Keeping the Noise Down: Approaches to the Mitigation and Regulation of Human-Caused Ocean Noise

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Most marine animals, including marine mammals, fish, and invertebrates, use sound for almost all aspects of their life, including reproduction, feeding, predator and hazard avoidance, communication, and navigation. In the marine environment, vision is only useful over tens of meters, whereas sound can be heard for thousands of kilometers. The potential area impacted by even one noise source can extend to millions of square kilometers. Ocean background human-caused noise levels have doubled every decade for the last several decades in some areas, mainly from commercial shipping.

So, how should a transboundary pollutant such as noise be regulated? Interestingly, the 1982 United Nations Convention on the Law of the Sea includes the word 'energy' to define 'pollution of the marine environment', as in "the introduction by man … of substances or energy into the marine environment … which … is likely to result in … harm to living resources…."[1] Energy in this context can include both thermal and acoustic or noise pollution.[2] Thus, the United Nations General Assembly (UNGA) in paragraph 107 of its resolution 61/222 on 'Oceans and the law of the sea', adopted on 20 December 2006: "Encourages further studies and consideration of the impacts of ocean noise on marine living resources…."[3] Further, UNGA resolution 70/235 adopted on 23 December 2015

> [n]otes with concern that human-related threats, such as … underwater noise … may severely impact marine life … and calls upon States and competent international organizations to cooperate and coordinate their

1 Montego Bay, 10 December 1982, 1833 *U.N.T.S.* 3, art. 1(4).

2 H.M. Dotinga and A.G. Oude Elferink, "Acoustic Pollution in the Oceans: The Search for Legal Standards," *Ocean Development & International Law* 31, no. 1–2 (2000): 151–182, doi.org/10.1080/009083200276102.

3 United Nations General Assembly, "Oceans and the Law of the Sea," UN Doc. A/Res/61/222, 16 March 2007, para. 107.

> research efforts in this regard so as to reduce these impacts and preserve the integrity of the whole marine ecosystem…[4]

The nineteenth meeting of the United Nations Open-Ended Informal Consultative Process on Oceans and the Law of the Sea, in 2018, is dedicated to the theme of ocean noise pollution. Other international fora recognizing ocean noise as a threat include the Convention on Biological Diversity, the European Union's Marine Strategy Framework Directive, the Convention on Migratory Species (CMS), the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area, the Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas, the Convention for the Protection of the Marine Environment of the North-East-Atlantic, the International Maritime Organization (IMO), the International Whaling Commission, and the International Union for Conservation of Nature.

The main sources of human-caused ocean noise are shipping, seismic airgun surveys to detect oil and gas reservoirs under the seafloor, anti-submarine warfare naval sonar, and pile driving such as used for offshore windfarms. Various mitigation approaches have been used by countries. For some proposed noise-producing projects, environmental impact assessments (EIAs) are required, especially since the CMS ratified and endorsed guidelines on EIAs for marine noise-generating activities in 2017. Depending on the country, EIAs sometimes must include an alternatives analysis, examining a range of suitable alternatives (including a 'no action' alternative) and their estimated environmental impact. Some of the most common weaknesses of EIAs are the lack of serious, quantitative risk analyses of cumulative or synergistic impacts (where various threats accumulate in a multiplicative rather than additive way). Power analyses are also often absent from EIAs. Scientific studies of noise impacts should include the statistical probability of finding an effect if one is indeed present. Would there need to be a dramatic, wholesale die-off of a population to detect any effect? Even subtle, hard-to-observe effects can have irreversible, serious impacts. Proof of mitigation effectiveness is also generally missing from EIAs. Frequently, there is not enough basic information on species' distribution and abundance in the proposed area or other baseline biological data before an EIA is produced, hamstringing the usefulness of an EIA.

Common mitigation tools include safety zones together with marine mammal observers. Marine mammal observers generally search a 500-m radius

4 United Nations General Assembly, "Oceans and the Law of the Sea," UN Doc. A/RES/70/235, 15 March 2016, para. 246.

around a noise source for marine mammals and turtles. If animals are detected within the safety zone, the sound source is powered or shut down until the animals leave. The large drawback here is that marine mammals spend a great deal of time underwater where they are out of sight, and turtles are hard to spot unless very close. Moreover, unless the ocean is very calm, without fog or rain, it is difficult to sight marine mammals or turtles. Disturbingly, many noise sources are allowed to operate even at night. Passive acoustic monitoring (PAM) is often used in such situations, deploying underwater microphones (hydrophones) to detect marine mammal sounds. Some species are very vocal, such as sperm whales and beaked whales, but others, less so. Furthermore, it can be difficult to determine the species, bearing (relative to the noise source), and distance of the calling animal. PAM shows some promise, especially when used with gliders, a type of autonomous underwater vehicle that moves slowly forward while going up and down through the water column. Gliders can be outfitted with hydrophones to survey an area for whales and dolphins ahead of a noise-producing project or military exercise. Theoretically, if an area is 'clear', the project can proceed with less risk of noise impact. 'Ramp-ups' or 'soft starts' are also used, whereby sound sources are gradually increased in volume, to theoretically allow animals time to move away. There is limited proof that animals actually do so. Some may be curious and approach the noise at quieter levels only to be hit with the full volume when they are close by. Similarly, acoustic deterrents are sometimes employed to chase animals away before the louder noise source begins operating. All of these mitigation tools are probably better than doing nothing, but generally not highly effective in preventing environmental degradation of an ecosystem through noise.

