardson *et al*, 1995) Sound

intensity levels vary with the type and amount of explosive used and the depth to which it is detonated. TNT, 1-100lbs, can produce a sound intensity level from 272-287 dB in water at 1m, zero to peak value, (272-287 dB re 1μPa zero to peak @ 1m) with a frequency range of 2-~1000Hz for a duration of <1-10ms. The core energy is between 6-21Hz. (Richardson *et al*, 1995, NRC, 2003)

E.4.2. Pile driving

Pile driving is associated with harbour work, bridge construction and wind farm foundations. Sound intensity levels vary depending on pile size and type of hammer. There are two types of hammers, an impact type (diesel or hydraulic) and vibratory type. Vibratory type hammers generate lower source levels, but the signal is continuous, where impact hammers are louder and plosive. The upper range is around 228 dB in water at 1m, peak value or 248-257 dB in water at 1m, peak to peak value, (228 dB re 1μPa peak @ 1 m/248-257 dB re 1μPa peak to peak @ 1m) with frequencies ranging within 20Hz-20KHz and a duration of 50ms. (Nedwell *et al*, 2003, Nedwell and Howell, 2004, Thomsen *et al*, 2006, OSPAR, 2009)

E.4.3. Dredging

Dredging is used to extract sand and gravel, to maintain shipping lanes and to route pipelines. The sound intensity level produced is approximately 168-186 dB in water at 1m, rms value, (168-186 dB re 1μPa @ 1m rms) with frequencies ranging from 20Hz->1KHz with the main concentration below 500Hz.

The majority of this sound is constant and non-plosive. (Richardson *et al*, 1995, OSPAR, 2009)

E.5. Offshore Platforms

E.5.1. Drilling

Drilling can be done from natural or manmade islands, platforms, drilling vessels, semi submersibles or drill ships.

For natural or manmade islands, the underwater sound intensity level has been measured at 145 dB in water at 1m, rms value, (145 dB re 1μPa @1m rms) with frequencies below 100Hz. (Richardson *et al*, 1995)

The sound intensity level transmitted down the caissons with platform drilling has been measured at approximately 150 dB in water at 1m, rms value, (150 dB re 1μPa rms @ 1m) at 30-40Hz frequency. (Richardson *et al*, 1995)

Drill ships seem to emit the highest sound intensity level, 190 dB in water at 1m, rms value, (190 dB re 1μPa @ 1m rms) with the frequencies ranging between 10Hz-10KHz, due to the efficient transmission of sound through the ship's hull. Additionally, ships use their location thrusters to keep them on target, combining propeller, dynamic positioning transponder (placed on the hull and sea floor) pingers (see below), and drill noise. (Richardson *et al*, 1995, OSPAR, 2009, Kyhn *et al*, 2014)

E.5.2. Positioning Transponders

Positioning transponders are used to dynamically position drill ships and other offshore platforms. Each system uses a concatenation of master and slave transponders. These systems have been recorded to have sound intensity level of 100 dB in water at 2km, rms value (100 dB re 1μPa @ 2km rms) with the frequencies ranging between 20KHz to 35KHz. (Kyhn *et al*, 2014)

E.5.3. Related Production Activities

During production, noise sources include seafloor equipment such as separators, injectors and multi-phase pumps operating at very high pressures.

There have also been studies to measure the sound intensity levels during production maintenance operations. Sound intensity levels of 190dB rms from the drill ship (distance unknown) with a frequency range between 20Hz-10KHz were recorded. (Kyhn *et al*, 2014) To date there have been no other systematic studies to measure the source levels of production maintenance. It is likely the sound intensity level is high. This is an area that needs focused attention.

E.6. Playback and Sound Exposure Experiments

E.6.1. Ocean Tomography

Ocean science uses a variety of sound sources. These include explosives, air guns and underwater sound projectors. Ocean tomography measures the physical properties of the ocean using frequencies between 50-200Hz with a sound intensity level of 165-220 dB in water at 1m (165-220 dB re 1μPa @ 1m). The *Acoustic Thermometry of Ocean Climate* research programme emitted a sound source of 195 dB in water at 1m, peak value, (195 dB re 1μPa @ 1m peak) at a frequency of 75Hz.

Geophysical research activities, one of which is the study of sediments in shallow water, also use typical mid or low frequency sonar systems or echo-sounders. (OSPAR, 2009) These are discussed under Civil High Power Sonar.

E.7. Shipping and Vessel Traffic

Marine vessels, small to large, contribute significantly to anthropogenic noise in the oceans. The trend is usually, the larger the vessel, the lower the frequencies produced resulting in the noise emitted travelling greater distances. The sound characteristics produced by individual vessels are determined by the vessels class/type, size, power plant, propulsion type/design and hull shape with relation to speed. Also, the vessel's age in terms of mechanical condition and the cleanliness of the hull: Less drag means less noise.

E.7.1. Small Vessels

Small vessels (leisure and commercial) for this paper are vessels up to 50m in length. These include planing hull designs such as jet skis, speed boats, light commercial run-abouts as well as displacement hull designs like motor yachts, fishing vessels and small trawlers.

The greater portion of sound produced by these vessels is mainly above 1KHz mostly from propeller cavitation. Factors that generate frequencies below 1KHz are engine and gearbox noise as well as propeller resonance. The sound intensity level produced is approximately 160-180 dB in water at 1m, rms value, (160-180 dB re 1µPa @ 1m rms) with frequencies ranging 20Hz ->10KHz. This, however, is dependent on the vessel's speed in relation to hull efficiency and economic speed to power settings. (Richardson *et al*, 1995, OSPAR, 2009)

E.7.2. Medium Vessels

Medium vessels for this paper are vessels between 50-100m, such as tugboats, crew-boats, larger fishing/trawler and research vessels. These vessels tend to have slower revving engines and power trains. The frequencies produced tend to mimic large vessels with the majority of sound energy below 1KHz. The sound intensity level produced is approximately 165-180 dB in water at 1m, rms value (165-180 dB re 1µPa @ 1m rms). (Richardson *et al*, 1995, OSPAR, 2009)

E.7.3. Large Vessels

Large vessels for this paper are vessel lengths greater than 100m, such as container/cargo ships, super-tankers and cruise liners.

Large vessels, depending on type, size and operational mode, produce their strongest sound intensity level of approximately 180-190 dB in water at 1m, rms value, (180-190 dB re 1µPa @ 1m rms) at a few hundred Hz. (Richardson *et al*, 1995, Arvenson and Vendittis, 2000) In addition, a significant amount of high frequency sound, 150 dB in water @ 1m, rms value, (150 dB re 1µPa @ 1m rms) or broadband frequencies, 0.354-44.8 kHz of 136 dB in water at 700m distance, rms value, (136 dB re: 1µPa @ >700m rms) can be generated through propeller cavitation. This near-field source of high-frequency sound is of concern particularly within shipping corridors, shallow coastal waters, waterways/canals and/or ports. (Arveson and Vendettis, 2000, Aguilar Soto *et al*, 2006, OSPAR, 2009)

E.8. Pingers

E.8.1. Acoustic Navigation and Positioning Beacons

Acoustic navigation and positioning beacons mark the position of an object and measure its height above the seabed. Most underwater beacons emit a short continuous wave tone, commonly 8-16 kHz octave band, with a stable ping rate. Typical sound intensity levels are around 160-190 dB in water at 1m, peak value (160-190 dB *re* 1µPa @ 1m peak). They are designed to be omnidirectional so as to be heard from any direction. Simple systems are programmed to transmit a fixed ping rate whilst more sophisticated systems transmit after receiving an interrogating signal. (Lurton, 2010)

E.8.2. Acoustic Deterrent Devices

Acoustic Deterrent Devices (ADDs) are a low powered device, 130-135 dB in water at 1m, peak value, (130-135 dB *re* 1µPa @ 1m peak) designed to deter fish from entering places of harm such as water inlets to power stations. The frequencies range from 9-15KHz for a duration 100-300ms every 3-4 seconds. (Carretta *et al*, 2008, Lepper *et al*, 2004, Lurton, 2010, OSPAR Commission, 2009)

E.8.3. Acoustic harassment devices

Acoustic Harassment Devices (AHDs) are a higher powered device, 190 dB in water

at 1m, peak value, (190 dB *re* 1µPa @ 1m peak) originally designed to keep marine mammals away from fish farms by causing them pain. Frequencies range from 5-20KHz for repelling pinipeds and 30-160KHz for delphinids. (Carretta *et al*, 2008, Lepper *et al*, 2004, Lurton, 2010, OSPAR, 2009)

E.9. Other Noise-generating Activities

E.9.1. Acoustic Data Transmission

Acoustic modems are used as an interface for subsurface data transmission. Frequencies range around 18-40KHz with a sound intensity level around 185-196dB in water at 1m (185-196 dB re 1µPa @ 1m). (OSPAR, 2009)

E.9.2. Offshore Tidal and Wave Energy Turbines

Offshore tidal and wave energy turbines are new, so acoustic information is limited. However, they appear to emit a frequency range of 10Hz-50KHz and a sound intensity level between 165-175dB in water at 1m, rms value, (165-175 dB re 1µPa @ 1m rms) depending on size. (OSPAR, 2009)

E.9.3. Wind turbines

The operational sound intensity levels for wind generators depend on construction type, size, environmental conditions, type of foundation, wind speed and the accumulative effect from neighbouring turbines. A 1.5MW turbine in 5-10m of water with a wind speed of 12m/s has been recorded producing 90-112 dB in water at 110m, rms value, (90-112 dB re 1µPa @ 110m rms) with frequencies ranging 50Hz-20KHz. (Thomsen *et al*, 2006, OSPAR, 2009)

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Table 9: Noise-generating activity, sound intensity level, bandwidth, major amplitude, duration and directionality

Sound	Sound Intensity Level (dB re1 ìPa)	Bandwidth	Major Amplitude	Duration	Directionality
Military					
Military Low Frequency Active Sonar	240 Peak @ 1m	<1KHz- 1Khz	[unknown]	600-1,000ms	Horizontally focused
Military Mid Frequency Active Sonar	235 Peak @ 1m	1-5KHz	[unknown]	1-2s	Horizontally focused (3 degrees down)
Continuous Active Sonar	182 Peak @ 1m	500Hz – 3KHz	[unknown]	18 seconds	Horizontally focused
Military Mine Counter Measures Sonar	[unknown]	100KHz-500KHz	[unknown]	[unknown]	[unknown]
Seismic Surveys					
Seismic Surveys	260-262 Peak to Peak @ 1m	10Hz-150KHz	10-120Hz also 120dB up to 100Kz	30-60ms	Vertically focused
Civil High Power Sonar					
Single Beam Sounders	240 Peak @ 1m	12KHz-700KHz depending on the application	[unknown]	0.1ms	Vertically focused
Sidescan Sonar	240 Peak @ 1m	12KHz-700KHz depending on the application	[unknown]	0.1ms	Vertically focused fan spread
Multibeam Echosounders	240 Peak @ 1m	12KHz-30KHz, 70KHz-200KHz, 300KHz-500KHz depending on the application	[unknown]	0.1ms	Vertically focused fan spread
Sparkers and Boomers	204-220rms @ 1m	80Hz-10KHz	[unknown]	0.2ms	[unknown]
Chirps	210-230 Peak @ 1m	20Hz-20KHz	[unknown]	250ms	[unknown]
Coastal and Offshore Construction Works					
Explosions, TNT 1-100lbs	272-287 Peak @ 1m	2Hz-~1,000Hz	6-21Hz	<1-10ms	Omnidirectional
Pile Driving	248-257 Peak to Peak @ 1m	20Hz-20KHz	100Hz-500Hz	50ms	Omnidirectional
Dredging	168-186 rms @ 1m	20Hz-1KHz	500Hz	Continuous	Omnidirectional
Offshore Platforms					
Platform Drilling	150 rms @1m	30Hz-40Hz	[unknown]	Continuous	Omnidirectional
Drill Ships (including maintenance)	190 rms @ 1m	10Hz-10KHz	[unknown]	Continuous	Omnidirectional
Positioning transponders	100 rms @ 2km	20KHz - 35KHz	[unknown]	Continuous	Omnidirectional

Sound	Sound Intensity Level (dB re1 ìPa)	Bandwidth	Major Amplitude	Duration	Directionality
Playback and Sound Exposure Experiments					
Ocean Tomography	165-220 Peak @ 1m	50Hz-200Hz	[unknown]	[unknown]	Omnidirectional
Shipping and Vessel Traffic					
Small Vessels	160-180 rms @ 1m	20Hz-10KHz	[unknown]	Continuous	Omnidirectional
Medium Vessels	165-180 rms @1m	Below 1KHz	[unknown]	Continuous	Omnidirectional
Large Vessels	Low Frequency 180-190 rms @ 1m High Frequency 136 rms @ 700m	Low Frequency A few hundred Hz High Frequency 0.354Khz-44.8Khz	[unknown]	Continuous	Omnidirectional
Pingers					
Acoustic Navigation Beacons	160-190 Peak @ 1m	8KHz-16KHz	[unknown]	[unknown]	Omnidirectional
Acoustic Deterrent Devices	130-135 Peak @ 1m	9KHz-15KHz	[unknown]	100-300ms	Omnidirectional
Acoustic Harassment Devices	190 Peak @ 1m	5Khz-20KHz, 30KHz-160KHz depending on the application	[unknown]	[unknown]	Omnidirectional
Other Noise-generating Activities					
Acoustic Data Transmission	185-196 @ 1m	18KHz-40KHz	[unknown]	[unknown]	Omnidirectional
Offshore Tidal and Wave Energy Turbines	165-175 rms @ 1m	10Hz-50KHz	[unknown]	Continuous	Omnidirectional
Wind Turbines	90-112 rms @ 110m	50Hz-20KHz	[unknown]	Continuous	Omnidirectional

F. Related Decisions of Intergovernmental Bodies or Regional Economic Organisations

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A series of important intergovernmental decisions have already determined the direction for regulating anthropogenic marine noise through EIAs. The following decisions are the latest from each of MEA.

F.1. CMS

'CMS Resolution 9.19: Adverse Anthropogenic Marine/Ocean Noise Impacts on Cetaceans and Other Biota' encourages Parties to:

> *'…to endeavour to control the impact of emission of man-made noise pollution in habitat of vulnerable species and in areas where marine mammals or other endangered species may be concentrated, and where appropriate, to undertake relevant* ***environmental assessments*** *on the introduction of systems which may lead to noise associated risks for marine mammals.'*

'CMS Resolution 10.24: Further Steps to Abate Underwater Noise Pollution for the Protection of Cetaceans and Other Migratory Species' encourages CMS Parties to:

> *'…prevent adverse effects on cetaceans and on other migratory marine species by restricting the emission of underwater noise, understood as keeping it to the lowest necessary level with particular priority given to situations where the impacts on cetaceans are known to be heavy"* and *"[u]rges Parties to ensure that* ***Environmental Impact Assessments*** *take full account of the effects of activities on cetaceans and to consider potential impacts on marine biota and their migration routes …'*

'Resolution 10.24' further articulates that CMS Parties should ensure that Environmental Impact Assessments take full account of the impact of anthropogenic marine noise on marine species, apply Best Available Techniques (BAT) and Best Environmental Practice (BEP), and integrate the issue of anthropogenic noise into the management plans of marine protected areas. 'Resolution 10.24' also 'invites the private sector to assist in developing …alternative techniques and technologies for coastal, offshore and maritime activities'.

F.2. ACCOBAMS

'ACCOBAMS Resolution 5.13: Conservation of Cuvier's beaked whales in the Mediterranean' and 'Resolution 5.15: Addressing the impact of anthropogenic noise' reinforces the commitments made in 'Resolution 4.17: Guidelines to Address the Impact of Anthropogenic Noise on Cetaceans in the ACCOBAMS Area (ACCOBAMS Noise Guidelines)' that urges ACCOBAMS Parties to:

> *'[r]ecogniz[e] that anthropogenic ocean noise is a form of pollution, caused by the introduction of energy into the marine environment, that can have adverse effects on marine life, ranging from disturbance to injury and death.'*

This Resolution also encourages ACCOBAMS Parties to:

> *' ... address fully the issue of anthropogenic noise in the marine environment, including cumulative effects, in the light of the best scientific information available and taking into consideration the applicable legislation of the Parties, particularly as regards the need for thorough* ***environmental impact assessments*** *being undertaken before granting approval to proposed noise-*

producing activities.'

The ACCOBAMS Noise Guidelines provide further comprehensive detail-specific considerations relating to military sonar, seismic surveys and offshore drilling, shipping and offshore renewable energy developments.

F.3. ASCOBANS

'ASCOBANS Resolution 5.4: Adverse Effects of Sound, Vessels and other Forms of Disturbance on Small Cetaceans', urges ASCOBANS Parties to:

> *'… develop, with military and other relevant authorities, effective mitigation measures including environmental impact assessments and relevant standing orders to reduce disturbance of, and potential physical damage to, small cetaceans, and to develop and implement procedures to assess the effectiveness of any guidelines or management measures introduced.'*

'ASCOBANS Resolution 6.2: Adverse Effects of Underwater Noise on Marine Mammals during Offshore Construction Activities for Renewable Energy Production', further recommends that Parties:

> *'… include Strategic Environmental Assessments and Environmental Impact Assessments carried out prior to the construction of marine renewable energy developments and taking into account the construction phase and cumulative impacts'*

and to:

> *'… introduce precautionary guidance on measures and procedures for all activities surrounding the development of renewable energy production in order to minimise risks to populations* … [that include] *measures for avoiding construction activities with high underwater noise source levels during the periods of the year with the highest densities of small cetaceans, and in so doing limiting the number of animals exposed, if potentially significant adverse effects on small cetaceans cannot be avoided by other measures;* [to include] *Measures for avoiding construction activities with high underwater noise source levels when small cetaceans are present in the vicinity of the construction site;* [and] *technical measures for reducing the sound emission during construction works, if potentially significant adverse effects on small cetaceans cannot be avoided by other measures.'*

F.4. CBD

'CBD Decisions VIII/28: CBD Voluntary Guidelines on Biodiversity-inclusive Impact Assessment'provides detailed guidance on whether, when and how to consider biodiversity in both project level and strategic levels assessments. The document clearly articulates screening, scoping, assessment and evaluation of impacts, development and alternatives; tranparency and consultation, reporting, review and decision-making. The guidelines urge that environmental impact assessments should be mandatory for activities known to be in habitats for threatened species and activities resulting in noise emissions in areas that provide key ecosystem services. The guidelines further articulate that environment impact assessment should be considered for activities resulting in noise emissions in areas providing other relevant ecosystem services.

'CBD Decision XII/23: Marine and coastal biodiversity: Impacts on marine and coastal biodiversity of anthropogenic underwater noise' encourages CBD Parties and others:

> *'… to take appropriate measures, as appropriate within competencies and in accordance with national and international laws, such as gathering additional data about noise intensity and noise types, and building capacity in developing regions where scientific capacity can be strengthened.'*

In 'Decision XII/23' CBD Parties have agreed to a significant list of technical commitments, including gathering additional data about noise intensity and noise types, and building capacity in developing regions where scientific capacity can be strengthened.

The CBD Parties also encouraged Parties to take appropriate measures, including:

> *'… (e) Combining acoustic mapping with habitat mapping of sound-sensitive species with regard to spatial risk assessments in order to identify areas where those species may be exposed to noise impacts,*
> *(f) Mitigating and managing anthropogenic underwater noise through the use of spatio-temporal management of activities, relying on sufficiently detailed temporal and spatial knowledge of species or*

population distribution patterns combined with the ability to avoid generating noise in the area at those times,

(g) Conducting impact assessments, where appropriate, for activities that may have significant adverse impacts on noise-sensitive species, and carrying out monitoring, where appropriate.'

'Decision XII/23' urges the transfer to quieter technologies and applying the best available practice in all relevant activities.

F.5. IMO

The International Maritime Organization (IMO), through 'Resolution A 28/Res.1061', has requested that the Marine Environment Protection Committee (MEPC) keep under review measures to reduce adverse impact on the marine environment by ships, including developing:

'[g]uidance for the reduction of noise from commercial shipping and its adverse impacts on marine life'

F.6. IWC

The Scientific Committee of the International Whaling Commission (IWC) continues to monitor and discuss the impacts of noise on cetaceans.

F.7. OSPAR

The Convention for the Protection of the Marine Environment of the North-East-Atlantic (OSPAR) has reached agreement on an 'OSPAR Monitoring Strategy for Ambient Underwater Noise'.

The OSPAR Intersessional Correspondence Group on Noise (ICG-NOISE) is currently working closely with the International Council for the Exploration of the Sea (ICES) data team to produce the 2017 OSPAR Intermediate Assessment for impulsive noise. This is the first regional assessment of its kind, and will give policy-makers and regulators a regional overview of cumulative impulsive noise activity in the Northeast Atlantic, including the noise source type (e.g. pile driver, explosion) and intensity. The 2017 Intermediate Assessment will serve as a 'roof report' to inform the subsequent 2018 MSFD assessments of EU Member States within the OSPAR region.

F.8. Espoo (EIA) Convention

In 'Decision II/8' Espoo Parties endorsed the Good Practice Recommendations on Public Participation in Strategic Environmental Assessment set out in document 'ECE/MP.EIA/SEA/2014/2', including and requirement that

'… the public to be given an opportunity to comment on draft plans or programmes and the associated environmental reports,'

And that:

'[p]eople who are affected by a plan or programme and are interested in participating must be given access to all necessary information and be able to participate in meetings and hearings related to the SEA process'

This applies during the different stages of the assessment, including screening, scoping, availability of the draft plan/programme and environmental report, opportunity for the public to express its opinions and decision.

F.9. HELCOM

The Baltic Marine Environment Protection Commission - Helsinki Commission (HELCOM) has two important programmes in development. The Baltic Sea Information on the Acoustic Soundscape Project surveyed national needs and requirements of information on noise and will recommend monitoring of ambient noise in the Baltic Sea. A registry of impulsive sounds project is also being considered.

F.10. Regional Seas Programmes

Most of the six UNEP administered Regional Seas Programmes including the Wider Caribbean Region, East Asian Seas, Eastern Africa Region, Mediterranean Region, North-West Pacific Region and the Western Africa Region and seven non-UNEP Administered Regional Seas Programmes including the Black Sea Region, North-East Pacific Region, Red Sea and Gulf of Aden, ROPME Sea Area, South Asian Seas, South-East Pacific Region and the Pacific Islands Region suggest some form of impact assessment should be conducted to mitigate threats the marine environment.

F.11. European Union Legislation and Implementation

A number of pieces of EU legislation on environmental impact assessment and nature protection are relevant and contain specific references to the marine environment and wildlife and noise.

Recital 12 of Directive 2014/52/EU of the European Parliament and the Council, which amends Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment, specifically mentions the marine environment and gives the example of one source of noise-generating activity:

> *'With a view to ensuring a high level of protection of the marine environment, especially species and habitats, environmental impact assessment and screening procedures for projects in the marine[1] environment should take into account the characteristics of those projects with particular regard to the technologies used (for example seismic surveys using active sonars).'*

In addition, Recital 33 of this Directive also requires that:

> *'Experts involved in the preparation of environmental impact assessment reports should be qualified and competent. Sufficient expertise, in the relevant field of the project concerned, is required for the purpose of its examination by the competent authorities in order to ensure that the information provided by the developer is complete and of a high level of quality.'*

The marine environment is mentioned in Annex III paragraph 2 (ii) related to legal article 4(3) and noise and vibration are listed in Annex IV paragraphs 1 (d) and 5 (c) among information to be supplied according to Article 5 (1).

The EIA Directive applies to all Member States and requires that, for certain types of projects listed in its Annexes, public and private projects likely to have significant effects on the environment by virtue inter alia of their size, nature or location are made subject to an assessment of their environmental effects.

Under the EIA Directive "project" means '*the execution of construction works or of other installations or schemes*' and '*other interventions in the natural surroundings and landscape including those involving the extraction of mineral resources*'.

For projects listed in Annex I of the EIA Directive an assessment should always be carried out, whereas for projects listed in Annex II, Member States have to determine whether an assessment is to be carried out through a case-by-case examination or according to thresholds or criteria set by the Member State.

The so-called EU nature directives (Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (Habitats Directive) and Council and European Parliament Directive 2009/147/EC on the conservation of wild birds (Birds Directive) are also relevant. For the Natura 2000 sites designated for the protection of features such as marine animal species listed in Annex II of the Habitats directive, measures are required under Art. 6(2) to avoid any significant disturbance of those species, while different human activities that are likely to have a significant effect on Natura 2000 sites need to be properly assessed and authorized in accordance with the provisions of article 6 (3) and (4) of the Habitats Directive. This provision also includes the obligation to assess the cumulative impacts of different activities on the conservation objectives of the site. Furthermore, the provisions of Article 12 of the Habitats Directive, which includes an obligation to prohibit deliberate disturbance of strictly protected species, are also particularly relevant in such situation, as all species of cetaceans and a number of marine vertebrates and invertebrates listed in Annex IV(a) benefit from a system of strict protection.

The Commission guidance document on '*establishing Natura 2000 sites in the marine environment*'[1] contains a specific section on noise pollution.

There is specific legislation on the marine environment. In 2008 the European Parliament and the Council adopted the Marine Strategy Framework Directive[2] which requires Member States to achieve or maintain good environmental status of European Union marine waters by 2020, by developing marine strategies. Marine strategies contain 5 main elements: the initial assessment, the determination of good environmental status, the establishment of environmental targets, the monitoring programmes and the programme of measures.

When determining good environmental status, Member States shall determine a set of characteristics on the basis of 11 qualitative

1 Guidelines for the establishment of the Natura 2000 network in the marine environment: Application of the Habitats and Birds Directives (pp. 94-96)

2 Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for Community action in the field of marine environmental policy.

descriptors. One of these descriptors state:

> "*Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.*"

This is further specified in Commission Decision 2010/477/EU[3] which states that:

> *"… anthropogenic sounds may be of short duration (e.g. impulsive such as from seismic surveys and piling for wind farms and platforms, as well as explosions) or be long lasting (e.g. continuous such as dredging, shipping and energy installations) affecting organisms in different ways."*

The following criteria and indicators are laid down in that Decision:

> *"11.1. Distribution in time and place of loud, low and mid frequency impulsive sounds*
>
> > *- Proportion of days and their distribution within a calendar year over areas of a determined surface, as well as their spatial distribution, in which anthropogenic sound sources exceed levels that are likely to entail significant impact on marine animals measured as Sound Exposure Level (in dB re 1μPa2.s) or as peak sound pressure level (in dB re 1μPapeak) at one metre, measured over the frequency band 10 Hz to 10 kHz (11.1.1)*
>
> *11.2. Continuous low frequency sound*
>
> > *- Trends in the ambient noise level within the 1/3 octave bands 63 and 125 Hz (centre frequency) (re 1μPa RMS, average noise level in these octave bands over a year) measured by observation stations and/or with the use of models if appropriate (11.2.1)."*

Within the context of the Marine Strategy Framework Directive, Member States sharing a marine region or sub-region are also encouraged to cooperate to deliver on the objectives of the Directive.

3 Commission Decision 2010/477/EU on criteria and methodological standards on good environmental status of marine waters.

G. Principles of EIAs

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The principle of Environmental Impact Assessment (EIA) was developed and introduced in the 1960s during a time where there was a growth of modern environmental concern, a drive for more rational, scientific and objective environmental decision-making and a desire for more public involvement in environmental decision making. (Weston, 2002)

Conducting EIAs is now a well established governance and environmental management process, institutionalized in most of the 193 United Nations Member States (Glasson *et al* 2013, Morrison-Saunders and Retief, 2012).

A number of intergovernmental bodies have elaborated the principles of what EIAs should present (see Module G).

Through the process of their adoption, governments have individually committed to reflecting these decisions in their domestic law. The ‘weight’ of these decisions taken by governments at an international level is considerable and provides significant clarity about the expectations to conduct EIAs and effectively manage impacts of marine noise-generating activities.

A number of jurisdictions have already developed national and regional operational guidelines about mitigating anthropogenic noise on marine fauna during activities. These began with the United Kingdom’s Joint Nature Conservation Committee guidelines. Similar guidelines have been iteratively developed in the United States of America, Brazil, Canada, Australia and New Zealand (Castellote 2007, Weir and Dolman 2007). These European Espoo Convention also provides guidance. These are important and necessary operational guidelines. They form a part of, but are not the totality of what should be considered within an EIA.

This Module provides some general principles to ensure environmental impacts (broadly defined to include the physical, life and social sciences) are an explicit and fundamental consideration both during the design of an activity and in the project authorisation by a regulator. (Cashmaore, 2004)

It is clear that there is sufficient international agreement that EIAs should be conducted. There is widespread national legal commitment and some detail in a few jurisdictions. What is now required is a change of practice: by regulators to insist thorough EIAs are presented, and by proponents to accept the same. (Morrison-Saunders and Retief, 2012, Prideaux and Prideaux, 2015)

G.1. The importance of early Strategic Environmental Assessment

There is strong value in governments' undergoing a level of assessment before inviting proponents to propose activities. Conducting proactive and early assessment of groups of activities, in the context of broader governmental vision, goals or objectives, can serve as a decision-support instrument that shapes as a process. (Morgan, 2012) Commonly called Strategic Environmental Assessments (SEA), these exercises can highlight the likely outcomes of anticipated activities and reduce stakeholder conflict by restricting or directing activity development before any commercial investment has been made. (Alshuwaikhat, 2005, Fundingsland Tetlow and Hanusch, 2012).

SEAs have the potential to act as a mediating instrument, bridging problem perceptions with technical solutions and steering the assessment to facilitate the integration of environmental values into decision-making processes. (Therivel, 2012, Fundingsland Tetlow and Hanusch, 2012)

SEA can enhance communication between different stakeholders, enabling discussion and agreement independently of different beliefs, convictions, social roles,

values, accumulated experiences, individual needs or other factors. (Vicente and Partidário, 2006) SEAs can also provide guidance to regulators about the institutional requirements needed to properly assess proposals. This will include their internal organizational structure, staffing and capacity. (Therivel, 2012, Fundingsland Tetlow and Hanusch, 2012)

SEA design should reflect the basic principles of the EIAs and the EIA Guidelines in Module I.

G.2. Basic Principles of EIAs

It is broadly accepted that the basic intent of EIAs is to anticipate the significant environmental impacts of development proposals before any commitment to a particular course of action. Often, the detail required within EIAs is poorly defined. Many legislative provisions for EIAs have been introduced without consideration of the institutional requirements, organizational structure, staffing and capacity development (Cashmore *et al*, 2004, Devlin and Yap 2008, Jay *et al*, 2007). Often the scientific basis and methods need sophisticated understanding.

Defensible EIAs, representing the Best Available Techniques (BAT) and Best Environmental Practice (BEP), should provide regulators with decision-making certainty by ensuring:

- Appropriate transparency
- Natural justice
- Independent peer-review
- Appropriate consultation

Each of these elements complements and supports the others.

G.2.1. Transparency and Commercial Sensitivity

Transparency is necessary for well-informed consultation, natural justice and independent peer-review.

The extent of transparency should complement the goals of natural justice and consultation, but does not need to provide information that is genuinely commercially or personally sensitive. However, far too often commercial sensitivity is a veil that industry proponents hide behind. (DiMento and Ingram, 2005, Sheaves *et al*, 2015) Currently a large body of data about public resources (the marine environment) is claimed as commercial-in-confidence with little justification. (Costanza *et al*, 2006, Sheaves *et al*, 2015)

The technical details of proposal for activities that generate noise should be fully and transparently available for comment before plans are submitted for approval to regulators.

Broadly, the information provided should include:

- comprehensive description of the noise to be generated and the equipment to be used, including elements of the sound that are auxiliary to the need,
- comprehensive description of the direct and surrounding area where the noise-generating activity is proposed and the species within this area,
- expert modelling of expected sound intensity levels and sound dispersal,
- timeframe of the noise-generation,
- scientific monitoring programmes conducted during and after noise-generating activity.

The full extent of information that should be transparently available is detailed in Module I.

None of this information should be considered commercially sensitive and proponents should not seek to hide it from view.

G.2.2. Natural Justice

Natural justice is both a legal and common concept with two parts: it ensure there is no bias, increasing public confidence, and enshrines a right to a fair hearing so that individuals are not unfairly impacted (penalized) by decisions that affect their rights or legitimate expectations.

In the case of decisions for activities in the marine environment, confidence that there is no hidden bias can be developed by ensuring there is full transparency and that all stakeholders are given reasonable notice of the plans, a fair opportunity to present their own concerns and that these concerns will factor in the final decision that is made. (DiMento and Ingram, 2005)

Stakeholders with a rightful interest in the marine environment include: traditional communities with cultural or spiritual connections, marine users such as fishermen (commercial and recreational), shipping and boating and tourism operators, scientists, conservation organizations, and general marine users such as tourism and recreation, who advocate for the conservation of marine wildlife or marine ecosystems. Their interest must be considered.

G.2.3. Independent Peer-review

There is concern in many countries over

the poor quality of EIA information. Depending on circumstance, this might reflect problems with institutional arrangements, low levels of commitment by proponents, or issues with the nature, extent and quality of training and capacity-building in the impact assessment, or elements of all of these. (Morgan, 2012) There is often a significant gap between the best practice thinking represented in the research and practice literature and the application of EIAs on the ground. (Morgan, 2012)

Proponent-funded independent peer-review of EIA proposals, before submission to regulators for assessment, is an important tool of BEP. (Sheaves *et al*, 2015) Comprehensive, independent peer-review is a logical requirement for ensuring alignment of EIAs with scientific understanding and standards, and ensuring that scientific understanding takes precedence over short-term benefits and political considerations. (Morrison-Saunders and Bailey, 2003, DiMento and Ingram, 2005, Sheaves *et al*, 2015)

In the case of marine noise-generating activities, independent peer-reviewers should include species experts and expert sound modelers and accousticians, who are able to declare full and verifiable independence from the proposal. Their peer-review reports should be fully transparent and submitted to regulators, without influence from proponents.

G.2.4. Consultation and burden of proof

True consultation has two key components: participation in the outcome of a decision and that the burden of proof rests with the proponent.

Development actions may have wide-ranging impacts on the environment, affecting many different groups in society. There is increasing emphasis by government at many levels on the importance of consultation and participation by key stakeholders in the planning and development of projects.

An EIA is an important vehicle for engaging with communities and stakeholders, helping those potentially affected by a proposed development to be much better informed and to influence the direction and precautions put in place by the proponent. This requires an appropriate exchange of information and a willingness by the proponent to be transparent about their likely impact. (O'Faircheallaigh, 2010, Glasson *et al*, 2013)

Burden of proof is often associated with the Latin maxim *semper necessitas probandi incumbit ei qui agit*, which broadly means "*the necessity for proof always lies with the person who makes the claim*." In the case of proponents of marine noise-generating activities, it is their claim that the activities they propose to undertake – in a shared marine environment – will cause minimal harm. To satisfy the burden of proof, the proponent must provide sufficient evidence to demonstrate that there is limited danger of damaging the marine environment or any species that have been highlighted as having importance.

Other stakeholders do not carry the burden of proof but instead carry the benefit of assumption, meaning they need no evidence to support their position of concern. It is up to the proponent to provide the assurance and bear all financial costs for doing so.

The current situation in far too many jurisdictions around the world is that industry has persuaded legislators to shift the burden of proof to stakeholders. Regulators need to take step to redress this imbalance, and the EIA Guidelines, outlined in Module I should provide this shift.

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H. CMS-Listed Species Potentially Impacted by Anthropogenic Marine Noise

Pinnipeds				
Scientific name	**Common name**	**App I**	**II**	**CMS Instruments**
Arctocephalus australis	South American fur seal		1979	CMS
Halichoerus grypus	Grey seal		1985	CMS
Monachus monachus	Mediterranean monk seal	1979	1979	CMS, Monk Seal in the Atlantic
Otaria flavescens	South American sea lion		1979	CMS
Phoca vitulina	Harbour seal		1985	CMS, Wadden Sea Seals

Cetaceans				
Scientific name	**Common name**	**App I**	**II**	**CMS Instruments**
Balaena mysticetus	Bowhead whale	1979		CMS
Balaenoptera bonaerensis	Antarctic minke whale		2002	CMS, Pacific Cetaceans
Balaenoptera borealis	Sei whale	2002	2002	CMS , ACCOBAMS , Pacific Cetaceans
Balaenoptera edeni	Bryde's whale		2002	CMS , Pacific Cetaceans
Balaenoptera musculus	Blue whale	1979		CMS, ACCOBAMS, Pacific Cetaceans
Balaenoptera physalus	Fin whale	2002	2002	ACCOBAMS, CMS, Pacific Cetaceans
Berardius bairdii	Baird's beaked whale		1991	CMS, Pacific Cetaceans
Caperea marginata	Pygmy right whale		1979	CMS, Pacific Cetaceans
Cephalorhynchus commersonii	Commerson's dolphin		1991	CMS
Cephalorhynchus eutropia	Chilean dolphin		1979	CMS
Cephalorhynchus heavisidii	Heaviside's dolphin		1991	CMS, Western African Aquatic Mammals
Cephalorhynchus hectori	Hector's dolphin			Pacific Cetaceans
Delphinapterus leucas	Beluga		1979	CMS
Delphinus capensis	Long-beaked common dolphin			Western African Aquatic Mammals, Pacific Cetaceans
Delphinus delphis	Common dolphin	2005	1988	CMS, ASCOBANS, ACCOBAMS, Western African Aquatic Mammals, Pacific Cetaceans
Eubalaena australis	Southern right whale	1979		CMS, Pacific Cetaceans
Eubalaena glacialis	Northern right whale	1979		CMS, ACCOBAMS
Eubalaena japonica	North Pacific right whale	1979		CMS
Globicephala melas	Long-finned pilot whale		1988	CMS, ACCOBAMS, ASCOBANS, Pacific Cetaceans, Western African Aquatic Mammals
Grampus griseus	Risso's dolphin		1988	CMS, ACCOBAMS, ASCOBANS, Western African Aquatic Mammals, Pacific Cetaceans
Hyperoodon ampullatus	Northern bottlenose whale		1991	CMS, ASCOBANS, Western African Aquatic Mammals
Lagenodelphis hosei	Fraser's dolphin		1979	CMS , Western African Aquatic Mammals, Pacific Cetaceans
Lagenorhynchus acutus	Atlantic white-sided dolphin		1988	CMS , ASCOBANS
Lagenorhynchus albirostris	White-beaked dolphin		1988	CMS , ASCOBANS
Lagenorhynchus australis	Peale's dolphin		1991	CMS
Lagenorhynchus obscurus	Dusky dolphin		1979	CMS, Western African Aquatic Mammals, Pacific Cetaceans
Megaptera novaeangliae	Humpback whale	1979		CMS, ACCOBAMS, Pacific Cetaceans
Monodon monoceros	Narwhal		1991	CMS
Neophocaena phocaenoides	Finless porpoise		1979	CMS, Pacific Cetaceans
Orcaella brevirostris	Irrawaddy dolphin	2009	1991	CMS, Pacific Cetaceans
Orcaella heinsohni	Australian snubfin dolphin		1979	CMS, Pacific Cetaceans

Orcinus orca	Killer whale		1991	CMS, ACCOBAMS, ASCOBANS, Western African Aquatic Mammals, Pacific Cetaceans
Phocoena dioptrica	Spectacled porpoise		1979	CMS, Pacific Cetaceans
Phocoena phocoena	Harbour porpoise		1988	CMS, ASCOBANS, ACCOBAMS, Western African Aquatic Mammals
Phocoena spinipinnis	Burmeister porpoise		1979	CMS
Phocoenoides dalli	Dall's porpoise		1991	CMS
Physeter macrocephalus	Sperm whale	2002	2002	CMS, ACCOBAMS, Pacific Cetaceans
Platanista gangetica	Ganges River dolphin	2002	1991	CMS
Pontoporia blainvillei	Franciscana	1997	1991	CMS
Sotalia fluviatilis	Tucuxi		1979	CMS
Sousa chinensis	Indo-Pacific hump-backed dolphin		1991	CMS, Pacific Cetaceans
Sousa teuszii	Atlantic hump-backed dolphin	2009	1991	CMS, Western African Aquatic Mammals
Stenella attenuata	Pantropical spotted dolphin		1999	CMS, Western African Aquatic Mammals, Pacific Cetaceans
Stenella clymene	Clymene dolphin		2009	CMS , Western African Aquatic Mammals
Stenella coeruleoalba	Striped dolphin		2001	CMS, ASCOBANS, ACCOBAMS, Western African Aquatic Mammals, Pacific Cetaceans
Stenella longirostris	Spinner dolphin		1999	CMS, Western African Aquatic Mammals, Pacific Cetaceans
Tursiops aduncus	Indian bottlenose dolphin		1979	CMS
Tursiops truncatus	Bottlenose dolphin	2009	1991	CMS, ASCOBANS, ACCOBAMS, Western African Aquatic Mammals, Pacific Cetaceans
Ziphius cavirostris	Cuvier's Beaked whale	2014		CMS, ACCOBAMS

Sirenians				
Scientific name	**Common name**	**App I**	**II**	**CMS Instruments**
Dugong dugon	Dugong		1979	CMS, Dugong
Trichechus manatus	Manatee	1999	1999	CMS
Trichechus senegalensis	West African manatee	2009	2002	CMS, Western African Aquatic Mammals

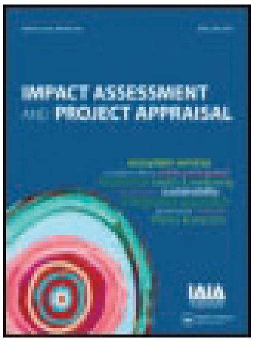
Sea turtles				
Scientific name	**Common name**	**App I**	**II**	**CMS Instruments**
Caretta caretta	Loggerhead turtle	1985	1979	CMS, IOSEA Marine Turtles , Atlantic Turtles
Chelonia mydas	Green turtle	1979	1979	CMS, IOSEA Marine Turtles, Atlantic Turtles
Dermochelys coriacea	Leatherback turtle	1979	1979	CMS, IOSEA Marine Turtles, Atlantic Turtles
Eretmochelys imbricata	Hawksbill turtle	1985	1979	CMS, IOSEA Marine Turtles, Atlantic Turtles
Lepidochelys kempii	Kemp's ridley turtle	1979	1979	CMS, Atlantic Turtles
Lepidochelys olivacea	Olive ridley turtle	1985	1979	CMS, IOSEA Marine Turtles, Atlantic Turtles
Natator depressus	Flatback turtle		1979	CMS, IOSEA Marine Turtles

Fish, Crustaceans and Cephalopods				
Fish, crustaceans and cephalopods are considered as listed CMS species as well as prey to CMS listed species.				
Scientific name	**Common name**	**App I**	**II**	**CMS Instruments**
Carcharodon carcharias	Great white shark	2002	2002	CMS, Sharks
Cetorhinus maximus	Basking shark	2005	2005	CMS, Sharks
Isurus oxyrinchus	Shortfin mako shark		2008	CMS, Sharks
Isurus paucus	Longfin mako shark		2008	CMS, Sharks
Lamna nasus	Porbeagle		2008	CMS, Sharks
Alopias pelagicus	Pelagic thresher shark		2014	CMS
Alopias superciliosus	Bigeye thresher shark		2014	CMS
Alopias vulpinus	Common thresher shark		2014	CMS
Carcharhinus falciformis	Silky shark		2014	CMS
Sphyrna lewini	Scalloped hammerhead shark		2014	CMS
Sphyrna mokarran	Great hammerhead shark		2014	CMS
Manta alfredi	Reef manta ray	2014	2014	CMS
Manta birostris	Manta ray	2011	2011	CMS
Manta alfredi	Reef manta ray	2014	2014	CMS
Mobula eregoodootenkee	Pygmy devil ray	2014	2014	CMS
Mobula hypostoma	Atlantic devil ray	2014	2014	CMS

Mobula japanica	Spinetail mobula	2014	2014	CMS
Mobula kuhlii	Shortfin devil ray	2014	2014	CMS
Mobula mobular	Giant devil ray	2014	2014	CMS
Mobula munkiana	Munk's devil ray	2014	2014	CMS
Mobula rochebrunei	Lesser Guinean devil ray	2014	2014	CMS
Mobula tarapacana	Box ray	2014	2014	CMS
Mobula thurstoni	Bentfin devil ray	2014	2014	CMS
Squalus acanthias	Spiny dogfish		2008	CMS, Sharks

Otters				
Scientific name	**Common name**	**App I**	**II**	**CMS Instruments**
Lontra felina	Marine otter	1979		CMS

Polar bear				
Scientific name	**Common name**	**App I**	**II**	**CMS Instruments**
Ursus maritimus	Polar bear		2002	CMS



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Environmental impact assessment guidelines for offshore petroleum exploration seismic surveys

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Environmental impact assessment guidelines for offshore petroleum exploration seismic surveys

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ABSTRACT
The ocean environment is filled with natural sound, but the last century has introduced many anthropogenic activities that have increased the levels of noise. Research on the impact of anthropogenic noise on marine fauna is now extensive. Levels of threat are well defined. Mitigation and monitoring guidelines exist in many parts of the world; especially for offshore petroleum exploration. In many jurisdictions, these guidelines rely on environmental impact assessments (EIAs) consideration by decision-makers, yet few jurisdictions stipulate what such assessments should contain. Sound propagation in the marine environment is complex, yet robust and defensible modelling is rarely conducted. Many impact assessments are inadequately checked. This stands in contrast to the equivalent process for land-based assessments. We argue that defensible EIAs should include modelling of the proposed noise impact in the region and under the conditions of planned activity. We articulate why clear guidelines about the content of EIAs are needed and propose a template for offshore petroleum exploration assessment.

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Introduction

The ocean environment is filled with natural sound from animals and physical processes. Species living in this environment are adapted to these sounds. Many species rely on sound as a primary sense, using it for hunting, reproduction and navigation (Southall et al. 2000, 2007; Simmonds et al. 2014). Over the past century, many anthropogenic marine activities have increased levels of noise (Hildebrand 2009; André et al. 2011). These modern anthropogenic noises have the potential for physical, physiological and behavioural impacts on marine fauna – mammals, reptiles, fish and invertebrates (Moriyasu et al. 2004; Southall et al. 2007; Payne et al. 2008; Clark et al. 2009; Miller et al. 2009; André et al. 2010; CBD CBD SBSTTA 2012). One noise-producing industry is offshore petroleum exploration.

There are national and regional operational guidelines available to the offshore petroleum exploration industry, each detailing the impacts to avoid and mitigation measures to take during operations. These began with the United Kingdom's Joint Nature Conservation Committee guidelines to minimise acoustic disturbance of marine mammals by oil and gas industry seismic surveys in 1995. Similar guidelines have been iteratively developed in the United States of America, Brazil, Canada, Australia and New Zealand (Castellote 2007; Weir & Dolman 2007; Compton et al. 2008). At a regional level, the intergovernmental Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) has established comprehensive guidelines for the Mediterranean region. Other regional and international instruments are gradually developing similar guidance.

These guidelines focus on mitigation measures during operations and rely on an assessment of risk having being considered and approved by decisions-makers before the operation starts. This is an important step in the process, yet there are few guidelines about the content of these environmental impact assessments (EIAs). Generalised assumptions about impact are often all that is presented. If an EIA is to be a good decision-aiding tool, it must provide decision-makers with a thorough and detailed understanding of the consequences of their decisions (Tenney et al. 2006).

The propagation of sound in water is complex and requires many variables to be carefully considered before it can be known if the proposal is appropriate or not. Despite this, proposals from the offshore petroleum exploration industry are presented to regulators with generalised, unsubstantiated information and often without having conducted basic consultation with other stakeholders reliant on the same environment.

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These hollow submissions perpetuate because the expectation from government has not been carefully prescribed. Regulators are forced to approve or reject projects without robust, defensible and impartial information on which to base their decisions. Regulator decisions are often made based on erroneous information. Such decisions are vulnerable to criticism of bias or tokenism (Court et al. 1996; Tenney et al. 2006; Jay et al. 2007; Devlin & Yap 2008; Prideaux & Prideaux 2012; 2013b, 2013c, 2013d, 2013e, 2013f; Wright et al. 2013).

This paper provides a basic explanation of the complexities of sound propagation in the marine environment and shows why generalised assumptions are inadequate to assess impact. A brief description of the common technology employed by the offshore petroleum exploration industry is provided. The next section will give a broad outline of the range of species susceptible to loud anthropogenic noise pollution and a general summary of the impacts they experience. The final section explores the trends in current EIAs for offshore petroleum exploration and introduces a template for EIA guidelines.

Sound propagation in water is complex

Often, offshore petroleum exploration industry statements are made in EIAs that a sound-producing activity is '*X*' distance from '*Y*' species or habitat. In these cases, distance is used as a basic proxy for impact, but is rarely backed with scientifically modelled information. To present a defensible EIA for offshore petroleum exploration proposal, proponents need to have professionally modelled the noise of the proposed activity in the region and under the conditions they plan to operate.

The behaviour of sound in the marine environment is different from sound in air. The extent and way that sound travels (propagation) is affected by many factors, including the frequency of the sound, water depth and density differences within the water column that vary with temperature, salinity and pressure (Wagstaff 1981; Clay & Medwin 1997; Lurton 2010; Etter 2013). Seawater is roughly 800–1500 times denser than air and sound travels around five times faster in this medium (Lurton 2010, p. 16). Consequently, a sound arriving at an animal is subject to propagation conditions that are complex (McCauley et al. 2000; Calambokidis et al. 2002; Hildebrand 2009; Lurton 2010).

While noise modelling is common for land-based anthropogenic noise-producing activities, it is less common for proposals in the marine environment. The lack of rigorous noise modelling in the marine setting needs to be urgently addressed. Modelling of each individual proposal should be professionally and impartially conducted to provide decision-makers with credible and defensible information. It should provide a clear indication of sound dispersal characteristics, informed by local propagation features (Urick 1983; Etter 2013). With this information, species exclusion zones can be identified with descriptions of how noise propagation into these zones will be minimised.

Elasticity

The speed of sound is not a fixed numerical value. Sound wave speed varies widely and depends on the medium, or material, it is transmitted through such as solids, gas or liquids. Each medium has its own elasticity (or resistance to molecular deformity). This elasticity factor affects the sound wave's movement significantly.

Sound waves move through a medium by transferring kinetic energy from one molecule to the next (Lurton 2010, pp. 14–20). Solid mediums, such as metal, transmit sound waves extremely fast because the solid molecules are tightly packed together, providing only tiny spaces for vibration. Sound waves move rapidly through this high elasticity medium, because the solid molecules act like small springs, aiding the wave's movement across the medium. The speed of sound through aluminium, for example, is around 6319 ms^{-1} (Goel 2007; Gottlieb 2007, pp. 22–23; Giordano 2012, p. 414). Gas, like air, naturally has large spaces between each molecule. As a result, sound waves take longer to move through a gas. Each air molecule vibrates at a slower speed after a sound wave passes through it, because there is more space surrounding the molecule. The gas molecule effectively deforms in shape from the passing sound wave, making gas reflect a low elasticity. Sound waves moving through air at a temperature of 20 °C will only travel around 342 ms^{-1} (Goel 2007; Gottlieb 2007). Liquid molecules, such as seawater, bond together in a tighter formation compared with gas molecules allowing only small vibration movements. Sound waves do not deform the liquid molecules as severely as gas molecules, creating a higher elasticity level. Sound waves moving through water at 22 °C travel at around 1484 ms^{-1} (Goel 2007; Gottlieb 2007).

Warmer temperatures across a medium also excite molecules. Molecules move faster under higher temperatures, transmitting sound waves more rapidly across the medium. Conversely, decreasing temperatures cause the molecules to vibrate at a slower pace, hindering the sound wave's movement (Goel 2007; Gottlieb 2007, p. 23; Giordano 2012). The temperature of the seawater at different depths is therefore of importance to modelling.

Spherical spreading, cylindrical spreading and transmission loss

The way sound propagates is also important. Spherical spreading is simply sound leaving a point source in an expanding spherical shape (Urick 1983, p. 100; Lurton 2010, p. 22). As sound waves reach the sea surface and sea

floor, they can no longer maintain their spherical shape and they begin to resemble the shape of an expanding cheese wheel. This is called cylindrical spreading (Urick 1983, p. 102). The transmission loss, or the decrease in the sound intensity levels, happens uniformly in all directions during spherical transmission. However, when sound is in a state of cylindrical transmission it cannot propagate uniformly. The sound is effectively contained between the sea surface and the sea floor, while the radius is still expanding uniformly (the sides of the cheese wheel) but the height is now fixed and so the sound intensity level decreases more slowly (Urick 1983, p. 102).

Given the seabed is rarely, if ever, flat and parallel to the sea surface, modelling cylindrical spreading in the marine environment is complex. Seabed characteristics must be known to model this spreading. Modelling must accommodate the water depth below the seismic survey, as well as the rise and fall of the seabed surrounding it (Lurton 2010, p. 13).

Sound Fixing and Ranging channels (SOFAR)

As well as spherical and cylindrical spreading, another variable can impact how far sound will be transmitted. This is usually called a SOFAR or deep sound channel and is a horizontal layer of water in the ocean at which depth, the speed of sound is at its minimum.

The SOFAR channel is created through the interactive effect of temperature and water pressure (and, to a smaller extent, salinity). This occurs because pressure in the ocean increases with depth, but temperature is more variable, generally falling rapidly in the main thermocline from the surface to around a thousand meters deep and then remaining almost unchanged from there to the ocean floor. Near the surface, the rapidly falling temperature causes a decrease in sound speed (or a negative sound speed gradient). With increasing depth, the increasing pressure causes an increase in sound speed (or a positive sound speed gradient). The depth where the sound speed is at a minimum is called the sound channel axis. The speed gradient above and below the sound channel axis acts like a lens, bending sound towards the depth of minimum speeds. The portion of sound that remains within the sound channel encounters no acoustic loss from reflection of the sea surface and sea floor. Because of this low transmission loss, very long distances can be obtained from moderate acoustic power (Urick 1983, p. 159; Lurton 2010, p. 58).

Offshore petroleum exploration

The commonly used surveying method used for offshore petroleum exploration is 'seismic reflection'. This is simply sound energy discharged from a sound source (air gun array) at the sea surface that penetrates subsurface layers of the seabed and is reflected to the surface where it is detected by acoustic receivers (hydrophones). These surveys are typically conducted using specially equipped vessels that tow one or more cables (streamers) with hydrophones at constant intervals. For the seismic reflection process to work, there needs to be enough energy discharged from the air gun array to travel, sometimes several kilometres, to the sea floor and then to be refracted as it passes from liquid into solid to a prescribed depth. Some of the energy is reflected and begins a return journey being refracted from solid to liquid then to travel to the hydrophone streamers. The analysis of these reflections provides a profile of the underlying rock strata and helps industry to identify hydrocarbon accumulations or anomalies that may correspond to hydrocarbon deposits. The typical discharge of each pulse of an air gun array is around 230 dB (re 1 μPa^2 @ 1m) every 10–15 s, and surveys typically run more or less continuously over many weeks (Urick 1983; Clay & Medwin 1997; Caldwell & Dragoset 2000; Dragoset 2000; Lurton 2010). These operations are usually called 'seismic surveys'.

Marine fauna susceptible to anthropogenic noise

Marine animals rely on sound for their vital life functions, such as communication, prey and predator detection, orientation and for sensing their surroundings (Simmonds et al. 2014). Noise affects the behaviour and physiology of animals in various ways, including disruptions in the neuroendocrine, cardiovascular and immune systems (Kight & Swaddle 2011).

Southall et al. (2007) reviewed the expanding literature on marine mammal hearing and their physiological and behavioural responses to anthropogenic noise. They developed predictions of noise exposure levels above which adverse effects, as either injury or behavioural disturbance, on various groups of marine mammals could be expected. While these researchers acknowledged limits in their proposed criteria, because of scarcity of information about some species, the work is valuable for establishing policy guidelines or regulations about anthropogenic noise.

An important recent Convention on Biological Diversity (CBD) Decision (XII/23) has recommended that further research is conducted for the remaining significant knowledge gaps. This includes knowledge about fish, invertebrates, turtles and birds. They also recommended research into the implications of cumulative and synergistic impacts of multiple sources of noise on marine species (CBD 2014).

Southall et al. (2007) highlighted that exposure criteria for single individuals and short-term (not chronic) exposure events are inadequate to describe the cumulative and ecosystem-level effects likely to result from repeated and/or sustained human input of sound into the marine environment and from potential interactions

with other stressors. It is therefore critical that modelling of noise propagation is conducted to determine the potential received levels of noise for different species and the duration of exposure.

An important volume of solid research should be considered directly for more detail about the unique characteristics of each of the species groups. The following section provides a summary of this knowledge base.

Fish, crustaceans and cephalopods

Fishermen worldwide complain that seismic surveys produce economic losses by reducing captures of a wide range of commercial species. The impact of anthropogenic noise on commercial fisheries is slowly being quantified. Behavioural responses of fish and cephalopods vary to received levels of seismic noise. These include leaving the area of the noise, through changes in depth distribution, schooling behaviour and startle responses to short-range start-up or high-level sounds. In some cases, behavioural responses from fish were observed up to 5 km distance from the seismic air gun array (McCauley et al. 2000, 2003; Hassel et al. 2004; McCauley & Fewtrell 2008). Short exposures to intense seismic signals are known to increase mortality of fish larvae at short ranges. Sublethal physiological impacts have been observed in crustaceans potentially impacting reproduction and recruitment. Significant developmental delays and abnormalities have been shown in mollusc larvae, including malformations in soft body tissues (Parry & Gason 2006; Payne et al. 2008; de Soto et al. 2013). Noise exposure during critical growth intervals may contribute to stock vulnerability (de Soto et al. 2013).

Pinnipeds

Pinnipeds (seals, sea lions and walrus) live part of their lives in both air and in water. Their hearing is adapted to both mediums and they are likely to be susceptible to the harmful effects of loud noise in each. Behavioural responses to anthropogenic sound have been recorded including pinnipeds removing themselves from feeding activities. Disturbances in marine and terrestrial environments can cause pinnipeds to abandon colonies, which could have serious implications, especially for species that are already endangered. In most respects, noise-induced threshold shifts in pinnipeds follow trends similar to those observed in other mammals (Southall et al. 2007). Pinnipeds, like many land-based mammals, have vibrissae (whiskers), which are well supplied with nerves, blood vessels and muscles and may function to detect the subtle movements of fish and other aquatic organisms. Vibrissae have been shown (for example, in harbour seals, *Phoca vitulina*) to be sensitive to low-frequency waterborne vibrations (Bohne et al. 1985; Mathews 1994; Southall et al. 2000; Harris et al. 2001; Kastak et al. 2005).

Sirenians

Similarly, sirenians (dugong and manatee) may be displaced from key feeding habitats by exposure to noise. While most research has focused on boating traffic, their behavioural response to the noise of passing vessels supports that these animals are sensitive to noise and should be considered carefully (Hodgson & Marsh 2007).

Cetaceans

Cetaceans (whales, dolphins and porpoises) are perhaps the most studied group of marine species when considering the impact of anthropogenic noise. Different taxonomic groups of cetaceans adopt different strategies for responding to acoustic disturbance from seismic noise. Baleen whales are susceptible to temporary threshold shift at a kilometre or more from seismic surveys (Gordon et al. 2003; Nowacek et al. 2007; Weilgart 2007; Di Iorio & Clark 2009; Gedamke et al. 2011; Gray & Van Waerebeek 2011). Toothed cetaceans have also shown significant avoidance behaviour at a range of distances (Madsen et al. 2002; Stone & Tasker 2006; Miller et al. 2009; Gray & Van Waerebeek 2011). Researchers are concerned that reducing an individual's ability to detect socially relevant signals could affect biologically important processes and they caution that short-term proxies, such as avoidance behaviour, are not sufficiently robust to assess the extent and biological significance of long-term individual and population-level impacts.

Sea turtles

Studies of the hearing capabilities of sea turtles show that they hear low-frequency sounds within the range of 100–1000 Hz with greatest sensitivity at 200–400 Hz for adult sea turtles, and 600 and 700 Hz for juveniles. Although sea turtles are poorly studied compared with cetacean and fish species, studies have demonstrated behavioural responses to received levels of seismic noise (O'Hara & Wilcox 1990; Moein Bartol & Musick 2003; Southwood et al. 2008).

The importance of considering stress

There is also need to consider the impact prolonged noise exposure may have on marine fauna beyond the direct physiological and behavioural impacts (Rolland et al. 2012). Chronic levels of stress can result in various pathological dysfunctions with possible damage to long-term health. This is especially relevant for resident species dependent on certain habitats, such as beluga, seals or sea lions.

Failures of current EIAs

The following sections build on the information we have provided about the complexities of sound propagation in the marine environment and overview of the range of species and types of impact that might occur. We comment about the depth of information provided in current EIAs and finally propose guidelines for EIAs.

Many jurisdictions have developed national and regional operational guidelines about mitigating anthropogenic noise on marine fauna and in particular noise produced by offshore petroleum exploration. These began with the United Kingdom's Joint Nature Conservation Committee guidelines with similar guidelines being iteratively developed in the United States of America, Brazil, Canada, Australia and New Zealand (Castellote 2007; Weir & Dolman 2007; Compton et al. 2008).

Several intergovernmental bodies have also elaborated principles of what EIAs should present. Collectively, these principles have been adopted by 196 governments who, through the process of their adoption, have individually committed to reflecting these decisions in their domestic law. The 'weight' of these decisions taken by governments at an international level is considerable.

The most notable of these is the 'Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area' (ACCOBAMS). ACCOBAMS 'Resolution 4.17: Guidelines to address the impact of anthropogenic noise on cetaceans in the ACCOBAMS area' articulate specifics for the Mediterranean region and

> [encourage] Parties: – to address fully the issue of anthropogenic noise in the marine environment, including cumulative effects, in the light of the best scientific information available and taking into consideration the applicable legislation of the Parties, particularly as regards the need for thorough environmental impact assessments being undertaken before granting approval to proposed noise-producing activities. (ACCOBAMS 2010)

The ACCOBAMS Noise Guidelines further prescribe specific considerations about seismic surveys, including the need for accurate modelling.

ACCOBAMS Resolution 5.15 calls on the Parties to:

- ensure that EIAs take full account of the effects of activities on cetaceans;
- implement the recommended use of Best Available Techniques and Best Environmental Practice in their efforts to reduce or mitigate marine noise pollution;
- integrate the issue of anthropogenic noise into the management plans of marine protected areas.

Resolution 5.15 also underlines that EIAs should include specific details that mirror those articulated in the ACCOBAMS Noise Guidelines (ACCOBAMS 2013).

The Convention on Migratory Species (CMS) 'Resolution 10.24: Further Steps to Abate Underwater Noise Pollution for the Protection of Cetaceans and Other Migratory Species' also strongly urges CMS Parties to prevent adverse effects on marine species by restricting the emission of underwater noise to the lowest necessary level and urges CMS Parties to ensure that EIAs take full account of the effects of activities on marine fauna (CMS 2011).

Most recently, the CBD 'Decision XII/23: Marine and coastal biodiversity: Impacts on marine and coastal biodiversity of anthropogenic underwater noise' has specifically encouraged CBD Parties to take suitable measures to avoid, lessen and mitigate adverse impacts of anthropogenic underwater noise on marine and coastal biodiversity, including:

> - combining acoustic mapping with habitat mapping of sound-sensitive species when developing spatial risk assessments to identify areas where those species may be exposed to noise impact;
> - using spatio-temporal management, including detailed knowledge of species or population distribution patterns, to mitigate and manage noise activities and avoiding producing noise in the area at critical times;
> - conducting EIAs for activities that may have significant adverse impacts on noise-sensitive species. (CBD 2014)

Assessment of likely impacts is also an emerging legal requirement in the European Union. The European Parliament and Council 'Environmental Impact Assessment Directive 2014/52/EU' requires that EIAs are carried out before development consent is given to activities (2014/52/EU Art 2.1) to identify impacts to biodiversity with particular attention to species and habitat protected under Directive 92/43/EEC and Directive 2009/147/EC (2014/52/EU Art 3.1). The Directive introduction states that:

> [w]ith a view to ensuring a high level of protection of the marine environment, especially species and habitats, environmental impact assessment and screening procedures for projects in the marine environment should take into account the characteristics of those projects with particular regard to the technologies used (for example seismic surveys using active sonars). (2014/52/EU)

Conducting EIAs is now a well-established governance and environmental management principle, institutionalised in over 100 countries (Court et al. 1996; Glasson et al. 2013). These four intergovernmental bodies provide significant clarity about the expectations to conduct EIAs and effectively manage impacts associated with offshore petroleum exploration activities, among other underwater noise-producing activities.

It is broadly accepted the basic intent of EIAs is to anticipate the significant environmental impacts of development proposals before any commitment to a particular course of action. However, often, the detail required within EIAs is poorly defined. Many legislative provisions for EIAs have been introduced without consideration of the institutional requirements: organisational structure, staffing and capacity development (Cashmore et al. 2004; Jay et al. 2007; Devlin & Yap 2008). Often the scientific basis and methods need sophisticated understanding.

Given this, it is not surprising the efficacy of many EIAs is being criticised (Slootweg & Kolhoff 2003; Cashmore et al. 2004, 2010; Devlin & Yap 2008). Indeed, the criticism of the 'low bar' requirements for EIAs in many jurisdictions might be, in part, a result of decision-makers themselves having limited understanding of the EIA purposes and potential (Cashmore et al. 2004; Jay et al. 2007) as well as the general poor quality of EIA information (Morgan 2012; Morrison-Saunders & Retief 2012).

This was revealed to be the case for offshore petroleum exploration EIAs by Wright et al. (2013). They found that many assessments were insufficiently researched, drawing heavily from previous EIAs. In a significant number of cases, approvals were given without careful consideration of the detail presented in the EIAs. Instances of duplicated information or missing species were not uncommon. Topics were dealt with by dismissal, often ignoring recent scientific literature, perpetuating misconceptions and containing analytical flaws. Discussions about wildlife often focused on lethal impact, with little or no consideration of sublethal impacts.

Our documentary examination of five EIAs, that spanned less than one year and took place within one regulatory jurisdiction, revealed similar trends to those highlighted by Wright et al. (2013). All were proposals for petroleum exploration in Australia's Exclusive Economic Zone under the same regulatory process and all were given approval by the National Offshore Petroleum Safety and Environmental Management Authority's (NOPSEMA) (Prideaux & Prideaux 2013b, 2013c, 2013d, 2013e, 2013f).

These five are by no means isolated cases. Since inception, 291 EIAs (so-called Environmental Plans) have been received by NOPSEMA. Most of these have been accepted by the authority. The authors have engaged in a correspondence trail with the authority to highlight significant errors, inaccuracies, misconceptions and analytical flaws in a number of the 291 submissions. Written responses from the authority confirm that their focus is on ensuring the industry commits to self-identified benchmarks. They assert the authority does not assess the efficacy of claims or assurances contained in the EIAs (correspondence on file with the authors).

An example of assessment relating to Australian sea lions

An example of assessments relating to Australian sea lions provides a useful illustration. The Australian sea lion (*Neophoca cinerea*) is Australia's only endemic and least numerous seal species. The species is listed as Vulnerable under the national environment legislation and has an IUCN Red List Criteria of Endangered (A2bd + 3d). The Australian Government's own 'South-west Marine Bioregional Plan and Species Group Report Card – Pinnipeds' identifies noise as a threat of concern (Department of Sustainability Environment, Water, Population & Communities 2012a, 2012b).

Under the 'South-west Marine Bioregional Plan' any individual Australian sea lion breeding colony is regarded as an important population. The government's Plan directs that all attempts should be made to avoid biologically important areas for the Australian sea lion, particularly water surrounding breeding colonies and foraging areas used by female sea lions, for any applications for offshore development. The Plan specifically states that 'actions with a real chance or possibility of increasing the ambient noise levels within female Neophoca cinerea foraging areas to a level that might result in site avoidance or other physiological or behavioural responses' have a high risk of a significant impact on this species (Department of Sustainability Environment, Water, Population & Communities 2012a, 2012b)

Clearly, the Australian Government has decided the status the sea lion demands a precautionary approach to ensure that human activities, including anthropogenic noise do not further jeopardise the species. Despite this, in a two-year period, NOPSEMA has accepted four EIAs, in the form of Environmental Plans. Each has failed to consider the impact of noise generated by offshore petroleum exploration on Australian sea lion populations and each has been given the proponent approval to proceed. These will or have already produced sound intensity levels around 230 dB (re water) that will transmit many hundreds of kilometres, including into and through areas of sea lion foraging habitat.

Given that offshore petroleum exploration activities typically span six to eight weeks, it is likely that sea lion foraging behaviour will be or has been significantly impacted or abandoned altogether. There could be reduced food availability, animals might show signs of reduced condition and may have difficulty feeding their pups. Colonies may or have been abandoned temporarily or permanently, which could have serious implications for this already endangered species. Review of the published EIAs (available on www.nopsema.gov.au) reveals that no modelling of noise propagation has been considered and no assessment of impact has been carried out. There is no description of the well-known

Australian sea lion colonies. There is no discussion of the foraging habitats of the species, nor is their recognition of the precaution flagged in the 'South-west Marine Bioregional Plan' and 'Species Group Report Card – Pinnipeds'. NOPSEMA has accepted and approved the EIAs. Even though the information was inconclusive or incomplete, NOPSEMA has not required any monitoring be established.

Anecdotal evidence for other regions shows similar trends in other jurisdictions including Europe, West Africa and East Africa (on file with the authors). There is a failure of current EIAs for offshore petroleum exploration.

It is important that government decision-makers can rely on sufficient technical, detailed and impartial information being presented to them to ensure credible and defensible decisions are made about offshore petroleum exploration. The following section proposes template guidelines on the detail of information that should be sought to support robust and defensible decisions.

Environmental impact assessment for offshore petroleum exploration seismic surveys

This section is built on the foundations of three important previous works. These are an important study on impact mitigation of offshore petroleum exploration in the Sakhalin region of the North Pacific Ocean (Nowacek et al. 2013); a framework for assessment of noise impact in the Arctic (Moore et al.2012); and a workshop on the requirements for marine noise EIAs during the 2014 European Cetacean Society meeting (Evans 2015). This collective work has elaborated that assessments should:

- collect baseline biological and environmental information to describe the area being impacted;
- fully characterise operations, including describing the sound source in some detail, the local sound propagation features and potential cumulative effects from other sound sources as well as other human activities that may not generate noise but can add to the pressures on the local animal populations; and
- describe how impacts will be monitored before, during and after the operation.

To provide regulators with greater technical detail about how to seek this level information, we have developed the proposed template through two important cross-disciplinary peer discussion forums:

(1) The Joint CMS/ASCOBANS/ACCOBAMS Noise Working Group where the template was formally developed as a contribution to the 'CBD Expert Workshop on Underwater Noise and its Impacts on Marine and Coastal Biodiversity'.
(2) The 18th CMS Scientific Council Meeting, where the template was presented and comments and input sought.

The template has also sought the input more broadly from regulators and industry. The proposal that follows is a reflection of this iterative discussion with experts through these processes (Prideaux & Prideaux 2013a).

Environmental impact assessment guidelines for offshore petroleum exploration proposals

In addition to jurisdictional specific requirements for impact mitigation during operations, such as observers or passive acoustic monitoring, EIAs for offshore petroleum exploration should be developed early in the proposal's development process and should transparently include:

(1) Description of area
   (a) Detailed description of the spatial extent and nature of the survey – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed survey, above natural ambient sound levels
   (b) Details of baseline data that have been gathered before developing the EIA, including consultation with regulating bodies and stakeholders
   (c) Identification of previous surveys, their seasons and duration in the same or adjoining areas, and a review of survey finding and implications
   (d) Identification of previous test wells in the same or adjoining areas including comment about any wells that may breach
(2) Description of the equipment to be used
   (a) Explanation of all survey technologies available and why the proposed technology is chosen
   (b) Detailed description of the survey technology to be used
   (c) Name and description of the survey vessel to be used
   (d) If an air gun array is proposed:
      (i) Number of arrays
      (ii) Number of air guns within each array
      (iii) Air gun charge pressure to be used (PSI)
      (iv) Volume of each air gun in cubic inches
      (v) Official calibration figures supplied by the survey vessel to be charted
      (vi) Modelled sound intensity level one metre from source derived from the official calibration figures

- (vii) Depth the air guns to be set
- (viii) Number of streamers
- (ix) Length of streamers
- (x) Distant set apart
- (xi) Depth the hydrophones are set

(3) Details of consultation and independent review
- (a) Identification of stakeholders who have been consulted
- (b) Identification of independent experts – especially species experts – that have been consulted including their affiliation and their qualifications
- (c) Explanation of information provided to stakeholders and experts, any opportunities given for appropriate engagement and the timeframe given for them to provide feedback
- (d) Description of the comments, queries, requests and concerns received from each of the stakeholders and experts
- (e) Explanation of what amendments and changes have been made to the proposed survey to the comments, queries, requests and concerns
- (f) Explanation of which comments, queries, requests and concerns have not been accommodated and why

(4) Comprehensive description of activity
- (a) Comprehensive description of the total area to be explored and the entire exploration plan (2D, 3D and test wells) and for each activity:
  - (i) Specifics of the activity including anticipated nautical miles to be covered, track-lines, speed of vessels, duration of track-lines, start up and shutdown procedures, distance and procedures for vessel turns including any planned air gun power setting changes
  - (ii) Computer modelling of sound dispersal in the same season/weather conditions as the proposed survey, local propagation features (spherical and cylindrical spreading, depth and type of sea bottom, local propagation paths related to thermal stratification) and out to a radius where the generated noise levels are close to natural ambient sound levels
  - (iii) Identification of any SOFAR or natural channels characteristics
  - (iv) Sound intensity level and frequencies (Hz) from a point source, as well as the duration of each pulse (milliseconds), interval between pulses (seconds) and expected duration of pulses (12/24 h days) for the survey
- (a) Identification and mapping of proposed species exclusion zones and description of how noise propagation into these zones will be minimised, taking into consideration the local propagation features (spherical and cylindrical spreading, depth and type of sea bottom, local propagation paths related to thermal stratification)
- (b) Identification of other impacting activities in the region during the planned survey, accompanied by the analysis and review of potential cumulative impacts

(5) Species likely to be encountered or impacted
- (a) Description of all listed/protected species likely to be present and that will experience sound transmission generated by the proposed survey above natural ambient sound levels, the total time they will experience these sound levels and proposed measures being taken for each to minimise impact
- (b) Description of all fisheries likely to be present or to rely on prey that might be present and that will experience sound transmission generated by the proposed survey above natural ambient sound levels and proposed measures being taken for each to minimise impact

(6) Details of likely impact for each listed/protected species, including:
- (a) Identification of safe/harmful exposure levels for various species that is precautionary enough to handle large levels of uncertainty and avoids erroneous conclusions
- (b) Type of impact predicted (direct, behavioural and the duration) as well as direct and indirect impacts to prey species
- (c) Soft start and shutdown protocols
- (d) Plans for 24 h visual detection, especially under conditions of poor visibility (including high winds, night conditions, sea spray or fog)
- (e) Plans for establishing exclusion zones to protect specific species. These should be established on a scientific and precautionary basis rather than as arbitrary and/or static designations

(7) Details of independent and transparent monitoring of all at-sea activities and observer coverage
- (a) Details of transparent processes for regular real-time public reporting of activity progress and all impacts encountered
- (b) Details of scientific monitoring programmes, conducted during and after the seismic survey, to assess impact

(8) Reporting plans

(a) Details of plans for post operation reporting including verification of the effectiveness of mitigation

The information requested in this template is well within the current technical competencies of the petroleum and scientific community. The detail within the EIA should be robust enough for independent review and not placed under a seal of commercial in-confidence. This process should prove sufficiently robust to ensure that regulators and decision-makers have access to an appropriate level of information before making approval decisions. It will allow them to seek expert technical critiques of the information if they do not have sufficient expertise within their department.

Conclusion

The ocean environment is filled with natural sound produced by animals and physical processes but modern anthropogenic activities have increased the levels of noise. Offshore petroleum exploration is a significant contributor to this noise. Sound propagation in the marine environment is complex and it is especially important that government decision-makers can rely on sufficient technical, detailed and impartial information being presented to them to ensure credible and defensible decisions are made about the impact of this industry and individual proposals.

While noise modelling is common for land-based anthropogenic noise-producing activities, we have shown that modelling and indeed robust EIAs for offshore petroleum exploration are failing this base need. EIAs should provide a clear indication of the sound propagation features across the full area the noise will impact. Proponents should be required to model the noise propagation of the proposed activity in the region and under the conditions they plan to operate. The documentation should demonstrate a clear understanding of the species present, necessary exclusion zones and descriptions of how noise propagation into these zones will be minimised.

This paper has proposed 'Environmental Impact Assessment Guidelines for Offshore Petroleum Exploration Proposals'. These template guidelines have been developed with the benefit of peer input and review through two official processes; to provide guidance about the specifics that should form the basis of appropriate assessments. In time, global noise standards may supersede such a need, but that time is still in the distant future and will need complex and controversial international oversight to be in place. For now, given the strong commitment of governments around the world to reducing anthropogenic marine noise, this information, if transparently supplied, would provide regulators and decision-makers with robust, defensible and impartial information on which to base their decisions.

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Chapter 17

Marine Mammals and Multiple Stressors: Implications for Conservation and Policy

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INTRODUCTION

For many centuries, in many maritime countries, human interest in marine mammals was limited to consideration of them as a resource to be exploited for human consumption and then for profit. For example, whales were regarded as having such value that King Edward II of England made a formal claim to their ownership, followed by several other heads of state (Brakes and Simmonds, 2011). Widespread commercial whaling in the 19th and 20th centuries, eventually involving diesel-driven fleets including factory vessels, led to decimation of populations. Attitudes changed in the 1960s and 1970s when the animals started to be valued and appreciated in other ways, including aesthetically and for their entertainment value in captivity.

Considerable knowledge has been gained in recent decades about both the biology of the animals and the fast-evolving threats that they face, but increasing knowledge does not automatically lead to improved protection, and some species and populations are still heading toward extinction (Campagna, 2015). At the root of this is a complex and evolving array of factors that can impact on these animals. For example, the endangered North Atlantic right whale, *Eubalaena glacialis*, population was initially devastated by whaling. Now, as this much diminished population struggles to recover, ship strikes and entanglement in fishing gear are regarded as the primary threats (Reilly et al., 2012). Looking to the future, it seems likely that climate change will cause the species yet more problems (Greene and Pershing, 2004).

Another example of populations being affected by multiple threats might be found in the case of delphinids in the Northeast Atlantic where pollution, in the form of PCBs, has recently been recognized again as a major threat

Marine Mammal Ecotoxicology. https://doi.org/10.1016/B978-0-12-812144-3.00017-6

(see, for example, Jepson et al., 2016). These are the same populations that, in many cases, are also being affected by deaths in fishing nets and other factors.

To conserve wildlife populations, we need to address not one but the multiple factors that are affecting them simultaneously, and this is not a new realization. Nor is the notion that some factors act synergistically, creating greater harm together than when acting on their own. For example, enhanced exposure to pathogens from discharges into cetacean habitat combined with enhanced exposure to immunosuppressive contaminants might be expected to create more disease and even, potentially, drive mass mortalities (Simmonds and Mayer, 1997).

However, marine mammal science tends to focus on particular classes of threat, rather than trying to address their multiplicity and the consequences of the interactions between them for the species and populations being affected. There have been good reasons for this. Typically, scientists have had to specialize to be effective (and successful in their careers), and natural sciences and veterinary sciences (including animal welfare science) have tended to follow separate paths. Perhaps, as argued subsequently, the time may have come for a reunification of these specializations, as we struggle to address the realities of multiple stressors in wildlife conservation. Indeed, how to sensibly address this complexity is arguably now one of the "holy grails" of modern conservation. Inherent in this is understanding how the factors interact to cause outcomes for the animals concerned and also how multiple exposures to stressors over a lifetime might best be considered. None of this is easy. Indeed it has recently been suggested that assessing "cumulative effects" is "a problem that has proven nearly impossible to solve" (Tyack, 2016). Nonetheless, it is also argued that to discern the factors contributing to population trends, scientists must consider the full complement of threats faced by marine mammals (NAS, 2016). Only with such knowledge can effective decisions be made about which stressors to reduce, to bring the population back to a more favorable state, and this kind of assessment can also provide the environmental context for evaluating whether an additional activity could threaten it. However, this view of science driving policy, while eminently logical, may not be fully realistic.

AN INVENTORY OF THREATS

There is a wide and growing range of potential stressors that affect marine mammals, and Table 17.1 provides a list. These stressors are not static over time, as new ones continue to be created by human activities (take, for example, the evolution of marine noise pollution as a threat, as described in Simmonds et al., 2014) and populations may be exposed to new stressors as conditions change. In fact, novel technologies (combined with retreating ice at the poles) now allow us to access even the deepest and previously most inaccessible regions. In the Arctic, in particular, we are witnessing an influx of activities new to the region, including large-scale fishing, fossil fuel exploration, and shipping, all presenting new threats to wildlife (Simmonds, 2016).

TABLE 17.1 Factors That May Adversely Affect Cetacean and Other Marine Mammal Populations and Their Habitats

Climate change	Storm intensity changes
	Sea ice changes
	Changes in runoff water circulations
	Ozone depletion
	Climate change–driven *changes in human activities, e.g.,* • *increased shipping and fishing in Arctic waters* • *increased directed take of marine mammals*
Pollution	Nutrient pollution/eutrophication
	Harmful algal blooms
	Oil spills
Persistent organic pollutants, especially PCBs (but also potentially including brominated flame retardants and perfluorinated compounds)	
Heavy metals	
Nonfishery-derived marine debris, including microdebris	
Fisheries/related activities	Overfishing and prey-culling *and depletion*
	Mariculture
	Marine debris, including ghost nets
	Bycatch
Noise pollution	Seismic surveys
	Boat traffic (*also causing ship strikes*)
	Military sonar
	Construction
Pathogen emergent disease	
Physical habitat degradation	Bottom trawling
	Dredging
	Other destructive fishing techniques
	Reclamation
	Coastal construction
	Wind farms
	Dams and barrages
	Marine fossil fuel exploration/extraction

Continued

TABLE 17.1 Factors That May Adversely Affect Cetacean and Other Marine Mammal Populations and Their Habitats–cont'd

Tourism	Whale watching
	"Swim with" programs
War-related activities	Mines
	Munitions dumps
Introduced species	
Intentional takes	*Commercial whaling*
	Other marine mammal takes for profit or food.

After International Whaling Commission (2006), with additional factors from Brakes and Simmonds (2011).

Simmonds and Brakes (2011) compared a review of threats to cetaceans made in 1996, with their understanding in 2011, and suggested the following key developments:

- There had been a general acceptance of noise pollution as a substantive threat and some movement to address this.
- Climate change had also become an accepted phenomenon, with implications for cetaceans.
- Levels of some of the more infamous pollutants had fallen.
- There was much recent new research into marine mammal diseases and a growing awareness of the vulnerability of marine mammal populations to disease events and the potential of human activities to contribute to them.

A few years further on (I am now writing in mid-2017), it is now possible to recognize the reemergence of the threat posed by PCBs as a significant issue for the survival of some populations. Likewise, the growing number of harmful algal blooms (e.g., Anderson, 2009), possibly boosted by nutrient discharges, combined with changing climate, seems to be coming more clearly to the fore as a pressing issue (IWC, 2017). It is also now much more clearly recognized that intense sounds from human activities—such as seismic air guns—can have direct physiologic effects on marine mammals and that naval sonar triggers behavioral reactions that can lead to death by stranding (NAS, 2016).

Emerging threats at this time include the growing amounts of macro- and microdebris in the seas and oceans and, as noted before, rapidly changing human activities in the Arctic. Factors impacting marine mammals populations can be lethal (e.g., a ship strike or a launched harpoon) or sublethal, and when describing "stressors" here, it is a sublethal impact that is being primarily considered. For example, while loud noise can be lethal, the most common effect of noise on marine

mammals is behavioral disturbance. From a population perspective, rather subtle behavioral changes affecting very large numbers of marine mammals may have greater consequences than occasional lethal events affecting a few (NAS, 2016).

AN EXAMPLE OF A COMPLEXITY: CLIMATE CHANGE

To help more fully comprehend the complex natures of the situations that marine mammal populations are facing, it may be worth considering further the various mechanisms through which climate change may come to impact them. Simmonds (2016) reviewed this, and it is apparent from the scientific literature that the primary concerns are not so much about a direct effect upon the individual marine mammals themselves (e.g., thermal stress) but more focused upon changes in prey and, to some extent, on changes in human activities (including their changing locations as highlighted for the Arctic earlier and discussed more broadly in Alter et al., 2010). This is not to say that there might not be direct responses from marine mammal populations to changing physical conditions in the sea. For example, cetacean population distribution is closely related to temperature, and it has long been theorized that there will be a general movement toward the poles as waters warm. There is already evidence that this is starting to happen. Prey may also change and shift distribution, so trying to separate out one effect from another in the future may be difficult.

Fig. 17.1 illustrates the various ways in which climate change–driven factors may come to affect marine mammals. It also highlights potential interactions with other factors. For example, access to prey might also be affected by competition with species that have changed distribution. And the fitness of the marine mammals (both as individuals and populations) might also be undermined by exposure to new pathogens, chemical and noise pollution, and so forth.

ENGAGING WITH MULTIPLE STRESSORS

The first serious attempt to try to address the issue of the multiple factors affecting marine mammals may have come from the International Whaling Commission (IWC). By the early 2000s, the member nations of the IWC had become concerned about the broad range of factors then known to be affecting cetaceans. It initiated an ambitious piece of work to look at this via a "Workshop on Habitat Degradation." While the workshop title indicates a focus on habitat, it was ultimately concerned with how to take an integrated approach to stressors/threats. The workshop was informed by an earlier smaller "scoping group" meeting of experts, and it is worth noting that this identified several potential ways forward, including consideration of individual health and body condition, "vital rates" (i.e., survival and fecundity and other life history parameters), population changes, and community-level changes (IWC, 2006). The scoping group suggested that the principal tools for linking habitat changes to these response variables were (1) correlative analyses comparing response variables across habitats with very different levels and patterns of impact; (2) "analogy

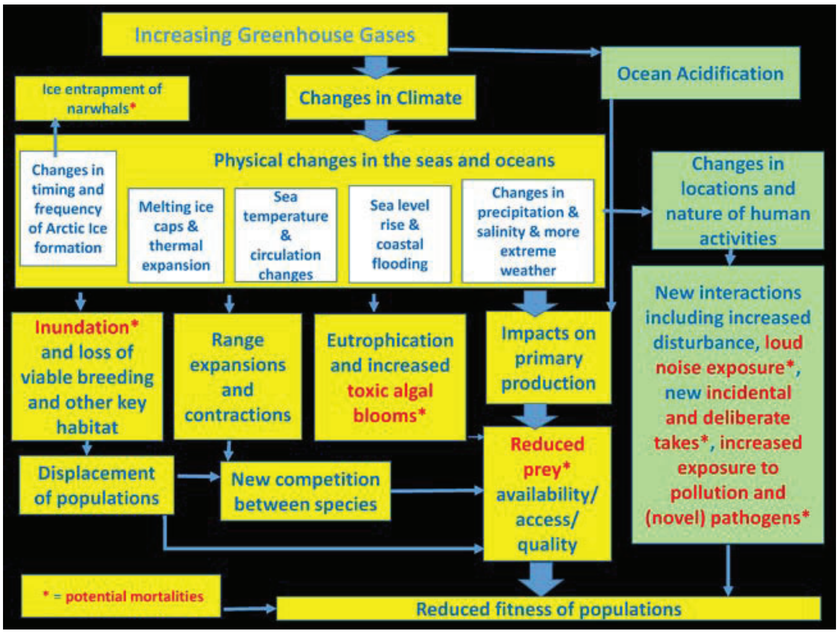

FIGURE 17.1 Climate change–driven factors and associated stressors and linkages. *(Modified from Simmonds, M.P., 2016. Impacts and effects of ocean warming on marine mammals. In: Laffoley, D., Baxter, J.M. (Eds.), Explaining Ocean Warming: Causes, Scale, Effects and Consequences. IUCN, pp. 305–322.)*

from more detailed mechanistic studies on model species"; and (3) modeling of population responses to changes in vital rates as a result of habitat degradation.

The IWC Workshop on Habitat Degradation met in 2004 and noted in its report that the IWC has been concerned about the influence of environmental changes on cetacean populations for many years, signified by various resolutions requesting that its Scientific Committee progress understanding of this issue (IWC, 2006). In response, the Scientific Committee had identified eight environmental priority topics:

- climate/environment change;
- physical and biologic habitat degradation;
- chemical pollution;
- direct and indirect effects of fisheries;
- impact of noise;
- disease and mortality events;
- ozone and UV-B radiation;
- Arctic issues.

The workshop's general conclusions stressed the importance of undertaking research relating habitat condition to cetacean status in the context of

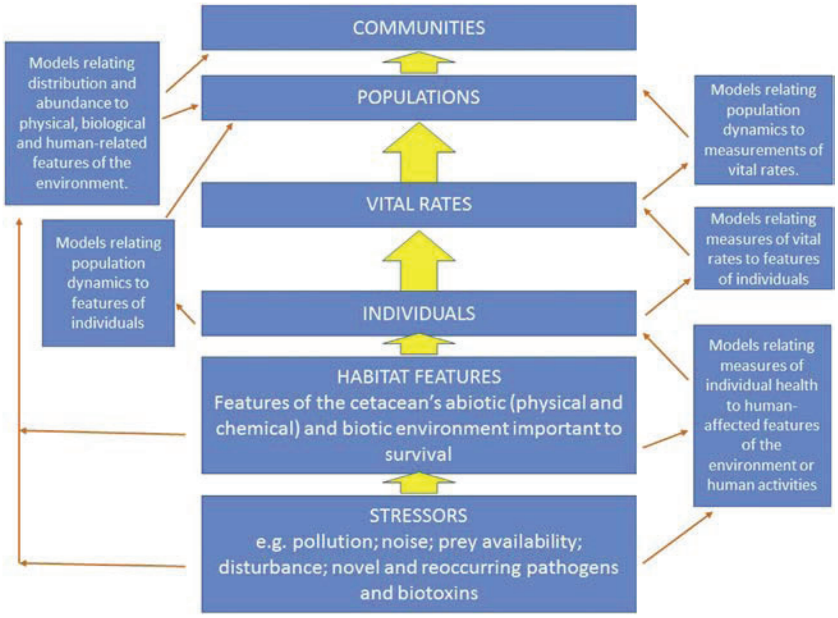

FIGURE 17.2 Framework for modeling the links between environmental stressors that degrade habitat and population effects. *(After IWC, 2006. Report of the IWC scientific committee workshop on habitat degradation. Journal of Cetacean Research and Management 8 (Suppl.), 313–335.)*

conservation and management. However, it also commented that "this is a particularly complex area of study, requiring both theoretical developments in modelling approaches and a commitment to long-term interdisciplinary data collection programmes." To help make progress, the workshop produced and strongly recommended a new framework for further investigation, which is shown in Fig. 17.2.

The workshop also commented that any general application of the framework would require that management and research bodies take a longer-term view and described the present ad hoc processes (giving "Environmental Impact Assessments," based on short-term limited datasets as an example) as unsatisfactory. In terms of further research, the workshop identified several cetacean populations with sufficiently broad sampling programs, covering sufficiently long time frames, which could be the focus of studies: Florida bottlenose dolphins; European harbor porpoises; and resident killer whales from the northwest coast of North America.

The workshop also proposed a workplan to develop the framework (as shown in Fig. 17.2) and that this should include:

1. application to specific case studies;
2. further development of approaches to distinguish the relative effects of different stressors via population and spatial modeling approaches;

3. application of the framework to one area and then using the results to make predictions for the same species in a different area and comparing this with the actual situation as a type of "validation";
4. a follow-up workshop to review the progress of this workplan.

Sadly, this comprehensive start to unraveling such a complex issue has not obviously positively resonated down the intervening years in terms of research either under the jurisdiction of the IWC or, as far as can be judged from the scientific literature, anywhere else! Perhaps the inherent problems were just too complicated, or perhaps, there was still too much to be done in terms of understanding the various stressors or developing the necessary models. However, most recently, at its 2017 meeting, the Scientific Committee of the IWC agreed to prepare for a workshop on cumulative threats, and it took note of the relevance of the outputs of the 2004 Habitat Degradation workshop to this (IWC, 2017). So, it may be hoped that there may yet be some further development and elaboration of the approaches and recommendations made by the 2004 workshop.

Certainly, there has been a lot of work on the factors affecting marine mammals and their habitats in the intervening years, and increasingly, this considers interactions with more than one stressor. The relevant scientific literature is too voluminous to review here, but examples include the copious amount of recent research on marine noise (Simmonds et al., 2014) and also on the effects of whale watching on cetacean populations (see, for example, New et al., 2015; Higham et al., 2014). Effort has also gone into modeling approaches, leading, for example, to the Population Consequences of Disturbance model (New et al., 2014).

THE LATEST WORK ON CUMULATIVE EFFECTS

Animals and populations of animals may be exposed to particular stressors once or many times. A good example is exposure to a loud noise, and multiple, frequent exposures might be more significant than rare exposures over a longer time. "Cumulative effect" has been defined as the combined effect of exposures to multiple stressors integrated over a defined relevant period: a day, a season, year, or lifetime (NAS, 2016).

In the United States, the National Academies of Sciences, Engineering, and Medicine has been looking at cumulative effects on marine mammals. The results of its deliberations were delivered in a substantive and substantial (250-page) report published in 2016 (NAS, 2016). The topic of cumulative effects was chosen by the federal agency sponsors because assessing cumulative effects has been an important part of US regulations protecting marine mammals since the 1970s, but "the approaches used have little predictive value." If cumulative effects cannot be accounted for, "then unexpected adverse impacts from interactions between stressors pose a risk to marine mammal populations and the marine ecosystems on which people and marine mammals depend" (Tyack, 2016).

Because quantitative prediction of cumulative effects of stressors on marine mammals is not currently possible, the authors of the NAS report have developed

a conceptual framework for assessing the population consequences of multiple stressors (NAS, 2016). They call this the "Population Consequences of Multiple Stressors" model, and it uses indicators of health that integrate the short-term effects of different stressors that affect survival and reproduction, and the report explores a variety of methods to estimate health, stressor exposure, and responses to stressors. (For a full explanation of this approach and the study's full and detailed recommendations, readers are directed to the full report.)

Importantly, the authors concluded that scientific knowledge is not up to the task of predicting the cumulative effects of different combinations of stressors on marine mammal populations (NAS, 2016) and comment that "even though exposure to multiple stressors is an unquestioned reality for marine mammals, the best current approach for management and conservation is to identify which stressor combinations cause the greatest risk."

CONCLUSIONS AND RECOMMENDATIONS

This short review cannot do justice to the investigations that have been made into the effects of stressors on marine mammals and their habitats, alone, in combination, or cumulatively. However, what is emerging from these studies is that this is a very complex sphere of endeavor. Clearly, much research is ongoing, and inherent in this is information that will help to inform those seeking to conserve marine mammal populations. However, the integration of research into effective conservation policy is itself far from being straightforward.

Claudio Campagna, in an inspiring keynote address at the 2015 Conference of the Society for Marine Mammalogy, challenged his audience with a bleak but well-informed view of modern conservation (Campagna, 2015). He opined that the continuing crisis of imminent extinctions is being driven by a paradigm that he summarized as

> *",,,provide me with a good economic reason or I do nothing… or I will make small adjustments of no consequence".*

He argued that the current approach to species conservation is flawed as it is based on the notion that science informs policy and policy informs conservation and sustainable economic growth. However, in practice, he argued new information is used to intervene only when it is no more costly than doing nothing! Valuing nature only in economic terms avoids recognizing the disastrous consequences of what Campagna called "the species crisis."

Sadly, my own experience of conservation work aligns closely with this, and while scientists may work hard to understand matters and give advice, including in the complex context of the multiple stressors now affecting marine mammals, this does not necessarily mean that any effective action will follow.

Related to this is that many conservation approaches require a good understanding and ongoing monitoring of the populations concerned. This is rare for many marine mammal populations (which is why many remain "data deficient" on the International Union for Conservation of Nature Red List). What is clear,

however, is that chemical pollution, noise pollution, disturbance (leading, for example, to displacement from important habitats), and other factors can substantially impact populations, and there are some instances where we know or can reasonably deduce which populations are being impacted to such an extent that their future is imperiled (for example, in the case of PCBs, certain populations in the Northeast Atlantic, including the Mediterranean and Black Sea areas). This then provides a case for action.

Pollution by PCBs and climate change are clearly difficult issues to address. There is no simple "off-tap" for either. However, it should be noted that various actions are being promoted, especially in a European context, to address PCBs (see Law and Jepson, 2017; Stuart-Smith and Jepson, 2017). However, in situations where we believe such intransigent stressors as these may be the primary cause of problems, addressing other more easily resolvable factors likely to be adversely affecting the population would seem at least precautionary and, indeed, sensible (e.g., taking action to stop or lessen incidental removals in fishing nets or death by ship strikes).

Such precautionary action—reducing stressors where this is possible—should not wait on perfect proof of impact or be inhibited by the knowledge that these stressors are not the primary causal factors in declines, but it should proceed to make populations as robust as possible to the multiple stressors they are facing. Sanctuaries or marine protected areas, wherein stressors are reduced or removed, will play an important role in this, and there is an ambitious program of work on this going forward at this time led by the Marine Mammal Protected Areas Task Force. The Task Force was created in 2013 and has been setting up regional workshops to identify Important Marine Mammal Areas, beginning with the Mediterranean in 2016, followed by the South Pacific, the Northeast Indian, the Northwest Indian and the Southeast Pacific oceans, and the waters of Oceania surrounding Australia and New Zealand (ICMMPA, 2017).

Another innovation (as hinted at in the introduction) is the use of animal health considerations to help pinpoint and better understand problems. Monitoring marine mammal population trends may not always be practical, and a measurable decline in a population should not necessarily be taken as the only possible cue for action. Welfare science and health assessments offer another set of tools. This idea is not entirely novel. While the 2004 IWC workshop did not formally include health assessments in its guiding framework (Fig. 17.2), the possible development and use of health parameters was certainly discussed there (IWC, 2006). Thirteen years later, the National Academies of Sciences, Engineering, and Medicine puts monitoring health at the center of its approach and recommendations.

More generally, monitoring the health of wild populations offers a new way to identify when significant problems are developing; perhaps providing a kind of early warning system. This relationship between welfare science and conservation now deserves to be further developed from the perspective

of improving both conservation and welfare responses, and interestingly, the IWC, with its growing interest in whale welfare outside of the hunting context (IWC, 2016), may prove to be the crucible in which such things productively come to mix.

Finally, one of the biggest problems faced by those who want to conserve and protect marine mammals (or for that matter address pressing threats, including climate change) is convincing those in power and the public more generally that this actually matters: specifically that the survival of marine mammals has relevance to our own species.

Somehow, it appears that the human race has become detached from the natural environment that supports it by maintaining functioning ecosystems of which wild animals (including marine mammals) are components. This detachment is so profound that we do not recognize the threat to ourselves as our activities disrupt and damage ecosystems. Part of the response to this has to be in education (in the broadest sense) and explaining how we inherently fit into—and are supported by—something much bigger than ourselves. Without a better informed and sympathetic public, and policy makers, we have little hope of effectively addressing the complex issues besetting marine and other ecosystems.

ACKNOWLEDGMENTS

With thanks to the editors for the opportunity to contribute here, to my anonymous reviewer for guidance, and to Mike Archer for his review. The views expressed are my own and do not necessarily reflect those of any organization that I am or have been affiliated with.

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From: Tony Nolan [redacted] >
Sent: Friday, 20 December 2019 7:41 AM
To: DPTI:State Commission Assessment Panel; Shauna Black
Subject: Fwd: Comment on the Addendum to the EIS [DLM=For-Official-Use-Only]

Playford Highway Gosse

Kangaroo Island

20th December 2019

Attention: Mr. Robert Kleeman

Unit Manager Policy and Strategic Assessment

Department of Planning, Transport and Infrastructure

The Western Districts Football Club with over 50 members, support the addendum to the EIS.

KIPT is showing that it is listening to the community while endeavouring to develop a business that will have tremendous economic benefits with sound environmental practices to Kangaroo Island.

We support KIPT, and look forward to a time when their business will increase the families working and living on Kangaroo Island, continuing to create economic benefit with sound environmental management to Kangaroo Island.

Our club is situated in the heartland of the forestry operations and will bring lasting benefits to our community.

Yours Sincerely

Tony Nolan

Western Districts Football Club President.

From:	Tony Willson
To:	DPTI:State Commission Assessment Panel
Subject:	Smith Bay Kangaroo Island
Date:	Wednesday, 11 December 2019 11:37:15 AM

Attention:
Robert Kleeman, Unit Manager Policy and Strategic Assessment Department of Planning,Transport and Infrastructure
GPO Box 1815 ADELAIDE SA 5000

Dear Sir,

I write in support of KIPT'S addendum to the EIS for a deep sea port at Smith Bay.

Our company A&G Willson Earthmovers Pty Ltd is a leading earthmoving contractor on the Island. Approval of the Smith Bay development is the key to unlocking the plantation industry, which will have significant and ongoing economic and social benefits for Kangaroo Island.

KIPT has made substantial changes to its design to accommodate perceived threats to neighbouring businesses and the environment. The new longer jetty addresses all major concerns raised by removing the solid causeway and eliminating dredging.

It is a further signal that KIPT is committed to making decisions that assist the local community and take into consideration the opinions of some local residents.

Please approve the development in a timely manner. Many businesses on the Island are looking forward to the growth this will bring to the island, including a much-needed increase in resident population (rates of the local Council) and all-year-round jobs.

Yours sincerely,

Tony Willson
A & G Willson Earthmovers Pty Ltd
PO Box 291 Lonsdale SA 5160
Ph: (08) 8384 5577 Fx: (08) 8384 5501
Email: [redacted]

Post marked 16/12/19
Received 18/12/19

Minister for Planning

C/- Robert Kleeman

Unit Manager Policy and Strategic Assessment

Department of Planning, Transport and Infrastructure,

GPO Box 1815, ADELAIDE. S.A. 5000

Dear Minister

Deep Water Port Facility, Smith Bay, Kangaroo Island

I write today to reiterate my support for the immediate development of the above project.

I believe that KI Timber Plantations have thoroughly and scientifically investigated all impacts of this proposal and have answered in detail all the relevant, and sometimes irrelevant objections which have been thrown at them by objectors to the proposal.

The significant alterations made to the plans of the facility in an attempt to satisfy objectors will surely render the scheme more environmentally acceptable to even the most critical and pedantic of those in opposition to the project.

As before stated, I see great benefits for our whole Island by the implementation of this proposal by way of employment, improved infrastructure and freight options for other local products, as well as those for which the facility has actually been designed.

I implore you to give your speedy approval to this sorely needed project in order that the benefits may quickly flow on to our local businesses and general population.

Yours sincerely

Vivienne D Willson

Vivienne Willson, Wisanger, KI

[redacted]

From:	Walter and Karin Florance
To:	DPTI:State Commission Assessment Panel
Subject:	Proposed new 650 metre Wharf at Smith Bay.
Date:	Wednesday, 18 December 2019 3:59:15 PM

To Whom it May Concern,
Increasing the length of the proposed "jetty" to 650 metres by KPT will in no way alter the impact on the existing valuable Marine Life of Smith Bay. A ridiculous number of piling are proposed...and with the eventuating hearing loss to marine life (and perhaps humans also) Bilge waters will still foul the Bay.Roads become death traps,and the presence, GOD forbid, of a mill...will SEVERLEY IMPACT the EXISTING RESIDENTS OF THE BAY. ...to their detriment. No residents want this Mill or "jetty".. and neither does the Kangaroo Island Council. It will interfere with tourism.
The world is watching. For once, we trust the "people" are heard......and a resounding no , comes from our government.
Yours Faithfully,
Walter Florance.Resident of Smith Bay.
Sent from my iPad

Workskil Australia Head Office
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Web: workskil.com.au

From now on.

5 December, 2019

Attention : Mr Robert Kleeman

Unit Manager Policy and Strategic Assessment
Department of Planning, Transport and Infrastructure
GPO Box 1815
ADELAIDE SA 5000
By Email : malordevadmin@sa.gov.au

Dear Mr Kleeman

Workskil Australia (WA) is a national not for profit organisation operating Employment Services contracts across South Australia, both in metropolitan and regional areas.

WA South Australian based operations work closely with Kangaroo Island Plantation Timbers (KIPT), placing a range of jobseekers into sustainable employment opportunities on Kangaroo Island.

We are familiar with the KIPT Smith Bay Wharf development. Our understanding is that if the approval of the Wharf is granted, it will open up approximately 174 direct forestry jobs. Further, it is expected that a number of other indirect positions will also become available for teachers, shop assistants and hospitality staff and provide an opportunity for individuals to secure ongoing well-paid employment, affording residents on Kangaroo Island a secure and meaningful quality of life.

Unemployment and under employment represent about 2.5% per cent of the KI population and is an indication of the bigger hidden problem of lack of opportunity for meaningful and well-paid work on Kangaroo Island. Through our interactions with KIPT, we have witnessed the opportunities employment with KIPT has afforded our customers.

We are aware that revised jetty designs have been submitted by KIPT in response to concerns raised. We fully support the changes as proposed, prepared by Environmental Projects in October 2019 and presented by KIPT in the Addendum to the Environmental Impact Statement.

WA and KIPT are committed to continuing this collaboration to further benefit jobseekers.

If you require any further information, please contact me via my details below.

Yours sincerely

Nicole Dwyer
Chief Executive Officer

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SMITH BAY WHARF ADDENDUM RESPONSE

by Yumbah Aquaculture

DECEMBER 2019

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ABBREVIATIONS

BIA	Biologically Important Area
DAWR	Department of Agriculture and Water Resources
EIS	Environmental Impact Statement
EPA	Environmental Protection Authority
EPBC	Environment Protection and Biodiversity Conservation
KI	Kangaroo Island
KIPT	Kangaroo Island Plantation Timbers
MAZ	Marine Activity Zone
MMO	Marine Mammal Observers
MNES	Matters of National Environmental Significance
PTS	Permanent Threshold Shift
SEL	Sound Exposure level
TTS	Tempory Threshold Shift

DISCLAIMER

This report has been prepared by Yumbah Aquaculture Ltd and may only be used and relied on by the South Australian Department of Planning and Infrastructure for the sole purpose of providing a public comment on the Environmental Impact Statement Addendum prepared by Kangaroo Island Plantation Timbers Limited for a "Deep Water Port Facility at Smith Bay, Kangaroo Island".

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EXECUTIVE SUMMARY

In March 2019, Kangaroo Island Plantation Timbers released the Draft Environmental Impact Statement (after having its first effort rejected by the South Australian Government) for its proposed KI Seaport at Smith Bay on the island's north coast.

This document drew nearly 1400 submissions from government agencies, residents, business operators, scientists, farmers and visitors. Of the 1400 submissions, 1265, or 90 per cent, opposed the KI Seaport.

The original draft EIS report's conclusions were challenged, its science contested, lack of rigour highlighted, the offhanded dismissal of alternative sites called out, and alarm bells rang at the proponent's failure to satisfy Commonwealth or State statutory obligations.

It comes as no surprise that less than six months after receiving this critique, the proponent has chosen – or was given a wise direction – to return to the drawing board.

Unfortunately, it chose the same drawing board – Smith Bay.

It elected to ignore and dismiss the wishes, requests and evidence that other sites on Kangaroo Island are better-suited to the purpose of a deepwater export wharf.

Even those sites it owns.

The Addendum presented now showcases a completely different wharf.

