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

Module B.1.

Inshore 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.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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