Ocean Noise: What We Learned in 2006

An Acoustic Ecology Institute Spotlight Report

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The oceans contain over 80% of the earth's total volume of habitat; because of limited light penetration, many ocean species rely heavily on sound for navigation, finding food, and maintaining group relationships. For decades, human activity has been increasing the noise levels in the oceans; over the past few years, we have begun to pause and consider the effects of our sounds on ocean life. The oil and gas industry, navies of the world, and field biologists are all putting more time and money into these questions than ever before. Here's what was learned in 2006.

Summary

Over the course of the past year, ocean noise has continued to attract increased attention from researchers, regulators, and the public. While media attention has focused on the loudest (yet least common) noise source, Naval active sonars, regulators and environmental advocates have begun addressing seismic surveys, which are nearly as loud and far more widespread. Meanwhile, the dominant source of human-made ocean noise, shipping, is just beginning to be considered, and researchers are raising potentially far-reaching alarms about the effects of chronic exposure to moderate noise.

Among the key developments this year:

- The failure of the 2-year Marine Mammal Commission Advisory Committee on Acoustic Impacts on Marine Mammals to agree on a consensus report, followed by the release of detailed statements by most of the participants
- An International Whaling Commission workshop on the noise effects of seismic surveys
- Navy planning for mid-frequency active sonar training ranges and expanded deployment of low-frequency active sonar

Also of special note are the following:

- US Chamber of Shipping encouraged collaborative effort aimed at long-term reductions in ship noise
- NMFS for the first time set a noise mitigation standard low enough to protect bowhead whales from behavioral disruption, not just physiological injury

Perhaps the most groundbreaking development of the year, however, was the widespread acknowledgement that **chronic exposure to moderate levels of noise is likely to be causing more significant biological impacts than occasional exposures to extremely loud noise.** Rising ambient background noise levels are suspected to cause masking of communication and navigation calls, as well as increased stress. Meanwhile, avoidance of boats and seismic surveys at distances where the noise is audible but not harmful lead to modest but repeated behavioral disruptions. This year, several studies and reports stressed the likelihood that these subtle effects are accumulating enough to cause population-level impacts.

This report will provide a concise look at what we learned about ocean noise during 2006, as well as a look ahead at 2007. Links are provided to more detailed, topical Special Reports and regularly updated resources available on the Acoustic Ecology Institute website.

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Moderate Noise

We'll start at the least "sexy" end of the spectrum, because this is where the ocean noise landscape is changing the fastest. While it can be difficult to take noise seriously as a major threat to ocean habitats that are struggling under an onslaught of destructive fishing practices, toxic river run-off, and warming seas, it is altogether possible that rising ocean noise is playing a systemic role as important as many of these better-known threats. The effects of noise-induced stress are of particular concern. A well-established body of research on terrestrial species has shown that stress makes animals dramatically more susceptible to disease, toxins, and other health threats (the synergistic effects of stress in combination with other threats is not trivial: in some studies, the percentage of a population affected by a toxin soared from 20% to 80% when the animals were stressed). Thus, especially in biologically sensitive areas, human noise could be making matters significantly worse in an already deeply disrupted environment.

In their statements to the **Marine Mammal Commission**, the Scientific Caucus (field researchers who participated in the Advisory Committee on Acoustic Impacts on Marine Mammals) and the Federal Caucus (agency staffers) both pointed out that short-term exposure to extreme noise sources is not the only issue at hand; they emphasized the pressing need to address chronic exposure to moderate noise, and to better understand the impacts of the rising levels of background ambient noise in the oceans. In particular, the Federal Caucus suggested that lower level chronic noise is more likely to cause population-level impacts, due to masking of communication and navigation signals. Similarly, the Federal Caucus listed as their first research priority a need to better assess the cumulative effects of multiple exposures that change behavior, combined with the effects of background noise. The MMC Advisory Committee's Environmental Caucus also addressed the rising background ambient noise issue, and further urged more attention to the effects of noise-induced stress, including effects on individuals and populations, including possible synergistic effects (by which increased noise-induced stress may make animals more susceptible to other health threats).

The ICES (**International Council for the Exploration of the Sea**, the oldest intergovernmental organization in the world concerned with marine and fisheries science) issued a report that stressed the need to address the impact of increasing ambient noise. The ICES is concerned that by inhibiting communication, rising ambient noise may affect the life history of cetaceans (including reproduction), stating that long-term impacts on populations "could be worse than direct killing" caused by fisheries by-catch or exposure to loud sounds.

