

**Aquatic Noise Pollution: Potential Concerns for Prince William Sound and
the Gulf of Alaska**

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Introduction

The presence of the Alyeska marine terminal at Port of Valdez and the associated oil tanker traffic generates a variety of environmental concerns. Previously overlooked are the potential dangers of underwater noise on marine wildlife in areas with high concentrations of tankers and other boat traffic such as Prince William Sound (PWS) and the Gulf of Alaska (GOA). However, an increasing amount of attention has been given to this issue, with literature now appearing in numerous studies, reports, and websites of environmental organizations. The primary goal of this project is to detail existing concerns regarding underwater noise pollution, to offer an overview of current scientific knowledge on the topic, and to show that further research must be conducted in order to establish the need for corrective action.

Existing Concerns

In March 1999, the Natural Resources Defense Council (NRDC) released “Sounding the Depths: Supertankers, Sonar, and the Rise of Undersea Noise,” which sparked concern on the topic amongst several other environmental organizations such as the Sierra Club and Greenpeace. The report asserts that the ocean can no longer be viewed as a “silent world,” but should be seen as “an exceptionally noisy place.” It further emphasizes that the “advent of the global economy” has caused the cumulative noise from increased shipping traffic to “dominate the lower frequencies in many regions of the world.” This poses a serious risk to whales, dolphins, and other marine organisms which utilize those same low frequencies to “hunt for food, detect predators, find mates, and keep their herds together in dark seas.” However, despite growing interest in aquatic noise pollution, the government has not played a significant role in investigation or regulation.

Major Studies

Scripps Acoustic Thermometry Ocean Climate Project (ATOC)/Marine Mammals Research Project (MMRP)

The \$40 million acoustic thermometry of ocean climate program of the Scripps Institution of Oceanography in La Jolla, California hopes to capitalize on the fact that sound travels through cold water faster than through warmer water. By tracking the variations in the time required for a 75 Hz tone (within the hearing range of many marine mammals) to travel from a sonar transmitter in California to a receiver 6,000 miles away, the ATOC program can begin to plot the changes in ocean temperature over time. Testing of the Navy’s Low-Frequency Active Sonar (LFAS) began in the Pacific Ocean, off the coast of Hawaii, in conjunction with the ATOC project. As opposed to passive sonar, which simply listens for

unnatural sounds, active sonar produces a low-frequency signal (between 75 and 1,000 Hz) to create echoes off of hostile submarines. These signals, which would cover vast tracts of ocean, are to be produced at 230 decibels (dB), well above the noise level of a jet engine (120 dB). However, such tests did not encounter national scrutiny until further testing sites were proposed near the National Marine Sanctuary on Monterey Bay. The Navy ultimately acknowledged the potential dangers to marine life and abandoned the Monterey Bay project.

Concern for marine mammals by environmental groups led ATOC to set up a sister program, the Marine Mammal Research Program, to monitor ATOC's effects. Dr. Christopher Clark of Cornell University's Bioacoustic Research Program is leading the MMRP to try to determine the hearing capabilities of marine mammals and sea turtles, and to measure their response to man-made sounds. The MMRP's six-month summary report claims, "In all types of data collection programs...no significant effects on marine animal abundance or distribution as a result of ATOC transmissions have occurred."

Navy Sonar Testing Affecting Marine Mammals in the Bahamas

Several of the rare Cuvier's beaked whales were found beached on the shores of the Bahamas after being exposed to U.S. naval sonar testing. It was subsequently hypothesized that such equipment caused disorientation and confusion in the whales. Government scientists later confirmed that a type of Navy sonar was likely responsible for the mass stranding of beaked whales in the Bahamas in March 2000. Necropsies showed six whales died from hemorrhaging around the brain and ear bones, presumably from intense internal vibrations caused by bursts of mid-frequency sound waves. Environmentalists have pointed to that case as proof that high-power sonar systems can disorient and kill whales. "It is undeniable evidence of just how dangerous and unpredictable intense sound can be in the ocean," claimed Joel Reynolds, senior attorney of the NRDC. The Navy is trying to persuade the fisheries service that the low-frequency active sonar can be operated without significant danger to sea creatures. However, a National Marine Fisheries Service and Navy joint investigation established with virtual certainty a connection between the strandings and the use of sonar as well as that active-sonar systems put out mid-frequency sound, which generally does not travel as far as LFAS.

