

Ocean Noise and Marine Mammals

A new report from the National Academies recommends a closer look at ocean noise and its effects on marine mammals. For the 119 species of marine mammals, as well as for some other aquatic animals, sound is the primary means of learning about the environment and of communicating, navigating, and foraging.

The possibility that human-generated noise could harm marine mammals or significantly interfere with their normal activities is an issue of increasing concern. Noise and its potential impacts have been regulated since the passage of the Marine Mammal Protection Act of 1972. Public awareness of the issue escalated in the 1990s when researchers began using high-intensity sound to measure changes in ocean temperature. More recently, the stranding of beaked whales in proximity to Navy sonar use has again put the issue in the spotlight.

Is the impact of noise on marine mammals sufficiently great to warrant concern? Current evidence says yes. Yet determining this impact is nearly impossible given our limited knowledge about ocean noise and marine mammals' responses to it. What is the overall level of noise in the ocean and what are the relative contributions from each source? What are the long-term trends in noise levels? What are the effects of short- and long-term noise exposure on marine mammals? We must find answers to these fundamental questions in order to inform policy decisions.

Sources of Noise and Long-term Trends

A broad range of sources, both natural and human-generated (anthropogenic), produces sound in the ocean. Wind, waves, earthquakes, precipitation, cracking ice, whale songs, and fish vocalizations are among the many and diverse natural sounds in the ocean. Human endeavors, such as shipping, offshore oil exploration and extraction, and even depth sounders contribute to ocean noise (see Box 1). For oceanographers, marine seismologists, mineral explorers, and others, sound is a powerful remote-sensing tool for exploring and mapping the seabed. Society has reaped substantial benefits from these endeavors, such as the discovery of substantial offshore oil reserves.

Although human-generated sounds were virtually absent before the Industrial Revolution and are widespread now, there are currently no long-term data that allow scientists to assess trends in ocean noise. Increases in commercial shipping during the past fifty years imply a gradual increase in noise levels from ship traffic based on limited observations. However, newer ships tend to be quieter and further study is needed to determine exactly how noise levels are changing. To aid our understanding of the overall noise budget in the ocean, the report recommends that researchers do the following:

- Collect, centralize, organize and analyze existing data on marine noise from human sources to provide a reference database and to establish the limitations of research to date.
- Initiate a long-term ocean noise-monitoring program over a broad range of frequencies.
- Conduct research to determine quantitative relationships between levels of human activity and resulting noise.
- Conduct research to describe the distribution and characteristics of sounds generated by marine mammals and other marine organisms seasonally, geographically, and within behavioral contexts.



Photo courtesy NOAA/NMFS/NMML

Box 1. Sources of Human-Generated Ocean Noise

Transportation: Aircraft, ships and boats, icebreakers, hovercrafts and vehicles on ice.

Dredging and Construction: Dredging, tunnel boring, other operations.

Oil Drilling and Production: Drilling from islands and caissons, bottom-mounted platforms, and vessels; and offshore oil and gas production.

Geophysical Surveys: Air-guns, sleeve exploders, and gas guns.

Sonars: Fish finders, depth sounders, and military systems.

Explosions

Ocean Research: Seismology, acoustic propagation, acoustic tomography, acoustic thermometry.

- Develop and verify a model of global ocean noise that properly reflects the impact of background and transient noise on marine mammals.

Understanding Effects on Marine Mammals

Although the stranding of beaked whales provides a tangible and alarming picture of the potential effects of high-energy mid-range sonar, there are very limited observations concerning the effects of most kinds of ocean noise on marine mammals. Potential effects include changes in hearing sensitivity and behavioral patterns, as well as acoustically induced stress and effects on other animals, such as fish, in the marine habitat. Most existing data are limited, short-term, non-repeatable observations of marine mammal responses to human activity. For example, changes in vocalization behavior, breathing and diving patterns, and active avoidance of noise sources have all been observed in response to anthropogenic noise. What is unclear is the importance of these responses to the well-being of the animals, their populations, and how these responses vary with age, sex, experience, and the individual. Like other animals, marine mammals have been shown to adapt their behaviors over time, for example, some change the frequency or duration of their vocalizations.

Computer simulation models are one way to elucidate relationships between variables, in this case ocean noise and marine mammals, and predict interactions. Models describing ocean noise, though limited, are better developed than models describing marine mammal distribution, hearing, and behavior. The biggest challenge lies in integrating the two types of models. For instance, as part of its antisubmarine warfare effort, the U.S. Navy has developed a wide variety of ambient noise models and databases. However, the focus on naval scenarios means that they are not ideally suited for marine mammal applications.

To aid our understanding of the impacts of ocean noise on marine mammals, the report recommends that researchers do the following:

- Target efforts to measure ocean noise toward important marine mammal habitats. Until these habitats are fully described, long-term monitoring programs should begin in coastal areas, marine mammal migration paths, foraging areas, and breeding grounds.
- Whenever possible, structure research to relate individual observed responses to population-level effects.
- Conduct research to determine whether subtle changes in marine mammal behavior might result from the masking of biologically important sounds by anthropogenic sounds.
- Determine whether there are reliable long-term stress indicators and whether they can be used to differentiate between noise-induced stress and other sources of stress in representative marine mammal species.
- Examine the impact of noise on non-mammalian organisms in the marine ecosystem. Fish are important members of the marine habitat and food web, and have been shown to use sound in many ways that are comparable to the ways marine mammals communicate and sense their environment.

In addition to the specific recommendations above, the report also encourages the acoustical oceanography community, marine mammal biologists, marine biological acousticians, and other users of sound in the ocean, such as the military and oil industry, to make greater efforts to educate the public about fundamental acoustic concepts in marine biology and ocean science.

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