Consideration of moderate noise impacts encompasses a wide range of noise sources. Some noise sources are only moderately noisy to begin with, such as smaller boats or, arguably, even large tankers; the impacts from these sources will be fairly localized (though in the case of shipping, shipping lanes and coastal areas can be subject to nearly constant ship noise). Likewise, offshore construction or wind farm noise is moderate to begin with. When we consider the moderate noise effects of louder noise sources, such as seismic survey airguns or naval sonars, it will mean watching for behavioral changes or induced stress over large areas. Finally, the gradual (but apparently rather steady) increase in overall background noise in the sea affects many coastal areas (where shipping is a large factor), and perhaps also open oceans (where long-range propagation of shipping and seismic survey noise may be occurring).

Several new field research studies addressed specific aspects of the impacts of moderate noise levels:

- For the first time, noise-induced stress was measured in fishes. This study looked at fresh-water river fish exposed to shipping noise, and found a doubling of cortisol, a key stress hormone, after thirty minutes of exposure to the ship noise. If this result is

replicated for other species, it could dramatically shift the debate about ocean noise, because of the role stress can play in exacerbating other health threats.

- A survey of literature on sound profiles and propagation of pile driving noise suggested that pile driving could mask (drown out) dolphin calls at ranges of several kilometers. Pile-driving is used to construct sturdy anchors for piers, bridges, and, increasingly, wind turbines. Pile-driving noise is loudest in frequency ranges that coincide with dolphin whistles (9kHz), and so are likely to mask whistles at ranges of up to 10-15km. Higher-frequency components of whistles can be masked up to 9km, and echolocation clicks for over one kilometer. These distances may be moderated somewhat by the fact that dolphins have directional hearing, and the noise is intermittent.
- An Australian study found that 75% of groups of traveling dolphins shifted to a "milling" behavior when a small powerboat came within 100 yards, then continued their travel after the boat passed by. The dolphins in this bay are exposed to regular boat traffic from commercial, military, and private boats; researchers noted, "As demonstrated in this study, a single anthropogenic event may cause a short-term disruption in dolphin behavior, and it is possible that an accumulation of these effects may lead ultimately to long-term changes. However, long-term cumulative effects of vessel noise remain to be determined."
- A number of similar studies of behavior changes triggered by nearby boats were presented in the IWC's annual State of the Cetacean Environment Report (SOCER). Researchers stressed that subtle behavioral changes could accumulate to cause population-level impacts over the long term; for example, Sini et al noted that "[s]hort-term interruptions of normal activity could have long-term adverse effects on a population of dolphins, through reductions in the time available for foraging or resting, abandonment of favoured habitats, disruption of social bonds, or through physiological effects of stress."
- A team of Dutch and British scientists investigating the effects of a new acoustic communication network to prevent ship collisions have proposed that the current regulatory standard of protection, which is based on preventing physiological injury (specifically exposure to sounds loud enough to cause temporary reduction in hearing sensitivity, or TTS/Temporary Threshold Shift) be replaced with a new standard based on "acoustic discomfort thresholds" or "discomfort zones." The discomfort standard would aim to minimize exposure to sounds that cause avoidance or other behavioral changes.
- A multi-year study of sperm whale dive patterns during exposure to airgun sounds found that foraging behaviors seem to be moderately reduced in sperm whales exposed to airgun sounds at ranges up to 13km.
- A new study found that wind farms add 80-110dB (re 1uPa) to the existing low-frequency ambient noise (under 400Hz); this could impact baleen whales communication and stress levels, and perhaps prey distribution.

Finally, two dramatic developments related to moderate ocean noise, one a groundbreaking regulatory shift, and the other a first step toward clarifying how widely seismic survey sounds are propagating into ocean basins:

> In the summer of 2006, the US National Marine Fisheries Service for the first time established a mitigation standard for seismic surveys that mandated airgun shut-down when bowhead whale cow and calf pairs are at distances where they would begin to avoid the sound, rather than only when they were close enough to be physically injured. The permit issued for surveys in the Chukchi Sea north of Alaska called for monitoring out to distances where airgun sounds had dissipated to 120dB; previous permits had set monitoring and "safety" zones only in areas where sound is 180dB or above (occasionally dropping to 160dB). Conoco challenged the 120dB standard as "arbitrary,"

and won a temporary restraining order, allowing it to proceed through the 2006 bowhead migration season without monitoring beyond the immediate vicinity of the seismic vessel. The NMFS is fighting the suit, joined by the Alaskan native community at Point Hope. NMFS maintains that the 120dB standard is appropriate; despite good recovery by bowheads, long-term population health requires minimizing stress on the especially sensitive cow-calf pairs, which have been shown to avoid even low-level airgun noise (see research paper noted below).

