

AEI Special Report:
Ocean Noise 2008
 Science, Policy, Legal Developments

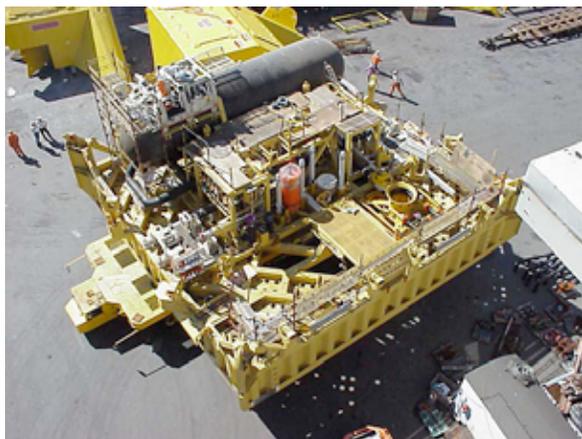
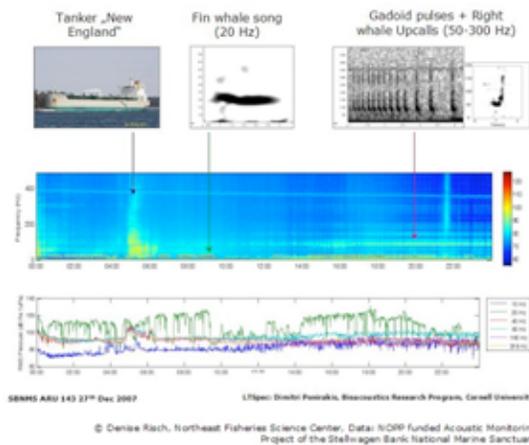


Photo credits: Stellwagen Bank National Marine Sanctuary Noise Budget: Denise Risch; Beaked whale receiving a D-tag: Ari Friedlaender; Subsea oil separator: National Energy Technology Laboratory, US Dept. of Energy; Container ship: Ebb and Flow Institute

In this, AEI's third annual overview of ocean noise, we take a slightly different approach to the material. In addition to our established "just the facts, ma'am" summaries of new field research, regulatory decisions, and legal rulings, we will include more narrative that aims to provide some context on the ways that this year's developments suggest important new directions in our society's approach to noise-making, and noise regulation, in the oceans.

As ever, the Acoustic Ecology Institute's primary mission is to "translate" complex science and regulatory developments for the general public. AEI does not engage in direct advocacy activities, though our work is inspired by a desire to encourage mindful and respectful co-habitation with other species, and to further our society's re-integration with the natural world. Toward this end, AEI's Special Reports, News Digest, and lay summaries of new research, along with our ongoing conversations with agency managers, researchers, the press, NGOs, and industry and Navy staff, focus on clearly understanding the state of current science, and providing integration and context to help the public and press cultivate informed understanding of the issues.

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Introduction

During 2008, it appears to us here at AEI that **four key pathways to future engagement with ocean noise issues clarified**. Each of these overarching developments will be fleshed out in more detail on the pages that follow.

- **Behavioral impacts clearly replaced strandings and deaths as the key issue for marine mammals encountering human noise.** Several studies released during 2008 all suggest that whales of many species may stop or reduce their feeding when loud human sounds enter their habitat, and this particular impact is likely to become a central focus of future research and regulatory consideration.
- The legal tussles over mid-frequency and low-frequency active sonars continued, and the **Supreme Court decision does not put an end to the controversy**. The Navy crossed an important threshold, completing full Environmental Impact Statements for their sonar training procedures for the first time; the lack of sufficient NEPA analysis was the root of most of the legal challenges. The plans they are putting forward to govern sonar training off most of the US coastline continue to rely on safety measures that Federal Courts have found wanting, though it appears that challenges to their proposals are more likely to focus on avoiding biologically important areas than increasing the safety zones that are designed to avoid injury. All parties seem to be accepting that gross injury is rare to the point of being difficult to use as a lever to shift the balance of interests with the Navy's national security imperative, but NGOs, many field researchers, and agency staff are all looking more closely at the behavioral impacts that take place at much longer ranges (up to several or even tens of kilometers). The next round of Navy sonar conflicts will center on how willing the Navy is to consider these subtler impacts, and whether NMFS or the courts will impose broader territorial restrictions on sonar training to protect areas where whales may be more susceptible to repeated disruption by sonar transmissions.
- **Shipping noise is moving very quickly to the forefront of international concerns about rising ocean noise.** This year the US, with strong German support, asked the International Maritime Organization to come up with ship quieting recommendations as a high-priority work item over the next two years; and the unusual sensitivity of harbour porpoises to boat noise has become clearer.
- **The scientific community appears to be entering a new phase in its engagement with ocean noise,** a natural result of the increasing emphasis on these issues since about 2004. The European Science Foundation, the US Marine Mammal Commission, and a National Marine Fisheries Service-led group have all recently published important reports that attempt to provide frameworks within which future research priorities can be clearly considered. These frameworks promise to provide much-needed big-picture coherence to what has been largely a scattershot approach to increasing our understanding of ocean noise. An independent and striking development this year was the emergence of more scientists speaking out forcefully about their concerns about ocean noise; these scientists have, at times, directly critiqued the more modest and diligently objective conclusions of the larger institutional reports just noted, and are representative of a subset of scientists who are more willing to push for extra precaution in our noise-making until we better understand what the effects are.

Behavioral Impacts of Moderate Noise: Death by a Thousand Cuts? Or...Maybe Just a Thousand Cuts: Should We Worry?

Behavioral impacts surely moved to the forefront of both research and advocacy agendas this year. The following sections review these areas in which behavioral disruption emerged as a key factor in 2008:

- Naval sonar EISs: behavioral impacts become key bone of contention
- Moderate noise disrupts feeding in many species: sonar, seismic, and boat noise all implicated
- How much noise is too much? NMFS and the Navy work to incorporate variability of behavioral impacts
- Awareness of the importance of behavioral disruption spurs concerns about new noise sources: wind farms, subsea oil processing, stress, and possible effects in Marine Protected Areas and on polar bears.

Behavioral Effect of Sonar Becomes Key Bone of Contention

NRDC's initial **responses to the Navy's Draft and Final Environmental Impact Statements for sonar training focused nearly exclusively on the behavioral impacts, rather than the (relatively small) risk of causing strandings**. Public comments submitted and statements released to the press stressed the "Level B Harassment" numbers contained in the documents; cumulatively for the first three EISs released (covering the bulk of US sonar training sites), the number was the admittedly shocking **2 million animals exposed** to what NRDC termed "sonar harm" (though the Navy and many others would stress that the vast majority of these are likely to experience sonar at the outer edges of its audibility, and to have very modest behavioral responses).



The Navy's new EISs quantify, for the first time, the numbers of animals that are likely to hear and respond to sonar training off the east coast, in the Gulf of Mexico, in Southern California, and Hawaii. Sonar training takes place in all the OPAREAs mapped above.

Image source: AFAST EIS

However you interpret the numbers, it is clear that the next battle will be fought over the idea that the Navy's mitigation measures, which are nearly solely designed to avoid causing physical injury, must be strengthened to do a better job of minimizing the widespread behavioral impacts that these numbers imply. The logical way to try to minimize the number of more distant behavioral disruptions would be to keep sonar training away from areas with higher concentrations of animals. The Navy's EISs did include Alternatives that set some places or times off-limits (to match key migratory, breeding, or birthing times); however, the total numbers of Level B (behavioral) harassments did not decrease much at all, so the Navy decided the benefit was not worth the loss of training opportunities. It is unclear why the numbers fell so little: were the areas set aside too small to keep ships away from whales, or are the sounds transmitted so far that it is hard to avoid impacts? **The Navy has written the EISs in close collaboration with NOAA's National Marine Fisheries Service, which has issued permits authorizing sonar training using the procedures outlined in the EISs (with, in some cases, some very modest nudges, urging the Navy to "minimize" use in certain biologically important areas).**

Mid-frequency active sonar signals drop below 170dB (quite loud but far from physically dangerous) at around 10km, but remain above 140dB for 50km and can remain above 120dB (generally easily audible) for 130km. Since some behavioral responses, such as modest changes including orienting to the sound or a brief change in breathing pattern, can occur at levels down to 120dB, and more noticeable changes or cessation in feeding activity are beginning to be noted at levels of 130-150db, it may be that sonar is inherently disruptive to animals in a very large area. One final detail to note: in most training ranges, sonar training is done relatively infrequently, and for periods of several minutes up to several hours; thus, the Navy feels that any impacts, even if widespread, are temporary and transient. Some animals may be repeatedly affected, but even the most impacted are unlikely to hear sonar more than a few times a month.

For more on Navy EISs, see <http://aeinews.org/?s=navy>, and

AEI Special Report: Navy/NRDC Sonar Debate <http://www.AcousticEcology.org/srSonarFactCheck.html>

Noise Interrupts Feeding: Many Species, Many Types of Noise

This year saw several new research papers that, together, offer **clear indications that human noise may disrupt the feeding behaviors of many different species.** Among these are:

The 5-year Sperm Whale Seismic Study (SWSS) in the Gulf of Mexico. This project tracked whales as they were exposed to sounds from a seismic airgun array; many were tracked via satellite tags (which remain on for days and tracked dozens of whales in large areas) and a few with D-tags (which remain on for hours and recorded the sounds heard and made by a handful of animals, as well as tracking their dive patterns). While the "take-away" message in media reports at the time of the release of the SWSS final report was centered on the apparent lack of large-scale effects of airguns (distribution of whales on scales of 5-100km were no different when airguns were active than when they were silent), a key observation was rarely noted: **the one whale that was D-tagged and that experienced sound levels of over 160dB ceased feeding and remained at the surface for the entire four hours that the survey vessel was nearby, then dove to feed as soon as the airguns were turned off.**

Jochens, A., D. Biggs, K. Benoit-Bird, D. Engelhaupt, J. Gordon, C. Hu, N. Jaquet, M. Johnson, R. Leben, B. Mate, P. Miller, J. Ortega-Ortiz, A. Thode, P. Tyack, and B. Würsig. 2008. *Sperm whale seismic study in the Gulf of Mexico: Synthesis report.* U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2008-006. 341 pp.

