An underwater photograph of a large school of fish swimming in clear blue water. A horizontal yellow banner is overlaid across the middle of the image. On the right side of the banner, there is a decorative graphic consisting of several concentric circles of small dots.

DROWNING IN SOUND

**A CALL FOR
INTERNATIONAL
ACTION TO
PROTECT
LIVING MARINE
RESOURCES**

Ocean Noise · A Growing Problem

Anthropogenic (human-generated) noise levels in the marine environment are increasing at an alarming rate. In some areas, noise levels have doubled every decade for the past 60 years. There is mounting concern that noise proliferation poses a significant threat to marine ecosystems and the survival of marine mammals, fish and other ocean wildlife.

Marine animals use sound to navigate, find food, locate mates, avoid predators and communicate. Flooding their world with intense sound interferes with these activities and results in serious consequences. A growing body of scientific research confirms anthropogenic noise can induce a range of adverse effects in fish, marine mammals and other ocean creatures, from disturbance to injury and death.

A review of the scientific literature revealed that at least 55 marine species have exhibited adverse impacts from intense and moderate underwater noise. Noise can work cumulatively or synergistically with other environmental threats. It can, for example, mask the acoustic cues an animal might use to avoid ships or entanglement in fishing gear. Anthropogenic noise may also make prey species that are already depleted from overfishing more difficult to locate and capture.

IMPACTS OF OCEAN NOISE ON FISHERIES

As the world human population increases, the dependence on fisheries to contribute to country economies and food security is also increasing. Fish consumption currently accounts for 16.5 percent of the global intake of animal protein and 6.4 percent of all protein consumed according to the FAO. Anthropogenic ocean noise pollution presents a direct threat to the security of this food source, and to the fishing industry. Arguably, this threat has not been given the attention it deserves thus far, despite available information.

Three decades of controlled scientific studies indicate that intense ocean noise damages fish and, consequently, fisheries. Research so far indicates adverse reactions to intense noise in 21 species of fish. Harmful effects include:

- Extensive damage to fish ears and hearing
- Reduced catch rates of 40-80 percent and fewer fish near seismic surveys reported for cod, haddock, rockfish, herring, sand eel and blue whiting
- Disruption in schooling structure, swimming behavior, and, possibly, migration in bluefin tuna
- Secretion of stress hormones in several fish species in the

- presence of shipping noise
- Alteration of gene expression in the brain of codfish following air gun exposure
- A significant increase in heart rate in embryonic clownfish with exposure to noise
- Avoidance behavior in capelin and eels when exposed to noise potentially affecting critical life-history events

There are harmful effects to commercial invertebrates, too.

These effects include:

- A reduction in growth and reproduction in brown shrimp exposed to noise
- Bruised organs, abnormal ovaries, smaller larvae, delayed development and stress in snow crabs when exposed to seismic noise
- Increased food consumption and histochemical changes in lobster after exposure to seismic noise

Since anthropogenic ocean noise can travel hundreds of miles from its source, the potential impact to fisheries from unregulated noise activities is immense. This could have significant effect on national economies, commercial fisheries and local fishing communities. An estimated 43.5 million people rely on capture fisheries and aquaculture job markets for full or part time employment. Eighty-six percent of this estimated total are citizens of Asia. An additional estimated 4 million people are occasionally engaged in the fisheries and aquaculture sector. 500 million people rely (indirectly and directly) on the fishery and aquaculture sector for employment. Developing countries produce \$24.6 billion annually from their fisheries exports. The increasing reliance on fisheries for employment and economic growth, especially for developing countries, will continue to

Dolphins: iStock photo



This Cuvier's beaked whale (Ziphius cavirostris) was a victim of the 2000 Bahamas stranding event, in which 17 individuals from several whale species stranded after naval exercises involving the use of active sonar.



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What is the Source of the Noise?

grow. As this dependency develops, so will the number of overexploited fish stocks.