A solid causeway is replaced by an open-pile jetty with a floating pontoon berth stretching 650 metres into Smith Bay and out to sea.

It seems Yumbah Aquaculture and others are expected to thank the proponent for this design change, where the proponent's clear belief is that "all concerns" are addressed.

Its Addendum says plainly:

"All stakeholders will agree there will be no harm to water quality in Smith Bay and no material risk to Yumbah."

At the same time as claiming no impact, how can KIPT also claim such complete understanding of the mass of science that underpins the success of Yumbah's onshore aquaculture business?

A new design does address some concerns, but by no means satisfies *all* concerns.

And it substantially raises the stakes with new issues and risks specific to Yumbah's operations at Smith Bay.

Beyond Smith Bay itself, every shortcoming, every risk, every matter consigned in the draft EIS to future, hypothetical management plans, remains real.

Yumbah supports improved sea freight options on Kangaroo Island.

Yumbah, like most Islanders, wants the trees gone and the land that was given over to failed, tax-led Managed Investment Schemes returned to productive agriculture and wilderness for tourism.

Our view aligns with Kangaroo Island Council's Economic Development Outlook and its commitment to agriculture, fine food, wine and tourism.

The failings of the past are revisited in this new proposal:

- The proponent has aired an ambition to double the area of plantations on Kangaroo Island yet fails to consider this in its Addendum
- Its seaport will be open to "third parties for other cargo", the details of which are unknown
- Replacing dredging with piling dramatically worsens the acoustic risk profile for marine mammals
- Biosecurity is still not adequately addressed in this pest-free bay
- The impact of lights around the clock, 650 metres out to sea, on marine species, abalone and human amenity are dismissed

Our greatest concern is the lack of modelling and technical information to support the revised plans.

The proponent has relied on old, easily contested modelling against its new design.

For the credibility of the State's Major Development Process, let alone for the science, modelling must match the proposal.

KIPT's seaport proponents refer to Yumbah Aquaculture's proposed abalone farm called 'Nyamat' at Bolwarra on the shores of Portland Bay in Victoria's west.

They say proximity to the Port of Portland is evidence abalone farms and industrial ports can co-exist on top of each other.

But they ignore the reality that Port of Portland is 4.8 kilometres across open sea from Yumbah's proposed intake pipes at the Nyamat farm.

At Smith Bay, the proposed seaport is 200 metres from Yumbah's intake pipes.

A seaport at Smith Bay will destroy Yumbah's Kangaroo Island business.

In doing so, not only will Yumbah's investment in the State cease, but sector confidence in South Australia will be lost – and investment in aquaculture will stall.

In 2016 the South Australian Government noted the State was:

"A world leader in the ecologically sustainable development of aquaculture, with one of Australia's most comprehensive legislations in place to protect and manage the state's aquatic resources".

That will no longer be true.

While these are matters beyond the scope of this submission in response to the proponent's Addendum, they form part of an argument that says the KI Seaport at Smith Bay does not stack up.

Distance comparison

Figure 1 – Distance comparison between the proposed Yumbah Nyamat and Port of Portland in Victorian and Yumbah Kangaroo Island and KIPTs Smith Bay seaport proposal in South Australia.

INTRODUCTION

KIPT's Addendum to the Smith Bay Wharf Draft Environmental Impact Statement provides an overview of a redesigned seaport for Smith Bay. The new design is offered as a solution, to remove the risks associated with the previous design to the coastal environment, to water quality, to flora and fauna, to neighbours, businesses and visitors to Smith Bay.

The following report outlines the issues Yumbah Aquaculture has with the proposed changes.

REDESIGN

This redesign does address some of the concerns Yumbah raised regarding the construction of a seaport at Smith Bay but does not remove the existential threat to our abalone farm that this proposal creates. The redesigned seaport also introduces new concerns and risks for Yumbah. And significantly, all concerns and risks associated with the operation of a seaport in such close proximity, regardless of the design, remain.

This remains a proposal for a seaport at Smith Bay that can accommodate Panamax class vessels of up to 60,000 deadweight tonnes, which have a draft of 11.75m. KIPT estimates 10-20 shipments a year arriving from foreign ports, with the Smith Bay facility used 30-75 days a year. It would be open to "third parties for other cargo", the details of which remain unknown. Changing the design of the seaport removes few of the risks and concerns, instead replacing them with other issues.

Scientific modelling and further technical assessments must be undertaken on the revised plan to ascertain the exact nature of the impacts of construction and operation of the seaport, particularly with regards to the effects on marine ecology and water quality, coastal processes and MNES.

MARINE WATER QUALITY

The redesign introduces new risks to marine water quality including chemicals in anti-corrosion marine paint necessary for steel piles. Meanwhile all the previous risks involved with an operational port remain, including chemical spills, leachate from woodchip piles and log piles, and biofouling, among others.

Scientific modelling and technical assessments must be undertaken on the revised plan to ascertain the exact impact construction and operation of the seaport will have on water quality.

COASTAL PROCESSES

The Addendum states that an open-piled jetty substructure would have a *"negligible effect on coastal processes at Smith Bay"*, but then states that the *"only residual effect would be a 30-50 per cent reduction in wave height in the immediate lee of the floating pontoon, and by less than 5 per cent at the nearest of Yumbah's seawater intakes"*. There cannot be a reduction in wave height by 30-50 per cent and at the same time have *"negligible disturbance to the Smith Bay foreshore"*. This decrease in wave height must have some effect on the foreshore and must be addressed with scientific modelling and additional assessment.

LAND-BASED AQAUCULTURE

There are numerous aspects relating to this proposal that create unacceptable risk for a land-based aquaculture business whose intake pipes are located in such close proximity to the seaport jetty.

These include potential toxicity to the marine environment from timber chemicals. Chemicals that may be used or introduced to the Smith Bay seaport from KIPT timber operations include herbicides, fumigants and preservatives, while fuel spills from shipping vessels are a common occurrence in seaports across the globe.

The Addendum states that the impacts of degraded marine water quality would be of *"negligible"* consequence for an abalone farm. However, it is not clear how this conclusion is reached without any scientific modelling. We do not believe that there will be a negligible impact on the abalone farm, in fact, the adverse impact we foresee would destroy the farm and our business. The consequence could more accurately be described as existential.

Similarly deeming that adverse impacts from hydrocarbon spills during construction and operation are "minor" is incorrect. In certain conditions, a hydrocarbon spill adjacent to a farm could be catastrophic for an aquaculture business.

MNES

Concerns remain for MNES, including southern right whales that inhabit Smith Bay, notably during mating and birthing seasons. There has been little consideration for the actual presence of whales at Smith Bay (historically known for supporting populations), the effects of noise and vessel strike, and no consideration of the potential impact of light shining 24 hours a day, seven days a week into the water.

It is estimated the redesigned seaport will need 225-235 steel piles along the 650m strip from the coast out to sea. Extensive pile driving will exacerbate noise issues for MNES, notably causing permanent hearing loss for southern right whales that heavily rely on acoustics for communication.

Five species of sea dragons protected under the EPBC Act have been identified at the proposed seaport site. The changed impacts as a result of the redesign have not been considered. This needs to be addressed.

BIOSECURITY

Smith Bay is a Coastal Conservation Zone free of any threats from exotic pests and diseases. The construction of any seaport in such close proximity, regardless of the design, will introduce exotic pests and diseases. No amount of mitigation plans will eliminate the introduction of exotic pests and diseases that is commonly accepted with ports.

The biosecurity issues that will be introduced to Smith Bay will threaten Yumbah KI and could have devastating impacts on the Island's environment, tourism and agricultural industries.

There is no "additional" risk with the revised plan, but this revised plan does nothing to reduce the biosecurity risks already identified in the Draft EIS. Clearer management and mitigation measures are required, plans that serve as commitments rather than just ideas, suggestions or abstract proposals.

NOISE

The Addendum states the noise generated by the proposed seaport, extending 650m offshore, will exceed 45dB at Yumbah. This is 3dB above the noise criteria of 42dB as stated by the EPA, doubling the sound intensity associated with the operation of the port.

LIGHTING

The lighting required by the proposed seaport will also have serious implications for Yumbah's aquaculture farm situated immediately next door, given that abalone are nocturnal feeders and require darkness for optimal feeding and growth.

VISUAL AMENITY

Under the revised plan, the increased length of the jetty would result in a significantly increased imposition on the visual amenity of most, if not all, sensitive receptors of Smith Bay.

The proposed seaport at Smith Bay is in direct contrast to the Coastal Conservation Zone and the commitment of the Kangaroo Island Council and SA Government to preserve Smith Bay and its high landscape and conservation values.

The Addendum states that, under these changed plans "*the visual amenity impacts would be noticeable and considered significant for the local residents*". The changes will exacerbate the visual amenity impacts for residents and visitors.

CONCLUSION

KIPT's seaport project delivers a portfolio of risks right to the door of the Yumbah Kangaroo Island farm. The changes through engineering solutions do not remove the significant risk to Yumbah KI. The best engineering solution is to locate KIPT's seaport elsewhere.

REVISED DESIGN

KIPT ADDENDUM RESPONSE SUMMARY

The revised design consists of a suspended deck (with no causeway), which is connected to a pontoon by a linkspan bridge. The pontoon would be held in place by restraint dolphins (i.e. piled steel structures that extend above the water level and are not connected to the shore) (see Figure 3-1).

The berth pocket would no longer require dredging. The berth face of the wharf would be positioned at a location where the natural depth of water safely accommodates Panamax-class vessels in a range of sea conditions.

In all other respects the KI Seaport design criteria remain unchanged.

- **Addendum page 6**

YUMBAH RESPONSE SUMMARY

- The redesign addresses some concerns but not the majority of the concerns, mainly associated with the location of the seaport immediately adjacent to Yumbah's aquaculture operation.
- The redesign introduces new risks including chemicals in anti-corrosion marine paints necessary for steel piles, and extensive pile driving which creates noise issues for MNES. These risks are not addressed in the Addendum.
- The Marine Activity Zone which covers the construction area for the revised design seaport, prohibits public access. Yet it overlaps with Yumbah's licenced operational area – these two activities are mutually exclusive.

REDESIGN DOESN'T ADDRESS MOST OF THE ISSUES

The design change to create a suspended deck (with no causeway) connected to a pontoon by a linkspan bridge does not alleviate many of Yumbah's concerns. Issues with the location and design of the seaport still exist.

With these design changes, KIPT states it "*trusts all stakeholders will now agree there will be no harm to water quality in Smith Bay and no material risk to Yumbah, and therefore, no credible argument that both operations cannot co-exist".* This is far from a realistic summation of the situation.

KIPT itself states there is "no change" to the risk of biofouling associated with the redesign. "No change" does not mean "no threat". In fact, the risk has been exacerbated with the increased exposure to high seas.

HOW MANY PILES?

The piled jetty structure is now proposed to be 650m long with piles driven at 12m horizontal spacing. It is estimated that there will be at least three piles every 12m (as suggested in Appendix C1 of the Addendum). This equates to at least 165 piles for the jetty (650m x 12m horizontal spacing x three piles for every 12m). The Addendum states that an additional 50-60 piles will be used for the suspended deck, equating to a minimum of 225-235 piles. This all points to substantial underwater noise created when hammering piles into the hard seabed.

Based on the above calculations, the estimate of 309 days of construction may blow out beyond this due to unforeseen circumstances such as inclement weather. The duration of the jetty construction (309 days) has not been partitioned into the expected duration of piling explicitly. However, it is stated that two piles per day will be driven, but KIPT also discusses that it will initially establish the suspended deck to allow construction of the jetty from the north and south.

KIPT must provide accurate estimates of the total number of piles expected. Pile driving will generate a substantial amount of noise by the hydraulic pile hammers, which will create significant noise impacts on marine megafauna or MNES.

KIPT also needs to provide a realistic construction program to ensure there is no overlap with critical windows of sensitivity for marine megafauna.

GEOTECHNIC FOOTPRINT

A significant and concerning unknown is how the geotechnical status of the wharf footprint, which if comprised of hard substrate, would potentially increase the time needed for piling activities and increase the 20-minute estimate for the insertion of one pile via the hydraulic hammer (and increase the duration of substantive underwater marine noise impacts). The draft EIS made reference to core refusal during the geotechnical investigations that were carried out in the hope of characterising the seabed for dredging. This core refusal is indicative of unconsolidated material, most likely rock. Locals know that the seabed is hard and composed of what is referred to as "ironstone".

The construction staging is not specified suitably for a proper noise impact assessment. Further, the uncertainty of the geotechnical status of the jetty corridor in terms of pile driving can readily increase noise impacts above the rudimentary estimates provided here, as they are seemingly based on “best case” conditions for pile driving.

The characterisation of the seabed along the piling alignment is required so that the actual duration of pile driving is understood.

NEW DESIGN ELEMENTS OF CONCERN

The use of anti-corrosion marine paints is flagged for application on the steel piles. The details of this paint are unknown and poses a risk to the sensitive life forms of abalone. Abalone are particularly sensitive to chemicals, and exhibit a greater degree of toxicity than other marine species.

Of additional concern is the application of silane as a concrete impregnant to damaged concrete. Silane is a colourless, flammable and poisonous gas, with a strong, repulsive odour. It is easily ignited in air, reacts with oxidizing agents, is toxic by inhalation, and is a strong irritant to skin, eyes and mucous membranes. Silane is used as an anti-fouling film that inhibits the formation of diatom and bacterial slime. The use of chemicals in the surrounding environment is a significant risk to Yumbah KI.

MARINE ACTIVITY ZONE OVERLAP

The proposed Marine Activity Zone (MAZ), the footprint required for the on-water construction, is shown in Figure 3-4 of the EIS Addendum. The MAZ is a clearly defined area from which the public would be excluded, to reduce navigational risks during construction. This MAZ intersects with Yumbah’s infrastructure license area and as such, could restrict Yumbah’s use of its designated land.

This is unacceptable.

LOCATION

Irrespective of its design, the proximity of any proposed KIPT seaport at Smith Bay to Yumbah continues to pose a significant risk to the existing and ongoing operation of the abalone farm. The impending seaport, solid causeway or not, prohibits any possibility of Yumbah’s ongoing investment in KI.

The extension of the seaport from Yumbah KI by an additional 250m does nothing to curtail the risk. As highlighted in the original submission, a risk-based approach should be applied to define an adequate separation distance between the KIPT seaport and Yumbah. The proposed location of the seaport an additional 250m offshore does not provide an effective buffer between port operations and the sensitive use of aquaculture.

REVISED IMPACT ASSESSMENT AND MANAGEMENT

The EIS Addendum reports on Revised Impact Assessment and Management for a number of elements associated with the seaport at Smith Bay including:

- Marine water quality
- Coastal processes
- Land-based aquaculture
- Marine ecology
- MNES
- Biosecurity
- Noise and Light
- Climate change and sustainability
- Visual amenity

The revised assessments do not alleviate Yumbah's concern regarding the risks if the seaport were to be built built directly adjacent to its aquaculture farm.

KIPT states that *removing a risk through engineering solutions is considered preferable to implementing mitigation measures,* suggesting that the new design no longer requires mitigation measures. This is incorrect as the new design does not change many of the risk profiles of a seaport, in terms of both the construction and ongoing operation.

Figure 2 – KIPT's revised seaport design from the company's EIS Addendum.

MARINE WATER QUALITY

KIPT ADDENDUM CONCLUSION

BMT's advice on the likely impact of the revised wharf design on marine water quality in Smith Bay ... confirms that piling during construction would have significantly less impact on water quality in Smith Bay compared to the potential impact from dredging. It is likely that the effects on seawater quality at Yumbah's seawater intakes would be indistinguishable from natural variation. It is concluded that piling operations during construction of the jetty would have a negligible effect on marine water quality in Smith Bay and at Yumbah's seawater intakes. Concerns expressed about adverse effects on water quality during construction of the wharf have been effectively addressed by removing dredging from the design.

The results also confirm that ship movements would result in only very minor effects on water quality in Smith Bay that would be confined to the immediate vicinity of the pontoon. It is likely that the effects on water quality would be less than those associated with a dredged berth pocket as the revised no dredge design would not disturb the existing rubbly seafloor (see Figure 4-1).

Furthermore, with the wharf positioned an additional 250 metres from shore, potential risks to water quality at Yumbah's seawater intakes as a result of sediment winnowing would be negligible.

- **Addendum page 15**

YUMBAH RESPONSE SUMMARY

- The removal of the dredging process does not address all risks to water quality that exist during the construction of a seaport that extends 650m into the ocean and involves pile driving chemical-coated piles into the seabed.
- Concerns expressed about adverse effects on water quality during construction and operation are still relevant.
- Scientific modelling must be undertaken on the revised plan to ascertain the exact impact construction and operation of the seaport will have on water quality.

REMOVING DREDGING DOES NOT REMOVE ALL RISKS TO WATER QUALITY

The reference to the draft EIS providing a detailed assessment of the effects of dredging and ship movements on water quality in Smith Bay is false. The assessments were far from detailed and fraught with gaps and incorrect assumptions. Yumbah acknowledges that some of the risks to its abalone farm have been reduced by replacing the solid causeway with a piled structure and negating the need to dredge. But significant risks to Yumbah's business still exist.

There is a lack of scientific evidence to support KIPT's statement that construction of the suspended pile jetty with no dredging is expected to significantly reduce potential adverse effects on marine water quality in Smith Bay during construction.

The effects of water quality associated with ship movements must also be addressed and measured with scientific modelling to establish exactly what changes will occur once the port is operational.

The assumption that effects on seawater quality at Yumbah's intake from piling during construction would be indistinguishable from natural variation is not quantified in any way. Based on the poor quality of the assessments used to inform the draft EIS, Yumbah has no confidence in KIPT's assumptions of impact without adequate data.

MODELLING MUST BE DONE

Advice provided to support the EIS Addendum cannot be referred to as results. KIPT claims that results confirm that *"very minor effects on water quality in Smith Bay"* would result from ship movements. It is not clear how it arrived at these results as they are not presented in the EIS Addendum.

Similarly, the speculation that sediment winnowing would be negligible due to the wharf being positioned an additional 250m offshore is not supported by any modelling or data.

Hydrodynamic modelling of the revised seaport design must be completed to substantiate statements made in the Addendum and research must be undertaken to quantify the impact or otherwise at Yumbah's intake pipes.

COASTAL PROCESSES

KIPT ADDENDUM CONCLUSION

An open-piled jetty substructure would have a negligible effect on coastal processes at Smith Bay. It would not impede currents or waves and would allow sand and wrack to move freely along the shore. It would have no effect on seawater temperatures.

Furthermore, an open-piled jetty substructure would result in negligible disturbance to the Smith Bay foreshore. The rocky shoreline would not be disturbed during construction and would therefore remain as resistant to coastal erosion as is currently the case.

The only residual effect would be a 30–50 per cent reduction in wave height in the immediate lee of the floating pontoon, and by less than five per cent at the nearest of Yumbah's seawater intakes. This could provide a slight benefit to Yumbah during north westerly storms as it could result in slightly less sediment being resuspended and entering Yumbah's seawater intakes.

It is concluded that removing the causeway from the design has addressed all of the concerns that the development would adversely affect coastal processes in Smith Bay.

\- **Addendum page 16**

YUMBAH RESPONSE SUMMARY:

- The removal of the causeway from the design does not address all the concerns that the development would adversely affect coastal processes in Smith Bay.
- The term "negligible" is vague and inadequate.
- The claims lack scientific investigation and/or data to substantiate.
- "Negligible effects" and "negligible disturbances" are effects and disturbances nonetheless and must be addressed scientifically, with modelling to substantiate all claims.

WHAT IS "NEGLIGIBLE", AND WHERE IS THE EVIDENCE?

The EIS Addendum reports that an open-piled jetty structure would result in

"negligible effects on coastal processes at Smith Bay".

What does "negligible" mean, and on what scientific evidence or data is this based?

Furthermore, this claim accepts that there will be some effects on coastal processes. KIPT needs to provide detail on what these effects are and what management plans it has put in place to deal with them.

After stating that an open-piled jetty substructure would have a

"negligible effect on coastal processes at Smith Bay"

The Addendum goes on to say that the

"only residual effect would be a 30-50 per cent reduction in wave height in the immediate lee of the floating pontoon, and by less than 5 per cent at the nearest of Yumbah's seawater intakes".

These two claims contradict each other. There cannot be a reduction in wave height by 30-50 per cent and at the same time have

"negligible disturbance to the Smith Bay foreshore".

This dramatic decrease in wave height must have some effect on the foreshore.

There are further questions that require answers. For instance, what modelling has been used by KIPT to arrive at the 30-50 per cent wave height reduction? What is the radius of influence of this change to Smith Bay, and how far will the influence extend?

BMT was engaged to provide advice on potential impacts to coastal processes at Smith Bay associated with the revised design. However, BMT considered additional hydrodynamic modelling to be unnecessary.

Modelling is required to quantify the effects of the changed plan.

The decision to remove the solid causeway does not remove all the risks associated with impacts on coastal processes. In particular, it does not change the effects of the construction of the seaport or the activities of an operational seaport on coastal processes including erosion, stormwater runoff, construction effects (including chemical spills), leachate from woodchip piles and log piles, among others.

Finally, in the Government's response to the EIS, the Government stated that

"The environmental significance and/or ecological function of the coastal foreshore is given little weight throughout the document".

This has not been given any additional study in this Addendum.

The Government also stated that

"There has been no in-depth analysis/discussion regarding the ecosystem/habitat value that this area may provide therefore the determination of minor ecological significance is not able to be substantiated".

This remains the case.

LAND-BASED AQUACULTURE

KIPT ADDENDUM RESPONSE SUMMARY

The decision to redesign the in-sea infrastructure, to remove the necessity for any dredging activities and to remove the causeway, would address all of the concerns raised by Yumbah. Replacing the causeway with a piled jetty substructure that extends further out to sea, would avoid all of the associated risks (identified in Section 4.4.1).

Extending the jetty further offshore would eliminate the need for either a capital dredging program or for any ongoing maintenance dredging. As a consequence, the risks associated with elevated suspended sediment loads, the mobilisation of toxicants, pollutants or other contaminants, the risks of elevated pathogen levels and changes in the nutrient status of these waters would be addressed.

Similarly, the decision to remove the causeway would remove all risks associated with impacts on coastal processes. There would no longer be a risk of changes to the circulation patterns in the lee of the causeway or any concomitant effects on seawater temperature profiles or nutrient status at Yumbah's seawater intakes.

Diatom productivity would remain unaffected and there would be no increase in the risk of harmful algal blooms.

The changes (to the design of the seaport) would remove all risks to land-based aquaculture resulting from the capital dredging program, the maintenance dredging program and the causeway construction and operation of the causeway.

Suspended sediment regimes, circulation patterns, temperature profiles, wave regimes, nutrient, toxicant and pathogen levels and algal productivity would all remain unchanged relative to the current (ambient) situation.

The increased distance from the berth face to the abalone farm intakes (an additional 250 metres) would have added benefits of decreasing the proximity between the shipping activities (manoeuvring, loading and unloading) and Yumbah's seawater intake pipes relative to the original proposal, although such activities would not be expected to pose any threat to aquaculture.

- **Addendum page 17-18**

YUMBAH RESPONSE SUMMARY

- The redesigned port does **not** *"address all of the concerns raised by Yumbah"*. There are numerous aspects relating to the construction of this redesign that create unacceptable risk for a land-based aquaculture business whose intake pipes are located in such close proximity to the seaport jetty.
- The redesigned port does **not** *"avoid all of the operational risks"* involved in the adjacent seaport.
- There are many concerns and risks associated with the ongoing operation of the adjacent seaport. These have not been addressed in this redesign.

THE LEVEL OF RISK REMAINS UNACCEPTABLY HIGH

Nothing in the revised jetty design changes the fundamental issue identified by Professor Paul McShane in Yumbah's response to the draft EIS:

"The proximity of the proposed wharf facility and the seawater intake of the Yumbah Aquaculture facility presents an unacceptable risk to the viable operation of the abalone farm that cannot be effectively mitigated either during construction or continuing operation."

To be clear we are talking about building a seaport on and projecting from land where the abalone farm is the neighbour and whose intake pipes are but hundreds of metres away from the jetty operation.

Removing the dredging, redesigning a piled jetty substructure and moving the berth face further offshore does not address "all of the concerns" for Yumbah. It certainly doesn't

"avoid all of the associated risks".

The success of an aquaculture farm hinges on a number of critical factors.

Figure 3 – Yumbah Aquaculture's farm at Smith Bay.

WATER QUALITY

The proposed seaport located in such close proximity to Yumbah promises risks to water quality of Smith Bay during both construction and then operation into perpetuity. Extending the causeway does not alleviate any of the water quality concerns.

CHEMICAL RISKS

The EIS Addendum fails to address potential toxicity to the marine environment from timber chemicals. Chemicals that may be used or introduced to the Smith Bay seaport from KIPT timber operations include, but are not limited to, herbicides, fumigants and preservatives. The draft EIS appears to indicate that at this point in the regulatory approvals process, timber-associated chemicals are unlikely to be used on site.
This remains unconfirmed.

Fuel spills from shipping vessels are a common occurrence in seaports across the globe. This poses a significant risk to any aquaculture farm located so close to the spill origin, and with the seaport in close proximity to Yumbah KI's intake pipes, the threat from fuel spills is unacceptable. KIPT has incorrectly assessed the risks of hydrocarbon spills during both construction and operation.

As highlighted in the draft EIS submission, the risk assessment and corresponding matrices continue to be problematic. Inclusion of rudimentary mitigation and management measures often result in reductions to residual likelihood and consequence. However, management measures can only reduce residual likelihood, not residual consequence.
As such the residual risks are misleading and do not reflect the actual risk level.

BIOSECURITY CONCERNS

See Page 31.

MITIGATION AND MANAGEMENT CONCEPTS ARE NOT ENOUGH

Several mitigation and management measures require more information. Clearer management and mitigation measures are required, plans that serve as commitments rather than just ideas, suggestions or abstract proposals.

The risk assessment in the BMT report in Appendix C1 is unacceptable. The assessment indicates that *"Degradation in marine water quality causing adverse impacts to sensitive ecological receptors (e.g. seagrass) and aquaculture receptors"* is deemed a *"negligible"* consequence. It is not a negligible consequence for an abalone farm – such adverse impacts to abalone would destroy the farm and the business. The consequence could more accurately be described as catastrophic.

Similarly deeming that adverse impacts to marine water quality and sensitive ecological receptors from hydrocarbon spills during construction and operation are "minor" is incorrect. In certain conditions, a hydrocarbon spill so close to an abalone farm would allow no time for any defence and could be catastrophic for an aquaculture business.

The Addendum states the changes made to the seaport design remove *"all risks to land-based aquaculture resulting from the capital dredging program, the maintenance dredging program and the causeway construction and operation of the causeway*". The important qualification here is that the redesign removes risks that result specifically and only from dredging and causeway construction. The plan does not remove risks associated with construction of the redesigned seaport, or any operational risks.

The introduction of pest species and diseases into marine waters of Smith Bay that will inevitably occur as they do at ports around the globe is not "minor" to a land-based aquaculture business. More accurately, these would have major consequence for an otherwise pristine marine environment, and the likelihood of pest species and diseases being introduced to the marine waters of Smith Bay as a result of the seaport is not "unlikely" but certain.

LOST OPPORTUNITY COSTS

As highlighted in the draft EIS submission, Yumbah Kangaroo Island acquired another licence (Active as of 1 July, 2018) which is immediately adjacent to the KIPT Seaport land holding on Kangaroo Island. Yumbah's intention with this licence was to expand production of abalone and investigate aquaculture production of other permitted species. However, this has been placed on hold as a consequence of this proposed seaport.

THE WRONG SITE

Site selection is a key factor in any aquaculture operation, affecting both success and sustainability. A key guideline for site selection is spatial separation from sources of risk. KIPT's seaport project delivers a portfolio of risks right to the door of the Yumbah Kangaroo Island farm.

The draft EIS recognises that good water quality is paramount to the success and viability of Yumbah –

"In summary, the importance of good water quality to the health of the abalone aquaculture sector cannot be understated."

The changes through engineering solutions do not remove the significant risk to Yumbah KI.

The best engineering solution is to locate KIPT's seaport elsewhere.

MARINE ECOLOGY

KIPT ADDENDUM RESPONSE

As expected, the seagrass communities that were present closer to shore were much sparser in the deeper water (i.e. 14–17 metres), with the cover ranging from zero to five per cent of mainly Posidonia sinuosa, with occasional patches of Amphibolis sp. and Halophila australis.

Two additional crab species (the smooth seagrass crab and the bristled sponge crab) were found during the subtidal survey, but neither is of particular conservation significance. Similarly, the intertidal survey revealed a typical assemblage of fauna, none of which is of particular conservation significance (see Appendix C2).

Much of the seafloor in the vicinity of the revised location for the pontoon and approach consisted mainly of rubble, shells and sand, which is unlikely to be particularly prone to mobilisation during ship and tug movements.

The only benthic communities that would be directly affected during construction of the jetty would be where piles would be driven into the seafloor. Assuming that 156 piles are required, and each pile would adversely impact one square metre of seafloor, approximately 0.02 ha of benthic communities (mostly seagrass) would be directly affected.

It is likely the shading effects of the pontoon in the revised design would be similar to the effects associated with the previous design. As discussed in the Draft EIS, shading effects associated with the pontoon could result in the loss of up to 0.5 ha of sparse seagrass. It is likely the maximum total loss of seagrass would be 0.52 ha, compared to 7.5 ha for the original design.

KIPT has proposed making a monetary payment to the Native Vegetation Council (NVC) to offset the seagrass loss. Using the NVC's formula for calculating significant environmental benefit (SEB) payments, the seagrass loss would result in a payment of approximately $5000 to the NVC. KIPT considers the seagrass loss to be too small to offset via the Catchment Management Plan proposed in the Draft EIS, which was intended to reduce nutrient loads entering into Nepean Bay, thereby promoting seagrass recovery.

- **Addendum page 18-19**

YUMBAH RESPONSE SUMMARY

- The stability of the marine ecology of Smith Bay is at risk from the proposed seaport.
- The revised design no longer requires dredging, but the construction and ongoing operation of the seaport will still have a material effect on Smith Bay's marine ecology.
- Calculating the revised seaport's effect on Smith Bay's flora and fauna is not as simple as adding up the footprint of the piles and stating this to be the extent of the ocean floor disturbance.

NOT TO BE UNDERESTIMATED

The marine ecology of Smith Bay cannot be underestimated. Studies in the draft EIS indicated that Smith Bay supports a mixture of reef and seagrass communities in the relatively shallow sections, with seagrass communities becoming more dominant in the deeper waters, before eventually becoming sparse in 15m-plus water depths.

The seagrass supports a variety of ecological communities as well as a significant number of pipefish which were threatened by the proposed seaport as it appeared in the Draft EIS. The redesigned seaport does not require dredging, which will reduce the impact on the local marine ecology, but the construction and operation of the revised design, which extends 650m from the coastline out to sea, will undoubtedly still have a material effect on local seagrasses and pipefish, the true nature of which cannot be accurately estimated. The assessment method undertaken included five dives with a 30m tape placed randomly on the seabed to study all flora and fauna within 1m of the tape, and three rocky shore surveys. A more thorough study over time would need to be undertaken to more accurately understand the effects of the piles and shadowing on local seabed flora and fauna.

TRUE SEAPORT FOOTPRINT

The Addendum has calculated the revised seaport's effect on the ocean floor by calculating the physical footprint of the 156 piles and comparing this to the physical footprint of the former solid causeway as well as dredging activities.

This comparison is too simplistic to assess the relative effect of the new seaport, which extends 650m from the coastline out to sea, on the ocean floor and surrounding benthic communities at Smith Bay.

Figure 4 – Damage to Smith Bay seagrass caused by an anchor during KIPT's explorative drilling.

BIOSECURITY RISKS AND THEIR EFFECTS ON MARINE ECOLOGY

The biosecurity of Smith Bay is pertinent to the survival of the endemic marine species that inhabit the area. Biosecurity risks from the construction and operation of a seaport at Smith Bay are significant. Introduced pest species are opportunistic in their behaviour and extremely invasive. Exotic species are highly effective at outcompeting established endemic species within a marine environment. Once invasive pests are introduced, the marine ecology of Smith Bay will be forever changed.

KIPT has proposed a monetary payment to the Native Vegetation Council to offset the seagrass losses. The proposed payment of $5000 to abate the damage, unknown and known, is unlikely to cover the true cost of the damage.

MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

KIPT ADDENDUM CONCLUSION

The changes to the design do not change the risk profile of the development as described in the Draft EIS. No additional MNES would be triggered by the changes to the proposal. Existing mitigation measures as described in the Draft EIS are considered effective to manage any direct or indirect impacts to the southern right whale. The revised proposal would not generate any residual significant impacts on the southern right whale.

- **Addendum page 20**

YUMBAH RESPONSE SUMMARY

- There is no evidence of new modelling or assessment of the effects of the extended seaport on MNES. It's simply inadequate to address the effects based on estimates.
- All other risks related to construction and operation of the seaport to land-based MNES remain, regardless of the redesign. These have not been addressed.
- Five species of sea dragons protected under the EPBC Act have been identified at the proposed seaport site. The changed impacts as a result of the redesign have not been considered. This is inadequate and should be addressed.

SOUTHERN RIGHT WHALES

KIPT disregards the environmental values that exist at Smith Bay and more broadly across Kangaroo Island. The company continues to ignore the fact that southern right whales are an endangered mammal under the EPBC and only recently have they begun to emerge from the brink of extinction.

KIPT has stated that there is "*no significant change to the risk profile of the development*".

However, this development still presents a significant impact to southern right whales.

KIPT maintains its assumption that a seaport in Smith Bay will have negligible impact on MNES. Locating a seaport the size and scale proposed by KIPT, within a widely recognised area renowned for sheltering populations of southern right whales, fails on science and fails on responsibility. The assumption that the increased length of jetty substructure and increased piling activity (number of piles to be installed, and extended area in which they would be installed) would have a negligible impact on southern right whales is not substantiated, and further work should be done to provide a sound evidence base.

KIPT cannot assume "negligible impact" when it has not quantified the number of southern right whales that frequent the area or their migratory trajectory along Smith Bay. KIPT has not provided any data to support its assumptions or untested statements.

A quantitative assessment is required during whale season to substantiate the actual impact on whales. KIPT needs to monitor the whales present in Smith Bay for at least two whale seasons to substantiate the assumptions that the seaport will not affect whales.

MORE DATA REQUIRED

It is KIPT's corporate responsibility to meet the requirement of the various legislative and regulatory regimes. Any assessment to MNES needs to be completed by an expert. There is no indication of the author or qualification of the author that has compiled Appendix D – MNES Assessment in the EIS Addendum.

SIGNIFICANCE OF SMITH BAY

KIPT continues to ignore the fact that southern right whales are prevalent in Smith Bay between June and September. There is a wealth of advice presented by qualified parties that supports their presence in Smith Bay.

Current understanding of southern right whales distribution and movement is the result of direct observation, primarily being visual. The Head of Bight, located west of Kangaroo Island, is recognised as a primary aggregation ground for southern right whales, with up to 172 individuals, including 81 mother and calf pairs and 29 unaccompanied adults, sighted on any one day within the study area (Charlton *et al.* 2019).

Smith Bay provides safe, protected waters for southern right whales during June to September each year. Between 2006 and 2018 there were 57 confirmed sightings of southern right whales, including 16 individuals confirmed as calves. A maximum of five individuals have been sighted at any one time in Smith Bay. It is clear that southern right whales, particularly mothers with newborn calves (56 per cent of all sightings), use these waters.

The most recent estimate for the total population of southern right whales in Australia was 3,500 individuals (Smith *et al.* 2019), comprised of approximately 3,200 individuals in the south-western "sub-population" extending as far east as Ceduna, and less than 300 individuals in the south-eastern "sub-population", including Kangaroo Island. The sighting of 57 southern right whales individuals in Smith Bay over the past 12 years, from a total population of 300 is a significant number of southern right whales and represents close to 20 per cent of the total population. As such, Smith Bay should be considered an emerging aggregation area for southern right whales.

There is no question that Smith Bay is displaying the attributes of a Biologically Important Area (BIA) for southern right whales. BIAs are not defined under the EPBC Act, but they are areas that are particularly important for the conservation of protected species and where aggregations of individuals display biologically important behaviour such as calving, foraging, resting or migration.

VESSEL STRIKES

In the Draft EIS, KIPT states that incidents of vessels *"occasionally"* striking whales are *"extremely rare and would not be capable of affecting the population of Southern Right Whales"* is at odds with the Commonwealth's submission which states:

"In the case of a species that is recovering, such as the east and west coast populations of humpback whales the loss of one individual would be unlikely to impact on either population. However, in the case of south-eastern Australian population of the southern right whale which is showing little evidence of recovery, the loss of a female individual would be considered significant." [1]

Death or injury to whales from vessel strike is one of the primary threats to whale populations worldwide. This is particularly as a result of the co-occurrence of vessels and whales in "high risk areas", whereby there are either high volumes of shipping (ie. shipping lanes or port areas) or conversely high numbers of whales (ie. known aggregation areas for feeding or breeding and areas of critical habitat)[2].

Dr Rhianne Ward is a researcher in southern right whales who works with scientific institutions, the community, oil and gas operators, government and regulators and other stakeholders. She focusses on bridging the gap between science and industry to promote species conservation management.

Dr Ward states that southern right whales are highly susceptible to vessel strike (Appendix 1). Their northern counterpart, the North Atlantic right whale is facing near extinction as a result of vessel strikes and commercial fishing activities. The large vessels that will be used during construction of the wharf, along with the vessels entering the seaport, are a significant threat to the southern right whale in Smith Bay. In 2019, three southern right whales calves were found deceased or critically injured on the shoreline of known aggregation areas. Autopsy revealed the cause of death of one of these calves as possible ship strike.

The National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna[3] states that:

"to quantify relative risk, data on vessel and megafauna densities is required to identify where the co-occurrence of megafauna and vessels occur".

Information including species behaviour such as speed and manoeuvrability, time spent at the surface, and habitat use, and surveys of megafauna distribution patterns should aim to cover areas beyond known hot spots.

KIPT's assumption that the seaport will have a negligible impact on whales is not borne out by evidence.

The idea that KIPT could extend the seaport an additional 250m into the path of southern right whale migration without affecting them is inconceivable and

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[1] Department of the Environment and Energy 2016, *Draft National Strategy for Mitigating Vessel Strike of Marine Mega-fauna*, p. 17 <http://www.environment.gov.au/system/files/consultations/bd6174ee-1a4e-4b6d-b786-2d0675b3dbec/files/draft-national-vessel-strike-strategy.pdf>

[2] Vessel Strike of Whales in Australia: The Challenges of Analysis of Historical Incident Data https://www.frontiersin.org/articles/10.3389/fmars.2018.00069/full

[3] National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna 2017, Commonwealth of Australia 2017 p.6 https://www.environment.gov.au/system/files/resources/ce6d7bec-0548-423d-b47f-d896afda9e65/files/vessel-strike-strategy.pdf

emphasises KIPT's lack of consideration to the significance of the proposed seaport at this location.

Data collected over multiple whale seasons is required before it can be stated that the proposed seaport would have a negligible impact on a species recovering from the brink of extinction.

IMPACT OF NOISE

The EIS Addendum (Page 19) indicates that KIPT's notification to Department of Environment and Energy concluded that there was no significant change to the risk profile of the development. Without data, this cannot be stated with any certainty or authority.

A statement included in the EIS Addendum purports that the increased length of jetty substructure and increased piling activity (number of piles to be installed, and the distance the activity would occur further out to sea) would have a negligible impact on southern right whales.

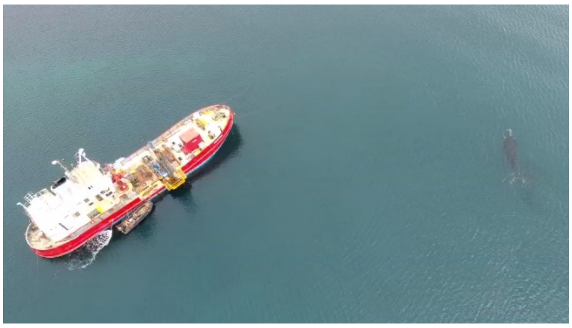

Figure 5 – KIPT investigative drilling in the immediate vicinity of a southern right whale mother and calf.

There is no qualitative nor quantitative data to indicate the extent of noise generated or subsequent attenuation of noise underwater during piling. The reference to monitoring the presence of whales within a 1km buffer from the construction is made without any supporting data. What is the basis for this distance? Modelling of noise during the worst-case scenario for pile driving is required to understand the extent of underwater noise to confirm adequacy of the suggested 1km buffer.

As highlighted by Dr Ward, southern right whales rely heavily on acoustic cues to communicate. The primary frequency range at which southern right whales communicate is about 50 to 500 Hz. During pile driving activities, most of the sound energy occurs at frequencies of 100 to 1000 Hz. Therefore, during pile driving southern right whales vocalisations are masked, effectively stopping or at least reducing communication in an impact area. The extent of the impact area needs to be understood.

Furthermore, concern prevails during port operations as noise emitted from vessels may also hinder communication between the whales.

The migratory patterns of the southern right whales around Kangaroo Island in relation to the proposed approaching channel(s) for the seaport proposed at Smith Bay needs to be substantiated to understand impacts from vessels.

SCIENTIFIC SUPPORT REQUIRED

KIPT does not consider the communication of southern right whales to be a priority. KIPT states damage to the hearing for marine fauna would be considered unlikely as the normal behaviour response of whales to loud noise would be to move away. Who has assessed the behaviour of whales to make this assumption? Again, this statement does not appear to be supported by adequate or robust science.

KIPT has identified a medium level of risk resulting in a permanent threshold shift (PTS) in the hearing of southern right whales as a result of pile driving activities. Permanent hearing damage is unacceptable for a species that relies heavily on sound for communication.

The EIS Addendum (Page 19) reports that the impact assessment considers the revised construction program with installation of one pile at a time, but with the possibility of piling in two locations simultaneously. The Addendum states

"Piling in two places simultaneously would effectively double the number of blows per minute per day, which would have the effect of increasing the cumulative sound exposure level (SEL) by 3 dB, and increasing the 'threshold distances' for temporary threshold shift (TTS) and permanent threshold shift (PTS) onset by approximately 1.6 times the values in Table 18.11 of the Draft EIS, assuming the exposure time is the same.

An increase of 3 dB is the equivalent of doubling the sound intensity of the piling, which would have a significant effect on marine mammals that rely on sound for navigating and communicating. This increase in risk is unacceptable for a species that is contingent on auditory prowess for vital communication across communities.

The Draft EIS states

"damage to the hearing of marine fauna would be considered unlikely as the normal behavioural response to loud noise would be to move away. Behavioural changes in response to noise are expected to be temporary and ecologically inconsequential as Smith Bay is not known to provide important feeding or breeding habitat."

As previously stated, Smith Bay is widely known to provide important feeding and breeding habitat for southern right whales. There have been 57 confirmed sightings of southern right whales, including 16 individuals confirmed as calves between 2006 and 2018. This is approximately 33 per cent of the sightings for a similar period at The Head of Bight, located west of KI, where up to 172 individuals have been sighted. The Head of Bight is recognised as a primary aggregation ground for southern right whales.

Figure 6 – Southern right whales swimming at Smith Bay – 27 August 2018.

THERE IS A LOT AT RISK

AusOcean, a not-for-profit organisation that is developing underwater technology to monitor the health of marine environments, conducted a detailed underwater marine survey of the new site that KIPT's extended seaport will affect.

During this underwater marine survey, divers identified five species of *Syngnathidae* (pipefish) which are protected under the EPBC act.
The Syngnathidae likely to be affected by KIPT's new proposal include:

- Wide bodied pipefish (Stigmatopora nigra)
- Spotted pipefish (Stigmatopora argus)
- Mother of pearl pipefish (Vanacampus margaritifer)
- Weedy sea dragon (Phyllopteryx taeniolatus)
- Leafy sea dragon (Phycodurus eques)

AusOcean's findings are significant for Smith Bay, and identify exactly species that are at risk if this proposal were to be approved by the South Australian government.   AusOcean's findings at Smith Bay have been meticulously recorded on iNaturalist[4].

Figure 7 – Leafy sea dragon sighted by AusOcean in Smith Bay. Photo: Trek Hopton

[4] https://www.inaturalist.org/projects/smith-bay-kangaroo-island

OPERATIONAL IMPACT

KIPT considers that operationally, the suspended piled jetty and reduced in-water footprint would have a negligible impact on whale behaviour. The Addendum states that design changes remove the solid causeway from the design (which may be considered a potential barrier to movement) and any future maintenance dredging activity would no longer be required.

The footprint of the revised seaport would involve a structure extending 650m offshore. **Quantitative data over a number of whale seasons on the use of Smith Bay by the southern right whales is required.**

KIPT further claims there would be no residual significant impacts on the southern right whale as a result of the revised design for the KI Seaport. This is flawed and unsubstantiated without any data.

EXPERT ADVICE REQUIRED

Any assessment to MNES needs to be completed by an expert. There is no indication of the author or qualification of the author that has completed the assessment in Appendix D of the EIS Addendum. **A quantitative assessment is required during a number of whale seasons to substantiate the actual impact on whales.**

KIPT's failure to accurately represent the ecological values at its proposed Smith Bay seaport site is deplorable. The continued lack of consideration for Smith Bay and scant and misleading information in the draft EIS and again in the EIS Addendum confirms that this proponent disrespects the EPBC Act, has no regard for Smith Bay as a Coastal Conservation Zone, and lacks concern for the ecological values across the development footprint.

BIOSECURITY

KIPT ADDENDUM CONCLUSION

The revised design removes the risks associated with importing rock material and dredging, and would not introduce any additional risks to the biosecurity status of Kangaroo Island.

- **Addendum page 21**

YUMBAH RESPONSE SUMMARY

Smith Bay is a Coastal Conservation Zone free of any threats from exotic pests and diseases. The construction of any seaport, regardless of the design, will introduce exotic pests and diseases.

- No amount of mitigation plans will eliminate the introduction of exotic pests and diseases to Smith Bay.
- The biosecurity issues that will be introduced to Smith Bay will present a major threat to Yumbah KI and can have devastating impacts on the Island's environment, tourism and agricultural industries.
- The revised plan trades previous risks such as sediment transfer and the causeway with a raft of new risks in both the construction and operating phases. In addition this revised plan does nothing to reduce the risks already identified in the Draft EIS.

EXOTIC PESTS AND DISEASES ARE INEVITABLE

Irrespective of the design change, the mitigation measures proposed by KIPT during both construction and operation of the seaport will not be adequate to eliminate all risks to the biosecurity and conservation of Smith Bay.

There is no level of risk to Smith Bay's biosecurity that is acceptable. Colonisation of exotic species and disease is inevitable. The changes to the design do not eliminate the significant risk to Smith Bay and Yumbah, they simply shift the biosecurity risk profile from sediments to biofouling.

The Addendum states the revised design removes the potential risks associated with importing rock material and dredging and does not introduce any additional risks to the biosecurity status of Kangaroo Island. But risks to Smith Bay, a Coastal Conservation Zone free from exotic pests, exist with any seaport at this location. It is not acceptable to compromise a largely untouched, environmentally sensitive location such as Smith Bay and introduce biosecurity risks to Smith Bay.

KIPT appears to believe that the design change, which increases the separation distance of the wharf's berth face from the shore, and from Yumbah's seawater intake pipes, would also reduce the potential operational risks associated with marine vessels. Establishing a seaport at Smith Bay presents a significant risk to Yumbah on a number of fronts that are not mitigated by the additional 250m separation granted by the jetty extension.

Extending the berth further offshore will not obviate biosecurity threats associated with ballast water discharge or biofouling.

Many ports in Australia with extended offshore jetties have still been invaded and provide a beachhead for new introduced species to establish.

The following risks still prevail:

- Ballast water exchange is largely ineffective at reducing the risks associated with ballast sediments, particularly for the cysts of toxic dinoflagellates.
- Biofouling of commercial vessels, particularly in niche areas and dry-docking support strips (areas that were not repainted during the previous dry-docking), can transfer mature communities resulting in the spawning or accidental dislodgment of material.
- Disease agents and parasites can be transferred and harboured in mature biofouling communities on wharves.

CONSTRUCTION RISKS

Professor Chad Hewitt and Professor Marnie Campbell's *Review of Biosecurity Aspects of the Addendum to the Smith Bay Wharf Draft Environmental Impact Statement* (Appendix 2) notes that the biosecurity risks to Smith Bay associated with sediment transfer from dredge and hopper barges, and the solid causeway, have been removed with the solid causeway. But those risks have been replaced by a barged pile driver, transport of construction materials (piles and suspended dock), and the floating pontoon. As a result, the species' transfer risks associated with the construction phase persist with the redesigned seaport.

The Addendum states that the expected duration of deck construction, including piling, is 309 days. Construction activities will largely be marine-based and will involve a number of vessels entering and exiting the area. Pile drivers and supporting construction barges are directly linked to the spread and transfer of non-native marine biofouling species. Slow-moving vessels (pile drivers, dumb barges, pontoons) represent a high biofouling risk (and associated disease and parasite risk) due to long port residence times.

The Addendum suggests that the potential biosecurity risks from construction would be removed as a consequence of the design change, particularly as the requirement to import rock material for the solid causeway would not be required and seabed dredging will be avoided.

It is true that the available surfaces on which invasive species could attach is reduced with the removal of the solid causeway, but protection of endemic species at Smith Bay will be sacrificed forever for the sake of a seaport that could and should be located elsewhere.

The floating pontoon will be barged in, which, in itself, represents a biofouling risk based on the previous port of call and residence time of the barge. Biofouling on domestic vessels, particularly in niche areas or on slow-moving vessels (such as dumb barges), can transfer mature communities, resulting in the spawning or accidental dislodgment of material.
KIPT states:

"no in-water or dry dock cleaning would be permitted at Smith Bay."

This will limit intentional discharge of material but, a more thorough method would require all vessels used during the construction phase to be

"cleaned prior to entry".

BALLAST WATER RISKS

Biosecurity is a major risk with ballast water exchange and ship fouling introducing exotic species and disease agents to the pristine environment of Smith Bay. Ballast water is a conduit for marine pests and disease, and mitigation measures are inappropriate and unlikely to be applied. As highlighted in the original submission, compliance with national ballast water exchange and the legally sanctioned mechanisms does little to mitigate risk to the environment. There is not a seaport in the world that is void of issues associated with introduced marine pests.

High seas ballast exchange is moderately successful at reducing the planktonic component of the assemblage, however it is inadequate when it comes to reducing the ballast sediment load. Additionally, it is unlikely that domestic movements will be able to undertake ballast exchange in the "high seas" and indeed are not required to under international or Commonwealth legislation. This mitigation is unlikely to be applied unless explicit agreements and requirements are made.

HARD SURFACE RISKS

The risk of colonisation of hard surfaces would still be prevalent and is not obsolete. KIPT is introducing 156 piles to the marine environment - infrastructure and hard surfaces that would otherwise not exist. When coupled with contaminated ballast and vessel hulls that would not otherwise be in the area, the provision of unoccupied hard surfaces will provide perfect substrate for colonisation. Treatment of piles with anti-corrosion paint off-site would only provide protection for a limited time. The effects of the anti-corrosion paint are unknown.
In-water treatment of piles is impossible.

VESSEL RISKS

KIPT has not adequately identified source ports for vessel transfer to and from the proposed seaport. This information is required to support the draft EIS and better understand the potential marine pests and disease agents that may be introduced to Smith Bay. Further explanation is required elaborating on potential species known from those ports/regions that might pose a risk of transfer and impact abalone.

Biofouling communities on vessels and wharf structures have been demonstrated to harbour disease agents and parasites, such as *Perkensis,* that can be transferred to native communities on natural substrates.

MANAGEMENT PLANS NEEDED

KIPT claims regular inspection of structures, including the jetty, would be undertaken in accordance with the Marine Pest Management Plan and Biosecurity Management Plan. These plans need to be seen. The mitigation actions listed are inadequate, and it is difficult to imagine any management plan would sufficiently deal with the raft of significant risks that exist with the seaport, irrespective of the design.

It is difficult to monitor for the early detection of marine exotic organisms at or near the site, especially on and around the causeway and wharf. Introduced species are difficult to detect in planktonic or microscopic form and are only evident when in abundance and prolific. Removal of marine pests and exotic organisms will be impossible once species have colonised and proliferated in Smith Bay.

"Regular inspections" will do nothing to manage the biosecurity risks.

LAND-BASED AQUACULTURE

At previously highlighted, the Federal Government's Department of Agriculture and Water Resources (DAWR) *National Guidelines - Biosecurity Plan Guidelines for land based abalone farms* (the Guideline) recognises ports as high-risk sites with the potential to compromise biosecurity of aquaculture. An objective of the guideline is to strengthen existing biosecurity within abalone farms and implement preventative biosecurity measures, rather than reacting to a disease outbreak. Eliminating biosecurity risks associated with ballast water, biofouling and imported seafood products, as well as maintaining water quality and disease-free status, are essential to the success of aquaculture industries, including Yumbah KI.

AUTHOR QUALIFICATIONS

The authors of the EIS Addendum's section on biosecurity risks have not been identified, specifically regarding their qualifications to assess the biosecurity risks. Who will author the Biosecurity Management Plan? Where is the modelling that looks at the hydrodynamic influences at the extended seaport location to confirm the assumptions of KIPT that the biosecurity risks to Yumbah are reduced with the proposed distance offshore?

ORIGINAL CONCERNS REMAIN

Hewitt and Campbell have concluded in their most recent review that the Addendum does not address the biosecurity risks that were raised previously and are still of significant concern.

1. The methodology for determining marine biosecurity risk activities, vectors and species is unclear and, based on the material presented, inadequate.
    a) The species assessments do not appropriately consider either the domestic or international source locations to determine the species (and disease agents and parasites) likely to be transported into Smith Bay waters.
    b) The assessment of disease agents (pathogens and parasites) does not adequately consider the suite of licensed aquaculture species permitted to Yumbah KI.
    c) An additional nine diseases or etiological agent species from Japan or China are known to affect Genera licensed to Yumbah KI, and known to have caused mass mortalities of aquaculture species in China or Japan.
2. The risk mitigation measures proposed are generic and meet the letter, rather than the intent, of international, Commonwealth and State requirements.

3. The measures for discharges and ballast water management focus explicitly on the operational phase using commercial trading vessels and are insufficiently detailed to address the construction phase, particularly for the risks associated with slow moving vessels including barges.
4. Domestic ballast water movement is unlikely to attain distances offshore to meet the definition of “high seas” and therefore will not be able to undertake adequate protections.
5. Biofouling species hazards associated with both construction and operational phases will continue to pose unmitigated risks. The restriction on “in water or dry dock cleaning” at Smith Bay will not prevent mature species from spawning or being dislodged into Smith Bay waters.
6. Additionally, mature biofouling assemblages are likely to pose the additional risk of transferring disease agents and parasites into Smith Bay.

NOISE AND LIGHT

KIPT ADDENDUM CONCLUSION

The noise and lighting assessments presented in the Draft EIS have been revised following the proposed redesign of the in-water structures. The revised assessments indicate that the noise and lighting impacts described in the Draft EIS remain valid and present a realistic picture of the impacts associated with the revised configuration. Underwater piling noise would not be expected to increase although impact thresholds could extend a further 250 metres into Smith Bay, in keeping with the extended jetty structure. Terrestrial noise impacts would decrease slightly as a result of moving noise-generating shiploading activities further offshore, and lighting would comply with the requirements of the relevant Australian standards at all sensitive receptor locations.

- **Addendum page 24**

YUMBAH RESPONSE SUMMARY

- There has been no new modelling done on noise levels with regards to the new seaport design. This must occur. The noise generated by pile driving will have serious implications for MNES, including southern right whales.
- The Addendum states the noise generated by the proposed seaport, extending 650m, offshore will generate noise exceeding 45db at Yumbah. This is a doubling of sound intensity above the noise criteria of 42dB as stated by the EPA.
- The lighting required by the proposed seaport will have serious implications for an aquaculture farm situated immediately next door, given that abalone are nocturnal feeders and require darkness for optimal feeding and growth. This fact has not been addressed in the Addendum.
- There is no commitment by KIPT to respect the EPA requirement that "piling should not be undertaken during whale migration season nor when dolphins, which frequent the region, are present".

UNDERWATER NOISE

The EIS Addendum presents an alternative design of the seaport which will create increased noise in the marine environment. KIPT has not conducted any additional noise modelling on the construction or operation of the alternative seaport design but have instead relied on modelling for a construction scenario that is now no longer applicable. KIPT has flagged that there may be a possibility of piling in two locations simultaneously, clearly increasing the frequency of noise creation.

The EIS Addendum states that the underwater noise and vibration from pile-driving operations during construction would create the same noise source (and levels) and associated noise contours would exist over a greater distance (due to the increased jetty length). It also states that the increased length of jetty substructure and increased piling activity (number of piles to be installed, and the distance the activity would occur further out to sea) would have a negligible impact on southern right whales.

KIPT states that behavioural changes of marine mammals in response to loud noise are expected to be temporary and ecologically inconsequential as Smith Bay is not known to provide important feeding or breeding habitat. Without collecting data during whale seasons to substantiate this statement, the claim of “inconsequential impact” is unproven and speculative.

Yumbah engaged GHD to review the EIS Addendum and the information presented by KIPT regarding the redesign and its associated underwater noise. Val Lenchine of GHD is qualified in the field of underwater acoustics and was an author of the South Australian *Underwater Piling Noise Guidelines* (2012). The report completed by Val Lenchine titled *Smith Bay Wharf- EIS Addendum, Underwater Construction Noise* (7 December 2019) is presented in Appendix 3.

Lenchine has noted that the draft EIS forecasted a medium risk for permanent hearing damage to southern right whales within 900m of the piling and temporary hearing damage effects may be observed within 6.5km of piling. This is a significant area where effects on marine species would be considered high.

INCREASED NOISE WILL HINDER MAMMAL OBSERVATION

As highlighted by Lenchine (2019), the revised design involves a greater number of piles to be placed at the jetty with simultaneous pile driving of two piles being considered. The distance for shut-down zones and observation zones were originally suggested by KIPT as 1km. Pile driving activities raises the sound impact by 3dB, essentially doubling the sound intensity. This would increase the shut-down and observation zones by 40 per cent compared to the initial estimates in the acoustic report of the draft EIS. This would create added difficultly in performing effective visual marine species identification by Marine Mammal Observers (MMO) in significantly extended zones around the construction site. Further details are required regarding the use of MMOs and procedures which would ensure management of these species during sensitive migration and calving seasons.

This increased extension of noise intensification should not be deemed as low risk to marine mammals, particularly southern right whales.

The risks from the intensified pile driving should be classified as medium to high, given the added difficulty in visually detecting marine species across a larger construction zone and during prolonged periods of high noise impact.

DELAYS WILL OCCUR

Underwater noise levels around the construction zone may be significant for a prolonged period and cause substantial change of typical behavioural, reproductive and migration patterns of multiple marine species. The extension of the jetty to 650m offshore will result in a significantly greater number of piles required for the jetty. The EIS Addendum estimates that 309 continuous days will be required to construct the piled jetty. The required construction time will likely be extended as if often the case, due to unforeseen circumstances, such as inclement weather and storm conditions, equipment failure, and also geotechnical conditions that result in pile refusal. The draft EIS recognised that consolidated rock was present under the seabed and there has not been any further information presented to confirm the seabed strata particularly at the depth the piles will be driven to.

The pile driving and construction will need to avoid May to October each year when waters around Kangaroo Island are frequented by whales. Correspondingly, the actual construction time of the extended jetty may require around two years assuming that pile driving will not be performed during the whale season.

KIPT has not fully considered the increased risk from prolonged pile driving and the range of noise source levels associated with impact pile driving. An amended acoustic report and underwater noise impact assessment is required to reflect new acoustic inputs and details of the pile construction such as type of piles, depth of piling etc. The existing modelling report does not clearly relate to the noise source levels and underwater noise predictions for the revised seaport design.

The revised assessment may show the necessity for a substantial change of noise mitigation practices and pile driving technologies. More advanced technologies for the piling may be considered to reduce duration and severity of the expected underwater noise impact to reduce the risk of unacceptable environmental impacts in the area. The EPA has noted that use of vibration piling should be considered rather than hammer piling methods to reduce underwater noise impacts.

Without additional noise modelling and assessment, KIPT cannot claim that the increased length of jetty substructure and increased piling activity would have a negligible impact on southern right whales.

TERRESTRIAL NOISE – SEAPORT OPERATION

The Addendum states that the redesigned seaport will result in a minor decrease in predicted noise levels between the ship loading activities and the shore-based receivers. The noise levels at Yumbah KI are still predicted to exceed the noise planning criteria. The draft EIS states that this is not expected to be material based on an assessment of the current operations at the facility and the measured and predicted noise levels currently associated with this facility.

As highlighted in Yumbah's submission to the draft EIS, abalone farming creates minimal noise, equivalent to ambient in the marine environment and does not impact amenity. There are a number of noise sources within an abalone farm that create isolated noise within close proximity to the source, but generally noise is comparable to background. The noise generated by the proposed seaport, extending 650m offshore will generate noise exceeding 45db at Yumbah which is above the noise criteria of 42dB.

EPA CONCERNS

The EPA has highlighted in their comments following the review of the draft EIS:

Noise Terrestrial

The Environment Protection (Noise) Policy 2007 Cl.20(3)&(4) predicted noise criteria should be met at not only residential premises but also at the adjacent Yumbah Aquaculture facility. The following noise criteria need to be met at the Yumbah Aquaculture facility:

(a) 42dB(A) Leq between the hours of 7am and 10pm when measured and adjusted#; and

(b) 35dB(A) Leq between the hours of 10pm and 7am when measured and adjusted#; and

(c) 60dB(A) LAmax between the hours of 10pm and 7am when measured and adjusted#.

#The above measured noise levels should be adjusted in accordance with the Environment Protection (Noise) Policy 2007 by the inclusion of a penalty for each characteristic where tonal/modulating/impulsive/low frequency characteristics are present.

Similarly, the EPA has highlighted that there has been no consideration of the actual duration and frequency of the noise that is likely to be generated 24 hours a day, seven days a week. More information is required to comprehensively address clause 20(6) (a)-(f) of the Noise Policy. Additional information is required that describes the:

- frequency and duration of continuous and maximum dB that will be generated
- characteristics of the noise compared to Yumbah's activities
- times of noise from the noise source
- number of people likely to be adversely affected

Continuous activities at the proposed seaport will generate excessive noise that will have a detrimental impact on Yumbah KI. Further assessment of the actual impact of the noise, estimated to be above noise criteria, including the duration, frequency, and maximum extent, is required. EPA noted that noise mitigation measures have not been outlined in the draft EIS nor the EIS Addendum, which is problematic considering noise generated by the wharf activities and experienced at Yumbah KI will exceed SA statutory noise criteria. Noise mitigation measures that will be employed at KIPT's seaport must be outlined in order for KIPT to demonstrate the seaport will meet the noise criteria at Yumbah.

NOISE (UNDERWATER)

The EPA noted when reviewing the draft EIS:

Clause 9 of the Environment Protection (Water Quality) Policy states that "a person must comply with in taking all reasonable and practicable measures to prevent or minimize environmental harm resulting from undertaking an activity that pollutes or might pollute waters..." Additionally, the Environment Protection Act 1993 defines noise as a pollutant. As such the EPA regulates noise including underwater noise to prevent environmental harm. Accordingly, the EPA is concerned about potential impacts of underwater noise on marine mammals within the environment.

Piling should not be undertaken during whale migration season nor when dolphins, which frequent the region, are present. There is a need for Marine Mammal Observers (MMOs) to stop works *until marine mammal have left the caution zone. Dredging vessels need to use MMOs if dredging in dolphin breeding season and/or whale migration season.*

Further details are required regarding the use of MMOs and procedures which would ensure management of these species during sensitive seasons for migration and calving. The use of vibration piling should be considered rather than hammer piling methods to reduce underwater noise impacts.

Required details can be included in Environmental Management Plans.

This was categorised as a minor concern by the EPA with the initial draft EIS design. Yumbah argues that due to the change in construction and the massive increase in both the quantity of the piles required and the proposed frequency of pile driving that this should be classified as a required response.

LIGHT

The Addendum states that light spill during ship-loading operations would occur much further out at sea with an extended jetty, and a pontoon berth face further offshore. There has not been any consideration of the potential impact of light shining 24 hours a day, seven days a week into the water and the impact on whales and marine mammals that frequent the area.

KIPT states that a lighting assessment was undertaken to confirm compliance with AS4282-1997: *Control of the obtrusive effects of outdoor lighting.* It suggests this standard sets the requirements and the relevant light technical parameters to control the obtrusive effects of light with the intention to minimise effects of outdoor lighting on nearby residents, users of adjacent roads and transport signalling systems and on astronomical observations.

KIPT presume that compliance with this standard indicates that light levels below the limits designated for a residence is directly correlated to suitable light levels for abalone. This is incorrect. This standard does not relate to optimal lighting for the successful cultivation of abalone. The Yumbah KI draft EIS submission explained that light has a detrimental effect on abalone feeding behaviour. Abalone prefer nocturnal feeding and exhibit the most movement and feeding behaviour during darkness. Darkness stimulates both higher grazing and growth rates compared to light exposure.

EPA CONCERNS

The SA Government required that the impact of light on abalone feeding rates to be included in the draft EIS. This information was not included in the draft EIS nor the EIS Addendum. The EPA expressed concern with the information submitted as part of the draft EIS, acknowledging that the content of the draft EIS was deficient, and that further assessment of potential light impacts on the abalone farm relating to the position and intensity of lighting was still required. The Light Spill Assessment (Appendix E EIS Addendum) specifically excluded the assessment of environmental impact on local terrestrial and aquatic fauna.

KIPT has again ignored the impact of lighting on abalone. It has also continued to state that Yumbah KI has floodlights running at all times. This is false, as can be seen in the image below (Figure 8), which shows Yumbah Aquaculture’s lighting at night.

Figure 8 – Drone photo of Yumbah KI at night.

As a guide, the image below (Figure 9) shows a seaport at night and the lighting requirements. Also (Figure 10) is the lighting as predicted in the proposed seaport. This is in stark contrast to darkness required by an abalone farm and will have serious consequences to the farm's ability to operate.

KIPT must complete further assessment on light impacts to abalone.

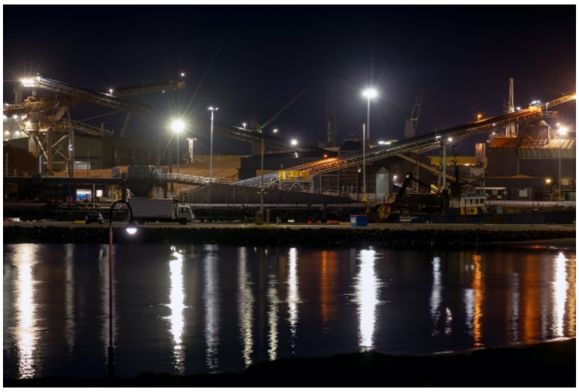

Figure 9 – Port of Portland at night.

Figure 10 – Proposed lighting outline from KIPT's EIS Addendum.

VISUAL AMENITY

KIPT ADDENDUM CONCLUSION

As discussed in the Draft EIS, the KI Seaport would intensify the relatively disturbed, semi-industrial-like character of this particular section of Smith Bay and the visual amenity impacts would be noticeable and considered significant for the residents who are on elevated land with views to Smith Bay.

The visual amenity assessment undertaken using the original sensitive receiver locations and the updated conceptual 3D model shows slight changes in visual amenity expected for some locations with the revised design. The pontoon and berthed vessel would be more visible from some locations because they would not be hidden by Yumbah Aquaculture's facility. Other locations would have a clearer view of a berthed vessel because it would be located further offshore.

Locations at either end of Smith Bay would have a clearer view of the offshore infrastructure (jetty and pontoon) and berthed vessel as these extend past the background landscape. However, the overall design of the offshore infrastructure could be considered to be less imposing than the original design given key elements of the structure would be further out to sea.

In conclusion, although there would be slight variations in the visual amenity for many locations, the overall change seen in the line of sight views presented in the Draft EIS is considered insignificant. The design change could be considered an improvement to the overall visual amenity impact that the KI Seaport would be expected to bring to Smith Bay because the jetty and pontoon infrastructure would be less conspicuous in the coastal environment than a rock armoured causeway closer to the shore. The increased length of the jetty would mean the sight of the infrastructure and berthed vessel would be less imposing visually.

- **Addendum page 24-25**

YUMBAH RESPONSE SUMMARY:

- Under the revised plan, the increased length of the jetty would result in a significantly increased imposition on the visual amenity of most, if not all, sensitive receptors of Smith Bay.
- The proposed seaport at Smith Bay is in direct contrast to the Coastal Conservation Zone and the commitment of the Kangaroo Island Council and SA Government to preserve Smith Bay and its high landscape and conservation values.
- The Addendum states that, under these changed plans ,"*the visual amenity impacts would be noticeable and considered significant for the local residents*". The changes will exacerbate the visual amenity impacts for residents and visitors.

A PROTECTED COASTAL CONSERVATION ZONE

The coastal landscape of Kangaroo Island is identified as the Island's most important landscape element and plays an integral role in the island's economy [5]. Smith Bay is in a Coastal Conservation Zone. As stated in Kangaroo Island Council's Development Plan (2015), objectives of this zone's critical Development Controls include:

1. To enhance and conserve the natural features of the coast including visual amenity, landforms, fauna and flora.
2. Low-intensity recreational uses located where environmental impacts on the coast will be minimal.
3. Development that contributes to the desired character of the zone.[6]

Kangaroo Island Council's Development Plan (2015)[6] is the key development assessment document for Kangaroo Island. It contains the rules that set out what can be done on any piece of land across the island, and the detailed criteria against which development applications will be assessed.

The Development Plan requires that facilities within the Coastal Conservation Zone align with the desired character for the zone and should be sited and designed to be subservient to the natural and coastal environment. It also requires that adverse impact on natural features and landscapes are minimised.

Developments in the zone should maintain a strong visual impression of a sparsely developed or undeveloped coastline from public roads and land-based vantage points.

KIPT's proposal for an elevated seaport that extends 650m offshore, being fed by towers of woodchips stored on the landside, does not fit within the legislated requirements for a Coastal Conservation Zone. Smith Bay deserves to be protected from significant intrusion that is at direct odds with the zoning and Development Controls stipulated for the protection of the area.

[5] https://www.kangarooisland.sa.gov.au/webdata/resources/files/Coastal%20Conservation%20Zone.pdf
[6] https://www.dpti.sa.gov.au/__data/assets/pdf_file/0009/249975/Kangaroo_Island_Council_Development_Plan.pdf

A COASTLINE WORTH PROTECTING

The Addendum states this part of Smith Bay has a "*relatively disturbed, semi-industrial-like character*". The following pictures attest to the fact that this is inaccurate.

Figure 11 – The coastline at Smith Bay.

Figure 12 – Rocky outcrop at Smith Bay.

A SEAPORT'S INNEVITABLE SUPPORT INFRASTRUCTURE

Council's land use principles for the zone stipulate:

"Buildings and structures should mainly be for essential purposes, such as shelters and toilet facilities associated with public recreation, navigation purposes or necessary minor public works."

For the proposed seaport, there will be multiple buildings and structures associated with shipping, truck transport, exports, woodchips and logging. Meanwhile, woodchips will be constantly dumped by a continuous stream of trucks to the proposed seaport.

A seaport cannot be defined as an "essential purpose" for Smith Bay when it is at odds with the desired character for the zone. Any development in Smith Bay, as a Coastal Conservation Zone, should be designed and sited to be compatible with conservation and enhancement of the coastal environment and scenic beauty of the zone.

RIGHT TO FARM

Council's Development Plan explicitly states that

"the desired character of the zone does not seek to encroach on the existing use rights of farmers".

Yumbah is an existing abalone farm with significantly important economic, social and environmental links to Kangaroo Island. The proposed seaport will encroach significantly on Yumbah KI.

The Development Plan also states,

"the creation of economic initiatives and employment opportunities, combined with appropriate land use allocation, is sought to establish a robust and sustainable economic climate that contributes to the wellbeing of the local community".

While a seaport may contribute to employment opportunities, the opportunity costs must also be considered, including the loss of employment and economic contribution with the closure of Yumbah KI, which will occur if the seaport is built.

MORE TIMBER

The Plan states

"further expansion of forestry plantations on the Island is not encouraged so as to ensure land is available on a continuous basis for a full range of other primary industries, particularly those capitalising on the Island's 'clean and green' food and wine image and that enrich visitor experiences".

In contrast to what KIPT claims in the Addendum about the expansion of forestry plantations on Kangaroo Island, the company has made comments at the recent KI Economic Development Forum saying the number of trees on the island could grow from 17,000 to 30,000 hectares if plantation timber planting restrictions were removed[7].

In the KIPT's AGM presentation, released to the ASX, the company states that a

"modest expansion plan in net productive estate area could lift production from 2030 onwards".[8]

KIPT's proposed seaport, which relies on perpetuating and possibly expanding the forestry plantations at Smith Bay, is in direct conflict with the intention of the Kangaroo Island Council to protect the amenity of the island.

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[7] https://www.theislanderonline.com.au/story/6537431/kipt-says-trees-could-double-as-smith-bay-comments-are-due/
[8] https://www.asx.com.au/asxpdf/20191121/pdf/44bsw6q45yh28b.pdf

BLURRED VISION

The conceptual 3D model presented by KIPT in the EIS Addendum Appendix F (Figure 13) is overly simplistic. There are no technical details for the authors of this integral representation of KIPT's proposed seaport. The images in Appendix F are blurry and cartoon-like, and do not give a true presentation of the intrusion of the visual amenity from many important perspectives.

As concluded by KIPT in Appendix F, the visual amenity of the area of most, if not all, residents and visitors of Smith Bay would be adversely affected by the extended seaport. The extension of the seaport will be more noticeable, visible and considered significant from most vantage points.

YUMBAH'S LOW-LYING FOOTPRINT FROM SOME VANTAGE POINTS

Appendix F of the EIS Addendum attests to the fact that locations at either end of Smith Bay would have a clearer view of the berthed vessels and the offshore infrastructure. Views would extend past the background landscape. Appendix F also notes that the pontoon and berthed vessels will be more visible with the extended seaport.

The increased length of the jetty would result in a significantly increased imposition on the visual amenity of most, if not all, sensitive receptors of Smith Bay. The seaport at this location is in direct contrast to the Coastal Conservation Zone and the commitment of the Kangaroo Island Council and SA Government to preserve Smith Bay and its high landscape and conservation values.

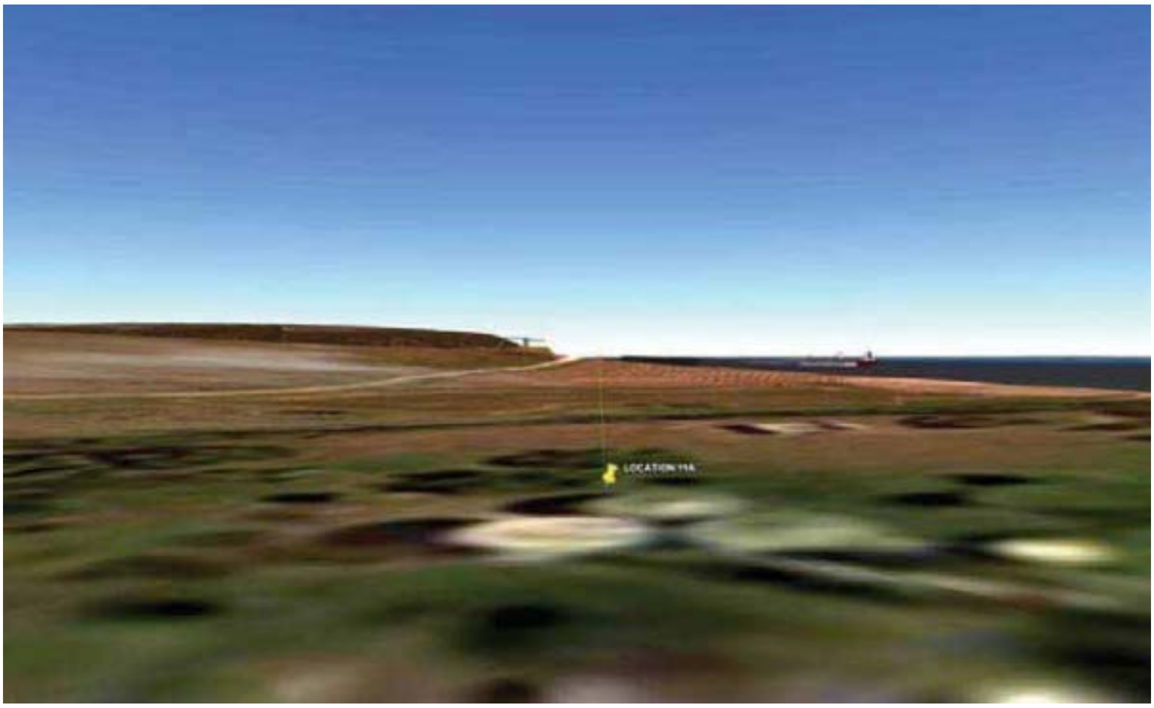

Figure 13 – 3D conceptual model from KIPT's EIS Addendum.

APPENDICES

APPENDICES

Response to KIPT - RE: Southern right whales

Rhianne Ward

PhD Candidate - Curtin University, Acoustic Lead - Great Australian Bight Right Whale Study

Southern right whales inhabit southern hemisphere waters, feeding in southern, cold waters in the sub-Antarctic and Antarctic, and aggregating in northern, warmer waters along the southern coastlines to rest, mate and calve during the austral winter.

In Australia, the southern right whale (*Eubalaena australis*, SRW) is listed as an endangered and migratory species under the EPBC Act 1999. The most recent estimate for the total population of SRW in Australia was 3,500 individuals (Smith *et al.* 2019), comprised of approximately 3,200 individuals in the south-western "sub-population" (or "management unit") extending as far east as Ceduna, and less than 300 individuals in the south-eastern "sub-population", including Kangaroo Island (KI). The south-western sub-population is recovering at a rate of approximately 5.5% per year, while population increase in the south-eastern sub-population is not documented (Bannister 2017, Smith *et al.* 2019).

The offshore movements and distribution of SRW in the waters surrounding Australia are largely unknown, and as such is it a priority of the Commonwealth Management Plan for the Southern Right Whale 2011-2021 to understand this (DSEWPaC 2012). Our current understanding of SRW distribution and movement is the result of direct observation, primarily visual. The Head of Bight, located west of KI is recognised as a primary aggregation ground for SRW, with up to 172 individuals, including 81 mother and calf pairs and 29 unaccompanied adults sighted on any one day within the study area (Charlton *et al.* 2019).

Southern right whale abundance at Smith Bay and potential for Smith Bay BIA

Sightings records indicate that Smith Bay provides safe, protected waters for SRW to aggregate during the months of June/July to September each year, although SRW are known to aggregate in nearby waters between May to October each year. Between 2006 and 2018 there were a total of 57 confirmed sightings of SRW, including 16 individuals confirmed as calves. Whilst the total number of SRW was relatively low (maximum of 5 individuals sighted at any one time) it is clear that SRW, and particularly mothers with newborn calves (56% of all sightings) utilise these waters. SRW reproduce in 3 to 4 year breeding cycles (Charlton 2017), therefore yearly variation in numbers of whales sighted is expected. SRW mother and calf pairs that occupy Smith Bay are reported to spend as long as four weeks in the area, although the species is known to occupy aggregation areas for three months or more (Charlton *et al.* 2019).

The Commonwealth Management Plan for the Southern Right Whale 2011-2021 defines a small, established aggregation area for SRW as "containing up to 10 (usually less than 5) calving females at the peak of the season" and an emerging aggregation area as "not occupied every winter, but in some winters contain a small number (around three) calving females at the peak of the season" (DSEWPaC 2012). At Smith Bay SRW have been sighted in small numbers (usually one to two mother and calf pairs) annually since 2006. Therefore, at a minimum, Smith Bay should be considered an emerging aggregation area for SRW. Emerging aggregation areas are considered of high importance as they increase habitat occupancy, contribute the overall population increase of the species and may lead to an increase in genetic diversity (DSEWPaC 2012).

Additionally, the management plan considers Biologically Important Areas (BIAs) as those that are "particularly important for the conservation of protected species and where aggregations of individuals display biologically-important behaviour such as calving, foraging, resting or migration" (DSEWPaC 2012). Smith Bay is utilised by SRW for resting, rearing young and potentially calving. Under this criteria, Smith Bay should be considered a BIA for the SRW.

Lack of survey data

It is important to note that a lack of survey data *i.e.* visual sightings by KIPT does not denote the absence of a species. While KIPT report a single SRW sighting at Smith Bay, local observers have recorded the presence of 57 individual SRW from 2006-2018, with total numbers likely higher than this.

Masking of SRW vocalisations during pile driving

SRW rely heavily on acoustic cues to communicate. The primary frequency range at which SRW communicate is around 50 to 500 Hz. During pile driving activities, most of the sound energy occurs at frequencies of 100 to 1000 Hz. Therefore, during pile driving, SRW vocalisations are masked, effectively stopping or at least reducing communication.

Concerns of vessels

SRW are highly susceptible to vessel strike due to their slow swim speeds and large surfacing periods. Their northern counterpart, the North Atlantic Right Whale (*Eubalaena glacialis*, NARW) is facing near extinction as a result of vessel strike and commercial fishing activities. The presumably large vessels that will be used during construction of the wharf and thereafter are a significant threat to the SRW in the Smith Bay area. In 2019, three SRW calves were found deceased or critically injured on the shoreline of known aggregation areas. Autopsy revealed the cause of death of one of these calves as possible ship strike. Moreover, a SRW adult was killed by ship strike off Kangaroo Island in 2001.

Further to this, noise emitted from nearby vessels may also mask the vocalisations of SRW as ships are known to produce broadband noise within the frequency range of around 100 Hz to tens of kHz (1 kHz = 1000 Hz).

Rebut negligible impact to whales

The response by KIPT that impacts to SRW will be negligible, including their prediction that the whales will simply "move" or "relocate to other habitat" is in itself completely negligent. As demonstrated above, Smith Bay is an important area for SRW and any movement away from this area should be of great concern. Given the number of increased threats to SRW that inhabit Smith Bay due to KIPT's proposed it should be considered likely that SRW will move away from these waters.

Additionally, a medium level of risk resulting in a permanent threshold shift (PTS) in the hearing of SRW as a result of pile driving activities is unacceptable, particularly for a species that relies so heavily on sound.

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Yumbah AQUACULTURE

APPENDIX 2 –

ADDENDUM REVIEW BIOSECURITY SECURITY

HEWITT AND CAMPBELL

2019

Smith Bay Wharf Draft Environmental Impact Statement

Marine Biosecurity Review

Prepared by:

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Harry Butler Institute, Murdoch University, Murdoch, Western Australia

Harry Butler Institute
MURDOCH UNIVERSITY

REVIEW OF THE BIOSECURITY ASPECTS OF THE ADDENDUM TO THE SMITH BAY WHARF DRAFT ENVIRONMENTAL IMPACT ASSESSMENT

As requested by Yumbah Kangaroo Island (Yumbah KI), we have undertaken a follow on analysis of the Addendum to the Smith Bay Wharf Draft Environmental Impact Statement (hereafter Addendum). This assesses the changes proposed in the Addendum, specifically focused on how these changes address the marine biosecurity hazards identified in our first report (Hewitt and Campbell 2019).

The Addendum addresses concerns specifically raised with the design and construction of the jetty. It proposes to shift from a causeway with a dredged deep water pocket, to a longer suspended deck (on piles) connected to a floating pontoon.

We note that the changes remove biosecurity concern we had raised over the sediment transfer risks associated with dredge and hopper barges, and the creation of novel benthic habitat (causeway).

However, these changes transfer the biosecurity risks as follows:

CHANGE OF DESIGN

Port construction phase

The Addendum indicates that the shift from a causeway with dredging, to a pile and floating pontoon will mitigate biosecurity risks associated with the construction phase. We note that species' transfer risks associated with the construction phase persist, shifting from risks associated with dredges and transport of causeway construction materials (rock) to a barged pile driver, transport of construction materials (piles and suspended dock), and the floating pontoon.

As stated previously, the movement of slow moving vessels (pile drivers, dumb barges, pontoons) represent a very high biofouling (and associated disease and parasite) risk due to long port residence times resulting in extensive biofouling. **The proposed changes retain these risks** associated with a barged pile driver, transport of construction materials (piles and suspended dock), and the floating pontoon

As with previous, we would expect to see an identification of source ports for vessel transfer during this phase, and some explicit statements surrounding species known from those ports/regions that might pose a risk of transfer.

The changes in design of the wharf structure do not obviate the biosecurity risks, but shift the biosecurity risk profile from sediments to biofouling. These new risks have not been adequately assessed in the addendum. Therefore the mitigation measures *as stated* are <u>unlikely to be adequate to mitigate risk</u> during the construction phase.

- **Pile drivers and supporting construction barges should have an explicit cleaning protocol prior to departing the last port of call.** These vessels have been explicitly linked to the transfer and spread of non-native marine biofouling species from the last port of operations.
- During the construction phase it is unlikely that vessels will be "in ballast" due to transfer of goods and materials for construction, however once construction is complete, material and equipment will need to be removed/relocated and it is likely that vessels will arrive in

ballast. The mitigation measures for discharges and ballast water management state that they will adhere to international and Commonwealth law protocols for "complete ballast exchange enroute." High seas ballast exchange is moderately successful at reducing the planktonic component of the assemblage, however is poor at reducing the ballast sediment load (eg Ruiz and Reid 2007). Additionally it is unlikely that domestic movements will be able to undertake ballast exchange in the "high seas" and indeed are not required to under international or Commonwealth legislation. **Therefore this mitigation is unlikely to be applied unless explicit agreements and requirements are made.**

- **The floating pontoon will be barged in and represents a biofouling risk based on the previous port of call and residence time**. As stated previously, biofouling on domestic vessels, particularly in niche areas or on slow moving vessels (such as dumb barges) can transfer mature communities resulting in the spawning or accidental dislodgment of material. While the mitigation requiring "no in-water or dry dock cleaning would be permitted at Smith Bay" will limit intentional discharge of material, a more thorough method would require all vessels used during the construction phase to be "cleaned prior to entry". This would significantly minimize the likelihood of transferring biofouling species from domestic ports into Smith Bay during the construction phase.

Port operation phase

The Addendum indicates that the shift from a causeway with dredging, to a pile and floating pontoon will mitigate biosecurity risks associated with the operation phase by "reducing available substratum" for colonisation, and transferring the inoculation of material an additional 250m offshore.

While the removal of the causeway reduces the placement of natural substrate, the extensive number of piles to support the floating dock represent an artificial substrate that has been demonstrated to support a higher diversity of introduced benthic marine species (eg Glasby et al 2007). As stated previously, biofouling communities on vessels and wharf structures have been demonstrated to harbour disease agents and parasites, such as *Perkensis,* that can be transferred to native communities on natural substrates.

Extending the berth further offshore will not obviate biosecurity threats associated with ballast water discharge or biofouling. We note that many ports in Australia with extended offshore jetties have still been invaded and provide a beachhead for new introduced species to establish.

Additionally the use of a floating dock will potentially enhance the transfer and establishment of biofouling species from domestic and international vessels.

This design change alone does not represent a mitigation of biosecurity risk.

The considerations identified by Hewitt and Campbell (2019) have not been addressed in the Addendum. Therefore the mitigation measures *as stated* are <u>unlikely to be adequate to mitigate risk</u> during the operation phase.

- As noted in the previous assessment, ballast water exchange is poor at reducing the risks associated with ballast sediments, particularly for the cysts of toxic dinoflagellates.
- Biofouling of commercial vessels, particularly in niche areas and dry docking support strips (areas that were not repainted during the previous dry docking), can transfer mature communities resulting in the spawning or accidental dislodgment of material. At present there are only international guidelines to mitigate biofouling risks, and several States and

Territories have undertaken independent measures, primarily focused on recreational vessels and High Value Areas.

- Disease agents and parasites can be transferred and harboured in mature biofouling communities on wharves.

SUMMARY

The Addendum addresses only one of the concerns raised in our previous review (Hewitt and Campbell 2019), namely the sediment transfer risk either in dredges or barges to prevent harmful algal bloom introductions.

We found that the design changes do not mitigate the biosecurity risks, but transfer them from sediment based concerns to biofouling concerns:

1. The use of slow moving vessels (pile driver, supporting barges) in construction will continue to represent a biosecurity threat from biofouling accumulation.
2. The replacement of causeway with extensive piles will provide artificial benthic habitat known to support non-indigenous species (Glasby et al 2007)
3. The use of a floating pontoon will enhance the likelihood of biofouling establishment.

The Addendum does not address the remaining biosecurity concerns. Therefore we consider the following concerns to remain active from our original report:

1. The methodology for determining marine biosecurity risk activities, vectors and species is unclear and, based on the material presented, inadequate.
    a. The species assessments do not appropriately consider either the domestic or international source locations to determine the species (and disease agents and parasites) likely to be transported into Smith Bay waters.
    b. The assessment of disease agents (pathogens and parasites) does not adequately consider the suite of licensed aquaculture species permitted to Yumbah KI.
    c. Nine OIE listed diseases or etiological agents present in Japan or China are known to affect Genera licensed to Yumbah KI.
    d. An additional nine diseases or etiological agents species from Japan or China are known to affect Genera licensed to Yumbah KI, and known to have caused mass mortalities of aquaculture species in China or Japan.
2. The risk mitigation measures proposed are generic and meet the letter, rather than the intent, of international, Commonwealth and State requirements.
3. The measures for discharges and ballast water management focus explicitly on the operational phase using commercial trading vessels and are insufficiently detailed to address the construction phase, particularly for the risks associated with slow moving vessels including [~~dredges~~] and barges.
4. Domestic ballast water movement is unlikely to attain distances offshore to meet the definition of “high seas” and therefore will not be able to undertake adequate protections.
5. Biofouling species hazards associated with both construction and operational phases will continue to pose unmitigated risks. The restriction on “in water or dry dock cleaning” at Smith Bay will not prevent mature species from spawning or being dislodged into Smith Bay waters.
6. Additionally, mature biofouling assemblages are likely to pose the additional risk of transferring disease agents and parasites into Smith Bay waters.

REFERENCES

Glasby TM, Connell SD, Holloway MG, Hewitt CL. 2007. Nonindigenous biota on artificial structures: Could habitat creation facilitate biological invasions? *Marine Biology* 151: 887-895. DOI:10.1007/s00227-006-0552-5

Hewitt CL, Campbell ML. 2019. Smith Bay Wharf Draft Environmental Impact Assessment Marine Biosecurity Review. Client Report, Harry Butler Institute, Murdoch University. 15pp.

Ruiz GM, Reid DF. 2007. Current State of Understanding about the Effectiveness of Ballast Water Exchange (BWE) in Reducing Aquatic Nonindigenous Species (ANS) Introductions to the Great Lakes Basin and Chesapeake Bay, USA: Synthesis and Analysis of Existing Information. NOAA Technical Memorandum GLERL-142. GL:ERL, Ann Arbor, USA. 127 pp.

APPENDIX 3 –

ADDENDUM REVIEW UNDERWATER CONSTRUCTION NOISE

LENCHINE

2019

6 December 2019

Jacquelle Gorski
Principal Consultant - Director
Sustainable Project Management Pty Ltd
13 Banksia Close
Torquay VIC 3228

Our ref: 12521898-10908
Your ref:

Dear Jacquelle

Smith Bay Wharf - DRAFT EIS
Underwater Construction Noise

1 Introduction

Kangaroo Island Plantation Timbers proposes to build a port at Smith Bay, Kangaroo Island, South Australia for exporting log and woodchip products. The original Environmental Impact Statement (EIS) included predictions for underwater construction noise and included construction of a 250 m rock armoured causeway and 170 m of suspended deck jetty. Pile driving during construction of the jetty has the potential to cause significant underwater noise impacts on marine fauna in the area.

A revised design considers construction of an extended jetty that would provide a pontoon jetty spanning approximately 650 m from the shore. Thus noise associated with pile driving during installation of the jetty may impact on a larger marine area than previously proposed, extending into waters that may be frequented by whales, dolphins and other marine species. Noting, there is a higher probability that marine species would be affected by high noise levels in an area which is more distant from the shore.

This short letter based report reviews the likelihood of higher underwater noise impacts from construction activities associated with the construction of the extended jetty and change of associated construction practices.

2 Previous underwater construction noise assessment

The EIS was accompanied by an underwater noise assessment report prepared by Resonate Consultants (Report A17557RP1, 17 December 2018). An underwater noise prediction scenario was considered for impact driving. It was assumed that peak source levels are 190-245 dB (re 1 µPa) and Sound Exposure Levels (SEL) are order of 170- 225 dB for a single pulse. Most of noise energy is assumed to be in 100- 1000 Hz frequency range. Exact acoustical inputs are not detailed in the report.

It is noted that risk of hearing damage for marine species in the area is not considered high for distances more than 100 m from the pile driving zone. The executive summary in the EIS shows a medium risk is forecast for permanent hearing damage to southern right whales within 900 m of the piling and temporary hearing damage effects may be observed within 6.5 km of piling. This is a significant area where effects on the marine species would be considered high.

The acoustic report suggests a number of noise mitigation practices to reduce risk of adverse effects. They include a "soft start" procedure (where impact energy is gradually increased), minimisation of duration of impact piling and confining construction activities to day time only when mammals can be clearly observed in the adjacent area. Also vibro-driving instead of impact piling has been considered as an alternative construction method. However the project documentation suggests that implementation of piling methods other than impact piling would challenge the economic viability of the construction.

3 Applicable criteria

The SA Department of Planning Transport and Infrastructure (DPTI) introduced the *Underwater Piling Noise Guidelines (2012)* to address concerns related to high levels of underwater noise during construction of jetties, berths and similar structures. The guidelines suggest noise criteria for impulsive noise based on peak and sound exposure levels (SELs) to protect against possible physiological impacts and sound pressure level criteria for behavioural impacts. The criteria for cetaceans and pinnipeds are summarised in the table below, they are based on temporary hearing threshold shifts.

Table 1 Underwater noise criteria for cetaceans and pinnipeds based on temporary threshold shift

Descriptor	DPTI Guidelines criterion, dB (re 1 µPa)	EIS criterion, dB (re 1 µPa)
SPL (behavioural impact)	160	160
Peak	212- 230	213-226
SEL (re 1 µPa s^2) *	171-198	168-188

* Sound exposure level (SEL) for cetaceans and pinnipeds is calculated with different weighting applied to measured noise to reflect auditory bandwidth of the species

The most recent studies (Popper, A. N., *et al.* (2014), *ASA S3/SC1.4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANS/Accredited Standards Committee S3/SC1and registered with ANSI*.; and the *NOAA Marine Mammal Acoustic Technical Guidance, 2018*) also consider similar groups of criteria for underwater noise impact. The acoustic report adopted criteria presented in Table 1. They are consistent with the criteria in the DPTI guideline and can be considered appropriate for assessing possible underwater noise impacts from construction activities.

4 Possible underwater noise impact

It is understood that the addendum to the draft EIS considers a revised scenario of extending the jetty and simultaneous driving of two piles per section. Similar to seismic testing, impact piling results in a high noise level that may have adverse effects on marine mammals. In accordance *with Monitoring Guidance for Underwater Noise European Seas* (Report EUR 26555 EN, 2014) operation of airgun arrays may result in peak source levels 209-253 dB. This is comparable with peak levels from impact pile driving and should be a matter of concern from a marine fauna preservation perspective.

The revised design involves a greater number of piles to be placed at the jetty. It is understood that the project may require simultaneous pile driving of two piles which will result in an increase of the noise impact. Assuming a 3 dB increase of acoustical inputs at the source for pile driving noise prediction, it may result in approximately 40% increase of distances for shut- down zones and observation zones in comparison to the initial estimates in the acoustic report. It is difficult to perform effective visual marine species identification in significantly extended zones around a construction site.

The addendum also forecasts that construction of the piled jetty may take around 309 days which may require continuous construction activities including over the period when waters around Kangaroo Island are frequented by whales (May to October). The required construction time may be lengthened by unforeseen circumstances and unfavourable geotechnical conditions which may require a longer time for pile driving. Correspondingly, the actual construction time of the extended jetty may require around 2 years assuming that pile driving will not be performed during the whale season. Underwater noise levels around the construction zone may be significant for a prolonged period and cause substantial change of typical behavioural, reproductive and migration patterns of multiple marine species.

There is a wide range of noise source levels associated with impact pile driving. Acoustic report does not clarify details of the pile construction such as type of piles, depth of piling etc. Therefore it is not clear what noise source levels were used for the modelling and what is expected accuracy of the underwater noise prediction. Errors in assumed inputs and modelling results may increase zones of high underwater noise impacts and risk associated with permanent or temporary damage of marine species' hearing.

5 Submissions for the EIS addendum and risk assessment

The addendum contains a summary of submissions that resulted from consultations with stakeholders. The comments do not fully consider the increased risk from prolonged pile driving. Also the updated risk assessment in the document considers residual risk from underwater noise as low. This risk should be classified as medium to high taking to account the difficulties of visual marine species detection in larger areas around construction zones and prolonged periods of high noise impact.

6 Possible noise mitigation measures

Underwater noise impact depends not only on assumed acoustic inputs (such as simultaneous pile driving of two piles rather than one), but also the geometry and acoustic properties of the seabed and water depth. An updated acoustic assessment of underwater construction noise was not performed for the revised jetty construction scenario. It would be useful to identify new distance guidance for critical noise impact zones based on the new construction scenario.

The acoustic report and addendum summarise a number of noise mitigation measures. They also consider potential vibro-driving instead of impact driving. It should be noted that vibro-driving still results in a high noise SPL in the area adjacent to the source.

The acoustic report quotes range of the source level 160-190 dB re 1 μPa with most of the energy concentrated in 100- 2,000 Hz band. Taking into account predicted long period of construction activities and increased levels, managerial noise control measures such as "soft start" and marine species observations may not be sufficient to mitigate the risk of impact from construction activities down to acceptable levels. The assessment may require a more in-depth revision of the project options like the extension of the causeway rather than increasing part of the jetty that rests on the piles. More advanced technologies for the piling may be considered to reduce duration and severity of the expected underwater noise impact. Air bubble curtains, temporary shields, special pads to reduce underwater noise levels may be considered amongst additional noise mitigation measures.

7 Summary

Amended project designs and construction practices are considered in the addendum to the Smith Bay EIS. The document envisages a lengthened open-piled jetty which extends approximately 650 m out to the sea. Possible adverse effects from extensive pile driving have not been fully considered in the addendum and in the stakeholders' comments. The relevant acoustic report was not updated to reflect new acoustic inputs and the recommended distances for marine species observations and work stop zones due to the projected long period of the jetty construction and possible modification of construction procedures that may result in a higher noise impact. Risk reduction of behavioural and physiological impact from underwater noise requires a more substantial review of noise mitigation practices and/or construction technologies.

It is recommended that an amended underwater noise impact assessment be performed for the revised project design taking into account the possible effects on the marine environment from a long term pile driving program which affects a significant area adjacent to the construction zone. The assessment may show the necessity for a substantial change of noise mitigation practices and pile driving technologies. It may also require revision of the project design options to reduce the risk of unacceptable environmental impacts in the area.

Sincerely
GHD

Val Lenchine
Technical Director- Noise & Vibration+61 3 86878710

APPENDIX 4 –

ADDENDUM REVIEW WATER QUALITY AND COASTAL PROCESSES

Romero

2019

25 November 2019

David Connell
General Manager
Yumbah Kangaroo Island

Our ref: 6137616-98313
Your ref:

Dear David

KIPT Smith Bay Wharf EIS Addendum
Review of Water Quality and Coastal Process Impacts

1 Introduction

Yumbah Kangaroo Island (YKI) requested a review of the Addendum to the Smith Bay Wharf Draft EIS (hereafter referred to as Addendum) by Kangaroo Island Plantation Timbers Ltd (KIPT). This review has focused primarily on:

- The following Addendum main body sections:
  - Section 02: Design Changes.
  - Section 03: Revised Design.
  - Sections 4.2 (Water Quality) and 4.3 (Coastal Processes).
- Appendix C1 (Revised Water Quality and Coastal Processes Impact Assessment).
- Appendix G: Updated Risk Assessment

2 Section 02: Design Changes

KIPT has made the following changes to their marine infrastructure design:

- Moving the berth ~250 m further offshore thereby eliminating the need for dredging.
- Replacing the solid causeway with a piled jetty thereby minimising effects on natural coastal processes and flushing.

These design revisions by KIPT of their proposed wharf addresses many of the construction (e.g. dredging) and operational (e.g. flushing, seagrass wrack) impacts/risks that YKI raised in the comments to the draft EIS.

3 Section 03: Revised Design

The piled jetty structure is now proposed to be ~650 m in length with piles driven at 12 m horizontal spacing. Supposing that there was at least 3 piles every 12 m (as suggested in Appendix C1 of the Addendum) then that is at least 165 piles for the jetty (650 m / 12 m horizontal spacing x 3 piles for every 12 m). The addendum also states that 50-60 piles will be utilised for the suspended deck, so that’s a minimum of 225-235 piles. So this all points to substantive underwater noise impacts, so I suggest the following lines of enquiry:

- KIPT need to provide much better estimates of the total number of piles expected. Pile driving will generate a substantial amount of noise by the hydraulic hammer, and offers an avenue to challenge on the basis of noise impacts to marine megafauna (i.e. MNES).

- The duration of the jetty construction (309 days) has not been partitioned into the expected duration of piling explicitly. However, it is stated that two piles per day will be driven, but they also discuss that they will initially establish the suspended deck to allow construction of the jetty from the north and south. A request for a realistic duration of piling needs to be provided by the proponent so that overlaps with critical windows of sensitivity of marine megafauna can be evaluated.
- The other major unknown is the geotechnical status of the wharf footprint, which if comprised of hard substrate would potentially increase the duration need for piling activities and increase the 20 minute estimate of for the insertion of one pile via the hydraulic hammer (and increase the duration of substantive underwater marine noise impacts).

In short, the construction staging is not specified suitably for a proper noise impact assessment. Further, the uncertainty of the geotechnical status of the jetty corridor in terms of pile driving can readily increase noise impacts above the rudimentary estimates provided here, as they are seemingly based on 'best case' conditions for pile driving.

4 Section 4.2: Water Quality

Very short section that effectively refers to Appendix C1. Refer to review comments below in regards to Appendix C1.

5 Section 4.3: Coastal Processes

Very short section that effectively refers to Appendix C1. Refer to review comments below in regards to Appendix C1.

6 Appendix C1: Revised Water Quality and Coastal Process Impact Assessment

6.1 Construction Phase Water Quality Impacts

I agree with BMT's assessment of minor turbid plumes generated from driving or 'drilling/driving in hard rock' of the piles. Further, the commitment in the draft EIS that for the 'drilling/driving' approach that all cuttings and sediments will be captured in the piles, transferred onto the barge and disposed elsewhere, will indeed generate negligible turbidity. Hence, a very small turbid source will occur from either piling method and I concur that there is no need for modelling to demonstrate this obvious inference. I also agree that any turbidity from associated construction mechanisms (e.g. anchoring, construction vessel movements) is negligible and does not require any further reassessment.

Similarly, BMT's assessment of sediment deposition, mobilisation of contaminants and the risk of fuel/oil spills are all appropriate and industry-standard positions for such impacts/risks.

6.2 Operational Phase Water Quality Impacts

I agree with BMT's assessment of potential operational wash impacts on the TSS climate of the YKI intake water quality. Their reassessment is reasonable.

6.3 Water Quality Risk Assessment

BMT's risk assessment is fine and per industry-standard. However, the proposed mitigation measures to reduce the likelihood of hydrocarbon spills (references, 4 and 6) and ballast water (reference 7) would need to be commitments in the EPA licence. Again, these are reasonably industry-standard types of commitments for such port operations.

6.4 Coastal Process Impact Assessment

I agree with BMT's assessment of negligible effects of the revised KIPT design on water levels, currents, water temperatures, Smith Creek plumes, waves, sediment transport and seagrass wrack.

6.5 Coastal Process Risk Assessment

I agree with BMT's risk assessment that the revised design has effectively 'engineered/designed out' all water quality and coastal process risks to a negligible consequence.

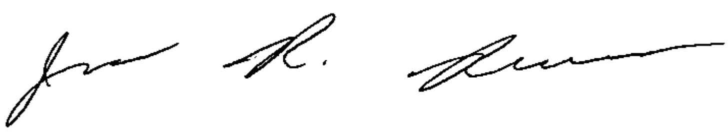
7 Appendix G: Updated Risk Assessment

The grasp of the KIPT project team on the fundamentals of environmental risk assessment is still lacking.

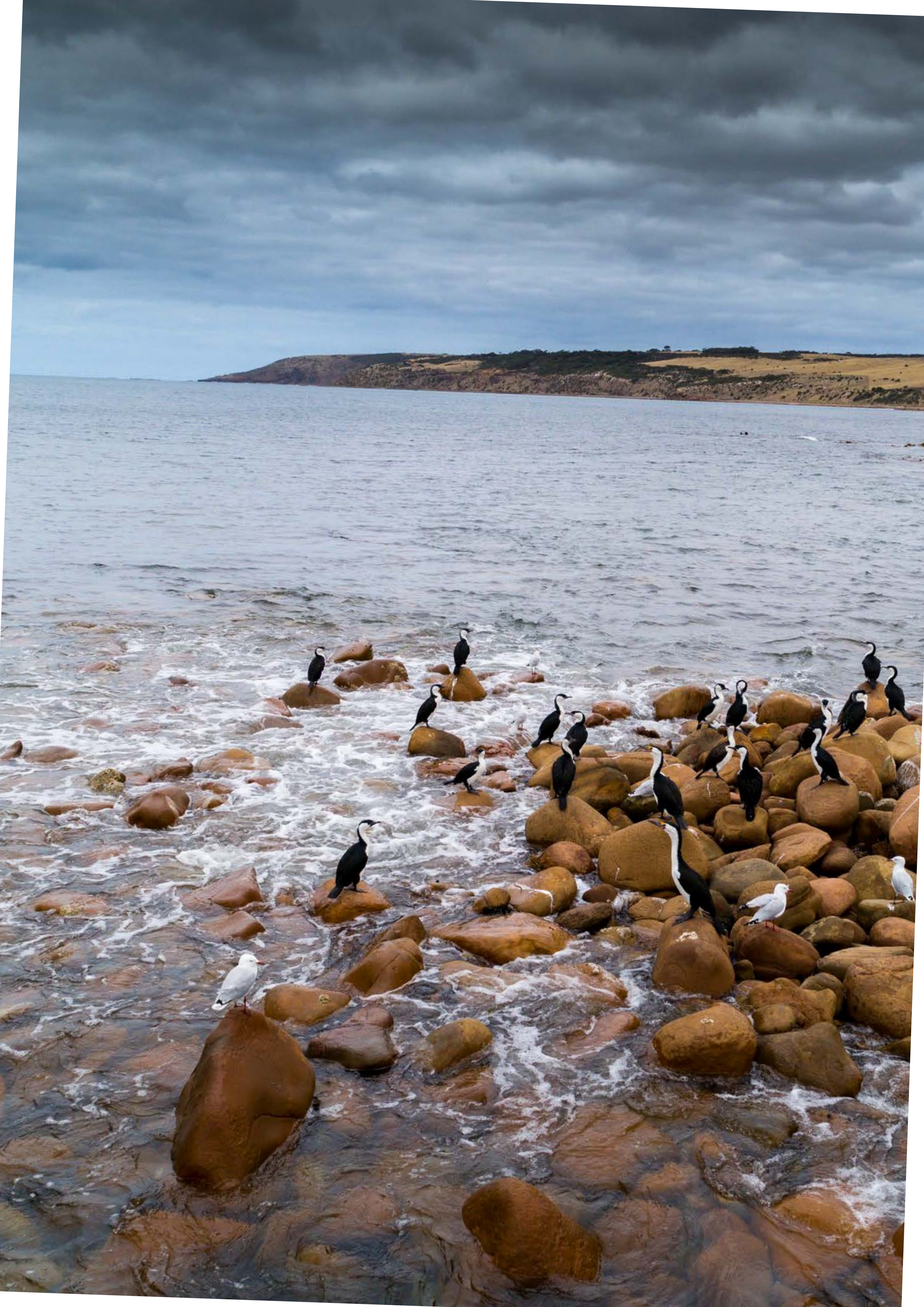
Reference Item 8 (Hydrocarbon Spills during Construction) changes the inherence consequence from 'Moderate' to 'Minor' for implementation of a CEMP. This is wrong. The consequence should stay the same, and the likelihood may decrease from Possible to Unlikely. Utilisation of BMT's management/mitigation measures for their reference items 4 (spill during construction phase) and 6 (spill during operational phase) in Appendix C1 ought to be the manner that the KIPT project team conduct their risk assessment in Appendix G with clearer management/mitigation measures (that serve as commitments).