At the International Whaling Commission Scientific Committee workshop on seismic surveys, Chris Clark (Cornell) presented a paper suggesting that seismic survey activities produce very low frequency sound (under 100 Hz) that can ensonify large areas (10,000 square nautical miles) for considerable periods of time (weeks). Acoustic maps suggest that sound levels may reach thresholds at which fin whales stop singing during the surveys. (Note: this paper was based on sound propagation modeling, not direct measurements of sound at sea.) Clark noted that if one assumes that such intrusions of anthropogenic sounds into an animal's acoustic ecology are stressful, then these observations should be further considered within the context of synergistic effects from multiple stressors. The Committee asked Clark to synthesize and analyze existing data that he presented and make final results available for further consideration. The Committee further recommended that research be undertaken to quantify the degree of ensonification at large ranges, and give special consideration to impacts on areas of special biological concern.

Other New Field Research of Note

An infant Risso's dolphin was found to be much more sensitive to sound than adults of that species. At 100kHz, the infant could hear sounds 60dB quieter than the adult, and could also detect higher frequencies than adults have been known to hear. This could reflect age-related hearing loss (much as we routinely see in humans); it surely suggests that acoustic sensitivity data gathered using older and/or captive animals may be underestimating potential impacts of anthropogenic sound on this species.

A review of long-term data showed that North Atlantic Right whales have been changing their call patterns, likely in response to increasing ocean noise. On short time scales (minutes), both the fundamental and peak frequency of calls increase in the presence of elevated noise levels. On longer time scales (decades), the minimum and maximum frequency of a key whale call, the "upcall", have increased between the late 1950s and 2004; this increasing frequency has been gradually noted over decades. The North Atlantic Right whale upcalls are at a significantly higher frequency than the southern right whales' calls, which may be a result of differing ambient noise conditions in their environment. These results are significant, as they present evidence for a long-term, chronic behavioral change in the North Atlantic right whale calling behavior that may be a result of increased levels of anthropogenic noise.

Beaked whales were the subject of a rash of studies, since they are the family seemingly most affected by mid-frequency active sonar (most of the strandings associated with sonar exercises have involved beaked whales or other deep-diving relations). This year's studies clarified several possible reasons for their sensitivity. Most striking is that their normal dive patterns include slower ascents than descents: it is possible that sonar exposure triggers them to surface too quickly, causing the tissue hemorrhaging seen in beached victims. They also exhibit an unusual series of shallow dives between deep dives; it is possible that disruption of this re-acclimation period could make them more susceptible to injury on a subsequent dive. (for more details on these important studies, see the AEI Science Research page, linked below).

Seismic Surveys: Key New Findings and Developments

The IWC Scientific Committee workshop on seismic surveys noted several points of interest:

- The number of surveys peaked in the early to mid 1990's (100 crews active/month). While the numbers of surveys taking place now are on the rise (40 crews/month in 2004), they are not expected to reach earlier peaks.
- Recent studies confirm more higher-frequency components of airgun sound than previously assumed. Two studies are underway (NSF and industry) to measure horizontal propagation of high-frequency sounds.
- Bowhead whale studies offshore Alaska indicate that the whales are extremely sensitive to noise during migration. While feeding, they were routinely seen in areas where the received level would be 160-170dB (rms), but during migration they avoided seismic vessels by about 20km, rarely exposing themselves to more than 120dB (rms).
- A new industry-funded research initiative was announced. The program was formalized just days before the seismic workshop, and currently is funded with over 7 million dollars. Two research efforts are already settled upon: one to characterize the source sound spectrum of a typical industry array in deep water, and one to further develop PAMGUARD, a passive acoustic monitoring system. The program expects to fund cumulative effects studies in an ecosystem context, and the development of alternative sound sources and sound attenuation technologies.
- The Sperm Whale Seismic Study confirmed that sound propagation is not linear; for example, an animal 400m from the vessel but more than 50m below the surface was exposed to acceptably low sound levels, while an animal 6 km away was exposed to levels above the mitigation threshold (note: these levels are consistent with known physics of sound propagation; they are not a mystery). In this case the mitigation measures (monitored safety radius of 1km, and assumption that animals at risk would be observed) were ineffective because the sound prediction model was inappropriate. Therefore, the group recommended that readily available and appropriate sound propagation models for predicting sound exposure levels, although more complicated, should be employed and validated with empirical data, where available.