Delaware Bay Project

In coordination with the marine studies program of the University of Delaware, the Office of Naval Research applied to the state governments of Delaware and New Jersey for permission to conduct a 165-decibel test seven miles from Fourteen Foot Bank Lighthouse. Associate Professor Mohsen Baidey, the experiment's coordinator, said the research is aimed at learning about the physics of underwater sound and that it could perhaps be used to monitor the bay's health. The Delaware Department of Natural Resources and Environmental Control approved the experiment, though not New Jersey's Department of Environmental Protection. Both states' approvals are required under the federal Coastal Zone Management Act of 1972. The test was allowed to continue in the fall of 2000 when fewer marine mammals were present in the bay. The results are still being analyzed.

Durlston Bay Marine Project

Intermittent surveys have been carried out since 1995, all of which aimed at monitoring the levels of underwater noise that are damaging to marine wildlife. The Durlston Marine Research Area is home to the world's first permanent hydrophone (underwater microphone). The instrument, which lies 400m offshore under 12m of water, has recorded high levels of ultrasonic interference.

Gulf of Mexico Sperm Whale Research

A 1999 workshop on cetaceans in the Gulf of Mexico addressed the issue of underwater noise. On the recommendation of a panel of experts, The Mineral Management Service (MMS), which oversees the lease of oil deposits in U.S. waters, the National Marine Fisheries Service (NMFS), which makes regulations to protect endangered animals, and the Office of Naval Research (ONR) planned a four-year, \$4 million research program. The study is designed to measure underwater noise levels and attempt to determine how marine mammals are affected. MMS has funded numerous studies on the effects of oil and gas industry noise on whales in Alaska and Pacific waters, which should be reviewed for possible correlation to Prince William Sound and Gulf of Alaska application.

Newfoundland's Memorial University Testing

Dr. Jon Lien of Newfoundland's Memorial University has developed a localized underwater acoustical alarm to help North Atlantic commercial fishermen solve the problem of the unintentional by-catch of marine mammals, such as harbor porpoises. By attaching "pingers" to the nets of commercial fishing boats, marine mammals are alerted to the net's presence without scaring away targeted fish species such as cod. So far, the experiment has been successful. According to Dr. Lien, the data "overwhelmingly indicated that the devices worked to reduce by-catch." The ratio of marine mammal by-catch in unalarmed nets to alarmed nets was 20 to 1.

Icebreaker Noise Simulation

In a 2000 study on the effects of noise on beluga whales of the Arctic, Christine Erbe of the Institute of Ocean Sciences (IOS) in Sidney, British Columbia, said, "Since the industrialization of the Arctic, the beluga's habitat has become very noisy." Erbe hopes her simulation software might be used by scientists to study broader noise effects on sea mammals. Erbe and her colleagues fed the data into a computer simulation they developed that mimics the beluga's hearing. They found that the vessels are noisy enough to mask beluga communications, inducing behavioral changes almost 14 kilometers from the icebreaker. If the disturbance affects behavior such as mating, nursing, or feeding, the animals may be "permanently scared away from critical habitat." The simulation suggests that hearing damage can occur after 20 minutes of exposure to the sound up to 4 kilometers away. By analyzing long-range effects of noise patterns, the IOS hopes to advise icebreaker operators, oilrigs, and ocean dredgers on ways to alleviate noise at crucial times.

Navy seeks exemption from Marine Mammal Protection Act (April 25, 2001)

The U.S. Navy is requesting exemption from a federal law that forbids harassing or killing whales as it begins exercises with powerful new sonar designed to hunt for "super-quiet" submarines. Three hearings will be held around the United States conducted by the National Marine Fisheries Service. Joe Johnson, a Navy sonar engineer in charge of environmental studies on low-frequency sonar, said the Navy is seeking exclusion from the Marine Mammal Protection Act due to the law's ban on harassing whales - not the ban on whale deaths. To avoid more significant harm, Navy officials promise to use shipboard observers and fish-finding sonar to ensure that no marine mammals or sea turtles are within a kilometer of a sonar broadcast. Should a whale come too close, the sonar would be shut off, according to the proposal.

Recommended Course of Action

Until further scientific studies positively conclude that underwater ultrasonic noise is a valid concern, it seems that specific preventative actions need not be taken. Accordingly, research must begin immediately to conclusively determine both short-term and long-term effects of aquatic noise pollution so as not to inflict an irreparable amount of harm to the ecosystem. Should future investigation point to the necessity for reform of the industry, it must be recognized that legislative action has its limitations. It should be noted, however, that U.S. law restrains only domestic ships and foreign vessels within the twelve nautical miles of territorial waters. Tankers entering the Port of Valdez require domestic ownership; thus, legislation to protect PWS is viable.