Again the weak link in the revised KIPT design/proposal is underwater noise impacts as per Appendix G reference item 11 (Underwater Noise and Vibration). Allocation of a 'minor' consequence may be too low for the scale of pile driving that is proposed. Has noise modelling even been carried out by KIPT for the pile driving? In my view this is the likely to be the most fruitful line of enquiry to challenge KIPT on the basis of marine impacts of their proposal, as their revised design has mitigated/designed many of the previous unpalatable impacts to a negligible status.

Sincerely



Jose Romero
Team Leader, Marine and Aquatic Services
+61 8 6222 8992



From:	Alison Higgs
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Thursday, 19 December 2019 5:34:52 PM

Firstly the obvious reason, to protect a very special place. We cannot keep destroying habitats for greed. Our community needs support to protect this special place for the future. Secondly, the roads. These roads just won't cope. Neither will the some 70 thousand tourists. There are so many near misses daily. We don't need more. I lived for 20 years in a logging area where the roads were inadequate, and you only need to see the result of car vs logging truck once in your life to feel strongly on this issue. Please do the right thing and help us save people, places, and our future.

From:	Alison Wallace
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Tuesday, 10 December 2019 11:46:18 AM

There are better places for this development that won't harm the unique diversity of this area.

From:	Andrew Neighbour
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Tuesday, 10 December 2019 7:44:40 AM

I oppose kipt plans at smith bay because the marine wildlife is being pushed aside in favour of this development Ausocean a local marine research organisation has uncovered significant endangered marine creatures & ancient corals that are found no where else .... a wharf is not the answer we already have commercial shipping at Penneshaw pleas leave our precious marine environment as it is ..... pristine

From:	ANTHONY JONES
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Friday, 6 December 2019 12:19:58 PM

I am extremely concerned that our roads are in no condition to handle these heavy vehicles.
I dont believe the island people should pay for the future up keep.
KIPT must budget this in .
Im also concerned about the damage that will be done to the marine life in the bay

From:	Anthony Jones
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Friday, 20 December 2019 3:24:37 PM

If this goes ahead not only will it destroy Smiths Bay, but the entire North Coast.

From:	Ashleigh Younger
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Friday, 20 December 2019 2:59:15 PM

It’s ridiculous.. a jetty that long.. still disturbs the aqua culture.. the traffic pollution.. in this previous coastline . It needs to go somewhere where it won’t impact on the coastal environment and animals.

From:	Bob Nicholson
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Friday, 13 December 2019 8:50:01 PM

Oue business relies on a clean green environment.
Im sure there are more suitable locations for a port.

From:	Brett Haggett
To:	DPTI:State Commission Assessment Panel
Subject:	KIPT PROPOSED WHARF
Date:	Friday, 20 December 2019 7:10:42 PM

Attention Robert Kleeman.
Good afternoon, i would like to submit my support my for KIPT's proposed multi use wharf at smiths bay on Kangaroo Island. i have lived on Kangaroo Island for the past 25 years and have worked in forestry for that entire period, Due to uncertainty within in the forestry operations on K.I in recent years, i have moved to Tasmania to continue working within the forestry industry. Prior to my relocation i was leasing timber processing equipment from KIPT, including post peeler and CCA timber treatment plant. Due to the high cost of transport of my products to the mainland and the volume of waste generated because of there being no available avenue for me to sell larger timber logs at economical gain, i decided to cease operations and move to an area that supported the forestry industry better, This cost the jobs of several local K.I residents. I look forward to positive support from the S.A government regarding the KIPT wharf, When there is certainty regarding this proposal i will happily move my operations back to K.I and be able to employ K.I locals.
Yours sincerely Brett Haggett
Total Land Maintenance Services
20/12/19

From:	Bronwyn Rees
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Monday, 9 December 2019 9:17:03 AM

The ocean is under extraordinary stress. Whatever life is still there desperately needs protection not interference.

From: Bush Organics <bushorganics@gmail.com>
Sent: Friday, 20 December 2019 3:54 PM
To: DPTI:State Commission Assessment Panel
Subject: Fwd: Re; Submission in response to KIPT Addendum
Attachments: KI VH Dolphin Watch KIPT Smith Bay Addendum Response Dec 18th 2019.docx; Attachment 1 cms_cop12_res.12.14_marine-noise_e.doc; Attachment 2 CMS-Guidelines-EIA-Marine-Noise_TechnicalSupportInformation.doc; Attachment 3 Environmental Impact Assessment Guidelines Prideaux_Prideaux2015.pdf; Attachment 4 Simmonds2018MultipleStressorsChapter.pdf

Categories: Green Category

I am making a submission in response to the proposed development of Smiths Bay by KIPT.

I run a sustainable family buisness on Kangaroo Island. This development is not consistent with protecting our unique environment. It must be protected at all costs

My family have experienced dolphins and whales along the north coast, it is a marine hot spot, 85% of the species that live here, live no where else in the world.

Let stop and really think about the impacts! We need to support our marine life at all cost by offering sanctuaries, not increasing traffic and noise. Dolphins breed all year round. No time is a good time.

I have grave concerns for Smiths Bay and the impacts on surrounding marine environments as well as the impacts on threatened and EPBC listed species in the ocean and on land.

I am in full support all the of the research information that has been complied by experts attached below.

bush
organics
KANGAROO ISLAND

p : [redacted]
w : bushorganics.com.au
e : bushorganics@gmail.com
i : @bushorganics

Kangaroo Island / Victor Harbor Dolphin Watch

in partnership with

Whale and Dolphin Conservation

www.kangarooislanddolphinwatch.com.au www.islandmind.com

Facebook Twitter & Instagram: @KIVHDolphinWatch

PO Box 30 American River, Kangaroo Island, SA 5221

[redacted]

Dec 18th 2019

Kangaroo Island Plantation Timbers Addendum Response

PREAMBLE

Ever since the research findings of the **Rolland Study** following 9/11 were published it has been acknowledged as fact that anthropogenic sound has enormous impacts upon the lives of cetaceans.

These marine mammals use sound as their major sense for meeting their lifestyle needs and our interference with this element of their lives is of extreme concern to scientists around the globe.

We can no longer claim we act with impunity and in light of our expressed desire to maintain biological diversity, we must do everything we can to mitigate the impacts of human induced noise on the marine environment.

- Sound Propagation Modelling:

The proponents have stated their sound propagation modelling is adequate to cater for the changes outlined in the addendum document. They make consistent statements that the mitigation measures described in the EIS are considered adequate to cater for the amended design.

An example below is drawn from their conclusion to Appendix D of the Addendum:

"The changes to the design do not change the risk profile of the development as described in the Draft EIS. No additional MNES would be triggered by the changes to the proposal. Mitigation measures as described in the Draft EIS and in Table 1-2 are considered effective to manage any direct or indirect

impacts to the southern right whale. The revised proposal would not generate any residual significant impacts on the southern right whale."

In keeping with the scant regard for MNES demonstrated in the EIS, KIPT have asserted throughout the Addendum in **Sections 4.6 Matters of National Environmental Significance** and **4.8 Noise and Light**, that there is no need to change anything in their mitigation measures.

4.6.2 ASSESSMENT OF LIKELY DIRECT AND INDIRECT IMPACTS

"Table 14-2 of the Draft EIS identifies the development's potential impacts on the southern right whale. The impact assessments (direct and indirect) for the southern right whale have been reviewed (see Appendix D).

The increased length of jetty substructure and increased piling activity (number of piles to be installed, and the distance the activity would occur further out to sea) would have a negligible impact on southern right whales.

Noise modelling (Resonate 2018) undertaken on piling for the original design in the Draft EIS considered two scenarios which are consistent with the redesign: a duration of 30 minutes per day, assuming 60 blows per minute; and a duration of 15 minutes per day, assuming 120 blows per minute.

The revised impact assessment considers the revised construction program that plans for the installation of one pile at a time, but with the possibility of piling in two locations simultaneously.

Piling in two places simultaneously would effectively double the number of blows per minute per day, which would have the effect of increasing the cumulative sound exposure level (SEL) by 3 dB, and increasing the 'threshold distances' for temporary threshold shift (TTS) and permanent threshold shift (PTS) onset by approximately 1.6 times the values in Table 18.11 of the Draft EIS, assuming the exposure time is the same.

It is important to note that with the extended piled jetty substructure, the duration per day of the impact pilling is consistent with the assumptions used for the original modelling, and would occur for a total period of up to 20 minutes per pile installed, with up to two piles being installed per day."

4.8 NOISE AND LIGHT

4.8.1 ASSESSMENT OF POTENTIAL IMPACTS

"The Draft EIS assessed potential noise and vibration impacts which may have resulted from constructing a shorter section of suspended piled jetty. (This was incorporated into the original design). The approach would now be a full length suspended piled jetty and the impact assessments have been reviewed in that context. The onshore components of the KI Seaport have not changed."

Underwater Noise – Construction

"The suspended piled jetty requires the installation of approximately 156 tubular steel piles using a jack-up (piling) barge and impact hammer (refer Section 3.2.1). Increasing the number of pile installations to construct a longer jetty would also potentially extend the duration of the impact (noise source).

The baseline underwater noise environment at Smith Bay was described in Section 18.4.2 of the Draft EIS, and the effects of piling activities on the underwater noise environment were described in Section 18.4.4 of the Draft EIS. The revised design uses the same construction methodology described in the Draft EIS, which is summarised in Section 3.2 of the Addendum.

Underwater environmental impacts were assessed based on the:

- *existing conditions (such as ambient noise environment, local bathymetry, wave and wind climate)*
- *significant marine species in the study area*
- *significance of the area as a habitat for marine species*

- *species' sensitivity to sound*
- *characteristics of the identified noise sources in terms of duration, source level and frequency*
- *sound propagation characteristics of the marine study area.*

The potential impacts that were considered in the assessment are, in increasing order of severity:

- *behavioural change*
- *temporary threshold shift (TSS) in marine species' hearing*
- *permanent threshold shift (PTS) in hearing*
- *organ damage (possibly leading to death).*

To assess the impacts of the construction and operational sources, noise criteria were established for each of the considered impact levels. The underwater noise criteria adopted are based on National Oceanic and Atmospheric Administration (NOAA) Marine Mammal Acoustic Technical Guidance and the Sound Exposure Guidelines for Fishes and Sea Turtles. These represent the most up-to-date research and approach for the species considered in this assessment and are generally more stringent than the DPTI Underwater Piling Noise Guidelines.

As noted in the Draft EIS, damage to the hearing of marine fauna would be considered unlikely as the normal behavioural response to loud noise would be to move away.

Behavioural changes in response to noise are expected to be temporary and ecologically inconsequential as Smith Bay is not known to provide important feeding or breeding habitat.

The management and mitigation measures described in the Draft EIS include using a soft start, establishing a 1 km shutdown zone around the site (i.e. beyond the predicted PTS distance, see Table 21 of Resonate 2018 of the Draft EIS), and monitoring by marine mammal observers. The use of two piling rigs would reduce the total duration of piling, which would also be a consideration for planning the construction program.

Operationally, it is considered that the suspended piled jetty and reduced in-waterfootprint would have a negligible impact on whale behaviour. The design changes would remove the solid causeway from the design (which may be considered a potential barrier to movement) and any future maintenance dredging activity would no longer be required.

The proposed management measures for identified potential impacts to the southern right whale (see Appendix D Table 1-1), are consistent with the principles described in the EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales (DEWHA 2008) and are considered effective.

The assessment of the revised design against the 'significant impact criteria' is provided in Appendix D (Table 1-2)."

4.6.3 ASSESSMENT OF RESIDUAL IMPACTS

"Based on the above assessment, there would be no residual significant impacts on the southern right whale as a result of the revised design for the KI Seaport."

4.6.4 CONCLUSIONS

"The changes to the design do not change the risk profile of the development as described in the Draft EIS.

No additional MNES would be triggered by the changes to the proposal.

Existing mitigation measures as described in the Draft EIS are considered effective to manage any direct or indirect impacts to the southern right whale. The revised proposal would not generate any residual significant impacts on the southern right whale."

<u>This is a completely false assumption and assertion.</u>

It is based on **convenience, not Science**.

In **Section 2.2 Government Agency Consultations on the Design Change** in specific discussions with the Department of the Environment and Energy (Commonwealth) the following is stated:

"Underwater noise baseline data collection and predictive modeling assessment review in relation to the design change".

We are obviously not the only people concerned about the lack of adequate sound modeling in light of the changes to the design of the wharf.

Their response is simply to suggest what was in place was good enough previously so it's good enough now, albeit 250 metres further out to sea.

This is extremely unscientific and shows a complete **lack of understanding of sound propagation in the marine environment**.

- Potential Impacts:

Sound propagation properties change markedly in different situations as described in the **EIA Guidelines** attached. Also attached are the **CMS Technical Studies** for the guidelines.

Australia is a signatory to the CMS documentation provided and due consideration needs to be taken of the principles and findings of this world leading research.

The **EIA Guidelines** and accompanying **CMS Technical Details** were presented and adopted at the *CMS CoP 12, 2017* in the Philippines. They describe the possible impacts of all known forms of anthropogenic sound introduced to the marine environment and include information regarding construction noise production relevant to this submission.

**Reference 1 - Attachment 1: EIA Guidelines*

**Reference 2 - Attachment 2: CMS Guidelines: EIA Marine Noise Technical Support Information*

The following tracts from Page 9 from these extremely comprehensive documents make salutary reading.

They are an excellent starting point in any consideration of anthropogenic sound in the marine environment.

8. The propagation of sound in water is complex and requires many variables to be carefully considered before it can be known if a noise-generating activity is appropriate or not.
It is inappropriate to generalize sound transmission without fully investigating propagation

(Prideaux, 2017a). Often, statements are made in Environmental Impact Assessments that a noise-generating activity is 'X' distance from 'Y' species or habitat and therefore, will have no impact. In these cases, distance is used as a basic proxy for impact but is rarely backed with scientifically modelled information. (Wright et.al. 2013; Prideaux and Prideaux 2015)

9. To present a defensible Environmental Impact Assessment for any noise-generating activity proposal, proponents need to have expertly modelled the noise of the proposed activity in the region and under the conditions they plan to operate. Regulators should have an understanding of the ambient or natural sound in the proposed area. This might require CMS Parties or jurisdictions to develop a metric or method for defining this, by drawing on the range of resources available worldwide. (Prideaux, 2017a)

10. All EIAs should include operational procedures to mitigate impact effectively during activities, and there should be proof of the mitigation's efficacy. These are the operational mitigation procedures that should be detailed in the national or regional regulations of the jurisdictions where the activity is proposed. Operational monitoring and mitigation procedures differ around the world, and may include industry/company best practices.

Monitoring often includes, inter alia:

a. *periods of visual and other observation before a noise-generating activity commences*
b. *passive acoustic monitoring*
c. *marine mammal observers*
d. *aerial surveys*

Primary mitigation often includes, inter alia:

e. *delay to start, soft start and shut-down procedures*
f. *sound dampers, including bubble curtains and cofferdams; sheathing and jacket tubes*
g. *alternative low-noise or noise-free options (such as compiled in the OSPAR inventory of measures to mitigate the emission and environmental impact of underwater noise)*

Secondary mitigation, where the aim is to prevent encounters of marine life with noise sources, includes inter alia:

h. *spatial & temporal exclusion of activities*

11. Approaches to mitigate the impact of particle motion (e.g. reducing substrate or sea ice vibration) should also be investigated. Assessment of the appropriateness and efficacy of all operational procedures should be the responsibility of the government agency assessing Environmental Impact Assessments (EIA).

Given the plethora of studies completed, some of which are noted here, and the data acquired regarding the impacts of construction noise upon the marine environment, it is timely for the government to consider the situation in light of **potential economic**, **social** and **environmental** implications.

**Reference 3 - Attachment 3: Environmental Impact Assessment Guidelines Prideaux_Prideaux2015*

From pages 11 and 12 of the EIA guidelines the following points are worthy of note:

23. Many propagation models have been developed such as ray theory, normal modes, multipath expansion, fast field, wavenumber integration or parabolic equation. However, no single model accounts for all frequencies and environments. Factors that influence which propagation model/s should be used include the activity noise frequencies, water depth, seabed topography, temperature and salinity, and spatial variations in the environment.
(Urick, 1983, Etter, 2013; Prideaux, 2017a)

The information provided below in **Sections 25 and 28** is especially relevant in consideration of impacts upon resident marine fauna, particularly Sygnathids, which include a number of endangered species.

25. Commonly missing in EIAs is the modelling of particle motion propagation. Invertebrates, and some fish, detect sound through particle motion to identify predator and prey. Like sound intensity, particle motion varies significantly close to noise sources and in shallow water. Excessive levels of ensonification of these animal groups may lead to injury (barotrauma). Specific modelling techniques are required to predict the impact on these species.

28. Sound exposure levels works well for marine mammals but not well for a number of other marine species, including crustaceans, bivalves and cephalopods, because these species are thought to mainly detect sound through particle motion. Particle motion or particle displacement is the displacement of a material element caused by the action of sound. For these Guidelines the motion concerned is the organism resonating in sympathy with the surrounding sound waves, oscillating back and forth in a particular direction, rather than through the tympanic mechanism of marine mammals or swim-bladders of some fish species.
(Mooney, et.al., 2010; André, et.al., 2011; Hawkins and Popper, 2016; NOAA, 2016)

- Inadequate Sound Propagation Modelling:

As the water properties modelled in the original EIS are significantly different from those now involved in the amended plan, **further, more comprehensive modelling should be undertaken**.

It is not conceivable to make decisions based on the previously provided modelling which is no longer relevant.

To suggest otherwise is irresponsible in the extreme and in keeping with KIPT's previous performance with respect to MNES.

- Questionable "Benefits" of Movement Offshore:

The proponents have been at pains to explain the "benefits" of the movement further offshore by 250 metres.

They have described the benefits in detail without any consideration of the difficulties this creates for marine fauna and cetaceans in particular. This is particularly so for impacts which will *"disrupt the breeding cycle of a population"* as specified under MNES/EPBC documentation.

In their documentation KIPT state the following:

*“**The National Conservation Values Atlas** identifies the entire coastline of Kangaroo Island as a biologically important area that is used for seasonal calving by the southern right whale (DoEE 2015), and there are no records of breeding in this area. The presence of the port is unlikely to impact breeding at other sites, such as Encounter Bay and Fowlers Bay, as they are too far away to be affected.”*

- No Understanding of the Conservation Management Plan:

There has been no understanding of the **Conservation Management Plan** as demonstrated, and the need to protect areas of possible recolonisation.

Nor is there any upgrading of their understanding related to data provided regarding **breeding observed in Smith Bay and adjacent areas**.

The Addendum is therefore extremely limited in scope and designed for a single purpose only ….. an attempt to appease Yumbah Aquaculture.

There is a **Conservation Management Plan** for this species due to their endangered status under the provisions of the EPBC Act. This plan covers the period from 2011 to 2021.

**Reference 4*: Conservation Management Plan for the Southern Right Whale - A Recovery Plan under the Environment Protection and Biodiversity Conservation Act 1999 2011–2021*

The movement further out to sea compounds the situations described in our previous submission in response to the EIS.

As they describe in their addendum documentation, in **Sections 4.6 and 4.8**, sound propagated by piling is now at a magnitude 1.6 times that previously considered as part of their mitigation strategies. That effectively moves the **potential for TTS impacts** from 6.5 metres to 10kms, or possibly greater, under new modelling.

This means the sound impacts will be affecting sensitive receptors in the middle of **Investigator Strait**. It is worth noting this is an extremely busy shipway and the potential for vessel strike situations is therefore heightened.

The following tract from Sharon Livermore of IFAW explains some of the difficulties:

Ship strikes and whales: Preventing a collision course

4 November 2019

“Today, many species of whale around the world are threatened by collisions with vessels, known as ship strikes, and unfortunately, these collisions often result in severe injury or death. ***Both ship numbers and the speeds at which ships are able to travel have increased globally in the last few decades and this means a***

greater risk of ship strikes and injuries to whales, particularly where shipping activities overlap with critical whale habitat.

For those whales that are not killed immediately, a collision can result in horrific and serious injuries; blunt trauma resulting in major internal injury, deep propeller scars, and severed spines, tail flukes and fins, are just some of the injuries recorded in live and stranded animals that have been victims of collisions. ***A whale that has sustained a serious injury from a ship strike will often suffer a slow, painful death.***

Certain whale populations are more vulnerable to ship strikes, particularly those found close to developed coastal areas or those found in high numbers in areas with large volumes of shipping traffic. ***Consequently, ship strikes are recognized as a serious conservation and welfare problem for many whale populations throughout the global ocean.***

Worryingly, the risk of ship strike is largely unrecognised and reports of ship strikes likely under represent actual incidents. Many mariners do not know about reporting requirements for ship strikes and in many cases collisions go unnoticed; even an animal as large as a whale pales into insignificance against a 300-metre cargo vessel.

IFAW is working hard to help reduce ship strikes in several regions, with a specific focus on areas where ship strikes are known to negatively impact endangered whale populations. The solutions that exist to prevent ship strike vary depending on many factors, including whale distribution, behaviour, habitat use, and ship routing options and limitations. ***Separating shipping lanes and whale habitat*** *is the most effective option, but where this is not possible,* ***slowing vessel speeds*** *can also help protect whales from strikes. Ensuring* ***mariners are aware*** *of ship strike risk is also key to reducing the problem.*

For example, our work in the Hellenic Trench, Greece, focuses on a small change in shipping routes, which is required to dramatically reduce risk to endangered Mediterranean sperm whales. This is also the case for blue whales off southern Sri Lanka. However in New Zealand, Bryde's whale distribution across the Hauraki Gulf means that vessel speed limits offer the most straightforward solution to reduce risk. Slower speeds also reduce the levels of underwater noise from ships, resulting in further benefits for whales. In the USA, IFAW and partners pioneered the Whale Alert app to help protect the North Atlantic right whale from ship strikes. This technology offers a tool for mariners, advising them of measures to reduce collision risk and the presence of seasonal management zones, where the U.S. government has put ship speed reduction measures in place in the areas most important to these critically endangered whales.

Slowing down helps to save the lives of whales because, in a similar way to the injuries sustained by a pedestrian hit by a vehicle on our roads, the speed at which a ship is travelling has a strong bearing on the likelihood of a fatal injury occurring to a whale. On roads, we use 'school zones' to control speed and reduce the risk of fatal injuries to children. In our oceans, the concept of 'whale zones,' or areas where ships need to slow down, could also be used in the areas of highest risk where separating whales and shipping is not an option.

These practical solutions that exist to reduce the risk of ship strikes to whales are already being used elsewhere around the world. All that is required is the political will to make the changes needed on the water. Critically, a lack of action puts both individual whales and their populations in danger, which is why at IFAW, we are working on practical, science-based solutions to protect whales from ship strikes in the places they call home."

Sharon Livermore: Program Officer, Marine Conservation November 4th 2019

**Reference 5: IFAW - Sharon Livermore Article*

Under **MNES provisions** there are a greater number of species likely to be impacted upon by the construction / piling noise, including:

- **Sperm whales** - *Physeter macrocephalus*
- **Blue whales** - *Balaenoptera musculus*
- **Humpback whales** - *Megaptera novaeangliae*
- **Beaked whales** - *Ziphiidae* etc

Some of these species are endangered, some vulnerable, others threatened and **ALL** migratory.

All are known to frequent Investigator Strait.

Also by pushing further out into deeper water the chances of impacting upon **Shortbeaked Common dolphins** *Delphinus delphis* are exacerbated.

The proponents imply that the **longer piling jetty will be less of a barrier to movement** than the solid causeway.

This supposition is **not** borne out by Science. It is purely convenient conjecture.

The paper by Heithaus et al referenced in our previous submission clearly indicates the impacts on inshore cetacean species of having to travel further offshore.

**Reference 6: "Spatial variations of shark-inflicted injuries to insular Indo-Pacific bottlenose dolphins (Tursiops aduncus) of the SW Indian Ocean."*

Heithaus et al Marine Mammal Science 33(1) January 2017

https://www.researchgate.net/publication/304778135_Spatial_variations_of_shark-inflicted_injuries_to_insular_IndoPacific_bottlenose_dolphins_Tursiops_aduncus_of_the_SW_Indian_Ocean

Given KIPT's demonstrated disregard for environmental concerns, public perceptions and lack of trust, it would be best if MMO's, upon which so much of the mitigation strategies rely, were **independent**, albeit at KIPT's expense.

In light of the potential impacts upon deep diving species it should be required that the MMO's observations be supplemented with **Passive Acoustic Monitoring** techniques, preferably boat based and mobile, rather than fixed.

This is a base level for ensuring proper safety for marine fauna and for mitigating possible impacts upon threatened, vulnerable and migratory species.

KIPT themselves have signaled the possibility of **usage of acoustic monitoring in Section 4.8**

Noise and Light:

"Using marine mammal observers to monitor this zone with an additional perhaps complemented by acoustic equipment to detect mammals; pile driving would stop if a marine mammal was sighted in the zone."

This rather strangely worded statement seems to indicate they would only stop if a mammal was seen, not necessarily if it was heard.

Very strange indeed?????

**Reference 7:* KIPT Addendum Page 22*

- Dolphin "Breeding Season" ?

In the State Government agencies response to the EIS in Section 36 concern was raised about **dolphins as well as whales during breeding season**.

While whales do have a discrete breeding season, this is not the case for Bottlenose dolphins - resident on the North Coast of Kangaroo Island.

Newborn calves have been observed in all months of the year. As the dolphins travel through Smith Bay on an almost daily basis this will mean enormous disruptions to construction through "shut down" mitigative practices.

This makes the situation almost untenable in terms of the timelines promoted in the Addendum document.

It is easy to consider the **potential impacts of this proposal**, particularly in light of the changes outlined in the Addendum, in isolation, rather than considering their impacts in light of likely cumulative impacts - a more important metric.

One relevant paper attached which deals with **matters of cetacean welfare** talks about cumulative impacts, including sound, and how it cannot simply be viewed in isolation.

This approach is worthy of consideration in the assessment/approval process.

**Reference 8 - Attachment 4: Marine Mammals and Multiple Stressors: Implications for Conservation and Policy Mark P. Simmonds1,2 1Humane Society International, London, United Kingdom; 2University of Bristol, School of Veterinary Sciences, Bristol, United Kingdom*

Following are some tracts particularly relevant to sound impacts:

"Simmonds and Brakes (2011) compared a review of threats to cetaceans made in 1996, with their understanding in 2011, and suggested the following key developments: (There had been a general acceptance of noise pollution as a substantive threat and some movement to address this.)

It is also now much more clearly recognized that intense sounds from human activities—such as seismic air guns—can have direct physiologic effects on marine mammals and that naval sonar triggers behavioral reactions that can lead to death by stranding (NAS, 2016).

Factors impacting marine mammals populations can be lethal (e.g., a ship strike or a launched harpoon) or sublethal, and when describing "stressors" here, it is a sublethal impact that is being primarily considered. For example, while loud noise can be lethal, the most common effect of noise on marine mammals is behavioral disturbance. From a population perspective, rather subtle behavioral changes affecting very large numbers of marine mammals may have greater consequences than occasional lethal events affecting a few (NAS, 2016).

A good example is exposure to a loud noise, and multiple, frequent exposures might be more significant than rare exposures over a longer time. "Cumulative effect" has been defined as the combined effect of exposures to multiple stressors integrated over a defined relevant period: a day, a season, year, or lifetime (NAS, 2016)."

The following passage, again from **Simmonds 2017** explores and defines this approach:

"Claudio Campagna, in an inspiring keynote address at the 2015 Conference of the Society for Marine Mammalogy, challenged his audience with a bleak but well-informed view of modern conservation (Campagna, 2015). He opined that the continuing crisis of imminent extinctions is being driven by a paradigm that he summarized as

"provide me with a good economic reason or I do nothing… or I will make small adjustments of no consequence". He argued that the current approach to species conservation is flawed as it is based on the notion that science informs policy and policy informs conservation and sustainable economic growth. However, in practice, he argued new information is used to intervene only when it is no more costly than doing nothing! Valuing nature only in economic terms avoids recognizing the disastrous consequences of what Campagna called "the species crisis." "

**Reference 9 - Attachment 4: Marine Mammals and Multiple Stressors: Implications for Conservation and Policy Mark P. Simmonds1,2 1Humane Society International, London, United Kingdom; 2University of Bristol, School of Veterinary Sciences, Bristol, United Kingdom*

The fundamental questions therefore become:

What price true marine fauna safety?   What price extinction?

- Biologically Important Area For Southern Right Whales

In relation to the mitigations described in the EIS and the Addendum, in can be argued that mitigative practises, for example *"soft start"* and *"ramping up"* procedures, while presumably protecting whales from **Temporary Threshold Shift** and **Permanent Threshold Shift** can actively impact in deleterious ways by driving them out of critical habitat.

Smith Bay is emerging as a Biologically Important Area for Southern right whales.

If true mitigations come down to temporal and spatial, it could well be argued that in light of the flexibility of timings of migrations, especially in light of climate change impacts and the like, it would be not too extreme to suggest that some **important areas should be out of bounds for development activities as described in the EIS and Addendum**.

As temporal mitigation is problematic, spatial mitigation is the only reasonable solution and this is easily employed by moving the proposed development away from sensitive receptors.

Please do not hesitate to contact me for further information or clarification.

Thank you for your consideration of this submission with respect to the Addendum to the EIS prepared for KIPT with regard to the Smith Bay Wharf proposal.

Yours sincerely,

Tony Bartram

Tony Bartram

Kangaroo Island / Victor Harbor Dolphin Watch Coordinator

Please find attached the following documents:

**Reference 1 - Attachment 1*: EIA Guidelines*

**Reference 2 - Attachment 2*: CMS Guidelines: EIA Marine Noise Technical Support Information*

**Reference 3 - Attachment 3*: Environmental Impact Assessment Guidelines Prideaux_Prideaux2015*

**Reference 8 & 9 - Attachment 4*: Marine Mammals and Multiple Stressors: Implications for Conservation and Policy Mark P. Simmonds1,2 1Humane Society International, London, United Kingdom; 2University of Bristol, School of Veterinary Sciences, Bristol, United Kingdom*

CONVENTION ON MIGRATORY SPECIES

Distribution: General
UNEP/CMS/Resolution 12.14
Original: English

ADVERSE IMPACTS OF ANTHROPOGENIC NOISE ON CETACEANS AND OTHER MIGRATORY SPECIES

Adopted by the Conference of the Parties at its 12th Meeting (Manila, October 2017)

Recalling that in Resolution 9.19 and Resolution 10.24[1] the CMS Parties expressed concern about possible "adverse anthropogenic marine/ocean noise impacts on cetaceans and other biota",

Recognizing that anthropogenic marine noise, depending on source and intensity, is a form of pollution, composed of energy, that may degrade habitat and have adverse effects on marine life ranging from disturbance of communication or group cohesion to injury and mortality,

Aware that, over the last century, anthropogenic noise levels in the world's oceans have significantly increased as a result of multiple human activities,

Recalling the obligations of Parties to the United Nations Convention on the Law of the Sea (UNCLOS) to protect and preserve the marine environment and to cooperate on a global and regional basis concerning marine mammals, paying special attention to highly migratory species, including cetaceans listed in Annex I of UNCLOS,

Recalling that the United Nations General Assembly Resolution A/RES/71/257 on *Oceans and the Law of the Sea* adopted in 2016 "[n]otes with concern that human-related threats, such as marine debris, ship strikes, underwater noise, persistent contaminants, coastal development activities, oil spills and discarded fishing gear, together may severely impact marine life, including its higher trophic levels, and calls upon States and competent international organizations to cooperate and coordinate their research efforts in this regard so as to reduce these impacts and preserve the integrity of the whole marine ecosystem while fully respecting the mandates of relevant international organizations",

Recalling CMS Resolution 10.15 on *Global Programme of Work for Cetaceans*, which urges Parties and non-Parties to promote the integration of cetacean conservation into all relevant sectors by coordinating their national positions among various conventions, agreements and other international fora and instructs the Aquatic Mammals Working Group of the Scientific Council to develop advisory positions for use in Environmental Impact Assessments at the regional level and to provide support to governments and regional bodies for assessing and defining appropriate standards for noise pollution,

[1] Both now consolidated as Resolution 12.14

Recalling that other international fora recognize anthropogenic marine noise as a potential threat to marine species conservation and welfare, and have adopted related decisions and resolutions or issued guidance, including:

a) the Convention on Biological Diversity (CBD) through Decision X.29 concerning marine and coastal biodiversity and in particular its paragraph 12 relating to anthropogenic underwater noise and Decision XIII.10 addressing impacts of anthropogenic underwater noise on marine and coastal biodiversity and in particular paragraphs 1-2 relating to anthropogenic underwater noise,

b) the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) through Resolution 2.16 on *Impact Assessment of Man-Made Noise*, Resolution 3.10 on *Guidelines to Address the Impact of Anthropogenic Noise on Marine Mammals in the ACCOBAMS Area*, Resolution 4.17 on *Guidelines to address the impact of anthropogenic noise on cetaceans in the ACCOBAMS area*, Resolution 5.15 on *Addressing the Impact of Anthropogenic Noise* and Resolution 6.17 on *Anthropogenic Noise*,

c) the Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) through Resolution 5.4 on *Adverse Effects of Sound, Vessels and other Forms of Disturbance on Small Cetaceans*, Resolution 6.2 on *Adverse Effects of Underwater Noise on Marine Mammals during Offshore Construction Activities for Renewable Energy Production* and Resolution 8.11 on *CMS Family Guidelines on Environmental Impact Assessments for Marine Noise-generating Activities*,

d) the International Maritime Organization (IMO), which in 2008 established in its Marine Environmental Protection Committee a high priority programme of work on minimizing the introduction of incidental noise from commercial shipping operations into the marine environment, and which in 2014 issued MEPC.1/Circ.833 *Guidelines for the Reduction of Underwater Noise from Commercial Shipping to Address Adverse Impacts on Marine Life*,

e) the Convention for the Protection of the Marine Environment of the North-East-Atlantic (OSPAR) Guidance on environmental considerations for offshore wind farm development,

f) the International Union for Conservation of Nature (IUCN) Resolution 3.068 concerning undersea noise pollution (World Conservation Congress at its 3rd Session in Bangkok, Thailand, 17–25 November 2004),

g) following International Whaling Commission (IWC) Resolution 1998-6, the IWC Scientific Committee has investigated the impacts of military sonar, seismic surveys, masking and shipping noise; it has concluded that, in addition to some instances of severe acute effects (e.g. from military sonar and similar noise sources), existing levels of ocean noise can have a chronic effect, and agreed that action should be taken to reduce noise in parallel with efforts to quantify these effects; and the IWC has identified the importance of continued and increased collaboration on this issue with other organizations including ACCOBAMS, ASCOBANS, IMO and IUCN,

Recalling that according to Article 236 of UNCLOS, that Convention's provisions regarding the protection and preservation of the marine environment do not apply to warships, naval auxiliary and other vessels or aircraft owned or operated by a State and used, for the time being, only on governmental non-commercial service; and that each State is required to ensure, by the adoption of appropriate measures not impairing operations or operational capabilities of such vessels or aircraft owned or operated by it, that such vessels or aircraft act in a manner consistent, so far as is reasonable and practicable, with UNCLOS,

Noting that the Convention on Biological Diversity (CBD) decision VI/20 recognized CMS as the lead partner in the conservation and sustainable use of migratory species over their entire range,

Acknowledging the ongoing activities in other fora to reduce underwater noise such as the activities within NATO to avoid negative effects of sonar use,

Noting Directive 2014/52/EU of the European Parliament and of the Council, amending Directive 2011/92/EU on the *Assessment of the Effects of Certain Public and Private Projects on the Environment*,

Noting the EU Marine Strategy Framework Directive and its implementing act, where Member States in European Union marine waters shall take necessary measures by 2020 to achieve or maintain their determined good environmental status, including on underwater noise, established by each of them and in coordination at Union, regional and sub-regional levels,

Grateful for the invitation of ACCOBAMS and ASCOBANS, accepted in 2014, that CMS participate in the Joint Noise Working Group, which provides detailed and precautionary advice to Parties, particularly on available mitigation measures, alternative technologies and standards required for achieving the conservation goals of the treaties,

Aware that some types of marine noise can travel faster than other forms of pollution over more than hundreds of kilometres underwater unrestricted by national boundaries and that these are ongoing and increasing,

Taking into account the lack of data on the distribution and migration of some populations of marine species and on the adverse human-induced impacts on CMS-listed marine species and their prey,

Aware that incidents of stranding and deaths of some cetacean species have coincided with and may be due to the use of high-intensity mid-frequency active sonar,

Reaffirming that the difficulty of proving possible negative impacts of acoustic disturbance on CMS-listed marine species and their prey necessitates a precautionary approach in cases where such an impact is likely,

Noting the draft research strategy developed by the European Science Foundation on "*the effects of anthropogenic sound on marine mammals",* which is based on a risk assessment framework,

Noting the OSPAR *Code of Conduct for Responsible Marine Research in the Deep Seas and High Seas of the OSPAR Marine Area* and the ISOM *Code of Conduct for Marine Scientific Research Vessels*, providing that marine scientific research is carried out in an environmentally friendly way using appropriate study methods reasonably available,

Aware of the calls on the IUCN constituency to recognize that, when there is reason to expect that harmful effects on biota may be caused by anthropogenic marine noise, lack of full scientific certainty should not be used as a reason for postponing measures to prevent or minimize such effects,

Recognizing with concern that cetaceans and other marine mammals, reptiles and fish species, and their prey, are vulnerable to noise disturbance and subject to a range of human impacts,

The Conference of the Parties to the
Convention on the Conservation of Migratory Species of Wild Animals

1. *Reaffirms* that there is a need for ongoing and further internationally coordinated research on the impact of underwater noise (including inter alia from offshore wind farms and associated shipping) on CMS-listed marine species and their prey, their migration routes and ecological coherence, in order to give adequate protection to cetaceans and other marine migratory species;

2. *Confirms* the need for international, national and regional limitation of harmful anthropogenic marine noise through management (including, where necessary, regulation), and that this Resolution remains a key instrument in this regard;

3. *Urges* Parties and invites non-Parties that exercise jurisdiction over any part of the range of marine species listed on the appendices of CMS, or over flag vessels that are engaged within or beyond national jurisdictional limits, to take special care and, where appropriate and practical, to endeavour to control the impact of anthropogenic marine noise pollution in habitats of vulnerable species and in areas where marine species that are vulnerable to the impact of anthropogenic marine noise may be concentrated, to undertake relevant environmental assessments on the introduction of activities that may lead to noise-associated risks for CMS-listed marine species and their prey;

4. *Strongly urges* Parties to prevent adverse effects on CMS-listed marine species and their prey by restricting the emission of underwater noise; and where noise cannot be avoided, *further urges* Parties to develop an appropriate regulatory framework or implement relevant measures to ensure a reduction or mitigation of anthropogenic marine noise;

5. *Calls* on Parties and *invites* non-Parties to adopt whenever possible mitigation measures on the use of high intensity active naval sonars until a transparent assessment of their environmental impact on marine mammals, fish and other marine life has been completed and as far as possible aim to prevent impacts from the use of such sonars, especially in areas known or suspected to be important habitat to species particularly sensitive to active sonars (e.g. beaked whales) and in particular where risks to marine species cannot be excluded, taking account of existing national measures and related research in this field;

6. *Urges* Parties to ensure that Environmental Impact Assessments take 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;

7. *Endorses* the “CMS Family Guidelines on Environmental Impact Assessments for Marine Noise-generating Activities” attached as Annex and *welcomes* the Technical Support Information contained in UNEP/CMS/COP12/Inf.11[2];

8. *Invites* Parties to ACCOBAMS and ASCOBANS to consider adopting these Guidelines, in the elaboration of which they were fully involved, at their next Meetings of the Parties;

9. *Further invites* Signatories to relevant Memoranda of Understanding concluded under CMS to consider using these Guidelines as guiding documents;

10. *Recognizes* that the work done in relation to marine noise is rapidly evolving, and *requests* the Scientific Council, in collaboration with the Joint Noise Working Group of CMS, ACCOBAMS and ASCOBANS, to review and update these Guidelines regularly;

[2] also provided online at http://www.cms.int/guidelines/cms-family-guidelines-EIAs-marine-noise

11. *Urges* Parties and *encourages* non-Parties to disseminate these Guidelines, where necessary translating the Guidelines into different languages for their wider dissemination and use;

12. *Invites* the private sector and other stakeholders to make full use of these Guidelines in order to assess, mitigate and minimize negative effects of anthropogenic marine noise on marine biota;

13. *Welcomes* the efforts of the private sector and other stakeholders to reduce their environmental impact and *strongly encourages* them to continue making this a priority;

14. *Recommends* that Parties, the private sector and other stakeholders apply Best Available Techniques (BAT) and Best Environmental Practice (BEP) including, where appropriate, clean technology, in their efforts to reduce or mitigate marine noise pollution;

15. *Further recommends* that Parties, the private sector and other stakeholders use, as appropriate, noise reduction techniques for offshore activities such as: air-filled coffer dams, bubble curtains or hydro-sound dampers, or different foundation types (such as floating platforms, gravity foundations or pile drilling instead of pile driving);

16. *Stresses* the need of Parties to consult with any stakeholder conducting activities known to produce anthropogenic marine noise with the potential to cause adverse effects on CMS-listed marine species and their prey, such as the oil and gas industry, shoreline developers, offshore extractors, marine renewable energy companies, other industrial activities and oceanographic and geophysical researchers recommending, how best practice of avoidance, diminution or mitigation of risk should be implemented. This also applies to military authorities to the extent that this is possible without endangering national security interests. In any case of doubt the precautionary approach should be applied;

17. *Encourages* Parties to integrate the issue of anthropogenic noise into the management plans of marine protected areas (MPAs) where appropriate, in accordance with international law, including UNCLOS;

18. *Invites* the private sector to assist in developing mitigation measures and/or alternative techniques and technologies for coastal, offshore and maritime activities in order to minimize anthropogenic noise pollution of the marine environment to the highest extent possible;

19. *Encourages* Parties to facilitate:

- regular collaborative and coordinated temporal and geographic monitoring and assessment of local ambient noise (both of anthropogenic and biological origin);
- further understanding of the potential for sources of noise to interfere with long-range movements and migration;
- the compilation of a reference signature database, to be made publicly available, to assist in identifying the source of potentially damaging sounds;
- characterization of sources of anthropogenic noise and sound propagation to enable an assessment of the potential acoustic risk for individual species in consideration of their auditory sensitivities;
- studies on the extent and potential impact on the marine environment of high- intensity active naval sonars and seismic surveys in the marine environment; and the extent of noise inputs into the marine environment from shipping and to provide an assessment, on the basis of information to be provided by the Parties, of the impact of current practices; and
- studies reviewing the potential benefits of “noise protection areas”, where the emission of underwater noise can be controlled and minimized for the protection of cetaceans and other biota;

whilst recognizing that some information on the extent of the use of military sonars (e.g. frequencies used) will be classified and would not be available for use in the proposed studies or databases;

20. *Recommends* that Parties that have not yet done so establish national noise registries to collect and display data on noise-generating activities in the marine area to help assess exposure levels and the likely impacts on the marine environment, and that data standards are made compatible with regional noise registries, such as the ones developed by the International Council for the Exploration of the Sea (ICES) and ACCOBAMS;

21. *Urges* all Parties to endeavour to develop provisions for the effective management of anthropogenic marine noise in CMS daughter agreements and other relevant bodies and Conventions;

22. *Invites* the Parties to strive, wherever possible, to ensure that their activities falling within the scope of this Resolution avoid harm to CMS-listed marine species and their prey;

23. *Requests* the Scientific Council, supported by the Joint Noise Working Group of CMS, ACCOBAMS and ASCOBANS, to continue monitoring new available information on the effects of underwater noise on marine species, as well as the effective assessment and management of this threat, and to make recommendations to Parties as appropriate;

24. *Requests* the Secretariat and *calls upon* Parties to contribute to the work of the IMO MEPC on noise from commercial shipping;

25. *Invites* Parties to provide the CMS Secretariat, for transmission to the Scientific Council, with copies of relevant protocols/guidelines and provisions for the effective management of anthropogenic noise, taking security needs into account, such as those of relevant CMS daughter agreements, OSPAR, IWC, IMO, NATO and other fora, thereby avoiding duplication of work; and

26. *Repeals*

    a) Resolution 9.19, *Adverse Anthropogenic Marine/Ocean Noise Impacts on Cetaceans and Other Biota*; and

    b) Resolution 10.24, *Further Steps to Abate Underwater Noise Pollution for the Protection of Cetaceans and Other Migratory Species*.

Annex to Resolution 12.14

CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities

These **CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities** have been developed to present the Best Available Techniques (BAT) and Best Environmental Practice (BEP), as called for in CMS Resolutions 9.19, 10.24 and 10.15, ACCOBAMS Resolution 5.15 and ASCOBANS Resolutions 6.2 and 8.11. In addition to the parent convention, CMS, these guidelines are relevant to:

- Agreement on the Conservation of Cetaceans of the Black Seas Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS)
- Agreement on the Conservation of Seals in the Wadden Sea (Wadden Sea Seals)
- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)
- MOU Concerning Conservation Measures for the Eastern Atlantic Populations of the Mediterranean Monk Seal (*Monachus monachus*) (Atlantic Monk Seals)
- MOU Concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa (Atlantic Marine Turtles)
- MOU Concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia (Western African Aquatic Mammals)
- MOU for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (Pacific Islands Cetaceans)
- MOU on the Conservation and Management of Dugongs (*Dugong dugon*) and their Habitats throughout their Range (Dugong)
- MOU on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (IOSEA)
- MOU on the Conservation of Migratory Sharks (Sharks)

Contents

I. Introduction

1. These **CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities** are designed to provide regulators with tailored advice to apply in domestic jurisdictions, as appropriate, to create EIA standards between jurisdictions seeking to manage marine noise-generating activities. The requirements within each of the modules are designed to ensure that the information being provided by proponents will provide decision-makers with sufficient information to make an informed decision about impacts. The modules should be read in tandem with the **Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessments for Marine Noise-generating Activities** (available at www.cms.int/guidelines/cms-family-guidelines-EIAs-marine-noise). They are structured to stand as one complete unit or to be used as discrete modules, tailored for national and agreement approaches.

2. The sea is the interconnected system of all the Earth's oceanic waters, including the five named 'oceans' - the Atlantic, Pacific, Indian, Southern and Arctic Oceans - a continuous body of salty water that covers over 70 per cent of the Earth's surface. This vast aquatic environment is home to a wider range of higher animal taxa than exists on land. Many marine species have yet to be discovered and the number known to science is expanding annually.

3. The sea also provides people with food—mainly fish, shellfish and seaweed—as well as other marine resources. It is a shared resource for us all.

4. Marine wildlife relies on sound for vital life functions, including communication, prey and predator detection, orientation and for sensing surroundings. The ocean environment is filled with natural sound (ambient noise) from biological (marine animals) and physical processes (earthquakes, wind, ice and rain) (Urick, 1983). Species living in this environment are adapted to these sounds.

5. Over the past century many anthropogenic marine activities have increased levels of noise (Hildebrand 2009; André et.al. 2010; Miksis-Olds and Nichols 2016) These modern anthropogenic noises have the potential for physical, physiological and behavioural impacts (Southall et.al. 2007).

6. Parties to CMS, ACCOBAMS and ASCOBANS have in several resolutions recognized underwater noise as a major threat to many marine species. These resolutions also call for noise-related considerations to be taken into account as early as the planning stages of activities, especially by making effective use of Environmental Impact Assessments (EIAs). The Convention on Biological Diversity Decision XII/23 also encourages governments to require EIAs for noise-generating offshore activities, and to combine acoustic mapping with habitat mapping to identify areas where these species may be exposed to noise impacts. (Prideaux, 2017b)

7. Wildlife exposed to elevated or prolonged anthropogenic noise can suffer direct injury and/or temporary or permanent auditory threshold shifts. Noise can mask important natural sounds, such as the call of a mate, or the sound made by prey or predator. Anthropogenic noise can also displace wildlife from important habitats. These impacts are experienced by a wide range of species including fish, crustaceans, cephalopods, pinnipeds (seals, sea lions and walrus), sirenians (dugong and manatee), sea turtles, the polar bear, marine otters and cetaceans (whales, dolphins and porpoises) (Southall et.al. 2007; Aguilar de Soto, 2017a; 2017b; Castellote, 2017a; 2017b; Frey, 2017; Hooker, 2017; McCauley, 2017; Marsh, 2017; Notarbartolo di Sciara, 2017a; 2017b; 2017c; Parks, 2017; Truda Palazzo, 2017; Vongraven, 2017). Where there is risk, full assessment of impact should be conducted.

8. The propagation of sound in water is complex and requires many variables to be carefully considered before it can be known if a noise-generating activity is appropriate or not. It is inappropriate to generalize sound transmission without fully investigating propagation (Prideaux, 2017a). Often, statements are made in Environmental Impact Assessments that a noise-generating activity is 'X' distance from 'Y' species or habitat and therefore, will have no impact. In these cases, distance is used as a basic proxy for impact but is rarely backed with scientifically modelled information. (Wright et.al. 2013; Prideaux and Prideaux 2015)

9. To present a defensible Environmental Impact Assessment for any noise-generating activity proposal, proponents need to have expertly modelled the noise of the proposed activity in the region and under the conditions they plan to operate. Regulators should have an understanding of the ambient or natural sound in the proposed area. This might require CMS Parties or jurisdictions to develop a metric or method for defining this, by drawing on the range of resources available worldwide. (Prideaux, 2017a)

10. All EIAs should include operational procedures to mitigate impact effectively during activities, and there should be proof of the mitigation's efficacy. These are the operational mitigation procedures that should be detailed in the national or regional regulations of the jurisdictions where the activity is proposed. Operational monitoring and mitigation procedures differ around the world, and may include industry/company best practices. Monitoring often includes, *inter alia*:

a. periods of visual and other observation before a noise-generating activity commences
b. passive acoustic monitoring
c. marine mammal observers
d. aerial surveys

Primary mitigation often includes, *inter alia*:

e. delay to start, soft start and shut-down procedures
f. sound dampers, including bubble curtains and cofferdams; sheathing and jacket tubes
g. alternative low-noise or noise-free options (such as compiled in the OSPAR inventory of measures to mitigate the emission and environmental impact of underwater noise)

Secondary mitigation, where the aim is to prevent encounters of marine life with noise sources, includes *inter alia*:

h. spatial & temporal exclusion of activities

11. Approaches to mitigate the impact of particle motion (e.g. reducing substrate or sea ice vibration) should also be investigated. Assessment of the appropriateness and efficacy of all operational procedures should be the responsibility of the government agency assessing Environmental Impact Assessments (EIA).

II. Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities

12. **Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessments for Marine Noise-generating Activities** is provided as a full document and as stand-alone modules at: www.cms.int/guidelines/cms-family-guidelines-EIAs-marine-noise.

13. This **Technical Support Information** has been specifically designed to provide clarity and certainty for regulators, when deciding to approve or restrict proposed activities. The document provides detailed information about species' vulnerabilities, habitat considerations, impact of exposure levels and proposed assessment criteria for all of the CMS-listed species groups and their prey.

14. The document is structured to cover specific areas, as follows:

- ‘Module A: Sound in Water is Complex’ provides an insight into the characteristics of sound propagation and dispersal. This module is designed to provide decision-makers with necessary foundation knowledge to interpret the other modules in these guidelines and any impact assessments that are presented to them for consideration.
- ‘Module B: Expert Advice on Specific Species Groups’ presents twelve separate detailed sub-modules covering each of the CMS species groups, focusing on species' vulnerabilities, habitat considerations, impact of exposure levels and assessment criteria.
- ‘Module C: Decompression Stress’ provides important information on bubble formation in marine mammals, source of decompression stress, source frequency, level and duration, and assessment criteria.
- ‘Module D: Exposure Levels’ presents a summary of the current state of knowledge about general exposure levels.
- ‘Module E: Marine Noise-generating Activities’ provides a brief summary of military sonar, seismic surveys, civil high-powered sonar, coastal and offshore construction works, offshore platforms, playback and sound exposure experiments, shipping and vessel traffic, pingers and other noise-generating activities. Each section presents current knowledge about sound intensity level, frequency range and the activities’ general characteristics. The information is summarized in a table within the module.
- ‘Module F: Related Intergovernmental or Regional Economic Organization Decisions’ presents the series of intergovernmental decisions that have determined the direction for regulation of anthropogenic marine noise.
- ‘Module G: Principles of EIAs’ establishes basic principles including strategic environmental assessments, transparency, natural justice, independent peer review, consultation and burden of proof.
- ‘Module H: CMS-Listed Species Potentially Impacted by Anthropogenic Marine Noise’

15. The evidence presented in the **Technical Support Information** Modules B, C and D establishes that the effective use of EIA for all marine noise-generating activities is in line with CMS Resolutions 9.19, 10.24 and 10.15, ACCOBAMS Resolution 5.15 and ASCOBANS Resolutions 6.2 and 8.11.

16. The **Technical Support Information** was developed before the release of ISO 18405: Underwater acoustics – Terminology that provides valuable consistency to language used. The Guidelines have been slightly adapted to reflect this new ISO standard, without losing the vital connection to the **Technical Support Information**. Decision-makers should refer to both documents wherever possible.

III. Technical Advisory Notes

17. The following advisory notes should be considered in conjunction with the individual EIA Guideline tables, as presented in Modules IV through XI.

III.1. Ambient Sound

18. ISO 18405 refers to ambient sound as “*sound that would be present in the absence of a specified activity*” and “*is location-specific and time-specific*”. These Guidelines more specifically define it as the average ambient (non-anthropogenic) sound levels from biological (marine animals) and physical processes (earthquakes, wind, ice and rain etc) of a given area. It should be measured (including daily and seasonal variations of frequency bands), for each component of an activity, prior to an EIA being developed and presented.

III.2 Sound Intensity

19. ISO 18405 defines sound intensity as "the product of the sound pressure", which is the contribution to total pressure caused by the action of sound, "and sound particle velocity", which is the contribution to velocity of a material element caused by the action of sound.

III.3. Exclusion Zones

20. Where exclusion zones are referred to in these Guidelines, these are areas that are designed for the protection of specific species and/or populations. Activities, and noise generated by activities, should not propagate into these areas.

III.4. Independent, Scientific Modelling of Noise Propagation

21. The objective of noise modelling for EIAs is to predict how much noise a particular activity will generate and how it will disperse. The aim is to model the received sound levels at given distances from the noise source. The amount of sound lost at the receiver from the sound source is propagation loss.

22. The intention of EIAs is to assess the impact of proposed activities on marine species and the environment. EIAs should not only present the main output of interest to the activity proponent, but should fully disclose the full frequency bandwidth of a proposed anthropogenic noise source, the intensity/pressure/energy output within that full range, and the principal or mean/median operating frequency of the source(s). (Urick, 1983, Etter, 2013; Prideaux, 2017a)

23. Many propagation models have been developed such as ray theory, normal modes, multipath expansion, fast field, wavenumber integration or parabolic equation. However, no single model accounts for all frequencies and environments. Factors that influence which propagation model/s should be used include the activity noise frequencies, water depth, seabed topography, temperature and salinity, and spatial variations in the environment. (Urick, 1983, Etter, 2013; Prideaux, 2017a)

24. The accuracy (i.e. bias) of sound propagation models depends heavily on the accuracy of their input data.

25. Commonly missing in EIAs is the modelling of particle motion propagation. Invertebrates, and some fish, detect sound through particle motion to identify predator and prey. Like sound intensity, particle motion varies significantly close to noise sources and in shallow water. Excessive levels of ensonification of these animal groups may lead to injury (barotrauma). Specific modelling techniques are required to predict the impact on these species.

III.5. Sound Exposure Level cumulative (SEL_{cum})

26. Sound Exposure Level (SEL) is generally referred to as dB 0 to peak or peak to peak (dB 0 to peak or dB p to p) for impulsive noise like air guns or pile driving, and dB Root Mean Squared (dB_{rms}) for non-impulsive noise such as ship noise, dredging or a wind farm's constant drone. Often this metric is normalized to a single sound exposure of one second (NOAA, 2016). The SEL cumulative (SEL_{cum}) metric allows the cumulative exposure of an animal to a sound field for an extended period (often 24 hours) to be assessed against a predefined threshold for injury. (Southall, 2007; NOAA, 2016)

27. NOAA recommends a baseline accumulation period of 24 hours, but acknowledges that there may be specific exposure situations where this accumulation period requires adjustment (e.g., if activity lasts less than 24 hours or for situations where receivers are predicted to experience unusually long exposure durations). (NOAA, 2016) The limit value for pile driving in Germany is a sound exposure level of SEL_{05} and the sound pressure level L_{peak} at a distance of 750 metres.

III.6. Particle Motion/Displacement

28. Sound exposure levels works well for marine mammals but not well for a number of other marine species, including crustaceans, bivalves and cephalopods, because these species are thought to mainly detect sound through particle motion. Particle motion or particle displacement is the displacement of a material element caused by the action of sound. For these Guidelines the motion concerned is the organism resonating in sympathy with the surrounding sound waves, oscillating back and forth in a particular direction, rather than through the tympanic mechanism of marine mammals or swim-bladders of some fish species. (Mooney, et.al., 2010; André, et.al., 2011; Hawkins and Popper, 2016; NOAA, 2016)

29. The detection of particle motion or particle displacement requires different types of sensors than those utilized by a conventional hydrophone. These sensors must specify the particle motion in terms of the particle displacement, or its time derivatives (particle velocity or particle acceleration).

IV. EIA Guideline for Military and Civil High-powered Sonar

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances.

The EIA Guideline for Shipping and Vessels Traffic (V) should be used when the vessel is underway/making way with sonar off.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the activity – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed activity, above natural ambient sound levels • Detail of the typical weather conditions and day length for the area during the proposed activity period • Identification of previous and simultaneous activities, their seasons and duration in the same or adjoining areas, existence and location of any marine protected areas, and a review of activity findings and implications

Component	Detail
Description of the equipment and activity	• Explanation of all activity technologies available and why each proposed technology is chosen • Description of the activity technology including: a. name and description of the vessel/s to be used (except where details would risk national security) b. total duration of the proposed activity c. proposed timing of operations – season/time of day/during all weather conditions d. signal duration and sound intensity level (dB peak to peak) in water @ 1 metre, frequency ranges and ping rate • Specification of the activity including anticipated nautical miles to be covered, track-lines, speed of vessels and sonar power setting changes • Identification of other activities having an impact in the region during and after the planned activity, if there is information, accompanied by the analysis and review of potential cumulative or synergistic impacts
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in the same season/weather conditions as the proposed activity accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed exclusion zones for species and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels; and calculated from this, the extent of the impact zones b. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts on prey species c. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summaries): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions. • Quantification of the effectiveness of proposed mitigation methods

Component	Detail
Mitigation and monitoring plans	• Detail of: a. Scientific monitoring programmes before the survey to assess species distribution and behaviour, to facilitate the incorporation of monitoring results into the impact assessment. b. Scientific monitoring programmes, conducted during and after the activity, to assess impact c. Transparent processes for regular real-time public reporting of activity progress and all impacts encountered d. Most appropriate methods of species detection (e.g. visual/acoustic) and the range of available methods, and their advantages and limitations, as well their practical application during the activity. e. Impact mitigation proposals: i. 24-hour visual or other means of detection, especially under conditions of poor visibility (including high winds, night conditions, sea spray or fog) ii. establishing exclusion zones to protect specific species, accompanied by scientific and precautionary justification for these zones iii. soft start and shut-down protocols iv. spatio-temporal restrictions
Reporting plans	• Detail of post operation reporting plans including verification of the effectiveness of mitigation
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

V. EIA Guideline for Shipping and Vessels Traffic

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances.

This EIA Guideline is directed to shipping regulators, including port and harbour authorities. Cumulative impact of shipping, identifying appropriate exclusion zones and shipping lanes should be the focus.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the activity – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed shipping, above natural ambient sound levels • Detail of the typical weather conditions and day length for the area during the proposed activity period • Existence and location of any marine protected areas
Description of vessels and equipment	• Description of vessel/s (tonnage, propulsion and displacement) and equipment activity • Detail of all activities including sound intensity levels (dB_{rms}) @ 1 metre and frequency ranges (all frequencies to encompass, *inter alia*, propeller resonance, harmonics, cavitations, engine and hull noise) • Identification of other activities having an impact in the region accompanied by the analysis and review of potential cumulative or synergistic impacts
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in confined areas (harbours and channels) and accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed species exclusion zones and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features

Component	Detail
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels. Calculated from this, the extent of the impact zones, and the number of animals affected by the activity. b. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts on prey species c. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summary): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions
Monitoring plans	• Explanation of access to the evaluation of ongoing scientific monitoring data to assess impacts • Quantification of the effectiveness of proposed mitigation methods • Spatio-temporal restrictions
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

VI. EIA Guideline for Seismic Surveys (Air Gun and Alternative Technologies)

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the survey – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed survey, above natural ambient sound levels • Detail of the typical weather conditions and day length for the area during the proposed activity period • Identification of previous and simultaneous activities, their seasons and duration in the same or adjoining areas, existence and location of any marine protected areas, and a review of activity findings and implications
Description of the equipment and activity	• Explanation of all survey technologies available (including low-noise or noise-free options) and why the proposed technology has been chosen. If low-noise options have not been chosen, an explanation should be provided about why these technologies are not preferred • Description of the survey technology including: a. name and description of the vessel/s to be used b. total duration of the proposed survey, date, timeframe c. proposed timing of operations – season/time of day/during all weather conditions d. sound intensity level (dB peak to peak) in water @ 1 metre and all frequency ranges and discharge rate e. if an air gun technology is proposed: i. number of arrays ii. number of air guns within each array iii. air gun charge pressure to be used iv. volume of each air gun in cubic inches v. official calibration figures supplied by the survey vessel to be charted, for noise modelling vi. depth the air guns to be set vii. number and length of streamers, distance set apart and depth the hydrophones are set • Specification of the survey including anticipated nautical miles to be covered, track-lines, speed of vessels, start-up and shut-down procedures, distance and procedures for vessel turns including any planned air gun power setting changes • Identification of other activities having an impact in the region during the planned survey, accompanied by the analysis and review of potential cumulative or synergistic impacts

Component	Detail
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in the same season/weather conditions as the proposed activity accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed species exclusion zones and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels. Calculated from this, the extent of the impact zones, and the number of animals affected by the activity. a. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts to prey species b. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summary): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions

Component	Detail
Mitigation and monitoring plans	• Detail of: a. Scientific monitoring before the survey to assess baselines, species distribution and behaviour to facilitate the incorporation of monitoring results into the impact assessment b. Scientific monitoring programmes, conducted during and after the survey, to assess impact, including noise monitoring stations placed at specified distances c. Transparent processes for regular real-time public reporting of survey progress and all impacts encountered d. Most appropriate methods of species detection (e.g. visual/acoustic) and the range of available methods, and their advantages and limitations, as well their practical application during the activity. e. Impact mitigation proposals: i. 24-hour visual or other means of detection, especially under conditions of poor visibility (including high winds, night conditions, sea spray or fog) ii. establishing exclusion zones to protect specific species, including scientific and precautionary justification for these zones iii. soft start and shut-down protocols iv. protocols in place for consistent and detailed data recording (observer/PAM sightings and effort logs, survey tracks and operations) v. detailed, clear, chain of command for implementing shut-down mitigation protocols vi. spatio-temporal restrictions • Quantification of the effectiveness of proposed mitigation methods
Reporting plans	• Detail of post operation reporting plans including verification of the effectiveness of mitigation, and any shut-down procedures occurring and reasons why
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed survey in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed survey in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

VII. EIA Guideline for Construction Works

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances. This guideline should be applied to all forms of marine construction, including dredging and similar vessel based activities where ships may be stationary, but under way. All commissioning and decommissioning activities should also follow these guidelines.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the activity – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed activity, above natural ambient sound levels • Detail of the typical weather conditions and day length for the area during the proposed activity period • Identification of previous and simultaneous activities, their seasons and duration in the same or adjoining areas, existence and location of any marine protected areas, and a review of activity findings and implications
Description of the equipment and activity	• Explanation of all activity technologies available and why each proposed technology is chosen, including consideration of noise-free installation methods • Specification of: a. total duration of the proposed activity b. proposed timing of operations – season/time of day/during all weather conditions c. sound intensity level (dB peak to peak) in water @ 1 metre and frequency ranges d. If explosives are proposed: i. what type of explosive and what charge weight is proposed, also whether the explosive is going to be used on the seabed or subsurface ii. specification of sound intensity level (dB 0 to peak) in water @ 1 metre, frequency range and number of detonations and interval time • Description of noise counter measures e.g.: bubble curtains, noise dampers and cofferdams, including a description of state-of-the-art technology, Best Environmental Practice (BEP) or Best Available Technology (BAT) • Identification of other activities having an impact in the region during the planned activity, accompanied by the analysis and review of potential cumulative or synergistic impacts
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in the same season/weather conditions as the proposed activity accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed exclusion zones for species and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features

Component	Detail
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels; and calculated from this, the extent of the impact zones b. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts to prey species c. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summary): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions
Mitigation and monitoring plans	• Detail of: a. Scientific monitoring programmes, conducted before, during and after the activity, to assess impact, including noise monitoring stations placed at specified distances b. Transparent processes for regular real-time public reporting of activity progress and all impacts encountered c. Most appropriate methods of species detection (e.g. visual/acoustic) and the range of available methods, and their advantages and limitations, as well their practical application during the activity. d. Impact mitigation proposals: i. 24-hour visual or other means of detection, especially under conditions of poor visibility (including high winds, night conditions, sea spray or fog) ii. establishing exclusion zones to protect specific species, including scientific and precautionary justification for these zones iii. soft start and shut-down protocols iv. spatio-temporal restrictions • Quantification of the effectiveness of proposed mitigation methods
Reporting plans	• Detail of post operation reporting plans including verification of the effectiveness of mitigation, and any shut-down procedures occurring and reasons why

Component	Detail
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why e. If it is decided that BEP or BAT is not used, this should be justified • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

VIII. EIA Guideline for Offshore Platforms

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances.

All commissioning and decommissioning activities should also follow these guidelines. Where impulsive activities, such as offshore platforms being constructed through impact driven piles, the guidelines for VII: Construction Works should also be applied.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the activity – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed activity, above natural ambient sound levels • Detail of the typical weather conditions and day length for the area during the proposed activity period • Identification of previous and simultaneous activities, their seasons and duration in the same or adjoining areas, existence and location of any marine protected areas, and a review of activity findings and implications

Component	Detail
Description of the equipment and activity	• Explanation of all activity technologies available and why each proposed technology is chosen, including consideration of alternatives • Description of the activity technology including name and description of the vessel/s and sea floor equipment to be used • Specification of: a. total duration of the proposed activity b. sound intensity level (dB_{rms}) in water @ 1 metre (from noise source e.g.: platform caissons or drill ship's hull etc.) and frequency ranges c. sound intensity levels (peak and rms) during planned maintenance schedules • Identification of other activities having an impact in the region during the planned activity, accompanied by the analysis and review of potential cumulative or synergistic impacts
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in the same season/weather conditions as the proposed activity accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed exclusion zones for species and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels; and calculated from this, the extent of the impact zones b. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts to prey species c. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summary): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration: iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions

Component	Detail
Mitigation and monitoring plans	• Detail of: a. Scientific monitoring programmes, conducted before, during and after the activity, to assess impact, including noise monitoring stations placed at specified distances b. Transparent processes for regular real-time public reporting of activity progress and all impacts encountered c. Most appropriate methods of species detection (e.g. visual/acoustic) and the range of available methods, and their advantages and limitations, as well their practical application during the activity. d. Impact mitigation proposals e. 24-hour visual or other means of detection, especially under conditions of poor visibility (including high winds, night conditions, sea spray or fog) f. Spatio-temporal restrictions • Quantification of the effectiveness of proposed mitigation methods
Reporting plans	• Detail of post operation reporting plans including verification of the effectiveness of mitigation
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

IX. EIA Guideline for Playback and Sound Exposure Experiments

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the activity – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed activity, above natural ambient sound levels • Detail of the typical weather conditions and day length for the area during the proposed activity period • Identification of previous and simultaneous activities, their seasons and duration in the same or adjoining areas, existence and location of any marine protected areas, and a review of activity findings and implications
Description of the equipment and activity	• Noting that the scale of the noise needed to elicit a response (with respect to level and duration) may be much lower than in industry activities; and that noise can be controlled in order to affect only a small area or small number of individuals, the noise control measures of the experimental design should be described in detail. • Explanation of all technologies available for the activity and why each proposed technology is chosen • Description of the chosen technology including name and description of the vessel/s to be used • Specification of: a. lowest practicable sound intensity level required b. total duration of the proposed activity c. proposed timing of operations – season/time of day/during all weather conditions d. sound intensity level (dB peak to peak) in water @ 1 metre and all frequency ranges and discharge rate e. if an air gun technology is proposed refer to VI f. if explosives are proposed refer to VII • Specification of the activity including anticipated nautical miles to be covered, track-lines, speed of vessels, start-up and shut-down procedures, distance and procedures for vessel turns including any planned air gun power setting changes • Identification of other activities having an impact in the region during the planned activity, accompanied by the analysis and review of potential cumulative or synergistic impacts
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in the same season/weather conditions as the proposed activity accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed exclusion zones for species and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features

Component	Detail
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels; and calculated from this, the extent of the impact zones b. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts to prey species c. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summary): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions iv. how the experiment design will monitor target and non-target species and the steps that will be taken to halt sound emission if adverse response or behavioural changes are observed v. how exposures that are expected to elicit particular behavioural responses (e.g. responses elicited by predator sounds, conspecific signals) will inform specific mitigation and monitoring protocols. In such cases, impact assessment should also articulate what responses may not be related to the loudness of the exposure but to the behavioural significance of the signal/noise used.

Component	Detail
Mitigation and monitoring plans	• Detail of: a. Scientific monitoring programmes, conducted before, during and after the activity, to assess impact b. Transparent processes for regular real-time public reporting of activity progress and all impacts encountered c. Most appropriate methods of species detection (e.g. visual/acoustic) and the range of available methods, and their advantages and limitations, as well their practical application during the activity. d. Impact mitigation proposals: i. 24-hour visual or other means of detection, especially under conditions of poor visibility (including high winds, night conditions, sea spray or fog) ii. establishing exclusion zones to protect specific species, including scientific and precautionary justification for these zones iii. soft start and shut-down protocols iv. spatio-temporal restrictions • Quantification of the effectiveness of proposed mitigation methods
Reporting plans	• Detail of post operation reporting plans including verification of the effectiveness of mitigation
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

X. EIA Guideline for Pingers (Acoustic Deterrent/Harassment Devices, Navigation)

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the activity – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed activity, above natural ambient sound levels. • Detail of the typical weather conditions and day length for the area during the proposed activity period • Identification of previous and simultaneous activities, their seasons and duration in the same or adjoining areas, existence and location of any marine protected areas, and a review of activity findings and implications
Description of the equipment and activity	• Explanation of all technologies available for the activity and why the proposed technology is chosen, including the description should also contain the consideration of alternatives • Specification of sound intensity level (dB peak to peak) in water @ 1 metre, frequency ranges and ping rate, sound exposure level (SEL), as well as proposed spacing of pingers • Identification of other activities having an impact in the region accompanied by the analysis and review of potential cumulative or synergistic impacts
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in the same season/weather conditions as the proposed activity accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed exclusion zones for species and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features

Component	Detail
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels; and calculated from this, the extent of the impact zones a. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts to prey species b. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summary): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions
Monitoring plans	• Detail of scientific monitoring programmes, conducted before, during and after the activity, to assess impact • Spatio-temporal restrictions • Quantification of the effectiveness of proposed mitigation methods
Reporting plans	• Detail of post operation reporting plans including verification of the effectiveness of mitigation
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

XI. EIA Guideline for Other Noise-generating Activities (Acoustic Data Transmission, Wind, Tidal and Wave Turbines and Future Technologies)

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances.

All commissioning and decommissioning activities should also follow these guidelines.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the activity – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed activity, above natural ambient sound levels • Detail of the typical weather conditions and day length for the area during the proposed activity period • Identification of previous and simultaneous activities, their seasons and duration in the same or adjoining areas, existence and location of any marine protected areas, and a review of activity findings and implications
Description of the equipment and activity	• Explanation of all technologies available for the activity • Specification of sound intensity level (dB) in water @ 1 metre, and frequency ranges. This should include dB peak to peak for acoustic data transmission for example, dB_{rms} for wind, tidal and wave turbines and future technologies categorized accordingly • Identification of other activities having an impact in the region during the planned activity, accompanied by the analysis and review of potential cumulative or synergistic impacts
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in the same season/weather conditions as the proposed activity accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed exclusion zones for species and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features

Component	Detail
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels; and calculated from this, the extent of the impact zones b. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts to prey species c. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summary): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions • Quantification of the effectiveness of proposed mitigation methods
Monitoring plans	• Explanation of ongoing scientific monitoring programmes to assess impact • Most appropriate methods of species detection (e.g. visual/acoustic) and the range of available methods, and their advantages and limitations, as well their practical application during the activity. • Spatio-temporal restrictions
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

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Additional references are detailed in the Technical Support Information at www.cms.int/guidelines/cms-family-guidelines-EIAs-marine-noise.

Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities

Parties to the Convention on Migratory Species (CMS), the Agreement on the Conservation of Cetaceans in the Black Sea Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) and the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) have recognized underwater noise as a major threat to many marine species. Several resolutions have been passed calling for effective measures to mitigate and minimize the impact of noise pollution on marine life.

CMS, ACCOBAMS and ASCOBANS decisions also recognize that addressing this issue effectively requires that noise-related considerations should be taken into account starting with the planning stage of activities, especially by making effective use of Environmental Impact Assessments (EIA). The Convention on Biological Diversity Decision XII/23 encourages governments to require EIAs for noise-generating offshore activities and to combine acoustic mapping with habitat mapping to identify areas where these species may be exposed to noise impacts.

A considerable number of national and regional operational guidelines detail the impacts to be avoided and mitigation measures to be taken during proposed operations. For the most part these focus on cetaceans. Few guidelines cover other species and almost none has been developed about the specific content that should be provided in EIAs before approvals and permits are granted.

Thanks to a voluntary contribution from the Principality of Monaco under the Migratory Species Champions programme, and an additional contribution from OceanCare, the CMS, ASCOBANS and ACCOBAMS Secretariats are pleased to have developed guidelines for Environmental Impact Assessments for noise-generating offshore industries, providing a clear pathway to implementing the Best Available Techniques (BAT) and Best Environmental Practice (BEP).

This Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities is structured to stand as one complete unit or to be used as discrete modules, tailored for national and agreement approaches.

The full document and the stand-alone modules are online at: cms.int/guidelines/cms-family-guidelines-EIAs-marine-noise

Development of this Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities has been possible with the generous funding of Principality of Monaco and OceanCare.

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Acronyms

ACCOBAMS	Agreement on the Conservation of Cetaceans in the Black Sea Mediterranean Sea and Contiguous Atlantic Area
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas
BAT	Best Available Techniques
BEP	Best Environmental Practice
CBD	Convention on Biological Diversity
CMS	Convention on the Conservation of Migratory Species of Wild Animals or Convention on Migratory Species
dB	decibels
DSC	deep sound channel
EEH	Equal Energy Hypothesis
EIA	Environmental Impact Assessment
IMO	International Maritime Organization
IWC	International Whaling Commission
NOAA	National Oceanic and Atmospheric Administration (US)
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PTS	permanent threshold shift
RMS	root mean squared
SEA	Strategic Environmental Assessment
SEL	sound exposure level
SELcum	cumulative sound exposure level
SIL	Sound Intensity Level
SOCAL-BRS	Biological and Behavioural Response Studies of Marine Mammals in Southern California
SOFAR	Sound Fixing and Ranging Channels
SPL	Sound Pressure Level
TTS	temporary threshold shift
UK	United Kingdom of Great Britain and Northern Ireland
US	United States of America

Tables

Executive Summary

The sea is the interconnected system of all the Earth's oceanic waters, including the five named 'oceans' - the Atlantic, Pacific, Indian, Southern and Arctic Oceans - a connected body of salty water that covers over 70 percent of the Earth's surface.

This vast environment is home to a broader spectrum of higher animal taxa than exists on land. Many marine species have yet to be discovered and the number known to science is expanding annually. The sea also provides people with substantial supplies of food, mainly fish, shellfish and seaweed, in addition to marine resource extraction. It is a shared resource for us all.

Levels of anthropogenic marine noise have doubled in some areas of the world, every decade, for the past 60 years. When considered in addition to the number other anthropogenic threats in the marine environment, noise can be a life-threatening trend for many marine species.

Marine wildlife rely on sound for vital life functions, including communication, prey and predator detection, orientation and for sensing surroundings. While the ocean is certainly a sound-filled environment and many natural (or biological) sounds are very loud, wildlife is not adapted to anthropogenic noise.

Animals exposed to elevated or prolonged anthropogenic noise can suffer direct injury and temporary or permanent auditory threshold shifts. Noise can mask important natural sounds, such as the call of a mate, the sound made by prey or a predator. These impacts are experienced by a wide range of species including fish, crustaceans and cephalopods, pinnipeds (seals, sea lions and walrus), sirenians (dugong and manatee), sea turtles, the polar bear, marine otters and cetaceans (whales, dolphins and porpoises).

The Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities has been developed to present the Best Available Techniques (BAT) and Best Environmental Practice (BEP). The document is structured to stand as one complete unit or to be used as discrete modules, tailored for national and agreement approaches.

The modules that follow are structured to cover species area, as follows:

'**Module A: Sound in Water is Complex**' provides an insight into the characteristics of sound propagation and dispersal. This module is designed to provide decisions-makers with necessary foundation knowledge to interpret the other modules in these guidelines and any impact assessments that are presented to them for consideration.

'**Module B: Expert Advice on Specific Species Groups**' presents 12 separate detailed sub-modules covering each of the CMS species groups, focusing on species' vulnerabilities, habitat considerations, impact of exposure levels and assessment criteria.

'**Module C: Decompression Stress**' provides important information on bubble formation in marine mammals, source of decompression stress, source frequency, level and duration, and assessment criteria.

'**Module D: Exposure Levels**' presents a summary of the current state of knowledge about general exposure levels.

'**Module E: Marine Noise-generating Activities**' provides a brief summary of military sonar, seismic surveys, civil high powered sonar, coastal and offshore construction works, offshore platforms, playback and sound exposure experiments, shipping and vessel traffic, pingers and other noise-generating activities. Each section presents current knowledge about sound intensity level, frequency range and the

activities general characteristics. The information is summarized in a table within the module.
'**Module F: Related Intergovernmental or Regional Economic Organisation Decisions**' presents the series of intergovernmental decisions that have determined the direction for regulation of anthropogenic marine noise.
'**Module G: Principles of EIAs**' establishes basic principles including strategic environmental assessments, transparency, natural justice, independent peer review, consultation and burden of proof.

The Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities is structured to stand as one complete unit or to be used as discrete modules, tailored for national and agreement approaches.

The complete document and the discrete modules are online at: cms.int/guidelines/cms-family-guidelines-EIAs-marine-noise

A. Sound in Water is Complex

Geoff Prideaux
Wild Migration

The ocean environment is filled with natural sound from animals and physical processes. Species living in this environment are adapted to these sounds. Over the past century many anthropogenic marine activities have increased levels of noise. (André *et al* 2010, Hildebrand 2009) These modern anthropogenic noises have the potential for physical, physiological and behavioural impacts on marine fauna–mammals, reptiles, fish and invertebrates. (Southall *et al* 2007)

The propagation of sound in water is complex and requires many variables to be carefully considered before it can be known if a noise-generating activity is appropriate or not. It is inappropriate to generalize sound transmission without fully investigating propagation.

Often, statements are made in Environmental Impact Assessments that a noise-generating activity is 'X' distance from 'Y' species or habitat and therefore, will have no impact. In these cases distance is used as a basic proxy for impact but is rarely backed with scientifically modelled information. (Wright *et al* 2013, Prideaux and Prideaux 2015)

The behaviour of sound in the marine environment is different from sound in air. The extent and way that sound travels (propagation) is affected by many factors, including the frequency of the sound, water depth and density differences within the water column that vary with temperature, salinity and pressure. (Clay and Medwin 1997, Etter 2013, Lurton 2010, Wagstaff 1981) Seawater is roughly 800–1,500 times denser than air and sound travels around five times faster in this medium. (Lurton 2010) Consequently, a sound arriving at an animal is subject to propagation conditions that are complex. (Calambokidis *et al* 2002, Hildebrand 2009, Lurton 2010, McCauley *et al* 2000)

To present a defensible Environmental Impact Assessment for any noise-generating activity proposal, proponents need to have expertly modelled the noise of the proposed activity in the region and under the conditions they plan to operate.

Understanding the basic concepts that should be presented is important to assess if the Environmental Impact Assessment is defensible and sufficient.

A.1. Basic concepts

The study of acoustics is a specialized and technical field. Professional acousticians will consider many more complexities beyond the scope of this paper.

The basic concepts that decision-makers may need to understand are outlined in a very simplified form, specifically to be accessible to a lay-audience.

A.1.1. Elasticity

The speed of sound is not a fixed numerical value. Sound wave speed varies widely and depends on the medium, or material, it is transmitted through, such as solids, gas or liquids. Sound waves move through a medium by transferring kinetic energy from one molecule to the next. (Lurton 2010) Each medium has its own elasticity (or resistance to molecular deformity). This elasticity factor affects the sound wave's movement significantly. Solid mediums, such as metal, transmit sound waves extremely fast because the solid molecules are tightly packed together, providing only tiny spaces for vibration. Through this high-elasticity medium, solid molecules act like small springs aiding the wave's movement. The speed of sound through aluminium, for example, is around 6,319ms^{-1}. Gas, such as air, vibrates at a slower speed because of larger spaces between each molecule. This allows greater deformation and results in lower elasticity. Sound waves moving through air at a temperature of 20°C will only travel around 342ms^{-1}. Liquid molecules, such as seawater, bond together in a tighter formation compared with gas molecules. This results in less

deformation, creating a higher elasticity than gas. Sound waves moving through water at 22°C travel at around 1,484ms^{-1}. (Brekhovskikh and Lysanov 2006, Au and Hastings 2009, Ross 2013) Temperature also has an effect on molecules. Molecules move faster under higher temperatures, transmitting sound waves more rapidly across the medium. Conversely, decreasing temperatures cause the molecules to vibrate at a slower pace, hindering the sound wave's movement. (Brekhovskikh and Lysanov 2006, Au and Hastings 2009, Ross 2013) The temperature of seawater at different depths is therefore of importance to modelling.

A.1.2. Spherical Spreading, Cylindrical Spreading and Transmission Loss

The way sound propagates is also important. Spherical spreading is simply sound leaving a point source in an expanding spherical shape. As sound waves reach the sea surface and sea floor, they can no longer maintain their spherical shape and they begin to resemble the shape of an expanding cheese wheel. This is called cylindrical spreading.

The transmission loss, or the decrease in the sound intensity levels, happens uniformly in all directions during spherical transmission. However, when sound is in a state of cylindrical transmission, it cannot propagate uniformly. The sound is effectively contained between the sea surface and the sea floor, while the radius still expands uniformly (the sides of the cheese wheel). The height is now fixed and so the sound intensity level decreases more slowly. (Urick 1983, Au and Hastings 2009, Lurton 2010, Jensen *et al* 2011)

In actuality, the seabed is rarely, if ever, flat and parallel to the sea surface. These natural variations add extra complexities to modelling cylindrical spreading. However, these characteristics must be known to model spreading accurately, as should the water depth and the rise and fall of the seabed surrounding it. (Lurton 2010, Jensen *et al* 2011)

A.1.3. Sound Fixing and Ranging Channels (SOFAR)

As well as spherical and cylindrical spreading, another variable can impact how far sound will be transmitted. This is usually called a Sound Fixing and Ranging Channel (SOFAR) and is a horizontal layer of water in the ocean at which depth, the speed of sound is at its minimum.

The SOFAR channel is created through the interactive effect of temperature and water pressure (and, to a smaller extent, salinity). This occurs because pressure in the ocean increases with depth, but temperature is more variable, generally falling rapidly in the main thermocline from the surface to around a thousand metres deep and then remaining almost unchanged from there to the ocean floor. Near the surface, the rapidly falling temperature causes a decrease in sound speed (or a negative sound speed gradient). With increasing depth, the increasing pressure causes an increase in sound speed (or a positive sound speed gradient). The depth where the sound speed is at a minimum is called the sound channel axis. The speed gradient above and below the sound channel axis acts like a lens, bending sound towards the depth of minimum speed. The portion of sound that remains within the sound channel encounters no acoustic loss from reflection of the sea surface and sea floor. Because of this low transmission loss, very long distances can be obtained from moderate acoustic power. (Urick 1983, Brekhovskikh and Lysanov 2006, Lurton 2010, Jensen *et al* 2011)

A.1.4. Decibels dB

The decibel (dB), 1/10th of a Bel, is used to measure sound level. It is the unit that will be presented in documentation.

The dB is a logarithmic unit used to describe a ratio. The ratio may be power, sound pressure or intensity.

The logarithm of a number is the exponent to which another fixed value, the base, must be raised to produce that number. For example, the logarithm of 1,000 to base 10 is 3, because 1,000 is 10 to the power 3:

$$1{,}000 = 10 \times 10 \times 10 = 10^3.$$

More generally, if $x = b^y$, then y is the logarithm of x to base b, and is written y = logb(x), so log10 (1,000) = 3. (Au and Hastings 2009, Jensen *et al* 2011, Ross, 2013)

A common mistake is to assume that 10dB is half as loud as 20dB and a third of 30dB.

To disprove this false assumption, suppose there are two loudspeakers, the first playing a sound with power P1, and another playing a louder version of the same sound with power P2, but everything else (distance and frequency) remains the same.

The difference in decibels between the two is defined as:

10 log (P2/P1) dB where the log is to base 10.

If the second produces twice as much power as the first, the difference in dB is:

$$10 \log (P2/P1) = 10 \log 2 = 3 \text{ dB}.$$

To continue the example, if the second has 10 times the power of the first, the difference in dB is:

10 log (P2/P1) = 10 log 10 = 10 dB.

If the second has a million times the power of the first, the difference in dB is:

10 log (P2/P1) = 10 log 1,000,000 = 60 dB.

This example shows one feature of decibel scales that is useful in discussing sound: they can describe very big ratios using manageable numbers.

A.1.5. Peak and RMS values

Peak value, as the term implies, is the point of a sound wave with the greatest amplitude. Peak values are associated with plosive sounds like seismic air guns, pile driving, low frequency sonar and explosives. (Au and Hastings 2009)

RMS (root mean squared) is the formula used to calculate the mean of a sound wave over time. RMS values are associated with constant non-plosive sounds like shipping propeller and engine noise, oil rig operations, some mid to high frequency sonar and water based wind turbines. (Au and Hastings 2009)

A.1.6. Phase

Phase can be best described as the relational alignment with two or more sound waves over time. Very simplistically, waves with the same phase will constructively interfere to produce a wave whose amplitude is the sum of the two interfering waves, while two waves which are 180 degrees out of phase will destructively interfere to cancel each other out. (Rossing and Fletcher 2013)

A.2. Understanding Sound Exposure Levels

A.2.1. Sound Exposure Level cumulative (SELcum)

Sound Exposure level (SEL) is generally referred to as dB 0 to peak or peak to peak (dB 0 to peak or dB p to p) for plosive or pulsive noise like air guns, military sonar etc and dB Root Mean Squared (dB rms) for non-plosive or non-pulsive noise such as ship noise, dredging, wind farms, constant drone (Au and Hastings 2009). These measurements are generally of a one second duration only. The question arises, is this a realistic measurement metric for understanding the effects on all marine species?

According to NOAA's paper, Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing, (NOAA, 2016) sound exposure level works well for marine mammals but not well for other marine species (crustaceans, bivalves, cephalopods, finned fish, etc) because non-mammal marine species detect sound through particle motion (the organism resonating in sympathy with the surrounding sound waves) rather than through a tympanic mechanism as with marine mammals. A more informed measurement introduced to modelling is sound exposure level cumulative (SELcum) by which a time component is added into SEL enabling it to encompass all marine species.

While SEL has been acceptable in the past, with the use of SELcum modelling, species experts have documented noticeable impacts on species' welfare that have otherwise gone unnoticed.

NOAA has set a default time of 24 hours for SELcum. An alternate prescribed time can be applied to SELcum if stated. Within the SELcum metric, reference to sound intensity level (0 to peak, peak to peak or rms) is not appropriate due to the extended time parameter. It may be displayed as 190 dB SELcum *re* 1µPa @ 1m pulsive or non-pulsive depending.

A.2.2. Equal Energy Hypothesis

NOAA also mentions the Equal Energy Hypothesis (EEH) which discusses the basic impact trends on marine species. They also comment that the EEH is pretty loose due to the complexity of all the potential factors, but it serves as a reasonable rule of thumb.
It states:

- Growth rate of threshold shift (TS) is higher for frequencies where hearing is more sensitive
- Non-impulsive intermittent exposures require higher SELcum to induce a TS compared to continuous exposures of the same duration
- Exposures for longer durations and lower levels induce TTS at a lower level than those exposed to a higher level and a shorter duration with the same duration SELcum
- With the same SELcum, longer exposures require longer recovery time.
- Intermittent exposures recover faster compared to continuous exposures of the same duration
- Animals may be exposed to multiple sound sources and stressors beyond acoustics during an activity. This also

may have a cumulative effect.

Also, pulsive/plosive SELcum noise will induce TS more quickly than a non-pulsive noise with the same SELcum due to the fast rise time characteristics of pulsive/plosive noise.

A.3. Necessity of Modelling

These complexities illustrate the necessity for expert modelling of sound propagation from noise-generating activities. (Urick 1983, Etter 2013) While noise modelling is common for land-based anthropogenic noise-producing activities, it is less common for proposals in the marine environment. The lack of rigorous noise modelling in the marine setting needs to be urgently addressed. (Prideaux and Prideaux 2015)

Modelling of each noise-generating activity proposal should be expertly and impartially conducted to provide decision-makers with credible and defensible information. The modelling should provide a clear indication of sound dispersal characteristics, informed by local propagation features. (Urick 1983, Etter 2013)

With this information, the acoustic footprint of the noise-generating activity can be identified and informed decisions about levels of noise propagation can be made. (Prideaux and Prideaux 2015)

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B. Expert Advice on Specific Species Groups

The sea is the interconnected system of all the Earth's oceanic waters, including the five named 'oceans' - the Atlantic, Pacific, Indian, Southern and Arctic Oceans - a connected body of salty water that covers over 70 percent of the Earth's surface.

This vast environment is home to a broader spectrum of higher animal taxa than exists on land. Many marine species have yet to be discovered and the number known to science is expanding annually. The sea also provides people with substantial supplies of food, mainly fish, shellfish and seaweed. It is a shared resource for us all.

Levels of anthropogenic marine noise have doubled in some areas of the world, every decade, for the past 60 years. (McDonald, Hildebrand *et al* 2006, Weilgart 2007) When considered in addition to the number other anthropogenic threats in the marine environment, noise can be a life-threatening trend for many marine species.

Marine wildlife rely on sound for its vital life functions, including communication, prey and predator detection, orientation and for sensing surroundings. (Hawkins and Popper 2014, Simmonds, Dolman *et al* 2014) While the ocean is certainly a sound-filled environment and many natural (or biological) sounds are very loud, wildlife is not adapted to anthropogenic noise.

The species groups covered in the following sub-modules are:

- Inshore Odontocetes
- Offshore Odontocetes
- Beaked Whales
- Mysticetes
- Pinnipeds
- Polar Bears
- Sirenians
- Marine and Sea Otters
- Marine Turtles
- Fin-fish
- Elasmobranchs
- Marine Invertebrates

General principles

Building on the information from module section B.1, sound waves move through a medium by transferring kinetic energy from one molecule to the next. Animals that are exposed to elevated or prolonged anthropogenic noise may experience passive resonance (particle motion) resulting in direct injury ranging from bruising to organ rupture and death (barotrauma). This damage can also include permanent or temporary auditory threshold shifts, compromising the animal's communication and ability to detect threats. Finally, noise can mask important natural sounds, such as the call of a mate, the sound made by prey or a predator.

Table 1: Potential results of sound exposure (from Hawkins and Popper 2016)

Impact	Effects on animal
Mortality	Death from damage sustained during sound exposure
Injury to tissues; disruption of physiology	Damage to body tissue, e.g internal haemorrhaging, disruption of gas-filled organs like the swim bladder, consequent damage to surrounding tissues
Damage to the auditory system	Rupture of accessory hearing organs, damage to hair cells, permanent threshold shift, temporary threshold shift
Masking	Masking of biologically important sounds including sounds from conspecifics
Behavioural changes	Interruption of normal activities including feeding, schooling, spawning, migration, and displacement from favoured areas
These effects will vary depending on the sound level and distance	

These mechanisms, as well as factors such as stress, distraction, confusion and panic, can affect reproduction, death and growth rates, in turn affecting the long-term welfare of the population. (Southall, Schusterman *et al*, 2000, Southall, Bowles *et al*, 2007, Clark,

Ellison *et al*, 2009, Popper *et al*, 2014, Hawkins and Popper 2016)

These impacts are experienced by a wide range of species including fish, crustaceans and cephalopods, pinnipeds (seals, sea lions and walrus), sirenians (dugong and manatee), sea turtles, the polar bear, marine otters and cetaceans (whales, dolphins and porpoises)–the most studied group of marine species when considering the impact of marine noise.

The current knowledge base is summarized in the following module.

This important volume of information should guide the assessment of Environmental Impact Assessment proposals.

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B.1. Inshore Odontocetes

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Odontocetes close to shore or in shallow waters

Consider when assessing

- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- Agreement on the Conservation of Cetaceans of the Black Seas Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS)
- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)
- MOU for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (Pacific Islands Cetaceans)
- MOU Concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia (West African Aquatic Mammals)

Related modules

- Refer also to modules B.10, B.12 and C when assessing impact to inshore odontocetes

B.1.1. Species Vulnerabilities

Close-range, acute noise exposure is known to generate spatial displacement, often extended over the duration of the noise exposure (Anderwald *et al* 2013, Pirotta *et al* 2013), temporary hearing impairment (temporary threshold shifts or TTS)(e.g. Kastelein *et al* 2015, Lucke *et al* 2009) reduction in both occurrence and efficiency, or even cessation, of foraging behaviour (e.g. Pirotta *et al* 2014).

Permanent hearing impairment (permanent threshold shifts or PTS) has not been documented empirically (unethical) but is expected to occur and exposure thresholds have been predicted (e.g. Southall *et al* 2007, NOAA 2016).

Long-range (and therefore of wider spatial magnitude), chronic noise exposure is also known to generate spatial displacement, often extended over the duration of the noise exposure (Campana *et al* 2015). Masking of communication and other biologically important acoustic signals also occurs (e.g. Gervaise *et al* 2012).

Spatial displacement can cause the temporary loss of important habitat, such as prime feeding ground, forcing individuals to exploit suboptimal foraging areas. This effect is of significant concern if foraging behaviour is seasonal and/or if foraging habitat is limited or patched. Similarly, displacement can reduce breeding opportunities if it occurs during the mating season. Therefore, foraging habitat and breeding season are particularly sensitive components to noise impact.

B.1.2. Habitat Considerations

Inshore odontocetes often feed on opportunistic, seasonally abundant prey (e.g. Shane *et al* 1986). Habitat is often degraded due to proximity to highly populated coastal areas. Thus, populations have been fragmented or are in the process of being fragmented. For these reasons, suboptimal habitat should be available to perform the biological tasks that will be disturbed by the introduction of noise. Population structure should be known in enough detail to allow evaluation of the population's resilience to the disturbance. Some odontocetes show diel (24 hour cycle) movement patterns from offshore to inshore regions for resting (Thorne *et al* 2012), or prey accessibility (Goodwin 2008). Similarly, seasonal patterns have been described for inshore odontocetes mainly driven by their prey's life cycle (Pirotta *et al* 2014) or seasonality in human disturbance (Castellote *et al* 2015). These movement patterns and co-occurring disturbances should be considered to minimize odontocetes' exposure to noise or reduce cumulative impact. Some species have small home ranges or show high site fidelity with low connectivity. They therefore may be more vulnerable to population level impacts, particularly in areas of repeated anthropogenic activity. Caution should be taken to minimise overlaps with such areas. Appropriate scheduling of noise-generating activities at periods with the lowest presence of odontocetes should be prioritized. Feeding can be concentrated in habitat specific features such as river mouths (Goetz *et al* 2007) or canyons (Moors-Murphy 2014). These spatial

particularities of habitat should also be considered and their disturbance minimized.

B.1.3. Impact of Exposure Levels

The harbour porpoise has been described as the inshore odontocete most sensitive to noise exposure among the species of which we have data (Lucke *et al* 2009, Dekeling *et al* 2014, but see Popov *et al* 2011).

Based on the NOAA acoustic guidelines (NOAA 2016), which imply the most up-to-date scientific information on the effects of noise on marine mammals, onset of physiological effects, that is TTS and PTS, for impulsive and non-impulsive noise sources is based on a dual metric (dB peak for instantaneous sound pressure and SEL accumulated over 24 h for both impulsive and non-impulsive, whichever is reached first) and is summarized in the table (over) for high frequency hearing specialists, which includes the harbour porpoise.

These thresholds are based on weighted measurements, which take into consideration hearing sensitivity across frequencies for each hearing functional group. For more details please see NOAA (2016).

A more restrictive decision from the German Federal Maritime and Hydrographic Agency on the onset for physiological effects on harbour porpoises must also be considered in this context. This Agency has implemented a different threshold since 2003, specifically for pile driving operations. Criteria consist of a dual metric, SEL = 160dB re 1 mPa^2/s and SPL(peak-peak) = 190 dB re 1µPa. Both measures should not be exceeded at a distance of 750 m from the piling site.

Table 2: TTS and PTS from impulsive and non-impulsive noise sources for inshore odontocetes (from NOAA 2015)

Metric	TTS onset		PTS onset	
	Impulsive	Non-impulsive	Impulsive	Non-impulsive
SEL cum 24h	140 dB	153 dB	155 dB	173 dB
dB peak	196 dB	n/a	202 dB	202 dB

Regarding onset of behavioural disruption, NOAA has not yet updated its guidelines, and a threshold of 120 dB RMS for non-impulsive and 160 dB RMS for impulsive noise remain as the onset thresholds for all cetacean species. New information obtained through controlled noise exposure studies on offshore cetacean species (e.g. SOCAL-BRS, 3S), suggests that onset of behavioural disruption is context dependent, and not only received levels but also distance to the source might play an important role in triggering a reaction. Few studies have been focused on behavioural reaction to noise on inshore odontocetes. These show how the onset of a response is triggered by the perceived loudness of the sound, not just received levels (Dyndo *et al* 2015). At least for harbour porpoises, this finding lends weight to the recent proposal by Tougaard *et al* (2015) that behavioural responses can be predicted from a certain level above their threshold at any given frequency (e.g. in the range of 40–50 dB above the hearing threshold for harbour porpoise).

For loud noise sources such as large diameter pile driving or seismic surveys commonly found in inshore odontocete habitat, the onset for behavioural response can occur at very substantial distances (e.g. Tougaard *et al* 2009, Thompson *et al* 2013).

B.1.4. Assessment Criteria

Several key characteristics on the biology of a species should be adequately assessed in an EIA. Population stock structure is a critical element to allow evaluating potential negative effects outside the scope of the individual level. This information is often unavailable for inshore odontocetes, and regulators or decision makers should adopt a much stricter position regarding this criterion for impact assessment decisions. Correct impact evaluation cannot be accomplished without understanding the extent of a potentially impacted population. Because spatial displacement is by far the most prominent effect to occur in noisy activities occurring in inshore odontocete habitat, sufficient information on habitat use and the availability of unaffected suboptimal habitat should be addressed in the evaluation. Other more general points should not be forgotten when determining if this species group has been adequately considered by an EIA, such as the correct relationship between the spectral content of the noise source and hearing information for the affected species, and the integration of both behavioural and physiological effects for the estimated proportion of the population to be affected by the activity.

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B.2. Offshore Odontocetes

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Odontocetes in deeper waters

Consider when assessing

- Military sonar
- Seismic surveys
- Civil high power sonar
- Offshore platforms
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons

Related CMS agreements

- Agreement on the Conservation of Cetaceans of the Black Seas Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS)
- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)
- MOU for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (Pacific Islands Cetaceans)
- MOU Concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia (West African Aquatic Mammals)

Related modules

- Beaked whales are considered separately in module B.3.
- Refer also to modules B.10, B.12 and C when assessing impact to offshore odontocetes

B.2.1. Species Vulnerabilities

While spatial displacement has been well documented in several inshore odontocetes species, little data is available for offshore odontocetes (other than beaked whale species), but similar behavioural responses are expected. Few direct measures of displacement are available (e.g. Goold 1996, Bowles *et al* 1994), and some indirect measures of disturbance exist, such as changes in vocal behaviour in short beaked common dolphins, Atlantic spotted dolphins and striped dolphins in the presence of anthropogenic noise (Papale *et al* 2015). Sperm whales exposed to tactical active sonar reduced energy intake or showed significant displacement with no immediate compensation (Isojunno *et al* 2016, Miller *et al* 2012). However, sperm whales chronically exposed to seismic airgun survey noise in the Gulf of Mexico did not appear to avoid a seismic airgun survey, though they significantly reduced their swimming effort during noise exposure along with a tendency toward reduced foraging (Miller *et al* 2009). Changes in vocal behaviour are normally associated with displacement in other odontocetes (e.g. Holt *et al* 2009, Lesage 1999).

Physiological impact by close-range, acute noise exposure, such as temporary threshold shift, has never been described in offshore odontocetes due to the difficulty to maintain these species in captivity. There is just one anecdotic description of physiological injury due to airgun noise exposure on a pantropical spotted dolphin (Graya and Van Waerebeek, 2011).

This lack of evidence should not be considered conclusive but rather as reflecting the absence of studies. Furthermore, due to similarities in sound functionality, hearing anatomy and physiology between offshore and inshore odontocetes, the vulnerabilities described for inshore species are expected to be very similar for offshore species.

Because of the lack of knowledge on offshore odontocete habitat seasonal preferences (e.g. it is not known whether reproduction occurs in similar habitats as where foraging occurs), noise impact on these species cannot be broken into lifecycle components.

B.2.2. Habitat Considerations

Little survey effort has been dedicated to offshore waters in most exclusive economic offshore zones and even less in international waters. As a consequence, data on offshore odontocete occurrence, distribution and habitat preferences is scarce for most species. However, some generalizations can be highlighted: Sperm whales do not use offshore regions uniformly, topography plays a key role in shaping their distribution (e.g Pirotta *et al* 2011). Moreover, solitary individuals use the habitat differently from groups (Whitehead 2003).

The occurrence of eddies, often associated with numerous seafloor topographic structures (canyons and seamounts), are known to favour ecosystem richness and consequently, cetacean occurrence (Ballance *et al* 2006, Hoyt 2011, Redfern *et al* 2006, Correia *et al* 2015). Therefore, areas were eddies are known to occur, particularly those related to underwater topography features,

should be taken into special consideration when assessing impact to offshore odontocetes, even if no knowledge on cetacean occurrence is available.

B.2.3. Impact of Exposure Levels

Offshore odontocetes fall in their majority into the mid frequency hearing specialists. This group was considered for noise impact assessments during an international panel review (Southall *et al* 2007). This review has been updated in recent efforts by the U.S. Navy and NOAA. NOAA's most updated draft on acoustic guidelines (NOAA 2016) considers TTS and PTS, for impulsive and non-impulsive noise sources is based on a dual metric (dB peak for instantaneous sound pressure and SEL accumulated over 24 h for both impulsive and non-impulsive, whichever is reached first) and is summarized in the table below for mid frequency hearing specialists (Table 3).

Table 3: TTS and PTS from impulsive and non-impulsive noise sources for offshore odontocetes, excluding beaked whales (from NOAA 2015)

Metric	TTS onset		PTS onset	
	Impulsive	Non-impulsive	Impulsive	Non-impulsive
SEL cum 24h	170 dB	178 dB	185 dB	198 dB
dB peak	224 dB	n/a	230 dB	230 dB

Please note these thresholds are based on weighted measurements, which take into consideration hearing sensitivity across frequencies for each hearing functional group. For more details please see NOAA (2016).

Regarding onset of behavioural disruption, NOAA has not yet updated its guidelines, and a threshold of 120 dB RMS for non-impulsive and 160 dB RMS for impulsive noise remains as the onset thresholds for all cetacean species. Recent results from one of the few behavioural response studies where offshore odontocetes, other than beaked whales, are targeted identified higher thresholds than expected for avoidance of military tactic sonar by free-ranging long-finned pilot whales (Antunes *et al* 2015). The US Navy currently uses a generic dose–response relationship to predict the responses of cetaceans to naval active sonar (US Navy 2008), which has been found to underestimate behavioural impacts on killer whales and beaked whales in multiple studies (Tyack *et al* 2011, DeRuiter *et al* 2013, Miller *et al* 2012 and 2014, Kuningas *et al* 2013). The navy curve appears to match more closely results with long-finned pilot whales, though the authors of this study suggest that the probability of avoidance for pilot whales at long distances from sonar sources could well be underestimated. These results highlight how functional hearing grouping, particularly for offshore odontocete species, might not be the most conservative approach for noise mitigation purposes. Behavioural responses of cetaceans to sound stimuli often are strongly affected by the context of the exposure, which implies that species and the received sound level alone is not enough to predict type and strength of a response. Although limited in sample size, this new information has not yet been profiled in EIA procedures. Contextual variables are important and should be included in the assessment of the effects of noise on cetaceans (see Ellison *et al* 2012 for a context-based proposed approach).

B.2.4. Assessment Criteria

Because our limited knowledge on offshore odontocete ecology and their seasonal habitat preferences, common sense mitigation procedures such as avoiding the season of higher odontocete occurrence might be difficult to implement. However, habitat predictive modelling is often applicable with limited data (Redfern *et al* 2006), and should be encouraged in situations where impact assessments suffer from odontocete data deficit.

