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The flukes of a Humpback whale (*Megaptera novaeangliae*) breaching at sunset in the waters south west of Gil Island in the Great Bear Rainforest, British Columbia, Canada.

UNDERWATER NOISE FAQs

In the darkness of the underwater world, marine animals have evolved to use sound as their primary way of sensing the environment. This means that the ability to detect their acoustic surroundings is critical to their survival. Toothed whales and dolphins use echolocation (i.e., sending and receiving sound waves) to navigate and find food. They and other marine mammals also use sound to communicate, find mates, and avoid predators. Many fish and invertebrates use sound in similar ways. However, underwater noise from human sources, like shipping and seismic exploration, is increasing in the world's oceans, and this has made some places in the ocean very noisy. Here we've collected some of the more common questions asked about the effects of underwater noise, and how it affects marine life.

Pacific herring (*Clupea pallasii*) swimming in the Strait of Georgia near the coastal forest of British Columbia, Canada. Fish are also affected by underwater noise.

What is underwater noise?

The term 'noise' is used to refer to unwanted sound. In contrast, a 'signal' is the component of sound that contains useful information, as defined by the listener. Accordingly, both terms may mean different things to different listeners. For example, the sound generated by a sonar device will be experienced as a signal by the human operator, but will likely be perceived as noise by a listening whale. The ability of a listener to hear sounds of interest to them depends a lot on how loud those sounds are in relation to the level of noise around them. This is known as the 'signal to noise ratio'.

The term 'underwater noise' is typically used to refer to the noise introduced into the oceans by human activities. As with the noise pollution that we humans hear in the air, underwater noise pollution can be disturbing – and sometimes even harmful – for marine life.

What kind of marine life can be affected by underwater noise?

Research has shown that underwater noise can affect a variety of marine animals, from whales to sea turtles, and from fish to squid.[1,2] Underwater noise is also likely to be affecting other marine species that use sound, at least to some extent.

How can underwater noise harm marine animals?

Underwater noise can harm marine animals in ways that range from minor to severe in impact. Excessive or unexpected noise can be a disturbance, altering behaviours or causing animals like porpoises or fish to leave an area where they may be seeking food, sheltering with their young, or carrying out some other activity important to their survival. Noise that is loud enough can cause temporary or permanent hearing loss, physical damage, or even death, as has been demonstrated for various marine mammals, fish, and invertebrates. As an example of extreme noise effects, there have now been numerous occurrences worldwide of dead or dying beaked whales stranding on beaches in the wake of navy sonar exercises.[3] In these cases, however, the whales appear to be stranding following a change in their behaviour caused by the sonar, rather than by any physical damage caused directly by the sonar itself.

For many animals, noise simply affects them by being 'noisy' – it drowns out the calls that they use to communicate with each other, or hides the sounds made by an approaching predator. This effect is called masking. Masking is particularly of concern where animals tend to hear at the same frequency as a predominant noise source. For example, there is a strong overlap between the frequencies of baleen whale calls and the underwater noise generated by large ships. Such shipping noise is known to make it harder for these whales to hear each other.[4] Even in the absence of more obvious responses, on-going exposure to noise can cause stress and its attendant health effects.[5]

Marine animals currently face an array of environmental threats, including entanglement in or ingestion of marine debris, chemical contaminants, and unsustainable harvesting. The health of an animal's population depends upon the total impact of all the threats that they face, known as the 'cumulative impacts' of human activity. Thus, underwater noise contributes yet another problematic stressor to many populations that are trying to recover from past harm, or that are currently in decline.

How far can these noises travel underwater?

The distance that noise travels underwater depends on various factors, including a sound's frequency, the ocean's temperature and salinity, and the characteristics of the surrounding land mass. For example, ship-generated noise will reverberate in a narrow channel for longer and may seem louder than the same sound in the open ocean. Low-frequency noise (like that from a ship's engine and propeller) can travel extraordinarily long distances under the sea. In fact, it is likely this property of low frequency sound that led to the evolution of low-frequency communication in baleen whales – their underwater vocalisations may be heard many hundreds of kilometres away.[6]

What are the main sources of underwater noise in Canada's Pacific Ocean?

In Canada's Pacific, underwater noise is generated by a variety of industrial, commercial, and recreational activities. Shipping and small vessels of all classes are considered to be the dominant source of underwater noise in British Columbia. Other sources, such as pile driving and shore-based construction, can also cause underwater noise pollution. While the noise associated with seismic surveys is a problem in many areas, such surveys are not presently carried out in this region. Nonetheless, seismic surveys in distant areas may contribute some low-level noise in British Columbia – as with ships, the noise they produce may travel long distances.

If ships are a major source of noise, are some of them noisier than others?

Yes. In fact there is a large amount of variation in the level of noise produced by different ships. Factors such as hull vibration, engine noise, and propeller sounds all contribute to a vessel's 'acoustic footprint', and these vary widely depending on ship design and condition. Fortunately, the sorts of modifications that can make a vessel quieter (e.g., elimination of propeller cavitation, improved hull design) will also often make it more fuel-efficient, providing an incentive for making quieter ships.

Are slower ships less noisy?

Yes, but only in a general sense. A vessel's slowest operating speed is not necessarily its quietest, although on average, slower vessels do make less noise. At its most efficient, ship noise reduction requires a detailed understanding of an individual vessel's acoustic footprint. This can be best assessed and manipulated during the design phase of new ships, although modifications to existing vessels can help too.

How much noise is too much?