Although the Marine Mammal Protection Act (MMPA) of 1972 affords general protection to aquatic wildlife, no legal precedents or statutes exist for the sole purpose of protecting marine wildlife from aquatic noise pollution. The most significant portion of this act is a moratorium on harassing, hunting, capturing, or killing any marine mammal. If an organization is in danger of potentially violating the regulations set forth by the MMPA, one must obtain a permit from the National Marine Fisheries Service (NMFS). Until recent years, few argued that any underwater noise caused a hindrance to marine life. Unfortunately, permits are given and received with relative ease, allowing many organizations to operate under potentially harmful acoustic levels. This policy has most recently encountered scrutiny after the April 2001 application by the U.S. Navy to continue LFAS testing off the Hawaiian Islands.

Obviously, the principle perpetrator of potential noise pollution in PWS and the GOA is the shipping industry. However, while some underwater noise is unavoidable, it can be decreased. Cavitation, the process by which a hiss is produced through the rupturing of water around the propeller blades, can be minimized through proper maintenance of propeller components. Similarly, thoroughly monitoring the extent of engine vibration would limit the noise produced from hull vibration, significantly decreasing the low-frequency sound waves. Implementation of this technology developed by the U.S. Navy for quieter ships can be applied to industry designs and engineering.

The cumulative sound of a multitude of ships, as found in PWS and the GOA, accounts for a substantial amount of underwater noise. Yet, until intensive studies are conducted, it is unclear the impact upon marine animals in PWS and the GOA. Further research is needed to establish that such noise inflicts a negative impact on the environment.

Literature Review

Congressional/Governmental Studies

Department of Commerce (DOC). 1995. "Small Takes of Marine Mammals; Harassment Takings Incidental to Specified Activities." Federal Register 60(104):28379-28286.

Department of Commerce (DOC). 1996. "Small Takes of Marine Mammals; Harassment Takings Incidental to Specified Activities in Arctic Waters; Regulation Consolidation; Update of Office Management and Budget (OMB) Approval Numbers." Federal Register 61(70):15884-15891.

General Accounting Office (GAO). 27 September 2000. "Aviation and the Environment: Federally Authorized Funding for Noise-Related Projects." RCED-00-285R.

Demonstrates that funding for noise-related studies exists in other areas. This report is a manifestation of such attention to noise control, as it determines the total historical funding of noise-related projects through both the Airport Improvement Program (AIP) and the Passenger Facility Charge program by the Federal Aviation Administration (FAA).

National Research Council (NRC). 1994. "Low-frequency Sound and Marine Mammals: Current Knowledge and Research Needs." Washington DC. p. 97.

National Research Council (NRC). 1996. "Marine Mammals and Low Frequency Sound: Progress Since 1994: An Interim Report." Washington DC. p. 26.

Academic Studies

Brodie, P.F. 1981. "Energetic and Behavioral Considerations with Respect to Marine Mammals and Disturbance from Underwater Noise." Peterson, N.M. ed.; Arctic Pilot Proj., Calgary, Alb. p. 287-290.

This article looks begins to ask questions concerning the effects of underwater noise on marine mammal, using Arctic icebreakers as the example of human activity.

Clark, C.W. 1993. "Application for Permit for Scientific Research under the Marine Mammal Protection Act, and for Scientific Purposes under the Endangered Species Act. Permit for Acoustic Thermometry of Ocean Climate (ATOC) Marine Mammal Research Program by Scripps Institute of Oceanography, Institutes for Geophysics and Planetary Physics, Acoustics Thermometry of Ocean Climate Program." La Jolla, CA.

Cosens, S.E. and L.P. Dueck. 1993. "Icebreaker noise in Lancaster Sound, N.W.T., Canada: Implications for Marine Mammal Behavior." *Marine Mammal Science* 9: 285-300.

Indicates that high-frequency noise generated by Arctic ice-breakers can be detected by belugas and narwhals up to 30 km from the source. Argues that this explain why belugas and narwhals react to ships at longer distances than do other stocks of arctic whales.

Frings, H. and M. Frings. 1967. "Underwater sound fields and behavior of marine invertebrates." Tavolga W.N. ed. *Marine Bio-Acoustics*. Oxford, U.K. Pergamon Press. p. 261-282.