IMPACTS OF OCEAN NOISE ON MARINE MAMMALS AND OTHER MARINE ANIMALS

In scientific studies, negative responses to anthropogenic noise have been observed in at least 27 species of marine mammals, as well as other marine animals. These effects include:

- Mortality or serious injury caused by hemorrhaging around the brain, air cavities, lungs and other organs in marine mammals
- Mortality or serious injury caused by the formation of nitrogen bubbles in the bloodstream, leading to embolism in marine mammals

- Temporary or permanent loss of hearing, impairing an animal's ability to perform essential life functions, such as communication, avoiding predators, avoiding vessel traffic, finding mates and catching prey
- Stranding caused by the above factors
- Avoidance behavior, which can lead to abandonment of habitat or migratory pathways and disruption of mating, feeding or nursing
- Aggressive behavior, which can result in injury
- Masking of biologically meaningful sounds, such as the call of predators or potential mates
- Depletion of prey species

Sources of anthropogenic ocean noise include the use of explosives, oceanographic experiments, geophysical research, underwater construction, ship traffic, military active sonar, and air guns used for oil and gas exploration, as well as oil drilling and shipping activities.

EXPLOSIVES

Explosives are detonated in the ocean by the military, scientific researchers, and the oil and gas industry for destruction purposes, seismic exploration or testing equipment—such as ship-shock trials, whereby ships are deliberately struck with explosives to test their durability. Explosions are created by chemical devices; they cause extremely high noise levels in the wideband frequency range and are characterized by rapid rise times.

SEISMIC AIRGUNS

Airgun arrays are used primarily for oil and gas exploration and research purposes. The airguns produce sound by introducing air into the water at high pressure, usually directed toward the sea floor, with up to 20 guns being fired in synchrony, while “streamers” of hydrophones listen for echoes. Seismic airgun pulses can penetrate tens to hundreds of kilometers into the Earth's

crust, after having already traveled through sometimes thousands of meters of water. Seismic surveys with airguns can last for many weeks at a time. During the surveys, every airgun in the array produces a pulse of noise lasting 20 to 30 milliseconds which is repeated every 10 seconds, often for 24 hours a day.

As all the easily obtained oil and gas reserves are depleted, airgun surveys are moving into more environmentally sensitive and difficult habitats, and using several ships to fire airguns in the same area (e.g., wide azimuth (WAZ), multi-azimuth (MAZ), rich azimuth (RAZ), full azimuth surveys (FAZ)), where previously only one ship was used. This will produce louder and more complex sound fields which will be ever more dangerous for marine life. Seismic airguns generate a great deal of waste noise (anything over 100 Hz up to as high as tens of kHz) that is unused by the oil and gas industry or geophysical researchers. They also produce a loud pulse that is damaging to marine life because it is so sharp (with a fast rise time). More environmentally benign alternatives exist, such as Marine Vibroseis, which can be over 1,000 times quieter without the sharp rise time and without any of the wasted

sound. In some environments, it even outperforms airguns in collecting geophysical data. This technology could be commercially available within 1–2 years, yet government regulators are not insisting on its use.

MARINE RENEWABLE ENERGIES

The marine renewable energy (MRE) industry is an emerging industry with novel technologies, often with unknown consequences for marine living resources. The recent *Oceans and the law of the sea – Report of the UN Secretary-General (A/67/79)* examines several environmental and other challenges that are linked to the development of marine renewable energies, including “killings or change in the behaviour of fish and mammals from noise and electromagnetic

fields...” Thus, potential acoustic impacts associated with the MREs need to be assessed scientifically, especially since some of these projects are expected to cover thousands of square kilometers. Research is needed that establishes baselines in order to assess distributional and behavioral changes in marine life from possible cumulative impacts caused by MREs.

MILITARY SONAR

Active sonar is used by military vessels during exercises and routine activities to hunt for objects in the path of the vessel. These Mid-Frequency Active (MFA) and Low-Frequency Active (LFA) sonar systems usually emit 100-second-long “pulses” of sound that can be deployed for hours and are designed to focus as much energy as possible in narrow ranges in a

horizontal direction. LFA sonar is a type of long-range surveillance sonar that saturates thousands of cubic miles of ocean with sound. Frequencies commonly used by sonar systems range from around 0.1 to 10 kHz, with source levels in excess of 230 decibels.