Active Sonars: Key New Findings and Developments

NOTE: It is crucial to keep in mind that there are two active sonar systems in use, both of which are subject to controversy. Mid-frequency active sonars have been deployed since the 1980's and are currently installed on over 200 American and NATO ally ships; their transmissions can travel tens of kilometers, and overlap the hearing range of many whales, including beaked whales, which are the most common species to be involved in strandings during sonar training. Low-frequency active sonars (LFAS) are a newer technology, currently installed on two US ships and a small number of UK ships; their transmissions are much lower frequency, and are designed to travel thousands of kilometers. No strandings have been associated with LFAS transmissions, though controversy remains about determinations made during environmental assessments that led the Navy to consider behavioral changes (ceasing singing, avoidance, mother/calf interaction anomalies) caused by exposure to LFAS sounds to be insignificant.

Investigation of several mass strandings of whales that occurred near naval exercises that were using mid-frequency active sonars have led to a clear pattern of injuries that have become the standard diagnostic indicator of sonar impacts. "Gas and fat embolic syndrome" includes a variety of specific injuries to tissues and blood vessels (including bleeding around the ears and brain, and tissue lesions in the liver and other organs), which seem to be related to "the bends" in human divers. The tissue hemorrhaging is seemingly related to the expansion of nitrogen gas bubbles in the tissues; it is considered likely that the bubble expansion is caused by surfacing too rapidly, though investigations continue to determine whether direct exposure to intense sound waves can trigger the bubble formation or expansion as well.

Based on examination of tissue damage in two strandings that occurred in early 2006, biologists determined that one, in Spain, was likely caused by a nearby NATO sonar transmission, while a larger mixed-species stranding in North Carolina did not exhibit typical sonar-induced injuries (the NMFS report on the NC strandings did not find a clear cause, and the multi-species nature of the stranding remains unusual; it is possible that avoidance of sonar sounds played a part, though only two animals showed any signs of injury). Another NMFS report, of an unusual congregation of deepwater melon-headed whales in a shallow bay during Navy exercises of Hawaii in 2004, found "no significant weather, natural oceanographic event or known biological factors that would explain the animals' movement into the bay nor the group's continued presence in the bay." While the presence of predators cannot be ruled out, the Naval exercises, including repeated use of mid-frequency active sonar, was deemed the most likely cause.

The Hawaii report upped the pressure on the Navy during the same bi-annual RIMPAC (Rim of the Pacific) exercises in June and July 2006. NOAA's permit for the exercises imposed more restrictions than ever before, including precluding use of active sonars in canyon areas (often habitat for beaked whales), except for three carefully monitored areas, and requiring sonar power-downs when safety zones could not be adequately observed. A consortium of environmental groups led by NRDC sought a court order to impose further protections; the Pentagon responded by issuing its first-ever exemption order, allowing activities to proceed. A quick out-of-court settlement added more marine mammal observers, including aerial observers, and required all military personnel doing any acoustic monitoring to be alert for and report whale sounds. Environmental attorney Richard Kendall called the settlement "a significant step forward in the protection of our oceans." A Navy admiral characterized it as requiring "a small number of additional mitigation measures." (Note: This exchange seems to affirm the NRDC position, which was that modest "common sense" improvements to the mitigation plan would provide the needed protection for whales.) No incidents were reported during the exercises.

The U.S. Navy had, earlier in the year, initiated planning for an **Undersea Warfare Training Range (USWTR)** off the east coast of the United States, with the preferred location being off the coast of North Carolina. The USWTR would be the site for 48 mid-frequency active sonar training missions per year. The Draft EIS, issued in late 2005, triggered concerns from local fishermen, state officials, and, unusually, from NOAA, which suggested that the Navy had set its allowable levels of noise too high, underestimated impacts on migrating right whales, and neglected to consider the likelihood of some whale deaths. In May, a Navy spokesman said that the Draft EIS may be resubmitted with some changes, before moving into its final phase.

In addition to the USWTR EIS, which covers just a specific set of locations, in early fall, the Navy announced a plan to develop a new EIS during 2007 to establish permanent standards for mid-frequency active sonar training missions off the east coast and in the Gulf of Mexico, and a separate but similar process for training around Hawaii (up to a dozen EIS's, covering various oceans throughout the world, may be in the works). The new EIS's aim to set clear standards for sonar use; it seems likely that the Navy wants to assure that the stringent measures imposed for RIMPAC do not become the default regulatory standard. The new EIS's may also have been initiated partially in response to a 2005 NRDC lawsuit claiming that the Navy was not submitting their mid-frequency sonar activities to the proper environmental review; that case is still awaiting a hearing.