DOWNLOAD REPORT: <http://www.gomr.mms.gov/PI/PDFImages/ESPIS/4/4444.pdf>

In Angola, another study done during a seismic survey came up with a **similar mix of easy to report overall effect, and suspicious secondary effect:** In this case, the study simply looked at the numbers of whales seen by marine mammal observers during several months on a particular vessel. There were no apparent large-scale distribution changes (i.e., the whales did not leave the area when surveys were occurring). But strangely, more whales were actually seen during airgun activity than when airguns were silent...again, we must wonder whether they were more apt to remain at the surface when the noise was occurring. (This could be either because the airgun noise makes it more difficult for the whales to hear

their own echolocation signals while looking for prey, or because the top several meters of the ocean remain quieter when the area is noisy).

Caroline Weir. Overt Responses of Humpback Whales (Megaptera novaeangliae), Sperm Whales (Physeter macrocephalus), and Atlantic Spotted Dolphins (Stellena frontalis) to Seismic Exploration off Angola. Aquatic Mammals 2008, 34 (1), 71-83.

And, a report from late last year looked at cetacean distributions near a seismic survey in the north Atlantic, where again, the overall number of marine mammals within 1-2km did not change significantly when the seismic source was 'on' compared to 'off', but it appeared that **larger and apparently less vocal groups were observed when the seismic source was active**. The researchers noted that "seismic surveying can apparently have a behavioral impact at a high level of statistical significance without visual observers reporting seeing fewer marine mammals".

Potter, J. R., Thillet, M., Douglas, C., Chitre, M.A., Doborzynski, Z. and Seekings, P.J. 2007. Visual and passive acoustic marine mammal observations and high-frequency seismic source characteristics recorded during a seismic survey. IEEE J. Oceanic Engineer. 32: 469-483

More striking are two recent studies looking at responses to mid-frequency active sonar:

A UK Defence Science and Technology Laboratory study found changes in beaked whale behavior that it termed "potentially very significant." The study took place on an un-named instrumented range (where researchers can listen to whales via bottom-mounted hydrophones while sonar exercises take place), where Beaked whale calls dropped to a quarter of the level heard at the start of the exercise; the researchers noted that **"Beaked whale species ... appear to cease vocalising and foraging for food in the area around active sonar transmissions,"** and noted, "Since these animals feed at depth, this could have the effect of preventing a beaked whale from feeding over the course of the trial and could lead to second or third order effects on the animal and population as a whole."

Reported in Nature, which received the report, with the authors name and location of the study removed, under a FOIA request. <http://www.nature.com/news/2008/080801/full/news.2008.997.html>



Beaked whale

Photo credit: Natacha Aguilar de Soto, University of La Laguna

Image source: http://www.whoi.edu/cms/images/oceanus/SS2_slide10_new_69693.jpg

In Norway, similarly dramatic yet more specific reactions were seen in orcas exposed to sonar signals. In a limited Controlled Exposure Experiment (CEE), in which two orcas in a group were D-tagged, **the group exposed to mid-frequency sonar signals (maximum received level was only 160dB, roughly equivalent to full-power transmissions at 10km) ceased feeding and moved rapidly away; in addition, they exhibited an unusual dive pattern**, diving about twice as deep (over 60m) as normal (20-45m), including a highly unusual reversal of their ascent (coming up to 15m from the surface, then retreating again to 60m). This was the third of five dives during the 35-minute CEE; we must wonder whether they were trying to find a

way to escape the sound. (We should note that the one orca group exposed to LFAS signals did not appear to respond, and herring responses to both sonars were not more noticeable than their responses to ship noise alone.)

Kvadsheim, Benders, Miller, Doksaeter, Knudsen, Tyack, Nordlund, Lam, Samarra, Kleivane, Godo. Herring (slid), killer whales (spekknogger) and sonar - the 3S-2006 cruise report with preliminary results. Norwegian Defence Research Establishment (FFI). 30 April 2007

Boat and Airplane Noise also cause disruptions:

Two new studies looked at the **effects of boat noise on dolphins and porpoises, and the results were equally dramatic and disturbing.** In the Mississippi sound, researchers watched the reactions of bottlenose dolphins to the jetskis, and in just under half the cases, within one minute of the presence of a high-speed personal watercraft, groups that were feeding shifted dramatically to "traveling" mode. Interestingly, groups of dolphins that were already in "traveling" mode often paused and began "milling." Researchers note that "The results demonstrated an immediate, short-term change in dolphin behaviour, suggesting that an increase in the frequency of high-speed personal watercraft in this area could produce long-term detrimental effects."

Miller, Solangi, Kuczaj II. Immediate response of Atlantic bottlenose dolphins to high-speed personal watercraft in the Mississippi Sound. Journal of the Marine Biological Association of the United Kingdom (2008), 88:1139-1143

ABSTRACT, CONTACT AUTHOR:

<http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=2183240&fulltextType=RA&fileId=S0025315408000908#cor1>

And, a study on captive animals found that harbour porpoises have a shorter detection range for prey than bottlenose dolphins (porpoise ecolocation clicks are not as loud), so may be more hampered by noise. Researchers note that "the limited ecolocation detection range **would make it difficult, if not impossible, for harbor porpoise to inhabit a noisy environment.**"

Au, W.W.L., Benoit-Bird, K.J. and Kastelein, R.A. 2007. Modeling the detection range of fish by echolocating bottlenose dolphins and harbor porpoises. J. Acoust. Soc. Am. 121: 3954–3962



Aerial monitoring is a key method used to learn about large-scale population trends. Routine aircraft overflights are far more common, and may cause repeated impacts on marine creatures.

Image source: http://www.rightwhale.ca/monitoring-surveillance_e.php

Not only in-water noise has an impact. During a population-monitoring study in the Gulf of Mexico, **half of the sperm whale groups within 360m (laterally) from the plane exhibited sudden behavioral responses: three groups dove immediately and one group gathered together in a defensive posture,** while the other four groups encountered showed no response (all groups more than 360m away also apparently ignored the plane). The researchers note that "repeated or prolonged exposure to aircraft overflights have the potential to result in significant disturbance of biological functions, especially in important nursery, breeding or feeding areas." They suggest that **such cumulative effects could be possible in areas frequented by military training exercises, ecotourism flights (e.g. off Hawaii or New Zealand), and helicopter flights servicing oil and gas installations** (which are projected to account for 25,000 to 55,000 flights per year in the northern Gulf of Mexico, centered on the Mississippi Delta area, a high-use area for

sperm whales, particularly females and calves, and are likely equally significant in the North Sea and, increasingly, in the South Pacific and West Africa). The researchers stress the need for further study including, among other things, individual variability of sensitivity to noise (i.e., is a subset of the population likely to be consistently more "skittish" and therefore more impacted by repeated noise intrusions?) *Smultea, Mobley, Fertl, Fulling. An unusual reaction and other observations of sperm whales near fixed-wing aircraft. Gulf and Caribbean Research Vol 20, 75-80, 2008.*

How Much Noise Does it Take to Cause Problems?

This is the \$100,000 Question, and this year saw some interesting attempts to address it in new ways.

NMFS Noise Criteria

First, the NMFS put together an **all-star team of researchers to look at the body of research into the impact of noise on marine mammals, and to recommend "noise criteria" for use in permitting.** This review was hampered, as are all "big-picture" attempts to look at this issue, by the need to extrapolate from very few studies—more often than not on species other than the ones being considered, even sometimes from terrestrial species—due to what one Navy EIS referred to as "the overwhelming lack of other information." (perhaps you've had to be immersed in this field for a few years to have that obviously well-considered phrase trigger the empathetic/frustrated guffaw it did for me...)

The NMFS team **recommended a modest increase in the threshold of noise that is considered likely to cause physical injury** (permanent hearing damage); these increases spurred considerable grumbling from NGOs and some researchers, but will have little practical effect, because this level of sound only occurs very close to noise sources, and most EISs lead to estimates of only a very few, if any, animals being close enough to be injured.

The **behavioral response section of this report was much more fascinating, and could have far more real-world impact.** Because of the wide variation in responses, the authors refrained from making any specific recommendations about noise limits to minimize behavioral disruption. Instead, they created a set of charts that are designed to be used in coming years to both organize new data and to design studies to fill in the many gaps in the data that they reveal. Each chart addresses one of five "hearing groups" and a particular sound type (e.g., one for low-frequency cetaceans and single pulses, one for low-frequency cetaceans and multiple pulses, and one for low-frequency cetaceans and nonpulses; with the same set for each of the 5 hearing groups). Into the chart, the authors placed results from all studies that have investigated the particular type of animal and sound, arranged with increasing received sound level across the top (in 10dB steps, from 80-200dB RMS), and increasing severity of behavioral change up the left side (a 0 to 9 scale, from brief or minor change, through moderate changes in swimming or vocalizing, to obvious and extended changes in behavior). Each chart shows the cumulative total of individuals that responded at each level of severity to each level of sound exposure. The fascination comes in seeing the wide range of responses shown in virtually every chart; in some cases, a given dB level of sound exposure includes observed reactions at every level of the scale, from no response at all to very obvious disruption, and similarly, a given severity of response (say, obvious flight) can be observed at low sound levels, but not at higher levels. The challenges to setting an absolute limit are clear.

At the same time, though, **the reasons that many environmentalists (and increasing numbers of scientists) are raising concerns about widespread and systemic noise impacts is also made crystal clear.** Among the most striking observations:

- Dolphin responses to boat noise: over half the extreme reactions observed (rated at Level 8: **obvious or long-term avoidance of the area, prolonged separation of females and calves, prolonged disruption of mating behavior**) occurred at sound levels of just 100-130dB re 1uPa RMS. These results are somewhat confounded by the fact that at the same time, a majority of the

animals who were exposed to 100-120dB showed little or no response (remember, these charts are compiling data from many different studies).

- Baleen whales responses to nonpulses (which include sonar, shipping, and enduring oil and gas noise such as drilling or seafloor processing): A clear threshold appears in the data: **below 110dB, virtually all observations show little or no response, but at both 110-120dB and 120-130dB, the majority of individuals observed respond at "level 6"** (avoidance, brief separation of females and calves, extended changes or cessation in vocalizing, visible startle response, brief cessation of reproductive behavior).
- Baleen whales response to multiple pulsed sounds (e.g. airguns): Another dramatic threshold at a moderate noise level: 60 out of 75 responses at 110-120dB were rated Level 0 (no response), while 47 out of 72 at 120-130dB were at Level 6; this clarity is somewhat muddled by a wide range of responses to sound at 150-180dB, with clusters at both Level 0 and Level 6.
- Seals and sea lions in water: the vast majority of responses to 120-130dB sound are at Level 0, and then jump to Level 4 at 130-140dB.