SHIP TRAFFIC

Ships produce noise that generally falls in the low frequency band, between 10 Hz and 1 kHz—capable of propagation over immense distances in all directions. These low frequencies coincide with the frequencies used, in particular, by baleen whales, fish, seals, sea lions and dolphins for communication and other biologically important activities. Ships generate sound primarily from the propeller and hull-mounted machinery. Over 90 percent of world trade is transported by ship, effectively



Photos: iStockphoto

Large vessels are the primary source of the rapidly rising level of ocean noise that falls within the frequency range some marine mammals and fish use to communicate. This interferes with their ability to interact and conduct essential biological functions, including finding food and mates and avoiding predators.

producing an ever-present and rising acoustic “fog” that masks crucial natural sounds and, along with seismic airguns, is the most pervasive source of ocean noise today. Most ships produce more noise the faster they go.

“The evidence of sonar causation [of whale beaching] is, in our opinion, completely convincing and...there is a serious issue of how best to avoid/minimize future beaching events.”

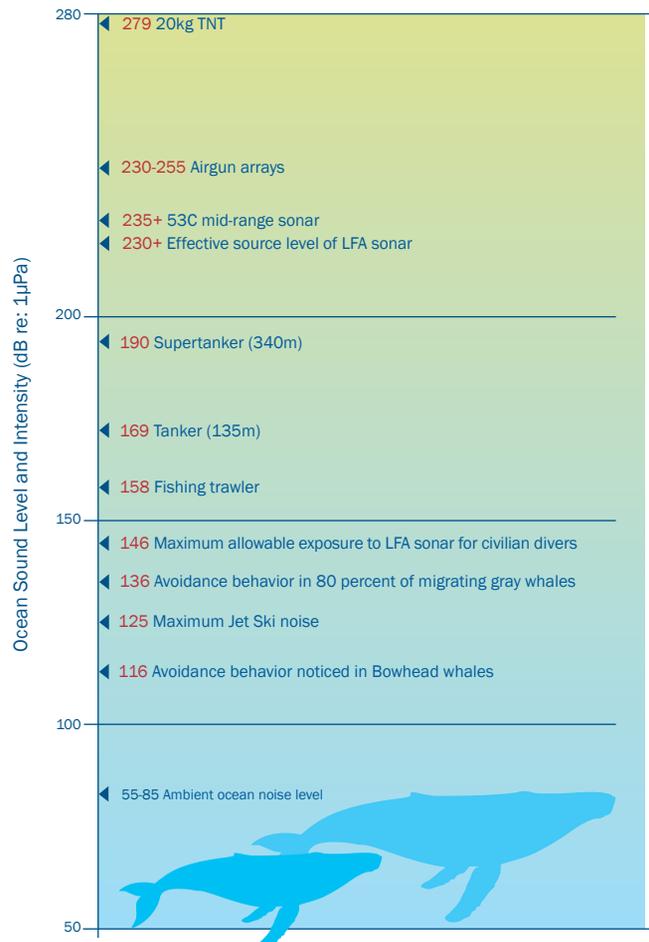
— Active Sonar Waveform, JSR-03-200, June 2004, under commission by the U.S. Office of Naval Research

Anthropogenic Ocean Noise is **LOUD**

Sound energy is measured in decibels (dB) relative to the threshold of human hearing. The decibel scale is logarithmic, which means 20dB is not twice as loud as 10dB, but 10 times

more sound energy, and 30dB is 100 times more. In the table below, the supertanker produces over 100 times more sound energy than the tanker.

Comparative Scale of Known Ocean Noises and Their Noise Levels



A Growing International Consensus on Regulating Ocean Noise

Although noise is a recognized form of pollution, sources of noise in the marine environment are not regulated at an international level. Recently, however, international institutions have begun to recognize the threat it poses to marine life and have been calling for precaution in the use of anthropogenic ocean noise.

