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

Module B.4.

Mysticetes

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.4. Mysticetes

Susan Parks
Syracuse University

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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