While there remains considerable ambiguity, in that a given level of sound can cause responses at nearly all levels of severity, from no response to dramatic avoidance or cessation of feeding or reproduction, these charts clearly show that the **many animals DO react to noise levels that are far lower than what regulators have generally considered (160-180dB are common regulatory thresholds for behavioral disruption). Sonar and seismic airgun noise can remain at levels above 130dB for fifty to a hundred kilometers, and around underwater construction or supertankers for ten or more kilometers.**

A Special Issue of the journal Aquatic Mammals \$12 on CD; \$138 printed.

WEBSITE: <http://store.aquaticmammalsjournal.org/>

Southall, Bowles, Ellison, Finneran, Gentry, Green Jr, Kastak, Ketten, James Miller, Nachtigall, Richardson, Thomas, Tyack. Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. Aquatic Mammals, Volume 33, Number 4, 2007

New Navy Approach to Estimating Behavioral Responses (Level 2 Harassment/Takes)

This wide range of responses has spurred the Navy, in consultation with NMFS, to develop a new approach to estimating the number of animals that will react to sonar signals. **Rather than the simplistic assumption that ALL animals exposed to 160dB will be affected, and NONE hearing sounds less intense than that will have a reaction, a "risk function" approach is being used in the current round of EISs.** In theory, this approach can be tuned as new research takes place (continuing to fill in and clarify the charts mentioned above). As currently being used, the risk functions assume that a few animals will respond at 120dB, half will respond at 165dB, and nearly all will respond at 180dB. (*see figure on next page*)

However, the "slope" of the risk function is a matter of some heated scientific debate: according to some environmental advocates and researchers, the slope of the curve (which charts the percentage of exposed animals who will react as sound increases) is too steep. While "mathematically" it begins to chart reactions at 120dB, the line remains at virtually zero all the way up to 140-145dB, then rises steeply to nearly a hundred percent reactions at 180dB. **To many observers, the very low proportions of reaction shown at 120-145dB is questionable.** To some degree, this might be forgiven if nearly all responses at these levels were very low on the severity scale (and indeed, Navy personnel stress this idea), but it is becoming more clear that moderate and occasionally even severe reactions can occur at these low levels—perhaps not commonly, but certainly more than "nearly never."

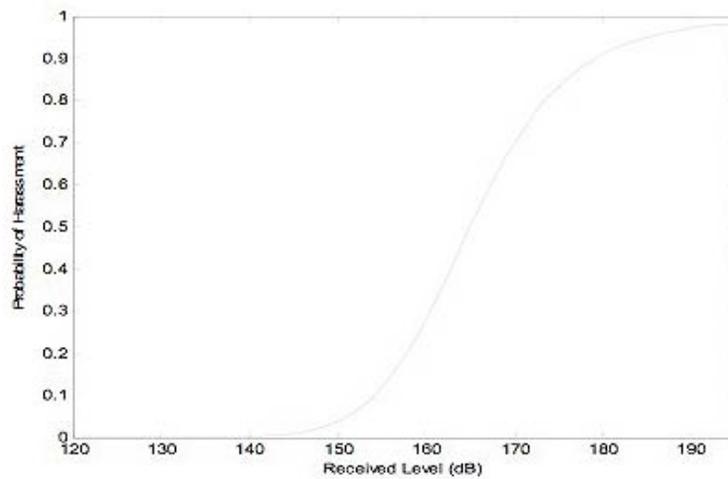


Figure 3.9-7: Risk Function Curve for Mysticetes (Baleen Whales)
 Source: NWTRC DEIS, p. 3.9-72

Interestingly, as shown in the following chart, the Navy estimates suggest that **about half of all exposures will occur beyond 5km, where visual observation is generally impossible, and that the majority of exposures will occur at received levels of 160-175dB, which are not insignificant levels of sound.**

Table D-12. Behavioral Harassments at each Received Level Band from 53C

Received Level (dB SPL)	Distance at which Levels Occur in NWTRC	Percent of Behavioral Harassments Occurring at Given Levels
Below 140	51 km - 130 km	< 1%
140<Level<150	25 km - 51 km	2%
150<Level<160	10 km - 25 km	18%
160<Level<170	3 km - 10 km	43%
170<Level<180	560 m - 3 km	28%
Above 180 dB	0 m - 560 m	< 9%

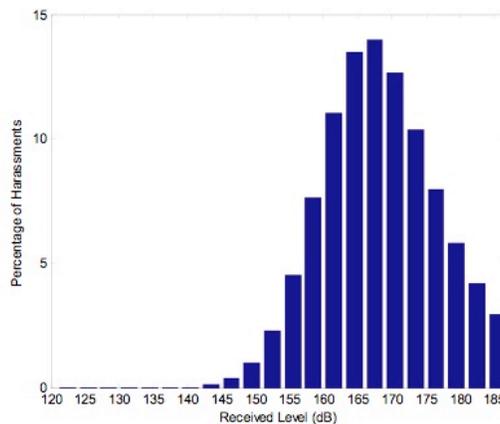


Figure D-26. Approximate Percentage of Behavioral Harassments for Every 5 Degree Band of Received Level from the 53C
 Source: NWTRC DEIS, p D-50

As we move forward in 2009 and beyond, **it will be very interesting to see how much the Navy adapts its risk function curves to account for the emerging awareness of moderate impacts in moderate noise**. It will also be interesting to see how the NRDC and others proceed in challenging the Navy about the underlying science in these EIS estimates—or lack of it: the question of the slope of the risk function is precisely the topic about which that previously noted “overwhelming lack of information” was referring (see p. 8).

See any of the recent Navy EISs for a discussion of their Risk Function analysis.

Behavioral Responses Spur Concerns About More Noise Sources: Wind Development, Stress, MPAs, and Subsea Oil Processing

The European Cetacean Society sponsored a workshop in late 2007, with the proceedings published in early 2008, that addressed the **burgeoning offshore wind energy industry in Europe**. Key findings included:

- The increasing pace of offshore windfarm development raises the likelihood that **construction noise, which is currently relatively temporary and transient, could become a chronic source of noise in coastal European waters**, as larger wind farms take several years to build, and multiple windfarms are under construction at any given time.
- Once construction is over, the assumption has long been that noise levels of turbine operations would be low enough that animals would return (and even that turbines may create “artificial reefs” that might increase fish and dolphin numbers). However, **in some cases, dolphins numbers have remained low for years after construction**; it may be that areas not crucial to them (as feeding grounds, for instance) are abandoned, or that wind farms in relatively quieter seas are loud enough to remain a deterrent.

Evans, P.G., Ed. ASCOBANS/ECS Workshop: Offshore Wind Farms and Marine Mammals: Impacts and Methodologies for Assessing Impacts. ECS Special Publication Series No. 49, February 2008. 70pp.

DOWNLOAD REPORT:

<http://www.seawatchfoundation.org.uk/docs/7.%20ECS%20proceeding%20workshop%20windfarm%20and%20marine%20mammals%202008.pdf>

A series of workshops sponsored by the German non-profit Okeanos over the past two years have reflected an increasing concern among many researchers about the impacts of moderate noise. The publications that resulted are opening doors to further consideration of many important ocean acoustics issues.

Okeanos ocean noise research website: <http://www.sound-in-the-sea.org>

Previous workshops have addressed:

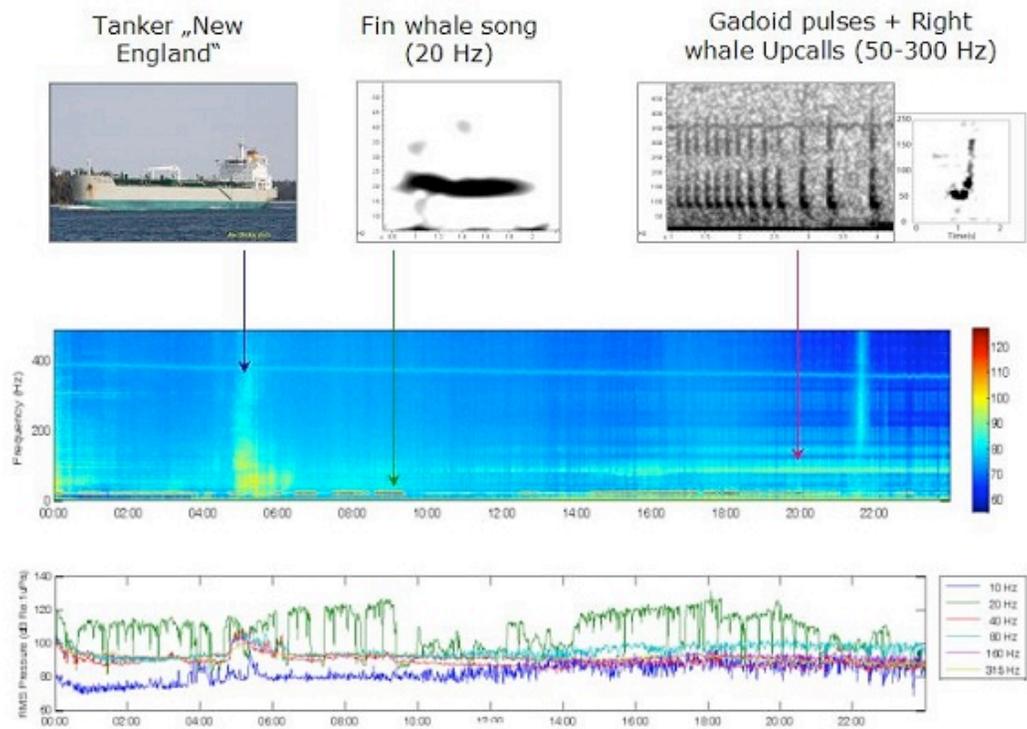
Impacts of noise on marine mammals, with a **special emphasis on considering noise exposure as a cause of increased stress**. This workshop made an important first step in bringing the well-established experience of terrestrial biologists who have been monitoring stress levels in animals for years, into the marine science community. **Stress is a major wild card in ocean noise; it is highly likely that marine animals do experience elevated stress levels in the presence of noise, even when only exhibiting a minor behavioral change**. The next steps will be targeting more research to measure these changes; after that, the really juicy questions will be on the table, including **the question of whether noise-induced stress makes animals more susceptible to other environmental challenges they are facing (as appears to be the case with terrestrial animals, including humans)**. If this door fully opens, it **will up the ante considerably in the need for regulation of moderate noise, and/or the preservation of what few acoustically pristine marine habitats still remain**.