Meanwhile, after confining use of the newer **Low-Frequency Active Sonar (LFAS)** to a remote region of the western Pacific (as per a court settlement imposed after the same NRDC-led consortium made similar claims against that system), the Navy is developing a revised Supplemental EIS for LFAS and has applied for the necessary permits to allow deployment

worldwide. The SEIS and take permits are based largely on changes to the language of the Marine Mammal Protection Act passed in 2004, which provide new statutory openings for wide-scale impacts by permitted activities (permits no longer are limited to small areas or small numbers of animals to be affected, so long as the overall impacts are still "negligible").

Putting sonar strandings in perspective?: The International Council on Exploration of the Seas reported that worldwide beaked whale deaths from likely exposure to mid-frequency active sonar (40 over 9 years) is outpaced by by-catch in American fisheries (35 in 6 years). (note: not all whales killed by sonar come ashore, so the counts are likely low.) They concluded that sonar exposure is not likely to cause a major impact on global populations, though they noted it has had a significant impact on local abundance in some cases (eg Bahamas) and they cautioned that increasing sonar use does warrant continued refinement of mitigation measures.

The UK Ministry of Defense announced that it will install passive listening systems on all ships that use active sonar systems. The passive monitoring systems will listen for any whales within a 2km radius, and if any are heard within 30 minutes of planned sonar transmissions, the transmission will be cancelled.

A new application of low-frequency sonar was announced in 2006: tracking large-scale fish movements in the open ocean. High-frequency fish finding sonars are widely used to locate ocean fish, but they can only "see" a 10m-wide section of water at a time. A new system, Ocean Acoustic Waveguide Remote Sensing, uses low frequency signals to track large groups of fish over thousands of square kilometers, enabling researchers to watch as schools and shoals form, divide, and scatter. The system uses lower-powered signals than those emitted by naval low-frequency active sonars. The system was deployed in large scale field tests during fall 2006 in the Gulf of Maine.

Commercial Shipping

There is little doubt that commercial shipping, especially increasing supertanker traffic, is the primary human contributor to overall background noise in the oceans. A study released in 2006 confirmed results obtained a couple years earlier, that background ambient noise is increasing at about 10dB per decade off the west coast of the United States (a 10dB increase indicates a ten-fold increase in noise levels).

In the past three years, representatives of the U.S. Chamber of Shipping, an industry trade group, participated in the MMC Advisory Committee and in an international symposium on ocean noise held in London. At the conclusion of the MMC committee's work, the shipping representative submitted a statement which indicated a willingness to work toward better understanding of the effects of shipping noise on marine ecosystems, and to pursue ship quieting, especially if such an initiative is implemented in a gradual way that includes the shipping industry in its development. It encouraged the involvement of naval architects and ship engineers, as well as global experts in ship routing and maritime trade, in order to identify current maritime traffic densities around the world. The statement also encouraged the United States to take a lead in the International Maritime Organization (a UN subsidiary that regulates international shipping), to encourage the IMO to address the impacts of shipping noise on ocean ecosystems.

The Federal Caucus of the MMC Advisory Committee also noted that the MMS and NMFS are engaged in an ongoing dialogue with the Coast Guard, Navy, and other Federal agencies to address shipping noise and ship quieting. They expect that Naval architects will be sharing expertise with private industry representatives and designers, and that the development of voluntary guidelines for ship quieting may result.

Looking Forward: What to Watch for in 2007

Low-frequency Active Sonar EIS and permitting. The Navy should complete its Supplemental EIS and NMFS should make a decision on the small-take permits.

Mid-frequency Active Sonar DEIS and court case. The Navy will work on and perhaps issue three Draft EISs governing sonar use: one for East Coast/Gulf of Mexico, one for Hawaii, and one for the Undersea Warfare Training Range. (up to a dozen EIS's may be in the works for oceans worldwide) It is also likely that the court challenge mounted by NRDC and others will move to the hearing phase.

Seismic survey noise. Watch for more studies of long-range propagation of seismic survey noise, designed to clarify whether surveys are adding significantly to low-frequency noise on an ocean-basin scale.