Greene, C.R. Jr., 1991. *Ambient Noise*. Chapter 4, "Effects of Noise on Marine Mammals." Report 90-0093. Prepared by LGL Ecological Research Associates under contract No. 14-12-0001-30362 for the U.S. Department of Interior, mineral Management Service, Herdon, VA.

Johnson, C.S. 1967. "Sound Detection Thresholds in Marine Mammals." p.247-260 W.N. Tavolga, ed. *Marine Bioacoustics*. Vol. 2 Pergamon Press, New York.

By a behavioral response method, an audiogram for a bottlenosed porpoise was obtained over a frequency range from 75 Hz to 150 kHz. Maximum sensitivity was found at about 50 kHz.

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack and J.E. Bird. 1983-1989. "Investigations of the Potential Effects of Underwater Noise from Petroleum Industry Activities on Migrating Gray Whale Behavior." BBN Rep. 5633. Report from Bolt, Beranek and Newman, Inc. Cambridge, MA, for U.S. Minerals Management Service, Anchorage, AK. NTIS PB-8617474.

Describes an experimental investigation of the behavioral response of migrating gray whales to sounds associated with oil and gas exploration and development activities. Study indicates behavior is altered by noise originating from methods used for oil and gas exploration.

Malme, C.I., P.R. Miles, C.W. Miller, W.J. Richardson, D.G. Roseneau, D.H. Thomson and C.R. Greene, Jr. 1989. "Analysis and Ranking of the Acoustic Disturbance Potential of Petroleum Industry Activities and Other Sources of Noise in the Environment of Marine Mammals in Alaska." BBN Report 6945; OCS Study MMS 89-0006. Report from BBN Systems and Technology Corporation, Cambridge, MA, for U.S. Mineral Management Service, Anchorage, AK. NTIS PB90-188673.

Compares the relative magnitudes and effects on marine mammals of noise from oil and gas industry activities with noise from other sources in Alaska, USA, outer continental shelf and coastal waters. Information on species sound production, hearing sensitivity (when known), and observed responses to noise sources is also included.

Myrberg, A.A. 1978. "Ocean Noise and Behavior of Marine Animals: Relationships and Implications. Fletcher, J.L. and R.G. Busnel, eds. *Effects of Noise on Wildlife*. Academic Press, New York. p. 169-208.

Article addressing the positive and negative effects of natural and artificial noise on marine animals. Found in a reference book containing various articles on the effects of sound in a variety of animals.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and P.H. Thomson. 1995. Marine Mammals and Noise. Academic Press, San Diego, CA. 576p.

An excellent reference source containing several sections dealing with man-made noises such as dredging, oil and gas drilling, sonar, explosions, and transportation noise.

Stewart, B.S., F.T. Awbrey, and W.E. Evans. 1983. "Beluga Whale Responses to Industrial Noise in Nashagak Bay, Alaska." NOAA/OCSEAO, Environmental Assessment Alaskan Cont. Shelf, Final Rep. Prin. Invest. 43(1986):587-616. NTIS PB87-1912118.

Stewart, B.S., W.E. Evans, and F.T. Awbrey. 1982. "Effects of Man-made Waterborne Noise on Behavior of Beluga Whales in Bristol Bay, Alaska. Hubbs/ Sea World Research Institute Report 82-145.

Suzuki, H., E. Hamada, K. Saito, Y. Maniwa, and Y. Shirai. 1980. "The Influence of Underwater Sound on Marine Organisms." *Journal of Navigation*, 33:291-295.

Describes measurement and analysis of ship-produced underwater sound and its effect on the behavior of marine life. Concludes that sound on marine organisms is a growing problem and should not be ignored by navigators, as it can frighten marine wildlife or cause changes in migration routes.

Swartz, R.L., and R.J. Hofman. 1991. "Marine Mammal and Habitat Monitoring: Requirements, Principles, Needs, and Approaches." Report prepared for Marine Mammal Commission. NTIS PB91-215046.

News and Journal Reports

"Caribbean Whale Strandings Linked to Navy Activities." Susan Soltero, *Environmental News Service*. 11 May 2000.

Article covering concerns of various environmental and animal groups which note Navy ultrasonic sonar's potential to "destroy the vital organs and tissue of marine mammals and to deafen, disorient, and disturb marine mammals."