Andrew J. Wright and Lauren Highfill, Guest Editors. *Noise Related Stress and Marine Mammals: An Introduction. International Journal of Comparative Psychology, 20(2-3), 2007.* <http://www2.gsu.edu/~wwwscp/ijcp-vol20-2-3-2007/ijcp-20-2-3.pdf>

Marine Protected Areas are based on restricting some activities in certain places or times (for example, limiting fishing at certain seasons, or all the time); an Okeanos workshop looked at the potential for **MPAs to add some noise restrictions as well** (currently, shipping is generally unrestricted in MPAs). Only the six largest of the world's 350-plus MPAs are large enough to keep noise out some areas, even if they tried, meaning that some acoustic buffers would be necessary to move forward with this idea.

Agardy, Aguilar, Canadas, Engel, Frantzis, Hatch, Hoyt, Kashner, LaBrecque, Martin, Notarbartolo di Sciarra, Pavan, Servidio, Smith, Want, Weilgart, Wintle, Wright. 2007. *A Global Scientific Workshop on Spatio-Temporal Management of Noise. Report of the Scientific Workshop.* 44 pages.

DOWNLOAD(pdf): http://www.sound-in-the-sea.org/download/str2007_en.pdf



SBNMS ARU 143 27th Dec 2007

LTSpec: Dimitri Ponirakis, Bioacoustics Research Program, Cornell University

© Denise Risch, Northeast Fisheries Science Center, Data: NOPP funded Acoustic Monitoring Project of the Stellwagen Bank National Marine Sanctuary

An example of the sorts of research being done at Stellwagen Bank National Marine Sanctuary, in Cape Cod Bay off Boston. While shipping noise will never be kept out of Stellwagen (major Boston shipping lanes pass through the Sanctuary), some leading-edge acoustics research is taking place there. A system of ten hydrophones is constantly recording both natural sounds (whales, waves and rain) and human noise sources (ships). The system is used to help ship captains know where Right whales are, and also is helping researchers to have a much better picture of the mix of sounds present in these waters, or the “noise budget.”

For more on the Stellwagen studies, see: http://stellwagen.noaa.gov/science/passive_acoustics_noise.html

Upcoming Okeanos workshops during 2009 will address other key ocean acoustics issues, including:

- **Cumulative and synergistic impacts of ocean noise**—how to assess the cumulative impact of recurring exposure to the same noise (such as shipping or airguns), as well as the ways that different marine stressors combine to have impacts that may be “more than the sum of the parts”

(e.g., does noise-induced stress make animals more susceptible to toxins or temporary shortages of food?).

- **Alternative technologies to airguns**—will consider ways to reduce the stray mid- to high-frequency components of airgun noise, which are not necessary for their purpose of looking into the seabed, but do impact animals, as well as ways to limit horizontal propagation of airgun noise. Also will address emerging technologies that may provide some of the information currently obtained by using high levels of sound.
- A working group is being formed to address the diversity of mitigation measures used to protect animals from seismic and sonar sound, and will attempt to propose some **standardized measures to be used worldwide** (though it must be noted that the scientists will not have any magical powers to get the nations of the world to adopt their proposals).



Subsea separator being prepared for installation

Image source: http://www.netl.doe.gov/technologies/pwmis/images/photos/seasep_subsis_photo.jpg

Another emerging noise source is subsea oil and gas processing. Rather than simply pumping crude oil to shore (or to the surface for shipping to shore), the offshore oil and gas industry is beginning to install relatively large processing units on the seafloor. These may separate the oil from the mud, or do more advanced processing, before pumping the final product to shore. The noise from these installations has not been studied, though it is highly likely that they will introduce a new source of chronic noise in some areas. It will be more of a steady noise, like shipping, but the nature of the sounds themselves (and thus how far they will travel, and what animals it may affect) is unknown. California-based Ocean Conservation Research is seeking funding for the necessary studies of the noise profiles of these installations.

Cohen and Fischer, Production systems hit the seafloor running. World Oil Magazine, Vol. 229, No. 1, January 2008
http://www.worldoil.com/magazine/MAGAZINE_DETAIL.asp?ART_ID=3412&MONTH_YEAR=Jan-2008
http://www.AcousticEcology.org/OCR_SeafloorProcessingOverview.doc

And finally, research has begun to investigate **how sensitive the now endangered polar bears are to increasing industrial noise in their habitat**, especially around winter dens. Initial studies by Hubbs-Sea World biologist Ann Bowles confirmed that polar bears do hear low-frequency sounds, but were unable to assess their ability to hear infrasonic sound, due to noise in the Zoo where the tests took place. Large carnivores are often quite sensitive to such extremely low frequencies, which are also common in industrial noise. This winter, a simulated bear den will be built, in order to record the sounds that can penetrate this normally quiet sanctuary. The research will help determine what levels of acoustic protection may be necessary in polar bear habitat.

American Institute of Physics Press Release, 7/29/08 <http://www.aip.org/isns/reports/2008/028.html>

Naval Active Sonars

Even as scientists and regulators (as well as NGOs) turn more attention toward the effects of moderate noise levels and ubiquitous sources such as shipping, Naval sonars continued to be an active hot-button issue during 2008. Here, we summarize the key developments:

- Supreme Court Case does not rule out future challenges
- NRDC and the Navy settle a major mid-frequency sonar case
- Low-Frequency Active Sonar (LFAS) limited to western Pacific for now, as Navy begins EIS process to allow world-wide deployment
- Key new research on sonar
- Controlled Exposure Experiments expand in 2008

Supreme Court Case is not the Last Word

Contrary to what you may believe, the [Supreme Court ruling in Winter v. NRDC](#) is far from the final word on the Navy's obligation to assure that its sonar training procedures comply with federal law. The questions before the Court were fairly narrow, and while the [ruling does provide the Navy with substantial—and surprisingly broad—power to shape future court cases](#), Chief Justice John Robert's [majority opinion did affirm the fundamental principle that the Navy must comply with environmental laws](#). And, the Court did not directly address the “balance of powers” question of whether the Executive Branch can legally exempt the military from laws passed by the Congressional Branch.

Rather, the Court ruled that the lower courts should have given more “deference” to statements by Navy commanders that additional safety measures would impede effective training of sailors and leave them unprepared for deployment into the hostile waters of the world. [The Court's majority clearly was unwilling to take on the mantle of “temporary experts” in marine biology or ocean acoustics, and basically ruled that the District Court and Appeals Court should give Navy assessments of the risks and impacts of their sonar procedures precedence over those of environmentalists or other scientists.](#) [It is unclear whether the Navy's assessments of the negative impacts of the safety measures really “hold water,” since a dozen training missions took place under the restrictions, and those fleets were presumably successfully cleared for overseas deployment.](#) The Navy had appealed just two of the additional measures, which would have ordered power downs or shut-downs in more situations during extended training missions, but also allowed commanders to ignore the power-down if a training was at a critical juncture. Still, [the Supreme Court ruling will certainly force federal judges to give the Navy's experts extra weight as they balance future competing claims.](#)

MFA Training EISs to Face Scrutiny in 2009

Navy training programs are likely to face continued public and legal scrutiny during 2009. The EISs that are now rolling out for sonar training ranges (as well as the permits issued by NMFS) adopt the safety measures the Navy has been using since early 2007, under which they claim no deaths have occurred (though two ambiguous stranding events took place using most of these techniques in 2006). [The key point of contention will be whether there is a biological need for “exclusion zones” in which sonar is not allowed.](#) The Navy reluctantly accepted a coastal exclusion imposed by the California District Court, but is not including such restrictions in their EIS planning. Likewise, the California court, and in some out-of-court settlements on Low-Frequency Active Sonar, the Navy has accepted some exclusions from areas with high biodiversity or key importance as feeding or birthing grounds, but again, [its EISs decided to not use Alternatives that included such restrictions.](#) [NMFS permits \(officially termed “Incidental Harassment Authorizations” \(IHA\) generally affirm the Navy's procedures, though at times add vague and non-binding clauses that urge the Navy to “minimize” or “reduce the time spent” using MFA in particular times and places of importance to whales.](#)

The large numbers of “Level B Harassments” predicted by the EISs is already the target of concerted effort by NRDC. Permits issued by NMFS authorize the “takes” of up to ten million marine mammals over five years (in the combined Navy sonar trainings taking place in waters off the East Coast, Gulf of Mexico, California, and Hawaii). Of course, the alarming nature of the word “take” plays into public fears, as it implies death, when in fact it includes any noticeable behavioral response to noise.

It is unclear how receptive the courts will be to being asked by NRDC to assess the biological significance of behavioral impacts. Indeed, the scientific community is itself very uncertain about how to determine when a series of minor behavioral disruptions might accumulate enough to cause any long-term risk to the health of either individuals or populations of marine mammals.

Navy-NRDC MFA Settlement

A recent agreement between NRDC and the Navy settle a program-wide legal challenge to mid-frequency active sonar (filed in 2005) includes **a plan for the two parties to have open discussions on any disagreements**, and to spend 120 days working to iron out issues prior to any legal challenges. We can be sure that the first 4 months of 2009 will tell us much about whether the two parties can work constructively together, as they discuss the EISs released in December and January.

The agreement also provides for the Navy to fund research that is of mutual interest to the NRDC and the Navy, focusing on three topics, including **developing techniques to measure stress levels in marine mammals, a development that could have far-reaching implications (as mentioned above).**

And, the Navy agreed to make some previously classified information about sonar training public, and to engage in regular consultations with NRDC in which some still-classified information will be shared, apparently in an effort to build trust and provide opportunities for the Navy and NRDC to address concerns by assessing real-world events that take place during training.