British Columbia academic seismic survey. A long-planned academic seismic survey in British Columbia is moving through Canadian agency evaluation, and may take place in fall 2007. This survey, aimed at investigating fault systems, will involve extensive airgun use in narrow fjords and biologically-rich intercoastal waters between Vancouver Island and the mainland. Environmental advocates are concerned that unpredictable sound reflection patterns and narrow channels will make it difficult or impossible to adequately monitor for possible extreme sound exposure and to allow animals to move away from the ships. The survey is being run by Lamont-Doherty Earth Observatory, which has typically used larger safety zones and more robust marine mammal monitoring than oil and gas industry seismic vessels.

NMFS Ocean Noise Criteria. In 2004, the National Marine Fisheries Service (aka, NOAA Fisheries) initiated a planning process to develop new criteria for issuing permits to projects that will expose animals to ocean noise. The initial draft of the Criteria proposed a complex analysis process, giving room to consider the different noise sources and different animal groups; it also proposed a new way of measuring noise, which would take more account of cumulative exposure over a period of minutes or hours. As with current standards, all the proposed alternatives except one were designed to protect animals from temporary and permanent hearing loss, rather than from behavioral disruption or other effects of moderate noise. During 2005, agency staff continued working on the draft; it is possible that the public will see a new version during 2006.

LNG Terminals. Perhaps the most dramatic expansion of large tanker noise currently underway is being propelled by the construction of new Liquefied Natural Gas terminals in coastal areas worldwide. (The US currently has 5 operating terminals, while 17 new terminals are in the regulatory approval pipeline; three new Canadian terminals are set to begin construction in 2007.) To accommodate the growing demand for relatively clean-burning LNG, these terminals are often being constructed just offshore. In some cases, LNG terminals are being proposed in coastal areas that currently have no large tanker traffic. During 2006, LNG terminals proposed for Long Island Sound, Tijuana, Fall River and Gloucester Massachusetts, and Passamaquody Bay Maine all spurred local resistance. Each terminal plays host to a couple of tankers per week; depending on how industrialized the waterways already are, this could cause a significant change in habitat quality.

Antarctica Tourism. Antarctica represents a rare opportunity to provide acoustic protection in a relatively pristine environment. International efforts to establish Marine Protected Areas are slowly moving forward, while at the same time cruise ships are just beginning to add Antarctica to their itineraries. Over the next ten years, we may see significant increases in ship numbers in these already-stressed habitats. This is an issue to bookmark for longer-term attention.

Links for more detailed information

The Acoustic Ecology Institute is the only comprehensive national clearinghouse for information on sound and the environment. We have focused largely on ocean noise and public lands management, and also have smaller programs dedicated to education and the interface between science and sound art. AEI's website offers a wide spectrum of reliable information, including websites for advocates on all sides of key issues. Our online Special Reports are designed to offer a solid "ten minute version" on key issues, with links to source material and more in-depth information.

To receive occasional news updates, contact cummings@acousticecology.org

http://www.AcousticEcology.org/scienceresearch.html
Laymen summaries of recent field research 23 studies from 2006 are summarized; similar pages available for 2005 and 2004.

http://www.AcousticEcology.org/ocean.html
AEI's main Ocean Issues portal Links to government and NGO ocean noise reports, ocean acoustics primer, and overviews of key issues

http://www.AcousticEcology.org/sriwc58.html
AEI Special Report on the annual IWC meeting scientific proceedings
Including workshop on seismic surveys and annual SOCER report

http://www.AcousticEcology.org/sr_mmc.html
AEI Special Report on the statements issued by parties to the Marine Mammal Commission's Advisory Committee on Acoustic Impacts on Marine Mammals These individual statements reflect the Committee's failure to reach consensus, and provide a good sense of what is generally shared understanding, and where tensions remain between various stakeholders.

http://www.AcousticEcology.org/sractivesonars.html
AEI Special Report on naval active sonars Includes information on the differences between systems, news updates, effects on wildlife, and links to government and NGO resources.

http://www.AcousticEcology.org/sractivesonars.html
AEI Special Reports index Links to Special Reports on all topics, including snowmobile and OHV management, noise effects of coalbed methane development, and ocean topics.

http://www.AcousticEcology.org/news.html
AEI News Digest The latest updates on continuing issues, new research, and other oddball sound-related news; with links to original press reports

http://www.AcousticEcology.org/
AEI's Home Page Coverage of ocean, wildlands, urban issues, as well as recent science and comprehensive resource links (research programs, advocacy organizations, government agencies).