It should also be noted that in some particular cases, spatial displacement has generated drastic indirect effects at the population level. Good examples are the several episodes of large numbers of narwhals entrapped in ice in Canada and West Greenland attributed to displacement caused by seismic surveys (Heide –Jørgensen *et al* 2013). Displacement in offshore areas could drive odontocetes towards fishing grounds, increasing the risk of entanglement. In cases where planned offshore disturbance is proposed near potential risk areas for odontocetes, this indirect impact mechanism must be evaluated. In the case of sperm whales, regulations tend to be made assuming that animals avoid areas with high sound levels. Thus some policies assume benefits of avoidance in terms of reduced sound exposure, even in the absence of evidence that it occurs for some noise sources (Madsen *et al* 2006). Avoidance can also have adverse effects, with the biological significance depending upon whether important activities are affected by

animal movement away from an aversive sound.

Other more general points should not be forgotten when determining if this species group has been adequately considered by an EIA, such as the correct relationship between the spectral content of the noise source and hearing information for the affected species, and the integration of both behavioural and physiological effects for the estimated proportion of the population to be affected by the activity.

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B.3. Beaked Whales

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Consider when assessing

- Military sonar
- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- Agreement on the Conservation of Cetaceans of the Black Seas Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS)
- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)
- MOU for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (Pacific Islands Cetaceans)

Related modules

- Refer also to modules B.10, B.12 and C when assessing impact to beaked whales

B.3.1. Species Vulnerabilities

Beaked whales (Ziphiids) became widely known to the public due to mass mortalities of whales stranded with gas/fat emboli when exposed to submarine-detection naval sonar or underwater explosions (Jepson *et al*, 2003, Fernández *et al*, 2005). Most researchers agree that a 'fight or flight' stress response is responsible for the deaths of whales following noise disturbances (Cox *et al*, 2006). Interruption of foraging and avoidance at high speed have been found in different species of beaked whales subject to playbacks of naval sonar at 1/3rd octave RMS received levels as low as 89–127 dB re 1 μPa (Tyack *et al*, 2011, DeRuiter *et al*, 2013, Miller *et al*, 2015). Beaked whales may also be sensitive to other sources of anthropogenic noise, as suggested by the effectiveness of acoustic pingers in reducing the bycatch of beaked whales in deep-water fisheries, much higher than for other species (Carretta *et al* 2011), and by their apparent response to low levels of ship noise (Aguilar de Soto *et al* 2006). There has been a number of mass-strandings of beaked whales coincident in time and space with seismic activities (Malakof 2001, Castellote and Llorens 2016), but the lack of adequate post-mortem examinations has prevented assessing possible cause-effects relationships in these cases. This means that any intense underwater anthropogenic noise can be considered as of concern for beaked whales: blasting, intense naval and scientific sonar, seismics, pingers, etc.

It is still unknown why beaked whales are more sensitive to noise than many other marine mammal species. The reasons may lie in their specialized way of life. Ziphiids stretch their physiological capabilities to perform dives comparable to sperm whales, but with a much smaller body size (Tyack *et al* 2006). Their poor social defences from predators such as highly vocal killer whales may explain why beaked whales limit their vocal output (Aguilar de Soto *et al* 2012) and respond behaviourally to sound at relatively low received levels. The combination of a low threshold of response and a potentially delicate physiological balance may explain why behavioural responses can cause mortalities (Cox *et al* 2006).

Population data for beaked whales are scarce offshore, but long-term monitoring shows that local populations in nearshore deep-waters are small (<100-150 individuals), have high site-fidelity and apparently low connectivity and calving rate (Claridge, 2013, Reyes *et al* 2015). These characteristics generally reduce animal resilience to population-level impacts. Differences in population structure, with a reduced number of young, have been found between beaked whales inhabiting a naval training range and a semi-pristine neighbouring area in the Bahamas (Claridge, 2013). In summary, while discrete noise activities are of concern due to potential acute exposures/responses, there is a risk for population-level effects of noise on beaked whales inhabiting areas where impacts are repetitive.

B.3.2. Habitat Considerations

Some of the 22 species of the Ziphiidae family can be found in the deep waters of all oceans. However, beaked whales have a low probability of visual and acoustic detection (Barlow *et al* 2006, Barlow *et al* 2013) and knowledge about their distribution and abundance is poor, preventing identification of hot-spots offshore. Until more data exist, the assumption is that any area with deep waters is potential beaked whale habitat year-round.

Most mass-strandings related to naval sonar or underwater explosives have been recorded when the activities occurred in nearshore areas of steep bathymetry, suggesting that whales might die due to the stranding process. However, there is at least one mass-stranding case indicating that animals can die offshore before stranding: the naval exercise "Majestic Eagle". This exercise occurred > 100 km offshore from the Canary Islands and dead whales were carried to the shore by the current and winds. The whales showed the same pathological findings identified previously as symptomatic of whales stranded alive in coincidence to naval exposure (Fernández *et al* 2012).

Thus, the vulnerability of beaked whales and their wide distribution make EIA relevant whenever human activities emitting intense sound occur near the slope or in abyssal waters offshore.

B.3.3. Impact of Exposure Levels

Beaked whales show strong avoidance reactions to a variety of anthropogenic sounds with the most sensitive fraction of the population responding at received levels of naval sonar below 100 dB re 1 µPa, and most of the animals tested responding at received levels of 140 dB re 1 µPa. This corresponds to ranges of several km from the ship operating the sonar (Miller *et al* 2015, Tyack *et al*, 2011).

There are no data for thresholds of response for other noise sources. The range at which beaked whales may be expected to be at risk of disturbance from a given anthropogenic noise can be estimated from the characteristics of the sound source, acoustic propagation modelling and the dose: response data provided by behavioural response studies. For example, Tolstoy *et al* (2009) present broadband calibrated acoustic data on a seismic survey performed in shallow waters and received at deep (1600 m) and shallow water (50 m) sites. The line fit to have 95% of the received levels falling below a given received level (RL) was RL = 175.64 – 29.21 $\log_{10}$(range in km) for the deep water site and RL = 183.62 – 19 $\log_{10}$(range in km) at the shallow site. Solving the equation for shallow water and a RL of 140 dB at which beaked whales may be expected to be disturbed, the potential disturbance range would be range = $10^{43.62/19}$ = 197 km. The range predicted to disturb more sensitive individuals within the population would be greater.

The spectrum of the air gun sounds reported by Tolstoy *et al* (2009) is highest below 80 Hz, well below the naval sonars whose effects have been studied for dose-response curves, and in a frequency range where beaked whales are expected to have less sensitive hearing. It is difficult to weight the level of air guns by the hearing of beaked whale given the data available, but it is possible to make a rough estimate of the energy from air guns in the third octave band (which roughly match the frequency bands over which the mammalian ear integrates energy) of the naval sonars whose effects have been measured. The broadband SEL measured at 1 km for shallow water was 175 dB re 1 $\mu Pa^2 s$. Third octave levels were also reported for a shot recorded in shallow water at 1 km range. The third octave level for this shot at the 3 kHz sonar frequency was about 130 dB re1 $\mu Pa^2 s$, suggesting that this frequency band was about 45 dB lower than the broadband source level (SL). This suggests using a sound pressure level of 183.62 - 45 dB to estimate received level in this frequency band at 1 km range. In addition, seawater absorbs sound at about 0.18 dB/km at the 3 kHz sonar frequencies, and this absorption must be accounted for in the transmission loss. Therefore Transmission Loss (TL)= 19 $\log_{10}$(range) + 0.18*range. The range at which sensitive beaked whales, which respond at 100 dB re 1 µPa may respond, given that TL = SL – RL, i.e. 19 $\log_{10}$(range) + 0.18*range = 183.62-45-100 = 38.62, is estimated at 43 km.

These rough calculations show that beaked whales could be expected to be disturbed by exposure to airguns at ranges of 43-197+ km, assuming conditions as found by Tolstoy *et al* (2009). The actual values will depend upon the actual signature of the air gun array to be used, and the propagation conditions in the area. This guidance coupled with current data on beaked whale responses to anthropogenic noise suggests that each proposer should assess how sound is expected to propagate from the survey site to any beaked whale habitat with hundreds of km. If any of this habitat is expected to be exposed to levels of sound above those shown to disturb beaked whales (i.e. 100 dB re 1 µPa for the most sensitive individuals tested), then a further assessment should be made of the number of animals likely to be disturbed.

B.3.4. Assessment Criteria

EIA should consider different types of impacts, ranging from exposure of whales to intense received levels causing hearing damage to behavioural reactions with potential physiological consequences in some cases, to displacement and ecological effects (e.g. reduction in feeding rates or displacement

from preferred habitat due to avoidance behaviour resulting in lower fitness).

A framework for mitigation targeted to reduce risk of the different impacts above needs to be included in the EIA, including actions during the planning-phase, real-time mitigation protocols and post-activity reporting to inform future planning and mitigation (e.g. Aguilar de Soto *et al* 2015). An effective mitigation method is spatio-temporal avoidance of high density areas (Dolman *et al* 2011). This is informed by surveys and habitat modelling and can be aided by simulation engines. However, the scarcity of data supporting density maps for beaked whales increases uncertainty about the number of whales to be expected in a given area and the identification of high density areas. Thus, planning-phase mitigation is essential but it does not eliminate the possibility of encountering and affecting/harming beaked whales. Another aspect of planning-phase mitigation is the choice of acoustic devices to be used during the activity, as well as the source levels required to achieve the objectives of the activity. *In situ* measurements of sound transmission loss shortly before the activity may allow adjustment of source level to below the maximum, so that the maximum is not used by default. A protocol towards reducing total acoustic energy and peak source levels transmitted to the environment should be defined before the activity, for any activity, within workable limits.

Depending on the activity, EIA may require updated information of the density of beaked whales and other vulnerable species, before the activity, in order to allow current data to be compared with existing density maps and to improve their accuracy. Also, if a choice of locations is evaluated, it would be possible to decide locating the activity in the place with lower concentration of vulnerable species.

A powerful and cost-effective way to monitor the effects would be to moor passive acoustic recorders in the beaked whale habitats exposed to sound levels above 100 dB re 1 μPa and to monitor both the actual levels of anthropogenic sound and also to monitor for the rates at which beaked whale echolocation clicks are detected. In the case of seismic, modern seismic surveys often include the deployment of cabled geophones at the seabed. These could be easily equipped with high frequency hydrophones to record beaked whales and other marine fauna.

Given the low probability of visual detection of beaked whales even in good sea conditions, real-time mitigation methods proposed in the EIA require increasing probability of detection by using passive acoustic monitoring systems with detectors programmed for automated classification of beaked whale vocalizations. Automatic detections can then be checked by trained personnel to take decisions about initiation of mitigation protocols.

B.3.5. Species not listed on the CMS Appendices that should also be considered during assessments

All beaked whales not currently listed by CMS seem to be particularly vulnerable to anthropogenic marine noise.

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B.4. Mysticetes

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Consider when assessing

- Military sonar
- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Playback and Sound Exposure Experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- Agreement on the Conservation of Cetaceans of the Black Seas Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS)
- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)
- MOU for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (Pacific Islands Cetaceans)

Related modules

- Refer also to modules B.12 and C when assessing impact to mysticetes

B.4.1. Species Vulnerabilities

Mysticete whales are all known to rely upon acoustic communication to mediate critical life history activities, including social interactions associated with breeding, raising young, migration and foraging (Edds-Walton 1997, Clark 1990). Research into the hearing capabilities of mysticetes, based primarily on anatomical modelling indicate that mysticetes, as a group, are possibly capable of hearing signals from a minimum of approximately 7 Hz ~ 22 kHz (Southall *et al* 2007). This range of frequencies spans many sources of anthropogenic noise in the ocean, excluding only the highest frequency sonar systems and pinger systems > 25 kHz (Hildebrand *et al* 2009). Previous research has documented impacts of noise exposure to physiology, behaviour, and habitat usage in mysticetes (Richardson *et al* 1995, Nowacek *et al* 2007, Tyack 2008).

Physiological impacts have been documented in mysticetes in response to noise exposure. This includes strong evidence of a decrease in physiological stress levels in North Atlantic right whale associated with a reduction in shipping noise (Rolland *et al* 2012). Techniques are currently under development to allow testing of acute stress responses to short-term high amplitude noise exposure (Hunt *et al* 2013).

Behavioral impacts have been documented in mysticetes in response to a variety of noise sources over the past three decades. This includes evidence of military sonar affecting movement, foraging and acoustic behaviour (Miller et a. 2000, Tyack 2009, Goldbogen *et al* 2013), Seismic survey and air guns affecting movement and acoustic behaviour (Malme *et al* 1988, Di Iorio and Clark 2010, Castellote *et al* 2012), Vessel noise affecting foraging, social and acoustic behaviour (Melcon *et al* 2012), and response to playback of predator and/or alarm stimuli (Cummings and Thompson 1971, Dunlop *et al* 2013, Nowacek *et al* 2004)

Habitat impacts have been documented in a number of cases. Previous studies have documented abandonment of habitat areas during periods of intense noise. One of the earliest documented cases occurred when commercial dredging and shipping activities resulted in abandonment of a critical calving ground in gray whales for the duration of human activities in an enclosed shallow water bay (Bryant *et al* 1984). Seismic surveys have resulted in large-scale, temporary, displacements of mysticete whales away from regions of seismic exploration in the Mediterranean (Castellote *et al* 2012). A further concern, of long-standing (Payne and Webb 1971), is the potential for even relatively low amplitude anthropogenic noise raising the background noise to a degree that it significantly reduces the range of communication for mysticetes. Recent studies have demonstrated the potential degree of masking experienced by mysticetes in urbanized habitat areas due to vessel traffic (Clark *et al* 2009, Hatch *et al* 2012). This is a major concern to result in chronic erosion of suitable habitat conditions through raising the baseline background noise levels.

B.4.2. Habitat Considerations

Based on previous studies, mysticetes show variable response to noise exposures in different habitat areas, possibly linked to differences in the behavioural states and/or the availability of suitable alternative habitats (Nowacek *et al* 2007). Most mysticete whales

show some level of seasonal migratory behaviours (Corkeron and Connor 1999), therefore many habitats may seasonably pose relatively higher or lower risk depending on presence or absence of particular species. Calving grounds, breeding grounds, and foraging grounds are seasonally vulnerable areas for which there may not be suitable alternate habitat for many species, and would be of particular concern to highly endangered populations with limited available critical habitat areas.

Studies of responsiveness to noise exposure have been conducted on calving and breeding grounds (Miller *et al* 2000), on migratory corridors (e.g. Malme *et al* 1988, Tyack 2009, Dunlop *et al* 2013), and on foraging grounds for a variety of species (Di Iorio and Clark 2010, Parks *et al* 2011, Goldbogen *et al* 2013). Studies of migrating whales indicate that individuals may be highly responsive to noise exposure during migration, but may be able to deviate around acoustic disturbance without significant changes to the migratory distance (Malme *et al* 1988, Tyack 2009, Dunlop *et al* 2013).

The greatest data gaps regarding relative risk by habitat and season come from the facts that a) many species only have been tested in one type of habitat area and b) detection of an overt behavioural response may not truly indicate disturbance if animals are unable or unwilling to leave the habitat for foraging or breeding purposes. Also, for several species there is little known on the location of biologically important habitats (breeding, calving and fishing grounds).Future research to assess physiological responses to the same acoustic disturbance in multiple habitat areas are needed to have a high level of confidence regarding the actual impacts of noise exposure to mysticetes.

B.4.3. Impact of Exposure Levels

Relatively little data are available regarding the hearing abilities of mysticetes. Much of the current level of understanding comes from either anatomical modelling studies (Ketten 2000) or indirectly through interpretation of behavioural responses of mysticetes to controlled exposure experiments (Mooney *et al* 2012). A thorough review of exposure criteria for behavioural responses for mysticetes is summarized in Southall *et al* (2007). The thresholds for detectable behavioural responses to noise exposure varied by species, location and time of year, giving a wide range of thresholds for responses to multiple pulses and non-pulse signals.

Table 4: TTS and PTS from impulsive and non-impulsive noise sources for mysticetes (NOAA 2016)

Metric	TTS onset		PTS onset	
	Impulsive	Non-impulsive	Impulsive	Non-impulsive
SEL cum 24h	n/a	179 dB	183 dB	199 dB
dB peak	224 dB	n/a	219 dB	n/a

B.4.4. Assessment Criteria

Based on an extensive body of literature on the effects of noise on mysticetes (including physiology, behaviour and temporary habitat abandonment), a number of detailed criteria should be considered to assess potential risk of an signal generating activity. These include:

- Amplitudes, signal structure (pulse, multi-pulse, non-pulse), and anticipated cumulative time of exposure.
- Vulnerability of the species or sustainable 'take' – Some mysticete species and stocks are highly endangered, and warrant additional consideration if proposed activities have any potential to cause impacts at any level.
- Seasonal variability in the potential risk due to migratory timing of occupancy (can activities be seasonally shifted to minimize overlap with mysticete presence in critical habitat areas?).
- Data on noise exposure studies of target species, or closely related species, with similar signal type
- Comparison of the proposed acoustic exposure relative to the ambient, background levels and spectra of environmental noise (i.e. relatively low level noise exposure may be more significant in acoustically 'pristine' habitats).
- Consideration of potential cumulative effects of an additional introduction of sound into the environment (i.e. increase in potential for masking, increase in duration of exposure on daily and/or seasonal scales).

B.4.5. Species not listed on the CMS Appendices that should also be considered during assessments

Several of the CMS Appendix I and II species have not previously been studied regarding responses to noise exposure.

In particular, relatively little is known regarding the acoustic behaviours of sei whale, *Balaenoptera borealis*, Antarctic minke whale, *Balaenoptera bonaerensis*, Bryde's whale, *Balaenoptera edeni* and Omura's whale, *Balaenoptera omurai.*

In addition to the species listed in CMS Appendix I and II gray whale, *Eschrichtius robustus*, should be considered, due to recent documentation of individuals in 'novel' habitats including multiple confirmed sightings in the Atlantic Ocean (McKeon *et al* 2016) and severely threatened stocks in the Eastern Pacific (Rugh 2005).

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B.5. Pinnipeds

Facilitated by
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Consider when assessing

- Military sonar
- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- Agreement on the Conservation of Seals in the Wadden Sea (Wadden Sea seals)
- MOU Concerning Conservation Measures for the Eastern Atlantic Populations of the Mediterranean Monk Seal (*Monachus monachus*) (Atlantic monk seals)

Related modules

- Refer also to modules B.10, B.12 and C when assessing impact to pinnipeds

B.5.1. Species Vulnerabilities

Pinnipeds are sensitive to sound in both air and under water, therefore, they are likely to be susceptible to the harmful effects of loud noise in both media. Recent research has revealed that many pinnipeds have a better hearing sensitivity in water than was previously believed. (Southall *et al*, 2000, 2008, Reichmuth *et al*, 2013)

In developing guidelines for underwater acoustic threshold levels for the onset of permanent and temporary threshold shifts in marine mammals, NOAA has been considering two pinniped families: Phocidae and Otariidae. Phocid species have consistently been found to have a more acute underwater acoustic sensitivity than otariids, especially in the higher frequency range. This reflects the fact that phocid ears are better adapted underwater for hearing than those of otariids, with larger, more dense middle ear ossicles. (NOAA, 2016) The effective auditory bandwidth in water of typical Phocid pinnipeds (underwater) is thought to be 50 Hz to 86 kHz while for Otariid pinnipeds (underwater) it is 60 Hz to 39 kHz (NOAA, 2016). The draft NOAA guidelines do not pertain to marine mammal species under the U.S. Fish and Wildlife Service's jurisdiction, including the third family of pinnipeds: Odobenidae (walrus), which means there is no update on the auditory bandwidth of walrus.

Behavioural responses to anthropogenic noise have been documented in a number of different pinnipeds at considerable ranges indicating the need for precautionary mitigation (Kelly *et al*, 1988) In addition to noise-induced threshold shifts, behavioural responses have included seals hauling out (possibly to avoid the noise) (Bohne *et al*, 1985, 1986, Kastak *et al* 1999) and cessation of feeding (Harris *et al*, 2001).

It is likely that pinniped foraging strategies also place them at risk from anthropogenic noise. Some pinnipeds forage at night, others transit to foraging locations by swimming along the bottom, and many dive to significant depths or forage over significant distances (Fowler *et al*, 2007, Villegas-Amtmann *et al*, 2013, Cronin *et al*, 2013) with Australian sea lions foraging offshore out to 189 km (Lowther *et al*, 2011).

In most respects, noise-induced threshold shifts in pinnipeds follow trends similar to those observed in odontocete cetaceans. Unique to pinnipeds are their vibrissae (whiskers), which are well supplied with nerves, blood vessels and muscles, functioning as a highly sensitive hydrodynamic receptor system (Miersch *et al*, 2011). Vibrissae have been shown to be sufficiently sensitive to low frequency waterborne vibrations to be able to detect even the subtle movements of fish and other aquatic organisms (Renouf, 1979, Hanke *et al*, 2012, Shatz and Groot, 2013). Ongoing masking through ensonification may impede the sensitivity of vibrissae and the animal's ability to forage.

It is possible that even if no behavioural reaction to anthropogenic noise is evident, masking of intraspecific signals may occur. (Kastak and Schusterman, 1998)

B.5.2. Habitat Considerations

Spatial displacement of pinnipeds by noise has been observed (e.g Harris *et al*, 2001), however observations are too sparse and definitely require greater attention to be understood in ways that can inform management. Such displacement is likely to have serious consequences if affecting endangered species in their critical habitats, such as Mediterranean monk seals in Greece or Turkey. Displacement can cause the temporary loss of important habitat, such as feeding grounds, forcing individuals to either move to

sub-optimal feeding location, or to abandon feeding altogether. Noise can also reduce the abundance of prey (refer to modules on fin-fish and cephalopods in these guidelines).

Displacement can also reduce breeding opportunities, especially during mating seasons. Foraging habitat and breeding seasons are therefore important lifecycle components of pinniped vulnerabilities. In particular, the periods of suckling and weaning are vulnerable times for both mothers and pups.

Many pinnipeds species exhibit high site fidelity. For some there is little or no interchange of females between breeding colonies, even between those separated by short distances, such as in Australian sea lions, *Neophoca cinerea* (Campbell *et al*, 2008). Site fidelity has implications to the risk of local extinction, especially at sites with low population numbers (e.g monk seals).

Some species of pinnipeds can range far offshore and because they are difficult to sight and identify at sea their offshore foraging may only be revealed by telemetry studies. These studies usually involve tagging individuals that might come ashore hundreds or even thousands of miles from offshore foraging habitats.

B.5.3. Impact of Exposure Levels

Onset of temporary threshold shift (TTS) and permanent threshold shift (PTS) for impulsive and non-impulsive noise, and at peak levels (for instantaneous impact) as well as sound exposure levels (SEL) accumulated over a 24 hour period based on the latest updates of the NOAA acoustic guidelines (NOAA, 2016), are summarized in the tables that follow (right).

Walrus, *Odobenus rosmarus*, hearing is relatively sensitive to low frequency sound, thus the species is likely to be susceptible to anthropogenic noise. (Kastelein *et al*, 2002) TTS and PTS levels can be inferred from Southall *et al*, (2007) for Odobenidae.

Kastelein *et al*, 2002 has drawn useful general observations by comparing hearing studies of the California sea lion, *Zalophus californianus*, harbour seal, *Phoca vitulina*, ringed seal, *Pusa hispida*, harp seal, *Pagophilus groenlandicus*, northern fur seal, *Callorhinus ursinus*, gray seal, *Halichoerus grypus*, Hawaiian monk seal, *Monachus schauinslandi* and northern elephant seal, *Mirounga angustirostris* to those of walrus. The high frequency cut-off of walrus hearing is much lower than other pinnipeds tested so far. The hearing sensitivity of the walrus *Odobenus rosmarus*, between 500 Hz and 12 kHz is similar to that of some phocids. The walrus, is much more sensitive to frequencies below 1 kHz than sea lion species tested. (Kastelein *et al*, 2002) Other sensitive pinnipeds such as harbour seals (about 20 dB more sensitive to signals at 100 Hz than California sea lions) and elephant seal, *Mirounga angustirostris* and *Mirounga leonine*, are also more likely to hear low-frequency anthropogenic noise. (Kastak and Schusterman, 1998)

Assessment should consider that routine deep-divers, that dive to or below the deep sound channels, may be exposed to higher sound levels than would be predicted based on simple propagation models. Assessment should also consider convergence zones which may result in areas with higher sound levels at greater ranges.

Table 5: TTS and PTS from impulsive and non-impulsive noise sources for phocidae (from NOAA 2016)

Metric	TTS onset		PTS onset	
	Impulsive	Non-impulsive	Impulsive	Non-impulsive
SEL cum 24h	170dB	181dB	185dB	201dB
dB peak	212dB	n/a	218dB	218dB

Table 6: TTS and PTS from impulsive and non-impulsive noise sources for otariidae (from NOAA 2016)

Metric	TTS onset		PTS onset	
	Impulsive	Non-impulsive	Impulsive	Non-impulsive
SEL cum 24h	188dB	199dB	203dB	219dB
dB peak	226dB	n/a	232dB	232dB

Table 7: TTS and PTS from impulsive and non-impulsive noise sources for odobenidae (from Southall *et al* 2007)

Metric	TTS onset		PTS onset	
	Impulsive	Non-impulsive	Impulsive	Non-impulsive
SEL cum 24h	171dB	171dB	186dB	203dB
dB peak	212dB	212dB	218dB	218dB

B.5.4. Assessment Criteria

There have been surprisingly few studies of the effects of anthropogenic noise, particularly from seismic surveys, on pinnipeds (Gordon *et al*, 2003).

The lack of evidence of dramatic effects of anthropogenic noise on pinnipeds, in contrast to the well-known mortality incidents with some cetaceans, does not necessarily mean that noise has negligible consequences on pinniped conservation, and more attention should be dedicated to achieving a better understanding of possible impacts. For instance, some pinnipeds may not appear to have been physically displaced by loud noise, moving instead to the sea surface, but these animals may be effectively prevented from foraging, due to an ensonified foraging environment.

It is important that assessment of impact for pinnipeds considers both the physiological impact (TTS and PTS) as well as the very real possibility of masking, causing both behavioural responses and making prey less available.

B.5.5. Species not listed on the CMS Appendices that should also be considered during assessments

The following species are also sensitive to anthropogenic marine noise:

- walrus, *Odobenus rosmarus*
- harbour seal, *Phoca vitulina*
- northern elephant seal, *Mirounga angustirostris*
- southern elephant seal, *Mirounga leonine*
- Caspian seal, *Phoca caspica*
- Australian sea lion, *Neophoca cinerea*
- Hawaiian monk seal, *Neomonachus schauinslandi*

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B.6. Polar Bears

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Consider when assessing

- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Playback and sound exposure experiments
- Pingers and other noise-generating activities

Related modules

- Refer also to modules B.1 and B.5 when assessing impact to polar bears

B.6.1. Species Vulnerabilities

There are two studies of polar bear hearing, showing that polar bears have hearing similar to humans, and that best sensitivity was shown between 11.2 – 22.5 kHz (Nachtigall *et al* 2007), and 8 – 14 kHz (Owen and Bowles 2011).

There have not been many specific studies of polar bears and noise. It has been shown that polar bears in Spitsbergen are disturbed by snowmobiles and can show strong behavioural reactions on a distance of 2-3 km, females with cubs showing stronger reactions at longer distance than adult males (Andersen and Aars 2008).

Polar bear would be highly vulnerable when hunting, as they are hunting for seals and depend on stealth, either by sneaking up on seals or by waiting at seal breathing holes in the ice (Stirling 1974, Stirling and Latour 1978). Studies indicate that denning females could be somewhat protected from noise from seismic air guns, although they could be vulnerable if sound sources are within close proximity of the den (less than 100 m) (Blix and Lentfer 1992).

B.6.2. Habitat Considerations

Polar bear's essential habitat is sea ice. Polar bears would prefer to stay on sea ice covering shallow and productive shelf areas (Durner *et al* 2009, Schliebe *et al* 2006). There would be particular concerns associated with all activities that have an impact in areas which resource selection functions have shown are preferred sea ice habitat for polar bears (Durner *et al* 2009).

Some models project an ice-free Arctic Basin in summer in just a few years from now, before 2020 (Maslowski *et al* 2012), and modelling studies have shown that most subpopulations will be reduced and experience large environmental stress (Amstrup *et al* 2008, Hamilton *et al* 2014).

Although not exclusively associated with specific habitats, there are certain activities that might be a concern. Some industrial activities are located in important habitat, of special concern is oil drilling activities on sea ice in productive sea areas, and the prospect of new developments of petroleum exploration in critical habitat, especially in North America. It must be noted that there are little or no specific studies of the effect of noise or manmade sound on polar bears, thus the level of impact is to a large degree inferred from general expert knowledge of the effect of disturbance on these animals.

Future impact from disturbance from sound exposure needs to be focused on denning areas in spring, and areas of sea ice and glacier fronts that are used by females with cubs-of-the-year to find food immediately after den emergence. Arctic areas in northern Canada, bordering to the Arctic Basin are generally the areas where one expects sea ice habitat to persist for the longest period (Amstrup *et al* 2007).

B.6.3. Impact of Exposure Levels

Given the specific vulnerability of polar bears to habitat loss, the exposure level of polar bears, especially in denning areas in spring, and areas of sea ice and glacier fronts that are used by females with cubs-of-the-year to find food immediately after den emergence should be prioritized.

B.6.4. Assessment Criteria

An assessment of the future impact of noise would have to take into account the dramatically decreasing area of critical sea ice habitat, in some areas the length of the ice-free period from ice melt in spring till ice freeze-up in fall, has increased by more than 140 days in the period 1979-2015 (Laidre *et al* 2015).

A minimum would be that EIAs on impact of sound would assess to what extent sound exposure would be detrimental to reproductive success by directly considering the effect of sound in denning areas and productive sea ice areas in the vicinity of denning areas, and also areas of sea ice over productive shelf areas.

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B.7. Sirenians

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Consider when assessing

- Military sonar
- Seismic surveys
- Civil high power sonar
- Coastal construction works
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- MOU Concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia (West African Aquatic Mammals)
- MOU on the Conservation and Management of Dugongs (*Dugong dugon*) and their Habitats throughout their Range (Dugong)

B.7.1. Species Vulnerabilities

Even though traditional ecological knowledge and field observations (Marsh *et al* 1978, Hartman 1979) suggest that sirenians (manatees and dugongs) have 'exceptional acoustic sensitivity', scientific research on their hearing and reactions to marine noise is relatively sparse. Published hearing studies are based on the Florida manatee, *Trichechus manatus latirostis*, while behavioural studies on reactions to noise are limited to the Florida manatee, the Antillean manatee, *Trichechus manatus*, and the dugong, *Dugong dugon*. Although most of this research is limited to sounds in water, behavioural observations indicate that sirenians are capable of detecting some sounds in air above the surface (Hartman 1979).

Evoked potentials recorded for Florida manatees (Bullock *et al* 1982, Mann *et al* 2005) demonstrated variable sensitivity over a range of frequencies from about 200Hz to 35–40 kHz with greatest sensitivity in the lower range at 1–1.5 kHz. In-water behavioural audiograms of four captive Florida manatees identified the frequency range of best hearing as 6 to 32 kHz (Gerstein *et al* 1999, Gerstein 2002, Gaspard *et al* 2012), with individual variation within this range. Peak hearing sensitivity has been variously reported as 16-18 kHz (Gerstein *et al* 1999, Gerstein 2002) and 8 kHz (Gaspard *et al* 2012). Gaspard *et al* (2012) also reported that one of their test animals appeared to be able to hear loud sounds as low as 0.25 kHz and ultrasonic frequencies as high as 90.5 kHz. Gerstein *et al* (1999) speculated that the greater sensitivity to higher frequencies observed in their audiogram research may be an adaptation that enabled manatees to avoid the complications associated with perceiving sound reflections propagated from the water–air interface (Lloyd mirror effect) in the shallow depths typical of their habitats, raising the interesting question of what these animals can hear when at the surface.

Both Gerstein (1999) and Gaspard *et al* (2012) conducted in-water behavioural experiments on captive Florida manatees to measure critical ratios. The differences in their results likely reflect both their different experimental protocols and individual differences in the manatees' responses. Gaspard *et al* (2012) found that the manatees have relatively narrow auditory filters and struggle to hear lower and higher pitched sounds above background noise. However, manatee hearing was much sharper at 8 kHz – the frequency at which manatees communicate – where they could still distinguish tones that were only 18.3 dB louder than the background. This estimate of the manatee's critical ratio (8 kHz) is among the lowest measured in mammals (Gaspard *et al* 2012) suggesting that generic marine mammal impact guidelines may not be appropriate for sirenians.

Field studies show that both the Florida manatee (Miksis-Olds *et al* 2007) and the dugong (Hodgson and Marsh 2007) exhibit short-term behavioural responses to noise. Miksis-Olds and Wagner (2010) showed that elevated sound levels affect the patterns of behaviour of the Florida manatee and that the response is a function of the manatee's behavioural state. When ambient sounds were highest, the manatees spent more time feeding and less time milling. In contrast, Hodgson and Marsh's (2007) experimental and behavioural studies showed that the time that dugongs spent feeding and travelling was unaffected by boat presence, the number of boat passes and whether a pass included a stop and restart. However, focal dugongs were less likely to continue feeding if the boat passed within 50 m, than if the boat passed at a greater distance. Boats passing at a range of speeds, and at distances of less than 50 m to over 500 m evoked mass movements of dugong feeding herds, but such movements only lasted a

couple of minutes. Castelblanco-Martínez and Arévalo-González (2015) experimentally studied the effects of side-scan sonar operating 455 kHz on the behaviour of 12 captive Antillean manatees. All the observed manatees variously showed behavioural changes including stopping foraging and feeding, significantly reducing displacement and remaining still at the bottom or at the surface, and increasing displacement behaviour. One male displayed continuous spinning movements for almost the entire experimental session. Most animals avoided the area nearest to the transducer.

Sirenians are not wilderness animals (Marsh *et al* 2011). Manatees occur in the inshore waters of Florida and have continued to use the intra-coastal waterway and residential canal estates, despite a high level of vessel activity (for references see Marsh *et al* 2011). Dugongs continue to use Johore Strait between Singapore and Peninsula area, one of the most heavily-used coastal waterways in the world, and are often detected in ports and military training areas along the Queensland east coast on the basis of their feeding trails and satellite tracking (Marsh *et al* 2011, Cleguer *et al* 2016). Hodgson *et al* (2007) experimentally tested the behavioural responses of dugongs to 4 and 10 kHz acoustic alarms (pingers). The rate of decline of the number of dugongs within the focal arena did not change significantly while pingers were activated. Dugongs passed between the pingers irrespective of whether the alarms were active or inactive, fed throughout the experiments and did not change their orientation to investigate pinger noise, or their likelihood of vocalizing. Thus despite the short-term behavioural responses noted above, there is no evidence that wild dugongs or Florida manatees are displaced by underwater noise, including side scan sonar (Gonzalez-Socoloske *et al* 2009). The reaction of dugongs and manatees to plosive sounds does not appear to have been formally tested.

Both manatees and dugongs use underwater sound for communication. There have been numerous studies of sirenian communication sounds (see Marsh *et al* 2011) Characteristics of individual call notes seem fairly similar among the species of sirenians. Frequency ranges are typically from 1 to 18 kHz, often with harmonics and non-harmonically related overtones (e.g Anderson and Barclay 1995, Sousa-Lima *et al* 2002, O'Shea and Poche 2006).

Adults of both sexes produce vocalizations, but exchanges of communication calls are most common between cows and their nursing calves. Florida manatee calves vocalize at much greater rates than adults (Sousa-Lima *et al* 2002, O'Shea and Poche 2006). Manatees other than cows and calves vocalize at rates that vary with activity and behavioural context, and are lowest during resting, intermediate while travelling, and highest at nursing and other social situations (Reynolds 1981, Bengtson and Fitzgerald 1985, Williams 2005, O'Shea and Poche 2006, Miksis-Olds and Tyack 2009). Dugongs seem to vocalize more often during dark, early morning hours (Ichikawa *et al* 2006). No data are available on vocal communication in African manatees, *Trichechus senegalensis*, although recordings and sound spectrograms of calls of an isolated captive calf in Cote d'Ivoire were similar to those of some Florida and Amazonian manatee calves (TJ O'Shea unpublished). Florida manatees may alter vocalization parameters in response to environmental noise levels (Miksis-Olds and Tyack 2009). Sakamoto *et al* (2006) attempted to quantify the effect of vessel noise on the vocal characteristics of dugongs (number of call per minute, dominant frequency and call duration). None of the changes was significant.

We know of no information regarding PTS, TTS or noise-induced auditory damage in sirenians.

B.7.2. Habitat Considerations

In the marine environment, both manatees and dugongs mostly occur in shallow waters because of their dependence of seagrass communities (Marsh *et al* 2011). Antillean and African manatees are both riverine and estuarine and in the marine environment mainly occur in water less than 5 m deep. Dugongs are strictly marine, feeding in waters up to about 35 m deep. They may occasionally cross ocean trenches (see Marsh *et al* 2011), but typically spend most of their lives in much shallower inshore coastal and island waters often commuting with the tide to or from intertidal seagrass meadows (Marsh *et al* 2011). There is increasing evidence that dugong migration corridors follow topographic features such as coastlines (Zeh *et al* 2016 in press) or reef crests (Cleguer 2015).

B.7.3. Impact of Exposure Levels

Given that the available evidence suggests that manatees and dugongs are unlikely to be displaced by noise, the most practical approach to reducing the risk of impacts is avoidance of the overlap of acute sound impacts with seasonal aggregation sites

and periods when the animals are likely to be under stress. Seasonal aggregation sites are most likely at the high latitude limits of the ranges of dugongs and manatees and typically occur as a behavioural repose to thermal conditions or prolonged periods of rough weather (see Marsh *et al*, 2002 and 2011 for details of some well-known sites in Florida, Australia and the Arabian region). Site-specific information on this topic should be a focus of the Environmental Impact Assessment process. Extreme weather events such as cyclones or prolonged cold fronts can cause substantial increases in mortality (Marsh *et al* 2011, Meager and Limpus 2013) and noisy construction impacts should be planned to avoid times of likely environmental stress.

B.7.4. Assessment Criteria

We know of no field studies on the effects of anthropogenic noise, other than vessel noise on sirenians. The effect of vessel noise *per se* seems much less than that of vessel collisions. This lack of evidence does not prove that noise has negligible consequences for sirenian conservation, and more attention should be dedicated to a better understanding of possible impacts and ways to ameliorate them. A precautionary approach to the exposure of manatees and dugongs to noise, especially at key habitats and aggregation sites, is warranted.

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B.8. Marine and Sea Otters

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Consider when assessing

- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related modules

- Refer also to modules B.10, B.12 and C when assessing impact to marine and sea otters

B.8.1. Species Vulnerabilities

The marine otter, *Lontra feline*, and sea otter, *Enhydra lutris*, are amphibious marine mammals that may be vulnerable to coastal anthropogenic disturbance. Auditory thresholds for sea otters have been measured in air and underwater from 125 Hz to 40 kHz. Critical ratios data indicate that although sea otters can detect underwater sounds, their hearing appears to be primarily air adapted and not specialized for detecting signals in background noise. (Ghoul and Reichmuth 2012, 2014, 2016)

B.8.2. Habitat Considerations

There is little definitive research available about the specific anthropogenic noise vulnerabilities of this species group, but given the frequency range of hearing and the knowledge that these animals are social communicators and benthic foragers, (McShane *et al*, 1995, Leuchtenberger *et al*, 2014, Lemasson *et al*, 2014, Thometz *et al*, 2015) this species group should be considered. Their dependence on restricted nearshore habitats puts sea otters at risk from acoustic disturbance and activities occurring both on land and at sea. (Ghoul and Reichmuth 2016)

B.8.3. Impact of Exposure Levels

Ghoul and Reichmuth (2016) have conducted the only known assessment of sea otter hearing sensitivity. They found that hearing was most sensitive at 8 and 16 kHz, where measured thresholds were the lowest at 69 dB re 1 μPa. The range of best sensitivity in water spanned ~4.5 octaves, from 4 to 22.6 kHz. The roll-off in high-frequency hearing was typically steep and had a 28-dB increase within a half-octave frequency step. Low-frequency hearing (0.125–1 kHz) was notably poor. The sea otter was unable to detect signals below 100 dB re 1 μPa within this frequency range. Noise spectral density levels in the underwater testing enclosure were sufficiently low to ensure that the measured thresholds were not influenced by background noise, especially at frequencies above 0.5 kHz, where noise levels were below 60 dB re 1 μPa/√Hz. (Ghoul and Reichmuth 2016)

B.8.4. Assessment Criteria

Regulators estimating zones of auditory masking for sea otters should follow the guidance given for other marine mammals and opt for conservative estimates until additional data are available. (Southall *et al*, 2000)

B.8.5. Species not listed on the CMS Appendices that should also be considered during assessments

Sea otters, *Enhydra lutris*, are classified by IUCN as Endangered, and should also be considered during assessments.

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B.9. Marine Turtles

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Consider when assessing

- Military sonar
- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- MOU Concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa (Atlantic marine turtles)
- MOU on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (IOSEA)

Related modules

- Refer also to modules B.12 and C when assessing impact to marine turtles

B.9.1. Species Vulnerabilities

Although the ecological role of hearing has not been well studied for sea turtles, hearing capacity has been inferred from morphological and electrophysiological studies. (Southwood *et al*, 2008)

Sea turtles do not have an external ear, in fact, the tympanum is simply a continuation of the facial tissue. Researchers have speculated that the cochlea and saccule are not optimized for hearing in air, but rather are adapted for sound conduction through two media, bone and water. Recent imaging data strongly suggest that the fats adjacent to the tympanal plates in at least three sea turtle species are highly specialized for underwater sound conduction. (Moein Bartol and Musick, 2003)

Hearing range (50-1200 Hz: Viada *et al*, 2008, Martin *et al*, 2012, Popper *et al*, 2014) coincides with the predominant frequencies of anthropogenic noise, increasing the likelihood that sea turtles might experience negative effects from noise exposure.

At present, sea turtles are known to sense low frequency sound, however, little is known about the extent of noise exposure from anthropogenic sources in their natural habitats, or the potential impacts of increased anthropogenic noise exposure on sea turtle biology. Behaviour responses have been clearly demonstrated. (Samuel *et al*, 2005)

Prolonged exposure could be highly disruptive to the health and ecology of the animals, encouraging avoidance behaviour, increasing stress and aggression levels, causing physiological damage through either temporary or even permanent threshold shifts, altering surfacing and diving rates, or masking orientation cues. (Samuel *et al*, 2005)

B.9.2. Habitat Considerations

Sea turtles have been shown to exhibit strong fidelity to fixed migratory corridors, habitual foraging grounds, and nesting areas (Avens *et al*, 2003), and such apparent inflexibility could prevent sea turtles from selecting alternate, quieter habitats.

The potential of noise for displacing turtles from their favoured or optimal habitat is unknown, but if it were to occur it could have negative consequences on growth, orientation, etc.

B.9.3. Impact of Exposure Levels

Sea turtles are low frequency specialists, but their range appears to differ between populations. Animals belonging to one population of subadult green turtles have been shown to detect frequencies between 100-500 Hz with their most sensitive hearing between 200-400Hz. Another responded to sounds from 100-800 Hz, with their most sensitive range being 600-700Hz. Juvenile Kemp's ridley turtles had a range of 100-500Hz, with their most sensitive hearing been 110-200Hz. (Moein Bartol and Ketten, 2006)

B.9.4. Assessment Criteria

It is important that assessment of impact for sea turtles both considers the physiological impact (TTS and PTS) as well as the very real possibility of masking prey movements. Some sea turtles may not appear to noise-generating industries to have been physically displaced by loud noise but these animals may be effectively prevented from foraging, due to an ensonified foraging environment. Possible effects of distribution (avoidance behaviour) orientation, and even communication (e.g in the hatching phase) cannot be discounted.

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B.10. Fin-fish

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Consider when assessing

- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons

Related CMS agreements

- Agreement on the Conservation of Cetaceans of the Black Seas Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS)
- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)
- MOU for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (Pacific Islands Cetaceans)
- MOU Concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia (West African Aquatic Mammals)
- Agreement on the Conservation of Seals in the Wadden Sea (Wadden Sea seals)
- MOU Concerning Conservation Measures for the Eastern Atlantic Populations of the Mediterranean Monk Seal (*Monachus monachus*) (Atlantic monk seals)
- MOU Concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa (Atlantic marine turtles)
- MOU on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (IOSEA)
- MOU on the Conservation of Migratory Sharks (Sharks)

Related modules

- Refer also to modules B.12 when assessing impact to fish

B.10.1. Species Vulnerabilities

The use of explosives will kill fin-fish inside a certain range (Yelverton *et al* 1975), with impact zones given in Popper *et al* (2014). Intense non-explosive, impulse noise such as pile driving or seismic surveys may impact adult fin-fish by: a) creating physiological damage such as rupturing gas spaces (ie. Halverson *et al* 2012), b) damaging sensory systems (McCauley *et al* 2003), c) creating adverse behavioural responses (e.g. Pearson *et al* 1996, McCauley *et al* 2003, Slotte *et al* 2004, Fewtrell and McCauley 2012, Hawkings *et al* 2014), d) masking the reception of signals of interest, or e) disrupting prey physiology, behaviour or abundance. For fin-fish the sustained but less intense noise from vessels or offshore construction activities may commonly produce behavioural impacts or masking of communication signals as indicated above. Fin-fish exposed to lower level, man-made noise for suitable time periods may receive damage to hearing systems and so suffer a loss of fitness.

There is an enormous amount of variability in the degree of sophistication of fin-fish hearing systems and habits which may pre-dispose or protect them from impacts of man-made noise sources, thus it is difficult to generalize known impacts across all fin-fish species with a high degree of confidence. In general terms: explosives routinely cause fin-fish deaths out to some range and sub-lethal injuries beyond this, pile driving is known to produce serious physiological and organ damage to fin-fish at short range, in some cases marine seismic surveys with air guns have produced hearing damage to fin-fish while in other cases such damage has not been observed, and most man-made noise sources are capable of producing fin-fish behavioural or masking impacts to some degree. Behavioural response to an approaching noise source by fin-fish seems to be reasonably generic, pelagic fin-fish tend to move downwards to eventually lie close to the seabed or flee laterally while site-attached fish may initially seek shelter in refuges or flee. At least some species of fin-fish do habituate to continual and stationary low level noise as they readily colonize man-made offshore facilities. The longer-term implications of consistent behaviour changes or slight physiological impairment from intense signals produced by seismic surveys are not well understood.

Many fin-fish form aggregations at specific times and places to spawn and produce fertilized eggs. Such aggregations may be spaced across several months or may occur only on few occasions per season. Many fin-fish species produce communication sounds as part of such aggregations (ie. McCauley 2001). Disruptions to such fin-fish spawning aggregations by excessive noise causing physiological or behavioural changes and which overlaps a large fraction of the species' seasonal spawning period will have deleterious

impacts on the following years reproductive output.

All fin-fish are dependent on smaller prey species which may be impacted by man-made noise sources. Prey may include fin-fish or invertebrates. In general terms small, common, fin-fish prey species, such as sardines, herring or pilchards, have well developed sensory systems thus may be equally or more vulnerable to exposure to intense man-mad noise than the larger fin-fish which prey on them. The response of marine invertebrates to intense signals such as seismic survey noise, are poorly known so it is difficult to draw conclusions or comparisons on how invertebrate prey fields will be impacted by noise exposure. Any changes to prey fields induced by a man-made noise source will impact fauna, possibly negatively, higher up the food chain.

All impacts of man-made noise sources on fin-fish need to be gauged at the population level. Noise sources which produce short term impacts, localized impacts compared with a species range, or which do not overlap well with habitats or time and spatial overlap of spawning periods would be expected to be of low severity form a population perspective, and vice versa.

B.10.2. Habitat Considerations

Fin-fish occupy an enormous variety of habitats, from deep ocean depths, pelagic systems, reefs and shoals, estuarine waters to inland waterways. Some fish may utilize multiple habitats on a seasonal or life cycle basis. In general terms habitats which are enclosed, such as estuaries, bays or reefs for site attached fin-fish, may be more susceptible to exposure by intense sound sources as the fin-fish have little options to escape the source. By contrast fin-fish that occupy physically larger spaces, such as oceanic species, have more options of where to flee and may be less constrained by the implications of moving geographical regions to avoid a noise source.

B.10.3. Impact of Exposure Levels

Known impacts of intense impulse noise exposure on fin-fish include consistencies in fish behavioural response to sound, but many anomalies. For high-energy impulse signals, such as seismic survey signals, the following can be said:

Fish behaviour most often changes at some range near to an approaching seismic vessel and generalized changes include diving, lateral spread or fleeing an area (e.g. Pearson *et al* 1996, McCauley *et al* 2003, Slotte *et al* 2004, Fewtrell and McCauley 2012, Hawkings *et al* 2014).

Fish behaviour is strongly impacted by an approaching seismic source above received levels of 145–150 dB re 1 µPa^2.s (SEL) (McCauley *et al* 2003), which equates to around 2–10 km using measured air gun arrays > 2000 cui.

Avoidance to an approaching seismic vessel by fish may be partly driven by the fish behavioural state, with feeding fishes appearing to be more tolerant and in one instance not showing avoidance to an approaching seismic survey vessel (Penä *et al* 2013).

Catch rates in some fisheries are altered during and after seismic operations, prolonged seismic can cause large-scale displacement of fish resulting in decreased fish abundance in and near a seismic operations area and increased fish abundance at long range (tens of km) from the seismic operations area (Engås *et al* 1996, Slotte *et al* 2004),

Long-term monitoring of reef fish community structure before and after a seismic survey programme showed no large-scale change in community structure (Miller and Cripps 2013) and fish sound production behaviour (chorusing) continued after a seismic programme with no apparent long-term change (McCauley 2011),

Exposure to accurately emulated repeated pile driving signals suggest physical injury (organ damage) arises at levels equivalent to 1920 strikes at 179 dB re 1 µPa^2.s or 960 strikes at 182 dB re 1 µPa^2.s, or an equivalent single strike SEL of 210–211 dB re 1 µPa^2.s (Halvorsen *et al* 2012).

In a review of experimental findings of sound on fishes Popper *et al* (2014) present sound exposure guidelines for fin-fish in the form of estimated levels at which the following occur: 1) mortality and potential mortal injury, 2) impairment – recoverable injury, 3) impairment – TTS, 4) impairment – masking, and 5) behavioural changes. They present these impacts for three categories of fin-fish, 1) no swim bladder, 2) swim bladder present but no links to otolith system, or 3) swim bladder present with links to otolith system, plus sea turtles and eggs/larvae. Popper *et al* (2014) present this data for sources of explosives, pile driving, air gun arrays, sonar and shipping. Given the lack of experimental evidence for most of these categories they were forced to: 1) either extrapolate from another exposure type, animal group or both, and 2) rather than presenting threshold levels often present the subjectively evaluated likelihood of an impact type occurring at 'near' (tens of m),

'intermediate' (hundreds of m) and 'far' (thousands of m) ranges. The thresholds listed for physical injury (mortality and impairment-recoverable injury) for pile driving and seismic air gun signals are the same, being primarily based on the pile driving work of Halverson *et al* (2012). Readers are referred to Popper *et al* (2014) for the particular thresholds for a fin-fish and sound exposure type as the reader should see their text for the reasoning and caveats behind the values presented.

B.10.4. Assessment Criteria

In assessing impacts of a noise source on fin-fish any EIA document should consider species which:

- are important for commercial fisheries,
- are listed as threatened, vulnerable or are endemic to an area,
- can be considered as important 'bait fish' or are important as prey species for higher order fauna,
- have limited ability to flee an intense noise source,
- utilize a noise impacted area for specific purposes such as feeding or spawning events.

In considering impacts of underwater noise on a species of fin-fish, factors which must be taken into account include:

- hearing capabilities of the species in question including knowledge of morphological adaptations to increase hearing capability, noting fin-fish primarily respond to motion of the water particles and less to measures of sound pressure. Fin-fish have a diverse range of morphological adaptations to improve hearing capability,
- studies of known impacts on this species,
- studies of known impacts on related species either taxonomically, morphologically or in general terms if no other comparison is available (ie. pelagic fishes, benthic fishes etc),
- particular spatial and temporal features which are critical to that fin-fish population's survival (ie. specific feeding areas or prey types, spawning locations and periods).

For migratory fin-fish impact assessment must consider if a noise producing action may cause a species to leave an area and if so, the consequences of this to the species in question, for other fauna and for commercial fisheries which target that species.

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B.11. Elasmobranchs

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Consider when assessing

- Military sonar
- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- MOU on the Conservation of Migratory Sharks (Sharks)

Related modules

- Refer also to modules B.10 and B.12 when assessing impact to elasmobranchs

B.11.1. Species Vulnerabilities

Elasmobranchs as a group are poorly studied in relation to the potential impact of anthropogenic sounds, although several studies over time have been directed at particular species of shark to improve knowledge of their hearing mechanisms, abilities and implications for management. From as early as the 1960s (e.g. Nelson and Gruber, 1963), studies have shown that large sharks (*Carcharhinidae*, *Sphyrnidae*), in their natural environment, were attracted to low-frequency (predominantly 20 to 60 Hz) pulsed sounds, but apparently not to higher frequency (400 to 600 Hz) pulsed sounds, or to low-frequency continuous sounds. More recent research has established the hearing range of sharks to be between 40 Hz to approximately 800 Hz (Myrberg 2001), with possible limits for elasmobranchs in general at 20–1000 Hz (Casper and Mann, 2006, 2010).

Noise within the sharks' audible range may be produced by several anthropogenic sources such as shipping, underwater construction, pile driving, dredging, power stations and sonic surveys. It has been suggested that loud sounds in their audible range may repel sharks whereas low sounds may attract them (Francis and Lyon, 2013), probably as these latter mimics sounds emitted by struggling prey. Response likely depends on its distance from the source and the volume of the source.

Although more recent research in elasmobranch hearing and impacts in the wild have been sparse at best, and nonexistent for most species, there is evidence of habituation or at least no negative reaction to noise levels and frequencies from small boats operating recreational diving or from SCUBA divers' noises, even when these are regularly present and arising from many sources (Lobel, 2009 and personal observations by the author of this summary).

It is likely that elasmobranchs might suffer more impacts from noise through the effects it has on its prey species (Popper and Hastings, 2009, Carlson, 2012), and perhaps through acute events that impact concentration sites such as social groupings of hammerhead sharks, *Sphyrna* spp., and white sharks, *Carcharodon carcharias*, around offshore islands, as well as those gathering at coral reef habitats, in these cases, displacement may occur, either temporary or permanent, although again lack of adequate field research prevents any definitive conclusions. Several studies (eg Klimley and Myrberg 1979, Banner 1972, Myrberg *et al* 1978) indicate that elasmobranchs show consistent withdrawal from sources that are at close range and when confronted with sudden onset of transmissions. However they may habituate to these too if events become frequent (Myrberg, 2001). Seismic activities, pylon-driving operations, explosive construction work and activities involving similar pulsed sound emissions are likely therefore to have the most impact on elasmobranch species directly.

B.11.2. Habitat Considerations

Several species of elasmobranchs exhibit some type of site-fidelity, either permanent or seasonal. This has been observed in particular regarding species of interest to the dive industry. Some species of shark (eg whitetip, *Triaenodon obesus*, blacktip, *Carcharinus melanopterus*, and grey reef, *Carcharhinus amblyrhynchos*) and the reef manta, *Manta alfredi*, are particularly attached to coral reef environments, while others exhibit seasonal concentration around offshore islands (eg hammerheads, *Sphyrna lewini*, at Galápagos, Cocos and Malpelo Islands, white sharks, *Carcharodon carcharias*, at Guadalupe and Farallon Islands, whale sharks, *Rhincodon typus*, at Holbox, Mexico, and several other sites). Giant mantas *Manta birostris* also can be found in seasonal concentrations such as in Revillagigedo Islands in Mexico, Laje de Santos in Brazil and La Plata in Ecuador.

Seasons for these aggregations vary from site to site and by species and need to be assessed on a case by case basis.

Acoustic impacts which might severely affect vulnerable or complex habitats such as coral reefs or mangrove forests (essential nursery areas for some shark and ray species) are certain to have an effect on its elasmobranch fauna if it includes displacement or damage to prey species and any physical disruption of the habitat. Seasonal concentration areas for sharks and rays can be particularly vulnerable to acute acoustic disturbance, which may result in abandonment of the area or disruption of gregarious behaviour whose implications are yet not fully understood. Acute acoustic disturbances such as seismic or sonic surveys and any activity involving explosives in or around these critical habitats (coral reefs, offshore islands and other known seasonal concentration sites, key feeding grounds) are likely to have serious impacts on elasmobranch populations.

Although migration paths are still poorly understood for most species, recent satellite tagging research (e.g. Domeier and Nasby-Lucas, 2008) has begun to reveal some consistent patterns and as yet unknown concentration areas away from above-water topographic features. These areas likely represent additional vulnerability corridors where protection from acute acoustic disturbance should be incorporated into management actions.

B.11.3. Impact of Exposure Levels

As a group, elasmobranchs have been poorly represented in field studies on acoustics, with most knowledge available for more "visible" species such as large sharks. For these, observed impacts refer mostly to short-term avoidance responses to loud, sudden bursts of sound in their audible range, although there´s evidence that the regularity of such sounds might lead to habituation (see references above).

Given that bony fish, which make the majority of prey species for most sharks, may be severely impacted by sound, especially in loud bursts (eg Carlson, op. cit.), it is perhaps this indirect effect on prey that holds the most severe potential for generating impacts on shark populations.

There is insufficient information to assess long-term impacts or behavioral changes in elasmobranchs from anthropogenic noise that might affect survivability of species. Existing studies indicate that the most direct negative impact on the animals seems to be displacement by sonic outbursts, while longer-term exposure often seems to lead to habituation.

B.11.4. Assessment Criteria

From available data it seems that there are two main aspects of potential impacts on elasmobranchs that merit particular consideration: displacement or elimination of prey species and displacement or disruption of behaviour associated with specific sites by sound bursts. Given that detailed studies are mostly lacking, a precautionary approach to the exposure of elasmobranchs to noise, especially at key habitats and aggregation sites, is warranted. In particular activities involving the use of equipment or methods that generate loud sonic outbursts near known or estimated aggregation areas, or which might physically injure or displace prey, need to be carried out with adequate assessment (including baseline surveys for elasmobranch species and their prey) and mitigation measures as feasible and appropriate. Also, proposed activities that alter or impact keys habitats such as coral reefs, mangroves or offshore islands with known aggregations of elasmobranch species should be carried out with extreme caution and this group of species should be explicitly considered in studies and proposed management measures to reduce potential impacts.

B.11.5. Species not listed on the CMS Appendices that should also be considered during assessments

In general, listed species include those for which several acoustic and hearing studies exist, but as for the entire group detailed acoustic impact studies are lacking. The development and collation of more detailed data on a species by species basis could greatly help improve our understanding of the impacts of anthropogenic noise on their physiology and life cycles. Lack of information on most elasmobranch species is an impediment to the provision of any meaningful advice on species not listed on the CMS Appendices,

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B.12. Marine Invertebrates

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Consider when assessing

- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- Agreement on the Conservation of Cetaceans of the Black Seas Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS)
- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)
- MOU for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (Pacific Islands Cetaceans)
- MOU Concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia (West African Aquatic Mammals)
- Agreement on the Conservation of Seals in the Wadden Sea (Wadden Sea seals)
- MOU Concerning Conservation Measures for the Eastern Atlantic Populations of the Mediterranean Monk Seal (*Monachus monachus*) (Atlantic monk seals)
- MOU Concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa (Atlantic marine turtles)
- MOU on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (IOSEA)
- MOU on the Conservation of Migratory Sharks (Sharks)

Related modules

- Refer also to modules B.10 when assessing impact to marine invertebrates

B.12.1. Species Vulnerabilities

Very little is known about effects of anthropogenic noise on invertebrates (Morley *et al*, 2014). This includes more than 170,000 described species of multicellular marine invertebrates in spite of their ecological and economic importance worldwide (Anderson *et al*, 2011). Most research targets molluscs (e.g. cephalopods, shellfish) and crustaceans (e.g. crabs, shrimps, barnacles) (reviewed in Aguilar de Soto, 2016).

Molluscs:

Two atypical mass-strandings involving nine giant squids, *Architeuthis dux*, were associated with seismic surveys co-occurring in nearby underwater canyons where this species concentrates (Guerra *et al*, 2004, 2011). Two specimens suffered extensive multiorganic damage to internal muscle fibres, gills, ovaries, stomach and digestive tract. Other squids were probably disoriented due to extensive damage in their statocysts. Damage to the sensory epithelium was also observed in four species of coastal cephalopods (*Sepia officinalis*, *Loligo vulgaris*, *Illex coindetii* and *Octopus vulgaris*) by exposure to two hours of low-frequency sweeps at 100 per cent duty cycle (André *et al*, 2011, Solé, 2012, Solé *et al*, 2013). Fewtrell and McCauley (2012) reported that squid, *Sepioteuthis australis*, exposed to seismic pulses from a single air gun showed signs of stress such as significant increases in the number of startle and alarm responses, with ink ejection in many cases, increased activity and changing position in the water column.

Delayed and abnormal development as well as an increase in mortality rates in eggs and larvae of shellfish exposed to noise have been recorded in two species. New Zealand scallop larvae, *Pecten novaezelandiae*, exposed to playbacks of low frequency pulses in the laboratory showed significant developmental delays and developed body abnormalities (Aguilar de Soto *et al*, 2013). The number of eggs of sea hares, *Stylocheilus striatus*, that failed to develop at the cleavage stage, as well as the number that died shortly after hatching, were significantly higher in a group exposed to boat noise playback at sea compared with playback of ambient noise (Nedelec *et al*, 2014). In contrast, playbacks of ship-noise enhanced larval settlement in the mussel, *Perna canaliculus* (Wilkens *et al* 2012) while seemed to increase biochemical indicators of stress in adult mussels (*Mytilus edulis*) (Wale *et al* 2016).

Crustaceans:

Stress responses were observed in aquarium-dwelling brown shrimp, *Crangon crangon*, exposed to ambient noise of some 30 dB higher than normal at 25–400 Hz (Lagardere, 1982, Regnault and Lagardere,

1983). Shrimps did not seem to habituate throughout the experiment. Similarly, shore crabs, *Carcinus maenas*, increased metabolic consumption and showed signals of stress when exposed to playbacks of ship noise in the laboratory. Crustacean larvae seem to differ in their sensitivity to noise: larval dungeness crabs, *Metacarcinus magister*, did not show significant differences in survival nor in time-to-moult when exposed to a single pulse from a seven air gun array, even at the higher received level of 231 dB re 1µPa (Pearson *et al*, 1994). In contrast, larvae of other crab species, *Austrohelice crassa* and *Hemigrapsus crenulatus* megalopae, exposed to playbacks of noise from tidal turbines tended to suffer significant delays in time-to-moult (Pine *et al*, 2012) and low-frequency noise exposure inhibited settlement of early larvae of barnacle, *Balanus amphitrite* (Branscomb and Rittschof, 1984). The apparent contradiction in the larval responses from different species of crustaceans may be due, among other things, to the experimental set-up (wild versus laboratory, one pulse versus a continuous exposure), the biology of the species, or the characteristics of the sound treatment. Cellular and humoral immune responses of marine invertebrates to noise have also been examined. In the European spiny lobster, *Palinurus elephas*, exposure to sounds resembling shipping noise in the laboratory affected various haematological and immunological parameters considered to be potential health or disease markers in crustaceans (Celi *et al*, 2014).

B.12.2. Habitat Considerations

Marine invertebrates inhabit a range of habitats. Mainly, they may live associated to the seafloor (benthic or bentho-pelagic species) or free in the water column (pelagic). Many species have an initial pelagic phase as larvae, useful for dispersion, before finding suitable habitat for settling into their adult life. Sound from preferred habitats is one of the cues used by larvae to find a suitable location to settle (Stanley *et al* 2012). Once they settle, many species have limited capabilities to move fast enough at distances required to avoid noise exposure, due to morphological constrains or to territorial behaviour.

Species associated to the seafloor will be more exposed to ground-transmission of noise. This is especially relevant for intense low frequency sounds directed towards the seafloor, typical of seismic surveys. Seismic pulses coupled with the seafloor and low frequency vibrations can travel long distances through the ground and can re-radiate to the water depending on the structure and composition of the seafloor. Marine invertebrates are sensitive to the particle motion component of sound, more than to the pressure wave, they are well suited to detect low frequency vibrations because these are used, for example, to identify predators and prey.

The variability in the extent of barotrauma experienced by different giant squid stranding at the same time, in coincidence with the same seismic survey (Guerra *et al* 2004, 2011), underlines the difficulties inherent in predicting noise-induced damage to animals in the wild. Here, some giant squid suffered direct mortality from barotrauma, while the death of others seemed to be caused by indirect effects of physiological and behavioural responses to noise exposure. Direct injury (barotrauma) can be explained by some animals being exposed to higher sound levels due to complex patterns of sound radiation creating zones of convergence (Urick, 1983) of the seismic sound waves reflected by the sea surface/sea floor, and possibly by the walls of the steep underwater canyons in the area where the seismic survey took place.

Marine invertebrates often have discrete spawning periods. It is unknown if eggs/larvae have a greater vulnerability to sound-mediated physiological or mechanical stress, or even particular phases of larval development when larvae undergo metamorphosis.

Metamorphosis involves selective expression of genes mediating changes in body arrangement, gene expression is susceptible to stress, including from noise. Spawning periods are key for the recruitment of marine invertebrates and thus should be considered when planning activities.

B.12.3. Impact of Exposure Levels

There are no data about thresholds of pressure or particle motion initiating noise impacts on marine invertebrates. Studies have found a range of physiological effects (reviewed in Aguilar de Soto and Kight 2016) but there are no dose-response curves identifying levels of impact onset. Moreover, most studies report only sound pressure level, while particle motion is relevant for the effects of noise on these species. At a distance from an acoustic source (in the far-field) the pressure and particle motion components of sound are easily predicted in a free homogeneous environment such as the water column. In contrast, in the near-field animals may experience higher particle motions than would be expected for the same pressure level in the far-field. Intense underwater sound

sources such as air guns, pile driving, sonar and blasting have back-calculated peak source levels ranging from 230 to, in the case of blasting, >300 dB re 1 µPa at 1m. These activities routinely ensonify large areas with sound pressure levels higher than the thresholds of response observed in different studies of noise-impacts on marine invertebrates. For example, a seismic array with an equivalent source level of 260 dB pk-p re 1 µPa at 1m will produce levels in excess of 160 dB_{rms} over hundreds of km-squared. This level was measured in an experiment reporting noise-induced developmental delays and malformations in scallop larvae (Aguilar de Soto *et al* 2013). But the particle velocities experienced by the larvae in the experiment (about 4-6 mm s^{-1} RMS) imply higher far-field pressure levels of some 195-200 dB_{rms} re 1 µPa, reducing the potential impact zone to only short ranges from the source. However, there are several reasons why larvae in the wild may be impacted over larger distances than these approximate levels suggest. Given the strong disruption of larval development reported, weaker but still significant effects can be expected at lower exposure levels and shorter exposure durations. Moreover, low frequency sounds propagate in complex sound fields in which convergence zones and re-radiation of sound transmitted through the sea-floor can create regions with high sound levels far from the source (Madsen *et al* 2006). The sound field experienced by an organism is a complex function of its location with respect to the sound source and acoustic boundaries in the ocean necessitating *in situ* measurements to establish the precise exposure level.

B.12.4. Assessment Criteria

Benthic marine invertebrates often have little movement capabilities further than a few metres, limiting their options to avoid exposure to anthropogenic noise. In the case of intense low frequency noise, e.g. seismic or pile driving, it is essential to consider ground-transmission. For example, during a seismic survey animals will be exposed to sound received from the air gun array passing over the location of the animals, but these invertebrates will be receiving at the same time ground-transmitted vibrations originated by previous seismic pulses. Thus, animals will experience waves arising from the water and from the ground, differing in phase and other parameters. Complex patterns of wave addition mean that in some cases vibrations will sum, increasing the levels of sound exposure to the animals. Because ground vibrations may travel tens of kilometres or more, the time that benthic invertebrates will be exposed to a given threshold of pressure or particle motion will be increased when we consider seafloor transmission. An alternative source for seismic surveys (©Vibroseis) is currently being tested. In contrast to usual seismic surveys transmitting pulses every 6 to 15 s from an air gun array towed by a ship near the sea-surface, Vibroseis is towed near the seafloor and emits continuously, but at lower peak level. Thus, duty cycle increases to 100 per cent. EIA of Vibroseis and other low frequency sound sources should include modelling particle motion in the target area and consider exposures to benthic fauna.

Results of experiments about effects of noise on catch rates of marine invertebrates have not shown significant effects: Andriguetto-Filho *et al* (2005) did not find changes on catches of shrimps after the passage of a small air gun array. No effects of seismic activities on catches of rock-lobsters were found either by Parry *et al* (2006) performing a long-term analysis of commercial data. In contrast, fishermen have blamed seismic sources for mortalities of scallops and economic losses due to reduced catch rates.

Despite uncertainties about how noise may affect marine fauna and fisheries, several countries have already implemented regulations that reduce overlap between seismic surveys and fishing activities (mainly of fin-fish). However, these regulations do not address concerns of noise effects on eggs and larvae, i.e. that noise might affect stock recruitment and thereby cause delayed reductions in catch rates.

Marine invertebrates form the base of the trophic-web in the oceans, providing an important food source for fish, marine mammals and humans. In addition to direct effects to adults, noise exposure during critical growth intervals may contribute to stock vulnerability, underlining the urgency to investigate potential effects of acoustic pollution on marine invertebrates at different ontogenetic stages. Moreover, recent results investigating the effects of noise on a range of marine invertebrate species call for applying the precautionary principle when planning activities involving high-intensity sound sources, such as explosions, construction, pile driving or seismic exploration, in spawning areas/times of marine invertebrates with high natural and economic value.

B.12.5. Species not listed on the CMS Appendices that should also be considered during assessments

Some large cephalopods are migratory, including the giant squid, *Architeuthis sp* (Winkelmann *et al* 2013). Given the vulnerability of this species to acoustic sources, it should also be considered during assessments.

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C. Decompression Stress

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Decompression sickness (DCS, 'the bends') is a disease associated with gas uptake at pressure. As hydrostatic pressure increases with depth, the amount of nitrogen (N_2) that is absorbed by the blood and tissues increases, resulting in higher dissolved gas tensions that could at maximum reach equilibrium with the partial pressure of N_2 in the lungs. This is a long-known problem for human divers breathing pressurized air, but has often been discounted as a problem for breath-hold divers since they dive on only a single inhalation (Scholander 1940). However, for free-diving humans and other air-breathing animals, tissues can become highly saturated under certain circumstances depending on the iterative process of loading during diving and washout at the surface (Paulev 1967, Lemaitre *et al* 2009). During decompression, if the dissolved gas tension in the tissues cannot equilibrate fast enough with the reducing partial pressure of N_2 in the lungs, tissues will become supersaturated, with the potential for gas-bubble formation (Francis and Mitchell 2003).

Breath-hold diving vertebrates were previously thought to be relatively immune to DCS due to their multiple anatomical, physiological and behavioural adaptations (Fahlman *et al* 2006, Fahlman *et al* 2009, Hooker *et al* 2012). However, recent observations have shown that marine mammals and turtles may be affected by decompression sickness under certain circumstances (Jepson *et al* 2005, Dennison *et al* 2012, Van Bonn *et al* 2013, Garcia-Parraga *et al* 2014). Of most concern, however, are the beaked whales, which appear to be particularly vulnerable to anthropogenic stressors that may cause decompression sickness (Jepson *et al* 2003, Cox *et al* 2006, D'Amico *et al* 2009, Hooker *et al* 2009, Hooker *et al* 2012).

C.1.1. Bubble Formation

Among marine mammals, both acute and chronic gas emboli have been observed. The formation of bubbles has been suggested as a potential explanation for lesions coincident with intravascular and major organ gas emboli in beaked whales that mass stranded in conjunction with military exercises deploying sonar (Jepson *et al* 2003, Fernandez *et al* 2005). There is some controversy about the proximate cause of the gas emboli (Hooker *et al* 2012) although it is widely agreed that it appeared to be linked to man-made acoustic disturbance. However, these types of lesions have also been reported in some single-stranded cetaceans for which they do not appear to have been immediately fatal (Jepson *et al* 2005, Bernaldo de Quirós *et al* 2012, Bernaldo de Quirós *et al* 2013). Looking at species-specific variability in bubble presence among stranded animals, the deeper divers (Kogia, Physeter, Ziphius, Mesoplodon, Globicephala, and Grampus) appeared to have higher abundances of bubbles, suggesting that deep-diving behaviour may lead to a higher likelihood of decompression stress (Bernaldo de Quirós *et al* 2012).

In addition, osteonecrosis-type surface lesions have been reported in sperm whales (Moore and Early 2004). These were hypothesized to have been caused by repetitive formation of asymptomatic N_2 emboli over time and suggest that sperm whales live with sub-lethal decompression induced bubbles on a regular basis, but with long-term impacts on bone health. Bubbles have also been observed from marine mammals bycaught in fishing nets, which died at depth (Moore *et al* 2009, Bernaldo de Quirós *et al* 2013). These bubbles suggested the animals' tissues were supersaturated sufficiently to cause bubble formation when depressurized (as nets were hauled). B-mode ultrasound has also shown bubbles in stranded (common and white-sided) dolphins, which showed normal behaviour after release and did not re-strand, and so appeared to tolerate this bubble formation (Dennison *et al* 2012). Cerebral gas lesions have also been observed using Magnetic Resonance Imaging in California sea lions,

Zalophus californianus, admitted to a rehabilitation facility (Van Bonn *et al* 2011, Van Bonn *et al* 2013).

It therefore appears that gas supersaturation and bubble formation may occur more routinely than previously thought. These cases highlight a growing body of evidence that marine mammals are living with blood and tissue N_2 tensions that exceed ambient levels (Moore *et al* 2009, Bernaldo de Quirós *et al* 2013). However, our understanding of how marine mammals manage their blood gases during diving, and the mechanism causing these levels to become dangerous is very rudimentary (Hooker *et al* 2012). Some perceived threats appear to cause a behavioural response that may override normal N_2 management, resulting in decompression sickness, stranding and death.

C.1.2. Sources of Decompression Stress

There is a documented association between naval active sonar exercises and beaked whale mass strandings (Frantzis 1998, Evans and England 2001, Jepson *et al* 2003). However, a comprehensive review of beaked whale mass strandings (D'Amico *et al* 2009) suggests that some strandings may be associated with other events. It therefore seems likely that other high-intensity underwater sounds may also present conservation concerns for these species (Taylor *et al* 2004). Indeed, ship-noise also appears to cause a behavioural response disrupting foraging behaviour in Cuvier's beaked whales, *Ziphius cavirostris* (Soto *et al* 2006).

The process of diving causes oxidative stress (Hermes-Lima and Zenteno-Savin 2002). Episodic regional lack of oxygen and abrupt reperfusion upon re-surfacing creates a situation where post-ischemic reactive oxygen species (ROS) and physiological oxidative stress are likely to occur. However, a link between oxidative stress and DCS has not yet been confirmed (Wang *et al* 2015).

C.1.3. Source Frequency, Level and Duration

Understanding the responses of cetaceans to noise is a two-stage process: (1) understanding the noise required to cause the behavioural modification and (2) understanding the physiological mechanism by which that behavioural modification causes harm to the animal. At present, almost all research has focussed on the first of these, i.e. work evaluating playback and response, and almost nothing is known about how this response then leads to decompression stress.

Several recent studies have found similar behavioural responses of a small number of beaked whales to sonar signals (Tyack *et al* 2011, DeRuiter *et al* 2013, Stimpert *et al* 2014, Miller *et al* 2015). These studies have shown that beaked whales respond behaviourally to sonar and other human and natural stimuli, typically showing a combination of avoidance and cessation of noise-production associated with foraging (Table 8). Responses to simulated sonar have started at low received levels. These types of behavioural changes were also documented in work monitoring vocal activity using Navy range hydrophones (Tyack *et al* 2011, Moretti *et al* 2014). This type of 'flight' response could, if catastrophic, disrupt the normal physiological mechanisms of these animals, leading to DCS.

C.1.4. Assessment Criteria

At the planning stage, the primary mitigation method to reduce issues of decompression stress would be to reduce the interactions of stressor and animals (i.e. to reduce the number of "takes"). This can be done by placing any high-intensity noise into areas without high densities of species of concern. Thus proposals should take account of all survey and modelling information sources to predict areas of likelihood of high/low species density, and attempt to reduce the number of impacted animals by designing operations only for areas of low animal density.

To supplement this, or in areas in which such species densities are unknown, baseline studies should be conducted. Beaked whales are particularly difficult to monitor visually (surfacing for as little as 8 per cent of the time), but have more reliable detection acoustically (vocalising for 20 per cent of the time, de Soto *et al* 2012). Hydrophone arrays can detect animals at 2-6km distances (Moretti *et al* 2010, Von Benda-Beckmann *et al* 2010).

During the activity, real-time monitoring of animal presence should be conducted. This can be done using visual and acoustic monitoring, with detections within a specified range of the activity resulting in cessation of the sound source. On-board visual or towed hydrophone monitoring allows only limited detection distance and thus limits mitigation effectiveness.

Monitoring over a wider area can be achieved using hydrophone arrays placed on the seafloor (Moretti *et al* 2010). Such hydrophone arrays allow detection over a wide

but static area. Dynamic monitoring over a wide area could potentially be achieved using acoustic drones, allowing near real-time hydrophone arrays to be placed over a greater area to ensure more effective assessment of species presence prior to any disturbance event.

Modelling of animal likelihood and distance from the source should be carried out in order to aim to minimize received levels (Table 1), thus reducing the risk of animals receiving too high a dose which might incur DCS/death.

C.1.5. Species not listed on the CMS Appendices that should also be considered during assessments

Beaked whales, *Ziphius cavirostris* (Appendix I) and *Hyperoodon* spp and *Berardius* spp (Appendix II) require additional consideration. These species appear particularly vulnerable to noise impacts. 20 species of *Mesoplodon* are currently missing from the CMS Appendices and yet are likely to also be vulnerable to noise impacts. All of these species are likely to be particularly sensitive to decompression stress.

Of other deep diving species which may potentially be at increased risk of decompression stress, *Kogia* are currently not listed on either of the CMS Appendices, *Physeter* is listed on Appendices I and II, *Globicephala* on Appendix II, and Grampus should also be considered during assessments.

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Table 8: Responses of beaked whales to sound sources

Species	Sound source	Response observed as received level (dB re. 1µPa)
Cuvier's beaked whale, *Ziphius cavirostris* (DeRuiter *et al* 2013)	30 min playback of 1.6s MFA sonar signal repeated every 25 sec. Initial source level of 160 dB re 1 mPa-m was increased ('ramped up') by 3 dB per transmission to a maximum of 210 dB re 1 mPa-m.	89-127
Cuvier's beaked whale, *Ziphius cavirostris* (Soto *et al* 2006)	Maximum broadband (356 Hz–44.8 kHz) level received during the ship passage was 136 dB rms re 1 µPa, approx. 700m away.	106 (in click frequency range)
Northern bottlenose whale, *Hyperoodon ampullatus* (Miller *et al* 2015)	104 1-s duration 1–2 kHz upsweep pulses (naval sonar signals) at 20s intervals. The source level of the sonar pulses increased by 1 dB per pulse from 152 to 214 dB re 1 µPam over 20min (61 pulses), and the remaining pulses were transmitted for 15min at a source level of 214 dB re 1 µPa m.	107
Baird's beaked whale, *Berardius bairdii* (Stimpert *et al* 2014)	Simulated mid-frequency active (MFA) military sonar signal at 3.5-4 kHz, transmitting 1.6 s signal every 25 s. The initial source level of 160 dB re: 1 mPa was increased by 3 dB per transmission for the first 8 minutes to a maximum of 210 dB for 22 additional minutes (72 transmissions total over 30 minutes).	127
Blainville's beaked whale, *Mesoplodon densirostris* (Tyack *et al* 2011)	Simulated 1.4 s MFA sonar, killer whale and noise signals. MFA sonar had both constant frequency and frequency modulated tonal components in the 3–4 kHz band repeated every 25 s. Initial source level of 160 dB re 1 mPa-m was increased ('ramped up') by 3 dB per transmission to a maximum of 210 dB re 1 mPa-m.	138

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D. Exposure Levels

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D.1. Impact of Exposure Levels and Exposure Duration

One of the first comprehensive definitions of exposure criteria for noise impact on marine mammals considering two types of impacts, namely auditory injury and behavioural disturbances by three sound types (single pulse, multiple pulse and nonpulse) has been published by Southall *et al* (2007). Just recently, the National Oceanic and Atmospheric Administration (NOAA) compiled and synthesized best available science to guide the assessment of effects of anthropogenic noise on marine mammals (NOAA, 2016). Both guidance documents consider cetaceans and pinnipeds assigned to five functional hearing groups (i.e. low-frequency cetaceans, mid-frequency cetaceans, high-frequency cetaceans, pinniped in water, pinnipeds in air and low-frequency cetaceans, mid-frequency cetaceans, high-frequency cetaceans, phocid pinnipeds underwater, otariid pinnipeds underwater respectively). The assignment to functional hearing groups was based on functional hearing characteristics of the species (e.g. frequency range of hearing, auditory morphology) and with reference to Southall *et al* as well the medium in which the amphibious living pinnipeds were exposed to sound. The developed noise exposure criteria do not address polar bears, sirenians, and sea otters due to the absence of necessary data in these species. To account for different hearing bandwidths and thus differences in impacts of identical noise exposure frequency-weighting functions were developed for each functional hearing group and considered in the formulation of the noise exposure criteria. Southall *et al* and NOAA applied dual criteria for noise exposure using peak sound pressure level (SPL) and sound exposure level (SEL) in each of the considered functional hearing groups in order to account for all relevant acoustic features such as sound level, sound energy, and exposure duration that influence the impacts of noise on marine mammals.

The onset of a permanent threshold shift (PTS-onset) has been considered as the onset of auditory injury (Southall *et al* 2007, NOAA 2016, Finneran 2015). PTS-onset estimates are applied in order to formulate dual noise exposure levels. The PTS-onset thresholds were estimated from measured TTS-onset thresholds (=threshold where temporary change in auditory sensitivity occurs without tissue damage) in very few mid-frequency odontocetes (i.e. bottlenose dolphin and beluga) and pinnipeds (i.e. California sea lion, northern elephant seal, and harbour seal) and extrapolated to other marine mammals due to the scarcity of available TTS data. It has been noted, that this extrapolation from mid-frequency cetaceans and the subsequent formulation of exposure criteria may be delicate in particular for high-frequency cetaceans due to their generally lower hearing threshold as compared to other cetaceans. The growth rates of TTS were estimated based on data in terrestrial and marine mammals exposed to increasing noise levels. Noise exposure levels for single pulse, multipulse and nonpulse sounds were expressed for SPL and SEL whereby the latter has been frequency weighted to compensate for the differential frequency sensitivity in each functional marine mammal hearing group as described above. No noise exposure criteria were developed by Southall *et al* (2007) or NOAA (2016) for the occurrence of non-auditory injuries (e.g. altered immune response, energy reserves, reproductive efforts due to stress, tissue injury by gas and fat emboli), due to a lack of conclusive scientific data to formulate quantitative criteria for any other than auditory injuries caused by noise.

Additionally to auditory injuries Southall *et al* (2007) presented also explicit sound exposure levels for noise impacts on behaviour resulting in significant biological responses (e.g. altered survival, growth, reproduction) for single pulse noise. For the latter it has been assumed that given the nature

(high peak and short duration) of a single pulse behavioural disturbance may result from transient effects on hearing (i.e. TTS). Therefore, TTS values for SPL and SEL were proposed as noise exposure levels. In contrast, for multiple and nonpulse sounds it has been taken into account that behavioural reactions to sounds are highly context-dependent (e.g. activity animals are engaged at the time of noise exposure, habituation to sound) and depending also among others on environmental conditions and physiological characteristics such as age and sex. Thus noise impact on behaviour is less predictable and quantifiable than effects of noise on hearing. Moreover, adverse behavioural effects are expected to occur below noise exposure levels causing temporary loss of hearing sensitivity. Therefore, a descriptive method has been developed by the authors to assess the severity of behavioural responses to multipulse and nonpulse sound. A quantitative scoring paradigm has been developed by Southall *et al* (2007) which numerically ranks (scores) the severity of behavioural responses. Noise exposure levels have been identified in a scoring analysis based on a thorough review of empirical studies on behavioural responses of marine mammals to noise. Reviewed cases with adequate information on measured noise levels and behavioural effects were then considered in a severity scoring table with the two dimensions, severity score and received SPL.

In contrast to former sound exposure assessment attempts Southall *et al* (2007) and NOAA (2016) account for differences in functional hearing bandwidth between marine mammal groups through the developed frequency-weighting functions. Thus, this approach allows to assess the effects of intense sounds on marine mammals under the consideration of existing differences in auditory capabilities across species and groups respectively. Furthermore, as compared to the widely used RMS sound pressure Southall *et al* (2007) and NOAA (2016) propose dual criteria sound metrics (SPL and SEL) to assess the impact of noise on marine mammals, accounting not only for sound pressure but also for sound energy, duration and high-energy transients.

All these aspects are certainly major accomplishment as compared to earlier attempts to assess noise effects on marine mammals. However, it has also to be noted that due to the absence of data noise exposure criteria had to be based on extrapolations and assumptions and therefore, as Southall *et al* (2007) and Finneran (2015) pointed out, caution is needed regarding the direct application of the criteria presented and that it is expected that criteria would change as better data basis becomes available.

D.2. Species Vulnerabilities

The best documented vulnerabilities to noise in marine mammals in terms of number of studies and species involved are certainly behavioural responses to noise. Only a few studies considering a few species exist regarding noise impacts on hearing and hearing sensitivity and physiology in marine mammals and therefore the respective knowledge on specific vulnerabilities of noise is rather scarce.

Auditory effects resulting from intense noise exposure comprise temporary threshold shift (TTS) and permanent threshold shift (PTS) in hearing sensitivity. For marine mammals TTS measurements exist for only a few species and individuals whereas for PTS no such data exist (Southall *et al* 2007, Finneran 2015). Furthermore, noise may cause auditory masking, the reduction in audibility of biological important signals, as has been shown for pinniped species in air and water (Southall *et al* 2000, 2003) and in killer whales (Foote *et al* 2004) for example.

Physiological stress reactions induced by noise may occur in cetaceans as has been shown for few odontocete species where altered neuro-endocrine and cardiovascular functions occurred after high level noise exposure (Romano *et al* 2004, Thomas *et al* 1990c). Furthermore, regarding noise-related physiological effects it has to be noted that scientific evidence indicates that in particular beaked whales experience physiological trauma after military sonar exposure (Jepson *et al* 2003, Fernandez *et al* 2004, 2005) due to in vivo nitrogen gas bubble formation.

The magnitude of the effects of noise on behaviour may differ from biological insignificant to significant (= potential to affect vital rates such as foraging, reproduction, or survival). Noise-induced behaviour response may not only vary between individuals but also intra-individually and depends on a great variety of contextual (e.g. biological activity animals are engaged in such as feeding, mating), physiological (e.g. fitness, age, sex), sensory (e.g. hearing sensitivity), psychological (e.g. motivation, previous history with the sound) environmental (e.g. season, habitat type, sound transmission characteristics) and operational (e.g. sound type, sound source is moving / stationary, sound level, duration of exposure) variables

(Wartzok *et al* 2004).

Observable behavioural responses to noise include orientation reaction, change in vocal behaviour or respiration rates, changes in locomotion (speed, direction, dive profile), changes in group composition (aggregation, separation), aggressive behaviour related to noise exposure and/or towards conspecifics, cessation of reproductive behaviour, feeding or social interaction, startle response, separation of females and offspring, anti-predator response, avoidance of sound source, attraction by sound source, panic, flight, stampede, stranding, long term avoidance of area, habituation, sensitization, and tolerance (Richardson *et al* 1995, Gordon *et al* 2004, Nowacek *et al* 2007, Wartzok *et al* 2004).

Studies have shown that in mysticetes the reaction to the same received level of noise depends on the activity in which whales are engaged in at the time of exposure. For migrating bowhead whales strong avoidance behaviour to seismic air gun noise has been observed at received levels of noise around 120 dB re 1 µPa while engaged in migration. In contrast, strong behavioural disturbance in other mysticetes such as gray and humpback whales as well as feeding bowhead whales has been observed at higher received levels around 150-160 dB re 1 µPa (Richardson *et al* 1985, 1999, Malme *et al* 1983, 1984, Ljungblad *et al* 1988, Todd *et al* 1996, McCauley *et al* 1998, Miller *et al* 2005). Furthermore, in different dolphin species reactions to boat noise varied from avoidance, ignorance and attraction dependant on the activity state during exposure (Richardson *et al* 1995).

Noise-induced vocal modulation may include cessation of vocalization as observed in right whales (Watkins 1986), sperm whales and pilot whales (Watkins and Schevill 1975, Bowles *et al* 1994) for example. Furthermore, vocal response may include changes in output frequency and sound level as well as in signal duration (Au *et al* 1985, Miller *et al* 2000, Biassoni *et al* 2000).

Noise-induced behaviour depends on the characteristics of the area where animals are during exposure and/or of prior history with that sound. In belugas for example a series of strong responses to ship noise such as flight, abandonment of pod structure and vocal modifications, changes in surfacing, diving and respiration patterns has been observed at relatively low received sound levels of 94-105 dB re 1 µPa in a partially confined area but the animals returned after some days while ship noise was higher than before (LGL and Greeneridge 1986, Finley *et al* 1990).

The distance of a noise source or its movement pattern influences the nature of behavioural responses. For instance, in sperm whales, changes in respiration and surfacing rates has been observed in the vicinity of ships (Gordon *et al* 1992) and dependant on whether a ship is moving or not different reactions of bowhead whales and other cetaceans have been observed (Richardson *et al* 1995, Wartzok *et al*, 2004)

D.2.1. Species not listed on the CMS Appendices that should also be considered during assessments

- Deep-diving cetaceans, in particular beaked whales need special consideration regarding noise exposure levels due to the risk for tissue trauma due to gas and fat emboli under certain noise conditions.
- Due to their lower overall hearing thresholds, high-frequency hearing cetaceans (true porpoises, river dolphins, *Pontoporia blainvillei, Kogia breviceps, Kogia sima, cephalorhynchids*) may need additional consideration as their sensitivity to absolute levels of noise exposure may be higher than other cetacean hearing groups.
- Southall *et al* pointed out that due to a lack of data they could not formulate noise exposure levels for polar bears, sea otters, and sirenians. Certainly a point which needs consideration when dealing with areas where these marine mammal taxa occur.

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E. Marine Noise-generating Activities

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Wild Migration

E.1. Military Sonar

E.1.1. Low Frequency Active Sonar

The evolution of lower frequency active (LFA) sonar came from two needs. First, to increase detection ranges to overcome passive sonar systems and second, to compensate for the improvements of stealth designs in submarine hulls, part of which was an anechoic coating that absorbed incident waves. It was discovered this coating was less efficient when exposed to longer wave lengths.

LFA sonars work below the 1KHz range. For transmitting long distances efficiently, high powered modulated signals, typically 240 dB in water at 1m, peak value, (240 dB re 1μPa @ 1m peak) are produced lasting from tens of seconds to sometimes minutes. An example of this technology is the SURTASS-LFA of the US navy that operates within 100-500Hz range. (Lurton, 2010)

E.1.2. Mid Frequency Active Sonar

Mid frequency active (MFA) sonar is used for detecting submarines at moderate range, typically less than 10km.

MFA operates between 1-5 KHz range, with a sound intensity levels typically 235 dB in water at 1m, peak value, (235 dB re 1μPa @ 1m peak) with pulse duration of 1-2 seconds. (Hildebrand, 2009, Fildelfo *et al*, 2009)

E.1.3. Continuous Active Sonar

The concept of continuous active sonar (CAS) is generating interest in the anti-submarine warfare community, largely due to it's 100 per cent duty cycle offering the potential for rapid, continuous detection updates. CAS operates between 500Hz to 3KHz range with sound intensity levels typically 182 dB in water at 1m, peak value, (182 dB re 1μPa @ 1m peak) with a signal duration of 18 seconds (Murphy and Hines, 2015)

E.1.4. Mine Counter Measures Sonar

Underwater mines have proven, over time, to be very affective. There prevalence led to the development of the Mine Counter Measures (MCM) sonar. This system works at very high frequency, usually between 100-500KHz, to achieve high quality acoustic imaging of the sea floor and water column. Targets, semi-buried or suspended from the sea floor, are easily identified. (Lurton, 2010)

E.1.5. Acoustic Minesweeping Systems

Acoustic Minesweeping Systems are another mine counter-measure that produces a low frequency broadband transmission, mimicking the sound produced by certain vessels whereby detonating the mine. (Lurton, 2010)

E.2. Seismic Surveys

The commonly used surveying method for offshore petroleum exploration is ‘seismic reflection’. This is simply sound energy discharged from a sound source (air gun array) at the sea surface that penetrates subsurface layers of the seabed and is reflected to the surface where it is detected by acoustic receivers (hydrophones).

These surveys are typically conducted using specially equipped vessels that tow one or more cables (streamers) with hydrophones at constant intervals. Air guns vary in size and in conjunction with the charge pressure, determine the sound intensity level and frequency.

Frequencies used for seismic surveys are between 10-200Hz and down to 4-5Hz for the larger air guns. However, there are unused high frequency components up to 150KHz, with a very high discharge at the onset of the pulse. Sound intensity levels of 170dB in water at 1m, peak to peak value, (170 dB re 1μPa @

1m p-p) at 10KHz down to 120dB in water at 1m, peak to peak value, (120 dB re 1μPa @ 1m p-p) at 100KHz respectively. (Goold and Coates, 2006)

The typical discharge of each pulse of an air gun array is around 260-262 dB in water at 1m, peak to peak value, (260-262 dB re 1μPa @ 1m p-p) (OSPAR, 2009) every 10-15 seconds, and surveys typically run more or less continuously over many weeks. (Urick, 1983, Clay and Medwin, 1997, Caldwell and Dragoset, 2000, Dragoset, 2000, Lurton, 2010, Prideaux and Prideaux, 2015)

E.3. Civil High Power Sonar

Seafloor mapping sonar systems are probably one of the most prolific forms of underwater noise generation. The main application is coastal navigation for the production of bathymetric charts. Other applications include geology, geophysics, underwater cables and oil industry exploration and exploitation. Three examples are Single Beam Sounders (SBES), Sidescan Sonas and Multibeam Echo Sounders (MBES).

E.3.1. Single Beam Sounders

Single beam sounders point vertically below the vessel and transmit a short signal, typically 0.1ms. The frequencies vary on their application. For deep water, the frequency would be around 12KHz and increase to 200, 400 and even 700KHz for shallow water. The sound intensity level is usually around 240 dB in water at 1m, peak value (240 dB *re* 1μPa @ 1m peak). (Lurton, 2010)

E.3.2. Sidescan Sonar

Sidescan sonar system structures are similar to single-beam sonars. This sonar differs as it is installed on a platform or “towfish” and towed behind a vessel close to the seabed. Two antennae are placed perpendicularly to the body of the towfish, pointing fractionally to the sea floor. The transmission of the sidescan sonar insonifies the sea floor with a very narrow perpendicular band. The echo received along time, reflects the irregularities of the sea floor. A simple analogy is the scan mechanism of a photo copier. The operating frequency is usually in the range of many hundreds of KHz with the pulse duration 0.1ms or less. (Lurton, 2010)

E.3.3. Multibeam Echosounder

Multibeam echosounders are the major tool for seafloor mapping, for hydrography and offshore industry applications. The transmission and receiving arrays are mounted on the vessel to create a narrow beam, fan-like 150º spread, perpendicular to the keel.

Multibeam sounders can be put into three main catagories depending on their system structure and varied uses:

- Deep water systems, designed for regional mapping, 12Khz for deep ocean, 30Khz for continental slopes.
- Shallow water systems designed for mapping continental shelves, 70-200KHz and
- High-resolution systems for hydrography, shipwreck location and underwater structural inspection, 300-500Khz.

The attraction for multibeam systems is the scale of area that can be covered over time. For instance, a deep water configured multibeam sounder with a 20km fan/spread can cover 10,000km² per day. (Lurton, 2010)

E.3.4. Boomers, Sparkers and Chirps

Sparkers and boomers are high frequency devices which are generally used to determine shallow features in sediments. These devices may also be towed behind a survey vessel, with their signals penetrating several tens (boomer) or hundred (sparker) of metres of sediments. Typical sound intensity levels of sparkers are approximately 204-210 dB in water at 1m, rms value (204-210 dB re 1 μPa @ 1 m). Deep-tow boomer sound intensity levels are approximately 220 dB in water at 1m, rms value (220 dB re 1 μPa @ 1 m). The frequency range of both is 80Hz-10kHz and the pulse length is 0.2 ms. (Aiello *et al*, 2012, OSPAR, 2009)

Chirps produce sound in the upper frequency range around 20Hz-20 kHz. (Mosher and Simpkin, 1999) The sound intensity level for these devices is about 210-230 dB in water at 1m, peak value, (210-230 dB re 1 μPa @ 1 m) and the pulse length is 250ms. (Dybedal and Boe, 1994, Lee *et al*, 2008, OSPAR, 2009)

E.4. Coastal and Offshore Construction Works

E.4.1. Explosions

Explosions are used in construction and for the removal of unwanted seabed structures. Underwater explosions are one the strongest anthropogenic sound sources and can travel great distances. (Richardson *et al*, 1995) Sound

intensity levels vary with the type and amount of explosive used and the depth to which it is detonated. TNT, 1-100lbs, can produce a sound intensity level from 272-287 dB in water at 1m, zero to peak value, (272-287 dB re 1µPa zero to peak @ 1m) with a frequency range of 2-~1000Hz for a duration of <1-10ms. The core energy is between 6-21Hz. (Richardson *et al*, 1995, NRC, 2003)

E.4.2. Pile driving

Pile driving is associated with harbour work, bridge construction and wind farm foundations. Sound intensity levels vary depending on pile size and type of hammer. There are two types of hammers, an impact type (diesel or hydraulic) and vibratory type. Vibratory type hammers generate lower source levels, but the signal is continuous, where impact hammers are louder and plosive. The upper range is around 228 dB in water at 1m, peak value or 248-257 dB in water at 1m, peak to peak value, (228 dB re 1µPa peak @ 1 m/248-257 dB re 1µPa peak to peak @ 1m) with frequencies ranging within 20Hz-20KHz and a duration of 50ms. (Nedwell *et al*, 2003, Nedwell and Howell, 2004, Thomsen *et al*, 2006, OSPAR, 2009)

E.4.3. Dredging

Dredging is used to extract sand and gravel, to maintain shipping lanes and to route pipelines. The sound intensity level produced is approximately 168-186 dB in water at 1m, rms value, (168-186 dB re 1µPa @ 1m rms) with frequencies ranging from 20Hz->1KHz with the main concentration below 500Hz.

The majority of this sound is constant and non-plosive. (Richardson *et al*, 1995, OSPAR, 2009)

E.5. Offshore Platforms

E.5.1. Drilling

Drilling can be done from natural or manmade islands, platforms, drilling vessels, semi submersibles or drill ships.

For natural or manmade islands, the underwater sound intensity level has been measured at 145 dB in water at 1m, rms value, (145 dB re 1µPa @1m rms) with frequencies below 100Hz. (Richardson *et al*, 1995)

The sound intensity level transmitted down the caissons with platform drilling has been measured at approximately 150 dB in water at 1m, rms value, (150 dB re 1µPa rms @ 1m) at 30-40Hz frequency. (Richardson *et al*, 1995)

Drill ships seem to emit the highest sound intensity level, 190 dB in water at 1m, rms value, (190 dB re 1µPa @ 1m rms) with the frequencies ranging between 10Hz-10KHz, due to the efficient transmission of sound through the ship's hull. Additionally, ships use their location thrusters to keep them on target, combining propeller, dynamic positioning transponder (placed on the hull and sea floor) pingers (see below), and drill noise. (Richardson *et al*, 1995, OSPAR, 2009, Kyhn *et al*, 2014)

E.5.2. Positioning Transponders

Positioning transponders are used to dynamically position drill ships and other offshore platforms. Each system uses a concatenation of master and slave transponders. These systems have been recorded to have sound intensity level of 100 dB in water at 2km, rms value (100 dB re 1µPa @ 2km rms) with the frequencies ranging between 20KHz to 35KHz. (Kyhn *et al*, 2014)

E.5.3. Related Production Activities

During production, noise sources include seafloor equipment such as separators, injectors and multi-phase pumps operating at very high pressures.

There have also been studies to measure the sound intensity levels during production maintenance operations. Sound intensity levels of 190dB rms from the drill ship (distance unknown) with a frequency range between 20Hz-10KHz were recorded. (Kyhn *et al*, 2014) To date there have been no other systematic studies to measure the source levels of production maintenance. It is likely the sound intensity level is high. This is an area that needs focused attention.

E.6. Playback and Sound Exposure Experiments

E.6.1. Ocean Tomography

Ocean science uses a variety of sound sources. These include explosives, air guns and underwater sound projectors. Ocean tomography measures the physical properties of the ocean using frequencies between 50-200Hz with a sound intensity level of 165-220 dB in water at 1m (165-220 dB re 1µPa @ 1m). The *Acoustic Thermometry of Ocean Climate* research programme emitted a sound source of 195 dB in water at 1m, peak value, (195 dB re 1µPa @ 1m peak) at a frequency of 75Hz.

Geophysical research activities, one of which is the study of sediments in shallow water, also use typical mid or low frequency sonar systems or echo-sounders. (OSPAR, 2009) These are discussed under Civil High Power Sonar.

E.7. Shipping and Vessel Traffic

Marine vessels, small to large, contribute significantly to anthropogenic noise in the oceans. The trend is usually, the larger the vessel, the lower the frequencies produced resulting in the noise emitted travelling greater distances. The sound characteristics produced by individual vessels are determined by the vessels class/type, size, power plant, propulsion type/design and hull shape with relation to speed. Also, the vessel's age in terms of mechanical condition and the cleanliness of the hull: Less drag means less noise.

E.7.1. Small Vessels

Small vessels (leisure and commercial) for this paper are vessels up to 50m in length. These include planing hull designs such as jet skis, speed boats, light commercial run-abouts as well as displacement hull designs like motor yachts, fishing vessels and small trawlers.

The greater portion of sound produced by these vessels is mainly above 1KHz mostly from propeller cavitation. Factors that generate frequencies below 1KHz are engine and gearbox noise as well as propeller resonance. The sound intensity level produced is approximately 160-180 dB in water at 1m, rms value, (160-180 dB re 1µPa @ 1m rms) with frequencies ranging 20Hz ->10KHz. This, however, is dependent on the vessel's speed in relation to hull efficiency and economic speed to power settings. (Richardson *et al*, 1995, OSPAR, 2009)

E.7.2. Medium Vessels

Medium vessels for this paper are vessels between 50-100m, such as tugboats, crew-boats, larger fishing/trawler and research vessels. These vessels tend to have slower revving engines and power trains. The frequencies produced tend to mimic large vessels with the majority of sound energy below 1KHz. The sound intensity level produced is approximately 165-180 dB in water at 1m, rms value (165-180 dB re 1µPa @ 1m rms). (Richardson *et al*, 1995, OSPAR, 2009)

E.7.3. Large Vessels

Large vessels for this paper are vessel lengths greater than 100m, such as container/cargo ships, super-tankers and cruise liners.