Low-Frequency Active Sonar 2008 Settlement Keeps LFAS in Western Pacific; 2009 Supplemental EIS Aims to Open Other Oceans

In late 2007, the Navy completed a Supplemental EIS to cover its newer Low-Frequency Active Sonar system (LFAS), and received permits allowing it to deploy its two (and later four) LFAS-equipped ships around the world. LFAS, as you may remember, is an active sonar system that uses, as the name suggests, low frequency sound waves; its effective listening range is dozens to hundreds of miles, and the signals can be audible even thousands of miles away. (Mid-frequency active sonar, deployed on hundreds of ships worldwide, has an effective listening range of tens of miles, and can be heard for somewhat over a hundred miles). NRDC challenged the permits on the grounds that the EIS had not sufficiently considered the impacts on animals in biologically important habitats, and in early 2008, a federal judge ordered to two sides to commit to working out an agreement (and, perhaps in a bit of judicial humor, asked for them to report to her about their plans for negotiations on Valentines Day!). In August, **an agreement was announced that would keep the Navy’s two LFAS ships in the Western Pacific (where, in fact, the Navy had kept them since the EIS was released, to monitor Chinese and North Korean subs), and keep them out of some biologically important areas.**

In response, the Navy has initiated another Supplemental EIS, which will attempt to assess the concerns raised by NRDC, especially three topics:

- The need for larger coastal buffers (especially extending the current 12-mile limit in areas where the coastal shelf is wider than that)
- Formally excluding LFAS from more areas of biological importance, including migration corridors, breeding and calving grounds, and feeding grounds
- Cumulative impacts of LFAS exposure combined with exposure to MFAS

In the scoping announcement they asked interested parties to submit suggestions for areas that should be protected from LFAS impacts. The Navy has not released a projected timeline for completion of the Supplemental EIS; if the past is prologue, then we might expect a Draft SEIS in late 2009 or early 2010. It appears that the new SEIS **may be completed by the time that the Navy was planning to launch its next two LFAS-equipped ships in 2011; it is likely that these ships would be ideally deployed in areas other than the Western Pacific**, and thus the need to move beyond the current status quo of being limited to that region.

Federal Register Notice: <http://edocket.access.gpo.gov/2009/pdf/E9-1041.pdf>

Navy website: <http://www.surtass-lfa-eis.com>

Key Sonar Research Findings in 2008

Active sonar continued to be an active research topic during 2008. Some of the key new findings were:

- **Passive Acoustic Detection of Beaked Whales Not Likely From Sonar Vessels**—Since beaked whales dive for 90 minutes at a time, they are notoriously hard to spot at the surface; thus, listening for them has become an “improved” mitigation measure in efforts to avoid exposing them to sonar signals. This study showed that it is relatively easy to hear beaked whales when they are within one or two kilometers, but almost impossible when they are beyond 4km (because the echolocation clicks being listened for are relatively high frequency and do not travel far). Since it appears **likely that beaked whales react to sonar at distances great than 4km, passive detection may not be an effective mitigation measure**. In addition, **one must listen for over two hours without moving very far, making a sonar source vessel an inappropriate listening platform**. Zimmer, Harwood, Tyack, Johnson, Madsen. *Passive acoustic detection of deep-diving beaked whales. The Journal of the Acoustical Society of America, November 2008, Volume 124, Issue 5, pp. 2823-2832.* AEI Lay summary <http://aeinews.org/2008/12/16/pambeakedwhale/>
- **Orcas Avoid MFAS, but not LFAS; Herring Unaffected**—Norwegian controlled exposure experiments noted unusual dive patterns and general avoidance in orcas exposed to MFA sounds. Herring did not react to the sonar signals. *This study is summarized in more detail on page 7 of this report.* Kvadsheim, Benders, Miller, Doksaeter, Knudsen, Tyack, Nordlund, Lam, Samarra, Kleivane, Godo. *Herring (slid), killer whales (spekknogger) and sonar - the 3S-2006 cruise report with preliminary results. Norwegian Defence Research Establishment (FFI). 30 April 2007* AEI Lay summary: <http://aeinews.org/2008/06/22/orcamfa/>

Not directly related to sonar, but with implications for sonar impacts:

- **Beaked whales are very sensitive to pingers**—Adding to the increasing literature indicating that beaked whales are especially sensitive to sound, a new study reported that adding pingers to gill nets reduced by-catch to zero. While other cetacean species seem to be deterred as well, there are continued instances of bycatch even after pingers are installed. **Only beaked whales avoid the sound so diligently that they are seemingly always protected from the nets**. Carretta, Barlow, Enriquez. *Acoustic pingers eliminate beaked whale bycatch in a gill net fishery. Marine Mammal Science, 24(4):956-961 (October 2008).*
- **Sound Levels Can Vary Widely, up to 30dB, Contrary to Assumptions of Propagation Models**—A study released in early 2009 offers a fascinating glimpse into the real-world factors that will often confound simple geometric or spherical-spreading models generally used to predict sound exposure levels around any sound source. This study looked at the received sound levels from a pinger on a fishing net, and found that it could fluctuate widely at relatively equal distances, mostly due the way sound at a distance is a combination of sounds coming directly from the source, and reflections of sound from the surface and seabed. There was a **routine variation of 10-15dB**, with several more dramatic shifts: at 400m, the sound shifted from around **127dB to over 150dB**; and again, at just under 200m, from **just above 130dB to over 160dB** (around a general average at that distance of perhaps 150db). **Given the increasing concern among biologists about behavioral disruptions triggered by noise, it is extremely important to acknowledge that real-world exposures can vary to this degree; many more animals respond behaviorally at 150dB and above, than down at 120-140dB**. Shapiro, Tougaard, Jorgensen, Kyne, Balle, Bernardez, Fjalling, Karlsen, Wahlberg. *Transmission loss*

patterns from acoustic harassment and deterrent devices do not always follow geometrical spreading predictions. Marine Mammal Science, 25(1): 53067 (January 2009)
See lay summary with key graph: <http://www.AcousticEcology.org/scienceresearch.html>

Controlled-Exposure Experiments (CEE) Increase in 2008

Using a dramatic new research tool, the D-Tag, researchers continued to expand their studies of whales' reactions to MFAS this year, in Hawaii, the Bahamas, and Norway.

D-Tags are suction-cup tags that remain in place for several hours, all the while recording both the dive profile of the animal and the actual sounds made by and heard by the animal. In CEE studies, researchers play back sounds to tagged whales in order to see how they respond; the sonar sounds are played at less than full intensity, and received levels remain modest.

In 2007, CEEs took place in the Bahamas, on an "instrumented range" run by the Navy (seafloor hydrophones allow real-time tracking of animals via their vocalizations). In 2008, a second round of CEEs were held there, as well as a groundbreaking collaboration whereby animals were tagged during actual training missions in Hawaii.

Both 2008 studies were somewhat hampered by circumstance, as well as by the normal challenges of getting tags on enough whales; beaked whales, especially, are hard to see and approach on the surface. In Hawaii, animals that were tagged did not end up having close exposure to any sonar signals; in addition, some national security restrictions limit the researchers' ability to publish what data they did get. In the Bahamas, the studies took place during the month in the summer when three hurricanes blew through the region. In addition, there was more difficulty than expected at coordinating their use of the instrumented range, with Navy priorities keeping them out of the area for much of the time the weather was decent.



After this beaked whale was tagged, the device recorded and stored data about the animal's behavior and information about the surrounding ocean environment. Beyond time, depths, and sounds, the tag records temperatures in the ocean surrounding the whale, and the whale's pitch, roll, speed, and direction. It records sound 192,000 times per second and other information 50 times a second. After about 18 hours, the tag automatically pops off the whales and floats to the surface for the researchers to collect. (Photo by Ari Friedlaender, Duke University)

Photo source: http://www.whoi.edu/cms/images/oceanus/Tagging010_550_61877.jpg

The preliminary cruise report for the 2008 Bahamas study (shared with AEI in draft form) makes several overall observations (the “study area” is an instrumented range in the Navy’s AUTEK training range, where sonar and other Naval exercises take place on a regular basis):

- Based upon multi-year photo-identification and habitat mapping, Blainvilles beaked whales are a resident species within the study area and individuals forage within the study area over multiple years. **They appear to be able to survive, breed and forage successfully within this habitat in spite of considerable military acoustic sources, including on occasions MFA used at full power.** Beaked whale distributions are generally congruent with apparent food availability within the water column.
- Beaked whales are sensitive to noise, even at levels well below expected TTS (~160 dB re 1 μ Pa). This **sensitivity is manifest by an adaptive movement away from a sound source. BRS observed this response irrespective of the signal transmitted within the band width of mid-frequency active sonars.** This suggests that beaked whales may not respond to the specific sound signatures. Rather they may be sensitive to any pulsed sound from a point source in this frequency range. The response to such stimuli appears to involve maximizing the distance from the sound source.
- Overall, it appears that **beaked whales move out of the region in which MFA is being used.**
- Other species appear to be less sensitive to MFA and control sounds than beaked whales. Although reactions to sonar sounds and control sounds were observed in some cases, there was little consistency in the responses and none of these responses suggested a reaction that was hazardous to these species.
- Scenarios for stranding that could be derived from these results mainly involve situations in which there is inadvertent “pursuit” of cetaceans because of the movement of vessels operating MFA, likely involving activity in areas with limited egress that could magnify the avoidance responses seen here. The **most effective mitigation could be to (a) ensure there is an appropriate period of ramp up (possibly over several days) in a region in advance of any use of MFA and (b) to avoid the kind of regions and habitats in which “pursuit” is possible.**

In February 2008, the Woods Hole magazine *Oceanus* published a piece that gives a good look at the aims and procedures used in CEE experiments:

<http://www.whoi.edu/oceanus/viewArticle.do?id=37146§ionid=1021>

The NOAA Fisheries website also has a summary of the work, and will presumably post 2008 info as it is made available:

<http://www.nmfs.noaa.gov/pr/acoustics/brs-07.htm>

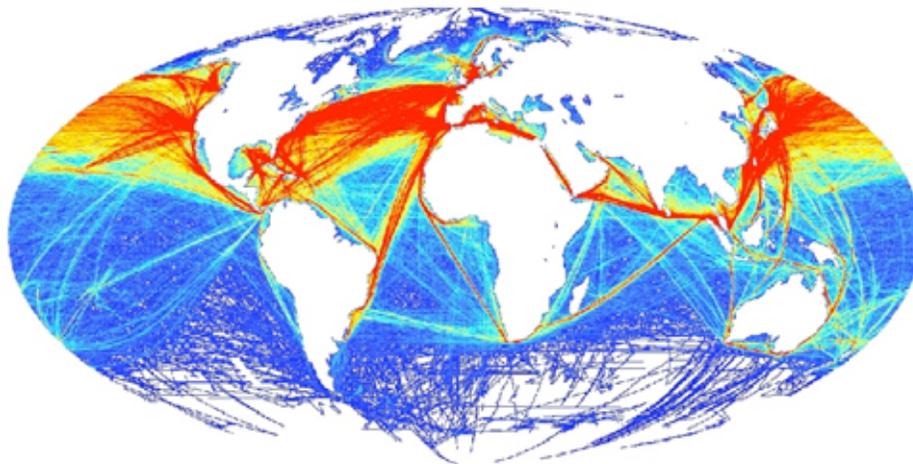
Regulatory Developments: Shipping Noise / Oil and Gas Exploration / Research Priorities

Shipping Noise Enters the Regulatory Radar

Since the NMFS and MMC first addressed shipping noise in symposia in 2004 and 2005, the **question of what to do about the steady increase of background ambient noise in the oceans, primarily consisting of shipping noise, has been addressed with increasing urgency by scientists and regulators.** The shipping industry has been very responsive to the concerns, with both the US Chamber of Shipping and German shipping organizations actively participating in international discussions about the topic.