By far one of the most effective mitigation tools is spatio-temporal restriction on noise activities. Avoiding areas or times of year which are particularly sensitive, such as breeding, spawning, migration, feeding, or resting, is likely to reduce noise impacts. Area-based noise mitigation can also employ marine protected areas (MPAs). MPAs have the advantage that various other (non-acoustic) kinds of stressors or threats are restricted, so that cumulative or synergistic impacts should be minimized. MPAs, however, must be managed with noise in mind, which may require noise buffer zones. Low-frequency noise which generally travels furthest, is most difficult to mitigate, because of the large areas required to keep noise out, compared with mid- and high-frequency noise. Nevertheless, lowering noise levels in MPAs is better than not regulating noise around MPAs at all. After a series of fatal mass strandings involving mainly beaked whales coincident with naval exercises using sonar around the Canary Islands, the Spanish government declared a ban on naval exercises in the Canary Islands within 93 km of shore, in 2004. There have been

no mass strandings in the Canaries since that moratorium began.[5] Another approach, albeit still theoretical, is to set aside still-quiet habitat now, knowing that vulnerable populations require it to recover. These 'acoustic refuges' would be designated in habitat that is vital to noise-sensitive populations and has remained quiet, in contrast to much of the rest of their habitat.

The other mitigation tool that is highly effective is reducing the noise levels through, for instance, quieting technologies. One noise source that does not lend itself very well to most of the above-mentioned tools, such as ramp-ups or safety zones, is commercial shipping, which is currently unregulated relative to noise. It falls into a separate category since the noise is unintentional and of no benefit to the noise producer. However, the IMO has agreed to voluntary guidelines to reduce propeller noise from cavitation and engine noise, for instance. Good maintenance and designing ships with noise in mind can cut noise levels, with the possibility of some attendant increases in fuel efficiency. A 2017 study showed that commercial ships retrofitted for energy efficiency also were 6 to 8 dB quieter.[6] Except for use by the military and sometimes fisheries science, ships are not designed to be quiet. If at the design stage, the hull is matched to the propeller design, so that a uniform wake field is produced, cavitation noise can be reduced. Some ports, such as the Port of Vancouver, are incentivizing quieter ships by cutting docking fees for them by up to 47 percent.[7] Green certification programs, such as Green Marine, are starting to include underwater radiated noise as one of the measures used for calculating the environmental rating of a ship. The IMO also uses Particularly Sensitive Sea Areas and Areas To Be Avoided as ways to change shipping routes to avoid sensitive marine life, which can also help with noise levels.[8] Shipping noise levels can, depending on the propulsion system, be reduced by simply slowing down. Often, but not always, slower ships are quieter. If ships avoid running along the continental shelf break, they could reduce the amount of noise entering the deep sound channel, a horizontal duct at depth in the ocean that transmits noise very efficiently over large distances. If ships could instead pass perpendicular over

5 A. Fernández, M. Arbelo and V. Martín, "Whales: No mass strandings since sonar ban," *Nature* 497 (16 May 2013): 317. doi:10.1038/497317d.

6 M. Gassmann et al., "Underwater Noise Comparison of Pre- and Post-Retrofitted MAERSK G-Class Container Vessels," MPL TM-616 Unpublished report, 30 pp.

7 M. Meuse, "Port of Vancouver to cut docking fees for quieter ships by nearly half," *CBC News*, 26 January 2017, http://www.cbc.ca/news/canada/british-columbia/vancouver-port-noise-incentives-1.3953522.

8 See "Particularly Sensitive Sea Areas," International Maritime Organization, http://www.imo.org/en/OurWork/Environment/PSSAs/Pages/Default.aspx.

the shelf break or at greater distance parallel to it, this might minimize the background shipping noise in the ocean.

Aside from reducing shipping noise, other quieting technologies have emerged. An alternative to seismic airguns is Marine Vibroseis, which uses the same energy as an airgun, but spread out over a longer duration, so that the amplitude (loudness) of the airgun shot is reduced. Although airguns produce sound up to 150 kHz, geophysicists only record sound below 200 Hz. Everything above 200 Hz is, in effect, 'wasted energy'. Marine Vibroseis is largely able to cut out these unnecessary frequencies, thus sparing mid- or high-frequency hearing whales and dolphins, like beaked whales, harbor porpoises, dolphins, killer whales, belugas, and narwhals. Marine Vibroseis helps even low-frequency hearing whales, such as the baleen whales, as overall levels are substantially lower.[9] Moreover, with Marine Vibroseis there is no injurious sharp onset, like a gunshot, where the levels rise almost instantaneously from zero to high. Marine Vibroseis prototypes are currently being tested, but are not yet commercially available. There are a wide variety of quieting technologies used for pile driving, such as bubble curtains and cofferdams. Innovation of these quieting technologies was mainly brought about by the German government's noise limits, the only country to legislate underwater noise in this way.

Overall, however, underwater noise is particularly deserving of precautionary management. Noise impacts on whales are especially difficult to document, particularly the most critical impacts on their populations.[10] The ocean is not a controlled laboratory; prey distributions change for unknown reasons, whale population estimates are very imprecise so population changes are hard to detect and moreover, to link to noise alone and not some other stressor. For these reasons, and because marine animals are highly dependent on sound and the potential area of impact is so large, the burden of proof should be on the project proponents, not those trying to preserve the environment from degradation through noise.

9 A.J. Duncan, et al., "A Modelling Comparison between Received Sound Levels Produced by a Marine Vibroseis Array and Those from an Airgun Array for Some Typical Seismic Survey Scenarios," *Marine Pollution Bulletin* 119 (2017): 277–288.

10 L.S. Weilgart, "The Need for Precaution in the Regulation and Management of Undersea Noise," *Journal of International Wildlife Law and Policy* 10, no. 3 (2007): 247–253.