Large vessels, depending on type, size and operational mode, produce their strongest sound intensity level of approximately 180-190 dB in water at 1m, rms value, (180-190 dB re 1µPa @ 1m rms) at a few hundred Hz. (Richardson *et al*, 1995, Arvenson and Vendittis, 2000) In addition, a significant amount of high frequency sound, 150 dB in water @ 1m, rms value, (150 dB re 1µPa @ 1m rms) or broadband frequencies, 0.354-44.8 kHz of 136 dB in water at 700m distance, rms value, (136 dB re: 1µPa @ >700m rms) can be generated through propeller cavitation. This near-field source of high-frequency sound is of concern particularly within shipping corridors, shallow coastal waters, waterways/canals and/or ports. (Arveson and Vendettis, 2000, Aguilar Soto *et al*, 2006, OSPAR, 2009)

E.8. Pingers

E.8.1. Acoustic Navigation and Positioning Beacons

Acoustic navigation and positioning beacons mark the position of an object and measure its height above the seabed. Most underwater beacons emit a short continuous wave tone, commonly 8-16 kHz octave band, with a stable ping rate. Typical sound intensity levels are around 160-190 dB in water at 1m, peak value (160-190 dB *re* 1µPa @ 1m peak). They are designed to be omnidirectional so as to be heard from any direction. Simple systems are programmed to transmit a fixed ping rate whilst more sophisticated systems transmit after receiving an interrogating signal. (Lurton, 2010)

E.8.2. Acoustic Deterrent Devices

Acoustic Deterrent Devices (ADDs) are a low powered device, 130-135 dB in water at 1m, peak value, (130-135 dB *re* 1µPa @ 1m peak) designed to deter fish from entering places of harm such as water inlets to power stations. The frequencies range from 9-15KHz for a duration 100-300ms every 3-4 seconds. (Carretta *et al*, 2008, Lepper *et al*, 2004, Lurton, 2010, OSPAR Commission, 2009)

E.8.3. Acoustic harassment devices

Acoustic Harassment Devices (AHDs) are a higher powered device, 190 dB in water

at 1m, peak value, (190 dB *re* 1μPa @ 1m peak) originally designed to keep marine mammals away from fish farms by causing them pain. Frequencies range from 5-20KHz for repelling pinipeds and 30-160KHz for delphinids. (Carretta *et al*, 2008, Lepper *et al*, 2004, Lurton, 2010, OSPAR, 2009)

E.9. Other Noise-generating Activities

E.9.1. Acoustic Data Transmission

Acoustic modems are used as an interface for subsurface data transmission. Frequencies range around 18-40KHz with a sound intensity level around 185-196dB in water at 1m (185-196 dB re 1μPa @ 1m). (OSPAR, 2009)

E.9.2. Offshore Tidal and Wave Energy Turbines

Offshore tidal and wave energy turbines are new, so acoustic information is limited. However, they appear to emit a frequency range of 10Hz-50KHz and a sound intensity level between 165-175dB in water at 1m, rms value, (165-175 dB re 1μPa @ 1m rms) depending on size. (OSPAR, 2009)

E.9.3. Wind turbines

The operational sound intensity levels for wind generators depend on construction type, size, environmental conditions, type of foundation, wind speed and the accumulative effect from neighbouring turbines. A 1.5MW turbine in 5-10m of water with a wind speed of 12m/s has been recorded producing 90-112 dB in water at 110m, rms value, (90-112 dB re 1μPa @ 110m rms) with frequencies ranging 50Hz-20KHz. (Thomsen *et al*, 2006, OSPAR, 2009)

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Table 9: Noise-generating activity, sound intensity level, bandwidth, major amplitude, duration and directionality

Sound	Sound Intensity Level (dB re1 ìPa)	Bandwidth	Major Amplitude	Duration	Directionality
Military					
Military Low Frequency Active Sonar	240 Peak @ 1m	<1KHz- 1Khz	[unknown]	600-1,000ms	Horizontally focused
Military Mid Frequency Active Sonar	235 Peak @ 1m	1-5KHz	[unknown]	1-2s	Horizontally focused (3 degrees down)
Continuous Active Sonar	182 Peak @ 1m	500Hz – 3KHz	[unknown]	18 seconds	Horizontally focused
Military Mine Counter Measures Sonar	[unknown]	100KHz-500KHz	[unknown]	[unknown]	[unknown]
Seismic Surveys					
Seismic Surveys	260-262 Peak to Peak @ 1m	10Hz-150KHz	10-120Hz also 120dB up to 100Kz	30-60ms	Vertically focused
Civil High Power Sonar					
Single Beam Sounders	240 Peak @ 1m	12KHz-700KHz depending on the application	[unknown]	0.1ms	Vertically focused
Sidescan Sonar	240 Peak @ 1m	12KHz-700KHz depending on the application	[unknown]	0.1ms	Vertically focused fan spread
Multibeam Echosounders	240 Peak @ 1m	12KHz-30KHz, 70KHz-200KHz, 300KHz-500KHz depending on the application	[unknown]	0.1ms	Vertically focused fan spread
Sparkers and Boomers	204-220rms @ 1m	80Hz-10KHz	[unknown]	0.2ms	[unknown]
Chirps	210-230 Peak @ 1m	20Hz-20KHz	[unknown]	250ms	[unknown]
Coastal and Offshore Construction Works					
Explosions, TNT 1-100lbs	272-287 Peak @ 1m	2Hz-~1,000Hz	6-21Hz	<1-10ms	Omnidirectional
Pile Driving	248-257 Peak to Peak @ 1m	20Hz-20KHz	100Hz-500Hz	50ms	Omnidirectional
Dredging	168-186 rms @ 1m	20Hz-1KHz	500Hz	Continuous	Omnidirectional
Offshore Platforms					
Platform Drilling	150 rms @1m	30Hz-40Hz	[unknown]	Continuous	Omnidirectional
Drill Ships (including maintenance)	190 rms @ 1m	10Hz-10KHz	[unknown]	Continuous	Omnidirectional
Positioning transponders	100 rms @ 2km	20KHz - 35KHz	[unknown]	Continuous	Omnidirectional

Sound	Sound Intensity Level (dB re1 ìPa)	Bandwidth	Major Amplitude	Duration	Directionality
Playback and Sound Exposure Experiments					
Ocean Tomography	165-220 Peak @ 1m	50Hz-200Hz	[unknown]	[unknown]	Omnidirectional
Shipping and Vessel Traffic					
Small Vessels	160-180 rms @ 1m	20Hz-10KHz	[unknown]	Continuous	Omnidirectional
Medium Vessels	165-180 rms @1m	Below 1KHz	[unknown]	Continuous	Omnidirectional
Large Vessels	Low Frequency 180-190 rms @ 1m High Frequency 136 rms @ 700m	Low Frequency A few hundred Hz High Frequency 0.354Khz-44.8Khz	[unknown]	Continuous	Omnidirectional
Pingers					
Acoustic Navigation Beacons	160-190 Peak @ 1m	8KHz-16KHz	[unknown]	[unknown]	Omnidirectional
Acoustic Deterrent Devices	130-135 Peak @ 1m	9KHz-15KHz	[unknown]	100-300ms	Omnidirectional
Acoustic Harassment Devices	190 Peak @ 1m	5Khz-20KHz, 30KHz-160KHz depending on the application	[unknown]	[unknown]	Omnidirectional
Other Noise-generating Activities					
Acoustic Data Transmission	185-196 @ 1m	18KHz-40KHz	[unknown]	[unknown]	Omnidirectional
Offshore Tidal and Wave Energy Turbines	165-175 rms @ 1m	10Hz-50KHz	[unknown]	Continuous	Omnidirectional
Wind Turbines	90-112 rms @ 110m	50Hz-20KHz	[unknown]	Continuous	Omnidirectional

F. Related Decisions of Intergovernmental Bodies or Regional Economic Organisations

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A series of important intergovernmental decisions have already determined the direction for regulating anthropogenic marine noise through EIAs. The following decisions are the latest from each of MEA.

F.1. CMS

'CMS Resolution 9.19: Adverse Anthropogenic Marine/Ocean Noise Impacts on Cetaceans and Other Biota' encourages Parties to:

> *'…to endeavour to control the impact of emission of man-made noise pollution in habitat of vulnerable species and in areas where marine mammals or other endangered species may be concentrated, and where appropriate, to undertake relevant environmental assessments on the introduction of systems which may lead to noise associated risks for marine mammals.'*

'CMS Resolution 10.24: Further Steps to Abate Underwater Noise Pollution for the Protection of Cetaceans and Other Migratory Species' encourages CMS Parties to:

> *'…prevent adverse effects on cetaceans and on other migratory marine species by restricting the emission of underwater noise, understood as keeping it to the lowest necessary level with particular priority given to situations where the impacts on cetaceans are known to be heavy"* and *"[u]rges Parties to ensure that Environmental Impact Assessments take full account of the effects of activities on cetaceans and to consider potential impacts on marine biota and their migration routes …'*

'Resolution 10.24' further articulates that CMS Parties should ensure that Environmental Impact Assessments take full account of the impact of anthropogenic marine noise on marine species, apply Best Available Techniques (BAT) and Best Environmental Practice (BEP), and integrate the issue of anthropogenic noise into the management plans of marine protected areas. 'Resolution 10.24' also 'invites the private sector to assist in developing …alternative techniques and technologies for coastal, offshore and maritime activities'.

F.2. ACCOBAMS

'ACCOBAMS Resolution 5.13: Conservation of Cuvier's beaked whales in the Mediterranean' and 'Resolution 5.15: Addressing the impact of anthropogenic noise' reinforces the commitments made in 'Resolution 4.17: Guidelines to Address the Impact of Anthropogenic Noise on Cetaceans in the ACCOBAMS Area (ACCOBAMS Noise Guidelines)' that urges ACCOBAMS Parties to:

> *'[r]ecogniz[e] that anthropogenic ocean noise is a form of pollution, caused by the introduction of energy into the marine environment, that can have adverse effects on marine life, ranging from disturbance to injury and death.'*

This Resolution also encourages ACCOBAMS Parties to:

> *' … address fully the issue of anthropogenic noise in the marine environment, including cumulative effects, in the light of the best scientific information available and taking into consideration the applicable legislation of the Parties, particularly as regards the need for thorough environmental impact assessments being undertaken before granting approval to proposed noise-*

producing activities.'

The ACCOBAMS Noise Guidelines provide further comprehensive detail-specific considerations relating to military sonar, seismic surveys and offshore drilling, shipping and offshore renewable energy developments.

F.3. ASCOBANS

'ASCOBANS Resolution 5.4: Adverse Effects of Sound, Vessels and other Forms of Disturbance on Small Cetaceans', urges ASCOBANS Parties to:

> *'… develop, with military and other relevant authorities, effective mitigation measures including environmental impact assessments and relevant standing orders to reduce disturbance of, and potential physical damage to, small cetaceans, and to develop and implement procedures to assess the effectiveness of any guidelines or management measures introduced.'*

'ASCOBANS Resolution 6.2: Adverse Effects of Underwater Noise on Marine Mammals during Offshore Construction Activities for Renewable Energy Production', further recommends that Parties:

> *'… include Strategic Environmental Assessments and Environmental Impact Assessments carried out prior to the construction of marine renewable energy developments and taking into account the construction phase and cumulative impacts'*

and to:

> *'… introduce precautionary guidance on measures and procedures for all activities surrounding the development of renewable energy production in order to minimise risks to populations …* [that include] *measures for avoiding construction activities with high underwater noise source levels during the periods of the year with the highest densities of small cetaceans, and in so doing limiting the number of animals exposed, if potentially significant adverse effects on small cetaceans cannot be avoided by other measures;* [to include] *Measures for avoiding construction activities with high underwater noise source levels when small cetaceans are present in the vicinity of the construction site;* [and] *technical measures for reducing the sound emission during construction works, if potentially significant adverse effects on small cetaceans cannot be avoided by other measures.'*

F.4. CBD

'CBD Decisions VIII/28: CBD Voluntary Guidelines on Biodiversity-inclusive Impact Assessment'provides detailed guidance on whether, when and how to consider biodiversity in both project level and strategic levels assessments. The document clearly articulates screening, scoping, assessment and evaluation of impacts, development and alternatives; tranparency and consultation, reporting, review and decision-making. The guidelines urge that environmental impact assessments should be mandatory for activities known to be in habitats for threatened species and activities resulting in noise emissions in areas that provide key ecosystem services. The guidelines further articulate that environment impact assessment should be considered for activities resulting in noise emissions in areas providing other relevant ecosystem services.

'CBD Decision XII/23: Marine and coastal biodiversity: Impacts on marine and coastal biodiversity of anthropogenic underwater noise' encourages CBD Parties and others:

> *'… to take appropriate measures, as appropriate within competencies and in accordance with national and international laws, such as gathering additional data about noise intensity and noise types, and building capacity in developing regions where scientific capacity can be strengthened.'*

In 'Decision XII/23' CBD Parties have agreed to a significant list of technical commitments, including gathering additional data about noise intensity and noise types, and building capacity in developing regions where scientific capacity can be strengthened.

The CBD Parties also encouraged Parties to take appropriate measures, including:

> *'… (e) Combining acoustic mapping with habitat mapping of sound-sensitive species with regard to spatial risk assessments in order to identify areas where those species may be exposed to noise impacts,*
> *(f) Mitigating and managing anthropogenic underwater noise through the use of spatio-temporal management of activities, relying on sufficiently detailed temporal and spatial knowledge of species or*

population distribution patterns combined with the ability to avoid generating noise in the area at those times,

(g) Conducting impact assessments, where appropriate, for activities that may have significant adverse impacts on noise-sensitive species, and carrying out monitoring, where appropriate.'

'Decision XII/23' urges the transfer to quieter technologies and applying the best available practice in all relevant activities.

F.5. IMO

The International Maritime Organization (IMO), through 'Resolution A 28/Res.1061', has requested that the Marine Environment Protection Committee (MEPC) keep under review measures to reduce adverse impact on the marine environment by ships, including developing:

'[g]uidance for the reduction of noise from commercial shipping and its adverse impacts on marine life'

F.6. IWC

The Scientific Committee of the International Whaling Commission (IWC) continues to monitor and discuss the impacts of noise on cetaceans.

F.7. OSPAR

The Convention for the Protection of the Marine Environment of the North-East-Atlantic (OSPAR) has reached agreement on an 'OSPAR Monitoring Strategy for Ambient Underwater Noise'.

The OSPAR Intersessional Correspondence Group on Noise (ICG-NOISE) is currently working closely with the International Council for the Exploration of the Sea (ICES) data team to produce the 2017 OSPAR Intermediate Assessment for impulsive noise. This is the first regional assessment of its kind, and will give policy-makers and regulators a regional overview of cumulative impulsive noise activity in the Northeast Atlantic, including the noise source type (e.g. pile driver, explosion) and intensity. The 2017 Intermediate Assessment will serve as a 'roof report' to inform the subsequent 2018 MSFD assessments of EU Member States within the OSPAR region.

F.8. Espoo (EIA) Convention

In 'Decision II/8' Espoo Parties endorsed the Good Practice Recommendations on Public Participation in Strategic Environmental Assessment set out in document 'ECE/MP.EIA/SEA/2014/2', including and requirement that

'… the public to be given an opportunity to comment on draft plans or programmes and the associated environmental reports,'

And that*:*

'[p]eople who are affected by a plan or programme and are interested in participating must be given access to all necessary information and be able to participate in meetings and hearings related to the SEA process'

This applies during the different stages of the assessment, including screening, scoping, availability of the draft plan/programme and environmental report, opportunity for the public to express its opinions and decision.

F.9. HELCOM

The Baltic Marine Environment Protection Commission - Helsinki Commission (HELCOM) has two important programmes in development. The Baltic Sea Information on the Acoustic Soundscape Project surveyed national needs and requirements of information on noise and will recommend monitoring of ambient noise in the Baltic Sea. A registry of impulsive sounds project is also being considered.

F.10. Regional Seas Programmes

Most of the six UNEP administered Regional Seas Programmes including the Wider Caribbean Region, East Asian Seas, Eastern Africa Region, Mediterranean Region, North-West Pacific Region and the Western Africa Region and seven non-UNEP Administered Regional Seas Programmes including the Black Sea Region, North-East Pacific Region, Red Sea and Gulf of Aden, ROPME Sea Area, South Asian Seas, South-East Pacific Region and the Pacific Islands Region suggest some form of impact assessment should be conducted to mitigate threats the marine environment.

F.11. European Union Legislation and Implementation

A number of pieces of EU legislation on environmental impact assessment and nature protection are relevant and contain specific references to the marine environment and wildlife and noise.

Recital 12 of Directive 2014/52/EU of the European Parliament and the Council, which amends Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment, specifically mentions the marine environment and gives the example of one source of noise-generating activity:

> *'With a view to ensuring a high level of protection of the marine environment, especially species and habitats, environmental impact assessment and screening procedures for projects in the marine[1] environment should take into account the characteristics of those projects with particular regard to the technologies used (for example seismic surveys using active sonars).'*

In addition, Recital 33 of this Directive also requires that:

> *'Experts involved in the preparation of environmental impact assessment reports should be qualified and competent. Sufficient expertise, in the relevant field of the project concerned, is required for the purpose of its examination by the competent authorities in order to ensure that the information provided by the developer is complete and of a high level of quality.'*

The marine environment is mentioned in Annex III paragraph 2 (ii) related to legal article 4(3) and noise and vibration are listed in Annex IV paragraphs 1 (d) and 5 (c) among information to be supplied according to Article 5 (1).

The EIA Directive applies to all Member States and requires that, for certain types of projects listed in its Annexes, public and private projects likely to have significant effects on the environment by virtue inter alia of their size, nature or location are made subject to an assessment of their environmental effects.

Under the EIA Directive "project" means '*the execution of construction works or of other installations or schemes*' and '*other interventions in the natural surroundings and landscape including those involving the extraction of mineral resources*'.

For projects listed in Annex I of the EIA Directive an assessment should always be carried out, whereas for projects listed in Annex II, Member States have to determine whether an assessment is to be carried out through a case-by-case examination or according to thresholds or criteria set by the Member State.

The so-called EU nature directives (Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (Habitats Directive) and Council and European Parliament Directive 2009/147/EC on the conservation of wild birds (Birds Directive) are also relevant. For the Natura 2000 sites designated for the protection of features such as marine animal species listed in Annex II of the Habitats directive, measures are required under Art. 6(2) to avoid any significant disturbance of those species, while different human activities that are likely to have a significant effect on Natura 2000 sites need to be properly assessed and authorized in accordance with the provisions of article 6 (3) and (4) of the Habitats Directive. This provision also includes the obligation to assess the cumulative impacts of different activities on the conservation objectives of the site. Furthermore, the provisions of Article 12 of the Habitats Directive, which includes an obligation to prohibit deliberate disturbance of strictly protected species, are also particularly relevant in such situation, as all species of cetaceans and a number of marine vertebrates and invertebrates listed in Annex IV(a) benefit from a system of strict protection.

The Commission guidance document on '*establishing Natura 2000 sites in the marine environment*'[1] contains a specific section on noise pollution.

There is specific legislation on the marine environment. In 2008 the European Parliament and the Council adopted the Marine Strategy Framework Directive[2] which requires Member States to achieve or maintain good environmental status of European Union marine waters by 2020, by developing marine strategies. Marine strategies contain 5 main elements: the initial assessment, the determination of good environmental status, the establishment of environmental targets, the monitoring programmes and the programme of measures.

When determining good environmental status, Member States shall determine a set of characteristics on the basis of 11 qualitative

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1 Guidelines for the establishment of the Natura 2000 network in the marine environment: Application of the Habitats and Birds Directives (pp. 94-96)

2 Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for Community action in the field of marine environmental policy.

descriptors. One of these descriptors state:

"*Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.*"

This is further specified in Commission Decision 2010/477/EU[3] which states that:

"… anthropogenic sounds may be of short duration (e.g. impulsive such as from seismic surveys and piling for wind farms and platforms, as well as explosions) or be long lasting (e.g. continuous such as dredging, shipping and energy installations) affecting organisms in different ways."

The following criteria and indicators are laid down in that Decision:

"11.1. Distribution in time and place of loud, low and mid frequency impulsive sounds

- Proportion of days and their distribution within a calendar year over areas of a determined surface, as well as their spatial distribution, in which anthropogenic sound sources exceed levels that are likely to entail significant impact on marine animals measured as Sound Exposure Level (in dB re 1μPa2.s) or as peak sound pressure level (in dB re 1μPapeak) at one metre, measured over the frequency band 10 Hz to 10 kHz (11.1.1)

11.2. Continuous low frequency sound

- Trends in the ambient noise level within the 1/3 octave bands 63 and 125 Hz (centre frequency) (re 1μPa RMS, average noise level in these octave bands over a year) measured by observation stations and/or with the use of models if appropriate (11.2.1)."

Within the context of the Marine Strategy Framework Directive, Member States sharing a marine region or sub-region are also encouraged to cooperate to deliver on the objectives of the Directive.

3 Commission Decision 2010/477/EU on criteria and methodological standards on good environmental status of marine waters.

G. Principles of EIAs

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The principle of Environmental Impact Assessment (EIA) was developed and introduced in the 1960s during a time where there was a growth of modern environmental concern, a drive for more rational, scientific and objective environmental decision-making and a desire for more public involvement in environmental decision making. (Weston, 2002)

Conducting EIAs is now a well established governance and environmental management process, institutionalized in most of the 193 United Nations Member States (Glasson *et al* 2013, Morrison-Saunders and Retief, 2012).

A number of intergovernmental bodies have elaborated the principles of what EIAs should present (see Module G).

Through the process of their adoption, governments have individually committed to reflecting these decisions in their domestic law. The 'weight' of these decisions taken by governments at an international level is considerable and provides significant clarity about the expectations to conduct EIAs and effectively manage impacts of marine noise-generating activities.

A number of jurisdictions have already developed national and regional operational guidelines about mitigating anthropogenic noise on marine fauna during activities. These began with the United Kingdom's Joint Nature Conservation Committee guidelines. Similar guidelines have been iteratively developed in the United States of America, Brazil, Canada, Australia and New Zealand (Castellote 2007, Weir and Dolman 2007). These European Espoo Convention also provides guidance. These are important and necessary operational guidelines. They form a part of, but are not the totality of what should be considered within an EIA.

This Module provides some general principles to ensure environmental impacts (broadly defined to include the physical, life and social sciences) are an explicit and fundamental consideration both during the design of an activity and in the project authorisation by a regulator. (Cashmaore, 2004)

It is clear that there is sufficient international agreement that EIAs should be conducted. There is widespread national legal commitment and some detail in a few jurisdictions. What is now required is a change of practice: by regulators to insist thorough EIAs are presented, and by proponents to accept the same. (Morrison-Saunders and Retief, 2012, Prideaux and Prideaux, 2015)

G.1. The importance of early Strategic Environmental Assessment

There is strong value in governments' undergoing a level of assessment before inviting proponents to propose activities. Conducting proactive and early assessment of groups of activities, in the context of broader governmental vision, goals or objectives, can serve as a decision-support instrument that shapes as a process. (Morgan, 2012) Commonly called Strategic Environmental Assessments (SEA), these exercises can highlight the likely outcomes of anticipated activities and reduce stakeholder conflict by restricting or directing activity development before any commercial investment has been made. (Alshuwaikhat, 2005, Fundingsland Tetlow and Hanusch, 2012).

SEAs have the potential to act as a mediating instrument, bridging problem perceptions with technical solutions and steering the assessment to facilitate the integration of environmental values into decision-making processes. (Therivel, 2012, Fundingsland Tetlow and Hanusch, 2012)

SEA can enhance communication between different stakeholders, enabling discussion and agreement independently of different beliefs, convictions, social roles,

values, accumulated experiences, individual needs or other factors. (Vicente and Partidário, 2006) SEAs can also provide guidance to regulators about the institutional requirements needed to properly assess proposals. This will include their internal organizational structure, staffing and capacity. (Therivel, 2012, Fundingsland Tetlow and Hanusch, 2012)

SEA design should reflect the basic principles of the EIAs and the EIA Guidelines in Module I.

G.2. Basic Principles of EIAs

It is broadly accepted that the basic intent of EIAs is to anticipate the significant environmental impacts of development proposals before any commitment to a particular course of action. Often, the detail required within EIAs is poorly defined. Many legislative provisions for EIAs have been introduced without consideration of the institutional requirements, organizational structure, staffing and capacity development (Cashmore *et al*, 2004, Devlin and Yap 2008, Jay *et al*, 2007). Often the scientific basis and methods need sophisticated understanding.

Defensible EIAs, representing the Best Available Techniques (BAT) and Best Environmental Practice (BEP), should provide regulators with decision-making certainty by ensuring:

- Appropriate transparency
- Natural justice
- Independent peer-review
- Appropriate consultation

Each of these elements complements and supports the others.

G.2.1. Transparency and Commercial Sensitivity

Transparency is necessary for well-informed consultation, natural justice and independent peer-review.

The extent of transparency should complement the goals of natural justice and consultation, but does not need to provide information that is genuinely commercially or personally sensitive. However, far too often commercial sensitivity is a veil that industry proponents hide behind. (DiMento and Ingram, 2005, Sheaves *et al*, 2015) Currently a large body of data about public resources (the marine environment) is claimed as commercial-in-confidence with little justification. (Costanza *et al*, 2006, Sheaves *et al*, 2015)

The technical details of proposal for activities that generate noise should be fully and transparently available for comment before plans are submitted for approval to regulators.

Broadly, the information provided should include:

- comprehensive description of the noise to be generated and the equipment to be used, including elements of the sound that are auxiliary to the need,
- comprehensive description of the direct and surrounding area where the noise-generating activity is proposed and the species within this area,
- expert modelling of expected sound intensity levels and sound dispersal,
- timeframe of the noise-generation,
- scientific monitoring programmes conducted during and after noise-generating activity.

The full extent of information that should be transparently available is detailed in Module I.

None of this information should be considered commercially sensitive and proponents should not seek to hide it from view.

G.2.2. Natural Justice

Natural justice is both a legal and common concept with two parts: it ensure there is no bias, increasing public confidence, and enshrines a right to a fair hearing so that individuals are not unfairly impacted (penalized) by decisions that affect their rights or legitimate expectations.

In the case of decisions for activities in the marine environment, confidence that there is no hidden bias can be developed by ensuring there is full transparency and that all stakeholders are given reasonable notice of the plans, a fair opportunity to present their own concerns and that these concerns will factor in the final decision that is made. (DiMento and Ingram, 2005)

Stakeholders with a rightful interest in the marine environment include: traditional communities with cultural or spiritual connections, marine users such as fishermen (commercial and recreational), shipping and boating and tourism operators, scientists, conservation organizations, and general marine users such as tourism and recreation, who advocate for the conservation of marine wildlife or marine ecosystems. Their interest must be considered.

G.2.3. Independent Peer-review

There is concern in many countries over

the poor quality of EIA information. Depending on circumstance, this might reflect problems with institutional arrangements, low levels of commitment by proponents, or issues with the nature, extent and quality of training and capacity-building in the impact assessment, or elements of all of these. (Morgan, 2012) There is often a significant gap between the best practice thinking represented in the research and practice literature and the application of EIAs on the ground. (Morgan, 2012)

Proponent-funded independent peer-review of EIA proposals, before submission to regulators for assessment, is an important tool of BEP. (Sheaves *et al*, 2015) Comprehensive, independent peer-review is a logical requirement for ensuring alignment of EIAs with scientific understanding and standards, and ensuring that scientific understanding takes precedence over short-term benefits and political considerations. (Morrison-Saunders and Bailey, 2003, DiMento and Ingram, 2005, Sheaves *et al*, 2015)

In the case of marine noise-generating activities, independent peer-reviewers should include species experts and expert sound modelers and accousticians, who are able to declare full and verifiable independence from the proposal. Their peer-review reports should be fully transparent and submitted to regulators, without influence from proponents.

G.2.4. Consultation and burden of proof

True consultation has two key components: participation in the outcome of a decision and that the burden of proof rests with the proponent.

Development actions may have wide-ranging impacts on the environment, affecting many different groups in society. There is increasing emphasis by government at many levels on the importance of consultation and participation by key stakeholders in the planning and development of projects.

An EIA is an important vehicle for engaging with communities and stakeholders, helping those potentially affected by a proposed development to be much better informed and to influence the direction and precautions put in place by the proponent. This requires an appropriate exchange of information and a willingness by the proponent to be transparent about their likely impact. (O'Faircheallaigh, 2010, Glasson *et al*, 2013)

Burden of proof is often associated with the Latin maxim *semper necessitas probandi incumbit ei qui agit*, which broadly means "*the necessity for proof always lies with the person who makes the claim*." In the case of proponents of marine noise-generating activities, it is their claim that the activities they propose to undertake – in a shared marine environment – will cause minimal harm. To satisfy the burden of proof, the proponent must provide sufficient evidence to demonstrate that there is limited danger of damaging the marine environment or any species that have been highlighted as having importance.

Other stakeholders do not carry the burden of proof but instead carry the benefit of assumption, meaning they need no evidence to support their position of concern. It is up to the proponent to provide the assurance and bear all financial costs for doing so.

The current situation in far too many jurisdictions around the world is that industry has persuaded legislators to shift the burden of proof to stakeholders. Regulators need to take step to redress this imbalance, and the EIA Guidelines, outlined in Module I should provide this shift.

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H. CMS-Listed Species Potentially Impacted by Anthropogenic Marine Noise

Pinnipeds				
Scientific name	**Common name**	**App I**	**II**	**CMS Instruments**
Arctocephalus australis	South American fur seal		1979	CMS
Halichoerus grypus	Grey seal		1985	CMS
Monachus monachus	Mediterranean monk seal	1979	1979	CMS, Monk Seal in the Atlantic
Otaria flavescens	South American sea lion		1979	CMS
Phoca vitulina	Harbour seal		1985	CMS, Wadden Sea Seals

Cetaceans				
Scientific name	**Common name**	**App I**	**II**	**CMS Instruments**
Balaena mysticetus	Bowhead whale	1979		CMS
Balaenoptera bonaerensis	Antarctic minke whale		2002	CMS, Pacific Cetaceans
Balaenoptera borealis	Sei whale	2002	2002	CMS , ACCOBAMS , Pacific Cetaceans
Balaenoptera edeni	Bryde's whale		2002	CMS , Pacific Cetaceans
Balaenoptera musculus	Blue whale	1979		CMS, ACCOBAMS, Pacific Cetaceans
Balaenoptera physalus	Fin whale	2002	2002	ACCOBAMS, CMS, Pacific Cetaceans
Berardius bairdii	Baird's beaked whale		1991	CMS, Pacific Cetaceans
Caperea marginata	Pygmy right whale		1979	CMS, Pacific Cetaceans
Cephalorhynchus commersonii	Commerson's dolphin		1991	CMS
Cephalorhynchus eutropia	Chilean dolphin		1979	CMS
Cephalorhynchus heavisidii	Heaviside's dolphin		1991	CMS, Western African Aquatic Mammals
Cephalorhynchus hectori	Hector's dolphin			Pacific Cetaceans
Delphinapterus leucas	Beluga		1979	CMS
Delphinus capensis	Long-beaked common dolphin			Western African Aquatic Mammals, Pacific Cetaceans
Delphinus delphis	Common dolphin	2005	1988	CMS, ASCOBANS, ACCOBAMS, Western African Aquatic Mammals, Pacific Cetaceans
Eubalaena australis	Southern right whale	1979		CMS, Pacific Cetaceans
Eubalaena glacialis	Northern right whale	1979		CMS, ACCOBAMS
Eubalaena japonica	North Pacific right whale	1979		CMS
Globicephala melas	Long-finned pilot whale		1988	CMS, ACCOBAMS, ASCOBANS, Pacific Cetaceans, Western African Aquatic Mammals
Grampus griseus	Risso's dolphin		1988	CMS, ACCOBAMS, ASCOBANS, Western African Aquatic Mammals, Pacific Cetaceans
Hyperoodon ampullatus	Northern bottlenose whale		1991	CMS, ASCOBANS, Western African Aquatic Mammals
Lagenodelphis hosei	Fraser's dolphin		1979	CMS , Western African Aquatic Mammals, Pacific Cetaceans
Lagenorhynchus acutus	Atlantic white-sided dolphin		1988	CMS , ASCOBANS
Lagenorhynchus albirostris	White-beaked dolphin		1988	CMS , ASCOBANS
Lagenorhynchus australis	Peale's dolphin		1991	CMS
Lagenorhynchus obscurus	Dusky dolphin		1979	CMS, Western African Aquatic Mammals, Pacific Cetaceans
Megaptera novaeangliae	Humpback whale	1979		CMS, ACCOBAMS, Pacific Cetaceans
Monodon monoceros	Narwhal		1991	CMS
Neophocaena phocaenoides	Finless porpoise		1979	CMS, Pacific Cetaceans
Orcaella brevirostris	Irrawaddy dolphin	2009	1991	CMS, Pacific Cetaceans
Orcaella heinsohni	Australian snubfin dolphin		1979	CMS, Pacific Cetaceans

Orcinus orca	Killer whale		1991	CMS, ACCOBAMS, ASCOBANS, Western African Aquatic Mammals, Pacific Cetaceans
Phocoena dioptrica	Spectacled porpoise		1979	CMS, Pacific Cetaceans
Phocoena phocoena	Harbour porpoise		1988	CMS, ASCOBANS, ACCOBAMS, Western African Aquatic Mammals
Phocoena spinipinnis	Burmeister porpoise		1979	CMS
Phocoenoides dalli	Dall's porpoise		1991	CMS
Physeter macrocephalus	Sperm whale	2002	2002	CMS, ACCOBAMS, Pacific Cetaceans
Platanista gangetica	Ganges River dolphin	2002	1991	CMS
Pontoporia blainvillei	Franciscana	1997	1991	CMS
Sotalia fluviatilis	Tucuxi		1979	CMS
Sousa chinensis	Indo-Pacific hump-backed dolphin		1991	CMS, Pacific Cetaceans
Sousa teuszii	Atlantic hump-backed dolphin	2009	1991	CMS, Western African Aquatic Mammals
Stenella attenuata	Pantropical spotted dolphin		1999	CMS, Western African Aquatic Mammals, Pacific Cetaceans
Stenella clymene	Clymene dolphin		2009	CMS , Western African Aquatic Mammals
Stenella coeruleoalba	Striped dolphin		2001	CMS, ASCOBANS, ACCOBAMS, Western African Aquatic Mammals, Pacific Cetaceans
Stenella longirostris	Spinner dolphin		1999	CMS, Western African Aquatic Mammals, Pacific Cetaceans
Tursiops aduncus	Indian bottlenose dolphin		1979	CMS
Tursiops truncatus	Bottlenose dolphin	2009	1991	CMS, ASCOBANS, ACCOBAMS, Western African Aquatic Mammals, Pacific Cetaceans
Ziphius cavirostris	Cuvier's Beaked whale	2014		CMS, ACCOBAMS

Sirenians				
Scientific name	**Common name**	**App I**	**II**	**CMS Instruments**
Dugong dugon	Dugong		1979	CMS, Dugong
Trichechus manatus	Manatee	1999	1999	CMS
Trichechus senegalensis	West African manatee	2009	2002	CMS, Western African Aquatic Mammals

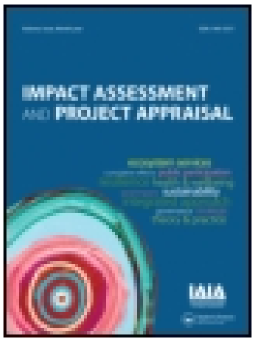
Sea turtles				
Scientific name	**Common name**	**App I**	**II**	**CMS Instruments**
Caretta caretta	Loggerhead turtle	1985	1979	CMS, IOSEA Marine Turtles , Atlantic Turtles
Chelonia mydas	Green turtle	1979	1979	CMS, IOSEA Marine Turtles, Atlantic Turtles
Dermochelys coriacea	Leatherback turtle	1979	1979	CMS, IOSEA Marine Turtles, Atlantic Turtles
Eretmochelys imbricata	Hawksbill turtle	1985	1979	CMS, IOSEA Marine Turtles, Atlantic Turtles
Lepidochelys kempii	Kemp's ridley turtle	1979	1979	CMS, Atlantic Turtles
Lepidochelys olivacea	Olive ridley turtle	1985	1979	CMS, IOSEA Marine Turtles, Atlantic Turtles
Natator depressus	Flatback turtle		1979	CMS, IOSEA Marine Turtles

Fish, Crustaceans and Cephalopods				
Fish, crustaceans and cephalopods are considered as listed CMS species as well as prey to CMS listed species.				
Scientific name	**Common name**	**App I**	**II**	**CMS Instruments**
Carcharodon carcharias	Great white shark	2002	2002	CMS, Sharks
Cetorhinus maximus	Basking shark	2005	2005	CMS, Sharks
Isurus oxyrinchus	Shortfin mako shark		2008	CMS, Sharks
Isurus paucus	Longfin mako shark		2008	CMS, Sharks
Lamna nasus	Porbeagle		2008	CMS, Sharks
Alopias pelagicus	Pelagic thresher shark		2014	CMS
Alopias superciliosus	Bigeye thresher shark		2014	CMS
Alopias vulpinus	Common thresher shark		2014	CMS
Carcharhinus falciformis	Silky shark		2014	CMS
Sphyrna lewini	Scalloped hammerhead shark		2014	CMS
Sphyrna mokarran	Great hammerhead shark		2014	CMS
Manta alfredi	Reef manta ray	2014	2014	CMS
Manta birostris	Manta ray	2011	2011	CMS
Manta alfredi	Reef manta ray	2014	2014	CMS
Mobula eregoodootenkee	Pygmy devil ray	2014	2014	CMS
Mobula hypostoma	Atlantic devil ray	2014	2014	CMS

Mobula japanica	Spinetail mobula	2014	2014	CMS
Mobula kuhlii	Shortfin devil ray	2014	2014	CMS
Mobula mobular	Giant devil ray	2014	2014	CMS
Mobula munkiana	Munk's devil ray	2014	2014	CMS
Mobula rochebrunei	Lesser Guinean devil ray	2014	2014	CMS
Mobula tarapacana	Box ray	2014	2014	CMS
Mobula thurstoni	Bentfin devil ray	2014	2014	CMS
Squalus acanthias	Spiny dogfish		2008	CMS, Sharks

Otters				
Scientific name	**Common name**	**App I**	**II**	**CMS Instruments**
Lontra felina	Marine otter	1979		CMS

Polar bear				
Scientific name	**Common name**	**App I**	**II**	**CMS Instruments**
Ursus maritimus	Polar bear		2002	CMS



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Environmental impact assessment guidelines for offshore petroleum exploration seismic surveys

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ABSTRACT
The ocean environment is filled with natural sound, but the last century has introduced many anthropogenic activities that have increased the levels of noise. Research on the impact of anthropogenic noise on marine fauna is now extensive. Levels of threat are well defined. Mitigation and monitoring guidelines exist in many parts of the world; especially for offshore petroleum exploration. In many jurisdictions, these guidelines rely on environmental impact assessments (EIAs) consideration by decision-makers, yet few jurisdictions stipulate what such assessments should contain. Sound propagation in the marine environment is complex, yet robust and defensible modelling is rarely conducted. Many impact assessments are inadequately checked. This stands in contrast to the equivalent process for land-based assessments. We argue that defensible EIAs should include modelling of the proposed noise impact in the region and under the conditions of planned activity. We articulate why clear guidelines about the content of EIAs are needed and propose a template for offshore petroleum exploration assessment.

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Anthropogenic marine noise; offshore petroleum exploration; environmental impact assessments; Australian sea lion

Introduction

The ocean environment is filled with natural sound from animals and physical processes. Species living in this environment are adapted to these sounds. Many species rely on sound as a primary sense, using it for hunting, reproduction and navigation (Southall et al. 2000, 2007; Simmonds et al. 2014). Over the past century, many anthropogenic marine activities have increased levels of noise (Hildebrand 2009; André et al. 2011). These modern anthropogenic noises have the potential for physical, physiological and behavioural impacts on marine fauna – mammals, reptiles, fish and invertebrates (Moriyasu et al. 2004; Southall et al. 2007; Payne et al. 2008; Clark et al. 2009; Miller et al. 2009; André et al. 2010; CBD CBD SBSTTA 2012). One noise-producing industry is offshore petroleum exploration.

There are national and regional operational guidelines available to the offshore petroleum exploration industry, each detailing the impacts to avoid and mitigation measures to take during operations. These began with the United Kingdom's Joint Nature Conservation Committee guidelines to minimise acoustic disturbance of marine mammals by oil and gas industry seismic surveys in 1995. Similar guidelines have been iteratively developed in the United States of America, Brazil, Canada, Australia and New Zealand (Castellote 2007; Weir & Dolman 2007; Compton et al. 2008). At a regional level, the intergovernmental Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) has established comprehensive guidelines for the Mediterranean region. Other regional and international instruments are gradually developing similar guidance.

These guidelines focus on mitigation measures during operations and rely on an assessment of risk having being considered and approved by decisions-makers before the operation starts. This is an important step in the process, yet there are few guidelines about the content of these environmental impact assessments (EIAs). Generalised assumptions about impact are often all that is presented. If an EIA is to be a good decision-aiding tool, it must provide decision-makers with a thorough and detailed understanding of the consequences of their decisions (Tenney et al. 2006).

The propagation of sound in water is complex and requires many variables to be carefully considered before it can be known if the proposal is appropriate or not. Despite this, proposals from the offshore petroleum exploration industry are presented to regulators with generalised, unsubstantiated information and often without having conducted basic consultation with other stakeholders reliant on the same environment.

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These hollow submissions perpetuate because the expectation from government has not been carefully prescribed. Regulators are forced to approve or reject projects without robust, defensible and impartial information on which to base their decisions. Regulator decisions are often made based on erroneous information. Such decisions are vulnerable to criticism of bias or tokenism (Court et al. 1996; Tenney et al. 2006; Jay et al. 2007; Devlin & Yap 2008; Prideaux & Prideaux 2012; 2013b, 2013c, 2013d, 2013e, 2013f; Wright et al. 2013).

This paper provides a basic explanation of the complexities of sound propagation in the marine environment and shows why generalised assumptions are inadequate to assess impact. A brief description of the common technology employed by the offshore petroleum exploration industry is provided. The next section will give a broad outline of the range of species susceptible to loud anthropogenic noise pollution and a general summary of the impacts they experience. The final section explores the trends in current EIAs for offshore petroleum exploration and introduces a template for EIA guidelines.

Sound propagation in water is complex

Often, offshore petroleum exploration industry statements are made in EIAs that a sound-producing activity is '*X*' distance from '*Y*' species or habitat. In these cases, distance is used as a basic proxy for impact, but is rarely backed with scientifically modelled information. To present a defensible EIA for offshore petroleum exploration proposal, proponents need to have professionally modelled the noise of the proposed activity in the region and under the conditions they plan to operate.

The behaviour of sound in the marine environment is different from sound in air. The extent and way that sound travels (propagation) is affected by many factors, including the frequency of the sound, water depth and density differences within the water column that vary with temperature, salinity and pressure (Wagstaff 1981; Clay & Medwin 1997; Lurton 2010; Etter 2013). Seawater is roughly 800–1500 times denser than air and sound travels around five times faster in this medium (Lurton 2010, p. 16). Consequently, a sound arriving at an animal is subject to propagation conditions that are complex (McCauley et al. 2000; Calambokidis et al. 2002; Hildebrand 2009; Lurton 2010).

While noise modelling is common for land-based anthropogenic noise-producing activities, it is less common for proposals in the marine environment. The lack of rigorous noise modelling in the marine setting needs to be urgently addressed. Modelling of each individual proposal should be professionally and impartially conducted to provide decision-makers with credible and defensible information. It should provide a clear indication of sound dispersal characteristics, informed by local propagation features (Urick 1983; Etter 2013). With this information, species exclusion zones can be identified with descriptions of how noise propagation into these zones will be minimised.

Elasticity

The speed of sound is not a fixed numerical value. Sound wave speed varies widely and depends on the medium, or material, it is transmitted through such as solids, gas or liquids. Each medium has its own elasticity (or resistance to molecular deformity). This elasticity factor affects the sound wave's movement significantly.

Sound waves move through a medium by transferring kinetic energy from one molecule to the next (Lurton 2010, pp. 14–20). Solid mediums, such as metal, transmit sound waves extremely fast because the solid molecules are tightly packed together, providing only tiny spaces for vibration. Sound waves move rapidly through this high elasticity medium, because the solid molecules act like small springs, aiding the wave's movement across the medium. The speed of sound through aluminium, for example, is around 6319 ms^{-1} (Goel 2007; Gottlieb 2007, pp. 22–23; Giordano 2012, p. 414). Gas, like air, naturally has large spaces between each molecule. As a result, sound waves take longer to move through a gas. Each air molecule vibrates at a slower speed after a sound wave passes through it, because there is more space surrounding the molecule. The gas molecule effectively deforms in shape from the passing sound wave, making gas reflect a low elasticity. Sound waves moving through air at a temperature of 20 °C will only travel around 342 ms^{-1} (Goel 2007; Gottlieb 2007). Liquid molecules, such as seawater, bond together in a tighter formation compared with gas molecules allowing only small vibration movements. Sound waves do not deform the liquid molecules as severely as gas molecules, creating a higher elasticity level. Sound waves moving through water at 22 °C travel at around 1484 ms^{-1} (Goel 2007; Gottlieb 2007).

Warmer temperatures across a medium also excite molecules. Molecules move faster under higher temperatures, transmitting sound waves more rapidly across the medium. Conversely, decreasing temperatures cause the molecules to vibrate at a slower pace, hindering the sound wave's movement (Goel 2007; Gottlieb 2007, p. 23; Giordano 2012). The temperature of the seawater at different depths is therefore of importance to modelling.

Spherical spreading, cylindrical spreading and transmission loss

The way sound propagates is also important. Spherical spreading is simply sound leaving a point source in an expanding spherical shape (Urick 1983, p. 100; Lurton 2010, p. 22). As sound waves reach the sea surface and sea

floor, they can no longer maintain their spherical shape and they begin to resemble the shape of an expanding cheese wheel. This is called cylindrical spreading (Urick 1983, p. 102). The transmission loss, or the decrease in the sound intensity levels, happens uniformly in all directions during spherical transmission. However, when sound is in a state of cylindrical transmission it cannot propagate uniformly. The sound is effectively contained between the sea surface and the sea floor, while the radius is still expanding uniformly (the sides of the cheese wheel) but the height is now fixed and so the sound intensity level decreases more slowly (Urick 1983, p. 102).

Given the seabed is rarely, if ever, flat and parallel to the sea surface, modelling cylindrical spreading in the marine environment is complex. Seabed characteristics must be known to model this spreading. Modelling must accommodate the water depth below the seismic survey, as well as the rise and fall of the seabed surrounding it (Lurton 2010, p. 13).

Sound Fixing and Ranging channels (SOFAR)

As well as spherical and cylindrical spreading, another variable can impact how far sound will be transmitted. This is usually called a SOFAR or deep sound channel and is a horizontal layer of water in the ocean at which depth, the speed of sound is at its minimum.

The SOFAR channel is created through the interactive effect of temperature and water pressure (and, to a smaller extent, salinity). This occurs because pressure in the ocean increases with depth, but temperature is more variable, generally falling rapidly in the main thermocline from the surface to around a thousand meters deep and then remaining almost unchanged from there to the ocean floor. Near the surface, the rapidly falling temperature causes a decrease in sound speed (or a negative sound speed gradient). With increasing depth, the increasing pressure causes an increase in sound speed (or a positive sound speed gradient). The depth where the sound speed is at a minimum is called the sound channel axis. The speed gradient above and below the sound channel axis acts like a lens, bending sound towards the depth of minimum speeds. The portion of sound that remains within the sound channel encounters no acoustic loss from reflection of the sea surface and sea floor. Because of this low transmission loss, very long distances can be obtained from moderate acoustic power (Urick 1983, p. 159; Lurton 2010, p. 58).

Offshore petroleum exploration

The commonly used surveying method used for offshore petroleum exploration is 'seismic reflection'. This is simply sound energy discharged from a sound source (air gun array) at the sea surface that penetrates subsurface layers of the seabed and is reflected to the surface where it is detected by acoustic receivers (hydrophones). These surveys are typically conducted using specially equipped vessels that tow one or more cables (streamers) with hydrophones at constant intervals. For the seismic reflection process to work, there needs to be enough energy discharged from the air gun array to travel, sometimes several kilometres, to the sea floor and then to be refracted as it passes from liquid into solid to a prescribed depth. Some of the energy is reflected and begins a return journey being refracted from solid to liquid then to travel to the hydrophone streamers. The analysis of these reflections provides a profile of the underlying rock strata and helps industry to identify hydrocarbon accumulations or anomalies that may correspond to hydrocarbon deposits. The typical discharge of each pulse of an air gun array is around 230 dB (re 1 μPa^2 @ 1m) every 10–15 s, and surveys typically run more or less continuously over many weeks (Urick 1983; Clay & Medwin 1997; Caldwell & Dragoset 2000; Dragoset 2000; Lurton 2010). These operations are usually called 'seismic surveys'.

Marine fauna susceptible to anthropogenic noise

Marine animals rely on sound for their vital life functions, such as communication, prey and predator detection, orientation and for sensing their surroundings (Simmonds et al. 2014). Noise affects the behaviour and physiology of animals in various ways, including disruptions in the neuroendocrine, cardiovascular and immune systems (Kight & Swaddle 2011).

Southall et al. (2007) reviewed the expanding literature on marine mammal hearing and their physiological and behavioural responses to anthropogenic noise. They developed predictions of noise exposure levels above which adverse effects, as either injury or behavioural disturbance, on various groups of marine mammals could be expected. While these researchers acknowledged limits in their proposed criteria, because of scarcity of information about some species, the work is valuable for establishing policy guidelines or regulations about anthropogenic noise.

An important recent Convention on Biological Diversity (CBD) Decision (XII/23) has recommended that further research is conducted for the remaining significant knowledge gaps. This includes knowledge about fish, invertebrates, turtles and birds. They also recommended research into the implications of cumulative and synergistic impacts of multiple sources of noise on marine species (CBD 2014).

Southall et al. (2007) highlighted that exposure criteria for single individuals and short-term (not chronic) exposure events are inadequate to describe the cumulative and ecosystem-level effects likely to result from repeated and/or sustained human input of sound into the marine environment and from potential interactions

with other stressors. It is therefore critical that modelling of noise propagation is conducted to determine the potential received levels of noise for different species and the duration of exposure.

An important volume of solid research should be considered directly for more detail about the unique characteristics of each of the species groups. The following section provides a summary of this knowledge base.

Fish, crustaceans and cephalopods

Fishermen worldwide complain that seismic surveys produce economic losses by reducing captures of a wide range of commercial species. The impact of anthropogenic noise on commercial fisheries is slowly being quantified. Behavioural responses of fish and cephalopods vary to received levels of seismic noise. These include leaving the area of the noise, through changes in depth distribution, schooling behaviour and startle responses to short-range start-up or high-level sounds. In some cases, behavioural responses from fish were observed up to 5 km distance from the seismic air gun array (McCauley et al. 2000, 2003; Hassel et al. 2004; McCauley & Fewtrell 2008). Short exposures to intense seismic signals are known to increase mortality of fish larvae at short ranges. Sublethal physiological impacts have been observed in crustaceans potentially impacting reproduction and recruitment. Significant developmental delays and abnormalities have been shown in mollusc larvae, including malformations in soft body tissues (Parry & Gason 2006; Payne et al. 2008; de Soto et al. 2013). Noise exposure during critical growth intervals may contribute to stock vulnerability (de Soto et al. 2013).

Pinnipeds

Pinnipeds (seals, sea lions and walrus) live part of their lives in both air and in water. Their hearing is adapted to both mediums and they are likely to be susceptible to the harmful effects of loud noise in each. Behavioural responses to anthropogenic sound have been recorded including pinnipeds removing themselves from feeding activities. Disturbances in marine and terrestrial environments can cause pinnipeds to abandon colonies, which could have serious implications, especially for species that are already endangered. In most respects, noise-induced threshold shifts in pinnipeds follow trends similar to those observed in other mammals (Southall et al. 2007). Pinnipeds, like many land-based mammals, have vibrissae (whiskers), which are well supplied with nerves, blood vessels and muscles and may function to detect the subtle movements of fish and other aquatic organisms. Vibrissae have been shown (for example, in harbour seals, *Phoca vitulina*) to be sensitive to low-frequency waterborne vibrations (Bohne et al. 1985; Mathews 1994; Southall et al. 2000; Harris et al. 2001; Kastak et al. 2005).

Sirenians

Similarly, sirenians (dugong and manatee) may be displaced from key feeding habitats by exposure to noise. While most research has focused on boating traffic, their behavioural response to the noise of passing vessels supports that these animals are sensitive to noise and should be considered carefully (Hodgson & Marsh 2007).

Cetaceans

Cetaceans (whales, dolphins and porpoises) are perhaps the most studied group of marine species when considering the impact of anthropogenic noise. Different taxonomic groups of cetaceans adopt different strategies for responding to acoustic disturbance from seismic noise. Baleen whales are susceptible to temporary threshold shift at a kilometre or more from seismic surveys (Gordon et al. 2003; Nowacek et al. 2007; Weilgart 2007; Di Iorio & Clark 2009; Gedamke et al. 2011; Gray & Van Waerebeek 2011). Toothed cetaceans have also shown significant avoidance behaviour at a range of distances (Madsen et al. 2002; Stone & Tasker 2006; Miller et al. 2009; Gray & Van Waerebeek 2011). Researchers are concerned that reducing an individual's ability to detect socially relevant signals could affect biologically important processes and they caution that short-term proxies, such as avoidance behaviour, are not sufficiently robust to assess the extent and biological significance of long-term individual and population-level impacts.

Sea turtles

Studies of the hearing capabilities of sea turtles show that they hear low-frequency sounds within the range of 100–1000 Hz with greatest sensitivity at 200–400 Hz for adult sea turtles, and 600 and 700 Hz for juveniles. Although sea turtles are poorly studied compared with cetacean and fish species, studies have demonstrated behavioural responses to received levels of seismic noise (O'Hara & Wilcox 1990; Moein Bartol & Musick 2003; Southwood et al. 2008).

The importance of considering stress

There is also need to consider the impact prolonged noise exposure may have on marine fauna beyond the direct physiological and behavioural impacts (Rolland et al. 2012). Chronic levels of stress can result in various pathological dysfunctions with possible damage to long-term health. This is especially relevant for resident species dependent on certain habitats, such as beluga, seals or sea lions.

Failures of current EIAs

The following sections build on the information we have provided about the complexities of sound propagation in the marine environment and overview of the range of species and types of impact that might occur. We comment about the depth of information provided in current EIAs and finally propose guidelines for EIAs.

Many jurisdictions have developed national and regional operational guidelines about mitigating anthropogenic noise on marine fauna and in particular noise produced by offshore petroleum exploration. These began with the United Kingdom's Joint Nature Conservation Committee guidelines with similar guidelines being iteratively developed in the United States of America, Brazil, Canada, Australia and New Zealand (Castellote 2007; Weir & Dolman 2007; Compton et al. 2008).

Several intergovernmental bodies have also elaborated principles of what EIAs should present. Collectively, these principles have been adopted by 196 governments who, through the process of their adoption, have individually committed to reflecting these decisions in their domestic law. The 'weight' of these decisions taken by governments at an international level is considerable.

The most notable of these is the 'Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area' (ACCOBAMS). ACCOBAMS 'Resolution 4.17: Guidelines to address the impact of anthropogenic noise on cetaceans in the ACCOBAMS area' articulate specifics for the Mediterranean region and

> [encourage] Parties: – to address fully the issue of anthropogenic noise in the marine environment, including cumulative effects, in the light of the best scientific information available and taking into consideration the applicable legislation of the Parties, particularly as regards the need for thorough environmental impact assessments being undertaken before granting approval to proposed noise-producing activities. (ACCOBAMS 2010)

The ACCOBAMS Noise Guidelines further prescribe specific considerations about seismic surveys, including the need for accurate modelling.

ACCOBAMS Resolution 5.15 calls on the Parties to:

- ensure that EIAs take full account of the effects of activities on cetaceans;
- implement the recommended use of Best Available Techniques and Best Environmental Practice in their efforts to reduce or mitigate marine noise pollution;
- integrate the issue of anthropogenic noise into the management plans of marine protected areas.

Resolution 5.15 also underlines that EIAs should include specific details that mirror those articulated in the ACCOBAMS Noise Guidelines (ACCOBAMS 2013).

The Convention on Migratory Species (CMS) 'Resolution 10.24: Further Steps to Abate Underwater Noise Pollution for the Protection of Cetaceans and Other Migratory Species' also strongly urges CMS Parties to prevent adverse effects on marine species by restricting the emission of underwater noise to the lowest necessary level and urges CMS Parties to ensure that EIAs take full account of the effects of activities on marine fauna (CMS 2011).

Most recently, the CBD 'Decision XII/23: Marine and coastal biodiversity: Impacts on marine and coastal biodiversity of anthropogenic underwater noise' has specifically encouraged CBD Parties to take suitable measures to avoid, lessen and mitigate adverse impacts of anthropogenic underwater noise on marine and coastal biodiversity, including:

> - combining acoustic mapping with habitat mapping of sound-sensitive species when developing spatial risk assessments to identify areas where those species may be exposed to noise impact;
> - using spatio-temporal management, including detailed knowledge of species or population distribution patterns, to mitigate and manage noise activities and avoiding producing noise in the area at critical times;
> - conducting EIAs for activities that may have significant adverse impacts on noise-sensitive species. (CBD 2014)

Assessment of likely impacts is also an emerging legal requirement in the European Union. The European Parliament and Council 'Environmental Impact Assessment Directive 2014/52/EU' requires that EIAs are carried out before development consent is given to activities (2014/52/EU Art 2.1) to identify impacts to biodiversity with particular attention to species and habitat protected under Directive 92/43/EEC and Directive 2009/147/EC (2014/52/EU Art 3.1). The Directive introduction states that:

> [w]ith a view to ensuring a high level of protection of the marine environment, especially species and habitats, environmental impact assessment and screening procedures for projects in the marine environment should take into account the characteristics of those projects with particular regard to the technologies used (for example seismic surveys using active sonars). (2014/52/EU)

Conducting EIAs is now a well-established governance and environmental management principle, institutionalised in over 100 countries (Court et al. 1996; Glasson et al. 2013). These four intergovernmental bodies provide significant clarity about the expectations to conduct EIAs and effectively manage impacts associated with offshore petroleum exploration activities, among other underwater noise-producing activities.

It is broadly accepted the basic intent of EIAs is to anticipate the significant environmental impacts of development proposals before any commitment to a particular course of action. However, often, the detail required within EIAs is poorly defined. Many legislative provisions for EIAs have been introduced without consideration of the institutional requirements: organisational structure, staffing and capacity development (Cashmore et al. 2004; Jay et al. 2007; Devlin & Yap 2008). Often the scientific basis and methods need sophisticated understanding.

Given this, it is not surprising the efficacy of many EIAs is being criticised (Slootweg & Kolhoff 2003; Cashmore et al. 2004, 2010; Devlin & Yap 2008). Indeed, the criticism of the 'low bar' requirements for EIAs in many jurisdictions might be, in part, a result of decision-makers themselves having limited understanding of the EIA purposes and potential (Cashmore et al. 2004; Jay et al. 2007) as well as the general poor quality of EIA information (Morgan 2012; Morrison-Saunders & Retief 2012).

This was revealed to be the case for offshore petroleum exploration EIAs by Wright et al. (2013). They found that many assessments were insufficiently researched, drawing heavily from previous EIAs. In a significant number of cases, approvals were given without careful consideration of the detail presented in the EIAs. Instances of duplicated information or missing species were not uncommon. Topics were dealt with by dismissal, often ignoring recent scientific literature, perpetuating misconceptions and containing analytical flaws. Discussions about wildlife often focused on lethal impact, with little or no consideration of sublethal impacts.

Our documentary examination of five EIAs, that spanned less than one year and took place within one regulatory jurisdiction, revealed similar trends to those highlighted by Wright et al. (2013). All were proposals for petroleum exploration in Australia's Exclusive Economic Zone under the same regulatory process and all were given approval by the National Offshore Petroleum Safety and Environmental Management Authority's (NOPSEMA) (Prideaux & Prideaux 2013b, 2013c, 2013d, 2013e, 2013f).

These five are by no means isolated cases. Since inception, 291 EIAs (so-called Environmental Plans) have been received by NOPSEMA. Most of these have been accepted by the authority. The authors have engaged in a correspondence trail with the authority to highlight significant errors, inaccuracies, misconceptions and analytical flaws in a number of the 291 submissions. Written responses from the authority confirm that their focus is on ensuring the industry commits to self-identified benchmarks. They assert the authority does not assess the efficacy of claims or assurances contained in the EIAs (correspondence on file with the authors).

An example of assessment relating to Australian sea lions

An example of assessments relating to Australian sea lions provides a useful illustration. The Australian sea lion (*Neophoca cinerea*) is Australia's only endemic and least numerous seal species. The species is listed as Vulnerable under the national environment legislation and has an IUCN Red List Criteria of Endangered (A2bd + 3d). The Australian Government's own 'South-west Marine Bioregional Plan and Species Group Report Card – Pinnipeds' identifies noise as a threat of concern (Department of Sustainability Environment, Water, Population & Communities 2012a, 2012b).

Under the 'South-west Marine Bioregional Plan' any individual Australian sea lion breeding colony is regarded as an important population. The government's Plan directs that all attempts should be made to avoid biologically important areas for the Australian sea lion, particularly water surrounding breeding colonies and foraging areas used by female sea lions, for any applications for offshore development. The Plan specifically states that 'actions with a real chance or possibility of increasing the ambient noise levels within female Neophoca cinerea foraging areas to a level that might result in site avoidance or other physiological or behavioural responses' have a high risk of a significant impact on this species (Department of Sustainability Environment, Water, Population & Communities 2012a, 2012b)

Clearly, the Australian Government has decided the status the sea lion demands a precautionary approach to ensure that human activities, including anthropogenic noise do not further jeopardise the species. Despite this, in a two-year period, NOPSEMA has accepted four EIAs, in the form of Environmental Plans. Each has failed to consider the impact of noise generated by offshore petroleum exploration on Australian sea lion populations and each has been given the proponent approval to proceed. These will or have already produced sound intensity levels around 230 dB (re water) that will transmit many hundreds of kilometres, including into and through areas of sea lion foraging habitat.

Given that offshore petroleum exploration activities typically span six to eight weeks, it is likely that sea lion foraging behaviour will be or has been significantly impacted or abandoned altogether. There could be reduced food availability, animals might show signs of reduced condition and may have difficulty feeding their pups. Colonies may or have been abandoned temporarily or permanently, which could have serious implications for this already endangered species. Review of the published EIAs (available on www.nopsema.gov.au) reveals that no modelling of noise propagation has been considered and no assessment of impact has been carried out. There is no description of the well-known

Australian sea lion colonies. There is no discussion of the foraging habitats of the species, nor is their recognition of the precaution flagged in the 'South-west Marine Bioregional Plan' and 'Species Group Report Card – Pinnipeds'. NOPSEMA has accepted and approved the EIAs. Even though the information was inconclusive or incomplete, NOPSEMA has not required any monitoring be established.

Anecdotal evidence for other regions shows similar trends in other jurisdictions including Europe, West Africa and East Africa (on file with the authors). There is a failure of current EIAs for offshore petroleum exploration.

It is important that government decision-makers can rely on sufficient technical, detailed and impartial information being presented to them to ensure credible and defensible decisions are made about offshore petroleum exploration. The following section proposes template guidelines on the detail of information that should be sought to support robust and defensible decisions.

Environmental impact assessment for offshore petroleum exploration seismic surveys

This section is built on the foundations of three important previous works. These are an important study on impact mitigation of offshore petroleum exploration in the Sakhalin region of the North Pacific Ocean (Nowacek et al. 2013); a framework for assessment of noise impact in the Arctic (Moore et al.2012); and a workshop on the requirements for marine noise EIAs during the 2014 European Cetacean Society meeting (Evans 2015). This collective work has elaborated that assessments should:

- collect baseline biological and environmental information to describe the area being impacted;
- fully characterise operations, including describing the sound source in some detail, the local sound propagation features and potential cumulative effects from other sound sources as well as other human activities that may not generate noise but can add to the pressures on the local animal populations; and
- describe how impacts will be monitored before, during and after the operation.

To provide regulators with greater technical detail about how to seek this level information, we have developed the proposed template through two important cross-disciplinary peer discussion forums:

(1) The Joint CMS/ASCOBANS/ACCOBAMS Noise Working Group where the template was formally developed as a contribution to the 'CBD Expert Workshop on Underwater Noise and its Impacts on Marine and Coastal Biodiversity'.

(2) The 18th CMS Scientific Council Meeting, where the template was presented and comments and input sought.

The template has also sought the input more broadly from regulators and industry. The proposal that follows is a reflection of this iterative discussion with experts through these processes (Prideaux & Prideaux 2013a).

Environmental impact assessment guidelines for offshore petroleum exploration proposals

In addition to jurisdictional specific requirements for impact mitigation during operations, such as observers or passive acoustic monitoring, EIAs for offshore petroleum exploration should be developed early in the proposal's development process and should transparently include:

(1) Description of area
  (a) Detailed description of the spatial extent and nature of the survey – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed survey, above natural ambient sound levels
  (b) Details of baseline data that have been gathered before developing the EIA, including consultation with regulating bodies and stakeholders
  (c) Identification of previous surveys, their seasons and duration in the same or adjoining areas, and a review of survey finding and implications
  (d) Identification of previous test wells in the same or adjoining areas including comment about any wells that may breach
(2) Description of the equipment to be used
  (a) Explanation of all survey technologies available and why the proposed technology is chosen
  (b) Detailed description of the survey technology to be used
  (c) Name and description of the survey vessel to be used
  (d) If an air gun array is proposed:
    (i) Number of arrays
    (ii) Number of air guns within each array
    (iii) Air gun charge pressure to be used (PSI)
    (iv) Volume of each air gun in cubic inches
    (v) Official calibration figures supplied by the survey vessel to be charted
    (vi) Modelled sound intensity level one metre from source derived from the official calibration figures

(vii) Depth the air guns to be set
(viii) Number of streamers
(ix) Length of streamers
(x) Distant set apart
(xi) Depth the hydrophones are set

(3) Details of consultation and independent review
(a) Identification of stakeholders who have been consulted
(b) Identification of independent experts – especially species experts – that have been consulted including their affiliation and their qualifications
(c) Explanation of information provided to stakeholders and experts, any opportunities given for appropriate engagement and the timeframe given for them to provide feedback
(d) Description of the comments, queries, requests and concerns received from each of the stakeholders and experts
(e) Explanation of what amendments and changes have been made to the proposed survey to the comments, queries, requests and concerns
(f) Explanation of which comments, queries, requests and concerns have not been accommodated and why

(4) Comprehensive description of activity
(a) Comprehensive description of the total area to be explored and the entire exploration plan (2D, 3D and test wells) and for each activity:
(i) Specifics of the activity including anticipated nautical miles to be covered, track-lines, speed of vessels, duration of track-lines, start up and shutdown procedures, distance and procedures for vessel turns including any planned air gun power setting changes
(ii) Computer modelling of sound dispersal in the same season/weather conditions as the proposed survey, local propagation features (spherical and cylindrical spreading, depth and type of sea bottom, local propagation paths related to thermal stratification) and out to a radius where the generated noise levels are close to natural ambient sound levels
(iii) Identification of any SOFAR or natural channels characteristics
(iv) Sound intensity level and frequencies (Hz) from a point source, as well as the duration of each pulse (milliseconds), interval between pulses (seconds) and expected duration of pulses (12/24 h days) for the survey

(a) Identification and mapping of proposed species exclusion zones and description of how noise propagation into these zones will be minimised, taking into consideration the local propagation features (spherical and cylindrical spreading, depth and type of sea bottom, local propagation paths related to thermal stratification)
(b) Identification of other impacting activities in the region during the planned survey, accompanied by the analysis and review of potential cumulative impacts

(5) Species likely to be encountered or impacted
(a) Description of all listed/protected species likely to be present and that will experience sound transmission generated by the proposed survey above natural ambient sound levels, the total time they will experience these sound levels and proposed measures being taken for each to minimise impact
(b) Description of all fisheries likely to be present or to rely on prey that might be present and that will experience sound transmission generated by the proposed survey above natural ambient sound levels and proposed measures being taken for each to minimise impact

(6) Details of likely impact for each listed/protected species, including:
(a) Identification of safe/harmful exposure levels for various species that is precautionary enough to handle large levels of uncertainty and avoids erroneous conclusions
(b) Type of impact predicted (direct, behavioural and the duration) as well as direct and indirect impacts to prey species
(c) Soft start and shutdown protocols
(d) Plans for 24 h visual detection, especially under conditions of poor visibility (including high winds, night conditions, sea spray or fog)
(e) Plans for establishing exclusion zones to protect specific species. These should be established on a scientific and precautionary basis rather than as arbitrary and/or static designations

(7) Details of independent and transparent monitoring of all at-sea activities and observer coverage
(a) Details of transparent processes for regular real-time public reporting of activity progress and all impacts encountered
(b) Details of scientific monitoring programmes, conducted during and after the seismic survey, to assess impact

(8) Reporting plans
   (a) Details of plans for post operation reporting including verification of the effectiveness of mitigation

The information requested in this template is well within the current technical competencies of the petroleum and scientific community. The detail within the EIA should be robust enough for independent review and not placed under a seal of commercial in-confidence. This process should prove sufficiently robust to ensure that regulators and decision-makers have access to an appropriate level of information before making approval decisions. It will allow them to seek expert technical critiques of the information if they do not have sufficient expertise within their department.

Conclusion

The ocean environment is filled with natural sound produced by animals and physical processes but modern anthropogenic activities have increased the levels of noise. Offshore petroleum exploration is a significant contributor to this noise. Sound propagation in the marine environment is complex and it is especially important that government decision-makers can rely on sufficient technical, detailed and impartial information being presented to them to ensure credible and defensible decisions are made about the impact of this industry and individual proposals.

While noise modelling is common for land-based anthropogenic noise-producing activities, we have shown that modelling and indeed robust EIAs for offshore petroleum exploration are failing this base need. EIAs should provide a clear indication of the sound propagation features across the full area the noise will impact. Proponents should be required to model the noise propagation of the proposed activity in the region and under the conditions they plan to operate. The documentation should demonstrate a clear understanding of the species present, necessary exclusion zones and descriptions of how noise propagation into these zones will be minimised.

This paper has proposed 'Environmental Impact Assessment Guidelines for Offshore Petroleum Exploration Proposals'. These template guidelines have been developed with the benefit of peer input and review through two official processes; to provide guidance about the specifics that should form the basis of appropriate assessments. In time, global noise standards may supersede such a need, but that time is still in the distant future and will need complex and controversial international oversight to be in place. For now, given the strong commitment of governments around the world to reducing anthropogenic marine noise, this information, if transparently supplied, would provide regulators and decision-makers with robust, defensible and impartial information on which to base their decisions.

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Chapter 17

Marine Mammals and Multiple Stressors: Implications for Conservation and Policy

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INTRODUCTION

For many centuries, in many maritime countries, human interest in marine mammals was limited to consideration of them as a resource to be exploited for human consumption and then for profit. For example, whales were regarded as having such value that King Edward II of England made a formal claim to their ownership, followed by several other heads of state (Brakes and Simmonds, 2011). Widespread commercial whaling in the 19th and 20th centuries, eventually involving diesel-driven fleets including factory vessels, led to decimation of populations. Attitudes changed in the 1960s and 1970s when the animals started to be valued and appreciated in other ways, including aesthetically and for their entertainment value in captivity.

Considerable knowledge has been gained in recent decades about both the biology of the animals and the fast-evolving threats that they face, but increasing knowledge does not automatically lead to improved protection, and some species and populations are still heading toward extinction (Campagna, 2015). At the root of this is a complex and evolving array of factors that can impact on these animals. For example, the endangered North Atlantic right whale, *Eubalaena glacialis*, population was initially devastated by whaling. Now, as this much diminished population struggles to recover, ship strikes and entanglement in fishing gear are regarded as the primary threats (Reilly et al., 2012). Looking to the future, it seems likely that climate change will cause the species yet more problems (Greene and Pershing, 2004).

Another example of populations being affected by multiple threats might be found in the case of delphinids in the Northeast Atlantic where pollution, in the form of PCBs, has recently been recognized again as a major threat

Marine Mammal Ecotoxicology. **https://doi.org/10.1016/B978-0-12-812144-3.00017-6**

(see, for example, Jepson et al., 2016). These are the same populations that, in many cases, are also being affected by deaths in fishing nets and other factors.

To conserve wildlife populations, we need to address not one but the multiple factors that are affecting them simultaneously, and this is not a new realization. Nor is the notion that some factors act synergistically, creating greater harm together than when acting on their own. For example, enhanced exposure to pathogens from discharges into cetacean habitat combined with enhanced exposure to immunosuppressive contaminants might be expected to create more disease and even, potentially, drive mass mortalities (Simmonds and Mayer, 1997).

However, marine mammal science tends to focus on particular classes of threat, rather than trying to address their multiplicity and the consequences of the interactions between them for the species and populations being affected. There have been good reasons for this. Typically, scientists have had to specialize to be effective (and successful in their careers), and natural sciences and veterinary sciences (including animal welfare science) have tended to follow separate paths. Perhaps, as argued subsequently, the time may have come for a reunification of these specializations, as we struggle to address the realities of multiple stressors in wildlife conservation. Indeed, how to sensibly address this complexity is arguably now one of the "holy grails" of modern conservation. Inherent in this is understanding how the factors interact to cause outcomes for the animals concerned and also how multiple exposures to stressors over a lifetime might best be considered. None of this is easy. Indeed it has recently been suggested that assessing "cumulative effects" is "a problem that has proven nearly impossible to solve" (Tyack, 2016). Nonetheless, it is also argued that to discern the factors contributing to population trends, scientists must consider the full complement of threats faced by marine mammals (NAS, 2016). Only with such knowledge can effective decisions be made about which stressors to reduce, to bring the population back to a more favorable state, and this kind of assessment can also provide the environmental context for evaluating whether an additional activity could threaten it. However, this view of science driving policy, while eminently logical, may not be fully realistic.

AN INVENTORY OF THREATS

There is a wide and growing range of potential stressors that affect marine mammals, and Table 17.1 provides a list. These stressors are not static over time, as new ones continue to be created by human activities (take, for example, the evolution of marine noise pollution as a threat, as described in Simmonds et al., 2014) and populations may be exposed to new stressors as conditions change. In fact, novel technologies (combined with retreating ice at the poles) now allow us to access even the deepest and previously most inaccessible regions. In the Arctic, in particular, we are witnessing an influx of activities new to the region, including large-scale fishing, fossil fuel exploration, and shipping, all presenting new threats to wildlife (Simmonds, 2016).

TABLE 17.1 Factors That May Adversely Affect Cetacean and Other Marine Mammal Populations and Their Habitats

Climate change	Storm intensity changes
	Sea ice changes
	Changes in runoff water circulations
	Ozone depletion
	Climate change–driven *changes in human activities, e.g.,* • *increased shipping and fishing in Arctic waters* • *increased directed take of marine mammals*
Pollution	Nutrient pollution/eutrophication
	Harmful algal blooms
	Oil spills
Persistent organic pollutants, especially PCBs (but also potentially including brominated flame retardants and perfluorinated compounds)	
Heavy metals	
Nonfishery-derived marine debris, including microdebris	
Fisheries/related activities	Overfishing and prey-culling *and depletion*
	Mariculture
	Marine debris, including ghost nets
	Bycatch
Noise pollution	Seismic surveys
	Boat traffic (*also causing ship strikes*)
	Military sonar
	Construction
Pathogen emergent disease	
Physical habitat degradation	Bottom trawling
	Dredging
	Other destructive fishing techniques
	Reclamation
	Coastal construction
	Wind farms
	Dams and barrages
	Marine fossil fuel exploration/extraction

Continued

TABLE 17.1 Factors That May Adversely Affect Cetacean and Other Marine Mammal Populations and Their Habitats–cont'd

Tourism	Whale watching
	"Swim with" programs
War-related activities	Mines
	Munitions dumps
Introduced species	
Intentional takes	*Commercial whaling*
	Other marine mammal takes for profit or food.

After International Whaling Commission (2006), with additional factors from Brakes and Simmonds (2011).

Simmonds and Brakes (2011) compared a review of threats to cetaceans made in 1996, with their understanding in 2011, and suggested the following key developments:

- There had been a general acceptance of noise pollution as a substantive threat and some movement to address this.
- Climate change had also become an accepted phenomenon, with implications for cetaceans.
- Levels of some of the more infamous pollutants had fallen.
- There was much recent new research into marine mammal diseases and a growing awareness of the vulnerability of marine mammal populations to disease events and the potential of human activities to contribute to them.

A few years further on (I am now writing in mid-2017), it is now possible to recognize the reemergence of the threat posed by PCBs as a significant issue for the survival of some populations. Likewise, the growing number of harmful algal blooms (e.g., Anderson, 2009), possibly boosted by nutrient discharges, combined with changing climate, seems to be coming more clearly to the fore as a pressing issue (IWC, 2017). It is also now much more clearly recognized that intense sounds from human activities—such as seismic air guns—can have direct physiologic effects on marine mammals and that naval sonar triggers behavioral reactions that can lead to death by stranding (NAS, 2016).

Emerging threats at this time include the growing amounts of macro- and microdebris in the seas and oceans and, as noted before, rapidly changing human activities in the Arctic. Factors impacting marine mammals populations can be lethal (e.g., a ship strike or a launched harpoon) or sublethal, and when describing "stressors" here, it is a sublethal impact that is being primarily considered. For example, while loud noise can be lethal, the most common effect of noise on marine

mammals is behavioral disturbance. From a population perspective, rather subtle behavioral changes affecting very large numbers of marine mammals may have greater consequences than occasional lethal events affecting a few (NAS, 2016).

AN EXAMPLE OF A COMPLEXITY: CLIMATE CHANGE

To help more fully comprehend the complex natures of the situations that marine mammal populations are facing, it may be worth considering further the various mechanisms through which climate change may come to impact them. Simmonds (2016) reviewed this, and it is apparent from the scientific literature that the primary concerns are not so much about a direct effect upon the individual marine mammals themselves (e.g., thermal stress) but more focused upon changes in prey and, to some extent, on changes in human activities (including their changing locations as highlighted for the Arctic earlier and discussed more broadly in Alter et al., 2010). This is not to say that there might not be direct responses from marine mammal populations to changing physical conditions in the sea. For example, cetacean population distribution is closely related to temperature, and it has long been theorized that there will be a general movement toward the poles as waters warm. There is already evidence that this is starting to happen. Prey may also change and shift distribution, so trying to separate out one effect from another in the future may be difficult.

Fig. 17.1 illustrates the various ways in which climate change–driven factors may come to affect marine mammals. It also highlights potential interactions with other factors. For example, access to prey might also be affected by competition with species that have changed distribution. And the fitness of the marine mammals (both as individuals and populations) might also be undermined by exposure to new pathogens, chemical and noise pollution, and so forth.

ENGAGING WITH MULTIPLE STRESSORS

The first serious attempt to try to address the issue of the multiple factors affecting marine mammals may have come from the International Whaling Commission (IWC). By the early 2000s, the member nations of the IWC had become concerned about the broad range of factors then known to be affecting cetaceans. It initiated an ambitious piece of work to look at this via a "Workshop on Habitat Degradation." While the workshop title indicates a focus on habitat, it was ultimately concerned with how to take an integrated approach to stressors/threats. The workshop was informed by an earlier smaller "scoping group" meeting of experts, and it is worth noting that this identified several potential ways forward, including consideration of individual health and body condition, "vital rates" (i.e., survival and fecundity and other life history parameters), population changes, and community-level changes (IWC, 2006). The scoping group suggested that the principal tools for linking habitat changes to these response variables were (1) correlative analyses comparing response variables across habitats with very different levels and patterns of impact; (2) "analogy

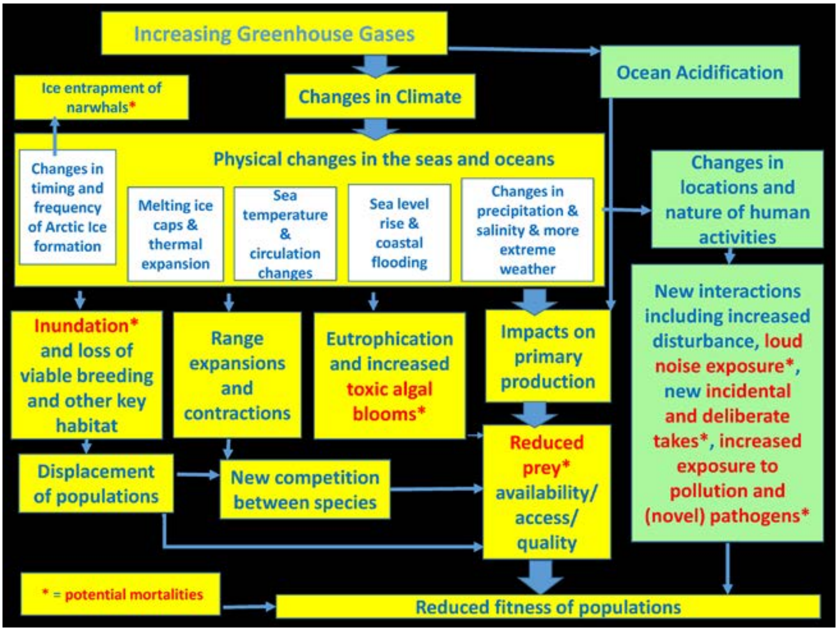

FIGURE 17.1 Climate change–driven factors and associated stressors and linkages. *(Modified from Simmonds, M.P., 2016. Impacts and effects of ocean warming on marine mammals. In: Laffoley, D., Baxter, J.M. (Eds.), Explaining Ocean Warming: Causes, Scale, Effects and Consequences. IUCN, pp. 305–322.)*

from more detailed mechanistic studies on model species"; and (3) modeling of population responses to changes in vital rates as a result of habitat degradation.

The IWC Workshop on Habitat Degradation met in 2004 and noted in its report that the IWC has been concerned about the influence of environmental changes on cetacean populations for many years, signified by various resolutions requesting that its Scientific Committee progress understanding of this issue (IWC, 2006). In response, the Scientific Committee had identified eight environmental priority topics:

- climate/environment change;
- physical and biologic habitat degradation;
- chemical pollution;
- direct and indirect effects of fisheries;
- impact of noise;
- disease and mortality events;
- ozone and UV-B radiation;
- Arctic issues.

The workshop's general conclusions stressed the importance of undertaking research relating habitat condition to cetacean status in the context of

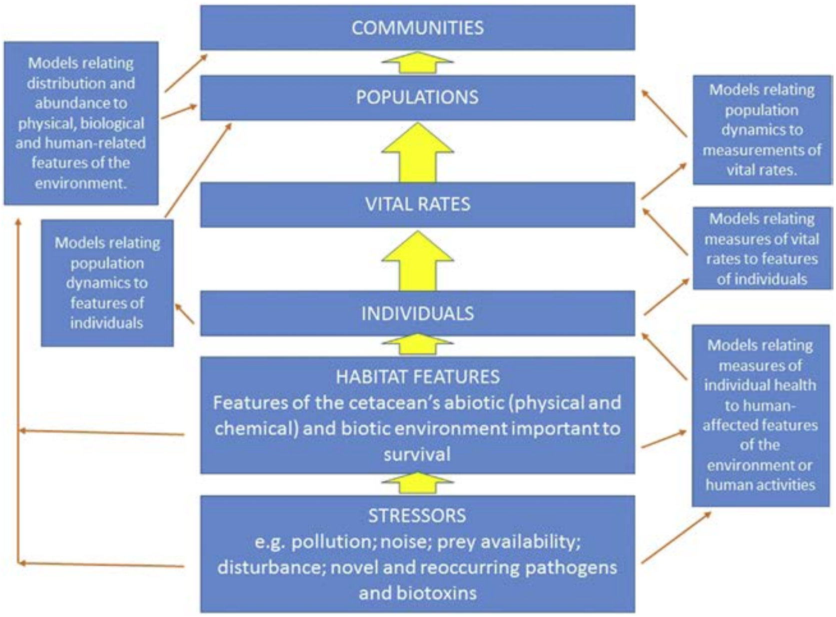

FIGURE 17.2 Framework for modeling the links between environmental stressors that degrade habitat and population effects. *(After IWC, 2006. Report of the IWC scientific committee workshop on habitat degradation. Journal of Cetacean Research and Management 8 (Suppl.), 313–335.)*

conservation and management. However, it also commented that "this is a particularly complex area of study, requiring both theoretical developments in modelling approaches and a commitment to long-term interdisciplinary data collection programmes." To help make progress, the workshop produced and strongly recommended a new framework for further investigation, which is shown in Fig. 17.2.

The workshop also commented that any general application of the framework would require that management and research bodies take a longer-term view and described the present ad hoc processes (giving "Environmental Impact Assessments," based on short-term limited datasets as an example) as unsatisfactory. In terms of further research, the workshop identified several cetacean populations with sufficiently broad sampling programs, covering sufficiently long time frames, which could be the focus of studies: Florida bottlenose dolphins; European harbor porpoises; and resident killer whales from the northwest coast of North America.

The workshop also proposed a workplan to develop the framework (as shown in Fig. 17.2) and that this should include:

1. application to specific case studies;
2. further development of approaches to distinguish the relative effects of different stressors via population and spatial modeling approaches;

3. application of the framework to one area and then using the results to make predictions for the same species in a different area and comparing this with the actual situation as a type of "validation";
4. a follow-up workshop to review the progress of this workplan.

Sadly, this comprehensive start to unraveling such a complex issue has not obviously positively resonated down the intervening years in terms of research either under the jurisdiction of the IWC or, as far as can be judged from the scientific literature, anywhere else! Perhaps the inherent problems were just too complicated, or perhaps, there was still too much to be done in terms of understanding the various stressors or developing the necessary models. However, most recently, at its 2017 meeting, the Scientific Committee of the IWC agreed to prepare for a workshop on cumulative threats, and it took note of the relevance of the outputs of the 2004 Habitat Degradation workshop to this (IWC, 2017). So, it may be hoped that there may yet be some further development and elaboration of the approaches and recommendations made by the 2004 workshop.

Certainly, there has been a lot of work on the factors affecting marine mammals and their habitats in the intervening years, and increasingly, this considers interactions with more than one stressor. The relevant scientific literature is too voluminous to review here, but examples include the copious amount of recent research on marine noise (Simmonds et al., 2014) and also on the effects of whale watching on cetacean populations (see, for example, New et al., 2015; Higham et al., 2014). Effort has also gone into modeling approaches, leading, for example, to the Population Consequences of Disturbance model (New et al., 2014).

THE LATEST WORK ON CUMULATIVE EFFECTS

Animals and populations of animals may be exposed to particular stressors once or many times. A good example is exposure to a loud noise, and multiple, frequent exposures might be more significant than rare exposures over a longer time. "Cumulative effect" has been defined as the combined effect of exposures to multiple stressors integrated over a defined relevant period: a day, a season, year, or lifetime (NAS, 2016).

In the United States, the National Academies of Sciences, Engineering, and Medicine has been looking at cumulative effects on marine mammals. The results of its deliberations were delivered in a substantive and substantial (250-page) report published in 2016 (NAS, 2016). The topic of cumulative effects was chosen by the federal agency sponsors because assessing cumulative effects has been an important part of US regulations protecting marine mammals since the 1970s, but "the approaches used have little predictive value." If cumulative effects cannot be accounted for, "then unexpected adverse impacts from interactions between stressors pose a risk to marine mammal populations and the marine ecosystems on which people and marine mammals depend" (Tyack, 2016).

Because quantitative prediction of cumulative effects of stressors on marine mammals is not currently possible, the authors of the NAS report have developed

a conceptual framework for assessing the population consequences of multiple stressors (NAS, 2016). They call this the "Population Consequences of Multiple Stressors" model, and it uses indicators of health that integrate the short-term effects of different stressors that affect survival and reproduction, and the report explores a variety of methods to estimate health, stressor exposure, and responses to stressors. (For a full explanation of this approach and the study's full and detailed recommendations, readers are directed to the full report.)

Importantly, the authors concluded that scientific knowledge is not up to the task of predicting the cumulative effects of different combinations of stressors on marine mammal populations (NAS, 2016) and comment that "even though exposure to multiple stressors is an unquestioned reality for marine mammals, the best current approach for management and conservation is to identify which stressor combinations cause the greatest risk."

CONCLUSIONS AND RECOMMENDATIONS

This short review cannot do justice to the investigations that have been made into the effects of stressors on marine mammals and their habitats, alone, in combination, or cumulatively. However, what is emerging from these studies is that this is a very complex sphere of endeavor. Clearly, much research is ongoing, and inherent in this is information that will help to inform those seeking to conserve marine mammal populations. However, the integration of research into effective conservation policy is itself far from being straightforward.

Claudio Campagna, in an inspiring keynote address at the 2015 Conference of the Society for Marine Mammalogy, challenged his audience with a bleak but well-informed view of modern conservation (Campagna, 2015). He opined that the continuing crisis of imminent extinctions is being driven by a paradigm that he summarized as

> *",,,provide me with a good economic reason or I do nothing… or I will make small adjustments of no consequence".*

He argued that the current approach to species conservation is flawed as it is based on the notion that science informs policy and policy informs conservation and sustainable economic growth. However, in practice, he argued new information is used to intervene only when it is no more costly than doing nothing! Valuing nature only in economic terms avoids recognizing the disastrous consequences of what Campagna called "the species crisis."

Sadly, my own experience of conservation work aligns closely with this, and while scientists may work hard to understand matters and give advice, including in the complex context of the multiple stressors now affecting marine mammals, this does not necessarily mean that any effective action will follow.

Related to this is that many conservation approaches require a good understanding and ongoing monitoring of the populations concerned. This is rare for many marine mammal populations (which is why many remain "data deficient" on the International Union for Conservation of Nature Red List). What is clear,

however, is that chemical pollution, noise pollution, disturbance (leading, for example, to displacement from important habitats), and other factors can substantially impact populations, and there are some instances where we know or can reasonably deduce which populations are being impacted to such an extent that their future is imperiled (for example, in the case of PCBs, certain populations in the Northeast Atlantic, including the Mediterranean and Black Sea areas). This then provides a case for action.

Pollution by PCBs and climate change are clearly difficult issues to address. There is no simple "off-tap" for either. However, it should be noted that various actions are being promoted, especially in a European context, to address PCBs (see Law and Jepson, 2017; Stuart-Smith and Jepson, 2017). However, in situations where we believe such intransigent stressors as these may be the primary cause of problems, addressing other more easily resolvable factors likely to be adversely affecting the population would seem at least precautionary and, indeed, sensible (e.g., taking action to stop or lessen incidental removals in fishing nets or death by ship strikes).

Such precautionary action—reducing stressors where this is possible—should not wait on perfect proof of impact or be inhibited by the knowledge that these stressors are not the primary causal factors in declines, but it should proceed to make populations as robust as possible to the multiple stressors they are facing. Sanctuaries or marine protected areas, wherein stressors are reduced or removed, will play an important role in this, and there is an ambitious program of work on this going forward at this time led by the Marine Mammal Protected Areas Task Force. The Task Force was created in 2013 and has been setting up regional workshops to identify Important Marine Mammal Areas, beginning with the Mediterranean in 2016, followed by the South Pacific, the Northeast Indian, the Northwest Indian and the Southeast Pacific oceans, and the waters of Oceania surrounding Australia and New Zealand (ICMMPA, 2017).

Another innovation (as hinted at in the introduction) is the use of animal health considerations to help pinpoint and better understand problems. Monitoring marine mammal population trends may not always be practical, and a measurable decline in a population should not necessarily be taken as the only possible cue for action. Welfare science and health assessments offer another set of tools. This idea is not entirely novel. While the 2004 IWC workshop did not formally include health assessments in its guiding framework (Fig. 17.2), the possible development and use of health parameters was certainly discussed there (IWC, 2006). Thirteen years later, the National Academies of Sciences, Engineering, and Medicine puts monitoring health at the center of its approach and recommendations.

More generally, monitoring the health of wild populations offers a new way to identify when significant problems are developing; perhaps providing a kind of early warning system. This relationship between welfare science and conservation now deserves to be further developed from the perspective

of improving both conservation and welfare responses, and interestingly, the IWC, with its growing interest in whale welfare outside of the hunting context (IWC, 2016), may prove to be the crucible in which such things productively come to mix.

Finally, one of the biggest problems faced by those who want to conserve and protect marine mammals (or for that matter address pressing threats, including climate change) is convincing those in power and the public more generally that this actually matters: specifically that the survival of marine mammals has relevance to our own species.

Somehow, it appears that the human race has become detached from the natural environment that supports it by maintaining functioning ecosystems of which wild animals (including marine mammals) are components. This detachment is so profound that we do not recognize the threat to ourselves as our activities disrupt and damage ecosystems. Part of the response to this has to be in education (in the broadest sense) and explaining how we inherently fit into—and are supported by—something much bigger than ourselves. Without a better informed and sympathetic public, and policy makers, we have little hope of effectively addressing the complex issues besetting marine and other ecosystems.

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From:	Caitlin Connell
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Friday, 20 December 2019 8:03:59 AM

I oppose the Smith Bay Wharf because of the proven environmental impact on our beautiful Smith Bay, I also oppose the wharf because of the impact on surrounding businesses.

From:	Caroline Iasanzaniro
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Thursday, 19 December 2019 11:46:28 PM

Wrong location for a start. Will destroy the dolphin, whale habitat. Not to mention destroying established business such as YUMBAH Abolone and Molly's Run B&B. The night skies will disappear under afterficial light. The animals will go. The roads will be destroyed. Just plain wrong

From: Cathy Fowler
To: DPTI:State Commission Assessment Panel
Subject: Concerns about KPT"s Seaport development at Smith Bay
Date: Friday, 20 December 2019 4:43:46 PM

Smith Bay
Just to add my voice to this cause.
There is no question that this is the wrong place for this development - for so many reasons - on land & sea.
It is a massive blow to the environment of Kangaroo Island - to the fragile surrounding sea and to the land through which the massive timber trucks will have to pass to get to the port itself.
This should never have even been suggested as a proposal & I shouldn’t have to be writing this now.
Please put the environment first here and not money, profit & destruction of a very special place.

From:	Chelsea Johnson
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Tuesday, 17 December 2019 7:55:31 AM

I don’t believe that Smith Bay is the ideal location for the wharf. The environmental upheaval required to build and maintain the wharf are an unacceptable cost. Additional maintenance of the dirt roads providing access to the wharf will fall on local council and drain much needed funds for the community. I agree wholeheartedly with every objection raised by the Save Smith Bay organisation.

From:	Chloe Buiting
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Tuesday, 17 December 2019 5:03:34 PM

To Whom It May Concern

Regarding: KIPT's Addendum for their proposed development at Smith Bay, 2019

My name is Chloe Buiting and I am a 29 year old Australian veterinarian and conservationist. I work with wildlife all over the world but have recently moved to Kangaroo Island to make it my home base. I am shocked and appalled about the proposed development at Smith Bay on KI for several reasons, namely because it is a completely inappropriate and dangerous location for such a development. We have the leading rate of mammal extinction in the world in Australia and a truly disgraceful track record with species conservation as a whole, and this development will further compromise two more species. Smith Bay is a home ground to the heavily endangered Southern Right Whales, and a safe breeding ground for common bottle nose dolphins. Contrary to popular belief, these dolphins have been documented to breed 12 months of the year in these waters, and the proposed development at this site and the increased human/marine activity around it will drastically compromise their ability to do this. If they are pushed into deeper waters, they have a much higher risk of predation which could have disastrous effects given that already, with the safe haven of Smith Bay, their juvenile survival rate is only 50%.

The development has failed to take into account the far-reaching and potentially irreversible effects of their proposal, and I respectfully request that it is withdrawn. There is also a 30 million dollar business and huge driver of our island economy (Yumbah) right on the foreshore at Smith Bay who will be forced to close should this proceed. They make no impact to the marine environment, and if they were to close, this would also mean the loss of 30-50 full time island jobs in an already struggling economy.

Please reconsider the location of this proposed development. The fact that it is not proceeding further West of the island, where the trees actually are, also makes me question the long-term intentions of KIPT and their activities here on KI.

Sincerely

Chloe Buiting

From:	Chris Paddon
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Wednesday, 18 December 2019 7:21:20 AM

As I Am a strong supporter of KI Dolphin Watch and have been for many years, their research states any development of Smith Bay would devestate the marine life. Therefore I strongly oppose it!!!

From:	David Ellis
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Friday, 20 December 2019 4:56:01 PM

I ha e read KIPT's addendum and have carefully reviewed all other documents made publicly available.

Smith Bay is a special and recognised biologically important area for marine mammals and a huge diversity of marine life. Dredging and construction of the wharf will destroy the ecological integrity of this important marine environment. Increased shipping movements may bring unwanted biosecurity risks to KI through ballast water and fouling of boats by noxious non-native marine species.

The abalone farm adjacent will also suffer from increased turbidity due to dredge sediments and the fluid dynamics of large vessel movements.

The terrestrial environment is known habitat for the endangered KI echidna subspecies and the vulnerable Rosenbergs goanna. Both species will suffer further losses due to more frequent truck and vehicle traffic increasing their risk of further decline.

KIPT and Hanson Bay Wildlife Sanctuary are performing an illegal experiment on Tasmanian blue gum felling and coppicing and observing responses of koalas to this activity. I have a full amd separate submission regarding this that has already been discussed the DEW Wildlife Ethics Committee. There is no ethics permit, scientific research permit or a licence for teaching, research experimentation requiring animal use. All three of these permits must be obtained for research of this nature to be legally authorised.

KIPT are therefore in serious breach of the Animal Wefare Act and have clearly demonstrated that they are prepared to take risks and shortcuts to proceed with their project.

I do not trust that KIPT can be trusted to do the right thing and I opppse the wharf and the plantations in general.

From: David Muirhead
To: DPTI:State Commission Assessment Panel
Subject: Concerns about KPT"s Seaport development at Smith Bay
Date: Saturday, 14 December 2019 7:13:41 PM

As secretary of the Marine Life Society of South Australia Inc, and as an individual with more than 5 decades of snorkeling and diving experience almost entirely in my home state of S.A., I consider myself well placed to comment.
A MLSSA position statement appears elsewhere however in a nutshell, Smith Bay contains a wealth of temperate marine biodiversity including some yet to be described species.
I've dived in Smith Bay in December 2018 and again in March this year, including to 22 m depth, and many of the animals and plants I photographed can be seen on the inaturalist.org website under the Smith Bay iNat project.
Included in the list of species I helped compile are at least four (possibly 5) Syngnathid fish species (both our Seadragons plus several Pipefish including the Mother of Pearl Pipefish),and ALL Syngnathid species are fully protected in South Australia.
Smith Bay is -to the best of my knowledge-one of the very few parts of Gulf Saint Vincent never trawled for prawns ,and the prolific invertebrate, marine plants and fishes observed on every dive was a revelation even though I have often dived at Western River ,Snug Cove, Stokes Bay, Ballast Head and the Kingscote area over my lifetime.
Any deep water port facility at Smith Bay, indeed anywhere along the north coast of K.I, is certain to generate serious turbidity every time a ship docks and departs i.e. not just during the construction phase, and available oceanographic/hydrological modelling demonstrates unequivocally that silt lifted high into the water column (even from a depth of 20m or more) by freighters will travel many km along the north coast, both westward and eastward, due tides even in benign weather conditions.
If the port proceeds we can kiss goodbye to ecotourism along nearly all of the North Coast of K.I.
Yours Sincerely,
(Dr) David Muirhead

From:	David Muirhead
To:	DPTI:State Commission Assessment Panel
Subject:	Smith Bay Kangaroo Island Deepwater port revised proposal. MLSSA Inc Position Statement. *Importance High.*
Date:	Friday, 20 December 2019 12:41:00 PM

Dear Sir/Madam/Staff Concerned,

I,as Secretary of the Marine Life Society of South Australia Inc.(hereafter MLSSA Inc) ,with the President and Committee's unanimous support,do hereby provide our position statement concerning KIPT's Smith Bay K.I proposal for a deep water port facility.

MLSSA Inc ,as the only incorporated not for profit community group within South Australia whose Constitution and Aims cover the entire marine and estuarine waters within our State borders, has a long and proud history of involvement in research, exploration, biodata collection, specimen collection under permit (I am one of two members who hold current Ministerial Exemption Collecting Permits, obtained via collaboration with Museum S.A. and Marine Ecological Professors and other qualified and internationally highly regarded experts associated with our major State tertiary education institutions),journal publications ,liasing on all relevant marine life topics with many other stakeholders over decades(such as DEW(formerly DEWNR) , PIRSA/Sardi, Reef Watch(c.f. Reef Life Survey),Museum S.A., EPA,Biosecurity S.A., Tourism S.A., State Herbarium, Experiencing Marine Sanctuaries,Malacolgical Society of South Australia Inc (MSSA Inc),Rec-Fish SA(and it's new overarching ministerial advisory body),and we are closely involved in the shellfish reef trials and monitoring thereof , in collaboration with Alan Noble of Aus Oceans (coincidentally a MLSSA member).

This list is far from complete, but in all cases MLSSA and any given collaborative group or project gain mutual benefit,with sustainable marine habitats the common goal.

MLSSA Inc has also long been a provider of quality underwater images for books and brochures,largely at the request of State Government Departments and sundry nature conservation community groups,aiding public education covering every facet of this State's marine life.

MLSSA is thus ideally placed to provide a carefully considered, science based, expert, non political view on the likely impacts of a deep water port facility at Smith Bay.

In the interest of brevity, I will now summarize our position.

Smith Bay DOES contain highly threatened Marine Habitats and Marine taxa.

Smith Bay is one of the very few parts of Gulf Saint Vincent never trawled for prawns, and is thus a very rare representation of what much of GSV's benthic habitats and biodiversity was like prior to the advent of prawn trawling.

Smith Bay DOES contain numerous species within the FULLY PROTECTED Syngnathid fish group.

As an individual with extensive experience-over 4 decades of SA diving, amassing a wealth of images of the majority of described Syngnathid taxa known to occur in South Australia ,due my special interest in Syngnathid species and my having logged more than 1500 scuba dives WITHIN South Australia over almost 5 decades, I do not make that statement lightly. (References available on request).

In December 2018,and again in March this year, I dived Smith Bay (from depths of a few meters to 22 m),and every aspect of the Bay screams Syngnathid Hotspot!
Almost a full complement of bottom types is one of the reasons, but there are quite a few other aspects that make Smith Bay unique.

MLSSA opposes the planned deep water port facility at Smith Bay.

Impacts on ecotourism (the fastest growing form of tourism globally)along the north coast of K.I, alone, should be enough to prevent such a proposal getting this far.

I refer not only to the short term impacts during construction but to the long term increase in turbidity every time a ship docks and departs, due the widely available,factually unassailable oceanographic and hydrological mapping data.
Put simply, lifted silt,even at 20 m depth, will travel many km east and west along the north coast of K.I, carried by tides even in benign weather conditions.

Any further decline in water clarity hence light penetration will inevitably lead to further seagrass loss, and have many other catastrophic consequences for the fantastic rocky reefs that line the north coast but which do not extend far offshore.

Thank you for reading the MLSSA submission.

Please don't hesitate to ask for further information on any of the content.

Yours Sincerely,

(Dr) David S Muirhead
Secretary, MLSSA Inc.
Mobile phone number [redacted]
Email address (private): [redacted]
Residential address: [redacted]

PS:-A taste of the marine life in Smith Bay can be had by visiting the Smith Bay iNat project on the inaturalist.org website.

From: [redacted]
To: DPTI:State Commission Assessment Panel
Subject: Smith Bay K.I proposal by K.I Plantation Timbers for a deep water port facility at Smith Bay
Date: Saturday, 14 December 2019 7:52:59 PM

Dear Sir/Madam,

I have dived Smith Bay to document the Marine Life there in December 2018 and again in March this year.

The number of undescribed species is considerable, and I will be very surprised if new (undiscovered not just undescribed) taxa are not awaiting discovery within Smith Bay itself.

Indeed I have clear photos (feel free to browse the inaturalist.org website, under the Smith Bay iNat project, and my user name on iNat is davemmdave)of a number of species that await taxonomic ID to species level despite having been reviewed by multiple highly qualified taxonomists, often global experts in their respective fields e.g. ascidians, echinoderms, corals, bryozoans,sponges ,and crustaceans.

At least 5 fish species occurring in Smith Bay are protected under state legislation.
#1:The 4-5 Syngnathid species already recorded in Smith Bay-and as an experienced citizen science studier of S.A. Syngnathid species I am certain that others will occur there, including the Western Upsidedown Pipefish,Heraldia nocturna,which is probably(personal communication with Graham Short c/-California Science Academy) the earliest extant species from which all the world's Syngnathid species evolved.
#2:The Western Blue Groper (fully protected in Gulf Saint Vincent which includes Smith Bay).

Smith Bay is one of the very few parts of Gulf Saint Vincent never trawled for prawns and the prolific invertebrate community I documented with others at depths of up to 22 m in the Bay is in remarkably pristine condition.

Unlike most of GSV, which has lost most of the deep water seagrass meadows (eelgrasses were prolific even at 30-40 m depth in Investigator Straight due excellent water clarity,before trawling, and are now absent) sponge gardens, bryozoan,ascidian and shellfish populations that stabilized the soft bottom prior to prawn trawling ,Smith Bay's unique benthic topography rendered it unsuitable for trawlers.

Marine ecotourism is THE economic future of the North Coast Kangaroo Island.

Kiss goodbye to that, if the port goes ahead.

Yours Sincerely,

Dr David Muirhead
Secretary, Marine Life Society of South Australia Inc
Holder of a Ministerial Exemption Permit for collecting marine life forms strictly for science (c/- Museum SA)
Past volunteer ship's doctor and marine life photographer on the Ngerin on 3 scientific expeditions to remote offshore islands in S.A. including The Investigator Group and The Sir Joseph Banks group, among other similar expeditions by NGOs e.g. the Waterhouse Club marine invertebrates expedition to Pearson Island circa 2001.

Sent from my Samsung Galaxy smartphone.

From:	Eliza Havelberg
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Wednesday, 18 December 2019 6:27:21 PM

Smith bay is beautiful, it'd be a shame to build a wharf in such a beautiful area.

From:	Emily Hinge
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Thursday, 19 December 2019 9:58:01 PM

Smith bay is one of the most beautiful/peaceful and full of animal life every where you look. That type of beauty needs to stay with nature only and left alone. The dolphins, whales, seals need smith bay, it’s their home

From:	Emma Errington
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Friday, 20 December 2019 4:28:27 PM

My family lives DIRECTLY across the road from Smith Bay and this will impact their farm as well as the beautiful biodiversity that makes up Smith Bay.

From: Fiona Fogg
To: DPTI:State Commission Assessment Panel
Subject: Concerns about KPT"s Seaport development at Smith Bay
Date: Friday, 13 December 2019 6:10:13 PM

The effects on the beautiful marine life like the sea dragons

From:	Graham Hind
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Saturday, 23 November 2019 5:50:40 PM

The desire by KPT to build a wharf that overshadows a pristine area of coastline on Kangaroo Island, encroaches on mature abalone areas and will restrict access by residents of Kangaroo Island to the immediate area will only ruin the overall general attractiveness of KI. The wharf will bring in larger ships that could damage the fragile environment of KI. By extending the wharf further out into the strait, will not remove the overall impact to the surrounding areas both on land and water. Do not allow this to happen.

From:	Grant Page
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Tuesday, 10 December 2019 8:01:59 AM

I am concerned about a world class abalone farm currently exporting world wide , this local employer has been in business for some 20 yrs & employs 100% locally ... a company should not be allowed to simply knock out another company just because they want if kipt were to move closer to there plantations to set up there operations it would not impact several established businesses in smith bay and surrounds ... b&b accom , abalone farm , marine tourism , dolphin tours ..... it’s bloody ridiculous this should even be considered.... I spoke to the guy who runs the dolphin tours and has for 14 yrs said it would finish his business because he sell nature & nature would be destroyed the marine mammals there are used to minimal noise & are some of the most reliable marine mammals on the planet ..... make kipt use existing freighting options like SeaLink or use that facility... thank you grant

From: Isobel Betheras
To: DPTI:State Commission Assessment Panel
Subject: Concerns about KPT"s Seaport development at Smith Bay
Date: Thursday, 19 December 2019 7:55:36 PM

I believe that the plans for further industrialisation in the area of Smith Bay is a beneficial plan for Kangaroo Island, although I believe it may help for our future on Kangaroo Island I would much rather the reconsideration of the placement, although Smith Bay has the space for constructing a wharf impacts the community in the Long term and is a very controversial process, the reconsideration would not only give more time for our community to express their opinions it would also help for the community to understand more about the species that live in the remote area of Kangaroo Island. the younger community is fuming with the lack of consideration we have had and on the be half of the younger generation I would love to have the committee form a group to discuss our opinions to understand the situations we are putting our island into, if any further comments or information is needed from my comment please feel free to contact my email listed before we make a big mistake as a divided community.

From: Jan Hawes
To: DPTI:State Commission Assessment Panel
Subject: Concerns about KPT"s Seaport development at Smith Bay
Date: Saturday, 7 December 2019 11:19:14 AM

Smith Bay is a pristine spot with many sea creatures which would be adversely effected (possibly just wiped out) by this proposal.
The road into the Bay is completely unsuitable for heavy trucks and even if upgraded I believe it would be detrimental to our island to have heavy trucks zooming along country roads. Not to mention all the native animals which would be displaced with the widening of the roads and would be killed by trucks as they graze on the roadside vegetation.
Smith Bay is NOT the place for this development. Sometimes you have to admit there are more important things than money and this just such an instance.

From:	Janelle Scotts
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Tuesday, 17 December 2019 7:14:59 PM

Smiths bay on kangaroo island is worth protecting
The Southern Right Whales breed there and there are many other species worth protecting.
There are other locations for this seaport which means economic development can still occur for the island
I know it is close to holiday time but if youcan spare a moment to voice your objection it will really help the SA government understand that the community value this area
Have a great break

From:	Jenni Mahony
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Tuesday, 17 December 2019 8:39:13 PM

Having been to kangaroo island recently and looking at the pristine beaches we don't have much un touched land in the world we should protect this small piece.

From:	Jennifer Iley
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Thursday, 19 December 2019 4:24:40 PM

Saving what’s left

From:	kathryn kleinig
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Tuesday, 17 December 2019 7:52:09 AM

To many marine species will be at risk off disease or death.

From:	lara tilbrook <[redacted]>
Sent:	Friday, 20 December 2019 3:42 PM
To:	DPTI:State Commission Assessment Panel
Subject:	Re; Submission in response to KIPT Addendum
Attachments:	KI VH Dolphin Watch KIPT Smith Bay Addendum Response Dec 18th 2019.docx; Attachment 1 cms_cop12_res.12.14_marine-noise_e.doc; Attachment 2 CMS-Guidelines-EIA-Marine-Noise_TechnicalSupportInformation.doc; Attachment 3 Environmental Impact Assessment Guidelines Prideaux_Prideaux2015.pdf; Attachment 4 Simmonds2018MultipleStressorsChapter.pdf
Categories:	Green Category

hello

I am making a submission in response to the proposed development of Smiths Bay by KIPT. I am a member of the Kangaroo Island community, keen to see the Island and it's surrounding waters protected for future generations.