In 2008, the International Maritime Organization (IMO) accepted a proposal from the US, with strong backing from Australia, Germany, and other European nations, to **initiate a “high priority work item” aimed at reducing the impacts of shipping noise, with the goal of coming up with voluntary ship-quieting technologies, as well as potential navigational and operational practices.** The IMO sets the ground rules for international shipping, including regulating pollutants and designating shipping lanes; adding noise to its management toolkit is a major step forward.

http://www.AcousticEcology.org/onc/IMO_MEPC_2008ShipNoiseProposalAndDecision.pdf



*Global shipping traffic, as mapped during a comprehensive analysis of human impacts on the worlds' oceans. For more on this important and rather shocking study, see: <http://globalmarine.nceas.ucsb.edu/> and <http://www.nceas.ucsb.edu/GlobalMarine>
Image source: <http://ebm.nceas.ucsb.edu/GlobalMarine/impacts/transformed/jpg/shipping.jpg>*

Also in 2008, the United Nations Environment Program (UNEP) meeting of the **Convention on Migratory Species (CMS)** adopted a statement calling on member states to, among many other clauses, **“endeavour to control the impact of emission of man-made noise pollution in habitat of vulnerable species and in areas where marine mammals or other endangered species may be concentrated,”** and to “consult with any stakeholder conducting activities known to produce underwater noise pollution with the potential to cause adverse effects on marine mammals and other biota, such as the oil and gas industry, shoreline developers, offshore extractors, marine renewable energy companies, other industrial activities and oceanographic and geophysical researchers.” Since many countries in the world who are parties to the UNEP and CMS do not currently pay much attention to ocean noise issues, this could be a useful development.

[DOWNLOAD(doc)]: http://www.AcousticEcology.org/onc/UNEP_CMS_noiseresolution2008.doc

Boat Noise

While shipping noise is the largest contributor to global background noise in the world's oceans, **on a regional level, recreational, fishing, and whale-watching boats often create the primary acoustic impact for local marine mammals.** While global background noise makes long-distance communication far more difficult, nearby smaller boats can interrupt feeding, drown out local communication, and generally disrupt the natural activity of marine species. Several studies during 2008 addressed these impacts.

Most comprehensive was a report from the NMFS on the **sound exposure impacts on Puget Sound orcas.** **This report is a treasure-trove of information,** as it summarizes most of the previous studies on orcas hearing and noise impacts. Among the key facts reported is that small boats increase the ambient noise by at least 10-15dB, and often much more, and that **orcas appear to be more susceptible to masking by noise than other delphinid species; target sounds (communication or echolocation) must be 20-40db louder than the ambient background noise to be heard.**

Marla Holt, *Sound Exposure and Southern Resident Killer Whales (Orcinus orca): A Review of Current Knowledge and Data Gaps.* NOAA Technical Memorandum NMFS-NWFSC-89, February 2008. 77pp.

[DOWNLOAD REPORT(pdf)]:

http://www.nwfsc.noaa.gov/assets/25/6741_03042008_154832_OrcaSoundExposureTM89Final.pdf



Whales in Sydney harbour attracts the attention of many boaters. These pictures were taken from a nearby bridge and the photographer noted that "the boats were slowly moving backward to give the whales some room."

Photo source: http://hoore.com/sydney/whales/whale_11_small.jpg

Studies on boat and shipping noise this year revealed that:

- **Orcas speak louder as boat noise increases**—Orca **calls increase by a decibel for every decibel the background noise increases, including short-term changes caused by passing boats.** The researchers note that "increasing vocal output to compensate for noise might have energetic costs, lead to increased stress levels, or degrade communication among individuals which could affect their activity budget. At some level, **background noise could also completely impede the use of calls by killer whales for communicative functions.**"
Holt, Noren, Veirs, Emmons, Veirs. Speaking up: Killer whale (Orcinus orca) increase their call amplitude in response to vessel noise. J. Acoust. Soc. Am. 125(1), January 2009.
- **Dolphin Whistles Adapt to Ambient and Boat Noise**—This study looked at differences in dolphin whistles in different locations, and found that dolphins seem to adapt to noise in two ways. Dolphins produced relatively higher frequency whistles in the noisiest habitats, and when multiple boats were nearby, dolphins whistled with greater frequency modulation (ie more

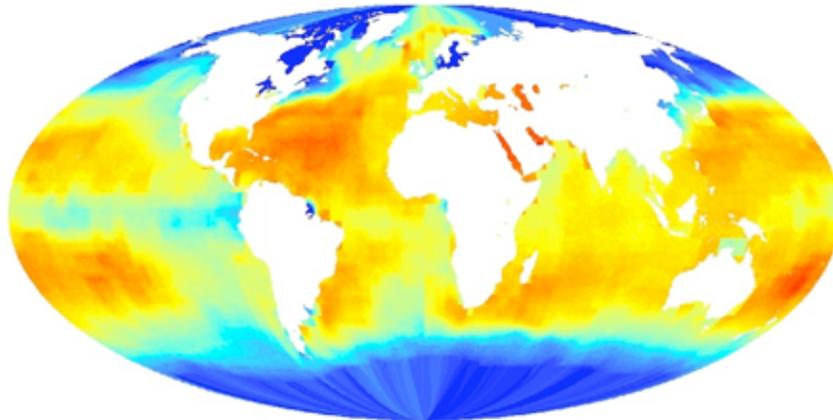
dramatically varying tones) and whistles were both longer and higher in maximum frequency than when just a single boat was present.

May-Collado, Laura J. and Douglas Wartzok. 2008. A comparison of bottlenose dolphin whistles in the Atlantic Ocean: Factors promoting whistle variation. *Journal of Mammalogy*, 89(5):1229-1240.

- **Coastal Shipping Noise Has Nearly Tripled**—A study that was primarily looking at the relative contribution of distant and nearby shipping to coastal shipping noise found that **in Southern California ships are audible 89% of the time, up from 31% in the early 1960s**, with median sound levels 6-9dB higher when ships are present.

McDonald, Wiggins, Hildebrand, Ross. A 50-year comparison of ambient ocean noise near San Clemente Island: a bathymetrically complex coastal region off Southern California. *J. Acoust. Soc. Am. Volume 124, Issue 4, pp. 1985-1992 (October 2008)*

- **Increasing Ocean Acidification Will Allow Sound to Travel Further, Increasing Ambient Noise of Shipping**— Low- and mid-frequency sound absorption has already decreased by 10-15% as ocean pH has been reduced by several things including increased CO₂; this means that **sound travels 10-15% further, with the effect that background ambient noise levels (predominantly wave noise and shipping noise at the frequencies being impacted) rise as the cumulative noise in any one place contains source noise from a larger area**. The most dramatic impact is in sound below 1kHz, with significant effects up to 10kHz. Projections for the continued acidification and therefore further increases in sound propagation suggest that by 2050, we will easily hear a 30% increase in sound propagation distances (based on a low-end prediction of a decrease in pH of .15); **more likely is a 40-60% increase in sound propagation distances**.
Hester, Peltzer, Kirkwood, Brewer. *Unanticipated consequences of ocean acidification: A noisier ocean at lower pH. Geophysical Research Letters, Vol. 35, L19601.*



Increased ocean acidification; note how closely these pattern match those of the shipping lanes, which are markers of the industrialization of many regions of the world ocean.

<http://globalmarine.nceas.ucsb.edu/> and <http://www.nceas.ucsb.edu/GlobalMarine>

Image source:

http://ebm.nceas.ucsb.edu/GlobalMarine/impacts/transformed/jpg/ocean_acidification.jpg

- **Dolphins Reduce Foraging Time in the Presence of Tour Boats**—Dolphins being studied reduced the proportion of time they spent foraging from about 35% of the time to under 25% of the time when boats were present. Average length of time spent foraging decreased from 10 minutes to 6 minutes when the tour boat was nearby, and once interrupted, it took the dolphins 54% longer than normal to return to foraging (14 minutes on average, instead of 9). As tour boat trips increase, the proportion of time that dolphins are disrupted is also increasing; at the study site, the dolphins spent 29% of their time in the presence of a tour boat, and since the study was completed, a second tour operator began trips in the same area.

Stockin, Lusseau, Binedell, Wiseman, Orams. *Tourism affects the behavioural budget of the common dolphin *Delphinus sp.* in the Hauraki Gulf, New Zealand. *Mar Ecol Prog Ser* 355: 287–295, 2008*

Oil and Gas Exploration

Controversy over oil and gas exploration noise continued this year, though it stayed largely below the public's radar. There was considerable action in Alaska, while the wheels of the bureaucracy spun slowly but steadily toward the possibility of re-opening the US Outer Continental Shelf to exploration off the Atlantic and Pacific coasts.



*Air bubbles from two airguns firing during a German academic seismic survey.
More info: <http://www.sfb574.ifm-geomar.de/php/goto/Sonne173-1/index.php?cc=258>
Image source: http://www.sfb574.ifm-geomar.de/php/goto/_data/so1731_gunning_air.jpg*

Alaska: Endangered Species, Native Peoples, and Off-shore Oil

Two key storylines played out in Alaska this year: endangered species and critical habitat decisions, and permitting/legal matters. First, **various listings and critical habitat designations for threatened species upped the ante for oil and gas development in the waters north of the Aleutian Islands and along the western and northern coasts of Alaska.**

Plans for oil development in Bristol Bay (north of the Aleutians) have begun, with the MMS aiming for a 2011 lease sale and starting planning for an EIS. On the same day that MMS announced the lease plan, the NMFS declared portions of the area critical habitat for the North Pacific right whale, spurring environmental advocates to say that any development will “eviscerate” these protections.