The United Nations (UN) Convention on the Law of the Sea (UNCLOS) is the most far-reaching treaty governing the global marine environment, and it has been partially adopted into common law. UNCLOS already provides a solid basis for treating harmful, human-generated noise as a form of pollution that must be reduced and controlled. The agreement defines the term “pollution” as “the introduction by man, directly or indirectly, of substances or energy into the marine environment..., which results or is likely to result in such deleterious effects as harm to living resources.” (Art. 1(1) (4)).

AGREEMENT ON THE CONSERVATION OF SMALL CETACEANS OF THE BALTIC AND NORTH SEAS (ASCOBANS)

ASCOBANS’ 1994 Conservation and Management Plan set forth mandatory conservation measures

to be applied to cetaceans. In 2003 a resolution requested parties to take steps to reduce the impact of noise on cetaceans from seismic surveys, military activities, shipping vessels, acoustic harassment devices and other acoustic disturbances. In 2006 ASCOBANS passed a second resolution on ocean noise, requesting that member states, inter alia, introduce guidelines on measures and procedures for seismic surveys and develop effective mitigation measures to reduce disturbance of, and potential physical damage to, small cetaceans. In 2009 it passed a resolution to mitigate adverse effects from noise generated by offshore renewable energy construction projects and in 2010 established an intersessional correspondence working group, to inter alia, draft noise guidelines for specific noise sources.

INTERNATIONAL WHALING COMMISSION (IWC)

The Scientific Committee of the IWC, at its 2004 meeting, stated that there is compelling evidence implicating anthropogenic sound as a potential threat to marine mammals, at both regional and ocean-scale levels, that could impact populations of animals. The body has consistently called for



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multinational cooperation to monitor ocean noise, and to develop basin-scale and regional noise budgets. Noise has been included in the body's work since then, including as a priority issue for cetacean research.

THE EUROPEAN PARLIAMENT AND EUROPEAN UNION

The European Parliament adopted a resolution in 2004 calling on member states to take urgent action to restrict the use of high-intensity sonar in waters under their jurisdiction until a global assessment of such sonar's cumulative environmental impact on marine mammals, fish and other marine life had been completed. In 2008 the EU took up the issue with its Marine Strategy Framework Directive, representing the first international legal instrument to explicitly include

man-made underwater noise within the definition of pollution (Article 3 (8)). The Directive lists "the introduction of energy, including underwater noise, at levels that do not adversely affect the marine environment" among the criteria to achieve Good Environmental Status (Annex I (11)) by 2020. Commission Decision 2010/477/EU(2) identified low and mid-frequency impulsive sound and continuous low frequency sound as potentially impactful on marine mammals and other marine life.

AGREEMENT ON THE CONSERVATION OF CETACEANS OF THE BLACK SEA, MEDITERRANEAN SEA AND CONTIGUOUS ATLANTIC AREA (ACCOBAMS)

A 2004 resolution recognized man-made ocean noise as a dangerous

pollutant that can disturb, injure and kill whales and other marine species. It called on member nations to avoid use of anthropogenic noise in certain areas, to research the issue, including on alternative technologies; and to require the use of best available control technologies and other mitigation measures, in order to reduce adverse impacts. A subsequent resolution adopted in 2007 established a working group to develop tools to assess noise impacts on cetaceans and mitigation measures, while urging parties to adhere to a set of principles to reduce noise impacts. In 2010 a third resolution promulgated guidelines to address noise impact on cetaceans in the ACCOBAMS area and a working group was formed to address mitigation of ocean noise impacts.

UNITED NATIONS

Since 2005, at successive meetings relating to oceans and the law of the sea, noise has been discussed as a threat to the marine environment. In his 2005 report to the General Assembly, the UN Secretary General listed anthropogenic underwater noise as one of five "current major threats to some populations of whales and other cetaceans," and included noise as one of the 10 "main current and foreseeable impacts on marine biodiversity" on the high seas.

The General Assembly (GA) has passed successive resolutions to address noise, encouraging "further studies and consideration of the

impacts of ocean noise on marine living resources" (2005, 2006 and 2007), and "requesting the Division [DOALOS] to compile the peer-reviewed scientific studies it receives from member states [and IGOs in 2009] and to make them available on its website" (2006, 2007, 2008 and 2009). In 2010, 2011 and 2012 the GA Oceans resolutions noted underwater noise as a potential threat to living marine resources and affirmed the importance of sound scientific studies in addressing the issue, while the GA Fisheries resolutions for those years encouraged further studies, including by the FAO, on the impacts of underwater noise on fish stocks and fishing catch rates.