I am blown away by the dolphins and whales I've seen on the north coast, it is a marine hot spot, 85% of the species that live here, live no where else in the world. Let stop and really think about the impacts! We need to support our marine life at all cost by offering sanctuaries, not increasing traffic and noise. Dolphins breed all year round. No time is a good time.

I have grave concerns for Smiths Bay and the impacts on surrounding marine environments as well as the impacts on threatened and EPBC listed species in the ocean and on land. I am in full support all the of the research information that has been complied by experts attached below.

Please contact me if you need any additional information

Lara Tilbrook
ARTIST · ENVIRONMENTALIST · GOLDSMITH

p : [redacted]
w : [redacted]
e : [redacted]
i : [redacted]

Kangaroo Island / Victor Harbor Dolphin Watch

in partnership with

Whale and Dolphin Conservation

www.kangarooislanddolphinwatch.com.au www.islandmind.com

Facebook Twitter & Instagram: @KIVHDolphinWatch

PO Box 30 American River, Kangaroo Island, SA 5221

[redacted] [redacted]

Dec 18th 2019

Kangaroo Island Plantation Timbers Addendum Response

PREAMBLE

Ever since the research findings of the **Rolland Study** following 9/11 were published it has been acknowledged as fact that anthropogenic sound has enormous impacts upon the lives of cetaceans.

These marine mammals use sound as their major sense for meeting their lifestyle needs and our interference with this element of their lives is of extreme concern to scientists around the globe.

We can no longer claim we act with impunity and in light of our expressed desire to maintain biological diversity, we must do everything we can to mitigate the impacts of human induced noise on the marine environment.

- ## Sound Propagation Modelling:

The proponents have stated their sound propagation modelling is adequate to cater for the changes outlined in the addendum document. They make consistent statements that the mitigation measures described in the EIS are considered adequate to cater for the amended design.

An example below is drawn from their conclusion to Appendix D of the Addendum:

"The changes to the design do not change the risk profile of the development as described in the Draft EIS. No additional MNES would be triggered by the changes to the proposal. Mitigation measures as described in the Draft EIS and in Table 1-2 are considered effective to manage any direct or indirect

impacts to the southern right whale. The revised proposal would not generate any residual significant impacts on the southern right whale."

In keeping with the scant regard for MNES demonstrated in the EIS, KIPT have asserted throughout the Addendum in **Sections 4.6 Matters of National Environmental Significance** and **4.8 Noise and Light**, that there is no need to change anything in their mitigation measures.

4.6.2 ASSESSMENT OF LIKELY DIRECT AND INDIRECT IMPACTS

"Table 14-2 of the Draft EIS identifies the development's potential impacts on the southern right whale. The impact assessments (direct and indirect) for the southern right whale have been reviewed (see Appendix D).

The increased length of jetty substructure and increased piling activity (number of piles to be installed, and the distance the activity would occur further out to sea) would have a negligible impact on southern right whales.

Noise modelling (Resonate 2018) undertaken on piling for the original design in the Draft EIS considered two scenarios which are consistent with the redesign: a duration of 30 minutes per day, assuming 60 blows per minute; and a duration of 15 minutes per day, assuming 120 blows per minute.

The revised impact assessment considers the revised construction program that plans for the installation of one pile at a time, but with the possibility of piling in two locations simultaneously.

Piling in two places simultaneously would effectively double the number of blows per minute per day, which would have the effect of increasing the cumulative sound exposure level (SEL) by 3 dB, and increasing the 'threshold distances' for temporary threshold shift (TTS) and permanent threshold shift (PTS) onset by approximately 1.6 times the values in Table 18.11 of the Draft EIS, assuming the exposure time is the same.

It is important to note that with the extended piled jetty substructure, the duration per day of the impact pilling is consistent with the assumptions used for the original modelling, and would occur for a total period of up to 20 minutes per pile installed, with up to two piles being installed per day."

4.8 NOISE AND LIGHT

4.8.1 ASSESSMENT OF POTENTIAL IMPACTS

"The Draft EIS assessed potential noise and vibration impacts which may have resulted from constructing a shorter section of suspended piled jetty. (This was incorporated into the original design). The approach would now be a full length suspended piled jetty and the impact assessments have been reviewed in that context. The onshore components of the KI Seaport have not changed."

Underwater Noise – Construction

"The suspended piled jetty requires the installation of approximately 156 tubular steel piles using a jack-up (piling) barge and impact hammer (refer Section 3.2.1). Increasing the number of pile installations to construct a longer jetty would also potentially extend the duration of the impact (noise source).

The baseline underwater noise environment at Smith Bay was described in Section 18.4.2 of the Draft EIS, and the effects of piling activities on the underwater noise environment were described in Section 18.4.4 of the Draft EIS. The revised design uses the same construction methodology described in the Draft EIS, which is summarised in Section 3.2 of the Addendum.

Underwater environmental impacts were assessed based on the:

- *existing conditions (such as ambient noise environment, local bathymetry, wave and wind climate)*
- *significant marine species in the study area*
- *significance of the area as a habitat for marine species*

- *species' sensitivity to sound*
- *characteristics of the identified noise sources in terms of duration, source level and frequency*
- *sound propagation characteristics of the marine study area.*

The potential impacts that were considered in the assessment are, in increasing order of severity:

- *behavioural change*
- *temporary threshold shift (TSS) in marine species' hearing*
- *permanent threshold shift (PTS) in hearing*
- *organ damage (possibly leading to death).*

To assess the impacts of the construction and operational sources, noise criteria were established for each of the considered impact levels. The underwater noise criteria adopted are based on National Oceanic and Atmospheric Administration (NOAA) Marine Mammal Acoustic Technical Guidance and the Sound Exposure Guidelines for Fishes and Sea Turtles. These represent the most up-to-date research and approach for the species considered in this assessment and are generally more stringent than the DPTI Underwater Piling Noise Guidelines.

As noted in the Draft EIS, damage to the hearing of marine fauna would be considered unlikely as the normal behavioural response to loud noise would be to move away.

Behavioural changes in response to noise are expected to be temporary and ecologically inconsequential as Smith Bay is not known to provide important feeding or breeding habitat.

The management and mitigation measures described in the Draft EIS include using a soft start, establishing a 1 km shutdown zone around the site (i.e. beyond the predicted PTS distance, see Table 21 of Resonate 2018 of the Draft EIS), and monitoring by marine mammal observers. The use of two piling rigs would reduce the total duration of piling, which would also be a consideration for planning the construction program.

Operationally, it is considered that the suspended piled jetty and reduced in-waterfootprint would have a negligible impact on whale behaviour. The design changes would remove the solid causeway from the design (which may be considered a potential barrier to movement) and any future maintenance dredging activity would no longer be required.

The proposed management measures for identified potential impacts to the southern right whale (see Appendix D Table 1-1), are consistent with the principles described in the EPBC Act Policy Statement 2.1 – Interaction between offshore seismic exploration and whales (DEWHA 2008) and are considered effective.

The assessment of the revised design against the 'significant impact criteria' is provided in Appendix D (Table 1-2)."

4.6.3 ASSESSMENT OF RESIDUAL IMPACTS

"Based on the above assessment, there would be no residual significant impacts on the southern right whale as a result of the revised design for the KI Seaport."

4.6.4 CONCLUSIONS

"The changes to the design do not change the risk profile of the development as described in the Draft EIS.

No additional MNES would be triggered by the changes to the proposal.

Existing mitigation measures as described in the Draft EIS are considered effective to manage any direct or indirect impacts to the southern right whale. The revised proposal would not generate any residual significant impacts on the southern right whale."

<u>This is a completely false assumption and assertion.</u>

It is based on **convenience, not Science**.

In **Section 2.2 Government Agency Consultations on the Design Change** in specific discussions with the Department of the Environment and Energy (Commonwealth) the following is stated:

"Underwater noise baseline data collection and predictive modeling assessment review in relation to the design change".

We are obviously not the only people concerned about the lack of adequate sound modeling in light of the changes to the design of the wharf.

Their response is simply to suggest what was in place was good enough previously so it's good enough now, albeit 250 metres further out to sea.

This is extremely unscientific and shows a complete **lack of understanding of sound propagation in the marine environment**.

- Potential Impacts:

Sound propagation properties change markedly in different situations as described in the **EIA Guidelines** attached. Also attached are the **CMS Technical Studies** for the guidelines.

Australia is a signatory to the CMS documentation provided and due consideration needs to be taken of the principles and findings of this world leading research.

The **EIA Guidelines** and accompanying **CMS Technical Details** were presented and adopted at the *CMS CoP 12, 2017* in the Philippines. They describe the possible impacts of all known forms of anthropogenic sound introduced to the marine environment and include information regarding construction noise production relevant to this submission.

**Reference 1 - Attachment 1: EIA Guidelines*

**Reference 2 - Attachment 2: CMS Guidelines: EIA Marine Noise Technical Support Information*

The following tracts from Page 9 from these extremely comprehensive documents make salutary reading.

They are an excellent starting point in any consideration of anthropogenic sound in the marine environment.

8. The propagation of sound in water is complex and requires many variables to be carefully considered before it can be known if a noise-generating activity is appropriate or not. It is inappropriate to generalize sound transmission without fully investigating propagation

(Prideaux, 2017a). Often, statements are made in Environmental Impact Assessments that a noise-generating activity is 'X' distance from 'Y' species or habitat and therefore, will have no impact. In these cases, distance is used as a basic proxy for impact but is rarely backed with scientifically modelled information. (Wright et.al. 2013; Prideaux and Prideaux 2015)

9. To present a defensible Environmental Impact Assessment for any noise-generating activity proposal, proponents need to have expertly modelled the noise of the proposed activity in the region and under the conditions they plan to operate. Regulators should have an understanding of the ambient or natural sound in the proposed area. This might require CMS Parties or jurisdictions to develop a metric or method for defining this, by drawing on the range of resources available worldwide. (Prideaux, 2017a)

10. All EIAs should include operational procedures to mitigate impact effectively during activities, and there should be proof of the mitigation's efficacy. These are the operational mitigation procedures that should be detailed in the national or regional regulations of the jurisdictions where the activity is proposed. Operational monitoring and mitigation procedures differ around the world, and may include industry/company best practices.

Monitoring often includes, inter alia:

a. *periods of visual and other observation before a noise-generating activity commences*
b. *passive acoustic monitoring*
c. *marine mammal observers*
d. *aerial surveys*

Primary mitigation often includes, inter alia:

e. *delay to start, soft start and shut-down procedures*
f. *sound dampers, including bubble curtains and cofferdams; sheathing and jacket tubes*
g. *alternative low-noise or noise-free options (such as compiled in the OSPAR inventory of measures to mitigate the emission and environmental impact of underwater noise)*

Secondary mitigation, where the aim is to prevent encounters of marine life with noise sources, includes inter alia:

h. *spatial & temporal exclusion of activities*

11. Approaches to mitigate the impact of particle motion (e.g. reducing substrate or sea ice vibration) should also be investigated. Assessment of the appropriateness and efficacy of all operational procedures should be the responsibility of the government agency assessing Environmental Impact Assessments (EIA).

Given the plethora of studies completed, some of which are noted here, and the data acquired regarding the impacts of construction noise upon the marine environment, it is timely for the government to consider the situation in light of **potential economic**, **social** and **environmental** implications.

**Reference 3 - Attachment 3: Environmental Impact Assessment Guidelines Prideaux_Prideaux2015*

From pages 11 and 12 of the EIA guidelines the following points are worthy of note:

23. Many propagation models have been developed such as ray theory, normal modes, multipath expansion, fast field, wavenumber integration or parabolic equation. However, no single model accounts for all frequencies and environments. Factors that influence which propagation model/s should be used include the activity noise frequencies, water depth, seabed topography, temperature and salinity, and spatial variations in the environment.
(Urick, 1983, Etter, 2013; Prideaux, 2017a)

<u>The information provided below in **Sections 25 and 28** is especially relevant in consideration of impacts upon resident marine fauna, particularly Sygnathids, which include a number of endangered species.</u>

25. Commonly missing in EIAs is the modelling of particle motion propagation. Invertebrates, and some fish, detect sound through particle motion to identify predator and prey. Like sound intensity, particle motion varies significantly close to noise sources and in shallow water. Excessive levels of ensonification of these animal groups may lead to injury (barotrauma). Specific modelling techniques are required to predict the impact on these species.

28. Sound exposure levels works well for marine mammals but not well for a number of other marine species, including crustaceans, bivalves and cephalopods, because these species are thought to mainly detect sound through particle motion. Particle motion or particle displacement is the displacement of a material element caused by the action of sound. For these Guidelines the motion concerned is the organism resonating in sympathy with the surrounding sound waves, oscillating back and forth in a particular direction, rather than through the tympanic mechanism of marine mammals or swim-bladders of some fish species.
(Mooney, et.al., 2010; André, et.al., 2011; Hawkins and Popper, 2016; NOAA, 2016)

- <u>Inadequate Sound Propagation Modelling:</u>

As the water properties modelled in the original EIS are significantly different from those now involved in the amended plan, **further, more comprehensive modelling should be undertaken**.

It is not conceivable to make decisions based on the previously provided modelling which is no longer relevant.

To suggest otherwise is irresponsible in the extreme and in keeping with KIPT's previous performance with respect to MNES.

- <u>Questionable "Benefits" of Movement Offshore:</u>

The proponents have been at pains to explain the "benefits" of the movement further offshore by 250 metres.

They have described the benefits in detail without any consideration of the difficulties this creates for marine fauna and cetaceans in particular. This is particularly so for impacts which will *"disrupt the breeding cycle of a population"* as specified under MNES/EPBC documentation.

In their documentation KIPT state the following:

***"The National Conservation Values Atlas** identifies the entire coastline of Kangaroo Island as a biologically important area that is used for seasonal calving by the southern right whale (DoEE 2015), and there are no records of breeding in this area. The presence of the port is unlikely to impact breeding at other sites, such as Encounter Bay and Fowlers Bay, as they are too far away to be affected."*

- No Understanding of the Conservation Management Plan:

There has been no understanding of the **Conservation Management Plan** as demonstrated, and the need to protect areas of possible recolonisation.

Nor is there any upgrading of their understanding related to data provided regarding **breeding observed in Smith Bay and adjacent areas**.

The Addendum is therefore extremely limited in scope and designed for a single purpose only ….. an attempt to appease Yumbah Aquaculture.

There is a **Conservation Management Plan** for this species due to their endangered status under the provisions of the EPBC Act. This plan covers the period from 2011 to 2021.

**Reference 4: Conservation Management Plan for the Southern Right Whale - A Recovery Plan under the Environment Protection and Biodiversity Conservation Act 1999 2011–2021*

The movement further out to sea compounds the situations described in our previous submission in response to the EIS.

As they describe in their addendum documentation, in **Sections 4.6 and 4.8**, sound propagated by piling is now at a magnitude 1.6 times that previously considered as part of their mitigation strategies. That effectively moves the **potential for TTS impacts** from 6.5 metres to 10kms, or possibly greater, under new modelling.

This means the sound impacts will be affecting sensitive receptors in the middle of **Investigator Strait**. It is worth noting this is an extremely busy shipway and the potential for vessel strike situations is therefore heightened.

The following tract from Sharon Livermore of IFAW explains some of the difficulties:

Ship strikes and whales: Preventing a collision course

4 November 2019

"Today, many species of whale around the world are threatened by collisions with vessels, known as ship strikes, and unfortunately, these collisions often result in severe injury or death. ***Both ship numbers and the speeds at which ships are able to travel have increased globally in the last few decades and this means a***

greater risk of ship strikes and injuries to whales, particularly where shipping activities overlap with critical whale habitat.

For those whales that are not killed immediately, a collision can result in horrific and serious injuries; blunt trauma resulting in major internal injury, deep propeller scars, and severed spines, tail flukes and fins, are just some of the injuries recorded in live and stranded animals that have been victims of collisions. ***A whale that has sustained a serious injury from a ship strike will often suffer a slow, painful death.***

Certain whale populations are more vulnerable to ship strikes, particularly those found close to developed coastal areas or those found in high numbers in areas with large volumes of shipping traffic. ***Consequently, ship strikes are recognized as a serious conservation and welfare problem for many whale populations throughout the global ocean.***

Worryingly, the risk of ship strike is largely unrecognised and reports of ship strikes likely under represent actual incidents. Many mariners do not know about reporting requirements for ship strikes and in many cases collisions go unnoticed; even an animal as large as a whale pales into insignificance against a 300-metre cargo vessel.

IFAW is working hard to help reduce ship strikes in several regions, with a specific focus on areas where ship strikes are known to negatively impact endangered whale populations. The solutions that exist to prevent ship strike vary depending on many factors, including whale distribution, behaviour, habitat use, and ship routing options and limitations. ***Separating shipping lanes and whale habitat*** *is the most effective option, but where this is not possible,* ***slowing vessel speeds*** *can also help protect whales from strikes. Ensuring* ***mariners are aware*** *of ship strike risk is also key to reducing the problem.*

For example, our work in the Hellenic Trench, Greece, focuses on a small change in shipping routes, which is required to dramatically reduce risk to endangered Mediterranean sperm whales. This is also the case for blue whales off southern Sri Lanka. However in New Zealand, Bryde's whale distribution across the Hauraki Gulf means that vessel speed limits offer the most straightforward solution to reduce risk. Slower speeds also reduce the levels of underwater noise from ships, resulting in further benefits for whales. In the USA, IFAW and partners pioneered the Whale Alert app to help protect the North Atlantic right whale from ship strikes. This technology offers a tool for mariners, advising them of measures to reduce collision risk and the presence of seasonal management zones, where the U.S. government has put ship speed reduction measures in place in the areas most important to these critically endangered whales.

Slowing down helps to save the lives of whales because, in a similar way to the injuries sustained by a pedestrian hit by a vehicle on our roads, the speed at which a ship is travelling has a strong bearing on the likelihood of a fatal injury occurring to a whale. On roads, we use 'school zones' to control speed and reduce the risk of fatal injuries to children. In our oceans, the concept of 'whale zones,' or areas where ships need to slow down, could also be used in the areas of highest risk where separating whales and shipping is not an option.

These practical solutions that exist to reduce the risk of ship strikes to whales are already being used elsewhere around the world. All that is required is the political will to make the changes needed on the water. Critically, a lack of action puts both individual whales and their populations in danger, which is why at IFAW, we are working on practical, science-based solutions to protect whales from ship strikes in the places they call home."

Sharon Livermore: Program Officer, Marine Conservation November 4th 2019

**Reference 5: IFAW - Sharon Livermore Article*

Under **MNES provisions** there are a greater number of species likely to be impacted upon by the construction / piling noise, including:

- **Sperm whales** - *Physeter macrocephalus*
- **Blue whales** - *Balaenoptera musculus*
- **Humpback whales** - *Megaptera novaeangliae*
- **Beaked whales** - *Ziphiidae* etc

Some of these species are endangered, some vulnerable, others threatened and **ALL** migratory.

All are known to frequent Investigator Strait.

Also by pushing further out into deeper water the chances of impacting upon **Shortbeaked Common dolphins** *Delphinus delphis* are exacerbated.

The proponents imply that the **longer piling jetty will be less of a barrier to movement** than the solid causeway.

This supposition is **not** borne out by Science. It is purely convenient conjecture.

The paper by Heithaus et al referenced in our previous submission clearly indicates the impacts on inshore cetacean species of having to travel further offshore.

**Reference 6: "Spatial variations of shark-inflicted injuries to insular Indo-Pacific bottlenose dolphins (Tursiops aduncus) of the SW Indian Ocean."*

Heithaus et al   Marine Mammal Science 33(1) January 2017

https://www.researchgate.net/publication/304778135_Spatial_variations_of_shark-inflicted_injuries_to_insular_IndoPacific_bottlenose_dolphins_Tursiops_aduncus_of_the_SW_Indian_Ocean

Given KIPT's demonstrated disregard for environmental concerns, public perceptions and lack of trust, it would be best if MMO's, upon which so much of the mitigation strategies rely, were **independent**, albeit at KIPT's expense.

In light of the potential impacts upon deep diving species it should be required that the MMO's observations be supplemented with **Passive Acoustic Monitoring** techniques, preferably boat based and mobile, rather than fixed.

This is a base level for ensuring proper safety for marine fauna and for mitigating possible impacts upon threatened, vulnerable and migratory species.

KIPT themselves have signaled the possibility of **usage of acoustic monitoring in Section 4.8**

Noise and Light:

"Using marine mammal observers to monitor this zone with an additional perhaps complemented by acoustic equipment to detect mammals; pile driving would stop if a marine mammal was sighted in the zone."

This rather strangely worded statement seems to indicate they would only stop if a mammal was seen, not necessarily if it was heard.

Very strange indeed?????

**Reference 7:* KIPT Addendum Page 22*

- Dolphin "Breeding Season" ?

In the State Government agencies response to the EIS in Section 36 concern was raised about **dolphins as well as whales during breeding season**.

While whales do have a discrete breeding season, this is not the case for Bottlenose dolphins - resident on the North Coast of Kangaroo Island.

Newborn calves have been observed in all months of the year. As the dolphins travel through Smith Bay on an almost daily basis this will mean enormous disruptions to construction through "shut down" mitigative practices.

This makes the situation almost untenable in terms of the timelines promoted in the Addendum document.

It is easy to consider the **potential impacts of this proposal**, particularly in light of the changes outlined in the Addendum, in isolation, rather than considering their impacts in light of likely cumulative impacts - a more important metric.

One relevant paper attached which deals with **matters of cetacean welfare** talks about cumulative impacts, including sound, and how it cannot simply be viewed in isolation.

This approach is worthy of consideration in the assessment/approval process.

**Reference 8 - Attachment 4: Marine Mammals and Multiple Stressors: Implications for Conservation and Policy Mark P. Simmonds1,2 1Humane Society International, London, United Kingdom; 2University of Bristol, School of Veterinary Sciences, Bristol, United Kingdom*

Following are some tracts particularly relevant to sound impacts:

"Simmonds and Brakes (2011) compared a review of threats to cetaceans made in 1996, with their understanding in 2011, and suggested the following key developments: (There had been a general acceptance of noise pollution as a substantive threat and some movement to address this.)

It is also now much more clearly recognized that intense sounds from human activities—such as seismic air guns—can have direct physiologic effects on marine mammals and that naval sonar triggers behavioral reactions that can lead to death by stranding (NAS, 2016).

Factors impacting marine mammals populations can be lethal (e.g., a ship strike or a launched harpoon) or sublethal, and when describing "stressors" here, it is a sublethal impact that is being primarily considered. For example, while loud noise can be lethal, the most common effect of noise on marine mammals is behavioral disturbance. From a population perspective, rather subtle behavioral changes affecting very large numbers of marine mammals may have greater consequences than occasional lethal events affecting a few (NAS, 2016).

A good example is exposure to a loud noise, and multiple, frequent exposures might be more significant than rare exposures over a longer time. "Cumulative effect" has been defined as the combined effect of exposures to multiple stressors integrated over a defined relevant period: a day, a season, year, or lifetime (NAS, 2016)."

The following passage, again from **Simmonds 2017** explores and defines this approach:

"Claudio Campagna, in an inspiring keynote address at the 2015 Conference of the Society for Marine Mammalogy, challenged his audience with a bleak but well-informed view of modern conservation (Campagna, 2015). He opined that the continuing crisis of imminent extinctions is being driven by a paradigm that he summarized as

"provide me with a good economic reason or I do nothing… or I will make small adjustments of no consequence". He argued that the current approach to species conservation is flawed as it is based on the notion that science informs policy and policy informs conservation and sustainable economic growth. However, in practice, he argued new information is used to intervene only when it is no more costly than doing nothing! Valuing nature only in economic terms avoids recognizing the disastrous consequences of what Campagna called "the species crisis." "

**Reference 9 - Attachment 4: Marine Mammals and Multiple Stressors: Implications for Conservation and Policy Mark P. Simmonds1,2 1Humane Society International, London, United Kingdom; 2University of Bristol, School of Veterinary Sciences, Bristol, United Kingdom*

The fundamental questions therefore become:

What price true marine fauna safety? What price extinction?

- Biologically Important Area For Southern Right Whales

In relation to the mitigations described in the EIS and the Addendum, in can be argued that mitigative practises, for example *"soft start"* and *"ramping up"* procedures, while presumably protecting whales from **Temporary Threshold Shift** and **Permanent Threshold Shift** can actively impact in deleterious ways by driving them out of critical habitat.

Smith Bay is emerging as a Biologically Important Area for Southern right whales.

If true mitigations come down to temporal and spatial, it could well be argued that in light of the flexibility of timings of migrations, especially in light of climate change impacts and the like, it would be not too extreme to suggest that some **important areas should be out of bounds for development activities as described in the EIS and Addendum**.

As temporal mitigation is problematic, spatial mitigation is the only reasonable solution and this is easily employed by moving the proposed development away from sensitive receptors.

Please do not hesitate to contact me for further information or clarification.

Thank you for your consideration of this submission with respect to the Addendum to the EIS prepared for KIPT with regard to the Smith Bay Wharf proposal.

Yours sincerely,

Tony Bartram

Tony Bartram

Kangaroo Island / Victor Harbor Dolphin Watch Coordinator

Please find attached the following documents:

**Reference 1 - Attachment 1*: EIA Guidelines*

**Reference 2 - Attachment 2*: CMS Guidelines: EIA Marine Noise Technical Support Information*

**Reference 3 - Attachment 3*: Environmental Impact Assessment Guidelines Prideaux_Prideaux2015*

**Reference 8 & 9 - Attachment 4*: Marine Mammals and Multiple Stressors: Implications for Conservation and Policy Mark P. Simmonds1,2 1Humane Society International, London, United Kingdom; 2University of Bristol, School of Veterinary Sciences, Bristol, United Kingdom*

CONVENTION ON MIGRATORY SPECIES

Distribution: General

UNEP/CMS/Resolution 12.14

Original: English

ADVERSE IMPACTS OF ANTHROPOGENIC NOISE ON CETACEANS AND OTHER MIGRATORY SPECIES

Adopted by the Conference of the Parties at its 12th Meeting (Manila, October 2017)

Recalling that in Resolution 9.19 and Resolution 10.24[1] the CMS Parties expressed concern about possible "adverse anthropogenic marine/ocean noise impacts on cetaceans and other biota",

Recognizing that anthropogenic marine noise, depending on source and intensity, is a form of pollution, composed of energy, that may degrade habitat and have adverse effects on marine life ranging from disturbance of communication or group cohesion to injury and mortality,

Aware that, over the last century, anthropogenic noise levels in the world's oceans have significantly increased as a result of multiple human activities,

Recalling the obligations of Parties to the United Nations Convention on the Law of the Sea (UNCLOS) to protect and preserve the marine environment and to cooperate on a global and regional basis concerning marine mammals, paying special attention to highly migratory species, including cetaceans listed in Annex I of UNCLOS,

Recalling that the United Nations General Assembly Resolution A/RES/71/257 on *Oceans and the Law of the Sea* adopted in 2016 "[n]otes with concern that human-related threats, such as marine debris, ship strikes, underwater noise, persistent contaminants, coastal development activities, oil spills and discarded fishing gear, together may severely impact marine life, including its higher trophic levels, and calls upon States and competent international organizations to cooperate and coordinate their research efforts in this regard so as to reduce these impacts and preserve the integrity of the whole marine ecosystem while fully respecting the mandates of relevant international organizations",

Recalling CMS Resolution 10.15 on *Global Programme of Work for Cetaceans*, which urges Parties and non-Parties to promote the integration of cetacean conservation into all relevant sectors by coordinating their national positions among various conventions, agreements and other international fora and instructs the Aquatic Mammals Working Group of the Scientific Council to develop advisory positions for use in Environmental Impact Assessments at the regional level and to provide support to governments and regional bodies for assessing and defining appropriate standards for noise pollution,

[1] Both now consolidated as Resolution 12.14

Recalling that other international fora recognize anthropogenic marine noise as a potential threat to marine species conservation and welfare, and have adopted related decisions and resolutions or issued guidance, including:

a) the Convention on Biological Diversity (CBD) through Decision X.29 concerning marine and coastal biodiversity and in particular its paragraph 12 relating to anthropogenic underwater noise and Decision XIII.10 addressing impacts of anthropogenic underwater noise on marine and coastal biodiversity and in particular paragraphs 1-2 relating to anthropogenic underwater noise,

b) the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) through Resolution 2.16 on *Impact Assessment of Man-Made Noise*, Resolution 3.10 on *Guidelines to Address the Impact of Anthropogenic Noise on Marine Mammals in the ACCOBAMS Area*, Resolution 4.17 on *Guidelines to address the impact of anthropogenic noise on cetaceans in the ACCOBAMS area*, Resolution 5.15 on *Addressing the Impact of Anthropogenic Noise* and Resolution 6.17 on *Anthropogenic Noise*,

c) the Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) through Resolution 5.4 on *Adverse Effects of Sound, Vessels and other Forms of Disturbance on Small Cetaceans*, Resolution 6.2 on *Adverse Effects of Underwater Noise on Marine Mammals during Offshore Construction Activities for Renewable Energy Production* and Resolution 8.11 on *CMS Family Guidelines on Environmental Impact Assessments for Marine Noise-generating Activities*,

d) the International Maritime Organization (IMO), which in 2008 established in its Marine Environmental Protection Committee a high priority programme of work on minimizing the introduction of incidental noise from commercial shipping operations into the marine environment, and which in 2014 issued MEPC.1/Circ.833 *Guidelines for the Reduction of Underwater Noise from Commercial Shipping to Address Adverse Impacts on Marine Life*,

e) the Convention for the Protection of the Marine Environment of the North-East-Atlantic (OSPAR) Guidance on environmental considerations for offshore wind farm development,

f) the International Union for Conservation of Nature (IUCN) Resolution 3.068 concerning undersea noise pollution (World Conservation Congress at its 3rd Session in Bangkok, Thailand, 17–25 November 2004),

g) following International Whaling Commission (IWC) Resolution 1998-6, the IWC Scientific Committee has investigated the impacts of military sonar, seismic surveys, masking and shipping noise; it has concluded that, in addition to some instances of severe acute effects (e.g. from military sonar and similar noise sources), existing levels of ocean noise can have a chronic effect, and agreed that action should be taken to reduce noise in parallel with efforts to quantify these effects; and the IWC has identified the importance of continued and increased collaboration on this issue with other organizations including ACCOBAMS, ASCOBANS, IMO and IUCN,

Recalling that according to Article 236 of UNCLOS, that Convention's provisions regarding the protection and preservation of the marine environment do not apply to warships, naval auxiliary and other vessels or aircraft owned or operated by a State and used, for the time being, only on governmental non-commercial service; and that each State is required to ensure, by the adoption of appropriate measures not impairing operations or operational capabilities of such vessels or aircraft owned or operated by it, that such vessels or aircraft act in a manner consistent, so far as is reasonable and practicable, with UNCLOS,

Noting that the Convention on Biological Diversity (CBD) decision VI/20 recognized CMS as the lead partner in the conservation and sustainable use of migratory species over their entire range,

Acknowledging the ongoing activities in other fora to reduce underwater noise such as the activities within NATO to avoid negative effects of sonar use,

Noting Directive 2014/52/EU of the European Parliament and of the Council, amending Directive 2011/92/EU on the *Assessment of the Effects of Certain Public and Private Projects on the Environment*,

Noting the EU Marine Strategy Framework Directive and its implementing act, where Member States in European Union marine waters shall take necessary measures by 2020 to achieve or maintain their determined good environmental status, including on underwater noise, established by each of them and in coordination at Union, regional and sub-regional levels,

Grateful for the invitation of ACCOBAMS and ASCOBANS, accepted in 2014, that CMS participate in the Joint Noise Working Group, which provides detailed and precautionary advice to Parties, particularly on available mitigation measures, alternative technologies and standards required for achieving the conservation goals of the treaties,

Aware that some types of marine noise can travel faster than other forms of pollution over more than hundreds of kilometres underwater unrestricted by national boundaries and that these are ongoing and increasing,

Taking into account the lack of data on the distribution and migration of some populations of marine species and on the adverse human-induced impacts on CMS-listed marine species and their prey,

Aware that incidents of stranding and deaths of some cetacean species have coincided with and may be due to the use of high-intensity mid-frequency active sonar,

Reaffirming that the difficulty of proving possible negative impacts of acoustic disturbance on CMS-listed marine species and their prey necessitates a precautionary approach in cases where such an impact is likely,

Noting the draft research strategy developed by the European Science Foundation on "*the effects of anthropogenic sound on marine mammals",* which is based on a risk assessment framework,

Noting the OSPAR *Code of Conduct for Responsible Marine Research in the Deep Seas and High Seas of the OSPAR Marine Area* and the ISOM *Code of Conduct for Marine Scientific Research Vessels*, providing that marine scientific research is carried out in an environmentally friendly way using appropriate study methods reasonably available,

Aware of the calls on the IUCN constituency to recognize that, when there is reason to expect that harmful effects on biota may be caused by anthropogenic marine noise, lack of full scientific certainty should not be used as a reason for postponing measures to prevent or minimize such effects,

Recognizing with concern that cetaceans and other marine mammals, reptiles and fish species, and their prey, are vulnerable to noise disturbance and subject to a range of human impacts,

The Conference of the Parties to the
Convention on the Conservation of Migratory Species of Wild Animals

1. *Reaffirms* that there is a need for ongoing and further internationally coordinated research on the impact of underwater noise (including inter alia from offshore wind farms and associated shipping) on CMS-listed marine species and their prey, their migration routes and ecological coherence, in order to give adequate protection to cetaceans and other marine migratory species;

2. *Confirms* the need for international, national and regional limitation of harmful anthropogenic marine noise through management (including, where necessary, regulation), and that this Resolution remains a key instrument in this regard;

3. *Urges* Parties and invites non-Parties that exercise jurisdiction over any part of the range of marine species listed on the appendices of CMS, or over flag vessels that are engaged within or beyond national jurisdictional limits, to take special care and, where appropriate and practical, to endeavour to control the impact of anthropogenic marine noise pollution in habitats of vulnerable species and in areas where marine species that are vulnerable to the impact of anthropogenic marine noise may be concentrated, to undertake relevant environmental assessments on the introduction of activities that may lead to noise-associated risks for CMS-listed marine species and their prey;

4. *Strongly urges* Parties to prevent adverse effects on CMS-listed marine species and their prey by restricting the emission of underwater noise; and where noise cannot be avoided, *further urges* Parties to develop an appropriate regulatory framework or implement relevant measures to ensure a reduction or mitigation of anthropogenic marine noise;

5. *Calls* on Parties and *invites* non-Parties to adopt whenever possible mitigation measures on the use of high intensity active naval sonars until a transparent assessment of their environmental impact on marine mammals, fish and other marine life has been completed and as far as possible aim to prevent impacts from the use of such sonars, especially in areas known or suspected to be important habitat to species particularly sensitive to active sonars (e.g. beaked whales) and in particular where risks to marine species cannot be excluded, taking account of existing national measures and related research in this field;

6. *Urges* Parties to ensure that Environmental Impact Assessments take 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;

7. *Endorses* the “CMS Family Guidelines on Environmental Impact Assessments for Marine Noise-generating Activities” attached as Annex and *welcomes* the Technical Support Information contained in UNEP/CMS/COP12/Inf.11[2];

8. *Invites* Parties to ACCOBAMS and ASCOBANS to consider adopting these Guidelines, in the elaboration of which they were fully involved, at their next Meetings of the Parties;

9. *Further invites* Signatories to relevant Memoranda of Understanding concluded under CMS to consider using these Guidelines as guiding documents;

10. *Recognizes* that the work done in relation to marine noise is rapidly evolving, and *requests* the Scientific Council, in collaboration with the Joint Noise Working Group of CMS, ACCOBAMS and ASCOBANS, to review and update these Guidelines regularly;

[2] also provided online at http://www.cms.int/guidelines/cms-family-guidelines-EIAs-marine-noise

11. *Urges* Parties and *encourages* non-Parties to disseminate these Guidelines, where necessary translating the Guidelines into different languages for their wider dissemination and use;

12. *Invites* the private sector and other stakeholders to make full use of these Guidelines in order to assess, mitigate and minimize negative effects of anthropogenic marine noise on marine biota;

13. *Welcomes* the efforts of the private sector and other stakeholders to reduce their environmental impact and *strongly encourages* them to continue making this a priority;

14. *Recommends* that Parties, the private sector and other stakeholders apply Best Available Techniques (BAT) and Best Environmental Practice (BEP) including, where appropriate, clean technology, in their efforts to reduce or mitigate marine noise pollution;

15. *Further recommends* that Parties, the private sector and other stakeholders use, as appropriate, noise reduction techniques for offshore activities such as: air-filled coffer dams, bubble curtains or hydro-sound dampers, or different foundation types (such as floating platforms, gravity foundations or pile drilling instead of pile driving);

16. *Stresses* the need of Parties to consult with any stakeholder conducting activities known to produce anthropogenic marine noise with the potential to cause adverse effects on CMS-listed marine species and their prey, such as the oil and gas industry, shoreline developers, offshore extractors, marine renewable energy companies, other industrial activities and oceanographic and geophysical researchers recommending, how best practice of avoidance, diminution or mitigation of risk should be implemented. This also applies to military authorities to the extent that this is possible without endangering national security interests. In any case of doubt the precautionary approach should be applied;

17. *Encourages* Parties to integrate the issue of anthropogenic noise into the management plans of marine protected areas (MPAs) where appropriate, in accordance with international law, including UNCLOS;

18. *Invites* the private sector to assist in developing mitigation measures and/or alternative techniques and technologies for coastal, offshore and maritime activities in order to minimize anthropogenic noise pollution of the marine environment to the highest extent possible;

19. *Encourages* Parties to facilitate:

- regular collaborative and coordinated temporal and geographic monitoring and assessment of local ambient noise (both of anthropogenic and biological origin);
- further understanding of the potential for sources of noise to interfere with long-range movements and migration;
- the compilation of a reference signature database, to be made publicly available, to assist in identifying the source of potentially damaging sounds;
- characterization of sources of anthropogenic noise and sound propagation to enable an assessment of the potential acoustic risk for individual species in consideration of their auditory sensitivities;
- studies on the extent and potential impact on the marine environment of high- intensity active naval sonars and seismic surveys in the marine environment; and the extent of noise inputs into the marine environment from shipping and to provide an assessment, on the basis of information to be provided by the Parties, of the impact of current practices; and
- studies reviewing the potential benefits of “noise protection areas”, where the emission of underwater noise can be controlled and minimized for the protection of cetaceans and other biota;

whilst recognizing that some information on the extent of the use of military sonars (e.g. frequencies used) will be classified and would not be available for use in the proposed studies or databases;

20. *Recommends* that Parties that have not yet done so establish national noise registries to collect and display data on noise-generating activities in the marine area to help assess exposure levels and the likely impacts on the marine environment, and that data standards are made compatible with regional noise registries, such as the ones developed by the International Council for the Exploration of the Sea (ICES) and ACCOBAMS;

21. *Urges* all Parties to endeavour to develop provisions for the effective management of anthropogenic marine noise in CMS daughter agreements and other relevant bodies and Conventions;

22. *Invites* the Parties to strive, wherever possible, to ensure that their activities falling within the scope of this Resolution avoid harm to CMS-listed marine species and their prey;

23. *Requests* the Scientific Council, supported by the Joint Noise Working Group of CMS, ACCOBAMS and ASCOBANS, to continue monitoring new available information on the effects of underwater noise on marine species, as well as the effective assessment and management of this threat, and to make recommendations to Parties as appropriate;

24. *Requests* the Secretariat and *calls upon* Parties to contribute to the work of the IMO MEPC on noise from commercial shipping;

25. *Invites* Parties to provide the CMS Secretariat, for transmission to the Scientific Council, with copies of relevant protocols/guidelines and provisions for the effective management of anthropogenic noise, taking security needs into account, such as those of relevant CMS daughter agreements, OSPAR, IWC, IMO, NATO and other fora, thereby avoiding duplication of work; and

26. *Repeals*

    a) Resolution 9.19, *Adverse Anthropogenic Marine/Ocean Noise Impacts on Cetaceans and Other Biota*; and

    b) Resolution 10.24, *Further Steps to Abate Underwater Noise Pollution for the Protection of Cetaceans and Other Migratory Species*.

Annex to Resolution 12.14

CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities

These **CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities** have been developed to present the Best Available Techniques (BAT) and Best Environmental Practice (BEP), as called for in CMS Resolutions 9.19, 10.24 and 10.15, ACCOBAMS Resolution 5.15 and ASCOBANS Resolutions 6.2 and 8.11. In addition to the parent convention, CMS, these guidelines are relevant to:

- Agreement on the Conservation of Cetaceans of the Black Seas Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS)
- Agreement on the Conservation of Seals in the Wadden Sea (Wadden Sea Seals)
- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)
- MOU Concerning Conservation Measures for the Eastern Atlantic Populations of the Mediterranean Monk Seal (*Monachus monachus*) (Atlantic Monk Seals)
- MOU Concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa (Atlantic Marine Turtles)
- MOU Concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia (Western African Aquatic Mammals)
- MOU for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (Pacific Islands Cetaceans)
- MOU on the Conservation and Management of Dugongs (*Dugong dugon*) and their Habitats throughout their Range (Dugong)
- MOU on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (IOSEA)
- MOU on the Conservation of Migratory Sharks (Sharks)

Contents

I. Introduction

1. These **CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities** are designed to provide regulators with tailored advice to apply in domestic jurisdictions, as appropriate, to create EIA standards between jurisdictions seeking to manage marine noise-generating activities. The requirements within each of the modules are designed to ensure that the information being provided by proponents will provide decision-makers with sufficient information to make an informed decision about impacts. The modules should be read in tandem with the **Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessments for Marine Noise-generating Activities** (available at www.cms.int/guidelines/cms-family-guidelines-EIAs-marine-noise). They are structured to stand as one complete unit or to be used as discrete modules, tailored for national and agreement approaches.

2. The sea is the interconnected system of all the Earth's oceanic waters, including the five named ‘oceans’ - the Atlantic, Pacific, Indian, Southern and Arctic Oceans - a continuous body of salty water that covers over 70 per cent of the Earth's surface. This vast aquatic environment is home to a wider range of higher animal taxa than exists on land. Many marine species have yet to be discovered and the number known to science is expanding annually.

3. The sea also provides people with food—mainly fish, shellfish and seaweed—as well as other marine resources. It is a shared resource for us all.

4. Marine wildlife relies on sound for vital life functions, including communication, prey and predator detection, orientation and for sensing surroundings. The ocean environment is filled with natural sound (ambient noise) from biological (marine animals) and physical processes (earthquakes, wind, ice and rain) (Urick, 1983). Species living in this environment are adapted to these sounds.

5. Over the past century many anthropogenic marine activities have increased levels of noise (Hildebrand 2009; André et.al. 2010; Miksis-Olds and Nichols 2016) These modern anthropogenic noises have the potential for physical, physiological and behavioural impacts (Southall et.al. 2007).

6. Parties to CMS, ACCOBAMS and ASCOBANS have in several resolutions recognized underwater noise as a major threat to many marine species. These resolutions also call for noise-related considerations to be taken into account as early as the planning stages of activities, especially by making effective use of Environmental Impact Assessments (EIAs). The Convention on Biological Diversity Decision XII/23 also encourages governments to require EIAs for noise-generating offshore activities, and to combine acoustic mapping with habitat mapping to identify areas where these species may be exposed to noise impacts. (Prideaux, 2017b)

7. Wildlife exposed to elevated or prolonged anthropogenic noise can suffer direct injury and/or temporary or permanent auditory threshold shifts. Noise can mask important natural sounds, such as the call of a mate, or the sound made by prey or predator. Anthropogenic noise can also displace wildlife from important habitats. These impacts are experienced by a wide range of species including fish, crustaceans, cephalopods, pinnipeds (seals, sea lions and walrus), sirenians (dugong and manatee), sea turtles, the polar bear, marine otters and cetaceans (whales, dolphins and porpoises) (Southall et.al. 2007; Aguilar de Soto, 2017a; 2017b; Castellote, 2017a; 2017b; Frey, 2017; Hooker, 2017; McCauley, 2017; Marsh, 2017; Notarbartolo di Sciara, 2017a; 2017b; 2017c; Parks, 2017; Truda Palazzo, 2017; Vongraven, 2017). Where there is risk, full assessment of impact should be conducted.

8. The propagation of sound in water is complex and requires many variables to be carefully considered before it can be known if a noise-generating activity is appropriate or not. It is inappropriate to generalize sound transmission without fully investigating propagation (Prideaux, 2017a). Often, statements are made in Environmental Impact Assessments that a noise-generating activity is 'X' distance from 'Y' species or habitat and therefore, will have no impact. In these cases, distance is used as a basic proxy for impact but is rarely backed with scientifically modelled information. (Wright et.al. 2013; Prideaux and Prideaux 2015)

9. To present a defensible Environmental Impact Assessment for any noise-generating activity proposal, proponents need to have expertly modelled the noise of the proposed activity in the region and under the conditions they plan to operate. Regulators should have an understanding of the ambient or natural sound in the proposed area. This might require CMS Parties or jurisdictions to develop a metric or method for defining this, by drawing on the range of resources available worldwide. (Prideaux, 2017a)

10. All EIAs should include operational procedures to mitigate impact effectively during activities, and there should be proof of the mitigation's efficacy. These are the operational mitigation procedures that should be detailed in the national or regional regulations of the jurisdictions where the activity is proposed. Operational monitoring and mitigation procedures differ around the world, and may include industry/company best practices. Monitoring often includes, *inter alia*:

a. periods of visual and other observation before a noise-generating activity commences
b. passive acoustic monitoring
c. marine mammal observers
d. aerial surveys

Primary mitigation often includes, *inter alia*:

e. delay to start, soft start and shut-down procedures
f. sound dampers, including bubble curtains and cofferdams; sheathing and jacket tubes
g. alternative low-noise or noise-free options (such as compiled in the OSPAR inventory of measures to mitigate the emission and environmental impact of underwater noise)

Secondary mitigation, where the aim is to prevent encounters of marine life with noise sources, includes *inter alia*:

h. spatial & temporal exclusion of activities

11. Approaches to mitigate the impact of particle motion (e.g. reducing substrate or sea ice vibration) should also be investigated. Assessment of the appropriateness and efficacy of all operational procedures should be the responsibility of the government agency assessing Environmental Impact Assessments (EIA).

II. Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities

12. **Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessments for Marine Noise-generating Activities** is provided as a full document and as stand-alone modules at: www.cms.int/guidelines/cms-family-guidelines-EIAs-marine-noise.

13. This **Technical Support Information** has been specifically designed to provide clarity and certainty for regulators, when deciding to approve or restrict proposed activities. The document provides detailed information about species' vulnerabilities, habitat considerations, impact of exposure levels and proposed assessment criteria for all of the CMS-listed species groups and their prey.

14. The document is structured to cover specific areas, as follows:

- 'Module A: Sound in Water is Complex' provides an insight into the characteristics of sound propagation and dispersal. This module is designed to provide decision-makers with necessary foundation knowledge to interpret the other modules in these guidelines and any impact assessments that are presented to them for consideration.
- 'Module B: Expert Advice on Specific Species Groups' presents twelve separate detailed sub-modules covering each of the CMS species groups, focusing on species' vulnerabilities, habitat considerations, impact of exposure levels and assessment criteria.
- 'Module C: Decompression Stress' provides important information on bubble formation in marine mammals, source of decompression stress, source frequency, level and duration, and assessment criteria.
- 'Module D: Exposure Levels' presents a summary of the current state of knowledge about general exposure levels.
- 'Module E: Marine Noise-generating Activities' provides a brief summary of military sonar, seismic surveys, civil high-powered sonar, coastal and offshore construction works, offshore platforms, playback and sound exposure experiments, shipping and vessel traffic, pingers and other noise-generating activities. Each section presents current knowledge about sound intensity level, frequency range and the activities' general characteristics. The information is summarized in a table within the module.
- 'Module F: Related Intergovernmental or Regional Economic Organization Decisions' presents the series of intergovernmental decisions that have determined the direction for regulation of anthropogenic marine noise.
- 'Module G: Principles of EIAs' establishes basic principles including strategic environmental assessments, transparency, natural justice, independent peer review, consultation and burden of proof.
- 'Module H: CMS-Listed Species Potentially Impacted by Anthropogenic Marine Noise'

15. The evidence presented in the **Technical Support Information** Modules B, C and D establishes that the effective use of EIA for all marine noise-generating activities is in line with CMS Resolutions 9.19, 10.24 and 10.15, ACCOBAMS Resolution 5.15 and ASCOBANS Resolutions 6.2 and 8.11.

16. The **Technical Support Information** was developed before the release of ISO 18405: Underwater acoustics – Terminology that provides valuable consistency to language used. The Guidelines have been slightly adapted to reflect this new ISO standard, without losing the vital connection to the **Technical Support Information**. Decision-makers should refer to both documents wherever possible.

III. Technical Advisory Notes

17. The following advisory notes should be considered in conjunction with the individual EIA Guideline tables, as presented in Modules IV through XI.

III.1. Ambient Sound

18. ISO 18405 refers to ambient sound as "*sound that would be present in the absence of a specified activity*" and "*is location-specific and time-specific*". These Guidelines more specifically define it as the average ambient (non-anthropogenic) sound levels from biological (marine animals) and physical processes (earthquakes, wind, ice and rain etc) of a given area. It should be measured (including daily and seasonal variations of frequency bands), for each component of an activity, prior to an EIA being developed and presented.

III.2 Sound Intensity

19. ISO 18405 defines sound intensity as “the product of the sound pressure”, which is the contribution to total pressure caused by the action of sound, “and sound particle velocity”, which is the contribution to velocity of a material element caused by the action of sound.

III.3. Exclusion Zones

20. Where exclusion zones are referred to in these Guidelines, these are areas that are designed for the protection of specific species and/or populations. Activities, and noise generated by activities, should not propagate into these areas.

III.4. Independent, Scientific Modelling of Noise Propagation

21. The objective of noise modelling for EIAs is to predict how much noise a particular activity will generate and how it will disperse. The aim is to model the received sound levels at given distances from the noise source. The amount of sound lost at the receiver from the sound source is propagation loss.

22. The intention of EIAs is to assess the impact of proposed activities on marine species and the environment. EIAs should not only present the main output of interest to the activity proponent, but should fully disclose the full frequency bandwidth of a proposed anthropogenic noise source, the intensity/pressure/energy output within that full range, and the principal or mean/median operating frequency of the source(s). (Urick, 1983, Etter, 2013; Prideaux, 2017a)

23. Many propagation models have been developed such as ray theory, normal modes, multipath expansion, fast field, wavenumber integration or parabolic equation. However, no single model accounts for all frequencies and environments. Factors that influence which propagation model/s should be used include the activity noise frequencies, water depth, seabed topography, temperature and salinity, and spatial variations in the environment. (Urick, 1983, Etter, 2013; Prideaux, 2017a)

24. The accuracy (i.e. bias) of sound propagation models depends heavily on the accuracy of their input data.

25. Commonly missing in EIAs is the modelling of particle motion propagation. Invertebrates, and some fish, detect sound through particle motion to identify predator and prey. Like sound intensity, particle motion varies significantly close to noise sources and in shallow water. Excessive levels of ensonification of these animal groups may lead to injury (barotrauma). Specific modelling techniques are required to predict the impact on these species.

III.5. Sound Exposure Level cumulative (SEL_{cum})

26. Sound Exposure Level (SEL) is generally referred to as dB 0 to peak or peak to peak (dB 0 to peak or dB p to p) for impulsive noise like air guns or pile driving, and dB Root Mean Squared (dB_{rms}) for non-impulsive noise such as ship noise, dredging or a wind farm’s constant drone. Often this metric is normalized to a single sound exposure of one second (NOAA, 2016). The SEL cumulative (SEL_{cum}) metric allows the cumulative exposure of an animal to a sound field for an extended period (often 24 hours) to be assessed against a predefined threshold for injury. (Southall, 2007; NOAA, 2016)

27. NOAA recommends a baseline accumulation period of 24 hours, but acknowledges that there may be specific exposure situations where this accumulation period requires adjustment (e.g., if activity lasts less than 24 hours or for situations where receivers are predicted to experience unusually long exposure durations). (NOAA, 2016) The limit value for pile driving in Germany is a sound exposure level of SEL_{05} and the sound pressure level L_{peak} at a distance of 750 metres.

III.6. Particle Motion/Displacement

28. Sound exposure levels works well for marine mammals but not well for a number of other marine species, including crustaceans, bivalves and cephalopods, because these species are thought to mainly detect sound through particle motion. Particle motion or particle displacement is the displacement of a material element caused by the action of sound. For these Guidelines the motion concerned is the organism resonating in sympathy with the surrounding sound waves, oscillating back and forth in a particular direction, rather than through the tympanic mechanism of marine mammals or swim-bladders of some fish species. (Mooney, et.al., 2010; André, et.al., 2011; Hawkins and Popper, 2016; NOAA, 2016)

29. The detection of particle motion or particle displacement requires different types of sensors than those utilized by a conventional hydrophone. These sensors must specify the particle motion in terms of the particle displacement, or its time derivatives (particle velocity or particle acceleration).

IV. EIA Guideline for Military and Civil High-powered Sonar

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances.

The EIA Guideline for Shipping and Vessels Traffic (V) should be used when the vessel is underway/making way with sonar off.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the activity – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed activity, above natural ambient sound levels • Detail of the typical weather conditions and day length for the area during the proposed activity period • Identification of previous and simultaneous activities, their seasons and duration in the same or adjoining areas, existence and location of any marine protected areas, and a review of activity findings and implications

Component	Detail
Description of the equipment and activity	• Explanation of all activity technologies available and why each proposed technology is chosen • Description of the activity technology including: a. name and description of the vessel/s to be used (except where details would risk national security) b. total duration of the proposed activity c. proposed timing of operations – season/time of day/during all weather conditions d. signal duration and sound intensity level (dB peak to peak) in water @ 1 metre, frequency ranges and ping rate • Specification of the activity including anticipated nautical miles to be covered, track-lines, speed of vessels and sonar power setting changes • Identification of other activities having an impact in the region during and after the planned activity, if there is information, accompanied by the analysis and review of potential cumulative or synergistic impacts
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in the same season/weather conditions as the proposed activity accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed exclusion zones for species and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels; and calculated from this, the extent of the impact zones b. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts on prey species c. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summaries): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions. • Quantification of the effectiveness of proposed mitigation methods

Component	Detail
Mitigation and monitoring plans	• Detail of: a. Scientific monitoring programmes before the survey to assess species distribution and behaviour, to facilitate the incorporation of monitoring results into the impact assessment. b. Scientific monitoring programmes, conducted during and after the activity, to assess impact c. Transparent processes for regular real-time public reporting of activity progress and all impacts encountered d. Most appropriate methods of species detection (e.g. visual/acoustic) and the range of available methods, and their advantages and limitations, as well their practical application during the activity. e. Impact mitigation proposals: i. 24-hour visual or other means of detection, especially under conditions of poor visibility (including high winds, night conditions, sea spray or fog) ii. establishing exclusion zones to protect specific species, accompanied by scientific and precautionary justification for these zones iii. soft start and shut-down protocols iv. spatio-temporal restrictions
Reporting plans	• Detail of post operation reporting plans including verification of the effectiveness of mitigation
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

V. EIA Guideline for Shipping and Vessels Traffic

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances.

This EIA Guideline is directed to shipping regulators, including port and harbour authorities. Cumulative impact of shipping, identifying appropriate exclusion zones and shipping lanes should be the focus.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the activity – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed shipping, above natural ambient sound levels • Detail of the typical weather conditions and day length for the area during the proposed activity period • Existence and location of any marine protected areas
Description of vessels and equipment	• Description of vessel/s (tonnage, propulsion and displacement) and equipment activity • Detail of all activities including sound intensity levels (dB_{rms}) @ 1 metre and frequency ranges (all frequencies to encompass, *inter alia*, propeller resonance, harmonics, cavitations, engine and hull noise) • Identification of other activities having an impact in the region accompanied by the analysis and review of potential cumulative or synergistic impacts
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in confined areas (harbours and channels) and accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed species exclusion zones and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features

<table>
<tr><th>Component</th><th>Detail</th></tr>
<tr><td>Species impact</td><td>• General:
a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels. Calculated from this, the extent of the impact zones, and the number of animals affected by the activity.
b. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts on prey species
c. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface).
• For each species group, also detail of the following (refer to module B species summary):
a. Species vulnerabilities:
i. specific vulnerabilities to noise
ii. lifecycle components of these vulnerabilities
b. Habitat:
i. specific habitat components considered
ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.)
c. Scientific assessment of impact:
i. exposure levels
ii. total exposure duration
iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions</td></tr>
<tr><td>Monitoring plans</td><td>• Explanation of access to the evaluation of ongoing scientific monitoring data to assess impacts
• Quantification of the effectiveness of proposed mitigation methods
• Spatio-temporal restrictions</td></tr>
<tr><td>Consultation and independent review</td><td>• Description of consultation, prior to EIA submission:
a. List of stakeholders consulted
b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback
c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns
d. Explanation of which comments, queries, requests and concerns have not been accommodated and why
• Description of independent review of draft EIA:
a. Detail of the independent reviewers (species experts) including affiliation and qualifications
b. Description of the comments, queries, requests and concerns received from each reviewer
c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns
d. Explanation of which comments, queries, requests and concerns have not been accommodated and why</td></tr>
</table>

VI. EIA Guideline for Seismic Surveys (Air Gun and Alternative Technologies)

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the survey – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed survey, above natural ambient sound levels • Detail of the typical weather conditions and day length for the area during the proposed activity period • Identification of previous and simultaneous activities, their seasons and duration in the same or adjoining areas, existence and location of any marine protected areas, and a review of activity findings and implications
Description of the equipment and activity	• Explanation of all survey technologies available (including low-noise or noise-free options) and why the proposed technology has been chosen. If low-noise options have not been chosen, an explanation should be provided about why these technologies are not preferred • Description of the survey technology including: a. name and description of the vessel/s to be used b. total duration of the proposed survey, date, timeframe c. proposed timing of operations – season/time of day/during all weather conditions d. sound intensity level (dB peak to peak) in water @ 1 metre and all frequency ranges and discharge rate e. if an air gun technology is proposed: i. number of arrays ii. number of air guns within each array iii. air gun charge pressure to be used iv. volume of each air gun in cubic inches v. official calibration figures supplied by the survey vessel to be charted, for noise modelling vi. depth the air guns to be set vii. number and length of streamers, distance set apart and depth the hydrophones are set • Specification of the survey including anticipated nautical miles to be covered, track-lines, speed of vessels, start-up and shut-down procedures, distance and procedures for vessel turns including any planned air gun power setting changes • Identification of other activities having an impact in the region during the planned survey, accompanied by the analysis and review of potential cumulative or synergistic impacts

Component	Detail
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in the same season/weather conditions as the proposed activity accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed species exclusion zones and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels. Calculated from this, the extent of the impact zones, and the number of animals affected by the activity. a. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts to prey species b. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summary): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions

Component	Detail
Mitigation and monitoring plans	• Detail of: a. Scientific monitoring before the survey to assess baselines, species distribution and behaviour to facilitate the incorporation of monitoring results into the impact assessment b. Scientific monitoring programmes, conducted during and after the survey, to assess impact, including noise monitoring stations placed at specified distances c. Transparent processes for regular real-time public reporting of survey progress and all impacts encountered d. Most appropriate methods of species detection (e.g. visual/acoustic) and the range of available methods, and their advantages and limitations, as well their practical application during the activity. e. Impact mitigation proposals: i. 24-hour visual or other means of detection, especially under conditions of poor visibility (including high winds, night conditions, sea spray or fog) ii. establishing exclusion zones to protect specific species, including scientific and precautionary justification for these zones iii. soft start and shut-down protocols iv. protocols in place for consistent and detailed data recording (observer/PAM sightings and effort logs, survey tracks and operations) v. detailed, clear, chain of command for implementing shut-down mitigation protocols vi. spatio-temporal restrictions • Quantification of the effectiveness of proposed mitigation methods
Reporting plans	• Detail of post operation reporting plans including verification of the effectiveness of mitigation, and any shut-down procedures occurring and reasons why
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed survey in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed survey in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

VII. EIA Guideline for Construction Works

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances. This guideline should be applied to all forms of marine construction, including dredging and similar vessel based activities where ships may be stationary, but under way. All commissioning and decommissioning activities should also follow these guidelines.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the activity – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed activity, above natural ambient sound levels • Detail of the typical weather conditions and day length for the area during the proposed activity period • Identification of previous and simultaneous activities, their seasons and duration in the same or adjoining areas, existence and location of any marine protected areas, and a review of activity findings and implications
Description of the equipment and activity	• Explanation of all activity technologies available and why each proposed technology is chosen, including consideration of noise-free installation methods • Specification of: a. total duration of the proposed activity b. proposed timing of operations – season/time of day/during all weather conditions c. sound intensity level (dB peak to peak) in water @ 1 metre and frequency ranges d. If explosives are proposed: i. what type of explosive and what charge weight is proposed, also whether the explosive is going to be used on the seabed or subsurface ii. specification of sound intensity level (dB 0 to peak) in water @ 1 metre, frequency range and number of detonations and interval time • Description of noise counter measures e.g.: bubble curtains, noise dampers and cofferdams, including a description of state-of-the-art technology, Best Environmental Practice (BEP) or Best Available Technology (BAT) • Identification of other activities having an impact in the region during the planned activity, accompanied by the analysis and review of potential cumulative or synergistic impacts
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in the same season/weather conditions as the proposed activity accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed exclusion zones for species and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features

Component	Detail
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels; and calculated from this, the extent of the impact zones b. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts to prey species c. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summary): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions
Mitigation and monitoring plans	• Detail of: a. Scientific monitoring programmes, conducted before, during and after the activity, to assess impact, including noise monitoring stations placed at specified distances b. Transparent processes for regular real-time public reporting of activity progress and all impacts encountered c. Most appropriate methods of species detection (e.g. visual/acoustic) and the range of available methods, and their advantages and limitations, as well their practical application during the activity. d. Impact mitigation proposals: i. 24-hour visual or other means of detection, especially under conditions of poor visibility (including high winds, night conditions, sea spray or fog) ii. establishing exclusion zones to protect specific species, including scientific and precautionary justification for these zones iii. soft start and shut-down protocols iv. spatio-temporal restrictions • Quantification of the effectiveness of proposed mitigation methods
Reporting plans	• Detail of post operation reporting plans including verification of the effectiveness of mitigation, and any shut-down procedures occurring and reasons why

Component	Detail
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why e. If it is decided that BEP or BAT is not used, this should be justified • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

VIII. EIA Guideline for Offshore Platforms

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances.

All commissioning and decommissioning activities should also follow these guidelines. Where impulsive activities, such as offshore platforms being constructed through impact driven piles, the guidelines for VII: Construction Works should also be applied.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the activity – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed activity, above natural ambient sound levels • Detail of the typical weather conditions and day length for the area during the proposed activity period • Identification of previous and simultaneous activities, their seasons and duration in the same or adjoining areas, existence and location of any marine protected areas, and a review of activity findings and implications

Component	Detail
Description of the equipment and activity	• Explanation of all activity technologies available and why each proposed technology is chosen, including consideration of alternatives • Description of the activity technology including name and description of the vessel/s and sea floor equipment to be used • Specification of: a. total duration of the proposed activity b. sound intensity level (dB_{rms}) in water @ 1 metre (from noise source e.g.: platform caissons or drill ship's hull etc.) and frequency ranges c. sound intensity levels (peak and rms) during planned maintenance schedules • Identification of other activities having an impact in the region during the planned activity, accompanied by the analysis and review of potential cumulative or synergistic impacts
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in the same season/weather conditions as the proposed activity accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed exclusion zones for species and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels; and calculated from this, the extent of the impact zones b. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts to prey species c. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summary): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration: iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions

Component	Detail
Mitigation and monitoring plans	• Detail of: a. Scientific monitoring programmes, conducted before, during and after the activity, to assess impact, including noise monitoring stations placed at specified distances b. Transparent processes for regular real-time public reporting of activity progress and all impacts encountered c. Most appropriate methods of species detection (e.g. visual/acoustic) and the range of available methods, and their advantages and limitations, as well their practical application during the activity. d. Impact mitigation proposals e. 24-hour visual or other means of detection, especially under conditions of poor visibility (including high winds, night conditions, sea spray or fog) f. Spatio-temporal restrictions • Quantification of the effectiveness of proposed mitigation methods
Reporting plans	• Detail of post operation reporting plans including verification of the effectiveness of mitigation
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

IX. EIA Guideline for Playback and Sound Exposure Experiments

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the activity – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed activity, above natural ambient sound levels • Detail of the typical weather conditions and day length for the area during the proposed activity period • Identification of previous and simultaneous activities, their seasons and duration in the same or adjoining areas, existence and location of any marine protected areas, and a review of activity findings and implications
Description of the equipment and activity	• Noting that the scale of the noise needed to elicit a response (with respect to level and duration) may be much lower than in industry activities; and that noise can be controlled in order to affect only a small area or small number of individuals, the noise control measures of the experimental design should be described in detail. • Explanation of all technologies available for the activity and why each proposed technology is chosen • Description of the chosen technology including name and description of the vessel/s to be used • Specification of: a. lowest practicable sound intensity level required b. total duration of the proposed activity c. proposed timing of operations – season/time of day/during all weather conditions d. sound intensity level (dB peak to peak) in water @ 1 metre and all frequency ranges and discharge rate e. if an air gun technology is proposed refer to VI f. if explosives are proposed refer to VII • Specification of the activity including anticipated nautical miles to be covered, track-lines, speed of vessels, start-up and shut-down procedures, distance and procedures for vessel turns including any planned air gun power setting changes • Identification of other activities having an impact in the region during the planned activity, accompanied by the analysis and review of potential cumulative or synergistic impacts
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in the same season/weather conditions as the proposed activity accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed exclusion zones for species and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features

Component	Detail
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels; and calculated from this, the extent of the impact zones b. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts to prey species c. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summary): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions iv. how the experiment design will monitor target and non-target species and the steps that will be taken to halt sound emission if adverse response or behavioural changes are observed v. how exposures that are expected to elicit particular behavioural responses (e.g. responses elicited by predator sounds, conspecific signals) will inform specific mitigation and monitoring protocols. In such cases, impact assessment should also articulate what responses may not be related to the loudness of the exposure but to the behavioural significance of the signal/noise used.

Component	Detail
Mitigation and monitoring plans	• Detail of: a. Scientific monitoring programmes, conducted before, during and after the activity, to assess impact b. Transparent processes for regular real-time public reporting of activity progress and all impacts encountered c. Most appropriate methods of species detection (e.g. visual/acoustic) and the range of available methods, and their advantages and limitations, as well their practical application during the activity. d. Impact mitigation proposals: i. 24-hour visual or other means of detection, especially under conditions of poor visibility (including high winds, night conditions, sea spray or fog) ii. establishing exclusion zones to protect specific species, including scientific and precautionary justification for these zones iii. soft start and shut-down protocols iv. spatio-temporal restrictions • Quantification of the effectiveness of proposed mitigation methods
Reporting plans	• Detail of post operation reporting plans including verification of the effectiveness of mitigation
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

X. EIA Guideline for Pingers (Acoustic Deterrent/Harassment Devices, Navigation)

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the activity – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed activity, above natural ambient sound levels. • Detail of the typical weather conditions and day length for the area during the proposed activity period • Identification of previous and simultaneous activities, their seasons and duration in the same or adjoining areas, existence and location of any marine protected areas, and a review of activity findings and implications
Description of the equipment and activity	• Explanation of all technologies available for the activity and why the proposed technology is chosen, including the description should also contain the consideration of alternatives • Specification of sound intensity level (dB peak to peak) in water @ 1 metre, frequency ranges and ping rate, sound exposure level (SEL), as well as proposed spacing of pingers • Identification of other activities having an impact in the region accompanied by the analysis and review of potential cumulative or synergistic impacts
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in the same season/weather conditions as the proposed activity accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed exclusion zones for species and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features

Component	Detail
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels; and calculated from this, the extent of the impact zones a. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts to prey species b. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summary): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions
Monitoring plans	• Detail of scientific monitoring programmes, conducted before, during and after the activity, to assess impact • Spatio-temporal restrictions • Quantification of the effectiveness of proposed mitigation methods
Reporting plans	• Detail of post operation reporting plans including verification of the effectiveness of mitigation
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

XI. EIA Guideline for Other Noise-generating Activities (Acoustic Data Transmission, Wind, Tidal and Wave Turbines and Future Technologies)

This EIA Guideline should be used in combination with the appropriate modules on species and impact from the **Technical Support Information** (B.1-12, C and D) as required for individual regional and domestic circumstances.

All commissioning and decommissioning activities should also follow these guidelines.

Component	Detail
Description of area	• Detail of the spatial extent and nature of the activity – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed activity, above natural ambient sound levels • Detail of the typical weather conditions and day length for the area during the proposed activity period • Identification of previous and simultaneous activities, their seasons and duration in the same or adjoining areas, existence and location of any marine protected areas, and a review of activity findings and implications
Description of the equipment and activity	• Explanation of all technologies available for the activity • Specification of sound intensity level (dB) in water @ 1 metre, and frequency ranges. This should include dB peak to peak for acoustic data transmission for example, dB_{rms} for wind, tidal and wave turbines and future technologies categorized accordingly • Identification of other activities having an impact in the region during the planned activity, accompanied by the analysis and review of potential cumulative or synergistic impacts
Modelling of noise propagation loss	• Detail of independent, scientific modelling of noise propagation loss in the same season/weather conditions as the proposed activity accounting for local propagation features (depth and type of sea bottom, local propagation paths related to thermal stratification, SOFAR or natural channel characteristics) from point source out to a radius where the noise levels generated are close to natural ambient sound levels • Identification and mapping of proposed exclusion zones for species and description of how noise propagation into these zones will be minimized, taking into consideration the local propagation features

Component	Detail
Species impact	• General: a. Identification and density of species likely to be present that will experience sound transmission generated by the proposed activity above natural ambient sound levels; and calculated from this, the extent of the impact zones b. Specification of the type of impact predicted (direct and indirect) as well as direct and indirect impacts to prey species c. Information on the behaviour of each species group, and the ability to detect each of the species for mitigation purposes (e.g. for marine mammals this will include diving behaviour, vocal behaviour, and conspicuousness when at the surface). • For each species group, also detail of the following (refer to module B species summary): a. Species vulnerabilities: i. specific vulnerabilities to noise ii. lifecycle components of these vulnerabilities b. Habitat: i. specific habitat components considered ii. presence of critical habitat (calving, spawning, feeding grounds, resting bays etc.) c. Scientific assessment of impact: i. exposure levels ii. total exposure duration iii. determination of precautionary safe/harmful exposure levels (direct impact, indirect impact and disturbance) that account for uncertainty and avoids erroneous conclusions • Quantification of the effectiveness of proposed mitigation methods
Monitoring plans	• Explanation of ongoing scientific monitoring programmes to assess impact • Most appropriate methods of species detection (e.g. visual/acoustic) and the range of available methods, and their advantages and limitations, as well their practical application during the activity. • Spatio-temporal restrictions
Consultation and independent review	• Description of consultation, prior to EIA submission: a. List of stakeholders consulted b. Detail of information provided to stakeholders, opportunities given for appropriate engagement and the timeframe for feedback c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why • Description of independent review of draft EIA: a. Detail of the independent reviewers (species experts) including affiliation and qualifications b. Description of the comments, queries, requests and concerns received from each reviewer c. Explanation of what amendments and changes have been made to the proposed activity in response to the comments, queries, requests and concerns d. Explanation of which comments, queries, requests and concerns have not been accommodated and why

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Additional references are detailed in the Technical Support Information at www.cms.int/guidelines/cms-family-guidelines-EIAs-marine-noise.

Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities

Parties to the Convention on Migratory Species (CMS), the Agreement on the Conservation of Cetaceans in the Black Sea Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) and the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) have recognized underwater noise as a major threat to many marine species. Several resolutions have been passed calling for effective measures to mitigate and minimize the impact of noise pollution on marine life.

CMS, ACCOBAMS and ASCOBANS decisions also recognize that addressing this issue effectively requires that noise-related considerations should be taken into account starting with the planning stage of activities, especially by making effective use of Environmental Impact Assessments (EIA). The Convention on Biological Diversity Decision XII/23 encourages governments to require EIAs for noise-generating offshore activities and to combine acoustic mapping with habitat mapping to identify areas where these species may be exposed to noise impacts.

A considerable number of national and regional operational guidelines detail the impacts to be avoided and mitigation measures to be taken during proposed operations. For the most part these focus on cetaceans. Few guidelines cover other species and almost none has been developed about the specific content that should be provided in EIAs before approvals and permits are granted.

Thanks to a voluntary contribution from the Principality of Monaco under the Migratory Species Champions programme, and an additional contribution from OceanCare, the CMS, ASCOBANS and ACCOBAMS Secretariats are pleased to have developed guidelines for Environmental Impact Assessments for noise-generating offshore industries, providing a clear pathway to implementing the Best Available Techniques (BAT) and Best Environmental Practice (BEP).

This Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities is structured to stand as one complete unit or to be used as discrete modules, tailored for national and agreement approaches.

The full document and the stand-alone modules are online at: cms.int/guidelines/cms-family-guidelines-EIAs-marine-noise

Development of this Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities has been possible with the generous funding of Principality of Monaco and OceanCare.

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Acronyms

ACCOBAMS	Agreement on the Conservation of Cetaceans in the Black Sea Mediterranean Sea and Contiguous Atlantic Area
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas
BAT	Best Available Techniques
BEP	Best Environmental Practice
CBD	Convention on Biological Diversity
CMS	Convention on the Conservation of Migratory Species of Wild Animals or Convention on Migratory Species
dB	decibels
DSC	deep sound channel
EEH	Equal Energy Hypothesis
EIA	Environmental Impact Assessment
IMO	International Maritime Organization
IWC	International Whaling Commission
NOAA	National Oceanic and Atmospheric Administration (US)
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PTS	permanent threshold shift
RMS	root mean squared
SEA	Strategic Environmental Assessment
SEL	sound exposure level
SELcum	cumulative sound exposure level
SIL	Sound Intensity Level
SOCAL-BRS	Biological and Behavioural Response Studies of Marine Mammals in Southern California
SOFAR	Sound Fixing and Ranging Channels
SPL	Sound Pressure Level
TTS	temporary threshold shift
UK	United Kingdom of Great Britain and Northern Ireland
US	United States of America

Tables

Executive Summary

The sea is the interconnected system of all the Earth's oceanic waters, including the five named ‘oceans’ - the Atlantic, Pacific, Indian, Southern and Arctic Oceans - a connected body of salty water that covers over 70 percent of the Earth's surface.

This vast environment is home to a broader spectrum of higher animal taxa than exists on land. Many marine species have yet to be discovered and the number known to science is expanding annually. The sea also provides people with substantial supplies of food, mainly fish, shellfish and seaweed, in addition to marine resource extraction. It is a shared resource for us all.

Levels of anthropogenic marine noise have doubled in some areas of the world, every decade, for the past 60 years. When considered in addition to the number other anthropogenic threats in the marine environment, noise can be a life-threatening trend for many marine species.

Marine wildlife rely on sound for vital life functions, including communication, prey and predator detection, orientation and for sensing surroundings. While the ocean is certainly a sound-filled environment and many natural (or biological) sounds are very loud, wildlife is not adapted to anthropogenic noise.

Animals exposed to elevated or prolonged anthropogenic noise can suffer direct injury and temporary or permanent auditory threshold shifts. Noise can mask important natural sounds, such as the call of a mate, the sound made by prey or a predator. These impacts are experienced by a wide range of species including fish, crustaceans and cephalopods, pinnipeds (seals, sea lions and walrus), sirenians (dugong and manatee), sea turtles, the polar bear, marine otters and cetaceans (whales, dolphins and porpoises).

The Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities has been developed to present the Best Available Techniques (BAT) and Best Environmental Practice (BEP). The document is structured to stand as one complete unit or to be used as discrete modules, tailored for national and agreement approaches.

The modules that follow are structured to cover species area, as follows:

‘**Module A: Sound in Water is Complex**’ provides an insight into the characteristics of sound propagation and dispersal. This module is designed to provide decisions-makers with necessary foundation knowledge to interpret the other modules in these guidelines and any impact assessments that are presented to them for consideration.

‘**Module B: Expert Advice on Specific Species Groups**’ presents 12 separate detailed sub-modules covering each of the CMS species groups, focusing on species' vulnerabilities, habitat considerations, impact of exposure levels and assessment criteria.

‘**Module C: Decompression Stress**’ provides important information on bubble formation in marine mammals, source of decompression stress, source frequency, level and duration, and assessment criteria.

‘**Module D: Exposure Levels**’ presents a summary of the current state of knowledge about general exposure levels.

‘**Module E: Marine Noise-generating Activities**’ provides a brief summary of military sonar, seismic surveys, civil high powered sonar, coastal and offshore construction works, offshore platforms, playback and sound exposure experiments, shipping and vessel traffic, pingers and other noise-generating activities. Each section presents current knowledge about sound intensity level, frequency range and the

activities general characteristics. The information is summarized in a table within the module.
'**Module F: Related Intergovernmental or Regional Economic Organisation Decisions**' presents the series of intergovernmental decisions that have determined the direction for regulation of anthropogenic marine noise.
'**Module G: Principles of EIAs**' establishes basic principles including strategic environmental assessments, transparency, natural justice, independent peer review, consultation and burden of proof.

The Technical Support Information to the CMS Family Guidelines on Environmental Impact Assessment for Marine Noise-generating Activities is structured to stand as one complete unit or to be used as discrete modules, tailored for national and agreement approaches.

The complete document and the discrete modules are online at: cms.int/guidelines/cms-family-guidelines-EIAs-marine-noise

A. Sound in Water is Complex

Geoff Prideaux
Wild Migration

The ocean environment is filled with natural sound from animals and physical processes. Species living in this environment are adapted to these sounds. Over the past century many anthropogenic marine activities have increased levels of noise. (André *et al* 2010, Hildebrand 2009) These modern anthropogenic noises have the potential for physical, physiological and behavioural impacts on marine fauna–mammals, reptiles, fish and invertebrates. (Southall *et al* 2007)

The propagation of sound in water is complex and requires many variables to be carefully considered before it can be known if a noise-generating activity is appropriate or not. It is inappropriate to generalize sound transmission without fully investigating propagation.

Often, statements are made in Environmental Impact Assessments that a noise-generating activity is 'X' distance from 'Y' species or habitat and therefore, will have no impact. In these cases distance is used as a basic proxy for impact but is rarely backed with scientifically modelled information. (Wright *et al* 2013, Prideaux and Prideaux 2015)

The behaviour of sound in the marine environment is different from sound in air. The extent and way that sound travels (propagation) is affected by many factors, including the frequency of the sound, water depth and density differences within the water column that vary with temperature, salinity and pressure. (Clay and Medwin 1997, Etter 2013, Lurton 2010, Wagstaff 1981) Seawater is roughly 800–1,500 times denser than air and sound travels around five times faster in this medium. (Lurton 2010) Consequently, a sound arriving at an animal is subject to propagation conditions that are complex. (Calambokidis *et al* 2002, Hildebrand 2009, Lurton 2010, McCauley *et al* 2000)

To present a defensible Environmental Impact Assessment for any noise-generating activity proposal, proponents need to have expertly modelled the noise of the proposed activity in the region and under the conditions they plan to operate.

Understanding the basic concepts that should be presented is important to assess if the Environmental Impact Assessment is defensible and sufficient.

A.1. Basic concepts

The study of acoustics is a specialized and technical field. Professional acousticians will consider many more complexities beyond the scope of this paper.

The basic concepts that decision-makers may need to understand are outlined in a very simplified form, specifically to be accessible to a lay-audience.

A.1.1. Elasticity

The speed of sound is not a fixed numerical value. Sound wave speed varies widely and depends on the medium, or material, it is transmitted through, such as solids, gas or liquids. Sound waves move through a medium by transferring kinetic energy from one molecule to the next. (Lurton 2010) Each medium has its own elasticity (or resistance to molecular deformity). This elasticity factor affects the sound wave's movement significantly. Solid mediums, such as metal, transmit sound waves extremely fast because the solid molecules are tightly packed together, providing only tiny spaces for vibration. Through this high-elasticity medium, solid molecules act like small springs aiding the wave's movement. The speed of sound through aluminium, for example, is around 6,319ms^{-1}. Gas, such as air, vibrates at a slower speed because of larger spaces between each molecule. This allows greater deformation and results in lower elasticity. Sound waves moving through air at a temperature of 20°C will only travel around 342ms^{-1}. Liquid molecules, such as seawater, bond together in a tighter formation compared with gas molecules. This results in less

deformation, creating a higher elasticity than gas. Sound waves moving through water at 22°C travel at around 1,484ms^{-1}. (Brekhovskikh and Lysanov 2006, Au and Hastings 2009, Ross 2013) Temperature also has an effect on molecules. Molecules move faster under higher temperatures, transmitting sound waves more rapidly across the medium. Conversely, decreasing temperatures cause the molecules to vibrate at a slower pace, hindering the sound wave's movement. (Brekhovskikh and Lysanov 2006, Au and Hastings 2009, Ross 2013) The temperature of seawater at different depths is therefore of importance to modelling.

A.1.2. Spherical Spreading, Cylindrical Spreading and Transmission Loss

The way sound propagates is also important. Spherical spreading is simply sound leaving a point source in an expanding spherical shape. As sound waves reach the sea surface and sea floor, they can no longer maintain their spherical shape and they begin to resemble the shape of an expanding cheese wheel. This is called cylindrical spreading.

The transmission loss, or the decrease in the sound intensity levels, happens uniformly in all directions during spherical transmission. However, when sound is in a state of cylindrical transmission, it cannot propagate uniformly. The sound is effectively contained between the sea surface and the sea floor, while the radius still expands uniformly (the sides of the cheese wheel). The height is now fixed and so the sound intensity level decreases more slowly. (Urick 1983, Au and Hastings 2009, Lurton 2010, Jensen *et al* 2011)

In actuality, the seabed is rarely, if ever, flat and parallel to the sea surface. These natural variations add extra complexities to modelling cylindrical spreading. However, these characteristics must be known to model spreading accurately, as should the water depth and the rise and fall of the seabed surrounding it. (Lurton 2010, Jensen *et al* 2011)

A.1.3. Sound Fixing and Ranging Channels (SOFAR)

As well as spherical and cylindrical spreading, another variable can impact how far sound will be transmitted. This is usually called a Sound Fixing and Ranging Channel (SOFAR) and is a horizontal layer of water in the ocean at which depth, the speed of sound is at its minimum.

The SOFAR channel is created through the interactive effect of temperature and water pressure (and, to a smaller extent, salinity). This occurs because pressure in the ocean increases with depth, but temperature is more variable, generally falling rapidly in the main thermocline from the surface to around a thousand metres deep and then remaining almost unchanged from there to the ocean floor. Near the surface, the rapidly falling temperature causes a decrease in sound speed (or a negative sound speed gradient). With increasing depth, the increasing pressure causes an increase in sound speed (or a positive sound speed gradient). The depth where the sound speed is at a minimum is called the sound channel axis. The speed gradient above and below the sound channel axis acts like a lens, bending sound towards the depth of minimum speed. The portion of sound that remains within the sound channel encounters no acoustic loss from reflection of the sea surface and sea floor. Because of this low transmission loss, very long distances can be obtained from moderate acoustic power. (Urick 1983, Brekhovskikh and Lysanov 2006, Lurton 2010, Jensen *et al* 2011)

A.1.4. Decibels dB

The decibel (dB), 1/10th of a Bel, is used to measure sound level. It is the unit that will be presented in documentation.

The dB is a logarithmic unit used to describe a ratio. The ratio may be power, sound pressure or intensity.

The logarithm of a number is the exponent to which another fixed value, the base, must be raised to produce that number. For example, the logarithm of 1,000 to base 10 is 3, because 1,000 is 10 to the power 3:

$$1{,}000 = 10 \times 10 \times 10 = 10^3.$$

More generally, if $x = b^y$, then y is the logarithm of x to base b, and is written y = logb(x), so log10 (1,000) = 3. (Au and Hastings 2009, Jensen *et al* 2011, Ross, 2013)

A common mistake is to assume that 10dB is half as loud as 20dB and a third of 30dB.

To disprove this false assumption, suppose there are two loudspeakers, the first playing a sound with power P1, and another playing a louder version of the same sound with power P2, but everything else (distance and frequency) remains the same.

The difference in decibels between the two is defined as:

10 log (P2/P1) dB where the log is to base 10.

If the second produces twice as much power as the first, the difference in dB is:

10 log (P2/P1) = 10 log 2 = 3 dB.

To continue the example, if the second has 10 times the power of the first, the difference in dB is:

10 log (P2/P1) = 10 log 10 = 10 dB.

If the second has a million times the power of the first, the difference in dB is:

10 log (P2/P1) = 10 log 1,000,000 = 60 dB.

This example shows one feature of decibel scales that is useful in discussing sound: they can describe very big ratios using manageable numbers.

A.1.5. Peak and RMS values

Peak value, as the term implies, is the point of a sound wave with the greatest amplitude. Peak values are associated with plosive sounds like seismic air guns, pile driving, low frequency sonar and explosives. (Au and Hastings 2009)

RMS (root mean squared) is the formula used to calculate the mean of a sound wave over time. RMS values are associated with constant non-plosive sounds like shipping propeller and engine noise, oil rig operations, some mid to high frequency sonar and water based wind turbines. (Au and Hastings 2009)

A.1.6. Phase

Phase can be best described as the relational alignment with two or more sound waves over time. Very simplistically, waves with the same phase will constructively interfere to produce a wave whose amplitude is the sum of the two interfering waves, while two waves which are 180 degrees out of phase will destructively interfere to cancel each other out. (Rossing and Fletcher 2013)

A.2. Understanding Sound Exposure Levels

A.2.1. Sound Exposure Level cumulative (SELcum)

Sound Exposure level (SEL) is generally referred to as dB 0 to peak or peak to peak (dB 0 to peak or dB p to p) for plosive or pulsive noise like air guns, military sonar etc and dB Root Mean Squared (dB rms) for non-plosive or non-pulsive noise such as ship noise, dredging, wind farms, constant drone (Au and Hastings 2009). These measurements are generally of a one second duration only. The question arises, is this a realistic measurement metric for understanding the effects on all marine species?

According to NOAA's paper, Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing, (NOAA, 2016) sound exposure level works well for marine mammals but not well for other marine species (crustaceans, bivalves, cephalopods, finned fish, etc) because non-mammal marine species detect sound through particle motion (the organism resonating in sympathy with the surrounding sound waves) rather than through a tympanic mechanism as with marine mammals. A more informed measurement introduced to modelling is sound exposure level cumulative (SELcum) by which a time component is added into SEL enabling it to encompass all marine species.

While SEL has been acceptable in the past, with the use of SELcum modelling, species experts have documented noticeable impacts on species' welfare that have otherwise gone unnoticed.

NOAA has set a default time of 24 hours for SELcum. An alternate prescribed time can be applied to SELcum if stated. Within the SELcum metric, reference to sound intensity level (0 to peak, peak to peak or rms) is not appropriate due to the extended time parameter. It may be displayed as 190 dB SELcum *re* 1µPa @ 1m pulsive or non-pulsive depending.

A.2.2. Equal Energy Hypothesis

NOAA also mentions the Equal Energy Hypothesis (EEH) which discusses the basic impact trends on marine species. They also comment that the EEH is pretty loose due to the complexity of all the potential factors, but it serves as a reasonable rule of thumb.
It states:

- Growth rate of threshold shift (TS) is higher for frequencies where hearing is more sensitive
- Non-impulsive intermittent exposures require higher SELcum to induce a TS compared to continuous exposures of the same duration
- Exposures for longer durations and lower levels induce TTS at a lower level than those exposed to a higher level and a shorter duration with the same duration SELcum
- With the same SELcum, longer exposures require longer recovery time.
- Intermittent exposures recover faster compared to continuous exposures of the same duration
- Animals may be exposed to multiple sound sources and stressors beyond acoustics during an activity. This also

may have a cumulative effect.

Also, pulsive/plosive SELcum noise will induce TS more quickly than a non-pulsive noise with the same SELcum due to the fast rise time characteristics of pulsive/plosive noise.

A.3. Necessity of Modelling

These complexities illustrate the necessity for expert modelling of sound propagation from noise-generating activities. (Urick 1983, Etter 2013) While noise modelling is common for land-based anthropogenic noise-producing activities, it is less common for proposals in the marine environment. The lack of rigorous noise modelling in the marine setting needs to be urgently addressed. (Prideaux and Prideaux 2015)

Modelling of each noise-generating activity proposal should be expertly and impartially conducted to provide decision-makers with credible and defensible information. The modelling should provide a clear indication of sound dispersal characteristics, informed by local propagation features. (Urick 1983, Etter 2013)

With this information, the acoustic footprint of the noise-generating activity can be identified and informed decisions about levels of noise propagation can be made. (Prideaux and Prideaux 2015)

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The sea is the interconnected system of all the Earth's oceanic waters, including the five named ‘oceans’ - the Atlantic, Pacific, Indian, Southern and Arctic Oceans - a connected body of salty water that covers over 70 percent of the Earth's surface.

This vast environment is home to a broader spectrum of higher animal taxa than exists on land. Many marine species have yet to be discovered and the number known to science is expanding annually. The sea also provides people with substantial supplies of food, mainly fish, shellfish and seaweed. It is a shared resource for us all.

Levels of anthropogenic marine noise have doubled in some areas of the world, every decade, for the past 60 years. (McDonald, Hildebrand *et al* 2006, Weilgart 2007) When considered in addition to the number other anthropogenic threats in the marine environment, noise can be a life-threatening trend for many marine species.

Marine wildlife rely on sound for its vital life functions, including communication, prey and predator detection, orientation and for sensing surroundings. (Hawkins and Popper 2014, Simmonds, Dolman *et al* 2014) While the ocean is certainly a sound-filled environment and many natural (or biological) sounds are very loud, wildlife is not adapted to anthropogenic noise.

The species groups covered in the following sub-modules are:

- Inshore Odontocetes
- Offshore Odontocetes
- Beaked Whales
- Mysticetes
- Pinnipeds
- Polar Bears
- Sirenians
- Marine and Sea Otters
- Marine Turtles
- Fin-fish
- Elasmobranchs
- Marine Invertebrates

General principles

Building on the information from module section B.1, sound waves move through a medium by transferring kinetic energy from one molecule to the next. Animals that are exposed to elevated or prolonged anthropogenic noise may experience passive resonance (particle motion) resulting in direct injury ranging from bruising to organ rupture and death (barotrauma). This damage can also include permanent or temporary auditory threshold shifts, compromising the animal’s communication and ability to detect threats. Finally, noise can mask important natural sounds, such as the call of a mate, the sound made by prey or a predator.

Table 1: Potential results of sound exposure (from Hawkins and Popper 2016)

Impact	Effects on animal
Mortality	Death from damage sustained during sound exposure
Injury to tissues; disruption of physiology	Damage to body tissue, e.g internal haemorrhaging, disruption of gas-filled organs like the swim bladder, consequent damage to surrounding tissues
Damage to the auditory system	Rupture of accessory hearing organs, damage to hair cells, permanent threshold shift, temporary threshold shift
Masking	Masking of biologically important sounds including sounds from conspecifics
Behavioural changes	Interruption of normal activities including feeding, schooling, spawning, migration, and displacement from favoured areas
	These effects will vary depending on the sound level and distance

These mechanisms, as well as factors such as stress, distraction, confusion and panic, can affect reproduction, death and growth rates, in turn affecting the long-term welfare of the population. (Southall, Schusterman *et al*, 2000, Southall, Bowles *et al*, 2007, Clark,

Ellison *et al*, 2009, Popper *et al*, 2014, Hawkins and Popper 2016)

These impacts are experienced by a wide range of species including fish, crustaceans and cephalopods, pinnipeds (seals, sea lions and walrus), sirenians (dugong and manatee), sea turtles, the polar bear, marine otters and cetaceans (whales, dolphins and porpoises)–the most studied group of marine species when considering the impact of marine noise.

The current knowledge base is summarized in the following module.

This important volume of information should guide the assessment of Environmental Impact Assessment proposals.

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B.1. Inshore Odontocetes

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Odontocetes close to shore or in shallow waters

Consider when assessing

- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- Agreement on the Conservation of Cetaceans of the Black Seas Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS)
- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)
- MOU for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (Pacific Islands Cetaceans)
- MOU Concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia (West African Aquatic Mammals)

Related modules

- Refer also to modules B.10, B.12 and C when assessing impact to inshore odontocetes

B.1.1. Species Vulnerabilities

Close-range, acute noise exposure is known to generate spatial displacement, often extended over the duration of the noise exposure (Anderwald *et al* 2013, Pirotta *et al* 2013), temporary hearing impairment (temporary threshold shifts or TTS)(e.g. Kastelein *et al* 2015, Lucke *et al* 2009) reduction in both occurrence and efficiency, or even cessation, of foraging behaviour (e.g. Pirotta *et al* 2014).

Permanent hearing impairment (permanent threshold shifts or PTS) has not been documented empirically (unethical) but is expected to occur and exposure thresholds have been predicted (e.g. Southall *et al* 2007, NOAA 2016).

Long-range (and therefore of wider spatial magnitude), chronic noise exposure is also known to generate spatial displacement, often extended over the duration of the noise exposure (Campana *et al* 2015). Masking of communication and other biologically important acoustic signals also occurs (e.g. Gervaise *et al* 2012).

Spatial displacement can cause the temporary loss of important habitat, such as prime feeding ground, forcing individuals to exploit suboptimal foraging areas. This effect is of significant concern if foraging behaviour is seasonal and/or if foraging habitat is limited or patched. Similarly, displacement can reduce breeding opportunities if it occurs during the mating season. Therefore, foraging habitat and breeding season are particularly sensitive components to noise impact.

B.1.2. Habitat Considerations

Inshore odontocetes often feed on opportunistic, seasonally abundant prey (e.g. Shane *et al* 1986). Habitat is often degraded due to proximity to highly populated coastal areas. Thus, populations have been fragmented or are in the process of being fragmented. For these reasons, suboptimal habitat should be available to perform the biological tasks that will be disturbed by the introduction of noise. Population structure should be known in enough detail to allow evaluation of the population's resilience to the disturbance. Some odontocetes show diel (24 hour cycle) movement patterns from offshore to inshore regions for resting (Thorne *et al* 2012), or prey accessibility (Goodwin 2008). Similarly, seasonal patterns have been described for inshore odontocetes mainly driven by their prey's life cycle (Pirotta *et al* 2014) or seasonality in human disturbance (Castellote *et al* 2015). These movement patterns and co-occurring disturbances should be considered to minimize odontocetes' exposure to noise or reduce cumulative impact. Some species have small home ranges or show high site fidelity with low connectivity. They therefore may be more vulnerable to population level impacts, particularly in areas of repeated anthropogenic activity. Caution should be taken to minimise overlaps with such areas. Appropriate scheduling of noise-generating activities at periods with the lowest presence of odontocetes should be prioritized. Feeding can be concentrated in habitat specific features such as river mouths (Goetz *et al* 2007) or canyons (Moors-Murphy 2014). These spatial

particularities of habitat should also be considered and their disturbance minimized.

B.1.3. Impact of Exposure Levels

The harbour porpoise has been described as the inshore odontocete most sensitive to noise exposure among the species of which we have data (Lucke *et al* 2009, Dekeling *et al* 2014, but see Popov *et al* 2011).

Based on the NOAA acoustic guidelines (NOAA 2016), which imply the most up-to-date scientific information on the effects of noise on marine mammals, onset of physiological effects, that is TTS and PTS, for impulsive and non-impulsive noise sources is based on a dual metric (dB peak for instantaneous sound pressure and SEL accumulated over 24 h for both impulsive and non-impulsive, whichever is reached first) and is summarized in the table (over) for high frequency hearing specialists, which includes the harbour porpoise.

These thresholds are based on weighted measurements, which take into consideration hearing sensitivity across frequencies for each hearing functional group. For more details please see NOAA (2016).

A more restrictive decision from the German Federal Maritime and Hydrographic Agency on the onset for physiological effects on harbour porpoises must also be considered in this context. This Agency has implemented a different threshold since 2003, specifically for pile driving operations. Criteria consist of a dual metric, SEL = 160dB re 1 mPa^2/s and SPL(peak-peak) = 190 dB re 1μPa. Both measures should not be exceeded at a distance of 750 m from the piling site.

Table 2: TTS and PTS from impulsive and non-impulsive noise sources for inshore odontocetes (from NOAA 2015)

Metric	TTS onset		PTS onset	
	Impulsive	Non-impulsive	Impulsive	Non-impulsive
SEL cum 24h	140 dB	153 dB	155 dB	173 dB
dB peak	196 dB	n/a	202 dB	202 dB

Regarding onset of behavioural disruption, NOAA has not yet updated its guidelines, and a threshold of 120 dB RMS for non-impulsive and 160 dB RMS for impulsive noise remain as the onset thresholds for all cetacean species. New information obtained through controlled noise exposure studies on offshore cetacean species (e.g. SOCAL-BRS, 3S), suggests that onset of behavioural disruption is context dependent, and not only received levels but also distance to the source might play an important role in triggering a reaction. Few studies have been focused on behavioural reaction to noise on inshore odontocetes. These show how the onset of a response is triggered by the perceived loudness of the sound, not just received levels (Dyndo *et al* 2015). At least for harbour porpoises, this finding lends weight to the recent proposal by Tougaard *et al* (2015) that behavioural responses can be predicted from a certain level above their threshold at any given frequency (e.g. in the range of 40–50 dB above the hearing threshold for harbour porpoise).

For loud noise sources such as large diameter pile driving or seismic surveys commonly found in inshore odontocete habitat, the onset for behavioural response can occur at very substantial distances (e.g. Tougaard *et al* 2009, Thompson *et al* 2013).

B.1.4. Assessment Criteria

Several key characteristics on the biology of a species should be adequately assessed in an EIA. Population stock structure is a critical element to allow evaluating potential negative effects outside the scope of the individual level. This information is often unavailable for inshore odontocetes, and regulators or decision makers should adopt a much stricter position regarding this criterion for impact assessment decisions. Correct impact evaluation cannot be accomplished without understanding the extent of a potentially impacted population. Because spatial displacement is by far the most prominent effect to occur in noisy activities occurring in inshore odontocete habitat, sufficient information on habitat use and the availability of unaffected suboptimal habitat should be addressed in the evaluation. Other more general points should not be forgotten when determining if this species group has been adequately considered by an EIA, such as the correct relationship between the spectral content of the noise source and hearing information for the affected species, and the integration of both behavioural and physiological effects for the estimated proportion of the population to be affected by the activity.

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B.2. Offshore Odontocetes

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Odontocetes in deeper waters

Consider when assessing

- Military sonar
- Seismic surveys
- Civil high power sonar
- Offshore platforms
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons

Related CMS agreements

- Agreement on the Conservation of Cetaceans of the Black Seas Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS)
- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)
- MOU for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (Pacific Islands Cetaceans)
- MOU Concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia (West African Aquatic Mammals)

Related modules

- Beaked whales are considered separately in module B.3.
- Refer also to modules B.10, B.12 and C when assessing impact to offshore odontocetes

B.2.1. Species Vulnerabilities

While spatial displacement has been well documented in several inshore odontocetes species, little data is available for offshore odontocetes (other than beaked whale species), but similar behavioural responses are expected. Few direct measures of displacement are available (e.g. Goold 1996, Bowles *et al* 1994), and some indirect measures of disturbance exist, such as changes in vocal behaviour in short beaked common dolphins, Atlantic spotted dolphins and striped dolphins in the presence of anthropogenic noise (Papale *et al* 2015). Sperm whales exposed to tactical active sonar reduced energy intake or showed significant displacement with no immediate compensation (Isojunno *et al* 2016, Miller *et al* 2012). However, sperm whales chronically exposed to seismic airgun survey noise in the Gulf of Mexico did not appear to avoid a seismic airgun survey, though they significantly reduced their swimming effort during noise exposure along with a tendency toward reduced foraging (Miller *et al* 2009). Changes in vocal behaviour are normally associated with displacement in other odontocetes (e.g. Holt *et al* 2009, Lesage 1999).

Physiological impact by close-range, acute noise exposure, such as temporary threshold shift, has never been described in offshore odontocetes due to the difficulty to maintain these species in captivity. There is just one anecdotic description of physiological injury due to airgun noise exposure on a pantropical spotted dolphin (Graya and Van Waerebeek, 2011).

This lack of evidence should not be considered conclusive but rather as reflecting the absence of studies. Furthermore, due to similarities in sound functionality, hearing anatomy and physiology between offshore and inshore odontocetes, the vulnerabilities described for inshore species are expected to be very similar for offshore species.

Because of the lack of knowledge on offshore odontocete habitat seasonal preferences (e.g. it is not known whether reproduction occurs in similar habitats as where foraging occurs), noise impact on these species cannot be broken into lifecycle components.

B.2.2. Habitat Considerations

Little survey effort has been dedicated to offshore waters in most exclusive economic offshore zones and even less in international waters. As a consequence, data on offshore odontocete occurrence, distribution and habitat preferences is scarce for most species. However, some generalizations can be highlighted: Sperm whales do not use offshore regions uniformly, topography plays a key role in shaping their distribution (e.g Pirotta *et al* 2011). Moreover, solitary individuals use the habitat differently from groups (Whitehead 2003).

The occurrence of eddies, often associated with numerous seafloor topographic structures (canyons and seamounts), are known to favour ecosystem richness and consequently, cetacean occurrence (Ballance *et al* 2006, Hoyt 2011, Redfern *et al* 2006, Correia *et al* 2015). Therefore, areas were eddies are known to occur, particularly those related to underwater topography features,

should be taken into special consideration when assessing impact to offshore odontocetes, even if no knowledge on cetacean occurrence is available.

B.2.3. Impact of Exposure Levels

Offshore odontocetes fall in their majority into the mid frequency hearing specialists. This group was considered for noise impact assessments during an international panel review (Southall *et al* 2007). This review has been updated in recent efforts by the U.S. Navy and NOAA. NOAA's most updated draft on acoustic guidelines (NOAA 2016) considers TTS and PTS, for impulsive and non-impulsive noise sources is based on a dual metric (dB peak for instantaneous sound pressure and SEL accumulated over 24 h for both impulsive and non-impulsive, whichever is reached first) and is summarized in the table below for mid frequency hearing specialists (Table 3).

Table 3: TTS and PTS from impulsive and non-impulsive noise sources for offshore odontocetes, excluding beaked whales (from NOAA 2015)

Metric	TTS onset		PTS onset	
	Impulsive	Non-impulsive	Impulsive	Non-impulsive
SEL cum 24h	170 dB	178 dB	185 dB	198 dB
dB peak	224 dB	n/a	230 dB	230 dB

Please note these thresholds are based on weighted measurements, which take into consideration hearing sensitivity across frequencies for each hearing functional group. For more details please see NOAA (2016).

Regarding onset of behavioural disruption, NOAA has not yet updated its guidelines, and a threshold of 120 dB RMS for non-impulsive and 160 dB RMS for impulsive noise remains as the onset thresholds for all cetacean species. Recent results from one of the few behavioural response studies where offshore odontocetes, other than beaked whales, are targeted identified higher thresholds than expected for avoidance of military tactic sonar by free-ranging long-finned pilot whales (Antunes *et al* 2015). The US Navy currently uses a generic dose–response relationship to predict the responses of cetaceans to naval active sonar (US Navy 2008), which has been found to underestimate behavioural impacts on killer whales and beaked whales in multiple studies (Tyack *et al* 2011, DeRuiter *et al* 2013, Miller *et al* 2012 and 2014, Kuningas *et al* 2013). The navy curve appears to match more closely results with long-finned pilot whales, though the authors of this study suggest that the probability of avoidance for pilot whales at long distances from sonar sources could well be underestimated. These results highlight how functional hearing grouping, particularly for offshore odontocete species, might not be the most conservative approach for noise mitigation purposes. Behavioural responses of cetaceans to sound stimuli often are strongly affected by the context of the exposure, which implies that species and the received sound level alone is not enough to predict type and strength of a response. Although limited in sample size, this new information has not yet been profiled in EIA procedures. Contextual variables are important and should be included in the assessment of the effects of noise on cetaceans (see Ellison *et al* 2012 for a context-based proposed approach).

B.2.4. Assessment Criteria

Because our limited knowledge on offshore odontocete ecology and their seasonal habitat preferences, common sense mitigation procedures such as avoiding the season of higher odontocete occurrence might be difficult to implement. However, habitat predictive modelling is often applicable with limited data (Redfern *et al* 2006), and should be encouraged in situations where impact assessments suffer from odontocete data deficit.

It should also be noted that in some particular cases, spatial displacement has generated drastic indirect effects at the population level. Good examples are the several episodes of large numbers of narwhals entrapped in ice in Canada and West Greenland attributed to displacement caused by seismic surveys (Heide –Jørgensen *et al* 2013). Displacement in offshore areas could drive odontocetes towards fishing grounds, increasing the risk of entanglement. In cases where planned offshore disturbance is proposed near potential risk areas for odontocetes, this indirect impact mechanism must be evaluated. In the case of sperm whales, regulations tend to be made assuming that animals avoid areas with high sound levels. Thus some policies assume benefits of avoidance in terms of reduced sound exposure, even in the absence of evidence that it occurs for some noise sources (Madsen *et al* 2006). Avoidance can also have adverse effects, with the biological significance depending upon whether important activities are affected by

animal movement away from an aversive sound.

Other more general points should not be forgotten when determining if this species group has been adequately considered by an EIA, such as the correct relationship between the spectral content of the noise source and hearing information for the affected species, and the integration of both behavioural and physiological effects for the estimated proportion of the population to be affected by the activity.

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B.3. Beaked Whales

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Consider when assessing

- Military sonar
- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- Agreement on the Conservation of Cetaceans of the Black Seas Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS)
- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)
- MOU for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (Pacific Islands Cetaceans)

Related modules

- Refer also to modules B.10, B.12 and C when assessing impact to beaked whales

B.3.1. Species Vulnerabilities

Beaked whales (Ziphiids) became widely known to the public due to mass mortalities of whales stranded with gas/fat emboli when exposed to submarine-detection naval sonar or underwater explosions (Jepson *et al*, 2003, Fernández *et al*, 2005). Most researchers agree that a 'fight or flight' stress response is responsible for the deaths of whales following noise disturbances (Cox *et al*, 2006). Interruption of foraging and avoidance at high speed have been found in different species of beaked whales subject to playbacks of naval sonar at 1/3rd octave RMS received levels as low as 89–127 dB re 1 μPa (Tyack *et al*, 2011, DeRuiter *et al*, 2013, Miller *et al*, 2015). Beaked whales may also be sensitive to other sources of anthropogenic noise, as suggested by the effectiveness of acoustic pingers in reducing the bycatch of beaked whales in deep-water fisheries, much higher than for other species (Carretta *et al* 2011), and by their apparent response to low levels of ship noise (Aguilar de Soto *et al* 2006). There has been a number of mass-strandings of beaked whales coincident in time and space with seismic activities (Malakof 2001, Castellote and Llorens 2016), but the lack of adequate post-mortem examinations has prevented assessing possible cause-effects relationships in these cases. This means that any intense underwater anthropogenic noise can be considered as of concern for beaked whales: blasting, intense naval and scientific sonar, seismics, pingers, etc.

