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

Module B.11.

Elasmobranchs

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.11. Elasmobranchs

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Divers for Sharks

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 on the Conservation of Migratory Sharks (Sharks)

Related modules

- Refer also to modules B.10 and B.12 when assessing impact to elasmobranchs

B.11.1. Species Vulnerabilities

Elasmobranchs as a group are poorly studied in relation to the potential impact of anthropogenic sounds, although several studies over time have been directed at particular species of shark to improve knowledge of their hearing mechanisms, abilities and implications for management. From as early as the 1960s (e.g. Nelson and Gruber, 1963), studies have shown that large sharks (*Carcharhinidae, Sphyrnidae*), in their natural environment, were attracted to low-frequency (predominantly 20 to 60 Hz) pulsed sounds, but apparently not to higher frequency (400 to 600 Hz) pulsed sounds, or to low-frequency continuous sounds. More recent research has established the hearing range of sharks to be between 40 Hz to approximately 800 Hz (Myrberg 2001), with possible limits for elasmobranchs in general at 20–1000 Hz (Casper and Mann, 2006, 2010).

Noise within the sharks' audible range may be produced by several anthropogenic sources such as shipping, underwater construction, pile driving, dredging, power stations and sonic surveys. It has been suggested that loud sounds in their audible range may repel sharks whereas low sounds may attract them (Francis and Lyon, 2013), probably as these latter mimics sounds emitted by struggling prey. Response likely depends on its distance from the source and the volume of the source.

Although more recent research in elasmobranch hearing and impacts in the wild have been sparse at best, and nonexistent for most species, there is evidence of habituation or at least no negative reaction to noise levels and frequencies from small boats operating recreational diving or from SCUBA divers' noises, even when these are regularly present and arising from many sources (Lobel, 2009 and personal observations by the author of this summary).

It is likely that elasmobranchs might suffer more impacts from noise through the effects it has on its prey species (Popper and Hastings, 2009, Carlson, 2012), and perhaps through acute events that impact concentration sites such as social groupings of hammerhead sharks, *Sphyrna* spp., and white sharks, *Carcharodon carcharias,* around offshore islands, as well as those gathering at coral reef habitats, in these cases, displacement may occur, either temporary or permanent, although again lack of adequate field research prevents any definitive conclusions. Several studies (eg Klimley and Myrberg 1979, Banner 1972, Myrberg *et al* 1978) indicate that elasmobranchs show consistent withdrawal from sources that are at close range and when confronted with sudden onset of transmissions. However they may habituate to these too if events become frequent (Myrberg, 2001). Seismic activities, pylon-driving operations, explosive construction work and activities involving similar pulsed sound emissions are likely therefore to have the most impact on elasmobranch species directly.

B.11.2. Habitat Considerations

Several species of elasmobranchs exhibit some type of site-fidelity, either permanent or seasonal. This has been observed in particular regarding species of interest to the dive industry. Some species of shark (eg whitetip, *Triaenodon obesus*, blacktip, *Carcharinus melanopterus,* and grey reef, *Carcharhinus amblyrhynchos*) and the reef manta, *Manta alfredi,* are particularly attached to coral reef environments, while others exhibit seasonal concentration around offshore islands (eg hammerheads, *Sphyrna lewini,* at Galápagos, Cocos and Malpelo Islands, white sharks, *Carcharodon carcharias,* at Guadalupe and Farallon Islands, whale sharks, *Rhincodon typus,* at Holbox, Mexico, and several other sites). Giant mantas *Manta birostris* also can be found in seasonal concentrations such as in Revillagigedo Islands in Mexico, Laje de Santos in Brazil and La Plata in Ecuador.

Seasons for these aggregations vary from site to site and by species and need to be assessed on a case by case basis.

Acoustic impacts which might severely affect vulnerable or complex habitats such as coral reefs or mangrove forests (essential nursery areas for some shark and ray species) are certain to have an effect on its elasmobranch fauna if it includes displacement or damage to prey species and any physical disruption of the habitat. Seasonal concentration areas for sharks and rays can be particularly vulnerable to acute acoustic disturbance, which may result in abandonment of the area or disruption of gregarious behaviour whose implications are yet not fully understood. Acute acoustic disturbances such as seismic or sonic surveys and any activity involving explosives in or around these critical habitats (coral reefs, offshore islands and other known seasonal concentration sites, key feeding grounds) are likely to have serious impacts on elasmobranch populations.

Although migration paths are still poorly understood for most species, recent satellite tagging research (e.g. Domeier and Nasby-Lucas, 2008) has begun to reveal some consistent patterns and as yet unknown concentration areas away from above-water topographic features. These areas likely represent additional vulnerability corridors where protection from acute acoustic disturbance should be incorporated into management actions.

B.11.3. Impact of Exposure Levels

As a group, elasmobranchs have been poorly represented in field studies on acoustics, with most knowledge available for more "visible" species such as large sharks. For these, observed impacts refer mostly to short-term avoidance responses to loud, sudden bursts of sound in their audible range, although there´s evidence that the regularity of such sounds might lead to habituation (see references above).

Given that bony fish, which make the majority of prey species for most sharks, may be severely impacted by sound, especially in loud bursts (eg Carlson, op. cit.), it is perhaps this indirect effect on prey that holds the most severe potential for generating impacts on shark populations.

There is insufficient information to assess long-term impacts or behavioral changes in elasmobranchs from anthropogenic noise that might affect survivability of species. Existing studies indicate that the most direct negative impact on the animals seems to be displacement by sonic outbursts, while longer-term exposure often seems to lead to habituation.

B.11.4. Assessment Criteria

From available data it seems that there are two main aspects of potential impacts on elasmobranchs that merit particular consideration: displacement or elimination of prey species and displacement or disruption of behaviour associated with specific sites by sound bursts. Given that detailed studies are mostly lacking, a precautionary approach to the exposure of elasmobranchs to noise, especially at key habitats and aggregation sites, is warranted. In particular activities involving the use of equipment or methods that generate loud sonic outbursts near known or estimated aggregation areas, or which might physically injure or displace prey, need to be carried out with adequate assessment (including baseline surveys for elasmobranch species and their prey) and mitigation measures as feasible and appropriate. Also, proposed activities that alter or impact keys habitats such as coral reefs, mangroves or offshore islands with known aggregations of elasmobranch species should be carried out with extreme caution and this group of species should be explicitly considered in studies and proposed management measures to reduce potential impacts.

B.11.5. Species not listed on the CMS Appendices that should also be considered during assessments

In general, listed species include those for which several acoustic and hearing studies exist, but as for the entire group detailed acoustic impact studies are lacking. The development and collation of more detailed data on a species by species basis could greatly help improve our understanding of the impacts of anthropogenic noise on their physiology and life cycles. Lack of information on most elasmobranch species is an impediment to the provision of any meaningful advice on species not listed on the CMS Appendices,

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