INTERNATIONAL MARITIME ORGANIZATION

The IMO recognized the harmful effects of ship-generated ocean noise at the 57th meeting of its Marine Environment and Protection Committee. The issue was later given a dedicated agenda item and work program to develop technical guidelines on ship-quieting technologies as well as potential navigation and operational practices. At the 2010 meeting, an agreement was reached to continue the work and develop a draft guidance document "to reduce the adverse impact of ships' noise," and in 2012 an agreement was reached on the need for technical guidelines designed to reduce the incidental introduction of underwater noise from commercial shipping."

Actions Needed

CONVENTION ON BIOLOGICAL DIVERSITY

The 10th Conference of the Parties to the CBD in Nagoya, Japan, recognized underwater noise as an issue that has advanced beyond consideration merely as a “new and emerging issue,” and requested its Secretariat to compile and synthesize scientific information on anthropogenic underwater noise and its impacts on marine and coastal biodiversity and habitats. The synthesis report was welcomed at the 11th Conference of the Parties in Hyderabad, India. At this Conference, it was noted that anthropogenic noise may have both short- and long-term negative consequences for marine animals and other biota in the marine environment, that this issue is predicted to increase in significance, and that uncontrolled increases in anthropogenic noise could add further stress to oceanic biota. Parties, other governments and relevant organizations were encouraged, according to their priorities, to take measures to minimize the significant adverse impacts of underwater noise on marine biodiversity, including the full range of best available technologies and best environmental practices where appropriate and needed, drawing upon existing guidance.

Because ocean noise is a form of pollution that knows no boundaries, nations must act together to protect marine living resources and ecosystems from its damaging effects. We call upon States, Intergovernmental Organizations and Non-governmental Organizations to work together to do the following:

FURTHER RECOGNIZE THE PROBLEM OF ANTHROPOGENIC OCEAN NOISE WITHIN THE CONTEXT OF

- the United Nations General Assembly;
- Regional Seas Conventions;
- other multilateral environmental agreements and organizations; and
- national environmental policy making.

ASSESS THE IMPACTS OF OCEAN NOISE

- in general, by establishing or continuing relevant bodies such as the UN Expert Groups, to ensure that potentially harmful human activities, including anthropogenic ocean noise, are subject to Environmental Impact Assessments that address cumulative and synergistic

effects on marine biodiversity; and

- on fisheries by requesting appropriate agencies, such as the FAO Fisheries and Aquaculture Department, conduct studies on the socioeconomic effects of noise related impacts on commercial fisheries and local fishing communities.

WORK TOWARD REDUCING/ELIMINATING IMPACTS OF ANTHROPOGENIC OCEAN NOISE

- by applying the Precautionary Approach to ensure that ocean noise levels are not harmful for marine life and humans;
- by developing effective guidelines to mitigate or eliminate intense noise producing activities in critical habitats, including biosphere preserves, UNESCO Marine World Heritage Sites and Marine Protected Areas; and
- by considering and adopting all measures necessary to prevent, reduce and control ocean noise pollution in the marine environment.
- Such measures could include seismic operators being

required to phase in Marine Vibroseis to replace airguns, following environmental impact assessments; ships being required to monitor their own noise using hull-mounted sensors to learn how maintenance and operation affects their underwater noise output; new ships being designed and built with underwater radiated noise in mind, preferably using model basins, optimizing the hull with the propeller to create the most uniform wake field; navies being required to train in ocean deserts, away from areas rich in life, with research carried out beforehand to identify and confirm they are unproductive areas; and regional areas being coordinated to stay under a regional noise budget to safeguard marine life.

This call for international regulation of ocean noise is expressed by over 150 NGOs across the globe represented by:

EUROPEAN COALITION FOR SILENT OCEANS (ECSO)

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