It is still unknown why beaked whales are more sensitive to noise than many other marine mammal species. The reasons may lie in their specialized way of life. Ziphiids stretch their physiological capabilities to perform dives comparable to sperm whales, but with a much smaller body size (Tyack *et al* 2006). Their poor social defences from predators such as highly vocal killer whales may explain why beaked whales limit their vocal output (Aguilar de Soto *et al* 2012) and respond behaviourally to sound at relatively low received levels. The combination of a low threshold of response and a potentially delicate physiological balance may explain why behavioural responses can cause mortalities (Cox *et al* 2006).

Population data for beaked whales are scarce offshore, but long-term monitoring shows that local populations in nearshore deep-waters are small (<100-150 individuals), have high site-fidelity and apparently low connectivity and calving rate (Claridge, 2013, Reyes *et al* 2015). These characteristics generally reduce animal resilience to population-level impacts. Differences in population structure, with a reduced number of young, have been found between beaked whales inhabiting a naval training range and a semi-pristine neighbouring area in the Bahamas (Claridge, 2013). In summary, while discrete noise activities are of concern due to potential acute exposures/responses, there is a risk for population-level effects of noise on beaked whales inhabiting areas where impacts are repetitive.

B.3.2. Habitat Considerations

Some of the 22 species of the Ziphiidae family can be found in the deep waters of all oceans. However, beaked whales have a low probability of visual and acoustic detection (Barlow *et al* 2006, Barlow *et al* 2013) and knowledge about their distribution and abundance is poor, preventing identification of hot-spots offshore. Until more data exist, the assumption is that any area with deep waters is potential beaked whale habitat year-round.

Most mass-strandings related to naval sonar or underwater explosives have been recorded when the activities occurred in nearshore areas of steep bathymetry, suggesting that whales might die due to the stranding process. However, there is at least one mass-stranding case indicating that animals can die offshore before stranding: the naval exercise “Majestic Eagle”. This exercise occurred > 100 km offshore from the Canary Islands and dead whales were carried to the shore by the current and winds. The whales showed the same pathological findings identified previously as symptomatic of whales stranded alive in coincidence to naval exposure (Fernández *et al* 2012).

Thus, the vulnerability of beaked whales and their wide distribution make EIA relevant whenever human activities emitting intense sound occur near the slope or in abyssal waters offshore.

B.3.3. Impact of Exposure Levels

Beaked whales show strong avoidance reactions to a variety of anthropogenic sounds with the most sensitive fraction of the population responding at received levels of naval sonar below 100 dB re 1 μPa, and most of the animals tested responding at received levels of 140 dB re 1 μPa. This corresponds to ranges of several km from the ship operating the sonar (Miller *et al* 2015, Tyack *et al*, 2011).

There are no data for thresholds of response for other noise sources. The range at which beaked whales may be expected to be at risk of disturbance from a given anthropogenic noise can be estimated from the characteristics of the sound source, acoustic propagation modelling and the dose: response data provided by behavioural response studies. For example, Tolstoy *et al* (2009) present broadband calibrated acoustic data on a seismic survey performed in shallow waters and received at deep (1600 m) and shallow water (50 m) sites. The line fit to have 95% of the received levels falling below a given received level (RL) was RL = 175.64 – 29.21 $\log_{10}$(range in km) for the deep water site and RL = 183.62 – 19 $\log_{10}$(range in km) at the shallow site. Solving the equation for shallow water and a RL of 140 dB at which beaked whales may be expected to be disturbed, the potential disturbance range would be range = $10^{43.62/19}$ = 197 km. The range predicted to disturb more sensitive individuals within the population would be greater.

The spectrum of the air gun sounds reported by Tolstoy *et al* (2009) is highest below 80 Hz, well below the naval sonars whose effects have been studied for dose-response curves, and in a frequency range where beaked whales are expected to have less sensitive hearing. It is difficult to weight the level of air guns by the hearing of beaked whale given the data available, but it is possible to make a rough estimate of the energy from air guns in the third octave band (which roughly match the frequency bands over which the mammalian ear integrates energy) of the naval sonars whose effects have been measured. The broadband SEL measured at 1 km for shallow water was 175 dB re 1 $\mu Pa^2 s$. Third octave levels were also reported for a shot recorded in shallow water at 1 km range. The third octave level for this shot at the 3 kHz sonar frequency was about 130 dB re1 $\mu Pa^2 s$, suggesting that this frequency band was about 45 dB lower than the broadband source level (SL). This suggests using a sound pressure level of 183.62 - 45 dB to estimate received level in this frequency band at 1 km range. In addition, seawater absorbs sound at about 0.18 dB/km at the 3 kHz sonar frequencies, and this absorption must be accounted for in the transmission loss. Therefore Transmission Loss (TL)= 19 $\log_{10}$(range) + 0.18*range. The range at which sensitive beaked whales, which respond at 100 dB re 1 μPa may respond, given that TL = SL – RL, i.e. 19 $\log_{10}$(range) + 0.18*range = 183.62-45-100 = 38.62, is estimated at 43 km.

These rough calculations show that beaked whales could be expected to be disturbed by exposure to airguns at ranges of 43-197+ km, assuming conditions as found by Tolstoy *et al* (2009). The actual values will depend upon the actual signature of the air gun array to be used, and the propagation conditions in the area. This guidance coupled with current data on beaked whale responses to anthropogenic noise suggests that each proposer should assess how sound is expected to propagate from the survey site to any beaked whale habitat with hundreds of km. If any of this habitat is expected to be exposed to levels of sound above those shown to disturb beaked whales (i.e. 100 dB re 1 μPa for the most sensitive individuals tested), then a further assessment should be made of the number of animals likely to be disturbed.

B.3.4. Assessment Criteria

EIA should consider different types of impacts, ranging from exposure of whales to intense received levels causing hearing damage to behavioural reactions with potential physiological consequences in some cases, to displacement and ecological effects (e.g. reduction in feeding rates or displacement

from preferred habitat due to avoidance behaviour resulting in lower fitness).

A framework for mitigation targeted to reduce risk of the different impacts above needs to be included in the EIA, including actions during the planning-phase, real-time mitigation protocols and post-activity reporting to inform future planning and mitigation (e.g. Aguilar de Soto *et al* 2015). An effective mitigation method is spatio-temporal avoidance of high density areas (Dolman *et al* 2011). This is informed by surveys and habitat modelling and can be aided by simulation engines. However, the scarcity of data supporting density maps for beaked whales increases uncertainty about the number of whales to be expected in a given area and the identification of high density areas. Thus, planning-phase mitigation is essential but it does not eliminate the possibility of encountering and affecting/harming beaked whales. Another aspect of planning-phase mitigation is the choice of acoustic devices to be used during the activity, as well as the source levels required to achieve the objectives of the activity. *In situ* measurements of sound transmission loss shortly before the activity may allow adjustment of source level to below the maximum, so that the maximum is not used by default. A protocol towards reducing total acoustic energy and peak source levels transmitted to the environment should be defined before the activity, for any activity, within workable limits.

Depending on the activity, EIA may require updated information of the density of beaked whales and other vulnerable species, before the activity, in order to allow current data to be compared with existing density maps and to improve their accuracy. Also, if a choice of locations is evaluated, it would be possible to decide locating the activity in the place with lower concentration of vulnerable species.

A powerful and cost-effective way to monitor the effects would be to moor passive acoustic recorders in the beaked whale habitats exposed to sound levels above 100 dB re 1 μPa and to monitor both the actual levels of anthropogenic sound and also to monitor for the rates at which beaked whale echolocation clicks are detected. In the case of seismic, modern seismic surveys often include the deployment of cabled geophones at the seabed. These could be easily equipped with high frequency hydrophones to record beaked whales and other marine fauna.

Given the low probability of visual detection of beaked whales even in good sea conditions, real-time mitigation methods proposed in the EIA require increasing probability of detection by using passive acoustic monitoring systems with detectors programmed for automated classification of beaked whale vocalizations. Automatic detections can then be checked by trained personnel to take decisions about initiation of mitigation protocols.

B.3.5. Species not listed on the CMS Appendices that should also be considered during assessments

All beaked whales not currently listed by CMS seem to be particularly vulnerable to anthropogenic marine noise.

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B.4. Mysticetes

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Consider when assessing

- Military sonar
- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Playback and Sound Exposure Experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- Agreement on the Conservation of Cetaceans of the Black Seas Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS)
- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)
- MOU for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (Pacific Islands Cetaceans)

Related modules

- Refer also to modules B.12 and C when assessing impact to mysticetes

B.4.1. Species Vulnerabilities

Mysticete whales are all known to rely upon acoustic communication to mediate critical life history activities, including social interactions associated with breeding, raising young, migration and foraging (Edds-Walton 1997, Clark 1990). Research into the hearing capabilities of mysticetes, based primarily on anatomical modelling indicate that mysticetes, as a group, are possibly capable of hearing signals from a minimum of approximately 7 Hz ~ 22 kHz (Southall *et al* 2007). This range of frequencies spans many sources of anthropogenic noise in the ocean, excluding only the highest frequency sonar systems and pinger systems > 25 kHz (Hildebrand *et al* 2009). Previous research has documented impacts of noise exposure to physiology, behaviour, and habitat usage in mysticetes (Richardson *et al* 1995, Nowacek *et al* 2007, Tyack 2008).

Physiological impacts have been documented in mysticetes in response to noise exposure. This includes strong evidence of a decrease in physiological stress levels in North Atlantic right whale associated with a reduction in shipping noise (Rolland *et al* 2012). Techniques are currently under development to allow testing of acute stress responses to short-term high amplitude noise exposure (Hunt *et al* 2013).

Behavioral impacts have been documented in mysticetes in response to a variety of noise sources over the past three decades. This includes evidence of military sonar affecting movement, foraging and acoustic behaviour (Miller et a. 2000, Tyack 2009, Goldbogen *et al* 2013), Seismic survey and air guns affecting movement and acoustic behaviour (Malme *et al* 1988, Di Iorio and Clark 2010, Castellote *et al* 2012), Vessel noise affecting foraging, social and acoustic behaviour (Melcon *et al* 2012), and response to playback of predator and/or alarm stimuli (Cummings and Thompson 1971, Dunlop *et al* 2013, Nowacek *et al* 2004)

Habitat impacts have been documented in a number of cases. Previous studies have documented abandonment of habitat areas during periods of intense noise. One of the earliest documented cases occurred when commercial dredging and shipping activities resulted in abandonment of a critical calving ground in gray whales for the duration of human activities in an enclosed shallow water bay (Bryant *et al* 1984). Seismic surveys have resulted in large-scale, temporary, displacements of mysticete whales away from regions of seismic exploration in the Mediterranean (Castellote *et al* 2012). A further concern, of long-standing (Payne and Webb 1971), is the potential for even relatively low amplitude anthropogenic noise raising the background noise to a degree that it significantly reduces the range of communication for mysticetes. Recent studies have demonstrated the potential degree of masking experienced by mysticetes in urbanized habitat areas due to vessel traffic (Clark *et al* 2009, Hatch *et al* 2012). This is a major concern to result in chronic erosion of suitable habitat conditions through raising the baseline background noise levels.

B.4.2. Habitat Considerations

Based on previous studies, mysticetes show variable response to noise exposures in different habitat areas, possibly linked to differences in the behavioural states and/or the availability of suitable alternative habitats (Nowacek *et al* 2007). Most mysticete whales

show some level of seasonal migratory behaviours (Corkeron and Connor 1999), therefore many habitats may seasonably pose relatively higher or lower risk depending on presence or absence of particular species. Calving grounds, breeding grounds, and foraging grounds are seasonally vulnerable areas for which there may not be suitable alternate habitat for many species, and would be of particular concern to highly endangered populations with limited available critical habitat areas.

Studies of responsiveness to noise exposure have been conducted on calving and breeding grounds (Miller *et al* 2000), on migratory corridors (e.g. Malme *et al* 1988, Tyack 2009, Dunlop *et al* 2013), and on foraging grounds for a variety of species (Di Iorio and Clark 2010, Parks *et al* 2011, Goldbogen *et al* 2013). Studies of migrating whales indicate that individuals may be highly responsive to noise exposure during migration, but may be able to deviate around acoustic disturbance without significant changes to the migratory distance (Malme *et al* 1988, Tyack 2009, Dunlop *et al* 2013).

The greatest data gaps regarding relative risk by habitat and season come from the facts that a) many species only have been tested in one type of habitat area and b) detection of an overt behavioural response may not truly indicate disturbance if animals are unable or unwilling to leave the habitat for foraging or breeding purposes. Also, for several species there is little known on the location of biologically important habitats (breeding, calving and fishing grounds).Future research to assess physiological responses to the same acoustic disturbance in multiple habitat areas are needed to have a high level of confidence regarding the actual impacts of noise exposure to mysticetes.

B.4.3. Impact of Exposure Levels

Relatively little data are available regarding the hearing abilities of mysticetes. Much of the current level of understanding comes from either anatomical modelling studies (Ketten 2000) or indirectly through interpretation of behavioural responses of mysticetes to controlled exposure experiments (Mooney *et al* 2012). A thorough review of exposure criteria for behavioural responses for mysticetes is summarized in Southall *et al* (2007). The thresholds for detectable behavioural responses to noise exposure varied by species, location and time of year, giving a wide range of thresholds for responses to multiple pulses and non-pulse signals.

Table 4: TTS and PTS from impulsive and non-impulsive noise sources for mysticetes (NOAA 2016)

Metric	TTS onset		PTS onset	
	Impulsive	Non-impulsive	Impulsive	Non-impulsive
SEL cum 24h	n/a	179 dB	183 dB	199 dB
dB peak	224 dB	n/a	219 dB	n/a

B.4.4. Assessment Criteria

Based on an extensive body of literature on the effects of noise on mysticetes (including physiology, behaviour and temporary habitat abandonment), a number of detailed criteria should be considered to assess potential risk of an signal generating activity. These include:

- Amplitudes, signal structure (pulse, multi-pulse, non-pulse), and anticipated cumulative time of exposure.
- Vulnerability of the species or sustainable 'take' – Some mysticete species and stocks are highly endangered, and warrant additional consideration if proposed activities have any potential to cause impacts at any level.
- Seasonal variability in the potential risk due to migratory timing of occupancy (can activities be seasonally shifted to minimize overlap with mysticete presence in critical habitat areas?).
- Data on noise exposure studies of target species, or closely related species, with similar signal type
- Comparison of the proposed acoustic exposure relative to the ambient, background levels and spectra of environmental noise (i.e. relatively low level noise exposure may be more significant in acoustically 'pristine' habitats).
- Consideration of potential cumulative effects of an additional introduction of sound into the environment (i.e. increase in potential for masking, increase in duration of exposure on daily and/or seasonal scales).

B.4.5. Species not listed on the CMS Appendices that should also be considered during assessments

Several of the CMS Appendix I and II species have not previously been studied regarding responses to noise exposure.

In particular, relatively little is known regarding the acoustic behaviours of sei whale, *Balaenoptera borealis*, Antarctic minke whale, *Balaenoptera bonaerensis*, Bryde's whale, *Balaenoptera edeni* and Omura's whale, *Balaenoptera omurai.*

In addition to the species listed in CMS Appendix I and II gray whale, *Eschrichtius robustus*, should be considered, due to recent documentation of individuals in 'novel' habitats including multiple confirmed sightings in the Atlantic Ocean (McKeon *et al* 2016) and severely threatened stocks in the Eastern Pacific (Rugh 2005).

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B.5. Pinnipeds

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Consider when assessing

- Military sonar
- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- Agreement on the Conservation of Seals in the Wadden Sea (Wadden Sea seals)
- MOU Concerning Conservation Measures for the Eastern Atlantic Populations of the Mediterranean Monk Seal (*Monachus monachus*) (Atlantic monk seals)

Related modules

- Refer also to modules B.10, B.12 and C when assessing impact to pinnipeds

B.5.1. Species Vulnerabilities

Pinnipeds are sensitive to sound in both air and under water, therefore, they are likely to be susceptible to the harmful effects of loud noise in both media. Recent research has revealed that many pinnipeds have a better hearing sensitivity in water than was previously believed. (Southall *et al*, 2000, 2008, Reichmuth *et al*, 2013)

In developing guidelines for underwater acoustic threshold levels for the onset of permanent and temporary threshold shifts in marine mammals, NOAA has been considering two pinniped families: Phocidae and Otariidae. Phocid species have consistently been found to have a more acute underwater acoustic sensitivity than otariids, especially in the higher frequency range. This reflects the fact that phocid ears are better adapted underwater for hearing than those of otariids, with larger, more dense middle ear ossicles. (NOAA, 2016) The effective auditory bandwidth in water of typical Phocid pinnipeds (underwater) is thought to be 50 Hz to 86 kHz while for Otariid pinnipeds (underwater) it is 60 Hz to 39 kHz (NOAA, 2016). The draft NOAA guidelines do not pertain to marine mammal species under the U.S. Fish and Wildlife Service's jurisdiction, including the third family of pinnipeds: Odobenidae (walrus), which means there is no update on the auditory bandwidth of walrus.

Behavioural responses to anthropogenic noise have been documented in a number of different pinnipeds at considerable ranges indicating the need for precautionary mitigation (Kelly *et al*, 1988) In addition to noise-induced threshold shifts, behavioural responses have included seals hauling out (possibly to avoid the noise) (Bohne *et al*, 1985, 1986, Kastak *et al* 1999) and cessation of feeding (Harris *et al*, 2001).

It is likely that pinniped foraging strategies also place them at risk from anthropogenic noise. Some pinnipeds forage at night, others transit to foraging locations by swimming along the bottom, and many dive to significant depths or forage over significant distances (Fowler *et al*, 2007, Villegas-Amtmann *et al*, 2013, Cronin *et al*, 2013) with Australian sea lions foraging offshore out to 189 km (Lowther *et al*, 2011).

In most respects, noise-induced threshold shifts in pinnipeds follow trends similar to those observed in odontocete cetaceans. Unique to pinnipeds are their vibrissae (whiskers), which are well supplied with nerves, blood vessels and muscles, functioning as a highly sensitive hydrodynamic receptor system (Miersch *et al*, 2011). Vibrissae have been shown to be sufficiently sensitive to low frequency waterborne vibrations to be able to detect even the subtle movements of fish and other aquatic organisms (Renouf, 1979, Hanke *et al*, 2012, Shatz and Groot, 2013). Ongoing masking through ensonification may impede the sensitivity of vibrissae and the animal's ability to forage.

It is possible that even if no behavioural reaction to anthropogenic noise is evident, masking of intraspecific signals may occur. (Kastak and Schusterman, 1998)

B.5.2. Habitat Considerations

Spatial displacement of pinnipeds by noise has been observed (e.g Harris *et al*, 2001), however observations are too sparse and definitely require greater attention to be understood in ways that can inform management. Such displacement is likely to have serious consequences if affecting endangered species in their critical habitats, such as Mediterranean monk seals in Greece or Turkey. Displacement can cause the temporary loss of important habitat, such as feeding grounds, forcing individuals to either move to

sub-optimal feeding location, or to abandon feeding altogether. Noise can also reduce the abundance of prey (refer to modules on fin-fish and cephalopods in these guidelines).

Displacement can also reduce breeding opportunities, especially during mating seasons. Foraging habitat and breeding seasons are therefore important lifecycle components of pinniped vulnerabilities. In particular, the periods of suckling and weaning are vulnerable times for both mothers and pups.

Many pinnipeds species exhibit high site fidelity. For some there is little or no interchange of females between breeding colonies, even between those separated by short distances, such as in Australian sea lions, *Neophoca cinerea* (Campbell *et al*, 2008). Site fidelity has implications to the risk of local extinction, especially at sites with low population numbers (e.g monk seals).

Some species of pinnipeds can range far offshore and because they are difficult to sight and identify at sea their offshore foraging may only be revealed by telemetry studies. These studies usually involve tagging individuals that might come ashore hundreds or even thousands of miles from offshore foraging habitats.

B.5.3. Impact of Exposure Levels

Onset of temporary threshold shift (TTS) and permanent threshold shift (PTS) for impulsive and non-impulsive noise, and at peak levels (for instantaneous impact) as well as sound exposure levels (SEL) accumulated over a 24 hour period based on the latest updates of the NOAA acoustic guidelines (NOAA, 2016), are summarized in the tables that follow (right).

Walrus, *Odobenus rosmarus*, hearing is relatively sensitive to low frequency sound, thus the species is likely to be susceptible to anthropogenic noise. (Kastelein *et al*, 2002) TTS and PTS levels can be inferred from Southall *et al*, (2007) for Odobenidae.

Kastelein *et al*, 2002 has drawn useful general observations by comparing hearing studies of the California sea lion, *Zalophus californianus*, harbour seal, *Phoca vitulina*, ringed seal, *Pusa hispida*, harp seal, *Pagophilus groenlandicus*, northern fur seal, *Callorhinus ursinus*, gray seal, *Halichoerus grypus*, Hawaiian monk seal, *Monachus schauinslandi* and northern elephant seal, *Mirounga angustirostris* to those of walrus. The high frequency cut-off of walrus hearing is much lower than other pinnipeds tested so far. The hearing sensitivity of the walrus *Odobenus rosmarus*, between 500 Hz and 12 kHz is similar to that of some phocids. The walrus, is much more sensitive to frequencies below 1 kHz than sea lion species tested. (Kastelein *et al*, 2002) Other sensitive pinnipeds such as harbour seals (about 20 dB more sensitive to signals at 100 Hz than California sea lions) and elephant seal, *Mirounga angustirostris* and *Mirounga leonine*, are also more likely to hear low-frequency anthropogenic noise. (Kastak and Schusterman, 1998)

Assessment should consider that routine deep-divers, that dive to or below the deep sound channels, may be exposed to higher sound levels than would be predicted based on simple propagation models. Assessment should also consider convergence zones which may result in areas with higher sound levels at greater ranges.

Table 5: TTS and PTS from impulsive and non-impulsive noise sources for phocidae (from NOAA 2016)

Metric	TTS onset		PTS onset	
	Impulsive	Non-impulsive	Impulsive	Non-impulsive
SEL cum 24h	170dB	181dB	185dB	201dB
dB peak	212dB	n/a	218dB	218dB

Table 6: TTS and PTS from impulsive and non-impulsive noise sources for otariidae (from NOAA 2016)

Metric	TTS onset		PTS onset	
	Impulsive	Non-impulsive	Impulsive	Non-impulsive
SEL cum 24h	188dB	199dB	203dB	219dB
dB peak	226dB	n/a	232dB	232dB

Table 7: TTS and PTS from impulsive and non-impulsive noise sources for odobenidae (from Southall *et al* 2007)

Metric	TTS onset		PTS onset	
	Impulsive	Non-impulsive	Impulsive	Non-impulsive
SEL cum 24h	171dB	171dB	186dB	203dB
dB peak	212dB	212dB	218dB	218dB

B.5.4. Assessment Criteria

There have been surprisingly few studies of the effects of anthropogenic noise, particularly from seismic surveys, on pinnipeds (Gordon *et al*, 2003).

The lack of evidence of dramatic effects of anthropogenic noise on pinnipeds, in contrast to the well-known mortality incidents with some cetaceans, does not necessarily mean that noise has negligible consequences on pinniped conservation, and more attention should be dedicated to achieving a better understanding of possible impacts. For instance, some pinnipeds may not appear to have been physically displaced by loud noise, moving instead to the sea surface, but these animals may be effectively prevented from foraging, due to an ensonified foraging environment.

It is important that assessment of impact for pinnipeds considers both the physiological impact (TTS and PTS) as well as the very real possibility of masking, causing both behavioural responses and making prey less available.

B.5.5. Species not listed on the CMS Appendices that should also be considered during assessments

The following species are also sensitive to anthropogenic marine noise:

- walrus, *Odobenus rosmarus*
- harbour seal, *Phoca vitulina*
- northern elephant seal, *Mirounga angustirostris*
- southern elephant seal, *Mirounga leonine*
- Caspian seal, *Phoca caspica*
- Australian sea lion, *Neophoca cinerea*
- Hawaiian monk seal, *Neomonachus schauinslandi*

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B.6. Polar Bears

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Consider when assessing

- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Playback and sound exposure experiments
- Pingers and other noise-generating activities

Related modules

- Refer also to modules B.1 and B.5 when assessing impact to polar bears

B.6.1. Species Vulnerabilities

There are two studies of polar bear hearing, showing that polar bears have hearing similar to humans, and that best sensitivity was shown between 11.2 – 22.5 kHz (Nachtigall *et al* 2007), and 8 – 14 kHz (Owen and Bowles 2011).

There have not been many specific studies of polar bears and noise. It has been shown that polar bears in Spitsbergen are disturbed by snowmobiles and can show strong behavioural reactions on a distance of 2-3 km, females with cubs showing stronger reactions at longer distance than adult males (Andersen and Aars 2008).

Polar bear would be highly vulnerable when hunting, as they are hunting for seals and depend on stealth, either by sneaking up on seals or by waiting at seal breathing holes in the ice (Stirling 1974, Stirling and Latour 1978). Studies indicate that denning females could be somewhat protected from noise from seismic air guns, although they could be vulnerable if sound sources are within close proximity of the den (less than 100 m) (Blix and Lentfer 1992).

B.6.2. Habitat Considerations

Polar bear's essential habitat is sea ice. Polar bears would prefer to stay on sea ice covering shallow and productive shelf areas (Durner *et al* 2009, Schliebe *et al* 2006). There would be particular concerns associated with all activities that have an impact in areas which resource selection functions have shown are preferred sea ice habitat for polar bears (Durner *et al* 2009).

Some models project an ice-free Arctic Basin in summer in just a few years from now, before 2020 (Maslowski *et al* 2012), and modelling studies have shown that most subpopulations will be reduced and experience large environmental stress (Amstrup *et al* 2008, Hamilton *et al* 2014).

Although not exclusively associated with specific habitats, there are certain activities that might be a concern. Some industrial activities are located in important habitat, of special concern is oil drilling activities on sea ice in productive sea areas, and the prospect of new developments of petroleum exploration in critical habitat, especially in North America. It must be noted that there are little or no specific studies of the effect of noise or manmade sound on polar bears, thus the level of impact is to a large degree inferred from general expert knowledge of the effect of disturbance on these animals.

Future impact from disturbance from sound exposure needs to be focused on denning areas in spring, and areas of sea ice and glacier fronts that are used by females with cubs-of-the-year to find food immediately after den emergence. Arctic areas in northern Canada, bordering to the Arctic Basin are generally the areas where one expects sea ice habitat to persist for the longest period (Amstrup *et al* 2007).

B.6.3. Impact of Exposure Levels

Given the specific vulnerability of polar bears to habitat loss, the exposure level of polar bears, especially in denning areas in spring, and areas of sea ice and glacier fronts that are used by females with cubs-of-the-year to find food immediately after den emergence should be prioritized.

B.6.4. Assessment Criteria

An assessment of the future impact of noise would have to take into account the dramatically decreasing area of critical sea ice habitat, in some areas the length of the ice-free period from ice melt in spring till ice freeze-up in fall, has increased by more than 140 days in the period 1979-2015 (Laidre *et al* 2015).

A minimum would be that EIAs on impact of sound would assess to what extent sound exposure would be detrimental to reproductive success by directly considering the effect of sound in denning areas and productive sea ice areas in the vicinity of denning areas, and also areas of sea ice over productive shelf areas.

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B.7. Sirenians

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Consider when assessing

- Military sonar
- Seismic surveys
- Civil high power sonar
- Coastal construction works
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- MOU Concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia (West African Aquatic Mammals)
- MOU on the Conservation and Management of Dugongs (*Dugong dugon*) and their Habitats throughout their Range (Dugong)

B.7.1. Species Vulnerabilities

Even though traditional ecological knowledge and field observations (Marsh *et al* 1978, Hartman 1979) suggest that sirenians (manatees and dugongs) have 'exceptional acoustic sensitivity', scientific research on their hearing and reactions to marine noise is relatively sparse. Published hearing studies are based on the Florida manatee, *Trichechus manatus latirostis*, while behavioural studies on reactions to noise are limited to the Florida manatee, the Antillean manatee, *Trichechus manatus*, and the dugong, *Dugong dugon*. Although most of this research is limited to sounds in water, behavioural observations indicate that sirenians are capable of detecting some sounds in air above the surface (Hartman 1979).

Evoked potentials recorded for Florida manatees (Bullock *et al* 1982, Mann *et al* 2005) demonstrated variable sensitivity over a range of frequencies from about 200Hz to 35–40 kHz with greatest sensitivity in the lower range at 1–1.5 kHz. In-water behavioural audiograms of four captive Florida manatees identified the frequency range of best hearing as 6 to 32 kHz (Gerstein *et al* 1999, Gerstein 2002, Gaspard *et al* 2012), with individual variation within this range. Peak hearing sensitivity has been variously reported as 16-18 kHz (Gerstein *et al* 1999, Gerstein 2002) and 8 kHz (Gaspard *et al* 2012). Gaspard *et al* (2012) also reported that one of their test animals appeared to be able to hear loud sounds as low as 0.25 kHz and ultrasonic frequencies as high as 90.5 kHz. Gerstein *et al* (1999) speculated that the greater sensitivity to higher frequencies observed in their audiogram research may be an adaptation that enabled manatees to avoid the complications associated with perceiving sound reflections propagated from the water–air interface (Lloyd mirror effect) in the shallow depths typical of their habitats, raising the interesting question of what these animals can hear when at the surface.

Both Gerstein (1999) and Gaspard *et al* (2012) conducted in-water behavioural experiments on captive Florida manatees to measure critical ratios. The differences in their results likely reflect both their different experimental protocols and individual differences in the manatees' responses. Gaspard *et al* (2012) found that the manatees have relatively narrow auditory filters and struggle to hear lower and higher pitched sounds above background noise. However, manatee hearing was much sharper at 8 kHz – the frequency at which manatees communicate – where they could still distinguish tones that were only 18.3 dB louder than the background. This estimate of the manatee's critical ratio (8 kHz) is among the lowest measured in mammals (Gaspard *et al* 2012) suggesting that generic marine mammal impact guidelines may not be appropriate for sirenians.

Field studies show that both the Florida manatee (Miksis-Olds *et al* 2007) and the dugong (Hodgson and Marsh 2007) exhibit short-term behavioural responses to noise. Miksis-Olds and Wagner (2010) showed that elevated sound levels affect the patterns of behaviour of the Florida manatee and that the response is a function of the manatee's behavioural state. When ambient sounds were highest, the manatees spent more time feeding and less time milling. In contrast, Hodgson and Marsh's (2007) experimental and behavioural studies showed that the time that dugongs spent feeding and travelling was unaffected by boat presence, the number of boat passes and whether a pass included a stop and restart. However, focal dugongs were less likely to continue feeding if the boat passed within 50 m, than if the boat passed at a greater distance. Boats passing at a range of speeds, and at distances of less than 50 m to over 500 m evoked mass movements of dugong feeding herds, but such movements only lasted a

couple of minutes. Castelblanco-Martínez and Arévalo-González (2015) experimentally studied the effects of side-scan sonar operating 455 kHz on the behaviour of 12 captive Antillean manatees. All the observed manatees variously showed behavioural changes including stopping foraging and feeding, significantly reducing displacement and remaining still at the bottom or at the surface, and increasing displacement behaviour. One male displayed continuous spinning movements for almost the entire experimental session. Most animals avoided the area nearest to the transducer.

Sirenians are not wilderness animals (Marsh *et al* 2011). Manatees occur in the inshore waters of Florida and have continued to use the intra-coastal waterway and residential canal estates, despite a high level of vessel activity (for references see Marsh *et al* 2011). Dugongs continue to use Johore Strait between Singapore and Peninsula area, one of the most heavily-used coastal waterways in the world, and are often detected in ports and military training areas along the Queensland east coast on the basis of their feeding trails and satellite tracking (Marsh *et al* 2011, Cleguer *et al* 2016). Hodgson *et al* (2007) experimentally tested the behavioural responses of dugongs to 4 and 10 kHz acoustic alarms (pingers). The rate of decline of the number of dugongs within the focal arena did not change significantly while pingers were activated. Dugongs passed between the pingers irrespective of whether the alarms were active or inactive, fed throughout the experiments and did not change their orientation to investigate pinger noise, or their likelihood of vocalizing. Thus despite the short-term behavioural responses noted above, there is no evidence that wild dugongs or Florida manatees are displaced by underwater noise, including side scan sonar (Gonzalez-Socoloske *et al* 2009). The reaction of dugongs and manatees to plosive sounds does not appear to have been formally tested.

Both manatees and dugongs use underwater sound for communication. There have been numerous studies of sirenian communication sounds (see Marsh *et al* 2011) Characteristics of individual call notes seem fairly similar among the species of sirenians. Frequency ranges are typically from 1 to 18 kHz, often with harmonics and non-harmonically related overtones (e.g Anderson and Barclay 1995, Sousa-Lima *et al* 2002, O'Shea and Poche 2006).

Adults of both sexes produce vocalizations, but exchanges of communication calls are most common between cows and their nursing calves. Florida manatee calves vocalize at much greater rates than adults (Sousa-Lima *et al* 2002, O'Shea and Poche 2006). Manatees other than cows and calves vocalize at rates that vary with activity and behavioural context, and are lowest during resting, intermediate while travelling, and highest at nursing and other social situations (Reynolds 1981, Bengtson and Fitzgerald 1985, Williams 2005, O'Shea and Poche 2006, Miksis-Olds and Tyack 2009). Dugongs seem to vocalize more often during dark, early morning hours (Ichikawa *et al* 2006). No data are available on vocal communication in African manatees, *Trichechus senegalensis*, although recordings and sound spectrograms of calls of an isolated captive calf in Cote d'Ivoire were similar to those of some Florida and Amazonian manatee calves (TJ O'Shea unpublished). Florida manatees may alter vocalization parameters in response to environmental noise levels (Miksis-Olds and Tyack 2009). Sakamoto *et al* (2006) attempted to quantify the effect of vessel noise on the vocal characteristics of dugongs (number of call per minute, dominant frequency and call duration). None of the changes was significant.

We know of no information regarding PTS, TTS or noise-induced auditory damage in sirenians.

B.7.2. Habitat Considerations

In the marine environment, both manatees and dugongs mostly occur in shallow waters because of their dependence of seagrass communities (Marsh *et al* 2011). Antillean and African manatees are both riverine and estuarine and in the marine environment mainly occur in water less than 5 m deep. Dugongs are strictly marine, feeding in waters up to about 35 m deep. They may occasionally cross ocean trenches (see Marsh *et al* 2011), but typically spend most of their lives in much shallower inshore coastal and island waters often commuting with the tide to or from intertidal seagrass meadows (Marsh *et al* 2011). There is increasing evidence that dugong migration corridors follow topographic features such as coastlines (Zeh *et al* 2016 in press) or reef crests (Cleguer 2015).

B.7.3. Impact of Exposure Levels

Given that the available evidence suggests that manatees and dugongs are unlikely to be displaced by noise, the most practical approach to reducing the risk of impacts is avoidance of the overlap of acute sound impacts with seasonal aggregation sites

and periods when the animals are likely to be under stress. Seasonal aggregation sites are most likely at the high latitude limits of the ranges of dugongs and manatees and typically occur as a behavioural repose to thermal conditions or prolonged periods of rough weather (see Marsh *et al*, 2002 and 2011 for details of some well-known sites in Florida, Australia and the Arabian region). Site-specific information on this topic should be a focus of the Environmental Impact Assessment process. Extreme weather events such as cyclones or prolonged cold fronts can cause substantial increases in mortality (Marsh *et al* 2011, Meager and Limpus 2013) and noisy construction impacts should be planned to avoid times of likely environmental stress.

B.7.4. Assessment Criteria

We know of no field studies on the effects of anthropogenic noise, other than vessel noise on sirenians. The effect of vessel noise *per se* seems much less than that of vessel collisions. This lack of evidence does not prove that noise has negligible consequences for sirenian conservation, and more attention should be dedicated to a better understanding of possible impacts and ways to ameliorate them. A precautionary approach to the exposure of manatees and dugongs to noise, especially at key habitats and aggregation sites, is warranted.

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B.8. Marine and Sea Otters

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Consider when assessing

- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related modules

- Refer also to modules B.10, B.12 and C when assessing impact to marine and sea otters

B.8.1. Species Vulnerabilities

The marine otter, *Lontra feline*, and sea otter, *Enhydra lutris*, are amphibious marine mammals that may be vulnerable to coastal anthropogenic disturbance. Auditory thresholds for sea otters have been measured in air and underwater from 125 Hz to 40 kHz. Critical ratios data indicate that although sea otters can detect underwater sounds, their hearing appears to be primarily air adapted and not specialized for detecting signals in background noise. (Ghoul and Reichmuth 2012, 2014, 2016)

B.8.2. Habitat Considerations

There is little definitive research available about the specific anthropogenic noise vulnerabilities of this species group, but given the frequency range of hearing and the knowledge that these animals are social communicators and benthic foragers, (McShane *et al*, 1995, Leuchtenberger *et al*, 2014, Lemasson *et al*, 2014, Thometz *et al*, 2015) this species group should be considered. Their dependence on restricted nearshore habitats puts sea otters at risk from acoustic disturbance and activities occurring both on land and at sea. (Ghoul and Reichmuth 2016)

B.8.3. Impact of Exposure Levels

Ghoul and Reichmuth (2016) have conducted the only known assessment of sea otter hearing sensitivity. They found that hearing was most sensitive at 8 and 16 kHz, where measured thresholds were the lowest at 69 dB re 1 μPa. The range of best sensitivity in water spanned ~4.5 octaves, from 4 to 22.6 kHz. The roll-off in high-frequency hearing was typically steep and had a 28-dB increase within a half-octave frequency step. Low-frequency hearing (0.125–1 kHz) was notably poor. The sea otter was unable to detect signals below 100 dB re 1 μPa within this frequency range. Noise spectral density levels in the underwater testing enclosure were sufficiently low to ensure that the measured thresholds were not influenced by background noise, especially at frequencies above 0.5 kHz, where noise levels were below 60 dB re 1 μPa/√Hz. (Ghoul and Reichmuth 2016)

B.8.4. Assessment Criteria

Regulators estimating zones of auditory masking for sea otters should follow the guidance given for other marine mammals and opt for conservative estimates until additional data are available. (Southall *et al*, 2000)

B.8.5. Species not listed on the CMS Appendices that should also be considered during assessments

Sea otters, *Enhydra lutris*, are classified by IUCN as Endangered, and should also be considered during assessments.

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B.9. Marine Turtles

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Consider when assessing

- Military sonar
- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- MOU Concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa (Atlantic marine turtles)
- MOU on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (IOSEA)

Related modules

- Refer also to modules B.12 and C when assessing impact to marine turtles

B.9.1. Species Vulnerabilities

Although the ecological role of hearing has not been well studied for sea turtles, hearing capacity has been inferred from morphological and electrophysiological studies. (Southwood *et al*, 2008)

Sea turtles do not have an external ear, in fact, the tympanum is simply a continuation of the facial tissue. Researchers have speculated that the cochlea and saccule are not optimized for hearing in air, but rather are adapted for sound conduction through two media, bone and water. Recent imaging data strongly suggest that the fats adjacent to the tympanal plates in at least three sea turtle species are highly specialized for underwater sound conduction. (Moein Bartol and Musick, 2003)

Hearing range (50-1200 Hz: Viada *et al*, 2008, Martin *et al*, 2012, Popper *et al*, 2014) coincides with the predominant frequencies of anthropogenic noise, increasing the likelihood that sea turtles might experience negative effects from noise exposure.

At present, sea turtles are known to sense low frequency sound, however, little is known about the extent of noise exposure from anthropogenic sources in their natural habitats, or the potential impacts of increased anthropogenic noise exposure on sea turtle biology. Behaviour responses have been clearly demonstrated. (Samuel *et al*, 2005)

Prolonged exposure could be highly disruptive to the health and ecology of the animals, encouraging avoidance behaviour, increasing stress and aggression levels, causing physiological damage through either temporary or even permanent threshold shifts, altering surfacing and diving rates, or masking orientation cues. (Samuel *et al*, 2005)

B.9.2. Habitat Considerations

Sea turtles have been shown to exhibit strong fidelity to fixed migratory corridors, habitual foraging grounds, and nesting areas (Avens *et al*, 2003), and such apparent inflexibility could prevent sea turtles from selecting alternate, quieter habitats.

The potential of noise for displacing turtles from their favoured or optimal habitat is unknown, but if it were to occur it could have negative consequences on growth, orientation, etc.

B.9.3. Impact of Exposure Levels

Sea turtles are low frequency specialists, but their range appears to differ between populations. Animals belonging to one population of subadult green turtles have been shown to detect frequencies between 100-500 Hz with their most sensitive hearing between 200-400Hz. Another responded to sounds from 100-800 Hz, with their most sensitive range being 600-700Hz. Juvenile Kemp's ridley turtles had a range of 100-500Hz, with their most sensitive hearing been 110-200Hz. (Moein Bartol and Ketten, 2006)

B.9.4. Assessment Criteria

It is important that assessment of impact for sea turtles both considers the physiological impact (TTS and PTS) as well as the very real possibility of masking prey movements. Some sea turtles may not appear to noise-generating industries to have been physically displaced by loud noise but these animals may be effectively prevented from foraging, due to an ensonified foraging environment. Possible effects of distribution (avoidance behaviour) orientation, and even communication (e.g in the hatching phase) cannot be discounted.

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B.10. Fin-fish

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Consider when assessing

- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons

Related CMS agreements

- Agreement on the Conservation of Cetaceans of the Black Seas Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS)
- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)
- MOU for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (Pacific Islands Cetaceans)
- MOU Concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia (West African Aquatic Mammals)
- Agreement on the Conservation of Seals in the Wadden Sea (Wadden Sea seals)
- MOU Concerning Conservation Measures for the Eastern Atlantic Populations of the Mediterranean Monk Seal (*Monachus monachus*) (Atlantic monk seals)
- MOU Concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa (Atlantic marine turtles)
- MOU on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (IOSEA)
- MOU on the Conservation of Migratory Sharks (Sharks)

Related modules

- Refer also to modules B.12 when assessing impact to fish

B.10.1. Species Vulnerabilities

The use of explosives will kill fin-fish inside a certain range (Yelverton *et al* 1975), with impact zones given in Popper *et al* (2014). Intense non-explosive, impulse noise such as pile driving or seismic surveys may impact adult fin-fish by: a) creating physiological damage such as rupturing gas spaces (ie. Halverson *et al* 2012), b) damaging sensory systems (McCauley *et al* 2003), c) creating adverse behavioural responses (e.g. Pearson *et al* 1996, McCauley *et al* 2003, Slotte *et al* 2004, Fewtrell and McCauley 2012, Hawkings *et al* 2014), d) masking the reception of signals of interest, or e) disrupting prey physiology, behaviour or abundance. For fin-fish the sustained but less intense noise from vessels or offshore construction activities may commonly produce behavioural impacts or masking of communication signals as indicated above. Fin-fish exposed to lower level, man-made noise for suitable time periods may receive damage to hearing systems and so suffer a loss of fitness.

There is an enormous amount of variability in the degree of sophistication of fin-fish hearing systems and habits which may pre-dispose or protect them from impacts of man-made noise sources, thus it is difficult to generalize known impacts across all fin-fish species with a high degree of confidence. In general terms: explosives routinely cause fin-fish deaths out to some range and sub-lethal injuries beyond this, pile driving is known to produce serious physiological and organ damage to fin-fish at short range, in some cases marine seismic surveys with air guns have produced hearing damage to fin-fish while in other cases such damage has not been observed, and most man-made noise sources are capable of producing fin-fish behavioural or masking impacts to some degree. Behavioural response to an approaching noise source by fin-fish seems to be reasonably generic, pelagic fin-fish tend to move downwards to eventually lie close to the seabed or flee laterally while site-attached fish may initially seek shelter in refuges or flee. At least some species of fin-fish do habituate to continual and stationary low level noise as they readily colonize man-made offshore facilities. The longer-term implications of consistent behaviour changes or slight physiological impairment from intense signals produced by seismic surveys are not well understood.

Many fin-fish form aggregations at specific times and places to spawn and produce fertilized eggs. Such aggregations may be spaced across several months or may occur only on few occasions per season. Many fin-fish species produce communication sounds as part of such aggregations (ie. McCauley 2001). Disruptions to such fin-fish spawning aggregations by excessive noise causing physiological or behavioural changes and which overlaps a large fraction of the species' seasonal spawning period will have deleterious

impacts on the following years reproductive output.

All fin-fish are dependent on smaller prey species which may be impacted by man-made noise sources. Prey may include fin-fish or invertebrates. In general terms small, common, fin-fish prey species, such as sardines, herring or pilchards, have well developed sensory systems thus may be equally or more vulnerable to exposure to intense man-mad noise than the larger fin-fish which prey on them. The response of marine invertebrates to intense signals such as seismic survey noise, are poorly known so it is difficult to draw conclusions or comparisons on how invertebrate prey fields will be impacted by noise exposure. Any changes to prey fields induced by a man-made noise source will impact fauna, possibly negatively, higher up the food chain.

All impacts of man-made noise sources on fin-fish need to be gauged at the population level. Noise sources which produce short term impacts, localized impacts compared with a species range, or which do not overlap well with habitats or time and spatial overlap of spawning periods would be expected to be of low severity form a population perspective, and vice versa.

B.10.2. Habitat Considerations

Fin-fish occupy an enormous variety of habitats, from deep ocean depths, pelagic systems, reefs and shoals, estuarine waters to inland waterways. Some fish may utilize multiple habitats on a seasonal or life cycle basis. In general terms habitats which are enclosed, such as estuaries, bays or reefs for site attached fin-fish, may be more susceptible to exposure by intense sound sources as the fin-fish have little options to escape the source. By contrast fin-fish that occupy physically larger spaces, such as oceanic species, have more options of where to flee and may be less constrained by the implications of moving geographical regions to avoid a noise source.

B.10.3. Impact of Exposure Levels

Known impacts of intense impulse noise exposure on fin-fish include consistencies in fish behavioural response to sound, but many anomalies. For high-energy impulse signals, such as seismic survey signals, the following can be said:

Fish behaviour most often changes at some range near to an approaching seismic vessel and generalized changes include diving, lateral spread or fleeing an area (e.g. Pearson *et al* 1996, McCauley *et al* 2003, Slotte *et al* 2004, Fewtrell and McCauley 2012, Hawkings *et al* 2014).

Fish behaviour is strongly impacted by an approaching seismic source above received levels of 145–150 dB re 1 µPa^2.s (SEL) (McCauley *et al* 2003), which equates to around 2–10 km using measured air gun arrays > 2000 cui.

Avoidance to an approaching seismic vessel by fish may be partly driven by the fish behavioural state, with feeding fishes appearing to be more tolerant and in one instance not showing avoidance to an approaching seismic survey vessel (Penä *et al* 2013).

Catch rates in some fisheries are altered during and after seismic operations, prolonged seismic can cause large-scale displacement of fish resulting in decreased fish abundance in and near a seismic operations area and increased fish abundance at long range (tens of km) from the seismic operations area (Engås *et al* 1996, Slotte *et al* 2004),

Long-term monitoring of reef fish community structure before and after a seismic survey programme showed no large-scale change in community structure (Miller and Cripps 2013) and fish sound production behaviour (chorusing) continued after a seismic programme with no apparent long-term change (McCauley 2011),

Exposure to accurately emulated repeated pile driving signals suggest physical injury (organ damage) arises at levels equivalent to 1920 strikes at 179 dB re 1 µPa^2.s or 960 strikes at 182 dB re 1 µPa^2.s, or an equivalent single strike SEL of 210–211 dB re 1 µPa^2.s (Halvorsen *et al* 2012).

In a review of experimental findings of sound on fishes Popper *et al* (2014) present sound exposure guidelines for fin-fish in the form of estimated levels at which the following occur: 1) mortality and potential mortal injury, 2) impairment – recoverable injury, 3) impairment – TTS, 4) impairment – masking, and 5) behavioural changes. They present these impacts for three categories of fin-fish, 1) no swim bladder, 2) swim bladder present but no links to otolith system, or 3) swim bladder present with links to otolith system, plus sea turtles and eggs/larvae. Popper *et al* (2014) present this data for sources of explosives, pile driving, air gun arrays, sonar and shipping. Given the lack of experimental evidence for most of these categories they were forced to: 1) either extrapolate from another exposure type, animal group or both, and 2) rather than presenting threshold levels often present the subjectively evaluated likelihood of an impact type occurring at 'near' (tens of m),

'intermediate' (hundreds of m) and 'far' (thousands of m) ranges. The thresholds listed for physical injury (mortality and impairment-recoverable injury) for pile driving and seismic air gun signals are the same, being primarily based on the pile driving work of Halverson *et al* (2012). Readers are referred to Popper *et al* (2014) for the particular thresholds for a fin-fish and sound exposure type as the reader should see their text for the reasoning and caveats behind the values presented.

B.10.4. Assessment Criteria

In assessing impacts of a noise source on fin-fish any EIA document should consider species which:

- are important for commercial fisheries,
- are listed as threatened, vulnerable or are endemic to an area,
- can be considered as important 'bait fish' or are important as prey species for higher order fauna,
- have limited ability to flee an intense noise source,
- utilize a noise impacted area for specific purposes such as feeding or spawning events.

In considering impacts of underwater noise on a species of fin-fish, factors which must be taken into account include:

- hearing capabilities of the species in question including knowledge of morphological adaptations to increase hearing capability, noting fin-fish primarily respond to motion of the water particles and less to measures of sound pressure. Fin-fish have a diverse range of morphological adaptations to improve hearing capability,
- studies of known impacts on this species,
- studies of known impacts on related species either taxonomically, morphologically or in general terms if no other comparison is available (ie. pelagic fishes, benthic fishes etc),
- particular spatial and temporal features which are critical to that fin-fish population's survival (ie. specific feeding areas or prey types, spawning locations and periods).

For migratory fin-fish impact assessment must consider if a noise producing action may cause a species to leave an area and if so, the consequences of this to the species in question, for other fauna and for commercial fisheries which target that species.

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B.11. Elasmobranchs

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Consider when assessing

- Military sonar
- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Playback and sound exposure experiments
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- MOU on the Conservation of Migratory Sharks (Sharks)

Related modules

- Refer also to modules B.10 and B.12 when assessing impact to elasmobranchs

B.11.1. Species Vulnerabilities

Elasmobranchs as a group are poorly studied in relation to the potential impact of anthropogenic sounds, although several studies over time have been directed at particular species of shark to improve knowledge of their hearing mechanisms, abilities and implications for management. From as early as the 1960s (e.g. Nelson and Gruber, 1963), studies have shown that large sharks (*Carcharhinidae*, *Sphyrnidae*), in their natural environment, were attracted to low-frequency (predominantly 20 to 60 Hz) pulsed sounds, but apparently not to higher frequency (400 to 600 Hz) pulsed sounds, or to low-frequency continuous sounds. More recent research has established the hearing range of sharks to be between 40 Hz to approximately 800 Hz (Myrberg 2001), with possible limits for elasmobranchs in general at 20–1000 Hz (Casper and Mann, 2006, 2010).

Noise within the sharks' audible range may be produced by several anthropogenic sources such as shipping, underwater construction, pile driving, dredging, power stations and sonic surveys. It has been suggested that loud sounds in their audible range may repel sharks whereas low sounds may attract them (Francis and Lyon, 2013), probably as these latter mimics sounds emitted by struggling prey. Response likely depends on its distance from the source and the volume of the source.

Although more recent research in elasmobranch hearing and impacts in the wild have been sparse at best, and nonexistent for most species, there is evidence of habituation or at least no negative reaction to noise levels and frequencies from small boats operating recreational diving or from SCUBA divers' noises, even when these are regularly present and arising from many sources (Lobel, 2009 and personal observations by the author of this summary).

It is likely that elasmobranchs might suffer more impacts from noise through the effects it has on its prey species (Popper and Hastings, 2009, Carlson, 2012), and perhaps through acute events that impact concentration sites such as social groupings of hammerhead sharks, *Sphyrna* spp., and white sharks, *Carcharodon carcharias*, around offshore islands, as well as those gathering at coral reef habitats, in these cases, displacement may occur, either temporary or permanent, although again lack of adequate field research prevents any definitive conclusions. Several studies (eg Klimley and Myrberg 1979, Banner 1972, Myrberg *et al* 1978) indicate that elasmobranchs show consistent withdrawal from sources that are at close range and when confronted with sudden onset of transmissions. However they may habituate to these too if events become frequent (Myrberg, 2001). Seismic activities, pylon-driving operations, explosive construction work and activities involving similar pulsed sound emissions are likely therefore to have the most impact on elasmobranch species directly.

B.11.2. Habitat Considerations

Several species of elasmobranchs exhibit some type of site-fidelity, either permanent or seasonal. This has been observed in particular regarding species of interest to the dive industry. Some species of shark (eg whitetip, *Triaenodon obesus*, blacktip, *Carcharinus melanopterus*, and grey reef, *Carcharhinus amblyrhynchos*) and the reef manta, *Manta alfredi*, are particularly attached to coral reef environments, while others exhibit seasonal concentration around offshore islands (eg hammerheads, *Sphyrna lewini*, at Galápagos, Cocos and Malpelo Islands, white sharks, *Carcharodon carcharias*, at Guadalupe and Farallon Islands, whale sharks, *Rhincodon typus*, at Holbox, Mexico, and several other sites). Giant mantas *Manta birostris* also can be found in seasonal concentrations such as in Revillagigedo Islands in Mexico, Laje de Santos in Brazil and La Plata in Ecuador.

Seasons for these aggregations vary from site to site and by species and need to be assessed on a case by case basis.

Acoustic impacts which might severely affect vulnerable or complex habitats such as coral reefs or mangrove forests (essential nursery areas for some shark and ray species) are certain to have an effect on its elasmobranch fauna if it includes displacement or damage to prey species and any physical disruption of the habitat. Seasonal concentration areas for sharks and rays can be particularly vulnerable to acute acoustic disturbance, which may result in abandonment of the area or disruption of gregarious behaviour whose implications are yet not fully understood. Acute acoustic disturbances such as seismic or sonic surveys and any activity involving explosives in or around these critical habitats (coral reefs, offshore islands and other known seasonal concentration sites, key feeding grounds) are likely to have serious impacts on elasmobranch populations.

Although migration paths are still poorly understood for most species, recent satellite tagging research (e.g. Domeier and Nasby-Lucas, 2008) has begun to reveal some consistent patterns and as yet unknown concentration areas away from above-water topographic features. These areas likely represent additional vulnerability corridors where protection from acute acoustic disturbance should be incorporated into management actions.

B.11.3. Impact of Exposure Levels

As a group, elasmobranchs have been poorly represented in field studies on acoustics, with most knowledge available for more “visible” species such as large sharks. For these, observed impacts refer mostly to short-term avoidance responses to loud, sudden bursts of sound in their audible range, although there´s evidence that the regularity of such sounds might lead to habituation (see references above).

Given that bony fish, which make the majority of prey species for most sharks, may be severely impacted by sound, especially in loud bursts (eg Carlson, op. cit.), it is perhaps this indirect effect on prey that holds the most severe potential for generating impacts on shark populations.

There is insufficient information to assess long-term impacts or behavioral changes in elasmobranchs from anthropogenic noise that might affect survivability of species. Existing studies indicate that the most direct negative impact on the animals seems to be displacement by sonic outbursts, while longer-term exposure often seems to lead to habituation.

B.11.4. Assessment Criteria

From available data it seems that there are two main aspects of potential impacts on elasmobranchs that merit particular consideration: displacement or elimination of prey species and displacement or disruption of behaviour associated with specific sites by sound bursts. Given that detailed studies are mostly lacking, a precautionary approach to the exposure of elasmobranchs to noise, especially at key habitats and aggregation sites, is warranted. In particular activities involving the use of equipment or methods that generate loud sonic outbursts near known or estimated aggregation areas, or which might physically injure or displace prey, need to be carried out with adequate assessment (including baseline surveys for elasmobranch species and their prey) and mitigation measures as feasible and appropriate. Also, proposed activities that alter or impact keys habitats such as coral reefs, mangroves or offshore islands with known aggregations of elasmobranch species should be carried out with extreme caution and this group of species should be explicitly considered in studies and proposed management measures to reduce potential impacts.

B.11.5. Species not listed on the CMS Appendices that should also be considered during assessments

In general, listed species include those for which several acoustic and hearing studies exist, but as for the entire group detailed acoustic impact studies are lacking. The development and collation of more detailed data on a species by species basis could greatly help improve our understanding of the impacts of anthropogenic noise on their physiology and life cycles. Lack of information on most elasmobranch species is an impediment to the provision of any meaningful advice on species not listed on the CMS Appendices,

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B.12. Marine Invertebrates

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Consider when assessing

- Seismic surveys
- Civil high power sonar
- Coastal and offshore construction works
- Offshore platforms
- Vessel traffic greater than 100 metric tons
- Vessel traffic less than 100 metric tons
- Pingers and other noise-generating activities

Related CMS agreements

- Agreement on the Conservation of Cetaceans of the Black Seas Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS)
- Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS)
- MOU for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region (Pacific Islands Cetaceans)
- MOU Concerning the Conservation of the Manatee and Small Cetaceans of Western Africa and Macaronesia (West African Aquatic Mammals)
- Agreement on the Conservation of Seals in the Wadden Sea (Wadden Sea seals)
- MOU Concerning Conservation Measures for the Eastern Atlantic Populations of the Mediterranean Monk Seal (*Monachus monachus*) (Atlantic monk seals)
- MOU Concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa (Atlantic marine turtles)
- MOU on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia (IOSEA)
- MOU on the Conservation of Migratory Sharks (Sharks)

Related modules

- Refer also to modules B.10 when assessing impact to marine invertebrates

B.12.1. Species Vulnerabilities

Very little is known about effects of anthropogenic noise on invertebrates (Morley *et al*, 2014). This includes more than 170,000 described species of multicellular marine invertebrates in spite of their ecological and economic importance worldwide (Anderson *et al*, 2011). Most research targets molluscs (e.g. cephalopods, shellfish) and crustaceans (e.g. crabs, shrimps, barnacles) (reviewed in Aguilar de Soto, 2016).

Molluscs:

Two atypical mass-strandings involving nine giant squids, *Architeuthis dux*, were associated with seismic surveys co-occurring in nearby underwater canyons where this species concentrates (Guerra *et al*, 2004, 2011). Two specimens suffered extensive multiorganic damage to internal muscle fibres, gills, ovaries, stomach and digestive tract. Other squids were probably disoriented due to extensive damage in their statocysts. Damage to the sensory epithelium was also observed in four species of coastal cephalopods (*Sepia officinalis*, *Loligo vulgaris*, *Illex coindetii* and *Octopus vulgaris*) by exposure to two hours of low-frequency sweeps at 100 per cent duty cycle (André *et al*, 2011, Solé, 2012, Solé *et al*, 2013). Fewtrell and McCauley (2012) reported that squid, *Sepioteuthis australis*, exposed to seismic pulses from a single air gun showed signs of stress such as significant increases in the number of startle and alarm responses, with ink ejection in many cases, increased activity and changing position in the water column.

Delayed and abnormal development as well as an increase in mortality rates in eggs and larvae of shellfish exposed to noise have been recorded in two species. New Zealand scallop larvae, *Pecten novaezelandiae*, exposed to playbacks of low frequency pulses in the laboratory showed significant developmental delays and developed body abnormalities (Aguilar de Soto *et al*, 2013). The number of eggs of sea hares, *Stylocheilus striatus*, that failed to develop at the cleavage stage, as well as the number that died shortly after hatching, were significantly higher in a group exposed to boat noise playback at sea compared with playback of ambient noise (Nedelec *et al*, 2014). In contrast, playbacks of ship-noise enhanced larval settlement in the mussel, *Perna canaliculus* (Wilkens *et al* 2012) while seemed to increase biochemical indicators of stress in adult mussels (*Mytilus edulis*) (Wale *et al* 2016).

Crustaceans:

Stress responses were observed in aquarium-dwelling brown shrimp, *Crangon crangon*, exposed to ambient noise of some 30 dB higher than normal at 25–400 Hz (Lagardere, 1982, Regnault and Lagardere,

1983). Shrimps did not seem to habituate throughout the experiment. Similarly, shore crabs, *Carcinus maenas*, increased metabolic consumption and showed signals of stress when exposed to playbacks of ship noise in the laboratory. Crustacean larvae seem to differ in their sensitivity to noise: larval dungeness crabs, *Metacarcinus magister*, did not show significant differences in survival nor in time-to-moult when exposed to a single pulse from a seven air gun array, even at the higher received level of 231 dB re 1µPa (Pearson *et al*, 1994). In contrast, larvae of other crab species, *Austrohelice crassa* and *Hemigrapsus crenulatus* megalopae, exposed to playbacks of noise from tidal turbines tended to suffer significant delays in time-to-moult (Pine *et al*, 2012) and low-frequency noise exposure inhibited settlement of early larvae of barnacle, *Balanus amphitrite* (Branscomb and Rittschof, 1984). The apparent contradiction in the larval responses from different species of crustaceans may be due, among other things, to the experimental set-up (wild versus laboratory, one pulse versus a continuous exposure), the biology of the species, or the characteristics of the sound treatment. Cellular and humoral immune responses of marine invertebrates to noise have also been examined. In the European spiny lobster, *Palinurus elephas*, exposure to sounds resembling shipping noise in the laboratory affected various haematological and immunological parameters considered to be potential health or disease markers in crustaceans (Celi *et al*, 2014).

B.12.2. Habitat Considerations

Marine invertebrates inhabit a range of habitats. Mainly, they may live associated to the seafloor (benthic or bentho-pelagic species) or free in the water column (pelagic). Many species have an initial pelagic phase as larvae, useful for dispersion, before finding suitable habitat for settling into their adult life. Sound from preferred habitats is one of the cues used by larvae to find a suitable location to settle (Stanley *et al* 2012). Once they settle, many species have limited capabilities to move fast enough at distances required to avoid noise exposure, due to morphological constrains or to territorial behaviour.

Species associated to the seafloor will be more exposed to ground-transmission of noise. This is especially relevant for intense low frequency sounds directed towards the seafloor, typical of seismic surveys. Seismic pulses coupled with the seafloor and low frequency vibrations can travel long distances through the ground and can re-radiate to the water depending on the structure and composition of the seafloor. Marine invertebrates are sensitive to the particle motion component of sound, more than to the pressure wave, they are well suited to detect low frequency vibrations because these are used, for example, to identify predators and prey.

The variability in the extent of barotrauma experienced by different giant squid stranding at the same time, in coincidence with the same seismic survey (Guerra *et al* 2004, 2011), underlines the difficulties inherent in predicting noise-induced damage to animals in the wild. Here, some giant squid suffered direct mortality from barotrauma, while the death of others seemed to be caused by indirect effects of physiological and behavioural responses to noise exposure. Direct injury (barotrauma) can be explained by some animals being exposed to higher sound levels due to complex patterns of sound radiation creating zones of convergence (Urick, 1983) of the seismic sound waves reflected by the sea surface/sea floor, and possibly by the walls of the steep underwater canyons in the area where the seismic survey took place.

Marine invertebrates often have discrete spawning periods. It is unknown if eggs/larvae have a greater vulnerability to sound-mediated physiological or mechanical stress, or even particular phases of larval development when larvae undergo metamorphosis.

Metamorphosis involves selective expression of genes mediating changes in body arrangement, gene expression is susceptible to stress, including from noise. Spawning periods are key for the recruitment of marine invertebrates and thus should be considered when planning activities.

B.12.3. Impact of Exposure Levels

There are no data about thresholds of pressure or particle motion initiating noise impacts on marine invertebrates. Studies have found a range of physiological effects (reviewed in Aguilar de Soto and Kight 2016) but there are no dose-response curves identifying levels of impact onset. Moreover, most studies report only sound pressure level, while particle motion is relevant for the effects of noise on these species. At a distance from an acoustic source (in the far-field) the pressure and particle motion components of sound are easily predicted in a free homogeneous environment such as the water column. In contrast, in the near-field animals may experience higher particle motions than would be expected for the same pressure level in the far-field. Intense underwater sound

sources such as air guns, pile driving, sonar and blasting have back-calculated peak source levels ranging from 230 to, in the case of blasting, >300 dB re 1 µPa at 1m. These activities routinely ensonify large areas with sound pressure levels higher than the thresholds of response observed in different studies of noise-impacts on marine invertebrates. For example, a seismic array with an equivalent source level of 260 dB pk-p re 1 µPa at 1m will produce levels in excess of 160 dB_{rms} over hundreds of km-squared. This level was measured in an experiment reporting noise-induced developmental delays and malformations in scallop larvae (Aguilar de Soto *et al* 2013). But the particle velocities experienced by the larvae in the experiment (about 4-6 mm s^{-1} RMS) imply higher far-field pressure levels of some 195-200 dB_{rms} re 1 µPa, reducing the potential impact zone to only short ranges from the source. However, there are several reasons why larvae in the wild may be impacted over larger distances than these approximate levels suggest. Given the strong disruption of larval development reported, weaker but still significant effects can be expected at lower exposure levels and shorter exposure durations. Moreover, low frequency sounds propagate in complex sound fields in which convergence zones and re-radiation of sound transmitted through the sea-floor can create regions with high sound levels far from the source (Madsen *et al* 2006). The sound field experienced by an organism is a complex function of its location with respect to the sound source and acoustic boundaries in the ocean necessitating *in situ* measurements to establish the precise exposure level.

B.12.4. Assessment Criteria

Benthic marine invertebrates often have little movement capabilities further than a few metres, limiting their options to avoid exposure to anthropogenic noise. In the case of intense low frequency noise, e.g. seismic or pile driving, it is essential to consider ground-transmission. For example, during a seismic survey animals will be exposed to sound received from the air gun array passing over the location of the animals, but these invertebrates will be receiving at the same time ground-transmitted vibrations originated by previous seismic pulses. Thus, animals will experience waves arising from the water and from the ground, differing in phase and other parameters. Complex patterns of wave addition mean that in some cases vibrations will sum, increasing the levels of sound exposure to the animals. Because ground vibrations may travel tens of kilometres or more, the time that benthic invertebrates will be exposed to a given threshold of pressure or particle motion will be increased when we consider seafloor transmission. An alternative source for seismic surveys (©Vibroseis) is currently being tested. In contrast to usual seismic surveys transmitting pulses every 6 to 15 s from an air gun array towed by a ship near the sea-surface, Vibroseis is towed near the seafloor and emits continuously, but at lower peak level. Thus, duty cycle increases to 100 per cent. EIA of Vibroseis and other low frequency sound sources should include modelling particle motion in the target area and consider exposures to benthic fauna.

Results of experiments about effects of noise on catch rates of marine invertebrates have not shown significant effects: Andriguetto-Filho *et al* (2005) did not find changes on catches of shrimps after the passage of a small air gun array. No effects of seismic activities on catches of rock-lobsters were found either by Parry *et al* (2006) performing a long-term analysis of commercial data. In contrast, fishermen have blamed seismic sources for mortalities of scallops and economic losses due to reduced catch rates.

Despite uncertainties about how noise may affect marine fauna and fisheries, several countries have already implemented regulations that reduce overlap between seismic surveys and fishing activities (mainly of fin-fish). However, these regulations do not address concerns of noise effects on eggs and larvae, i.e. that noise might affect stock recruitment and thereby cause delayed reductions in catch rates.

Marine invertebrates form the base of the trophic-web in the oceans, providing an important food source for fish, marine mammals and humans. In addition to direct effects to adults, noise exposure during critical growth intervals may contribute to stock vulnerability, underlining the urgency to investigate potential effects of acoustic pollution on marine invertebrates at different ontogenetic stages. Moreover, recent results investigating the effects of noise on a range of marine invertebrate species call for applying the precautionary principle when planning activities involving high-intensity sound sources, such as explosions, construction, pile driving or seismic exploration, in spawning areas/times of marine invertebrates with high natural and economic value.

B.12.5. Species not listed on the CMS Appendices that should also be considered during assessments

Some large cephalopods are migratory, including the giant squid, *Architeuthis sp* (Winkelmann *et al* 2013). Given the vulnerability of this species to acoustic sources, it should also be considered during assessments.

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C. Decompression Stress

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Decompression sickness (DCS, 'the bends') is a disease associated with gas uptake at pressure. As hydrostatic pressure increases with depth, the amount of nitrogen (N_2) that is absorbed by the blood and tissues increases, resulting in higher dissolved gas tensions that could at maximum reach equilibrium with the partial pressure of N_2 in the lungs. This is a long-known problem for human divers breathing pressurized air, but has often been discounted as a problem for breath-hold divers since they dive on only a single inhalation (Scholander 1940). However, for free-diving humans and other air-breathing animals, tissues can become highly saturated under certain circumstances depending on the iterative process of loading during diving and washout at the surface (Paulev 1967, Lemaitre *et al* 2009). During decompression, if the dissolved gas tension in the tissues cannot equilibrate fast enough with the reducing partial pressure of N_2 in the lungs, tissues will become supersaturated, with the potential for gas-bubble formation (Francis and Mitchell 2003).

Breath-hold diving vertebrates were previously thought to be relatively immune to DCS due to their multiple anatomical, physiological and behavioural adaptations (Fahlman *et al* 2006, Fahlman *et al* 2009, Hooker *et al* 2012). However, recent observations have shown that marine mammals and turtles may be affected by decompression sickness under certain circumstances (Jepson *et al* 2005, Dennison *et al* 2012, Van Bonn *et al* 2013, Garcia-Parraga *et al* 2014). Of most concern, however, are the beaked whales, which appear to be particularly vulnerable to anthropogenic stressors that may cause decompression sickness (Jepson *et al* 2003, Cox *et al* 2006, D'Amico *et al* 2009, Hooker *et al* 2009, Hooker *et al* 2012).

C.1.1. Bubble Formation

Among marine mammals, both acute and chronic gas emboli have been observed. The formation of bubbles has been suggested as a potential explanation for lesions coincident with intravascular and major organ gas emboli in beaked whales that mass stranded in conjunction with military exercises deploying sonar (Jepson *et al* 2003, Fernandez *et al* 2005). There is some controversy about the proximate cause of the gas emboli (Hooker *et al* 2012) although it is widely agreed that it appeared to be linked to man-made acoustic disturbance. However, these types of lesions have also been reported in some single-stranded cetaceans for which they do not appear to have been immediately fatal (Jepson *et al* 2005, Bernaldo de Quirós *et al* 2012, Bernaldo de Quirós *et al* 2013). Looking at species-specific variability in bubble presence among stranded animals, the deeper divers (Kogia, Physeter, Ziphius, Mesoplodon, Globicephala, and Grampus) appeared to have higher abundances of bubbles, suggesting that deep-diving behaviour may lead to a higher likelihood of decompression stress (Bernaldo de Quirós *et al* 2012).

In addition, osteonecrosis-type surface lesions have been reported in sperm whales (Moore and Early 2004). These were hypothesized to have been caused by repetitive formation of asymptomatic N_2 emboli over time and suggest that sperm whales live with sub-lethal decompression induced bubbles on a regular basis, but with long-term impacts on bone health. Bubbles have also been observed from marine mammals bycaught in fishing nets, which died at depth (Moore *et al* 2009, Bernaldo de Quirós *et al* 2013). These bubbles suggested the animals' tissues were supersaturated sufficiently to cause bubble formation when depressurized (as nets were hauled). B-mode ultrasound has also shown bubbles in stranded (common and white-sided) dolphins, which showed normal behaviour after release and did not re-strand, and so appeared to tolerate this bubble formation (Dennison *et al* 2012). Cerebral gas lesions have also been observed using Magnetic Resonance Imaging in California sea lions,

Zalophus californianus, admitted to a rehabilitation facility (Van Bonn *et al* 2011, Van Bonn *et al* 2013).

It therefore appears that gas supersaturation and bubble formation may occur more routinely than previously thought. These cases highlight a growing body of evidence that marine mammals are living with blood and tissue N_2 tensions that exceed ambient levels (Moore *et al* 2009, Bernaldo de Quirós *et al* 2013). However, our understanding of how marine mammals manage their blood gases during diving, and the mechanism causing these levels to become dangerous is very rudimentary (Hooker *et al* 2012). Some perceived threats appear to cause a behavioural response that may override normal N_2 management, resulting in decompression sickness, stranding and death.

C.1.2. Sources of Decompression Stress

There is a documented association between naval active sonar exercises and beaked whale mass strandings (Frantzis 1998, Evans and England 2001, Jepson *et al* 2003). However, a comprehensive review of beaked whale mass strandings (D'Amico *et al* 2009) suggests that some strandings may be associated with other events. It therefore seems likely that other high-intensity underwater sounds may also present conservation concerns for these species (Taylor *et al* 2004). Indeed, ship-noise also appears to cause a behavioural response disrupting foraging behaviour in Cuvier's beaked whales, *Ziphius cavirostris* (Soto *et al* 2006).

The process of diving causes oxidative stress (Hermes-Lima and Zenteno-Savin 2002). Episodic regional lack of oxygen and abrupt reperfusion upon re-surfacing creates a situation where post-ischemic reactive oxygen species (ROS) and physiological oxidative stress are likely to occur. However, a link between oxidative stress and DCS has not yet been confirmed (Wang *et al* 2015).

C.1.3. Source Frequency, Level and Duration

Understanding the responses of cetaceans to noise is a two-stage process: (1) understanding the noise required to cause the behavioural modification and (2) understanding the physiological mechanism by which that behavioural modification causes harm to the animal. At present, almost all research has focussed on the first of these, i.e. work evaluating playback and response, and almost nothing is known about how this response then leads to decompression stress.

Several recent studies have found similar behavioural responses of a small number of beaked whales to sonar signals (Tyack *et al* 2011, DeRuiter *et al* 2013, Stimpert *et al* 2014, Miller *et al* 2015). These studies have shown that beaked whales respond behaviourally to sonar and other human and natural stimuli, typically showing a combination of avoidance and cessation of noise-production associated with foraging (Table 8). Responses to simulated sonar have started at low received levels. These types of behavioural changes were also documented in work monitoring vocal activity using Navy range hydrophones (Tyack *et al* 2011, Moretti *et al* 2014). This type of 'flight' response could, if catastrophic, disrupt the normal physiological mechanisms of these animals, leading to DCS.

C.1.4. Assessment Criteria

At the planning stage, the primary mitigation method to reduce issues of decompression stress would be to reduce the interactions of stressor and animals (i.e. to reduce the number of "takes"). This can be done by placing any high-intensity noise into areas without high densities of species of concern. Thus proposals should take account of all survey and modelling information sources to predict areas of likelihood of high/low species density, and attempt to reduce the number of impacted animals by designing operations only for areas of low animal density.

To supplement this, or in areas in which such species densities are unknown, baseline studies should be conducted. Beaked whales are particularly difficult to monitor visually (surfacing for as little as 8 per cent of the time), but have more reliable detection acoustically (vocalising for 20 per cent of the time, de Soto *et al* 2012). Hydrophone arrays can detect animals at 2-6km distances (Moretti *et al* 2010, Von Benda-Beckmann *et al* 2010).

During the activity, real-time monitoring of animal presence should be conducted. This can be done using visual and acoustic monitoring, with detections within a specified range of the activity resulting in cessation of the sound source. On-board visual or towed hydrophone monitoring allows only limited detection distance and thus limits mitigation effectiveness.

Monitoring over a wider area can be achieved using hydrophone arrays placed on the seafloor (Moretti *et al* 2010). Such hydrophone arrays allow detection over a wide

but static area. Dynamic monitoring over a wide area could potentially be achieved using acoustic drones, allowing near real-time hydrophone arrays to be placed over a greater area to ensure more effective assessment of species presence prior to any disturbance event.

Modelling of animal likelihood and distance from the source should be carried out in order to aim to minimize received levels (Table 1), thus reducing the risk of animals receiving too high a dose which might incur DCS/death.

C.1.5. Species not listed on the CMS Appendices that should also be considered during assessments

Beaked whales, *Ziphius cavirostris* (Appendix I) and *Hyperoodon* spp and *Berardius* spp (Appendix II) require additional consideration. These species appear particularly vulnerable to noise impacts. 20 species of *Mesoplodon* are currently missing from the CMS Appendices and yet are likely to also be vulnerable to noise impacts. All of these species are likely to be particularly sensitive to decompression stress.

Of other deep diving species which may potentially be at increased risk of decompression stress, *Kogia* are currently not listed on either of the CMS Appendices, *Physeter* is listed on Appendices I and II, *Globicephala* on Appendix II, and Grampus should also be considered during assessments.

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Table 8: Responses of beaked whales to sound sources

Species	Sound source	Response observed as received level (dB re. 1µPa)
Cuvier's beaked whale, *Ziphius cavirostris* (DeRuiter *et al* 2013)	30 min playback of 1.6s MFA sonar signal repeated every 25 sec. Initial source level of 160 dB re 1 mPa-m was increased ('ramped up') by 3 dB per transmission to a maximum of 210 dB re 1 mPa-m.	89-127
Cuvier's beaked whale, *Ziphius cavirostris* (Soto *et al* 2006)	Maximum broadband (356 Hz–44.8 kHz) level received during the ship passage was 136 dB rms re 1 µPa, approx. 700m away.	106 (in click frequency range)
Northern bottlenose whale, *Hyperoodon ampullatus* (Miller *et al* 2015)	104 1-s duration 1–2 kHz upsweep pulses (naval sonar signals) at 20s intervals. The source level of the sonar pulses increased by 1 dB per pulse from 152 to 214 dB re 1 µPam over 20min (61 pulses), and the remaining pulses were transmitted for 15min at a source level of 214 dB re 1 µPa m.	107
Baird's beaked whale, *Berardius bairdii* (Stimpert *et al* 2014)	Simulated mid-frequency active (MFA) military sonar signal at 3.5-4 kHz, transmitting 1.6 s signal every 25 s. The initial source level of 160 dB re: 1 mPa was increased by 3 dB per transmission for the first 8 minutes to a maximum of 210 dB for 22 additional minutes (72 transmissions total over 30 minutes).	127
Blainville's beaked whale, *Mesoplodon densirostris* (Tyack *et al* 2011)	Simulated 1.4 s MFA sonar, killer whale and noise signals. MFA sonar had both constant frequency and frequency modulated tonal components in the 3–4 kHz band repeated every 25 s. Initial source level of 160 dB re 1 mPa-m was increased ('ramped up') by 3 dB per transmission to a maximum of 210 dB re 1 mPa-m.	138

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D. Exposure Levels

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OceanCare

D.1. Impact of Exposure Levels and Exposure Duration

One of the first comprehensive definitions of exposure criteria for noise impact on marine mammals considering two types of impacts, namely auditory injury and behavioural disturbances by three sound types (single pulse, multiple pulse and nonpulse) has been published by Southall *et al* (2007). Just recently, the National Oceanic and Atmospheric Administration (NOAA) compiled and synthesized best available science to guide the assessment of effects of anthropogenic noise on marine mammals (NOAA, 2016). Both guidance documents consider cetaceans and pinnipeds assigned to five functional hearing groups (i.e. low-frequency cetaceans, mid-frequency cetaceans, high-frequency cetaceans, pinniped in water, pinnipeds in air and low-frequency cetaceans, mid-frequency cetaceans, high-frequency cetaceans, phocid pinnipeds underwater, otariid pinnipeds underwater respectively). The assignment to functional hearing groups was based on functional hearing characteristics of the species (e.g. frequency range of hearing, auditory morphology) and with reference to Southall *et al* as well the medium in which the amphibious living pinnipeds were exposed to sound. The developed noise exposure criteria do not address polar bears, sirenians, and sea otters due to the absence of necessary data in these species. To account for different hearing bandwidths and thus differences in impacts of identical noise exposure frequency-weighting functions were developed for each functional hearing group and considered in the formulation of the noise exposure criteria. Southall *et al* and NOAA applied dual criteria for noise exposure using peak sound pressure level (SPL) and sound exposure level (SEL) in each of the considered functional hearing groups in order to account for all relevant acoustic features such as sound level, sound energy, and exposure duration that influence the impacts of noise on marine mammals.

The onset of a permanent threshold shift (PTS-onset) has been considered as the onset of auditory injury (Southall *et al* 2007, NOAA 2016, Finneran 2015). PTS-onset estimates are applied in order to formulate dual noise exposure levels. The PTS-onset thresholds were estimated from measured TTS-onset thresholds (=threshold where temporary change in auditory sensitivity occurs without tissue damage) in very few mid-frequency odontocetes (i.e. bottlenose dolphin and beluga) and pinnipeds (i.e. California sea lion, northern elephant seal, and harbour seal) and extrapolated to other marine mammals due to the scarcity of available TTS data. It has been noted, that this extrapolation from mid-frequency cetaceans and the subsequent formulation of exposure criteria may be delicate in particular for high-frequency cetaceans due to their generally lower hearing threshold as compared to other cetaceans. The growth rates of TTS were estimated based on data in terrestrial and marine mammals exposed to increasing noise levels. Noise exposure levels for single pulse, multipulse and nonpulse sounds were expressed for SPL and SEL whereby the latter has been frequency weighted to compensate for the differential frequency sensitivity in each functional marine mammal hearing group as described above. No noise exposure criteria were developed by Southall *et al* (2007) or NOAA (2016) for the occurrence of non-auditory injuries (e.g. altered immune response, energy reserves, reproductive efforts due to stress, tissue injury by gas and fat emboli), due to a lack of conclusive scientific data to formulate quantitative criteria for any other than auditory injuries caused by noise.

Additionally to auditory injuries Southall *et al* (2007) presented also explicit sound exposure levels for noise impacts on behaviour resulting in significant biological responses (e.g. altered survival, growth, reproduction) for single pulse noise. For the latter it has been assumed that given the nature

(high peak and short duration) of a single pulse behavioural disturbance may result from transient effects on hearing (i.e. TTS). Therefore, TTS values for SPL and SEL were proposed as noise exposure levels. In contrast, for multiple and nonpulse sounds it has been taken into account that behavioural reactions to sounds are highly context-dependent (e.g. activity animals are engaged at the time of noise exposure, habituation to sound) and depending also among others on environmental conditions and physiological characteristics such as age and sex. Thus noise impact on behaviour is less predictable and quantifiable than effects of noise on hearing. Moreover, adverse behavioural effects are expected to occur below noise exposure levels causing temporary loss of hearing sensitivity. Therefore, a descriptive method has been developed by the authors to assess the severity of behavioural responses to multipulse and nonpulse sound. A quantitative scoring paradigm has been developed by Southall *et al* (2007) which numerically ranks (scores) the severity of behavioural responses. Noise exposure levels have been identified in a scoring analysis based on a thorough review of empirical studies on behavioural responses of marine mammals to noise. Reviewed cases with adequate information on measured noise levels and behavioural effects were then considered in a severity scoring table with the two dimensions, severity score and received SPL.

In contrast to former sound exposure assessment attempts Southall *et al* (2007) and NOAA (2016) account for differences in functional hearing bandwidth between marine mammal groups through the developed frequency-weighting functions. Thus, this approach allows to assess the effects of intense sounds on marine mammals under the consideration of existing differences in auditory capabilities across species and groups respectively. Furthermore, as compared to the widely used RMS sound pressure Southall *et al* (2007) and NOAA (2016) propose dual criteria sound metrics (SPL and SEL) to assess the impact of noise on marine mammals, accounting not only for sound pressure but also for sound energy, duration and high-energy transients.

All these aspects are certainly major accomplishment as compared to earlier attempts to assess noise effects on marine mammals. However, it has also to be noted that due to the absence of data noise exposure criteria had to be based on extrapolations and assumptions and therefore, as Southall *et al* (2007) and Finneran (2015) pointed out, caution is needed regarding the direct application of the criteria presented and that it is expected that criteria would change as better data basis becomes available.

D.2. Species Vulnerabilities

The best documented vulnerabilities to noise in marine mammals in terms of number of studies and species involved are certainly behavioural responses to noise. Only a few studies considering a few species exist regarding noise impacts on hearing and hearing sensitivity and physiology in marine mammals and therefore the respective knowledge on specific vulnerabilities of noise is rather scarce.

Auditory effects resulting from intense noise exposure comprise temporary threshold shift (TTS) and permanent threshold shift (PTS) in hearing sensitivity. For marine mammals TTS measurements exist for only a few species and individuals whereas for PTS no such data exist (Southall *et al* 2007, Finneran 2015). Furthermore, noise may cause auditory masking, the reduction in audibility of biological important signals, as has been shown for pinniped species in air and water (Southall *et al* 2000, 2003) and in killer whales (Foote *et al* 2004) for example.

Physiological stress reactions induced by noise may occur in cetaceans as has been shown for few odontocete species where altered neuro-endocrine and cardiovascular functions occurred after high level noise exposure (Romano *et al* 2004, Thomas *et al* 1990c). Furthermore, regarding noise-related physiological effects it has to be noted that scientific evidence indicates that in particular beaked whales experience physiological trauma after military sonar exposure (Jepson *et al* 2003, Fernandez *et al* 2004, 2005) due to in vivo nitrogen gas bubble formation.

The magnitude of the effects of noise on behaviour may differ from biological insignificant to significant (= potential to affect vital rates such as foraging, reproduction, or survival). Noise-induced behaviour response may not only vary between individuals but also intra-individually and depends on a great variety of contextual (e.g. biological activity animals are engaged in such as feeding, mating), physiological (e.g. fitness, age, sex), sensory (e.g. hearing sensitivity), psychological (e.g. motivation, previous history with the sound) environmental (e.g. season, habitat type, sound transmission characteristics) and operational (e.g. sound type, sound source is moving / stationary, sound level, duration of exposure) variables

(Wartzok *et al* 2004).

Observable behavioural responses to noise include orientation reaction, change in vocal behaviour or respiration rates, changes in locomotion (speed, direction, dive profile), changes in group composition (aggregation, separation), aggressive behaviour related to noise exposure and/or towards conspecifics, cessation of reproductive behaviour, feeding or social interaction, startle response, separation of females and offspring, anti-predator response, avoidance of sound source, attraction by sound source, panic, flight, stampede, stranding, long term avoidance of area, habituation, sensitization, and tolerance (Richardson *et al* 1995, Gordon *et al* 2004, Nowacek *et al* 2007, Wartzok *et al* 2004).

Studies have shown that in mysticetes the reaction to the same received level of noise depends on the activity in which whales are engaged in at the time of exposure. For migrating bowhead whales strong avoidance behaviour to seismic air gun noise has been observed at received levels of noise around 120 dB re 1 µPa while engaged in migration. In contrast, strong behavioural disturbance in other mysticetes such as gray and humpback whales as well as feeding bowhead whales has been observed at higher received levels around 150-160 dB re 1 µPa (Richardson *et al* 1985, 1999, Malme *et al* 1983, 1984, Ljungblad *et al* 1988, Todd *et al* 1996, McCauley *et al* 1998, Miller *et al* 2005). Furthermore, in different dolphin species reactions to boat noise varied from avoidance, ignorance and attraction dependant on the activity state during exposure (Richardson *et al* 1995).

Noise-induced vocal modulation may include cessation of vocalization as observed in right whales (Watkins 1986), sperm whales and pilot whales (Watkins and Schevill 1975, Bowles *et al* 1994) for example. Furthermore, vocal response may include changes in output frequency and sound level as well as in signal duration (Au *et al* 1985, Miller *et al* 2000, Biassoni *et al* 2000).

Noise-induced behaviour depends on the characteristics of the area where animals are during exposure and/or of prior history with that sound. In belugas for example a series of strong responses to ship noise such as flight, abandonment of pod structure and vocal modifications, changes in surfacing, diving and respiration patterns has been observed at relatively low received sound levels of 94-105 dB re 1 µPa in a partially confined area but the animals returned after some days while ship noise was higher than before (LGL and Greeneridge 1986, Finley *et al* 1990).

The distance of a noise source or its movement pattern influences the nature of behavioural responses. For instance, in sperm whales, changes in respiration and surfacing rates has been observed in the vicinity of ships (Gordon *et al* 1992) and dependant on whether a ship is moving or not different reactions of bowhead whales and other cetaceans have been observed (Richardson *et al* 1995, Wartzok *et al*, 2004)

D.2.1. Species not listed on the CMS Appendices that should also be considered during assessments

- Deep-diving cetaceans, in particular beaked whales need special consideration regarding noise exposure levels due to the risk for tissue trauma due to gas and fat emboli under certain noise conditions.
- Due to their lower overall hearing thresholds, high-frequency hearing cetaceans (true porpoises, river dolphins, *Pontoporia blainvillei, Kogia breviceps, Kogia sima, cephalorhynchids*) may need additional consideration as their sensitivity to absolute levels of noise exposure may be higher than other cetacean hearing groups.
- Southall *et al* pointed out that due to a lack of data they could not formulate noise exposure levels for polar bears, sea otters, and sirenians. Certainly a point which needs consideration when dealing with areas where these marine mammal taxa occur.

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E. Marine Noise-generating Activities

Geoff Prideaux
Wild Migration

E.1. Military Sonar

E.1.1. Low Frequency Active Sonar

The evolution of lower frequency active (LFA) sonar came from two needs. First, to increase detection ranges to overcome passive sonar systems and second, to compensate for the improvements of stealth designs in submarine hulls, part of which was an anechoic coating that absorbed incident waves. It was discovered this coating was less efficient when exposed to longer wave lengths.

LFA sonars work below the 1KHz range. For transmitting long distances efficiently, high powered modulated signals, typically 240 dB in water at 1m, peak value, (240 dB re 1µPa @ 1m peak) are produced lasting from tens of seconds to sometimes minutes. An example of this technology is the SURTASS-LFA of the US navy that operates within 100-500Hz range. (Lurton, 2010)

E.1.2. Mid Frequency Active Sonar

Mid frequency active (MFA) sonar is used for detecting submarines at moderate range, typically less than 10km.

MFA operates between 1-5 KHz range, with a sound intensity levels typically 235 dB in water at 1m, peak value, (235 dB re 1µPa @ 1m peak) with pulse duration of 1-2 seconds. (Hildebrand, 2009, Fildelfo *et al*, 2009)

E.1.3. Continuous Active Sonar

The concept of continuous active sonar (CAS) is generating interest in the anti-submarine warfare community, largely due to it's 100 per cent duty cycle offering the potential for rapid, continuous detection updates. CAS operates between 500Hz to 3KHz range with sound intensity levels typically 182 dB in water at 1m, peak value, (182 dB re 1µPa @ 1m peak) with a signal duration of 18 seconds (Murphy and Hines, 2015)

E.1.4. Mine Counter Measures Sonar

Underwater mines have proven, over time, to be very affective. There prevalence led to the development of the Mine Counter Measures (MCM) sonar. This system works at very high frequency, usually between 100-500KHz, to achieve high quality acoustic imaging of the sea floor and water column. Targets, semi-buried or suspended from the sea floor, are easily identified. (Lurton, 2010)

E.1.5. Acoustic Minesweeping Systems

Acoustic Minesweeping Systems are another mine counter-measure that produces a low frequency broadband transmission, mimicking the sound produced by certain vessels whereby detonating the mine. (Lurton, 2010)

E.2. Seismic Surveys

The commonly used surveying method for offshore petroleum exploration is ‘seismic reflection’. This is simply sound energy discharged from a sound source (air gun array) at the sea surface that penetrates subsurface layers of the seabed and is reflected to the surface where it is detected by acoustic receivers (hydrophones).

These surveys are typically conducted using specially equipped vessels that tow one or more cables (streamers) with hydrophones at constant intervals. Air guns vary in size and in conjunction with the charge pressure, determine the sound intensity level and frequency.

Frequencies used for seismic surveys are between 10-200Hz and down to 4-5Hz for the larger air guns. However, there are unused high frequency components up to 150KHz, with a very high discharge at the onset of the pulse. Sound intensity levels of 170dB in water at 1m, peak to peak value, (170 dB re 1µPa @

1m p-p) at 10KHz down to 120dB in water at 1m, peak to peak value, (120 dB re 1μPa @ 1m p-p) at 100KHz respectively. (Goold and Coates, 2006)

The typical discharge of each pulse of an air gun array is around 260-262 dB in water at 1m, peak to peak value, (260-262 dB re 1μPa @ 1m p-p) (OSPAR, 2009) every 10-15 seconds, and surveys typically run more or less continuously over many weeks. (Urick, 1983, Clay and Medwin, 1997, Caldwell and Dragoset, 2000, Dragoset, 2000, Lurton, 2010, Prideaux and Prideaux, 2015)

E.3. Civil High Power Sonar

Seafloor mapping sonar systems are probably one of the most prolific forms of underwater noise generation. The main application is coastal navigation for the production of bathymetric charts. Other applications include geology, geophysics, underwater cables and oil industry exploration and exploitation. Three examples are Single Beam Sounders (SBES), Sidescan Sonas and Multibeam Echo Sounders (MBES).

E.3.1. Single Beam Sounders

Single beam sounders point vertically below the vessel and transmit a short signal, typically 0.1ms. The frequencies vary on their application. For deep water, the frequency would be around 12KHz and increase to 200, 400 and even 700KHz for shallow water. The sound intensity level is usually around 240 dB in water at 1m, peak value (240 dB *re* 1μPa @ 1m peak). (Lurton, 2010)

E.3.2. Sidescan Sonar

Sidescan sonar system structures are similar to single-beam sonars. This sonar differs as it is installed on a platform or “towfish” and towed behind a vessel close to the seabed. Two antennae are placed perpendicularly to the body of the towfish, pointing fractionally to the sea floor. The transmission of the sidescan sonar insonifies the sea floor with a very narrow perpendicular band. The echo received along time, reflects the irregularities of the sea floor. A simple analogy is the scan mechanism of a photo copier. The operating frequency is usually in the range of many hundreds of KHz with the pulse duration 0.1ms or less. (Lurton, 2010)

E.3.3. Multibeam Echosounder

Multibeam echosounders are the major tool for seafloor mapping, for hydrography and offshore industry applications. The transmission and receiving arrays are mounted on the vessel to create a narrow beam, fan-like 150º spread, perpendicular to the keel.

Multibeam sounders can be put into three main catagories depending on their system structure and varied uses:

- Deep water systems, designed for regional mapping, 12Khz for deep ocean, 30Khz for continental slopes.
- Shallow water systems designed for mapping continental shelves, 70-200KHz and
- High-resolution systems for hydrography, shipwreck location and underwater structural inspection, 300-500Khz.

The attraction for multibeam systems is the scale of area that can be covered over time. For instance, a deep water configured multibeam sounder with a 20km fan/spread can cover 10,000km² per day. (Lurton, 2010)

E.3.4. Boomers, Sparkers and Chirps

Sparkers and boomers are high frequency devices which are generally used to determine shallow features in sediments. These devices may also be towed behind a survey vessel, with their signals penetrating several tens (boomer) or hundred (sparker) of metres of sediments. Typical sound intensity levels of sparkers are approximately 204-210 dB in water at 1m, rms value (204-210 dB re 1 μPa @ 1 m). Deep-tow boomer sound intensity levels are approximately 220 dB in water at 1m, rms value (220 dB re 1 μPa @ 1 m). The frequency range of both is 80Hz-10kHz and the pulse length is 0.2 ms. (Aiello *et al*, 2012, OSPAR, 2009)

Chirps produce sound in the upper frequency range around 20Hz-20 kHz. (Mosher and Simpkin, 1999) The sound intensity level for these devices is about 210-230 dB in water at 1m, peak value, (210-230 dB re 1 μPa @ 1 m) and the pulse length is 250ms. (Dybedal and Boe, 1994, Lee *et al*, 2008, OSPAR, 2009)

E.4. Coastal and Offshore Construction Works

E.4.1. Explosions

Explosions are used in construction and for the removal of unwanted seabed structures. Underwater explosions are one the strongest anthropogenic sound sources and can travel great distances. (Richardson *et al*, 1995) Sound

intensity levels vary with the type and amount of explosive used and the depth to which it is detonated. TNT, 1-100lbs, can produce a sound intensity level from 272-287 dB in water at 1m, zero to peak value, (272-287 dB re 1µPa zero to peak @ 1m) with a frequency range of 2-~1000Hz for a duration of <1-10ms. The core energy is between 6-21Hz. (Richardson *et al*, 1995, NRC, 2003)

E.4.2. Pile driving

Pile driving is associated with harbour work, bridge construction and wind farm foundations. Sound intensity levels vary depending on pile size and type of hammer. There are two types of hammers, an impact type (diesel or hydraulic) and vibratory type. Vibratory type hammers generate lower source levels, but the signal is continuous, where impact hammers are louder and plosive. The upper range is around 228 dB in water at 1m, peak value or 248-257 dB in water at 1m, peak to peak value, (228 dB re 1µPa peak @ 1 m/248-257 dB re 1µPa peak to peak @ 1m) with frequencies ranging within 20Hz-20KHz and a duration of 50ms. (Nedwell *et al*, 2003, Nedwell and Howell, 2004, Thomsen *et al*, 2006, OSPAR, 2009)

E.4.3. Dredging

Dredging is used to extract sand and gravel, to maintain shipping lanes and to route pipelines. The sound intensity level produced is approximately 168-186 dB in water at 1m, rms value, (168-186 dB re 1µPa @ 1m rms) with frequencies ranging from 20Hz->1KHz with the main concentration below 500Hz.

The majority of this sound is constant and non-plosive. (Richardson *et al*, 1995, OSPAR, 2009)

E.5. Offshore Platforms

E.5.1. Drilling

Drilling can be done from natural or manmade islands, platforms, drilling vessels, semi submersibles or drill ships.

For natural or manmade islands, the underwater sound intensity level has been measured at 145 dB in water at 1m, rms value, (145 dB re 1µPa @1m rms) with frequencies below 100Hz. (Richardson *et al*, 1995)

The sound intensity level transmitted down the caissons with platform drilling has been measured at approximately 150 dB in water at 1m, rms value, (150 dB re 1µPa rms @ 1m) at 30-40Hz frequency. (Richardson *et al*, 1995)

Drill ships seem to emit the highest sound intensity level, 190 dB in water at 1m, rms value, (190 dB re 1µPa @ 1m rms) with the frequencies ranging between 10Hz-10KHz, due to the efficient transmission of sound through the ship's hull. Additionally, ships use their location thrusters to keep them on target, combining propeller, dynamic positioning transponder (placed on the hull and sea floor) pingers (see below), and drill noise. (Richardson *et al*, 1995, OSPAR, 2009, Kyhn *et al*, 2014)

E.5.2. Positioning Transponders

Positioning transponders are used to dynamically position drill ships and other offshore platforms. Each system uses a concatenation of master and slave transponders. These systems have been recorded to have sound intensity level of 100 dB in water at 2km, rms value (100 dB re 1µPa @ 2km rms) with the frequencies ranging between 20KHz to 35KHz. (Kyhn *et al*, 2014)

E.5.3. Related Production Activities

During production, noise sources include seafloor equipment such as separators, injectors and multi-phase pumps operating at very high pressures.

There have also been studies to measure the sound intensity levels during production maintenance operations. Sound intensity levels of 190dB rms from the drill ship (distance unknown) with a frequency range between 20Hz-10KHz were recorded. (Kyhn *et al*, 2014) To date there have been no other systematic studies to measure the source levels of production maintenance. It is likely the sound intensity level is high. This is an area that needs focused attention.

E.6. Playback and Sound Exposure Experiments

E.6.1. Ocean Tomography

Ocean science uses a variety of sound sources. These include explosives, air guns and underwater sound projectors. Ocean tomography measures the physical properties of the ocean using frequencies between 50-200Hz with a sound intensity level of 165-220 dB in water at 1m (165-220 dB re 1µPa @ 1m). The *Acoustic Thermometry of Ocean Climate* research programme emitted a sound source of 195 dB in water at 1m, peak value, (195 dB re 1µPa @ 1m peak) at a frequency of 75Hz.

Geophysical research activities, one of which is the study of sediments in shallow water, also use typical mid or low frequency sonar systems or echo-sounders. (OSPAR, 2009) These are discussed under Civil High Power Sonar.

E.7. Shipping and Vessel Traffic

Marine vessels, small to large, contribute significantly to anthropogenic noise in the oceans. The trend is usually, the larger the vessel, the lower the frequencies produced resulting in the noise emitted travelling greater distances. The sound characteristics produced by individual vessels are determined by the vessels class/type, size, power plant, propulsion type/design and hull shape with relation to speed. Also, the vessel's age in terms of mechanical condition and the cleanliness of the hull: Less drag means less noise.

E.7.1. Small Vessels

Small vessels (leisure and commercial) for this paper are vessels up to 50m in length. These include planing hull designs such as jet skis, speed boats, light commercial run-abouts as well as displacement hull designs like motor yachts, fishing vessels and small trawlers.

The greater portion of sound produced by these vessels is mainly above 1KHz mostly from propeller cavitation. Factors that generate frequencies below 1KHz are engine and gearbox noise as well as propeller resonance. The sound intensity level produced is approximately 160-180 dB in water at 1m, rms value, (160-180 dB re 1µPa @ 1m rms) with frequencies ranging 20Hz ->10KHz. This, however, is dependent on the vessel's speed in relation to hull efficiency and economic speed to power settings. (Richardson *et al*, 1995, OSPAR, 2009)

E.7.2. Medium Vessels

Medium vessels for this paper are vessels between 50-100m, such as tugboats, crew-boats, larger fishing/trawler and research vessels. These vessels tend to have slower revving engines and power trains. The frequencies produced tend to mimic large vessels with the majority of sound energy below 1KHz. The sound intensity level produced is approximately 165-180 dB in water at 1m, rms value (165-180 dB re 1µPa @ 1m rms). (Richardson *et al*, 1995, OSPAR, 2009)

E.7.3. Large Vessels

Large vessels for this paper are vessel lengths greater than 100m, such as container/cargo ships, super-tankers and cruise liners.

Large vessels, depending on type, size and operational mode, produce their strongest sound intensity level of approximately 180-190 dB in water at 1m, rms value, (180-190 dB re 1µPa @ 1m rms) at a few hundred Hz. (Richardson *et al*, 1995, Arvenson and Vendittis, 2000) In addition, a significant amount of high frequency sound, 150 dB in water @ 1m, rms value, (150 dB re 1µPa @ 1m rms) or broadband frequencies, 0.354-44.8 kHz of 136 dB in water at 700m distance, rms value, (136 dB re: 1µPa @ >700m rms) can be generated through propeller cavitation. This near-field source of high-frequency sound is of concern particularly within shipping corridors, shallow coastal waters, waterways/canals and/or ports. (Arveson and Vendettis, 2000, Aguilar Soto *et al*, 2006, OSPAR, 2009)

E.8. Pingers

E.8.1. Acoustic Navigation and Positioning Beacons

Acoustic navigation and positioning beacons mark the position of an object and measure its height above the seabed. Most underwater beacons emit a short continuous wave tone, commonly 8-16 kHz octave band, with a stable ping rate. Typical sound intensity levels are around 160-190 dB in water at 1m, peak value (160-190 dB *re* 1µPa @ 1m peak). They are designed to be omnidirectional so as to be heard from any direction. Simple systems are programmed to transmit a fixed ping rate whilst more sophisticated systems transmit after receiving an interrogating signal. (Lurton, 2010)

E.8.2. Acoustic Deterrent Devices

Acoustic Deterrent Devices (ADDs) are a low powered device, 130-135 dB in water at 1m, peak value, (130-135 dB *re* 1µPa @ 1m peak) designed to deter fish from entering places of harm such as water inlets to power stations. The frequencies range from 9-15KHz for a duration 100-300ms every 3-4 seconds. (Carretta *et al*, 2008, Lepper *et al*, 2004, Lurton, 2010, OSPAR Commission, 2009)

E.8.3. Acoustic harassment devices

Acoustic Harassment Devices (AHDs) are a higher powered device, 190 dB in water

at 1m, peak value, (190 dB *re* 1µPa @ 1m peak) originally designed to keep marine mammals away from fish farms by causing them pain. Frequencies range from 5-20KHz for repelling pinipeds and 30-160KHz for delphinids. (Carretta *et al*, 2008, Lepper *et al*, 2004, Lurton, 2010, OSPAR, 2009)

E.9. Other Noise-generating Activities

E.9.1. Acoustic Data Transmission

Acoustic modems are used as an interface for subsurface data transmission. Frequencies range around 18-40KHz with a sound intensity level around 185-196dB in water at 1m (185-196 dB re 1µPa @ 1m). (OSPAR, 2009)

E.9.2. Offshore Tidal and Wave Energy Turbines

Offshore tidal and wave energy turbines are new, so acoustic information is limited. However, they appear to emit a frequency range of 10Hz-50KHz and a sound intensity level between 165-175dB in water at 1m, rms value, (165-175 dB re 1µPa @ 1m rms) depending on size. (OSPAR, 2009)

E.9.3. Wind turbines

The operational sound intensity levels for wind generators depend on construction type, size, environmental conditions, type of foundation, wind speed and the accumulative effect from neighbouring turbines. A 1.5MW turbine in 5-10m of water with a wind speed of 12m/s has been recorded producing 90-112 dB in water at 110m, rms value, (90-112 dB re 1µPa @ 110m rms) with frequencies ranging 50Hz-20KHz. (Thomsen *et al*, 2006, OSPAR, 2009)

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Table 9: Noise-generating activity, sound intensity level, bandwidth, major amplitude, duration and directionality

Sound	Sound Intensity Level (dB re1 ìPa)	Bandwidth	Major Amplitude	Duration	Directionality
Military					
Military Low Frequency Active Sonar	240 Peak @ 1m	<1KHz- 1Khz	[unknown]	600-1,000ms	Horizontally focused
Military Mid Frequency Active Sonar	235 Peak @ 1m	1-5KHz	[unknown]	1-2s	Horizontally focused (3 degrees down)
Continuous Active Sonar	182 Peak @ 1m	500Hz – 3KHz	[unknown]	18 seconds	Horizontally focused
Military Mine Counter Measures Sonar	[unknown]	100KHz-500KHz	[unknown]	[unknown]	[unknown]
Seismic Surveys					
Seismic Surveys	260-262 Peak to Peak @ 1m	10Hz-150KHz	10-120Hz also 120dB up to 100Kz	30-60ms	Vertically focused
Civil High Power Sonar					
Single Beam Sounders	240 Peak @ 1m	12KHz-700KHz depending on the application	[unknown]	0.1ms	Vertically focused
Sidescan Sonar	240 Peak @ 1m	12KHz-700KHz depending on the application	[unknown]	0.1ms	Vertically focused fan spread
Multibeam Echosounders	240 Peak @ 1m	12KHz-30KHz, 70KHz-200KHz, 300KHz-500KHz depending on the application	[unknown]	0.1ms	Vertically focused fan spread
Sparkers and Boomers	204-220rms @ 1m	80Hz-10KHz	[unknown]	0.2ms	[unknown]
Chirps	210-230 Peak @ 1m	20Hz-20KHz	[unknown]	250ms	[unknown]
Coastal and Offshore Construction Works					
Explosions, TNT 1-100lbs	272-287 Peak @ 1m	2Hz-~1,000Hz	6-21Hz	<1-10ms	Omnidirectional
Pile Driving	248-257 Peak to Peak @ 1m	20Hz-20KHz	100Hz-500Hz	50ms	Omnidirectional
Dredging	168-186 rms @ 1m	20Hz-1KHz	500Hz	Continuous	Omnidirectional
Offshore Platforms					
Platform Drilling	150 rms @1m	30Hz-40Hz	[unknown]	Continuous	Omnidirectional
Drill Ships (including maintenance)	190 rms @ 1m	10Hz-10KHz	[unknown]	Continuous	Omnidirectional
Positioning transponders	100 rms @ 2km	20KHz - 35KHz	[unknown]	Continuous	Omnidirectional

Sound	Sound Intensity Level (dB re1 ìPa)	Bandwidth	Major Amplitude	Duration	Directionality
Playback and Sound Exposure Experiments					
Ocean Tomography	165-220 Peak @ 1m	50Hz-200Hz	[unknown]	[unknown]	Omnidirectional
Shipping and Vessel Traffic					
Small Vessels	160-180 rms @ 1m	20Hz-10KHz	[unknown]	Continuous	Omnidirectional
Medium Vessels	165-180 rms @1m	Below 1KHz	[unknown]	Continuous	Omnidirectional
Large Vessels	Low Frequency 180-190 rms @ 1m High Frequency 136 rms @ 700m	Low Frequency A few hundred Hz High Frequency 0.354Khz-44.8Khz	[unknown]	Continuous	Omnidirectional
Pingers					
Acoustic Navigation Beacons	160-190 Peak @ 1m	8KHz-16KHz	[unknown]	[unknown]	Omnidirectional
Acoustic Deterrent Devices	130-135 Peak @ 1m	9KHz-15KHz	[unknown]	100-300ms	Omnidirectional
Acoustic Harassment Devices	190 Peak @ 1m	5Khz-20KHz, 30KHz-160KHz depending on the application	[unknown]	[unknown]	Omnidirectional
Other Noise-generating Activities					
Acoustic Data Transmission	185-196 @ 1m	18KHz-40KHz	[unknown]	[unknown]	Omnidirectional
Offshore Tidal and Wave Energy Turbines	165-175 rms @ 1m	10Hz-50KHz	[unknown]	Continuous	Omnidirectional
Wind Turbines	90-112 rms @ 110m	50Hz-20KHz	[unknown]	Continuous	Omnidirectional

F. Related Decisions of Intergovernmental Bodies or Regional Economic Organisations

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A series of important intergovernmental decisions have already determined the direction for regulating anthropogenic marine noise through EIAs. The following decisions are the latest from each of MEA.

