# Underwater Noise: Death Knell of our Oceans?

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Why is human-made ocean noise a problem?

**Most marine animals, particularly marine mammals and fish, are dependent on sound, sometimes for all aspects of their life including reproduction, feeding, predator avoidance, and navigation** (e.g. Popper 2003)**.** Marine life has used sound as its principal sense because sound travels so efficiently underwater, travelling 5x the speed of sound in air. Vision is only useful for tens of meters underwater, yet sound can be heard for hundreds, even thousands of kilometers.

Unfortunately, the same goes for noise, or unwanted sound. For instance, the U.S. Navy's Low Frequency Active (LFA) Sonar used to detect submarines could affect marine life over an area of about **3.9 million km$^2$** (Johnson 2003), an area covering much of the Pacific Ocean. (LFA sonar can be heard over an even larger area, but this figure is based on noise levels shown to actually affect whales and fish). Noise from just a single seismic survey (loud air guns used by the oil and gas industry to find oil up to 10 km underneath the ocean floor or by geophysicist to study the ocean floor) can flood through a region of almost 300,000 km$^2$, raising noise levels 100 x higher, continuously for days at a time (IWC 2004). Seismic noise from eastern Canada measured 3,000 km away in the middle of the Atlantic was the loudest part of the background noise heard underwater (Nieukirk et al. 2004). **Ocean background noise levels have doubled every decade for the last six decades in some areas, mainly due to shipping** (IWC 2004).

Such noise can prevent fish, whales, and dolphins from hearing their prey or predators, from avoiding dangers, from navigating or orienting to important habitat, from finding mates that are often widely spread out, or from staying in acoustic contact with their young or their group members. Whale calls seem to be becoming increasingly drowned out by our noise (Nieukirk et al. 2004).

What kinds of impacts from noise on marine life have been found?

**Recently, noise has been shown to be deadly for at least some species of whales.** The evidence linking intense military sonars with fatal whale strandings is undeniable (e.g. Frantzis 1998; Jepson et al. 2003). The International Whaling Commission's Scientific Committee noted "there is now compelling evidence implicating military sonar as a direct impact on beaked whales in particular"(IWC 2004). Even a U.S. Navy-commissioned report stated that "the evidence of sonar causation [of whale beachings] is, in our opinion, completely convincing." (Levine et al. 2004) Often whales show bleeding around their brain, in their ears, in other structures to do with hearing, and in other organs of their body (e.g. NOAA and U.S. Navy 2001; Fernandez et al. 2005). Mass strandings of certain types of whale increased dramatically after 1961 when more powerful naval sonars began to be used (Friedman 1989). Seismic air guns have been thought to cause whale strandings as well (Taylor et al. 2004; Engel et al. 2004). Even giant squid have apparently mass stranded because of air guns, suffering massive internal injuries and badly damaged ears (MacKenzie 2004).

Many sub-lethal effects have also been documented. These may be as serious as lethal effects, because they may affect more animals yet be harder to detect. Seismic air guns have been shown to severely damage fish ears, most likely permanently, at distances of from 500 m to several kilometers from seismic surveys (McCauley et al. 2003). **Reduced catch rates of 50-80% and fewer fish near seismic surveys**

**have been reported in species such as cod, haddock, rockfish, herring, and blue whiting** (Engås et al. 1996; Dalen and Knutsen 1987; Løkkeborg 1991; Slotte et al. 2004; Skalski et al. 1992). **These effects can last up to 5 days after exposure and at distances of more than 30 km from a seismic survey**. Increases in stress hormones (Santulli et al. 1999) and strong behavioral reactions have been observed in fish due to noise. Day-to-night movements of fish were changed near air guns (Wardle et al. 2001). Fish also showed reactions like dropping to deeper depths, becoming motionless, becoming more active, or forming a compact school (Dalen and Knutsen 1987; McCauley et al. 2000; Pearson et al. 1992; Santulli et al. 1999; Skalski et al. 1992; Slotte et al. 2004). Snow crabs under seismic noise conditions showed bruised organs, abnormal ovaries along with bleeding, stress, delayed embryo development, and smaller larvae (DFO 2004).

Whales have moved away from their feeding and mating grounds (e.g. Bryant et al. 1984; Morton and Symonds 2002; Weller et al. 2002), moved away from their migration route (e.g. Richardson et al. 1995), and have changed their calls due to noise (e.g. Miller et al. 2000). They have blundered into fishing nets (Todd et al. 1996) or were unable to avoid ships (Andre et al. 1997) most likely due to hearing damage as a result of noise. Indications of increased stress and a weakened immune system following noise broadcasts were also shown for a whale and dolphin (Romano et al. 2004).

Are these impacts serious?

Certainly deaths of individuals are serious, particularly in endangered species. But impacts on populations, even non-lethal ones, can severely affect species survival. The International Whaling Commission's Scientific Committee noted "…repeated and persistent acoustic insults [over] a large area…should be considered enough to cause population level impacts." (IWC 2004). Population impacts are hard to detect in animals as difficult to study as marine mammals, but noise has been thought to contribute to several whale species' decline or lack of recovery (NMFS 2002; Weller et al. 2002). Anything that interferes with a marine animal's ability to detect biologically important sounds could have a negative effect on its survival and the health of its populations. Reef fish larvae, for instance, use sound to orient toward or select suitable habitat (Simpson et al. 2005).

Certain whale species, such as beaked whales, could be highly threatened by noise not only because of their apparent sensitivity, but also because they seem to occur in small isolated populations that stay in the same area all year (Dalebout et al., in press), making them more vulnerable to local extinctions. Indeed, the best population data we have from the Bahamas 2000 stranding indicates that **almost the entire local population either moved away permanently or were killed by a single military sonar event** (Balcomb and Claridge 2001)**.** It is possible, even probable, that other local beaked whale populations have disappeared without our knowing it, since these are the most shy and difficult to study of all whales.

The impacts of noise can work cumulatively or synergistically with other environmental threats. For instance, human impacts on marine ecosystems such as over-fishing, eutrophication, climate change, and ultraviolet radiation interact to produce a magnified effect (Worm et al. 2002; Lotze and Worm 2002). Noise could interact with marine mammal by-catch or ship collisions, preventing animals from sensing fishing gear or oncoming ships. It is impossible to know what the effects of noise are on the entire marine ecosystem, but from what we know now, the consequences could be far-ranging and severe. **Noise has killed and deafened marine animals, caused them to move away from important breeding and feeding areas, and produced declines in fisheries' catch rates.** Ocean noise is getting dramatically louder every decade. It is time to start listening.

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