"Groups Fight Navy's Low-Frequency Sonar." *Environmental News Network*. 16 April 1998. <http://www.cnn.com/EARTH/9804/16/whales.sonar/index.html>

Article arguing against Navy's use of LFAS testing. Tests conducted by University of Athens, Greece in the Kyparissiakos Gulf in the Ionian Sea in 1996, which resulted in 12 beached whales, used to justify viewpoints.

"Impact of Underwater Noise: How Sensitive are the Ears of Marine Life?" *Environmental News Network*. 27 July 1999. http://www.enn.com/news/enn-stories/1999/07/072799/oceanoise_4577.asp

Article focusing on general concern regarding underwater noise pollution as based on an uncited report from the Naval Research Marine Mammal Science Program.

“Louder is Not Better!” William Rossiter, Whales Alive! Vol. IX, No. 4, October 2000, Cetacean Society International. <http://elfi.com/csi00408.html>

Opinion journal entry which raises ethical considerations for conducting tests with Low-Frequency Active Sonar. Characterizes tests as dangerous to marine mammals.

“Low-Frequency Sonar Noises Whale Advocates’ Hackles”: Part 1; “Marine Mammal Facts Just Drops in the Bucket”: Part 2; “Is Spreading Sonar Smart Science or Overkill?”: Part 3. Stephanie Siegel. 30 June 1999 to 2 July 1999. <http://www.cnn.com/NATURE/9906/30/sea.noise.part1/>

Comprehensive report covering history and current issues surrounding Low-Frequency Active Sonar. Gives arguments for and against use of such equipment.

“Navy’s Loud Ocean Sensor Draws Intense Objections.” Environmental News Service. 02 May 2001. <http://ens-news.com/ens/may2001/2001L-05-02-05.html>

Article outlining actual process of Navy’s testing of Low Frequency Active sonar. Attention given to Navy’s request for permission from National Marine Fisheries Service to “harass, injure, or kill” marine mammals as a consequence of deploying system. Also addresses concerns of protest groups.

“New Concerns about the Impact of Noise in Oceans: ‘Acoustic Smog’ a Danger to Sea Mammals?” John D. Cox, The Sacramento Bee. 29 June 1999.

Article concurring with NRDC report (“Sounding the Depths...”), warning against dangers of flooding oceans with “unnecessary sound clutter.”

“U.S. Navy Cancels Tests Believed to Harm Marine Mammals.” Environmental News Service. 29 May 2000.

Explores implications of and reasoning behind Navy’s first –ever decision to cancel submarine detection tests which use loud ultrasonic noises. Cancellations were made after fears raised about negative impact on marine wildlife.

“Whale Deaths Linked to Noise- Naval Role Unclear.” San Francisco Chronicle. 15 June 2000.

Coverage of concession of Assistant Secretary of Navy, Robert Pirie Jr., that recent Bahamas stranding of beaked whales near Navy operations sites were “unusual and significant” events. Further, article notes his promise that Navy would “reassess” its use of ultrasonic sonar if such equipment was proven to cause trauma in whales.

Related Organizations

Acoustical Society of America. <http://asa.aip.org>

Comprised of specialists and experts in field of acoustics in relation to both humans and animals. Members are responsible for many of the selected studies and articles. Also publish journal in which results of study regarding physiological effects of infrasonic noise on captive fish appeared. Study concluded that fish might not be able to adapt to ocean noise which occurs at high levels and for extended periods of time. Also revealed that fish might not be able to adapt to such noise, showing undesirable physiological effects such as lowered growth rate and hormone deficiencies.

American Society of Mammalogists. <http://www.mammalsociety.org/>

Established in 1919 for the purpose of promoting the study of mammals. Most members are professional scientists that are involved in providing information for public policy, resources management, conservation, and education. Also hosts annual meetings and maintains several publications. Its Marine Mammals Committee designed experiments in 1997 and 1998 to evaluate the potential impact of the U.S. Navy’s LFAS on marine mammals. Published 1998 report noting an “unusual stranding of beaked whales in the Mediterranean” near site of operation of a LFA sonar owned by the Italian Navy.

Animal Behavior Society. <http://www.animalbehavior.org/>

Non-profit scientific society and parent organization of Center to Study Human-Animal Relationships and Environments (CENSHARE). CENSHARE serves as an umbrella organization for a multitude of private and public agencies, including political bodies, humane societies, animal welfare and rights organizations, veterinarians, and others.