Unfortunately, the real answer to this question is "it depends". While hearing damage and direct physical harm in any given species may be relatively predictable, other impacts, such as behavioural reactions, masking, and stress, are much less so, even within one population of animals. This is partly because individual animals can show high variability in their sensitivity to a given sound, much like humans do. This means that a relatively low noise level might be more disruptive than a higher one under the right circumstances. An animal's age, sex, health, reproductive status (is it a male looking for mates? Is it a female caring for its offspring?), activity (what is it doing when it is exposed to the noise?), and experience (has it been exposed to a given noise before?) can all play a role in how much a noise might be disturbing or harmful. As an example of the complex relationship between noise level and degree of harm, it now appears that stranding deaths of beaked whales have actually resulted from exposures to relatively low noise levels.[7]

A large cruise ship docks in Prince Rupert on a misty day. WWF-Canada is working on solutions to underwater noise, including noise generated by shipping.

Whales are frequently seen around small boats and large ships on the coast. Maybe they're getting used to the noise?

It is often hard to interpret an animal's behaviour. Is a whale ignoring a boat's noise because it is not bothered by the sound, or is it because its hearing has become impaired? Or is an animal putting up with noise a trade-off that will allow it to access a critical resource – food, mates, or safety from predators – not available elsewhere? Behavioural effects may also be too subtle to be seen by a casual observer.[8] There is evidence for all of these factors playing a role in creating an animal's apparent indifference to a noisy underwater environment, and an animal that is not responding behaviourally may nonetheless be stressed by the noise.

Why should we care?

Imagine the stress (and possible hearing loss) you'd experience if you were unable to get away from the daily noise of a jackhammer outside your office or home. Many marine animals are unable to escape what's been called an "acoustic smog"[9] of constant underwater noise. Underwater noise is an escalating stressor that is affecting already-stressed species. There may also be economic impacts to noise if it forces commercial fish species out of their breeding sites, or if they produce fewer eggs following exposures. We really don't yet know how much of an impact underwater noise might have on our lives.

What can we do?

Although underwater noise is a complex problem without easy solutions, some steps are being taken to address the issue in various places around the world. Solutions to shipping noise can include building new ships to be quieter as well as more energy efficient, and retrofitting current vessels using the same goals. Turning off pleasure craft engines and echo-sounders when watching whales can reduce noise levels and exposure. In B.C., the geography of coastal inlets and multiple islands in some places provides an extensive natural buffer from distant shipping noise, and may provide an opportunity to protect certain ecologically important areas through the creation of quiet reserves. Marine plans can also create zones where different activities that create noise are restricted, at least at certain times of the year. (Go to http://mappocean.org/ for more information on this type of process).

Species recovery plans can also identify and help to protect the acoustic habitat of whales, (e.g., www.sararegistry.gc.ca/) and environmental assessments can (and should) require project proponents to protect against harmful underwater noise.

What is WWF-Canada doing?

WWF-Canada is working to educate decision-makers about the negative impacts of underwater noise, and to propose workable solutions in various sectors. We have commissioned maps and studies of ship noise off the Pacific Coast. We've also convened two expert workshops on this topic, the first of their kind in Canada.

We have also provided expert evidence to one major environmental assessment currently underway in a remote area of northern British Columbia, and we are communicating the issue of ocean noise through publications like this one. We are also partnering with citizen scientists who record underwater noise and whale songs.

Internationally, we are participating in an International Maritime Organisation (IMO) initiative to develop global ship quieting guidelines. We are also working with a number of experts to advance management solutions within the Canadian legal context. And we are working with the maritime industry to explore ways in which incentive programmes, like Green Marine (www.green-marine.org), might serve to decrease noise on a vessel-by-vessel basis.

Killer whale (*Orcinus orca*) at surface in front of a herring fishing boat. Ships and small vessels are a dominant source of underwater noise

1 André, Michel, et al. (2011) "Low-frequency sounds induce acoustic trauma in cephalopods." *Frontiers in Ecology and the Environment* 9:489-493.

2 Convention on Biological Diversity. (2012) *Scientific synthesis on the impacts of underwater noise on marine and coastal biodiversity and habitats*. UN Environmental Program, Convention on Biological Diversity, Montreal. 93 pp.

3 Cox, Tara M., et al. (2006) "Understanding the impacts of anthropogenic sound on beaked whales." *Journal of Cetacean Research and Management* 7:177-187.

4 Malakoff, David. (2010). A push for quieter ships. Science 328:1502–3. doi:10.1126/science.328.5985.1502

5 Rolland, Rosalind M., et al. (2012) "Evidence that ship noise increases stress in right whales." *Proceedings of the Royal Society B: Biological Sciences* 279:2363-2368.

6 Payne, Roger, and Douglas Webb. (1971) "Orientation by means of long range acoustic signaling in baleen whales." *Annals of the New York Academy of Sciences* 188:110-141.

7 Parsons, E. C. M., et al. (2008) "Navy sonar and cetaceans: Just how much does the gun need to smoke before we act?" *Marine Pollution Bulletin* 56:1248-1257.

8 Purser, Julia, and Andrew N. Radford. (2011) "Acoustic noise induces attention shifts and reduces foraging performance in three-spined sticklebacks (*Gasterosteus aculeatus*)." *PLOS ONE* 6: e17478. doi:10.1371/journal.pone.0017478.

9 Clark, Chris. W., et al. (2007) "Listening to their world: acoustics for monitoring and protecting right whales in an urbanized ocean." Pp. 333–357 in *The urban whale: North Atlantic right whales at the crossroads* (S. D. Kraus and R. M. Rolland, eds.). Harvard University Press, Cambridge, Massachusetts.

More information on our programs and publications on underwater noise can be found at the following websites:

www.wwf.ca/conservation/oceans/protecting_quiet_oceans/

www.wwf.ca/newsroom/reports/oceans/