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

Module B.9.

Marine Turtles

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.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.

References

Martin KJ, Alessi SC, Gaspard JC, Tucker AD, Bauer GB, Mann DA. 2012. Underwater hearing in the loggerhead turtle (*Caretta caretta*): a comparison of behavioral and auditory evoked potential audiograms. J Exp Biol 215:3001-3009

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