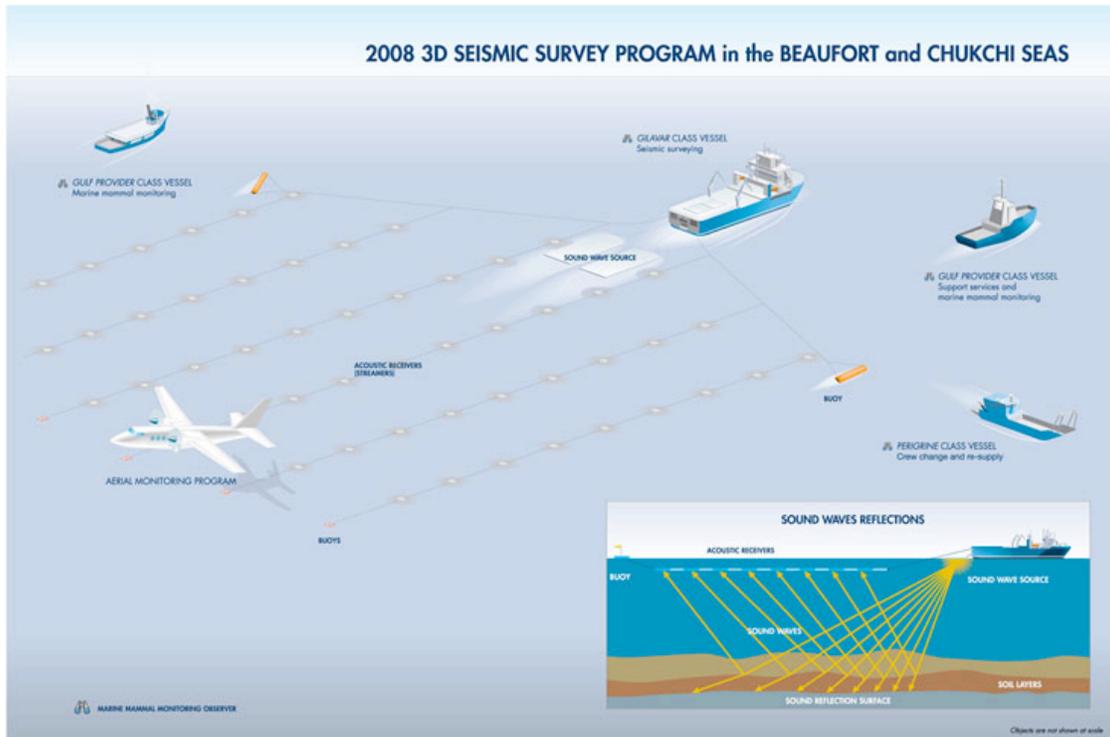
In Cook Inlet, a long bay leading up to Anchorage, **beluga whale numbers have plummeted in recent years, with both pollution and noise considered prime factors in the decline.** This year, NOAA declared the Cook Inlet belugas endangered, and began studies to determine critical habitat for their recovery. Much of the necessary research has already taken place, with NOAA releasing a draft recovery plan (mandated by the MMPA when the beluga was listed as depleted) at nearly the same time as the endangered listing; it appears that areas near Anchorage are especially critical for foraging and calving. Plans for further oil and gas development, as well as bridge and port construction, may be affected by these listings.

And, the listing of the Polar Bear as endangered will complicate permitting for oil and gas exploration off the North Slope. Studies are just beginning on the sensitivity of polar bears to noise. Construction noise may be a factor: a paper released this year noted that during construction of an artificial island to be used for oil processing, the noises of ice-auguring, pumping, backhoe trenching the seafloor, and pile driving

can be heard for several kilometers underwater. Sound measurements were made above the ice (in-air) and underwater; vibrations in the ice were also measured and indeed traveled the furthest. Airborne sounds dissipated to background ambient levels at less than 3km, while underwater sound reached median background levels at just over 7km, and in-ice vibrations reached natural levels at 10km.

Greene, Blackwell, McLennan. *Sounds and vibrations in the frozen Beaufort Sea during gravel island construction.* *Journal of the Acoustic Society of America*, February 2008, 123(2), p.687-695.

Meanwhile, in the Chukchi Sea (northwest of Alaska) and the Beaufort Sea (along the North Slope), further oil development is spurring intense resistance from both environmentalists and native peoples, who say that seismic surveys drive bowhead whales too far out to sea for their native hunts to continue safely.



A graphic produced by Shell, illustrating the components of a seismic survey

Image source:

http://www-static.shell.com/static/usa/imgs/generalcontent/full_width/exploration_production/3d_seismic_736.jpg

The big legal development this year was that the MMS's permits to allow Shell and others to conduct seismic surveys in the Beaufort were challenged in court, on the grounds that impacts on wildlife were not sufficiently considered, and a 3-judge panel of the 9th Circuit agreed. In the wake of the decision, MMS stressed that it had conducted a Programmatic EIS on North Slope exploration, as well as a specific Environmental Assessment for the surveys in question; in December, Shell announced plans to petition the 9th Circuit for a re-hearing before the full court. The company will push the argument put forth by the dissenting judge that the court has exceeded its field of expertise, and in so doing, ignored the expertise of the federal regulators. This will be an interesting variation on the Supreme Court sonar ruling, which held that the same District Court had not given sufficient deference to Navy experts.

MMS Planning Future Continental US Offshore Oil Development

The MMS announced two key research plans late this year. First, they announced a 5-year study that will assess how effective the mitigation measures used during seismic surveys and later oil and gas

development are at actually preventing excess sound exposures. Many of the measures used, including gradually ramping up the sound to give animals a chance to move away, and using marine mammal observers to see when whales are nearby, have not been carefully assessed.

[READ PRESS RELEASE]: <http://www.mms.gov/ooc/press/2008/press1029b.htm>

More dramatically, in the waning days of the Bush administration, the **MMS released preliminary plans for re-opening the US Outer Continental Shelf to oil and gas exploration**. Over the past two years, political pressure has been building to let states decide whether to allow offshore oil development, and both the Congress and President deferred for the first time from renewing long-standing federal bans. MMS released two documents, one of which outlines 21 lease sales that could take place during the next 5-year planning period, 2010-2015. The second document was a Notice of Intent to begin a Programmatic Environmental Impact Statement to investigate the environmental effects of multiple exploration activities on the Outer Continental Shelf, primarily seismic surveys. MMS Director Randall Luthi said, "Today, we are presenting options to the next Administration. The final decisions regarding the next steps are theirs. We're basically giving the next Administration a two-year head start. This a multi-step, multi-year process with a full environmental review and several opportunities for input from the states, other government agencies and interested parties, and the general public." Colorado Sen. Ken Salazar, Obama's choice as interior secretary, has indicated he likely will want to scale back the Bush administration's offshore drilling agenda. "There are places in the Outer Continental Shelf that are appropriate for drilling. There may be other places that are off limits," Salazar said Thursday during his Senate confirmation hearing. "We need to have a thoughtful process as we go forward." **In early February, Secretary Salazar announced that the comment period on the MMS proposals will be extended to 180 days (6 months).**



The MMS proposed 2010-2015 OCS leasing program classifies the entire three large planning areas off the east coast as "Draft Proposed Program Areas," along with three small coastal areas in Southern California and one in Northern California.

For more information, see the Draft Proposed OCS Program:

[http://www.mms.gov/5-year/PDFs/2010-2015/DPP%20FINAL%20\(HQPrint%20with%20landscape%20maps\).pdf](http://www.mms.gov/5-year/PDFs/2010-2015/DPP%20FINAL%20(HQPrint%20with%20landscape%20maps).pdf)

The US House of Representatives Committee on Natural Resources is scheduled to hold a series of hearings on offshore drilling from February 11-25. One key wildcard is the **current lack of funding for MMS to complete the required EIS**; the Notice of Intent notes that with funding, it could be completed by 2010, but without funding its future is uncertain; and, strangely, MMS even solicits investment from "outside sources" (presumably the oil and gas industry) to fund the research.

Scientists Address the Big Picture:

Reviews of What We Know, Calls for Action, Future Research Priorities

Several very useful “big picture” papers were published during 2008 that are **highly recommended reading for anyone who wants to get up to speed on the current state of scientific understanding of the impacts of noise on marine life**. These reports, as well as the NMFS noise exposure criteria work noted above (p. 8), are each an expression of the increasing emphasis placed on ocean noise in the past several years. **It is heartening to see agencies and researchers filling in a more comprehensive picture of the impacts of noise and planning future research strategies with more foresight; likewise, the emergence of some research scientists who are willing to speak more vigorously about the issue, including offering informed critiques of the pace or structure of regulatory responses, is a natural result of the maturation of the study of this issue.**

We complete this Special Report with summaries of:

- Two comprehensive overviews of the effects of noise on marine life
- An NGO “call to arms” report that offers a decent introduction to key issues
- A paper in which several scientists take a more aggressive stance on the need to address sonar noise impacts.
- Two agency attempts to address longer-term research priorities, one from the US Marine Mammal Commission, and one from the EU Science Foundation.

Review of Possible Ways that Increasing Ocean Noise May Affect Marine Mammals

In this wide-ranging literature review, Peter Tyack of Woods Hole Oceanographic Institute sketches the history of research into the effects of noise on marine life, with some references as well to effects seen in terrestrial creatures. He begins by noting that while acute disturbance of individuals attracts the most attention, the likely more profound effects of chronic disturbance on population vitality (success in foraging and mating) are much harder to discern. Several examples are presented of **studies that documented both temporary and long-term abandonment of key habitat when loud noise was present** (including grey whales abandoning a birthing lagoon for several years, then returning when the salt production facility was abandoned, and dolphins moving away from foraging habitat when shipping traffic is heavy). Other topics addressed in some detail by Tyack are:

- Whether global shipping may be decreasing the effective communication range of large whales (with the note that decreasing populations may tend to increase the distances between individuals or populations trying to communicate). He concludes that “the increase in ambient noise from shipping seems to have reduced the detectable range of low-frequency whale calls from many hundreds of kilometers in the prepropeller ocean down to tens of kilometers in many settings today.”
- Evidence of animals changing their call patterns in response to noise, presented as an indirect way to investigate the degree to which noise disrupts communication
- A summary of clear disturbance reactions noted in the literature, while stressing that the degree of response is not always a good indicator of impact (i.e., animals may not respond if they have a compelling reason to stay in that place).

He cites some startling studies on terrestrial animals showing that repeated disturbance exacts high costs in reproductive success and overall health (including a study of geese that showed that when undisturbed, geese increased their body mass and had a 46% breeding success, whereas in nearby areas where farmers scared them off their fields, they did not gain mass and had a breeding success of only 17%). To conclude, Tyack suggests that there are several lines of research that have so far received little attention, which could help to move key understanding of noise impacts forward, including making a case that we should be focusing on the most vulnerable animals as we study the effects of disturbance,

and noting that **impacts on communication, though less studied so far, may offer more useful insights** into longer-term impacts than focusing on more obvious behavioral changes.

