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

Module B.2.
Offshore Odontocetes

The full CMS Family Guidelines on Environmental Impact Assessments for Marine Noise-generating Activities and the stand-alone modules are online at:

cms.int/guidelines/cms-family-guidelines-EIAs-marine-noise

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.

References

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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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