Cetacean Society International. <http://elfnet1a.elfi.com/csihome.html#contents977>

Non-profit society is dedicated to the protection of all cetaceans and the marine environment. Ardently opposes use of LFAS, arguing that such devices are unnecessary and harmful to marine life.

Humane Society of the United States.

<http://hsus.org/programs/wildlife/news/lfasonaralert042301.html>

Produced recent news brief regarding dangers of underwater noise and how informed citizens can speak out against this.

LGL Limited Environmental Research Associates. www.lgl.com/~lgl/homepage.html

Firm offers expertise in environmental research, including the field of aquatic noise pollution. Independent organization that has conducted studies examining the effects of underwater noise on specific ecosystems.

Marine Conservation Biology Institute (MCBI). <http://www.mcbi.org/>

Organization dedicated to safeguarding life in the sea by advancing the multidisciplinary science of marine conservation biology. Attempted to ensure that a significant portion of the trust funds established through reparations paid by Exxon after the *Exxon-Valdez* spill be used for continued research and monitoring in the marine environment in the Gulf of Alaska.

Marine Mammal Commission. <http://www.federalregister.com/hpages/mmc.html>

Reported to Congress in 1998 the dangers of LFAS on marine species worldwide, including ear and lung damage, temporary hearing loss, disorientation, violent or aggressive behavior, movement away from migration routes, inability to hear quieter sounds such as prey or predators, and changes in breathing rate.

Marine Mammal Research Program (MMRP). http://atoc.ucsd.edu/MMRP_page.html

Designed to study effects of the ATOC on marine mammals in the study area. However, study is under attack for its lack of plans to examine long-range results and for the small amount of data it used. Also, study did not include all areas effected by low-frequency sonar, which is known to travel great distances underwater.

National Council of Acoustical Consultants. <http://www.ncac.com/>

Professional organization whose members consult on sound, noise vibration, and hearing to architects, engineers, and attorneys. Mission statement is to enhance "...the stature and effectiveness of the acoustical consulting profession for the mutual benefit of the member firms and the public they serve."

The National Research Council. <http://www.nas.edu/nrc/>

Has become primary operating agency of National Academy of Sciences and National Academy of Engineering in providing services to the government and the public. Its Committee on Low Frequency Sound and Marine Mammals, established under its Ocean Studies Board, was formed to review the current state of knowledge and ongoing research on the effects of low-frequency sound on marine mammals. In their 1994 report, they stated their recommendation that "an accelerated program of scientific studies of the acoustic effects on marine mammals and their major prey be taken.

Noise Control Engineering, Inc. <http://www.noise-control.com/>

Small business which has capabilities to detail design of noise control treatments, testing, and monitoring" in the areas of marine, industry, environment, architecture, and transportation. Currently a team member for Integrated Product Team put together by Lockheed/Martin.

Office of Naval Research. <http://www.onr.navy.mil/>

Renders technical advice to Chief of Naval Operations and Secretary of the Navy. Currently working on research related to the effects of LFAS use.

Ocean Mammal Institute. <http://www.oceanmammalinst.org/>

Collects data on the impact of human marine activities on whales and dolphins. Results are used to develop guidelines to protect these marine mammals. Organization has actively requested supporters and members to attend one of three public hearings and to write their elected representatives to deny the Navy the use of its LFAS.

Popper Laboratory- Aquatic Bioacoustics Laboratory, Department of Biology, University of Maryland. <http://www.life.umd.edu/biology/popperlab/>

Primarily involved in the study of hearing by aquatic organisms. Most work in laboratory focuses on various aspects of hearing in fishes that range from behavioral investigations to determine what an animal can hear to physiology investigations of the responses of the ear and brain. Investigations range from basic questions concerning evolution and mechanisms of sound detection to very applied studies on the effects of human-made sounds.

Quiet Sea Coalition. <http://www.maui.net/~mailbot/quietsea.html>

Comprised of citizens and organizations from the international community who support reduction and regulation of underwater noise, yet who also support “unbiased research” on the effects of such noise on marine wildlife.

Scripps Acoustic Thermometry of Ocean Climate (ATOC). <http://atoc.ucsd.edu/>

Four- year, \$40 million feasibility study funded by the Strategic Environmental Research and Development Program (SERDP) to the University of California. Source of much controversy surrounding debates over LFAS testing. Performed sonar testing in areas near Hawaiian Islands and proposed study off of the Monterey Bay National Marine Sanctuary in California.