Peter L. Tyack. *Implications for marine mammals of large-scale changes in the marine acoustic environment. Journal of Mammalogy*, 89(3): 549-558, 2008.

DOWNLOAD PAPER(pdf): <http://www.uvm.edu/%7ebmitchel/temp/Tyack - Marine acoustic environment.pdf>

The impacts of anthropogenic ocean noise on cetaceans and implications for management

Another comprehensive overview of ocean noise research, this one published late in 2007 by a Canadian biologist who has been forthright in expressing her concern that regulatory authorities are not doing enough to protect animals from noise exposure. This summary differs somewhat from the one above, in that Weilgart directly addresses some arguments made within the scientific community, especially those that stress a need to know precise sound exposure levels in order to craft regulatory responses. Weilgart holds that while exposure details are helpful, **there are many factors other than sound exposure that apparently determine an animals response, and that “dosage is not the only, or possibly even the most important, factor to consider...”** From this foundation, she goes on to report many studies that have documented reactions of animals to sound, and while she is not so diligent as Tyack to be sure to mention countervailing possibilities or evidence, the presentation is straightforward and very useful. Among the topics she addresses that are often overlooked are:

- We **only have good population estimates of a handful of the 84 species of cetaceans**, and our current monitoring efforts would be unlikely to notice even catastrophic population declines over the course of fifteen years. This is crucial in responding to the ongoing scientific debate over whether behavioral impacts have “population-level impacts”; the fact is that we are highly unlikely to see these impacts anyway, unless we significantly increase our monitoring efforts. If so, then it makes little sense to hold off on tighter regulations until we “know” they are happening, since we will perhaps never know until it is too late.
- **Limiting our assessment of deaths to bodies found on shore is likely an underestimate, and perhaps a huge one**: even in the well-studied near-shore orca population in the Pacific Northwest, just 14 carcasses of 200 orcas known to have died were found on the shore, a 7% recovery rate.
- The broad extrapolation of a few research results to set noise exposure limits is on shaky scientific ground: **TTS (temporary hearing loss) is highly variable among individuals, as well as between species**. One modeling study suggests that belugas may experience TTS after only 20 minutes of exposure to ice-breaker noise at 1-4km, and orcas may experience TTS after 30-50 minutes within 450m of whale-watching boats, with permanent hearing loss entirely possible from noise from several boats over prolonged periods.
- Apparent tolerance of noise or subtle responses (brief startle or modest avoidance) do not imply insignificant longer-term impact; Weilgart cites one study in which humpback showed no response to nearby explosions, but later became entangled in nets far more often than normal (implying some hearing loss), and of caribou who had lower calf-survival rates if exposed to low-level jets at certain critical periods, even though short-term reactions were minor.
- A critique of the value of Controlled Exposure Experiments as currently being designed: in order to assure that animals are kept safe from harm, sound levels are much lower than used in “real life”, and often, due to security requirements, sonar signals are not the same as those used by the military. In addition, CEEs fall into a sort of research limbo that Weilgart addresses separately, in which short-term studies produce results that are of limited applicability without some prior agreement about what sorts of short-term changes will be considered indicative of likely long-term impacts.

Weilgart concludes with a series of suggestions for future research, including developing quieter alternatives to some of today’s noise sources, and notes that because of the subtle, varying, and synergistically interacting effects of noise exposure, **“it is improbable that there will be conclusive evidence of causality...particularly within the time frames where irreversible population and ecosystem-level effects may occur,” so that “the application of precaution in management is particularly warranted.”**

L.S. Weilgart. *The impacts of anthropogenic ocean noise on cetaceans and implications for management. Can. J. Zool.* 85: 1091-1116 (2007)

IFAW Report: Turn it Down

The International Fund for Animal Welfare produced an easy-to-read summary-cum-call to action entitled *Ocean Noise: Turn it Down*. Illustrated throughout with attractive photos and pull-quotes from experts, it serves as a useful introduction to the broad themes being addressed in more detail in the scientific literature. It includes sections focusing on:

- The frequency ranges of various marine creatures and various human noise sources
- Case studies illustrating a wide range of impacts from many noise sources
- Brief descriptions of the key noise sources
- A comprehensive list of the various international calls for actions that have emerged in recent years

[DOWNLOAD REPORT]: http://www.AcousticEcology.org/onc/IFAW2008_OceanNoiseTurnItDown.pdf

Scientists Call Strongly for More Stringent Safety Thresholds for Sonar Exposure

This paper represents a **clarion call by several biologists who are convinced that we now have enough information about the impacts of sonar on whales to justify the imposition of more stringent safety measures**. In contrast to Navy insistence that there is no widespread problem, and to the slow and patient progression of scientific data to clarify exactly what the mechanisms that lead to strandings may be, these authors lay out a compelling case for a change in course. Among the highlights of this paper are an overview of stranding events that have stayed below the radar, and a summary of various international forums that have been stressing ocean noise concerns in the past several years. Strikingly, they detail several stranding events in which it appears that animals found on the beach died at sea, and question why ocean biologists do not follow the standard used in terrestrial biology, where it is widely acknowledged that only a small proportion of animals that die are actually found by humans, and each body found is considered likely to be indicative of many others never discovered. The authors stress that current safety standards, based on avoiding temporary or permanent hearing loss, are clearly inadequate, pointing out that likely population-level effects are much more apt to involve sub-lethal and non-physically injurious exposure levels that trigger behavioral and subtle physical changes, "e.g., repeated and widespread reduction in foraging or reproductive success, widespread impaired immune function, or large-scale displacement." They **conclude that "it must be assumed that military exercises involving sonar are not just affecting a small number of beaked whales, but are likely to be having wider effects on the ecosystem and quite possibly causing loss of biodiversity (at least locally, as appears to be the case in the Bahamas)."**

Parsons, Dolman, Wright, Rose, Burns. Navy sonar and cetaceans: Just how much does the gun need to smoke before we act? Marine Pollution Bulletin 56 (2008) 1248–1257
AEInews.org summary: <http://aeinews.org/2008/11/15/sonarlimits/>

Research Priorities: US, European Reports Address Future Directions

Two comprehensive reports that included focus on noise were released by government agencies this year, one in the US and one in Europe.

MMC Report on Population Vitality and Budgetary Priorities for Recovery of Endangered Marine Mammals

This report includes species-by-species assessment of endangered, threatened, and depleted marine mammals, focusing on historic and current populations, and the status of protection programs and an assessment of the population viability for each species. The report notes that **some species have received relatively high levels of attention via directed funding (e.g., western Stellar sea lions), while others have not received enough funding to prevent or even fully understand their ongoing declines (e.g., Cook Inlet beluga whales)**. Its key recommendation is that a coherent national strategy be developed, centered on a dynamic and adaptable approach that includes both a separate funding stream for research and management for marine mammal population recovery, and a strategy to prioritize recovery attention based on objective criteria including risk of extinction, expected conservation benefits, competing conservation needs, based on a structured and transparent risk/benefit analysis. One striking

element to the MMC report is the consistent attention paid to noise as a key factor in species stress, decline, and recovery.

European Science Foundation Marine Board Draft Research Strategy

The European Science Foundation Marine Board, in collaboration with the US National Science Foundation, released a Draft Research Strategy for continued research into the effects of human noise on marine mammals. The authors note that we face “a need to achieve a rapid improvement in the state of knowledge by undertaking new research that is focused on specific questions of high priority.” It **suggests a three-step process of digging deeper into the key unanswered questions**, and recommends continued review and integration of new research in order to assure that the next steps are being taken (e.g., we need to know the levels of sound actually being experienced by beaked whales in order to evaluate the responses that are observed, which then will inform studies of longer term impacts on individuals and populations). To provide more concrete examples of the approach they recommend, the report sketches the **likely research questions that would unfold over time in three key areas**: the effects of active sonar, especially on beaked whales, the effects of seismic surveys on marine mammals, and the effects of shipping noise. In each case, the report details first-layer questions that need to be answered, and then moves to the more detailed studies that could begin to answer these questions. These sections provide a blueprint for future research, though it remains unclear how the big-picture coordination might proceed.

Marine Board—European Science Foundation. The effects of anthropogenic sound on marine mammals: A draft research strategy. Coordinating author: Ian Boyd. Contributing authors: Bob Brownell, Doug Cato, Chris Clark, Dan Costa, Peter Evans, Jason Gedamke, Roger Gentry, Bob Gisiner, Jonathan Gordon, Paul Jepson, Patrick Miller, Luke Rendell, Mark Tasker, Peter Tyack, Erin Vos, Hal Whitehead, Doug Wartzok, Walter Zimmer.

[DOWNLOAD REPORT(pdf)]:

[http://www.esf.org/index.php?eID=tx_ccdamdl_file&p\[file\]=19340&p\[dl\]=1&p\[pid\]=1437&p\[site\]=European%20Science%20Foundation&p\[t\]=1224596288&hash=5bde7cebdfa6bf5817a183c1b4b86130&l=en](http://www.esf.org/index.php?eID=tx_ccdamdl_file&p[file]=19340&p[dl]=1&p[pid]=1437&p[site]=European%20Science%20Foundation&p[t]=1224596288&hash=5bde7cebdfa6bf5817a183c1b4b86130&l=en)

Links for more detailed information

The Acoustic Ecology Institute is the most 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 (3-4 times/year), contact Jim Cummings
EMAIL: cummings@acousticecology.org

[Lay summaries of recent field research](http://www.AcousticEcology.org/scienceresearch.html)
<http://www.AcousticEcology.org/scienceresearch.html>

[AEI Special Report on naval active sonars](http://www.AcousticEcology.org/sractivesonars.html) 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 FactCheck: Navy/NRDC Sonar Debate](http://acousticecology.org/srSonarFactCheck.html) Comprehensive analysis of both Navy and NRDC talking points on the active sonar issue, including consideration of how many incidents are relevant, the numbers of animals responding behaviorally, and the impacts of additional safety restrictions on training. <http://acousticecology.org/srSonarFactCheck.html>

[AEI Special Reports index](http://www.AcousticEcology.org/sractivesonars.html) 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/sractivesonars.html>

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

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

[AEInews.org](http://www.AEInews.org) The most important stories covered in the AEI News Digest and lay science summaries, presented in a blog/feed format, for delivery via RSS or email.
<http://www.AEInews.org>