F.1. CMS

'CMS Resolution 9.19: Adverse Anthropogenic Marine/Ocean Noise Impacts on Cetaceans and Other Biota' encourages Parties to:

> *'…to endeavour to control the impact of emission of man-made noise pollution in habitat of vulnerable species and in areas where marine mammals or other endangered species may be concentrated, and where appropriate, to undertake relevant environmental assessments on the introduction of systems which may lead to noise associated risks for marine mammals.'*

'CMS Resolution 10.24: Further Steps to Abate Underwater Noise Pollution for the Protection of Cetaceans and Other Migratory Species' encourages CMS Parties to:

> *'…prevent adverse effects on cetaceans and on other migratory marine species by restricting the emission of underwater noise, understood as keeping it to the lowest necessary level with particular priority given to situations where the impacts on cetaceans are known to be heavy"* and *"[u]rges Parties to ensure that Environmental Impact Assessments take full account of the effects of activities on cetaceans and to consider potential impacts on marine biota and their migration routes ...'*

'Resolution 10.24' further articulates that CMS Parties should ensure that Environmental Impact Assessments take full account of the impact of anthropogenic marine noise on marine species, apply Best Available Techniques (BAT) and Best Environmental Practice (BEP), and integrate the issue of anthropogenic noise into the management plans of marine protected areas. 'Resolution 10.24' also 'invites the private sector to assist in developing …alternative techniques and technologies for coastal, offshore and maritime activities'.

F.2. ACCOBAMS

'ACCOBAMS Resolution 5.13: Conservation of Cuvier's beaked whales in the Mediterranean' and 'Resolution 5.15: Addressing the impact of anthropogenic noise' reinforces the commitments made in 'Resolution 4.17: Guidelines to Address the Impact of Anthropogenic Noise on Cetaceans in the ACCOBAMS Area (ACCOBAMS Noise Guidelines)' that urges ACCOBAMS Parties to:

> *'[r]ecogniz[e] that anthropogenic ocean noise is a form of pollution, caused by the introduction of energy into the marine environment, that can have adverse effects on marine life, ranging from disturbance to injury and death.'*

This Resolution also encourages ACCOBAMS Parties to:

> *' ... address fully the issue of anthropogenic noise in the marine environment, including cumulative effects, in the light of the best scientific information available and taking into consideration the applicable legislation of the Parties, particularly as regards the need for thorough environmental impact assessments being undertaken before granting approval to proposed noise-*

producing activities.'

The ACCOBAMS Noise Guidelines provide further comprehensive detail-specific considerations relating to military sonar, seismic surveys and offshore drilling, shipping and offshore renewable energy developments.

F.3. ASCOBANS

'ASCOBANS Resolution 5.4: Adverse Effects of Sound, Vessels and other Forms of Disturbance on Small Cetaceans', urges ASCOBANS Parties to:

> *'… develop, with military and other relevant authorities, effective mitigation measures including environmental impact assessments and relevant standing orders to reduce disturbance of, and potential physical damage to, small cetaceans, and to develop and implement procedures to assess the effectiveness of any guidelines or management measures introduced.'*

'ASCOBANS Resolution 6.2: Adverse Effects of Underwater Noise on Marine Mammals during Offshore Construction Activities for Renewable Energy Production', further recommends that Parties:

> *'… include Strategic Environmental Assessments and Environmental Impact Assessments carried out prior to the construction of marine renewable energy developments and taking into account the construction phase and cumulative impacts'*

and to:

> *'… introduce precautionary guidance on measures and procedures for all activities surrounding the development of renewable energy production in order to minimise risks to populations …* [that include] *measures for avoiding construction activities with high underwater noise source levels during the periods of the year with the highest densities of small cetaceans, and in so doing limiting the number of animals exposed, if potentially significant adverse effects on small cetaceans cannot be avoided by other measures;* [to include] *Measures for avoiding construction activities with high underwater noise source levels when small cetaceans are present in the vicinity of the construction site;* [and] *technical measures for reducing the sound emission during construction works, if potentially significant adverse effects on small cetaceans cannot be avoided by other measures.'*

F.4. CBD

'CBD Decisions VIII/28: CBD Voluntary Guidelines on Biodiversity-inclusive Impact Assessment' provides detailed guidance on whether, when and how to consider biodiversity in both project level and strategic levels assessments. The document clearly articulates screening, scoping, assessment and evaluation of impacts, development and alternatives; tranparency and consultation, reporting, review and decision-making. The guidelines urge that environmental impact assessments should be mandatory for activities known to be in habitats for threatened species and activities resulting in noise emissions in areas that provide key ecosystem services. The guidelines further articulate that environment impact assessment should be considered for activities resulting in noise emissions in areas providing other relevant ecosystem services.

'CBD Decision XII/23: Marine and coastal biodiversity: Impacts on marine and coastal biodiversity of anthropogenic underwater noise' encourages CBD Parties and others:

> *'… to take appropriate measures, as appropriate within competencies and in accordance with national and international laws, such as gathering additional data about noise intensity and noise types, and building capacity in developing regions where scientific capacity can be strengthened.'*

In 'Decision XII/23' CBD Parties have agreed to a significant list of technical commitments, including gathering additional data about noise intensity and noise types, and building capacity in developing regions where scientific capacity can be strengthened.

The CBD Parties also encouraged Parties to take appropriate measures, including:

> *'… (e) Combining acoustic mapping with habitat mapping of sound-sensitive species with regard to spatial risk assessments in order to identify areas where those species may be exposed to noise impacts,*
> *(f) Mitigating and managing anthropogenic underwater noise through the use of spatio-temporal management of activities, relying on sufficiently detailed temporal and spatial knowledge of species or*

> *population distribution patterns combined with the ability to avoid generating noise in the area at those times,*
> *(g) Conducting impact assessments, where appropriate, for activities that may have significant adverse impacts on noise-sensitive species, and carrying out monitoring, where appropriate.'*

'Decision XII/23' urges the transfer to quieter technologies and applying the best available practice in all relevant activities.

F.5. IMO

The International Maritime Organization (IMO), through 'Resolution A 28/Res.1061', has requested that the Marine Environment Protection Committee (MEPC) keep under review measures to reduce adverse impact on the marine environment by ships, including developing:

> *'[g]uidance for the reduction of noise from commercial shipping and its adverse impacts on marine life'*

F.6. IWC

The Scientific Committee of the International Whaling Commission (IWC) continues to monitor and discuss the impacts of noise on cetaceans.

F.7. OSPAR

The Convention for the Protection of the Marine Environment of the North-East-Atlantic (OSPAR) has reached agreement on an 'OSPAR Monitoring Strategy for Ambient Underwater Noise'.

The OSPAR Intersessional Correspondence Group on Noise (ICG-NOISE) is currently working closely with the International Council for the Exploration of the Sea (ICES) data team to produce the 2017 OSPAR Intermediate Assessment for impulsive noise. This is the first regional assessment of its kind, and will give policy-makers and regulators a regional overview of cumulative impulsive noise activity in the Northeast Atlantic, including the noise source type (e.g. pile driver, explosion) and intensity. The 2017 Intermediate Assessment will serve as a 'roof report' to inform the subsequent 2018 MSFD assessments of EU Member States within the OSPAR region.

F.8. Espoo (EIA) Convention

In 'Decision II/8' Espoo Parties endorsed the Good Practice Recommendations on Public Participation in Strategic Environmental Assessment set out in document 'ECE/MP.EIA/SEA/2014/2', including and requirement that

> *'… the public to be given an opportunity to comment on draft plans or programmes and the associated environmental reports,'*

And that:

> *'[p]eople who are affected by a plan or programme and are interested in participating must be given access to all necessary information and be able to participate in meetings and hearings related to the SEA process'*

This applies during the different stages of the assessment, including screening, scoping, availability of the draft plan/programme and environmental report, opportunity for the public to express its opinions and decision.

F.9. HELCOM

The Baltic Marine Environment Protection Commission - Helsinki Commission (HELCOM) has two important programmes in development. The Baltic Sea Information on the Acoustic Soundscape Project surveyed national needs and requirements of information on noise and will recommend monitoring of ambient noise in the Baltic Sea. A registry of impulsive sounds project is also being considered.

F.10. Regional Seas Programmes

Most of the six UNEP administered Regional Seas Programmes including the Wider Caribbean Region, East Asian Seas, Eastern Africa Region, Mediterranean Region, North-West Pacific Region and the Western Africa Region and seven non-UNEP Administered Regional Seas Programmes including the Black Sea Region, North-East Pacific Region, Red Sea and Gulf of Aden, ROPME Sea Area, South Asian Seas, South-East Pacific Region and the Pacific Islands Region suggest some form of impact assessment should be conducted to mitigate threats the marine environment.

F.11. European Union Legislation and Implementation

A number of pieces of EU legislation on environmental impact assessment and nature protection are relevant and contain specific references to the marine environment and wildlife and noise.

Recital 12 of Directive 2014/52/EU of the European Parliament and the Council, which amends Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment, specifically mentions the marine environment and gives the example of one source of noise-generating activity:

> *'With a view to ensuring a high level of protection of the marine environment, especially species and habitats, environmental impact assessment and screening procedures for projects in the marine[1] environment should take into account the characteristics of those projects with particular regard to the technologies used (for example seismic surveys using active sonars).'*

In addition, Recital 33 of this Directive also requires that:

> *'Experts involved in the preparation of environmental impact assessment reports should be qualified and competent. Sufficient expertise, in the relevant field of the project concerned, is required for the purpose of its examination by the competent authorities in order to ensure that the information provided by the developer is complete and of a high level of quality.'*

The marine environment is mentioned in Annex III paragraph 2 (ii) related to legal article 4(3) and noise and vibration are listed in Annex IV paragraphs 1 (d) and 5 (c) among information to be supplied according to Article 5 (1).

The EIA Directive applies to all Member States and requires that, for certain types of projects listed in its Annexes, public and private projects likely to have significant effects on the environment by virtue inter alia of their size, nature or location are made subject to an assessment of their environmental effects.

Under the EIA Directive "project" means '*the execution of construction works or of other installations or schemes*' and '*other interventions in the natural surroundings and landscape including those involving the extraction of mineral resources*'.

For projects listed in Annex I of the EIA Directive an assessment should always be carried out, whereas for projects listed in Annex II, Member States have to determine whether an assessment is to be carried out through a case-by-case examination or according to thresholds or criteria set by the Member State.

The so-called EU nature directives (Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (Habitats Directive) and Council and European Parliament Directive 2009/147/EC on the conservation of wild birds (Birds Directive) are also relevant. For the Natura 2000 sites designated for the protection of features such as marine animal species listed in Annex II of the Habitats directive, measures are required under Art. 6(2) to avoid any significant disturbance of those species, while different human activities that are likely to have a significant effect on Natura 2000 sites need to be properly assessed and authorized in accordance with the provisions of article 6 (3) and (4) of the Habitats Directive. This provision also includes the obligation to assess the cumulative impacts of different activities on the conservation objectives of the site. Furthermore, the provisions of Article 12 of the Habitats Directive, which includes an obligation to prohibit deliberate disturbance of strictly protected species, are also particularly relevant in such situation, as all species of cetaceans and a number of marine vertebrates and invertebrates listed in Annex IV(a) benefit from a system of strict protection.

The Commission guidance document on *'establishing Natura 2000 sites in the marine environment'*[1] contains a specific section on noise pollution.

There is specific legislation on the marine environment. In 2008 the European Parliament and the Council adopted the Marine Strategy Framework Directive[2] which requires Member States to achieve or maintain good environmental status of European Union marine waters by 2020, by developing marine strategies. Marine strategies contain 5 main elements: the initial assessment, the determination of good environmental status, the establishment of environmental targets, the monitoring programmes and the programme of measures.

When determining good environmental status, Member States shall determine a set of characteristics on the basis of 11 qualitative

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1 Guidelines for the establishment of the Natura 2000 network in the marine environment: Application of the Habitats and Birds Directives (pp. 94-96)

2 Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for Community action in the field of marine environmental policy.

descriptors. One of these descriptors state:

> "*Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.*"

This is further specified in Commission Decision 2010/477/EU[3] which states that:

> *"… anthropogenic sounds may be of short duration (e.g. impulsive such as from seismic surveys and piling for wind farms and platforms, as well as explosions) or be long lasting (e.g. continuous such as dredging, shipping and energy installations) affecting organisms in different ways."*

The following criteria and indicators are laid down in that Decision:

> *"11.1. Distribution in time and place of loud, low and mid frequency impulsive sounds*
>
> > - *Proportion of days and their distribution within a calendar year over areas of a determined surface, as well as their spatial distribution, in which anthropogenic sound sources exceed levels that are likely to entail significant impact on marine animals measured as Sound Exposure Level (in dB re 1μPa2.s) or as peak sound pressure level (in dB re 1μPapeak) at one metre, measured over the frequency band 10 Hz to 10 kHz (11.1.1)*
>
> *11.2. Continuous low frequency sound*
>
> > - *Trends in the ambient noise level within the 1/3 octave bands 63 and 125 Hz (centre frequency) (re 1μPa RMS, average noise level in these octave bands over a year) measured by observation stations and/or with the use of models if appropriate (11.2.1)."*

Within the context of the Marine Strategy Framework Directive, Member States sharing a marine region or sub-region are also encouraged to cooperate to deliver on the objectives of the Directive.

3 Commission Decision 2010/477/EU on criteria and methodological standards on good environmental status of marine waters.

G. Principles of EIAs

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The principle of Environmental Impact Assessment (EIA) was developed and introduced in the 1960s during a time where there was a growth of modern environmental concern, a drive for more rational, scientific and objective environmental decision-making and a desire for more public involvement in environmental decision making. (Weston, 2002)

Conducting EIAs is now a well established governance and environmental management process, institutionalized in most of the 193 United Nations Member States (Glasson *et al* 2013, Morrison-Saunders and Retief, 2012).

A number of intergovernmental bodies have elaborated the principles of what EIAs should present (see Module G).

Through the process of their adoption, governments have individually committed to reflecting these decisions in their domestic law. The 'weight' of these decisions taken by governments at an international level is considerable and provides significant clarity about the expectations to conduct EIAs and effectively manage impacts of marine noise-generating activities.

A number of jurisdictions have already developed national and regional operational guidelines about mitigating anthropogenic noise on marine fauna during activities. These began with the United Kingdom's Joint Nature Conservation Committee guidelines. Similar guidelines have been iteratively developed in the United States of America, Brazil, Canada, Australia and New Zealand (Castellote 2007, Weir and Dolman 2007). These European Espoo Convention also provides guidance. These are important and necessary operational guidelines. They form a part of, but are not the totality of what should be considered within an EIA.

This Module provides some general principles to ensure environmental impacts (broadly defined to include the physical, life and social sciences) are an explicit and fundamental consideration both during the design of an activity and in the project authorisation by a regulator. (Cashmaore, 2004)

It is clear that there is sufficient international agreement that EIAs should be conducted. There is widespread national legal commitment and some detail in a few jurisdictions. What is now required is a change of practice: by regulators to insist thorough EIAs are presented, and by proponents to accept the same. (Morrison-Saunders and Retief, 2012, Prideaux and Prideaux, 2015)

G.1. The importance of early Strategic Environmental Assessment

There is strong value in governments' undergoing a level of assessment before inviting proponents to propose activities. Conducting proactive and early assessment of groups of activities, in the context of broader governmental vision, goals or objectives, can serve as a decision-support instrument that shapes as a process. (Morgan, 2012) Commonly called Strategic Environmental Assessments (SEA), these exercises can highlight the likely outcomes of anticipated activities and reduce stakeholder conflict by restricting or directing activity development before any commercial investment has been made. (Alshuwaikhat, 2005, Fundingsland Tetlow and Hanusch, 2012).

SEAs have the potential to act as a mediating instrument, bridging problem perceptions with technical solutions and steering the assessment to facilitate the integration of environmental values into decision-making processes. (Therivel, 2012, Fundingsland Tetlow and Hanusch, 2012)

SEA can enhance communication between different stakeholders, enabling discussion and agreement independently of different beliefs, convictions, social roles,

values, accumulated experiences, individual needs or other factors. (Vicente and Partidário, 2006) SEAs can also provide guidance to regulators about the institutional requirements needed to properly assess proposals. This will include their internal organizational structure, staffing and capacity. (Therivel, 2012, Fundingsland Tetlow and Hanusch, 2012)

SEA design should reflect the basic principles of the EIAs and the EIA Guidelines in Module I.

G.2. Basic Principles of EIAs

It is broadly accepted that the basic intent of EIAs is to anticipate the significant environmental impacts of development proposals before any commitment to a particular course of action. Often, the detail required within EIAs is poorly defined. Many legislative provisions for EIAs have been introduced without consideration of the institutional requirements, organizational structure, staffing and capacity development (Cashmore *et al*, 2004, Devlin and Yap 2008, Jay *et al*, 2007). Often the scientific basis and methods need sophisticated understanding.

Defensible EIAs, representing the Best Available Techniques (BAT) and Best Environmental Practice (BEP), should provide regulators with decision-making certainty by ensuring:

- Appropriate transparency
- Natural justice
- Independent peer-review
- Appropriate consultation

Each of these elements complements and supports the others.

G.2.1. Transparency and Commercial Sensitivity

Transparency is necessary for well-informed consultation, natural justice and independent peer-review.

The extent of transparency should complement the goals of natural justice and consultation, but does not need to provide information that is genuinely commercially or personally sensitive. However, far too often commercial sensitivity is a veil that industry proponents hide behind. (DiMento and Ingram, 2005, Sheaves *et al*, 2015) Currently a large body of data about public resources (the marine environment) is claimed as commercial-in-confidence with little justification. (Costanza *et al*, 2006, Sheaves *et al*, 2015)

The technical details of proposal for activities that generate noise should be fully and transparently available for comment before plans are submitted for approval to regulators.

Broadly, the information provided should include:

- comprehensive description of the noise to be generated and the equipment to be used, including elements of the sound that are auxiliary to the need,
- comprehensive description of the direct and surrounding area where the noise-generating activity is proposed and the species within this area,
- expert modelling of expected sound intensity levels and sound dispersal,
- timeframe of the noise-generation,
- scientific monitoring programmes conducted during and after noise-generating activity.

The full extent of information that should be transparently available is detailed in Module I.

None of this information should be considered commercially sensitive and proponents should not seek to hide it from view.

G.2.2. Natural Justice

Natural justice is both a legal and common concept with two parts: it ensure there is no bias, increasing public confidence, and enshrines a right to a fair hearing so that individuals are not unfairly impacted (penalized) by decisions that affect their rights or legitimate expectations.

In the case of decisions for activities in the marine environment, confidence that there is no hidden bias can be developed by ensuring there is full transparency and that all stakeholders are given reasonable notice of the plans, a fair opportunity to present their own concerns and that these concerns will factor in the final decision that is made. (DiMento and Ingram, 2005)

Stakeholders with a rightful interest in the marine environment include: traditional communities with cultural or spiritual connections, marine users such as fishermen (commercial and recreational), shipping and boating and tourism operators, scientists, conservation organizations, and general marine users such as tourism and recreation, who advocate for the conservation of marine wildlife or marine ecosystems. Their interest must be considered.

G.2.3. Independent Peer-review

There is concern in many countries over

the poor quality of EIA information. Depending on circumstance, this might reflect problems with institutional arrangements, low levels of commitment by proponents, or issues with the nature, extent and quality of training and capacity-building in the impact assessment, or elements of all of these. (Morgan, 2012) There is often a significant gap between the best practice thinking represented in the research and practice literature and the application of EIAs on the ground. (Morgan, 2012)

Proponent-funded independent peer-review of EIA proposals, before submission to regulators for assessment, is an important tool of BEP. (Sheaves *et al*, 2015) Comprehensive, independent peer-review is a logical requirement for ensuring alignment of EIAs with scientific understanding and standards, and ensuring that scientific understanding takes precedence over short-term benefits and political considerations. (Morrison-Saunders and Bailey, 2003, DiMento and Ingram, 2005, Sheaves *et al*, 2015)

In the case of marine noise-generating activities, independent peer-reviewers should include species experts and expert sound modelers and accousticians, who are able to declare full and verifiable independence from the proposal. Their peer-review reports should be fully transparent and submitted to regulators, without influence from proponents.

G.2.4. Consultation and burden of proof

True consultation has two key components: participation in the outcome of a decision and that the burden of proof rests with the proponent.

Development actions may have wide-ranging impacts on the environment, affecting many different groups in society. There is increasing emphasis by government at many levels on the importance of consultation and participation by key stakeholders in the planning and development of projects.

An EIA is an important vehicle for engaging with communities and stakeholders, helping those potentially affected by a proposed development to be much better informed and to influence the direction and precautions put in place by the proponent. This requires an appropriate exchange of information and a willingness by the proponent to be transparent about their likely impact. (O'Faircheallaigh, 2010, Glasson *et al*, 2013)

Burden of proof is often associated with the Latin maxim *semper necessitas probandi incumbit ei qui agit*, which broadly means "*the necessity for proof always lies with the person who makes the claim*." In the case of proponents of marine noise-generating activities, it is their claim that the activities they propose to undertake – in a shared marine environment – will cause minimal harm. To satisfy the burden of proof, the proponent must provide sufficient evidence to demonstrate that there is limited danger of damaging the marine environment or any species that have been highlighted as having importance.

Other stakeholders do not carry the burden of proof but instead carry the benefit of assumption, meaning they need no evidence to support their position of concern. It is up to the proponent to provide the assurance and bear all financial costs for doing so.

The current situation in far too many jurisdictions around the world is that industry has persuaded legislators to shift the burden of proof to stakeholders. Regulators need to take step to redress this imbalance, and the EIA Guidelines, outlined in Module I should provide this shift.

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H. CMS-Listed Species Potentially Impacted by Anthropogenic Marine Noise

Pinnipeds				
Scientific name	**Common name**	**App I**	**II**	**CMS Instruments**
Arctocephalus australis	South American fur seal		1979	CMS
Halichoerus grypus	Grey seal		1985	CMS
Monachus monachus	Mediterranean monk seal	1979	1979	CMS, Monk Seal in the Atlantic
Otaria flavescens	South American sea lion		1979	CMS
Phoca vitulina	Harbour seal		1985	CMS, Wadden Sea Seals

Cetaceans				
Scientific name	**Common name**	**App I**	**II**	**CMS Instruments**
Balaena mysticetus	Bowhead whale	1979		CMS
Balaenoptera bonaerensis	Antarctic minke whale		2002	CMS, Pacific Cetaceans
Balaenoptera borealis	Sei whale	2002	2002	CMS , ACCOBAMS , Pacific Cetaceans
Balaenoptera edeni	Bryde's whale		2002	CMS , Pacific Cetaceans
Balaenoptera musculus	Blue whale	1979		CMS, ACCOBAMS, Pacific Cetaceans
Balaenoptera physalus	Fin whale	2002	2002	ACCOBAMS, CMS, Pacific Cetaceans
Berardius bairdii	Baird's beaked whale		1991	CMS, Pacific Cetaceans
Caperea marginata	Pygmy right whale		1979	CMS, Pacific Cetaceans
Cephalorhynchus commersonii	Commerson's dolphin		1991	CMS
Cephalorhynchus eutropia	Chilean dolphin		1979	CMS
Cephalorhynchus heavisidii	Heaviside's dolphin		1991	CMS, Western African Aquatic Mammals
Cephalorhynchus hectori	Hector's dolphin			Pacific Cetaceans
Delphinapterus leucas	Beluga		1979	CMS
Delphinus capensis	Long-beaked common dolphin			Western African Aquatic Mammals, Pacific Cetaceans
Delphinus delphis	Common dolphin	2005	1988	CMS, ASCOBANS, ACCOBAMS, Western African Aquatic Mammals, Pacific Cetaceans
Eubalaena australis	Southern right whale	1979		CMS, Pacific Cetaceans
Eubalaena glacialis	Northern right whale	1979		CMS, ACCOBAMS
Eubalaena japonica	North Pacific right whale	1979		CMS
Globicephala melas	Long-finned pilot whale		1988	CMS, ACCOBAMS, ASCOBANS, Pacific Cetaceans, Western African Aquatic Mammals
Grampus griseus	Risso's dolphin		1988	CMS, ACCOBAMS, ASCOBANS, Western African Aquatic Mammals, Pacific Cetaceans
Hyperoodon ampullatus	Northern bottlenose whale		1991	CMS, ASCOBANS, Western African Aquatic Mammals
Lagenodelphis hosei	Fraser's dolphin		1979	CMS , Western African Aquatic Mammals, Pacific Cetaceans
Lagenorhynchus acutus	Atlantic white-sided dolphin		1988	CMS , ASCOBANS
Lagenorhynchus albirostris	White-beaked dolphin		1988	CMS , ASCOBANS
Lagenorhynchus australis	Peale's dolphin		1991	CMS
Lagenorhynchus obscurus	Dusky dolphin		1979	CMS, Western African Aquatic Mammals, Pacific Cetaceans
Megaptera novaeangliae	Humpback whale	1979		CMS, ACCOBAMS, Pacific Cetaceans
Monodon monoceros	Narwhal		1991	CMS
Neophocaena phocaenoides	Finless porpoise		1979	CMS, Pacific Cetaceans
Orcaella brevirostris	Irrawaddy dolphin	2009	1991	CMS, Pacific Cetaceans
Orcaella heinsohni	Australian snubfin dolphin		1979	CMS, Pacific Cetaceans

Orcinus orca	Killer whale		1991	CMS, ACCOBAMS, ASCOBANS, Western African Aquatic Mammals, Pacific Cetaceans
Phocoena dioptrica	Spectacled porpoise		1979	CMS, Pacific Cetaceans
Phocoena phocoena	Harbour porpoise		1988	CMS, ASCOBANS, ACCOBAMS, Western African Aquatic Mammals
Phocoena spinipinnis	Burmeister porpoise		1979	CMS
Phocoenoides dalli	Dall's porpoise		1991	CMS
Physeter macrocephalus	Sperm whale	2002	2002	CMS, ACCOBAMS, Pacific Cetaceans
Platanista gangetica	Ganges River dolphin	2002	1991	CMS
Pontoporia blainvillei	Franciscana	1997	1991	CMS
Sotalia fluviatilis	Tucuxi		1979	CMS
Sousa chinensis	Indo-Pacific hump-backed dolphin		1991	CMS, Pacific Cetaceans
Sousa teuszii	Atlantic hump-backed dolphin	2009	1991	CMS, Western African Aquatic Mammals
Stenella attenuata	Pantropical spotted dolphin		1999	CMS, Western African Aquatic Mammals, Pacific Cetaceans
Stenella clymene	Clymene dolphin		2009	CMS , Western African Aquatic Mammals
Stenella coeruleoalba	Striped dolphin		2001	CMS, ASCOBANS, ACCOBAMS, Western African Aquatic Mammals, Pacific Cetaceans
Stenella longirostris	Spinner dolphin		1999	CMS, Western African Aquatic Mammals, Pacific Cetaceans
Tursiops aduncus	Indian bottlenose dolphin		1979	CMS
Tursiops truncatus	Bottlenose dolphin	2009	1991	CMS, ASCOBANS, ACCOBAMS, Western African Aquatic Mammals, Pacific Cetaceans
Ziphius cavirostris	Cuvier's Beaked whale	2014		CMS, ACCOBAMS

Sirenians				
Scientific name	**Common name**	**App I**	**II**	**CMS Instruments**
Dugong dugon	Dugong		1979	CMS, Dugong
Trichechus manatus	Manatee	1999	1999	CMS
Trichechus senegalensis	West African manatee	2009	2002	CMS, Western African Aquatic Mammals

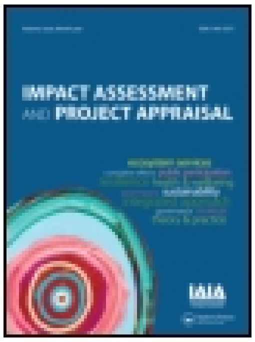
Sea turtles				
Scientific name	**Common name**	**App I**	**II**	**CMS Instruments**
Caretta caretta	Loggerhead turtle	1985	1979	CMS, IOSEA Marine Turtles , Atlantic Turtles
Chelonia mydas	Green turtle	1979	1979	CMS, IOSEA Marine Turtles, Atlantic Turtles
Dermochelys coriacea	Leatherback turtle	1979	1979	CMS, IOSEA Marine Turtles, Atlantic Turtles
Eretmochelys imbricata	Hawksbill turtle	1985	1979	CMS, IOSEA Marine Turtles, Atlantic Turtles
Lepidochelys kempii	Kemp's ridley turtle	1979	1979	CMS, Atlantic Turtles
Lepidochelys olivacea	Olive ridley turtle	1985	1979	CMS, IOSEA Marine Turtles, Atlantic Turtles
Natator depressus	Flatback turtle		1979	CMS, IOSEA Marine Turtles

Fish, Crustaceans and Cephalopods				
Fish, crustaceans and cephalopods are considered as listed CMS species as well as prey to CMS listed species.				
Scientific name	**Common name**	**App I**	**II**	**CMS Instruments**
Carcharodon carcharias	Great white shark	2002	2002	CMS, Sharks
Cetorhinus maximus	Basking shark	2005	2005	CMS, Sharks
Isurus oxyrinchus	Shortfin mako shark		2008	CMS, Sharks
Isurus paucus	Longfin mako shark		2008	CMS, Sharks
Lamna nasus	Porbeagle		2008	CMS, Sharks
Alopias pelagicus	Pelagic thresher shark		2014	CMS
Alopias superciliosus	Bigeye thresher shark		2014	CMS
Alopias vulpinus	Common thresher shark		2014	CMS
Carcharhinus falciformis	Silky shark		2014	CMS
Sphyrna lewini	Scalloped hammerhead shark		2014	CMS
Sphyrna mokarran	Great hammerhead shark		2014	CMS
Manta alfredi	Reef manta ray	2014	2014	CMS
Manta birostris	Manta ray	2011	2011	CMS
Manta alfredi	Reef manta ray	2014	2014	CMS
Mobula eregoodootenkee	Pygmy devil ray	2014	2014	CMS
Mobula hypostoma	Atlantic devil ray	2014	2014	CMS

Mobula japanica	Spinetail mobula	2014	2014	CMS
Mobula kuhlii	Shortfin devil ray	2014	2014	CMS
Mobula mobular	Giant devil ray	2014	2014	CMS
Mobula munkiana	Munk's devil ray	2014	2014	CMS
Mobula rochebrunei	Lesser Guinean devil ray	2014	2014	CMS
Mobula tarapacana	Box ray	2014	2014	CMS
Mobula thurstoni	Bentfin devil ray	2014	2014	CMS
Squalus acanthias	Spiny dogfish		2008	CMS, Sharks

Otters				
Scientific name	**Common name**	**App I**	**II**	**CMS Instruments**
Lontra felina	Marine otter	1979		CMS

Polar bear				
Scientific name	**Common name**	**App I**	**II**	**CMS Instruments**
Ursus maritimus	Polar bear		2002	CMS



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Environmental impact assessment guidelines for offshore petroleum exploration seismic surveys

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Environmental impact assessment guidelines for offshore petroleum exploration seismic surveys

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ABSTRACT
The ocean environment is filled with natural sound, but the last century has introduced many anthropogenic activities that have increased the levels of noise. Research on the impact of anthropogenic noise on marine fauna is now extensive. Levels of threat are well defined. Mitigation and monitoring guidelines exist in many parts of the world; especially for offshore petroleum exploration. In many jurisdictions, these guidelines rely on environmental impact assessments (EIAs) consideration by decision-makers, yet few jurisdictions stipulate what such assessments should contain. Sound propagation in the marine environment is complex, yet robust and defensible modelling is rarely conducted. Many impact assessments are inadequately checked. This stands in contrast to the equivalent process for land-based assessments. We argue that defensible EIAs should include modelling of the proposed noise impact in the region and under the conditions of planned activity. We articulate why clear guidelines about the content of EIAs are needed and propose a template for offshore petroleum exploration assessment.

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Introduction

The ocean environment is filled with natural sound from animals and physical processes. Species living in this environment are adapted to these sounds. Many species rely on sound as a primary sense, using it for hunting, reproduction and navigation (Southall et al. 2000, 2007; Simmonds et al. 2014). Over the past century, many anthropogenic marine activities have increased levels of noise (Hildebrand 2009; André et al. 2011). These modern anthropogenic noises have the potential for physical, physiological and behavioural impacts on marine fauna – mammals, reptiles, fish and invertebrates (Moriyasu et al. 2004; Southall et al. 2007; Payne et al. 2008; Clark et al. 2009; Miller et al. 2009; André et al. 2010; CBD CBD SBSTTA 2012). One noise-producing industry is offshore petroleum exploration.

There are national and regional operational guidelines available to the offshore petroleum exploration industry, each detailing the impacts to avoid and mitigation measures to take during operations. These began with the United Kingdom's Joint Nature Conservation Committee guidelines to minimise acoustic disturbance of marine mammals by oil and gas industry seismic surveys in 1995. Similar guidelines have been iteratively developed in the United States of America, Brazil, Canada, Australia and New Zealand (Castellote 2007; Weir & Dolman 2007; Compton et al. 2008). At a regional level, the intergovernmental Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) has established comprehensive guidelines for the Mediterranean region. Other regional and international instruments are gradually developing similar guidance.

These guidelines focus on mitigation measures during operations and rely on an assessment of risk having being considered and approved by decisions-makers before the operation starts. This is an important step in the process, yet there are few guidelines about the content of these environmental impact assessments (EIAs). Generalised assumptions about impact are often all that is presented. If an EIA is to be a good decision-aiding tool, it must provide decision-makers with a thorough and detailed understanding of the consequences of their decisions (Tenney et al. 2006).

The propagation of sound in water is complex and requires many variables to be carefully considered before it can be known if the proposal is appropriate or not. Despite this, proposals from the offshore petroleum exploration industry are presented to regulators with generalised, unsubstantiated information and often without having conducted basic consultation with other stakeholders reliant on the same environment.

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These hollow submissions perpetuate because the expectation from government has not been carefully prescribed. Regulators are forced to approve or reject projects without robust, defensible and impartial information on which to base their decisions. Regulator decisions are often made based on erroneous information. Such decisions are vulnerable to criticism of bias or tokenism (Court et al. 1996; Tenney et al. 2006; Jay et al. 2007; Devlin & Yap 2008; Prideaux & Prideaux 2012; 2013b, 2013c, 2013d, 2013e, 2013f; Wright et al. 2013).

This paper provides a basic explanation of the complexities of sound propagation in the marine environment and shows why generalised assumptions are inadequate to assess impact. A brief description of the common technology employed by the offshore petroleum exploration industry is provided. The next section will give a broad outline of the range of species susceptible to loud anthropogenic noise pollution and a general summary of the impacts they experience. The final section explores the trends in current EIAs for offshore petroleum exploration and introduces a template for EIA guidelines.

Sound propagation in water is complex

Often, offshore petroleum exploration industry statements are made in EIAs that a sound-producing activity is '*X*' distance from '*Y*' species or habitat. In these cases, distance is used as a basic proxy for impact, but is rarely backed with scientifically modelled information. To present a defensible EIA for offshore petroleum exploration proposal, proponents need to have professionally modelled the noise of the proposed activity in the region and under the conditions they plan to operate.

The behaviour of sound in the marine environment is different from sound in air. The extent and way that sound travels (propagation) is affected by many factors, including the frequency of the sound, water depth and density differences within the water column that vary with temperature, salinity and pressure (Wagstaff 1981; Clay & Medwin 1997; Lurton 2010; Etter 2013). Seawater is roughly 800–1500 times denser than air and sound travels around five times faster in this medium (Lurton 2010, p. 16). Consequently, a sound arriving at an animal is subject to propagation conditions that are complex (McCauley et al. 2000; Calambokidis et al. 2002; Hildebrand 2009; Lurton 2010).

While noise modelling is common for land-based anthropogenic noise-producing activities, it is less common for proposals in the marine environment. The lack of rigorous noise modelling in the marine setting needs to be urgently addressed. Modelling of each individual proposal should be professionally and impartially conducted to provide decision-makers with credible and defensible information. It should provide a clear indication of sound dispersal characteristics, informed by local propagation features (Urick 1983; Etter 2013). With this information, species exclusion zones can be identified with descriptions of how noise propagation into these zones will be minimised.

Elasticity

The speed of sound is not a fixed numerical value. Sound wave speed varies widely and depends on the medium, or material, it is transmitted through such as solids, gas or liquids. Each medium has its own elasticity (or resistance to molecular deformity). This elasticity factor affects the sound wave's movement significantly.

Sound waves move through a medium by transferring kinetic energy from one molecule to the next (Lurton 2010, pp. 14–20). Solid mediums, such as metal, transmit sound waves extremely fast because the solid molecules are tightly packed together, providing only tiny spaces for vibration. Sound waves move rapidly through this high elasticity medium, because the solid molecules act like small springs, aiding the wave's movement across the medium. The speed of sound through aluminium, for example, is around 6319 ms^{-1} (Goel 2007; Gottlieb 2007, pp. 22–23; Giordano 2012, p. 414). Gas, like air, naturally has large spaces between each molecule. As a result, sound waves take longer to move through a gas. Each air molecule vibrates at a slower speed after a sound wave passes through it, because there is more space surrounding the molecule. The gas molecule effectively deforms in shape from the passing sound wave, making gas reflect a low elasticity. Sound waves moving through air at a temperature of 20 °C will only travel around 342 ms^{-1} (Goel 2007; Gottlieb 2007). Liquid molecules, such as seawater, bond together in a tighter formation compared with gas molecules allowing only small vibration movements. Sound waves do not deform the liquid molecules as severely as gas molecules, creating a higher elasticity level. Sound waves moving through water at 22 °C travel at around 1484 ms^{-1} (Goel 2007; Gottlieb 2007).

Warmer temperatures across a medium also excite molecules. Molecules move faster under higher temperatures, transmitting sound waves more rapidly across the medium. Conversely, decreasing temperatures cause the molecules to vibrate at a slower pace, hindering the sound wave's movement (Goel 2007; Gottlieb 2007, p. 23; Giordano 2012). The temperature of the seawater at different depths is therefore of importance to modelling.

Spherical spreading, cylindrical spreading and transmission loss

The way sound propagates is also important. Spherical spreading is simply sound leaving a point source in an expanding spherical shape (Urick 1983, p. 100; Lurton 2010, p. 22). As sound waves reach the sea surface and sea

floor, they can no longer maintain their spherical shape and they begin to resemble the shape of an expanding cheese wheel. This is called cylindrical spreading (Urick 1983, p. 102). The transmission loss, or the decrease in the sound intensity levels, happens uniformly in all directions during spherical transmission. However, when sound is in a state of cylindrical transmission it cannot propagate uniformly. The sound is effectively contained between the sea surface and the sea floor, while the radius is still expanding uniformly (the sides of the cheese wheel) but the height is now fixed and so the sound intensity level decreases more slowly (Urick 1983, p. 102).

Given the seabed is rarely, if ever, flat and parallel to the sea surface, modelling cylindrical spreading in the marine environment is complex. Seabed characteristics must be known to model this spreading. Modelling must accommodate the water depth below the seismic survey, as well as the rise and fall of the seabed surrounding it (Lurton 2010, p. 13).

Sound Fixing and Ranging channels (SOFAR)

As well as spherical and cylindrical spreading, another variable can impact how far sound will be transmitted. This is usually called a SOFAR or deep sound channel and is a horizontal layer of water in the ocean at which depth, the speed of sound is at its minimum.

The SOFAR channel is created through the interactive effect of temperature and water pressure (and, to a smaller extent, salinity). This occurs because pressure in the ocean increases with depth, but temperature is more variable, generally falling rapidly in the main thermocline from the surface to around a thousand meters deep and then remaining almost unchanged from there to the ocean floor. Near the surface, the rapidly falling temperature causes a decrease in sound speed (or a negative sound speed gradient). With increasing depth, the increasing pressure causes an increase in sound speed (or a positive sound speed gradient). The depth where the sound speed is at a minimum is called the sound channel axis. The speed gradient above and below the sound channel axis acts like a lens, bending sound towards the depth of minimum speeds. The portion of sound that remains within the sound channel encounters no acoustic loss from reflection of the sea surface and sea floor. Because of this low transmission loss, very long distances can be obtained from moderate acoustic power (Urick 1983, p. 159; Lurton 2010, p. 58).

Offshore petroleum exploration

The commonly used surveying method used for offshore petroleum exploration is 'seismic reflection'. This is simply sound energy discharged from a sound source (air gun array) at the sea surface that penetrates subsurface layers of the seabed and is reflected to the surface where it is detected by acoustic receivers (hydrophones). These surveys are typically conducted using specially equipped vessels that tow one or more cables (streamers) with hydrophones at constant intervals. For the seismic reflection process to work, there needs to be enough energy discharged from the air gun array to travel, sometimes several kilometres, to the sea floor and then to be refracted as it passes from liquid into solid to a prescribed depth. Some of the energy is reflected and begins a return journey being refracted from solid to liquid then to travel to the hydrophone streamers. The analysis of these reflections provides a profile of the underlying rock strata and helps industry to identify hydrocarbon accumulations or anomalies that may correspond to hydrocarbon deposits. The typical discharge of each pulse of an air gun array is around 230 dB (re 1 μPa^2 @ 1m) every 10–15 s, and surveys typically run more or less continuously over many weeks (Urick 1983; Clay & Medwin 1997; Caldwell & Dragoset 2000; Dragoset 2000; Lurton 2010). These operations are usually called 'seismic surveys'.

Marine fauna susceptible to anthropogenic noise

Marine animals rely on sound for their vital life functions, such as communication, prey and predator detection, orientation and for sensing their surroundings (Simmonds et al. 2014). Noise affects the behaviour and physiology of animals in various ways, including disruptions in the neuroendocrine, cardiovascular and immune systems (Kight & Swaddle 2011).

Southall et al. (2007) reviewed the expanding literature on marine mammal hearing and their physiological and behavioural responses to anthropogenic noise. They developed predictions of noise exposure levels above which adverse effects, as either injury or behavioural disturbance, on various groups of marine mammals could be expected. While these researchers acknowledged limits in their proposed criteria, because of scarcity of information about some species, the work is valuable for establishing policy guidelines or regulations about anthropogenic noise.

An important recent Convention on Biological Diversity (CBD) Decision (XII/23) has recommended that further research is conducted for the remaining significant knowledge gaps. This includes knowledge about fish, invertebrates, turtles and birds. They also recommended research into the implications of cumulative and synergistic impacts of multiple sources of noise on marine species (CBD 2014).

Southall et al. (2007) highlighted that exposure criteria for single individuals and short-term (not chronic) exposure events are inadequate to describe the cumulative and ecosystem-level effects likely to result from repeated and/or sustained human input of sound into the marine environment and from potential interactions

with other stressors. It is therefore critical that modelling of noise propagation is conducted to determine the potential received levels of noise for different species and the duration of exposure.

An important volume of solid research should be considered directly for more detail about the unique characteristics of each of the species groups. The following section provides a summary of this knowledge base.

Fish, crustaceans and cephalopods

Fishermen worldwide complain that seismic surveys produce economic losses by reducing captures of a wide range of commercial species. The impact of anthropogenic noise on commercial fisheries is slowly being quantified. Behavioural responses of fish and cephalopods vary to received levels of seismic noise. These include leaving the area of the noise, through changes in depth distribution, schooling behaviour and startle responses to short-range start-up or high-level sounds. In some cases, behavioural responses from fish were observed up to 5 km distance from the seismic air gun array (McCauley et al. 2000, 2003; Hassel et al. 2004; McCauley & Fewtrell 2008). Short exposures to intense seismic signals are known to increase mortality of fish larvae at short ranges. Sublethal physiological impacts have been observed in crustaceans potentially impacting reproduction and recruitment. Significant developmental delays and abnormalities have been shown in mollusc larvae, including malformations in soft body tissues (Parry & Gason 2006; Payne et al. 2008; de Soto et al. 2013). Noise exposure during critical growth intervals may contribute to stock vulnerability (de Soto et al. 2013).

Pinnipeds

Pinnipeds (seals, sea lions and walrus) live part of their lives in both air and in water. Their hearing is adapted to both mediums and they are likely to be susceptible to the harmful effects of loud noise in each. Behavioural responses to anthropogenic sound have been recorded including pinnipeds removing themselves from feeding activities. Disturbances in marine and terrestrial environments can cause pinnipeds to abandon colonies, which could have serious implications, especially for species that are already endangered. In most respects, noise-induced threshold shifts in pinnipeds follow trends similar to those observed in other mammals (Southall et al. 2007). Pinnipeds, like many land-based mammals, have vibrissae (whiskers), which are well supplied with nerves, blood vessels and muscles and may function to detect the subtle movements of fish and other aquatic organisms. Vibrissae have been shown (for example, in harbour seals, *Phoca vitulina*) to be sensitive to low-frequency waterborne vibrations (Bohne et al. 1985; Mathews 1994; Southall et al. 2000; Harris et al. 2001; Kastak et al. 2005).

Sirenians

Similarly, sirenians (dugong and manatee) may be displaced from key feeding habitats by exposure to noise. While most research has focused on boating traffic, their behavioural response to the noise of passing vessels supports that these animals are sensitive to noise and should be considered carefully (Hodgson & Marsh 2007).

Cetaceans

Cetaceans (whales, dolphins and porpoises) are perhaps the most studied group of marine species when considering the impact of anthropogenic noise. Different taxonomic groups of cetaceans adopt different strategies for responding to acoustic disturbance from seismic noise. Baleen whales are susceptible to temporary threshold shift at a kilometre or more from seismic surveys (Gordon et al. 2003; Nowacek et al. 2007; Weilgart 2007; Di Iorio & Clark 2009; Gedamke et al. 2011; Gray & Van Waerebeek 2011). Toothed cetaceans have also shown significant avoidance behaviour at a range of distances (Madsen et al. 2002; Stone & Tasker 2006; Miller et al. 2009; Gray & Van Waerebeek 2011). Researchers are concerned that reducing an individual's ability to detect socially relevant signals could affect biologically important processes and they caution that short-term proxies, such as avoidance behaviour, are not sufficiently robust to assess the extent and biological significance of long-term individual and population-level impacts.

Sea turtles

Studies of the hearing capabilities of sea turtles show that they hear low-frequency sounds within the range of 100–1000 Hz with greatest sensitivity at 200–400 Hz for adult sea turtles, and 600 and 700 Hz for juveniles. Although sea turtles are poorly studied compared with cetacean and fish species, studies have demonstrated behavioural responses to received levels of seismic noise (O'Hara & Wilcox 1990; Moein Bartol & Musick 2003; Southwood et al. 2008).

The importance of considering stress

There is also need to consider the impact prolonged noise exposure may have on marine fauna beyond the direct physiological and behavioural impacts (Rolland et al. 2012). Chronic levels of stress can result in various pathological dysfunctions with possible damage to long-term health. This is especially relevant for resident species dependent on certain habitats, such as beluga, seals or sea lions.

Failures of current EIAs

The following sections build on the information we have provided about the complexities of sound propagation in the marine environment and overview of the range of species and types of impact that might occur. We comment about the depth of information provided in current EIAs and finally propose guidelines for EIAs.

Many jurisdictions have developed national and regional operational guidelines about mitigating anthropogenic noise on marine fauna and in particular noise produced by offshore petroleum exploration. These began with the United Kingdom's Joint Nature Conservation Committee guidelines with similar guidelines being iteratively developed in the United States of America, Brazil, Canada, Australia and New Zealand (Castellote 2007; Weir & Dolman 2007; Compton et al. 2008).

Several intergovernmental bodies have also elaborated principles of what EIAs should present. Collectively, these principles have been adopted by 196 governments who, through the process of their adoption, have individually committed to reflecting these decisions in their domestic law. The 'weight' of these decisions taken by governments at an international level is considerable.

The most notable of these is the 'Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area' (ACCOBAMS). ACCOBAMS 'Resolution 4.17: Guidelines to address the impact of anthropogenic noise on cetaceans in the ACCOBAMS area' articulate specifics for the Mediterranean region and

> [encourage] Parties: – to address fully the issue of anthropogenic noise in the marine environment, including cumulative effects, in the light of the best scientific information available and taking into consideration the applicable legislation of the Parties, particularly as regards the need for thorough environmental impact assessments being undertaken before granting approval to proposed noise-producing activities. (ACCOBAMS 2010)

The ACCOBAMS Noise Guidelines further prescribe specific considerations about seismic surveys, including the need for accurate modelling.

ACCOBAMS Resolution 5.15 calls on the Parties to:

- ensure that EIAs take full account of the effects of activities on cetaceans;
- implement the recommended use of Best Available Techniques and Best Environmental Practice in their efforts to reduce or mitigate marine noise pollution;
- integrate the issue of anthropogenic noise into the management plans of marine protected areas.

Resolution 5.15 also underlines that EIAs should include specific details that mirror those articulated in the ACCOBAMS Noise Guidelines (ACCOBAMS 2013).

The Convention on Migratory Species (CMS) 'Resolution 10.24: Further Steps to Abate Underwater Noise Pollution for the Protection of Cetaceans and Other Migratory Species' also strongly urges CMS Parties to prevent adverse effects on marine species by restricting the emission of underwater noise to the lowest necessary level and urges CMS Parties to ensure that EIAs take full account of the effects of activities on marine fauna (CMS 2011).

Most recently, the CBD 'Decision XII/23: Marine and coastal biodiversity: Impacts on marine and coastal biodiversity of anthropogenic underwater noise' has specifically encouraged CBD Parties to take suitable measures to avoid, lessen and mitigate adverse impacts of anthropogenic underwater noise on marine and coastal biodiversity, including:

> - combining acoustic mapping with habitat mapping of sound-sensitive species when developing spatial risk assessments to identify areas where those species may be exposed to noise impact;
> - using spatio-temporal management, including detailed knowledge of species or population distribution patterns, to mitigate and manage noise activities and avoiding producing noise in the area at critical times;
> - conducting EIAs for activities that may have significant adverse impacts on noise-sensitive species. (CBD 2014)

Assessment of likely impacts is also an emerging legal requirement in the European Union. The European Parliament and Council 'Environmental Impact Assessment Directive 2014/52/EU' requires that EIAs are carried out before development consent is given to activities (2014/52/EU Art 2.1) to identify impacts to biodiversity with particular attention to species and habitat protected under Directive 92/43/EEC and Directive 2009/147/EC (2014/52/EU Art 3.1). The Directive introduction states that:

> [w]ith a view to ensuring a high level of protection of the marine environment, especially species and habitats, environmental impact assessment and screening procedures for projects in the marine environment should take into account the characteristics of those projects with particular regard to the technologies used (for example seismic surveys using active sonars). (2014/52/EU)

Conducting EIAs is now a well-established governance and environmental management principle, institutionalised in over 100 countries (Court et al. 1996; Glasson et al. 2013). These four intergovernmental bodies provide significant clarity about the expectations to conduct EIAs and effectively manage impacts associated with offshore petroleum exploration activities, among other underwater noise-producing activities.

It is broadly accepted the basic intent of EIAs is to anticipate the significant environmental impacts of development proposals before any commitment to a particular course of action. However, often, the detail required within EIAs is poorly defined. Many legislative provisions for EIAs have been introduced without consideration of the institutional requirements: organisational structure, staffing and capacity development (Cashmore et al. 2004; Jay et al. 2007; Devlin & Yap 2008). Often the scientific basis and methods need sophisticated understanding.

Given this, it is not surprising the efficacy of many EIAs is being criticised (Slootweg & Kolhoff 2003; Cashmore et al. 2004, 2010; Devlin & Yap 2008). Indeed, the criticism of the 'low bar' requirements for EIAs in many jurisdictions might be, in part, a result of decision-makers themselves having limited understanding of the EIA purposes and potential (Cashmore et al. 2004; Jay et al. 2007) as well as the general poor quality of EIA information (Morgan 2012; Morrison-Saunders & Retief 2012).

This was revealed to be the case for offshore petroleum exploration EIAs by Wright et al. (2013). They found that many assessments were insufficiently researched, drawing heavily from previous EIAs. In a significant number of cases, approvals were given without careful consideration of the detail presented in the EIAs. Instances of duplicated information or missing species were not uncommon. Topics were dealt with by dismissal, often ignoring recent scientific literature, perpetuating misconceptions and containing analytical flaws. Discussions about wildlife often focused on lethal impact, with little or no consideration of sublethal impacts.

Our documentary examination of five EIAs, that spanned less than one year and took place within one regulatory jurisdiction, revealed similar trends to those highlighted by Wright et al. (2013). All were proposals for petroleum exploration in Australia's Exclusive Economic Zone under the same regulatory process and all were given approval by the National Offshore Petroleum Safety and Environmental Management Authority's (NOPSEMA) (Prideaux & Prideaux 2013b, 2013c, 2013d, 2013e, 2013f).

These five are by no means isolated cases. Since inception, 291 EIAs (so-called Environmental Plans) have been received by NOPSEMA. Most of these have been accepted by the authority. The authors have engaged in a correspondence trail with the authority to highlight significant errors, inaccuracies, misconceptions and analytical flaws in a number of the 291 submissions. Written responses from the authority confirm that their focus is on ensuring the industry commits to self-identified benchmarks. They assert the authority does not assess the efficacy of claims or assurances contained in the EIAs (correspondence on file with the authors).

An example of assessment relating to Australian sea lions

An example of assessments relating to Australian sea lions provides a useful illustration. The Australian sea lion (*Neophoca cinerea*) is Australia's only endemic and least numerous seal species. The species is listed as Vulnerable under the national environment legislation and has an IUCN Red List Criteria of Endangered (A2bd + 3d). The Australian Government's own 'South-west Marine Bioregional Plan and Species Group Report Card – Pinnipeds' identifies noise as a threat of concern (Department of Sustainability Environment, Water, Population & Communities 2012a, 2012b).

Under the 'South-west Marine Bioregional Plan' any individual Australian sea lion breeding colony is regarded as an important population. The government's Plan directs that all attempts should be made to avoid biologically important areas for the Australian sea lion, particularly water surrounding breeding colonies and foraging areas used by female sea lions, for any applications for offshore development. The Plan specifically states that 'actions with a real chance or possibility of increasing the ambient noise levels within female Neophoca cinerea foraging areas to a level that might result in site avoidance or other physiological or behavioural responses' have a high risk of a significant impact on this species (Department of Sustainability Environment, Water, Population & Communities 2012a, 2012b)

Clearly, the Australian Government has decided the status the sea lion demands a precautionary approach to ensure that human activities, including anthropogenic noise do not further jeopardise the species. Despite this, in a two-year period, NOPSEMA has accepted four EIAs, in the form of Environmental Plans. Each has failed to consider the impact of noise generated by offshore petroleum exploration on Australian sea lion populations and each has been given the proponent approval to proceed. These will or have already produced sound intensity levels around 230 dB (re water) that will transmit many hundreds of kilometres, including into and through areas of sea lion foraging habitat.

Given that offshore petroleum exploration activities typically span six to eight weeks, it is likely that sea lion foraging behaviour will be or has been significantly impacted or abandoned altogether. There could be reduced food availability, animals might show signs of reduced condition and may have difficulty feeding their pups. Colonies may or have been abandoned temporarily or permanently, which could have serious implications for this already endangered species. Review of the published EIAs (available on www.nopsema.gov.au) reveals that no modelling of noise propagation has been considered and no assessment of impact has been carried out. There is no description of the well-known

Australian sea lion colonies. There is no discussion of the foraging habitats of the species, nor is their recognition of the precaution flagged in the 'South-west Marine Bioregional Plan' and 'Species Group Report Card – Pinnipeds'. NOPSEMA has accepted and approved the EIAs. Even though the information was inconclusive or incomplete, NOPSEMA has not required any monitoring be established.

Anecdotal evidence for other regions shows similar trends in other jurisdictions including Europe, West Africa and East Africa (on file with the authors). There is a failure of current EIAs for offshore petroleum exploration.

It is important that government decision-makers can rely on sufficient technical, detailed and impartial information being presented to them to ensure credible and defensible decisions are made about offshore petroleum exploration. The following section proposes template guidelines on the detail of information that should be sought to support robust and defensible decisions.

Environmental impact assessment for offshore petroleum exploration seismic surveys

This section is built on the foundations of three important previous works. These are an important study on impact mitigation of offshore petroleum exploration in the Sakhalin region of the North Pacific Ocean (Nowacek et al. 2013); a framework for assessment of noise impact in the Arctic (Moore et al.2012); and a workshop on the requirements for marine noise EIAs during the 2014 European Cetacean Society meeting (Evans 2015). This collective work has elaborated that assessments should:

- collect baseline biological and environmental information to describe the area being impacted;
- fully characterise operations, including describing the sound source in some detail, the local sound propagation features and potential cumulative effects from other sound sources as well as other human activities that may not generate noise but can add to the pressures on the local animal populations; and
- describe how impacts will be monitored before, during and after the operation.

To provide regulators with greater technical detail about how to seek this level information, we have developed the proposed template through two important cross-disciplinary peer discussion forums:

(1) The Joint CMS/ASCOBANS/ACCOBAMS Noise Working Group where the template was formally developed as a contribution to the 'CBD Expert Workshop on Underwater Noise and its Impacts on Marine and Coastal Biodiversity'.

(2) The 18th CMS Scientific Council Meeting, where the template was presented and comments and input sought.

The template has also sought the input more broadly from regulators and industry. The proposal that follows is a reflection of this iterative discussion with experts through these processes (Prideaux & Prideaux 2013a).

Environmental impact assessment guidelines for offshore petroleum exploration proposals

In addition to jurisdictional specific requirements for impact mitigation during operations, such as observers or passive acoustic monitoring, EIAs for offshore petroleum exploration should be developed early in the proposal's development process and should transparently include:

(1) Description of area
  (a) Detailed description of the spatial extent and nature of the survey – including seabed bathymetry and composition, description of known stratification characteristics and broad ecosystem descriptions – as well as the spatial area that will experience anthropogenic noise, generated by the proposed survey, above natural ambient sound levels
  (b) Details of baseline data that have been gathered before developing the EIA, including consultation with regulating bodies and stakeholders
  (c) Identification of previous surveys, their seasons and duration in the same or adjoining areas, and a review of survey finding and implications
  (d) Identification of previous test wells in the same or adjoining areas including comment about any wells that may breach

(2) Description of the equipment to be used
  (a) Explanation of all survey technologies available and why the proposed technology is chosen
  (b) Detailed description of the survey technology to be used
  (c) Name and description of the survey vessel to be used
  (d) If an air gun array is proposed:
    (i) Number of arrays
    (ii) Number of air guns within each array
    (iii) Air gun charge pressure to be used (PSI)
    (iv) Volume of each air gun in cubic inches
    (v) Official calibration figures supplied by the survey vessel to be charted
    (vi) Modelled sound intensity level one metre from source derived from the official calibration figures

(vii) Depth the air guns to be set
(viii) Number of streamers
(ix) Length of streamers
(x) Distant set apart
(xi) Depth the hydrophones are set

(3) Details of consultation and independent review
(a) Identification of stakeholders who have been consulted
(b) Identification of independent experts – especially species experts – that have been consulted including their affiliation and their qualifications
(c) Explanation of information provided to stakeholders and experts, any opportunities given for appropriate engagement and the timeframe given for them to provide feedback
(d) Description of the comments, queries, requests and concerns received from each of the stakeholders and experts
(e) Explanation of what amendments and changes have been made to the proposed survey to the comments, queries, requests and concerns
(f) Explanation of which comments, queries, requests and concerns have not been accommodated and why

(4) Comprehensive description of activity
(a) Comprehensive description of the total area to be explored and the entire exploration plan (2D, 3D and test wells) and for each activity:
(i) Specifics of the activity including anticipated nautical miles to be covered, track-lines, speed of vessels, duration of track-lines, start up and shutdown procedures, distance and procedures for vessel turns including any planned air gun power setting changes
(ii) Computer modelling of sound dispersal in the same season/weather conditions as the proposed survey, local propagation features (spherical and cylindrical spreading, depth and type of sea bottom, local propagation paths related to thermal stratification) and out to a radius where the generated noise levels are close to natural ambient sound levels
(iii) Identification of any SOFAR or natural channels characteristics
(iv) Sound intensity level and frequencies (Hz) from a point source, as well as the duration of each pulse (milliseconds), interval between pulses (seconds) and expected duration of pulses (12/24 h days) for the survey
(a) Identification and mapping of proposed species exclusion zones and description of how noise propagation into these zones will be minimised, taking into consideration the local propagation features (spherical and cylindrical spreading, depth and type of sea bottom, local propagation paths related to thermal stratification)
(b) Identification of other impacting activities in the region during the planned survey, accompanied by the analysis and review of potential cumulative impacts

(5) Species likely to be encountered or impacted
(a) Description of all listed/protected species likely to be present and that will experience sound transmission generated by the proposed survey above natural ambient sound levels, the total time they will experience these sound levels and proposed measures being taken for each to minimise impact
(b) Description of all fisheries likely to be present or to rely on prey that might be present and that will experience sound transmission generated by the proposed survey above natural ambient sound levels and proposed measures being taken for each to minimise impact

(6) Details of likely impact for each listed/protected species, including:
(a) Identification of safe/harmful exposure levels for various species that is precautionary enough to handle large levels of uncertainty and avoids erroneous conclusions
(b) Type of impact predicted (direct, behavioural and the duration) as well as direct and indirect impacts to prey species
(c) Soft start and shutdown protocols
(d) Plans for 24 h visual detection, especially under conditions of poor visibility (including high winds, night conditions, sea spray or fog)
(e) Plans for establishing exclusion zones to protect specific species. These should be established on a scientific and precautionary basis rather than as arbitrary and/or static designations

(7) Details of independent and transparent monitoring of all at-sea activities and observer coverage
(a) Details of transparent processes for regular real-time public reporting of activity progress and all impacts encountered
(b) Details of scientific monitoring programmes, conducted during and after the seismic survey, to assess impact

(8) Reporting plans
  (a) Details of plans for post operation reporting including verification of the effectiveness of mitigation

The information requested in this template is well within the current technical competencies of the petroleum and scientific community. The detail within the EIA should be robust enough for independent review and not placed under a seal of commercial in-confidence. This process should prove sufficiently robust to ensure that regulators and decision-makers have access to an appropriate level of information before making approval decisions. It will allow them to seek expert technical critiques of the information if they do not have sufficient expertise within their department.

Conclusion

The ocean environment is filled with natural sound produced by animals and physical processes but modern anthropogenic activities have increased the levels of noise. Offshore petroleum exploration is a significant contributor to this noise. Sound propagation in the marine environment is complex and it is especially important that government decision-makers can rely on sufficient technical, detailed and impartial information being presented to them to ensure credible and defensible decisions are made about the impact of this industry and individual proposals.

While noise modelling is common for land-based anthropogenic noise-producing activities, we have shown that modelling and indeed robust EIAs for offshore petroleum exploration are failing this base need. EIAs should provide a clear indication of the sound propagation features across the full area the noise will impact. Proponents should be required to model the noise propagation of the proposed activity in the region and under the conditions they plan to operate. The documentation should demonstrate a clear understanding of the species present, necessary exclusion zones and descriptions of how noise propagation into these zones will be minimised.

This paper has proposed 'Environmental Impact Assessment Guidelines for Offshore Petroleum Exploration Proposals'. These template guidelines have been developed with the benefit of peer input and review through two official processes; to provide guidance about the specifics that should form the basis of appropriate assessments. In time, global noise standards may supersede such a need, but that time is still in the distant future and will need complex and controversial international oversight to be in place. For now, given the strong commitment of governments around the world to reducing anthropogenic marine noise, this information, if transparently supplied, would provide regulators and decision-makers with robust, defensible and impartial information on which to base their decisions.

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Chapter 17

Marine Mammals and Multiple Stressors: Implications for Conservation and Policy

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INTRODUCTION

For many centuries, in many maritime countries, human interest in marine mammals was limited to consideration of them as a resource to be exploited for human consumption and then for profit. For example, whales were regarded as having such value that King Edward II of England made a formal claim to their ownership, followed by several other heads of state (Brakes and Simmonds, 2011). Widespread commercial whaling in the 19th and 20th centuries, eventually involving diesel-driven fleets including factory vessels, led to decimation of populations. Attitudes changed in the 1960s and 1970s when the animals started to be valued and appreciated in other ways, including aesthetically and for their entertainment value in captivity.

Considerable knowledge has been gained in recent decades about both the biology of the animals and the fast-evolving threats that they face, but increasing knowledge does not automatically lead to improved protection, and some species and populations are still heading toward extinction (Campagna, 2015). At the root of this is a complex and evolving array of factors that can impact on these animals. For example, the endangered North Atlantic right whale, *Eubalaena glacialis*, population was initially devastated by whaling. Now, as this much diminished population struggles to recover, ship strikes and entanglement in fishing gear are regarded as the primary threats (Reilly et al., 2012). Looking to the future, it seems likely that climate change will cause the species yet more problems (Greene and Pershing, 2004).

Another example of populations being affected by multiple threats might be found in the case of delphinids in the Northeast Atlantic where pollution, in the form of PCBs, has recently been recognized again as a major threat

Marine Mammal Ecotoxicology. **https://doi.org/10.1016/B978-0-12-812144-3.00017-6**

(see, for example, Jepson et al., 2016). These are the same populations that, in many cases, are also being affected by deaths in fishing nets and other factors.

To conserve wildlife populations, we need to address not one but the multiple factors that are affecting them simultaneously, and this is not a new realization. Nor is the notion that some factors act synergistically, creating greater harm together than when acting on their own. For example, enhanced exposure to pathogens from discharges into cetacean habitat combined with enhanced exposure to immunosuppressive contaminants might be expected to create more disease and even, potentially, drive mass mortalities (Simmonds and Mayer, 1997).

However, marine mammal science tends to focus on particular classes of threat, rather than trying to address their multiplicity and the consequences of the interactions between them for the species and populations being affected. There have been good reasons for this. Typically, scientists have had to specialize to be effective (and successful in their careers), and natural sciences and veterinary sciences (including animal welfare science) have tended to follow separate paths. Perhaps, as argued subsequently, the time may have come for a reunification of these specializations, as we struggle to address the realities of multiple stressors in wildlife conservation. Indeed, how to sensibly address this complexity is arguably now one of the "holy grails" of modern conservation. Inherent in this is understanding how the factors interact to cause outcomes for the animals concerned and also how multiple exposures to stressors over a lifetime might best be considered. None of this is easy. Indeed it has recently been suggested that assessing "cumulative effects" is "a problem that has proven nearly impossible to solve" (Tyack, 2016). Nonetheless, it is also argued that to discern the factors contributing to population trends, scientists must consider the full complement of threats faced by marine mammals (NAS, 2016). Only with such knowledge can effective decisions be made about which stressors to reduce, to bring the population back to a more favorable state, and this kind of assessment can also provide the environmental context for evaluating whether an additional activity could threaten it. However, this view of science driving policy, while eminently logical, may not be fully realistic.

AN INVENTORY OF THREATS

There is a wide and growing range of potential stressors that affect marine mammals, and Table 17.1 provides a list. These stressors are not static over time, as new ones continue to be created by human activities (take, for example, the evolution of marine noise pollution as a threat, as described in Simmonds et al., 2014) and populations may be exposed to new stressors as conditions change. In fact, novel technologies (combined with retreating ice at the poles) now allow us to access even the deepest and previously most inaccessible regions. In the Arctic, in particular, we are witnessing an influx of activities new to the region, including large-scale fishing, fossil fuel exploration, and shipping, all presenting new threats to wildlife (Simmonds, 2016).

TABLE 17.1 Factors That May Adversely Affect Cetacean and Other Marine Mammal Populations and Their Habitats

Climate change	Storm intensity changes
	Sea ice changes
	Changes in runoff water circulations
	Ozone depletion
	Climate change–driven *changes in human activities, e.g.,* • *increased shipping and fishing in Arctic waters* • *increased directed take of marine mammals*
Pollution	Nutrient pollution/eutrophication
	Harmful algal blooms
	Oil spills
Persistent organic pollutants, especially PCBs (but also potentially including brominated flame retardants and perfluorinated compounds)	
Heavy metals	
Nonfishery-derived marine debris, including microdebris	
Fisheries/related activities	Overfishing and prey-culling *and depletion*
	Mariculture
	Marine debris, including ghost nets
	Bycatch
Noise pollution	Seismic surveys
	Boat traffic (*also causing ship strikes*)
	Military sonar
	Construction
Pathogen emergent disease	
Physical habitat degradation	Bottom trawling
	Dredging
	Other destructive fishing techniques
	Reclamation
	Coastal construction
	Wind farms
	Dams and barrages
	Marine fossil fuel exploration/extraction

Continued

TABLE 17.1 Factors That May Adversely Affect Cetacean and Other Marine Mammal Populations and Their Habitats–cont'd

Tourism	Whale watching
	"Swim with" programs
War-related activities	Mines
	Munitions dumps
Introduced species	
Intentional takes	*Commercial whaling*
	Other marine mammal takes for profit or food.

After International Whaling Commission (2006), with additional factors from Brakes and Simmonds (2011).

Simmonds and Brakes (2011) compared a review of threats to cetaceans made in 1996, with their understanding in 2011, and suggested the following key developments:

- There had been a general acceptance of noise pollution as a substantive threat and some movement to address this.
- Climate change had also become an accepted phenomenon, with implications for cetaceans.
- Levels of some of the more infamous pollutants had fallen.
- There was much recent new research into marine mammal diseases and a growing awareness of the vulnerability of marine mammal populations to disease events and the potential of human activities to contribute to them.

A few years further on (I am now writing in mid-2017), it is now possible to recognize the reemergence of the threat posed by PCBs as a significant issue for the survival of some populations. Likewise, the growing number of harmful algal blooms (e.g., Anderson, 2009), possibly boosted by nutrient discharges, combined with changing climate, seems to be coming more clearly to the fore as a pressing issue (IWC, 2017). It is also now much more clearly recognized that intense sounds from human activities—such as seismic air guns—can have direct physiologic effects on marine mammals and that naval sonar triggers behavioral reactions that can lead to death by stranding (NAS, 2016).

Emerging threats at this time include the growing amounts of macro- and microdebris in the seas and oceans and, as noted before, rapidly changing human activities in the Arctic. Factors impacting marine mammals populations can be lethal (e.g., a ship strike or a launched harpoon) or sublethal, and when describing "stressors" here, it is a sublethal impact that is being primarily considered. For example, while loud noise can be lethal, the most common effect of noise on marine

mammals is behavioral disturbance. From a population perspective, rather subtle behavioral changes affecting very large numbers of marine mammals may have greater consequences than occasional lethal events affecting a few (NAS, 2016).

AN EXAMPLE OF A COMPLEXITY: CLIMATE CHANGE

To help more fully comprehend the complex natures of the situations that marine mammal populations are facing, it may be worth considering further the various mechanisms through which climate change may come to impact them. Simmonds (2016) reviewed this, and it is apparent from the scientific literature that the primary concerns are not so much about a direct effect upon the individual marine mammals themselves (e.g., thermal stress) but more focused upon changes in prey and, to some extent, on changes in human activities (including their changing locations as highlighted for the Arctic earlier and discussed more broadly in Alter et al., 2010). This is not to say that there might not be direct responses from marine mammal populations to changing physical conditions in the sea. For example, cetacean population distribution is closely related to temperature, and it has long been theorized that there will be a general movement toward the poles as waters warm. There is already evidence that this is starting to happen. Prey may also change and shift distribution, so trying to separate out one effect from another in the future may be difficult.

Fig. 17.1 illustrates the various ways in which climate change–driven factors may come to affect marine mammals. It also highlights potential interactions with other factors. For example, access to prey might also be affected by competition with species that have changed distribution. And the fitness of the marine mammals (both as individuals and populations) might also be undermined by exposure to new pathogens, chemical and noise pollution, and so forth.

ENGAGING WITH MULTIPLE STRESSORS

The first serious attempt to try to address the issue of the multiple factors affecting marine mammals may have come from the International Whaling Commission (IWC). By the early 2000s, the member nations of the IWC had become concerned about the broad range of factors then known to be affecting cetaceans. It initiated an ambitious piece of work to look at this via a “Workshop on Habitat Degradation.” While the workshop title indicates a focus on habitat, it was ultimately concerned with how to take an integrated approach to stressors/threats. The workshop was informed by an earlier smaller “scoping group” meeting of experts, and it is worth noting that this identified several potential ways forward, including consideration of individual health and body condition, “vital rates” (i.e., survival and fecundity and other life history parameters), population changes, and community-level changes (IWC, 2006). The scoping group suggested that the principal tools for linking habitat changes to these response variables were (1) correlative analyses comparing response variables across habitats with very different levels and patterns of impact; (2) “analogy

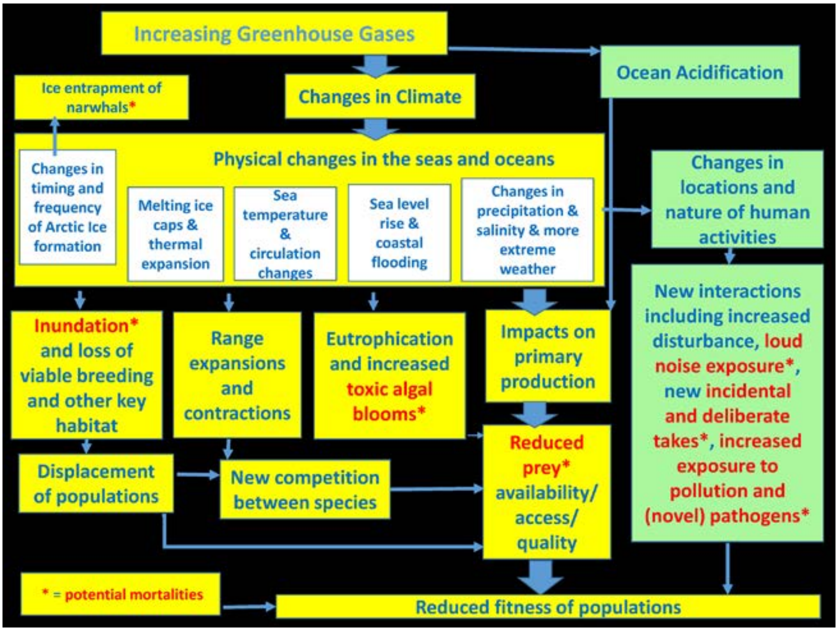

FIGURE 17.1 Climate change–driven factors and associated stressors and linkages. *(Modified from Simmonds, M.P., 2016. Impacts and effects of ocean warming on marine mammals. In: Laffoley, D., Baxter, J.M. (Eds.), Explaining Ocean Warming: Causes, Scale, Effects and Consequences. IUCN, pp. 305–322.)*

from more detailed mechanistic studies on model species"; and (3) modeling of population responses to changes in vital rates as a result of habitat degradation.

The IWC Workshop on Habitat Degradation met in 2004 and noted in its report that the IWC has been concerned about the influence of environmental changes on cetacean populations for many years, signified by various resolutions requesting that its Scientific Committee progress understanding of this issue (IWC, 2006). In response, the Scientific Committee had identified eight environmental priority topics:

- climate/environment change;
- physical and biologic habitat degradation;
- chemical pollution;
- direct and indirect effects of fisheries;
- impact of noise;
- disease and mortality events;
- ozone and UV-B radiation;
- Arctic issues.

The workshop's general conclusions stressed the importance of undertaking research relating habitat condition to cetacean status in the context of

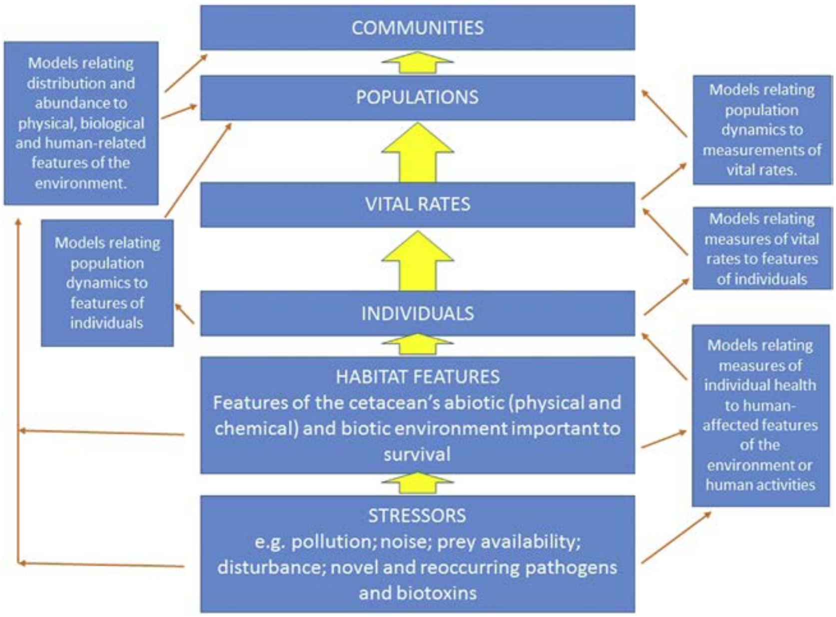

FIGURE 17.2 Framework for modeling the links between environmental stressors that degrade habitat and population effects. *(After IWC, 2006. Report of the IWC scientific committee workshop on habitat degradation. Journal of Cetacean Research and Management 8 (Suppl.), 313–335.)*

conservation and management. However, it also commented that "this is a particularly complex area of study, requiring both theoretical developments in modelling approaches and a commitment to long-term interdisciplinary data collection programmes." To help make progress, the workshop produced and strongly recommended a new framework for further investigation, which is shown in Fig. 17.2.

The workshop also commented that any general application of the framework would require that management and research bodies take a longer-term view and described the present ad hoc processes (giving "Environmental Impact Assessments," based on short-term limited datasets as an example) as unsatisfactory. In terms of further research, the workshop identified several cetacean populations with sufficiently broad sampling programs, covering sufficiently long time frames, which could be the focus of studies: Florida bottlenose dolphins; European harbor porpoises; and resident killer whales from the northwest coast of North America.

The workshop also proposed a workplan to develop the framework (as shown in Fig. 17.2) and that this should include:

1. application to specific case studies;
2. further development of approaches to distinguish the relative effects of different stressors via population and spatial modeling approaches;

3. application of the framework to one area and then using the results to make predictions for the same species in a different area and comparing this with the actual situation as a type of "validation";
4. a follow-up workshop to review the progress of this workplan.

Sadly, this comprehensive start to unraveling such a complex issue has not obviously positively resonated down the intervening years in terms of research either under the jurisdiction of the IWC or, as far as can be judged from the scientific literature, anywhere else! Perhaps the inherent problems were just too complicated, or perhaps, there was still too much to be done in terms of understanding the various stressors or developing the necessary models. However, most recently, at its 2017 meeting, the Scientific Committee of the IWC agreed to prepare for a workshop on cumulative threats, and it took note of the relevance of the outputs of the 2004 Habitat Degradation workshop to this (IWC, 2017). So, it may be hoped that there may yet be some further development and elaboration of the approaches and recommendations made by the 2004 workshop.

Certainly, there has been a lot of work on the factors affecting marine mammals and their habitats in the intervening years, and increasingly, this considers interactions with more than one stressor. The relevant scientific literature is too voluminous to review here, but examples include the copious amount of recent research on marine noise (Simmonds et al., 2014) and also on the effects of whale watching on cetacean populations (see, for example, New et al., 2015; Higham et al., 2014). Effort has also gone into modeling approaches, leading, for example, to the Population Consequences of Disturbance model (New et al., 2014).

THE LATEST WORK ON CUMULATIVE EFFECTS

Animals and populations of animals may be exposed to particular stressors once or many times. A good example is exposure to a loud noise, and multiple, frequent exposures might be more significant than rare exposures over a longer time. "Cumulative effect" has been defined as the combined effect of exposures to multiple stressors integrated over a defined relevant period: a day, a season, year, or lifetime (NAS, 2016).

In the United States, the National Academies of Sciences, Engineering, and Medicine has been looking at cumulative effects on marine mammals. The results of its deliberations were delivered in a substantive and substantial (250-page) report published in 2016 (NAS, 2016). The topic of cumulative effects was chosen by the federal agency sponsors because assessing cumulative effects has been an important part of US regulations protecting marine mammals since the 1970s, but "the approaches used have little predictive value." If cumulative effects cannot be accounted for, "then unexpected adverse impacts from interactions between stressors pose a risk to marine mammal populations and the marine ecosystems on which people and marine mammals depend" (Tyack, 2016).

Because quantitative prediction of cumulative effects of stressors on marine mammals is not currently possible, the authors of the NAS report have developed

a conceptual framework for assessing the population consequences of multiple stressors (NAS, 2016). They call this the "Population Consequences of Multiple Stressors" model, and it uses indicators of health that integrate the short-term effects of different stressors that affect survival and reproduction, and the report explores a variety of methods to estimate health, stressor exposure, and responses to stressors. (For a full explanation of this approach and the study's full and detailed recommendations, readers are directed to the full report.)

Importantly, the authors concluded that scientific knowledge is not up to the task of predicting the cumulative effects of different combinations of stressors on marine mammal populations (NAS, 2016) and comment that "even though exposure to multiple stressors is an unquestioned reality for marine mammals, the best current approach for management and conservation is to identify which stressor combinations cause the greatest risk."

CONCLUSIONS AND RECOMMENDATIONS

This short review cannot do justice to the investigations that have been made into the effects of stressors on marine mammals and their habitats, alone, in combination, or cumulatively. However, what is emerging from these studies is that this is a very complex sphere of endeavor. Clearly, much research is ongoing, and inherent in this is information that will help to inform those seeking to conserve marine mammal populations. However, the integration of research into effective conservation policy is itself far from being straightforward.

Claudio Campagna, in an inspiring keynote address at the 2015 Conference of the Society for Marine Mammalogy, challenged his audience with a bleak but well-informed view of modern conservation (Campagna, 2015). He opined that the continuing crisis of imminent extinctions is being driven by a paradigm that he summarized as

> *",,,provide me with a good economic reason or I do nothing… or I will make small adjustments of no consequence".*

He argued that the current approach to species conservation is flawed as it is based on the notion that science informs policy and policy informs conservation and sustainable economic growth. However, in practice, he argued new information is used to intervene only when it is no more costly than doing nothing! Valuing nature only in economic terms avoids recognizing the disastrous consequences of what Campagna called "the species crisis."

Sadly, my own experience of conservation work aligns closely with this, and while scientists may work hard to understand matters and give advice, including in the complex context of the multiple stressors now affecting marine mammals, this does not necessarily mean that any effective action will follow.

Related to this is that many conservation approaches require a good understanding and ongoing monitoring of the populations concerned. This is rare for many marine mammal populations (which is why many remain "data deficient" on the International Union for Conservation of Nature Red List). What is clear,

however, is that chemical pollution, noise pollution, disturbance (leading, for example, to displacement from important habitats), and other factors can substantially impact populations, and there are some instances where we know or can reasonably deduce which populations are being impacted to such an extent that their future is imperiled (for example, in the case of PCBs, certain populations in the Northeast Atlantic, including the Mediterranean and Black Sea areas). This then provides a case for action.

Pollution by PCBs and climate change are clearly difficult issues to address. There is no simple "off-tap" for either. However, it should be noted that various actions are being promoted, especially in a European context, to address PCBs (see Law and Jepson, 2017; Stuart-Smith and Jepson, 2017). However, in situations where we believe such intransigent stressors as these may be the primary cause of problems, addressing other more easily resolvable factors likely to be adversely affecting the population would seem at least precautionary and, indeed, sensible (e.g., taking action to stop or lessen incidental removals in fishing nets or death by ship strikes).

Such precautionary action—reducing stressors where this is possible—should not wait on perfect proof of impact or be inhibited by the knowledge that these stressors are not the primary causal factors in declines, but it should proceed to make populations as robust as possible to the multiple stressors they are facing. Sanctuaries or marine protected areas, wherein stressors are reduced or removed, will play an important role in this, and there is an ambitious program of work on this going forward at this time led by the Marine Mammal Protected Areas Task Force. The Task Force was created in 2013 and has been setting up regional workshops to identify Important Marine Mammal Areas, beginning with the Mediterranean in 2016, followed by the South Pacific, the Northeast Indian, the Northwest Indian and the Southeast Pacific oceans, and the waters of Oceania surrounding Australia and New Zealand (ICMMPA, 2017).

Another innovation (as hinted at in the introduction) is the use of animal health considerations to help pinpoint and better understand problems. Monitoring marine mammal population trends may not always be practical, and a measurable decline in a population should not necessarily be taken as the only possible cue for action. Welfare science and health assessments offer another set of tools. This idea is not entirely novel. While the 2004 IWC workshop did not formally include health assessments in its guiding framework (Fig. 17.2), the possible development and use of health parameters was certainly discussed there (IWC, 2006). Thirteen years later, the National Academies of Sciences, Engineering, and Medicine puts monitoring health at the center of its approach and recommendations.

More generally, monitoring the health of wild populations offers a new way to identify when significant problems are developing; perhaps providing a kind of early warning system. This relationship between welfare science and conservation now deserves to be further developed from the perspective

of improving both conservation and welfare responses, and interestingly, the IWC, with its growing interest in whale welfare outside of the hunting context (IWC, 2016), may prove to be the crucible in which such things productively come to mix.

Finally, one of the biggest problems faced by those who want to conserve and protect marine mammals (or for that matter address pressing threats, including climate change) is convincing those in power and the public more generally that this actually matters: specifically that the survival of marine mammals has relevance to our own species.

Somehow, it appears that the human race has become detached from the natural environment that supports it by maintaining functioning ecosystems of which wild animals (including marine mammals) are components. This detachment is so profound that we do not recognize the threat to ourselves as our activities disrupt and damage ecosystems. Part of the response to this has to be in education (in the broadest sense) and explaining how we inherently fit into—and are supported by—something much bigger than ourselves. Without a better informed and sympathetic public, and policy makers, we have little hope of effectively addressing the complex issues besetting marine and other ecosystems.

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From:	Lesley Gray
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Friday, 20 December 2019 7:22:25 AM

Smith Bay must be saved from this development. KIPT must acknowledge they have chosen the wrong location. Too bad that further west will cost more money. Bad luck KIPT just make less profit for a couple of years

From:	Liana Cockshell
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Thursday, 19 December 2019 4:57:40 PM

This going forward will have a hugely negative impact on the natural ecosystem of the area. It is destroying habitat and natural environments that are found no where else in the world. Preserving KIs natural environment is more important and will help various aspects such as tourism, species survival and lack of pollution.

From: Linda Briere
To: DPTI:State Commission Assessment Panel
Subject: Concerns about KPT"s Seaport development at Smith Bay
Date: Monday, 25 November 2019 11:17:39 AM

Given that Koalas on the Australian continent are facing extinction due to the recent brush fires and habitat loss, all of the eucalyptus trees on Kangaroo Island should be preserved so that the Kangaroo Island population can thrive and expand and be used to repopulate the Australian continent once their habitat has been restored.

From:	Louise Doyle
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Thursday, 19 December 2019 1:16:32 PM

Such a proposal is barbaric and the risk of endangering such a rare, magnificent area, definitely not worth it . We MUST preserve such amazing areas- not exploit them

Attention Mr. Robert Kleeman

Re: Smith's Bay Multi-purpose Harbour.

We are writing to ask that you consider giving the green light for the construction of Smith's Bay Harbour development and allowing KIPT (Kangaroo Island Plantation Timbers) to build their proposed multi-purpose jetty to enable well established timbers to be shipped off-Island. This timber was planted some 20-30 years ago and the companies involved in this venture went bankrupt before harvest and this very valuable commodity is now on hold, with no means to transport, 20 years later, the benefits to the people of Kangaroo Island will be many, which could include the shipping of other farm produce to and from the mainland. Currently we share the ferry with large transport trucks, loaded with sheep and as well as taking up valuable ferry space, crossing to the mainland with sheep is not always pleasant. Cruise ships could also have a safer disembarkation point for tourists. At present, these ships anchor offshore from Penneshaw and transfer passengers to land via tenders, a somewhat risky venture for some. Far too many tours have to cancel shore excursions due to poor weather resulting in losses to those people in the tourist industry, lost wages and food spoilage. Smith's Bay is situated on the northern side of the Island and is sheltered. After jetty completion, it is estimated that some 140 full time jobs will be created in the forestry industry and the knock on effect for housing, schools and local businesses will benefit all of KI.

In the last few years, proposals for forestry harvest have been planned and put forward by KIPT, who have invested a lot of time and money into promoting the rewards of those trees planted all those years ago. Kangaroo Island Plantation Timbers owns 86 per cent of the plantation forestry on Kangaroo Island. Its portfolio is about 80 per cent hardwood (bluegum) and 20 per cent softwood (pine). The remaining plantations are owned by 12 private growers, with whom KIPT is consulting regarding harvesting and use of wharf facilities. Replanted trees can be harvested every 13 years and coppice re-growth approximately every 5 years.

We attended a Forestry Field Day on November 17th and we were impressed with how KIPT have solved the many problems that arise from such a venture, and our questions were answered openly and honestly. Questions about koala disturbance, whale/dolphin disturbance and road hazards were all addressed with solutions on how to solve any problems that may arise.

It was disappointing to also learn that a local company Yumbah Aquaculture is actively opposing this venture and have reported in The Islander, (14th November) that "It's them or us" and only one company can operate in Smith's Bay. Their reasons are that a harbour will disturb their own abalone industry and will suffer to the point of not being able to continue as a result of KIPT's venture, citing pollution as the main cause. KIPT have assured us that woodchip transport to the jetty will be covered so that there will be no dust.

As a point of interest, this same company, (Yumbah), is proposing a huge abalone expansion in Bolwarra, near Portland (Vic) to establish a 45 hectare abalone farm. Portland is situated only 4 kilometers from Bolwarra and is the "biggest exporter of hardwood chips in the world" according to Portland's Port chief executive Jim Cooper. It would seem that Yumbah is hell bent on causing mischief and it will be the residents of Kangaroo Island that will suffer.

Please give consideration to this unique project and we can add 'Forestry' as a renewable industry to our Island; Kangaroo Island is in much need of a multi-use, deep harbour facility.

Yours faithfully,

Marcia and Chris van der Merwe
[redacted]
Brownlow, Kangaroo Island SA 5223.
2nd December, 2019.

From:	Maxine Freitag
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Wednesday, 18 December 2019 9:43:44 PM

I do not want to see the pristine waters of Smith Bay damaged by the activity this proposed development would cause. It is far more important to maintain the existing Abalone farm and dolphin tours that are already established and are proven to be environmentally friendly to the area.
Also, the damage that would be done to our existing and inadequate roads will only add huge costs to the island community.

From:	Michael Jones
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Friday, 20 December 2019 9:55:47 AM

Smith Bay is not a suitable or viable location for KPT'S proposed project as it will cause a detrimental impact to the ocean waters as well as the marine life including whales and dolphins that visit the same waters at this location. It will also have a detrimental impact on the road to and from the proposed site as the existing road was never designed to carry high volumes of large heavy trucks which will undermine the existing road and it will create dust and noise problems which will have an impact to the health and wellbeing of the people who live along that road or nearby and it will also result in the increased risk of motor vehicle accidents that cause injury and death.

If this project is allowed then it will no doubt set a precedent for other similar industrial projects to be based on Kangaroo Island. KI is for tourism and to promote a place or location of unspoilt natural beauty, a natural wilderness not industrialisation which should be kept to the mainland.

The majority of local people on KI do not want KPT to operate from Smith Bay and KPT should listen to and respect the local people of Kangaroo Island.

There are far better locations for this project such as Portland in Victoria which is close to the SA Border and where there are already long established Pine Forest Plantations. The established seaport of Portland has a purpose built wharf to handle large seagoing ships that already berth at this port and load wood chips for international export.

From:	Molly Watters
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Thursday, 19 December 2019 10:40:42 PM

I don’t like the idea of a 650 metre wharf getting put in Smith Bay. Smith Bay is a spectacular beach so why ruin it by putting a humongous strip of wood there. It just doesn’t make sense to me. It will have an impact of the loss of abalone and it will also cause the abalone businesses to go down hill.

From:	Nigel Gammon
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Thursday, 19 December 2019 10:22:10 AM

Dear Minister, there are a number of concerns that I have including;
1/ The recently released AusOcean survey is so concerned about the potential danger to the temperate ocean sea dragon and other world significant fish only found in KI waters. You can't go to The Great Barrier Reef, the Maldives or anywhere else to view them so why would we risk killing off another species
2/ The major shareholders of KPT include Washington Soul Pattison who own very large COAL HOLDINGS IN WESTMORELAND COAL MINE AND OTHERS. Paradice investments is a big holder of mining and like Soul Pattison' s have no association with KI and are located in Sydney.
3/ Yumbah Abalone is a major business on KI and will suffer significant losses when the farm may have to close down. The sprats, the babies of the abalone are very susceptible to any disruption to their raising and no one can say what will happen should they be wiped out by the building of the seaport. Why would the government of SA RISK LOSING THIS ICONIC BUSINESS. We are losing businesses daily.
4/There are alternatives like building businesses around biochar, greenhouses, micro energy installs. BDO have done a study for S A LIVESTOCK AND PIRSA recommending an abbatoir. Our company, GESTOR CONSULTING has done significant work to incorporate all of the above.
Kind regards, Nigel Gammon

From:	Ozzet Osborne
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Wednesday, 18 December 2019 1:44:00 PM

It is so wrong. Horrible to our marine life and Smith bay residents. Opens options up to oil spills and disturbing our marine life patterns and movements. Gives countrys the power access to come and go

From:	Ratu Nasese
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Sunday, 8 December 2019 2:50:18 PM

It will be an eye sore when smiths bay is currently an absolute beautiful place. Secondly, surely there would be some sort of damages to the marine ecosystems

From:	Rebecca Henson
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Saturday, 21 December 2019 10:11:06 AM

It’s a breeding ground for whales, please protect their environment and move the port to another location.

From:	S Davis
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Tuesday, 17 December 2019 5:39:58 PM

Please reconsider developing these plans in Smith Bay.
The Southern Right whales are one reason...protect their breeding environment.

From: Sarah Marr
To: DPTI:State Commission Assessment Panel
Subject: Major Development Proposal - KI Plantation Timber Ltd, Smith Bay Wharf
Date: Thursday, 19 December 2019 9:01:07 PM

Attention: Mr Robert Kleeman,
Unit Manager Policy and Strategic Assessment
Department of Planning, Transport and Infrastructure

Dear Mr Kleeman,

I am writing to respond to the Main EIS report and addendum EIS provided by Kangaroo Island Plantation Timbers. My concerns relate directly to the traffic and transport aspects of the proposal, specifically the long-term operational impacts.

The main report states that 730,000 tonnes per annum of timber product will be delivered to the KI Seaport from plantation areas. Section 23.1 of the main report states that the KIPT plantations are on the western part of Kangaroo Island. While it is useful to know that the KI Seaport is located 20km northwest of Kingscote, the report does not clearly indicate how far away the KI Seaport is from the KIPT plantations (neither providing a minimum nor maximum distance from the KIPT plantations); which I consider to be as equally, if not more important information to know when assessing the social and environmental impacts of this aspect of operations.

Can KIPT please confirm the average, minimum and maximum distances from KIPT plantations to the KI Seaport? As well as the expected durations at each plantation, or plantation area?

The main report also states "At the peak Annual Average Daily Traffic (AADT) rate (corresponding to 730,000 tpa of timber product movement plus a return trip), a single articulated truck would be expected to pass along the transport route every 22 minutes". Further noting that vehicle movements will be on a 24-hour a day, seven days a week operating schedule and taking Bark Hut Road as an example, Table 21-2 indicates that there will be 54 truck movements per day (per 24 hours), which equates to around 27 for a 12 hour period e.g. 6:00pm (dusk) to 6:00am (dawn); this on an average annual production basis.

Can KIPT provide an indication of what should be the expected maximum number of truck movements along each road (i.e. on a maximum production of 800,000 tonnes per annum basis)?

Table 21-4 of the main report indicates that Bark Hut Road recorded 55 traffic movements. The table does not clarify at what time of day these were recorded. As most local residents are aware, there is a very likely risk of colliding with native wildlife after dusk. Visitors are routinely advised to minimise driving at night or after dusk.

Can KIPT please clarify the time of day these traffic recordings were measured? Or in which supporting report this information is presented?

Using Bark Hut Road, as an example, with an average of 27 truck movements during the evening and night-time hours, on one road, the number of injured or killed wildlife should be expected to be a minimum of 27 (one collision per truck movement). And this refers to only one road, one section of the full distance a truck would need to travel from the plantation to the KI Seaport. Therefore, the total number of native animals killed or maimed during one night would be much greater.

Has KIPT estimated the number of animals likely to injured or killed through vehicle movements? I couldn't identify if there is a requirement in the guidelines for KIPT to assess this impact. Please clarify this aspect.

Therefore, I ask you, Mr Kleeman, whether a condition can be imposed on KIPT that would restrict operational truck movements (and construction phase truck movements for that matter) to the daytime hours only (adjusted according to the Winter and Summer months)?

I have also heard of (but have not used) the Roadkill Reporter app, which anyone can download and report injured or dead native animals. Would the Department consider placing a condition on KIPT to develop an effective management strategy that includes reporting (using such an app) and monitoring the number of collisions with native animals and setting goals to reduce the likelihood of road collisions?

Kind regards,
Sarah Marr
[redacted]
Cassini, SA 5223

From:	Shaun Harvey
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Friday, 20 December 2019 3:07:27 PM

Ballast water from the ships contain up to 5000 foreign pests and the ships are coming from the dirtiest ports in the world, Kangaroo Island has such a Untouched unique environment Like no other place in the world which will be destroyed by these ships

Minister for Planning
C/- Robert Kleeman
Unit Manager Policy and Strategic Assessment
Department of Planning, Transport and Infrastructure
GPO Box 1815, ADELAIDE SA 5000
majordevadmin@sa.gov.au

Dear Minister,

Deep Water wharf proposal for Smith Bay, Kangaroo Island

I have a long history of working in the forestry industry, both in the south-east of the state and also on Kangaroo Island. I moved back to my home town of Kingscote in 2008.

Since then I have worked for Kangaroo Island Plantation Timbers and its predecessor RuralAus both at the Timber Creek mill and in the forests.

My wife Janet also works for KIPT managing the rental properties at Smith Bay and in the plantations.

KIPT has been an excellent and reliable employer and we support its plans to mobilise the timber industry by building the wharf at Smith Bay. We believe they are genuine in their plans to create a new industry for this Island, which is badly needed. Many people here struggle to find all-year-round work.

It has been a difficult couple of years for us because we have family members on the island who strongly oppose this development. We respect their right to oppose it but we remain confident that KIPT has done a thorough assessment and developed a plan which proves the wharf can co-exist with the neighbouring businesses at Smith Bay.

We know of many people who support this project but perhaps won't write a letter. In a small community it can be difficult to speak openly for fear of reprisals or of upsetting your friends or relatives.

Please approve the Smith Bay wharf development now of the revised jetty design in response to concerns raised by our neighbours .

so we can get on with proving its value to the Island in developing the plantation timber industry.

Thus also to help secure some employment for the younger generation.

Yours truly

Stephen J Connell

Janet L Connell

Stephen and Janet Connell
Kingscote, Kangaroo Island

From:	Stephen Betheras
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Friday, 20 December 2019 9:27:29 AM

Inappropriate site road issues not addressed adequately Smith Bay is not the right choice

tilbrookrasheed
Chartered Accountants

13 December 2019

Tilbrook Rasheed Pty Ltd ACN 064 905 255
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Mr Robert Kleeman
Unit Manager Policy and Strategic Assessment
Planning and Development, Development Division
Dept of Planning, Transport and Infrastructure
GPO Box 1815
ADELAIDE SA 5000

Via email: majordevadmin@sa.gov.au

Dear Minister,

I am an Adelaide-based accountant and an advisor to an independent tree grower on Kangaroo Island. This grower has planted 1169 hectares of radiata pine at Kangaroo Island – Kyalla and Westmore Park - on the North Coast. He has tended these trees carefully with regular maintenance and pruning. They are undoubtedly the most valuable pine trees on the Island.

As they reach maturity, we must consider how we will harvest and market them. At the moment there is no cost-effective way to transport them from the Island because the freight costs via Sealink are prohibitive.

I was very pleased to learn that Kangaroo Island Plantation Timbers was planning to build a wharf at Smith Bay through which timber can be exported.

We have had several meetings through agents and other representatives to reach a Memorandum of Understanding with KIPT on how the trees might be harvested and transported through the proposed Smith Bay wharf. I have previously written in support of the EIS and wish to once again provide support for this endeavour.

I urge you to approve the development of a wharf at Smith Bay. It is an ideal site for the wharf given it is already an industrial site and that many other potential sites talked about locally are either in townships or currently undisturbed by development.

Regarding the impact on local wildlife and the Yumbah aquaculture facility at Smith Bay, I understand the Addendum to the Environmental Impact Statement addresses all areas of concern. The longer wharf avoids the concerns raised concerning dredging and has been well researched to avoid having a negative impact on local marine wildlife.

Yours sincerely
TILBROOK RASHEED PTY LTD

STEPHEN WATTS
DIRECTOR

Enc.

From: Suanne Jaquest

To: DPTI:State Commission Assessment Panel
Subject: Concerns about KPT"s Seaport development at Smith Bay
Date: Sunday, 15 December 2019 5:27:44 PM

KPT's new mega-warf proposal will have a massive effect on local marine life. It presents an unacceptable biosecurity risk for Smith Bay, it will inevitably introduce exotic pests and will forever destroy the remote, quiet aesthetic of Smith Bay.

From:	Toni Duka
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Monday, 9 December 2019 9:41:41 PM

Negatvie Impact on marine ecosystems.
Negative Impact on coastline.
Still concerned about impacts on local infrastructure.
Economic viability and returns to the Island will not outweigh the costs in terms of damage to roads, risk to residents road safety and visitors. The impact on existing industries such as tourism and aquaculture. And poosible impact on nature and biodiversity.
Native seagrasses will be impacted by turbidity.
So many concerns still exist regarding this proposal!

From:	Vic Lodge
To:	DPTI:State Commission Assessment Panel
Subject:	Concerns about KPT"s Seaport development at Smith Bay
Date:	Wednesday, 18 December 2019 2:23:49 PM

My objections are not in any particular order.
1. Bio Security is a major concern with overseas ships bringing in pests & diseases either in Ballast or on the ship.
2.Possible loss of Yumbah's world class Abalone Aquaculture business which already employs 40 local people. Expansion plans to double the size & increase the workforce by double I believe were put on hold when this Port was first mooted.
3.Huge loss of sea grass & leafy sea dragons .
4.Closure of the Highly successful Molly's Run Tourism business because of safety concerns with logging trucks going past regularly & causing vehicle accidents to overseas visitors unfamiliar with our roads. Dust & noise will also impact on the business.
5.The suggested figure of employing 250 is very suspect. The previous experienced owners New Forest who sold to KIPT & who manage in excess of 1 million Hectares of forests were going to only employ about 50 people A very big discrepancy).

Post marked 16/12/19
Received 18/12/19

Minister for Planning
C/- Robert Kleeman
Unit Manager Policy and Strategic Assessment
Department of Planning, Transport and Infrastructure
GPO Box 1815
ADELAIDE SA 5000

13/12/2019

Dear Minister

The Queensland Government refused a bottle water company's application to set up business on the grounds that the roads were not suitable for their trucks.

Kangaroo Island's roads are even less suitable for timber trucks which intend travelling every 3½ minutes each way along their route. KIPT's proposed route is along Playford Highway, Stokes Bay Road, Bark Hut Road, McBride's Road and North Coast Road to Smith Bay, if the Government gives approval for their port at Smith Bay. Bark Hut, McBride's and North Coast Roads are all narrow, unsealed roads and often extremely rough and dusty.

The school bus driver says these roads need to be made into 4 lane highways so that timber trucks do not impact as much on other traffic. He has already had experience with a timber truck accident which caused the death of a girl. The unsealed roads need to be widened and bituminised.

It is going to be extremely hazardous for school children who catch the school bus along the timber truck route. How are the children going to be able to cross the road to get to the school bus with trucks hurtling past every 3½ minutes **EACH** way? Children will be killed with that volume of traffic. Also, because Kangaroo Island's roads are so narrow and there is nowhere for the bus to pull right off the road safely, the bus will block the timber trucks so they either will pass the school bus on the wrong side of the road or will be held up and then there will end up being a backlog of trucks.

KIPT have stated that they intend having an "app" developed so that people will always know where their timber trucks are on the roads. The problem with this is that now there is little or no phone service along a lot of their route. Also, people are not supposed to be looking at their mobile phones whilst driving.

Tourists and locals will die with such frequent heavy vehicles travelling on the roads, especially the unsealed ones.

There has been a suggestion that KIPT could use a heavy lift helicopter to transport timbers and timber products directly from their plantation to a ship out at sea. Suitable helicopters such as Sikorsky S-64 Sky Crane or the Sikorsky CH-64 Tahre could be used. These helicopters are used overseas in the timber industry lifting heavy loads with a sling or sling and bin with wood chips.

I believe that there is a firm – Rent-a-heli which could be used.

As KIPT intend stockpiling the timber and wood chips at Smith Bay (if approved), using a helicopter would remove the need for that. The timber and wood chips could be stockpiled on their plantations until the ship is ready for loading. It would then mean possibly only one or two days to load the ship by helicopter each month if only one ship a month is expected.

There would be no need of a port for the ships.

This would remove the problems associated with using Smith Bay, the possibility of destruction to Yumbah, an existing profitable aquaculture business, the dangers on the roads to people associated with all those trucks travelling along the roads, the dust, noise and tremendous expense with upgrading the road system. KIPT could then get the timber off the Island safely.

I understand from KIPT that the Government had stated that they must have an all-weather port so that other ships can use it. Are the Government aware that the North Coast of Kangaroo Island can have some horrific storms damaging boats and even throwing one up onto the cliff at Stokes Bay? The only place suitable for an all-weather port is near Kingscote and it would not be good if the timber trucks have their port at Kingscote. This would be terribly disruptive for tourists and locals.

If the port goes ahead at Smith Bay, what other ships would want to use it anyway with having to travel along the terrible narrow rough dusty unsealed road from Smith Bay into Kingscote? The road is reasonable when it has just been graded, but as soon as traffic travels on it in any volume it becomes corrugated and rough.

Yours sincerely

WWallace

Wendy Wallace
[redacted]
STOKES BAY SA 5223