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

Module B.5.

Pinnipeds

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.

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B.5. Pinnipeds

Facilitated by
Giuseppe Notarbartolo di Sciara
CMS Aquatic Mammals Appointed Councillor

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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