RECOMMENDATIONS

Risk assessment methodology provides the framework for rational management of the risks from various threats to marine mammals. In many, if not most, cases the information needed to conclude that a given source of sound will result in biologically significant effects is simply not available (NRC, 2005). There is therefore an urgent need for a *U.S. National Research Program on Marine Mammals and Sound* that engages multiple federal agencies in order to provide the needed information. A second implication is that there is an urgent need for developing a process for *Rational Management with Incomplete Data,* by "identifying activities that do not reach a de minimus standard for biological significance" (NRC, 2005). A related, but distinct, issue is that the complex and lengthy permitting process under the MMPA, ESA, and NEPA has become a major impediment to conducting ocean research, hindering the research needed to improve our understanding of the effects of anthropogenic sound on marine mammals and of the environment in which they live. The ocean science community is urgently in need of an *Improved Regulatory Process* designed to foster badly needed research, while ensuring protection for marine mammals. Finally, given the controversy and misinformation surrounding the topic of marine mammals and sound, there is a need for a program of *Public Education and Outreach*.

U.S. NATIONAL RESEARCH PROGRAM ON MARINE MAMMALS AND SOUND

We strongly endorse the following recommendation by the U.S. Commission on Ocean Policy (2004):

Weddell seals locate breathing holes by listening for cracking ice at the surface. Photo courtesy of Michael Van Woert, NOAA, NESDIS, ORA.

Recommendation 20–9. The National Science Foundation, National Oceanic and Atmospheric Administration, U.S. Geological Survey, and Minerals Management Service should expand research on ocean acoustics and the potential impacts of noise on marine mammals. These additional sources of support are important to decrease the reliance on U.S. Navy research in this area. The research programs should be complementary and well coordinated, examining a range of issues relating to noise generated by scientific, commercial, and operational activities.

Hearing sensitivity studies provide information on what frequencies an animal can hear and how loud a sound must be to be heard. This dolphin is stationed underwater, waiting for the presentation of a sound from an underwater speaker. A suction-cup hydrophone is attached to its chest to record heartbeat sounds. In this experiment, heart rate changes were used as a response to sounds presented. Photo courtesy of Jen Miksis, University of Rhode Island.

A U.S. national research program should be established to support research to understand interactions between marine mammals and all sources of sound in the world's coastal and global oceans. This should be an interagency program with a mechanism to allow the participating Federal agencies to coordinate decisions with regard to disbursement of funding. Provision should be made to allow private, as well as public, funders to contribute to this program. At the U.S. federal level, participating agencies should include the National Science Foundation, U.S. Navy, National Oceanographic and Atmospheric Administration, Minerals Management Service, U.S. Fish and Wildlife Service, and other interested agencies. Diversity of funding sources is essential to bring a variety of perspectives to the research program and to help maintain the long-term stability needed for research on marine mammals.

The first step in this national research program would be a national workshop charged with converting the research recommendations in the National Research Council reports (NRC, 1994b, 2000, 2003, 2005) into a research strategy and implementation plan. We recommend that a national program office be established to assist with coordination and public outreach. The research strategy and implementation plan should call for proposals from the broad scientific community, including those at universities and at research institutions outside of the mission and regulatory agencies, to ensure that the greatest possible pool of expertise is brought to bear on the problem. In addition, since one obstacle to progress in the required research is a shortage of trained personnel, the research strategy and implementation plan should include a component designed to increase graduate student and postdoctoral training and participation in the research projects. Although it would be a U.S. national program, the goal is to foster a cooperative, international research effort as soon as possible. This is, in fact, a global issue and its solution will be best sought via international cooperation. The total program should grow over its first 3-4 years to a funded level on the order of $25M/year. New appropriations to the participating agencies are required to support this activity.

The well-established procedures of the scientific process should be followed in

this program. For example, all grants under the program would be competitively selected using established peer review procedures. Each year, a Program Announcement will be published defining the priorities for the program. The content of the program announcement would be agreed to by the agency program managers, but would be based on priorities determined by input from all stakeholders. The program should place strong emphasis on the open, peer-reviewed publication of research results. An initial 10-year commitment should be made to support this program, at which time a thorough, independent, expert review of accomplishments is important.

Marine Mammal Observers watching for whales & dolphins from the flying bridge of R/V Maurice Ewing in the Northern Gulf of Mexico, May, 2003. Photo courtesy of John Diebold, L-DEO.

Appendix A provides an initial assessment of research priorities, using the risk assessment framework to prioritize the research recommendations in the NRC reports (1994b, 2000, 2003, 2005).

RATIONAL MANAGEMENT WITH INCOMPLETE DATA

In the long term we strongly support the recommendation of NRC (2005) that a conceptual model, such as the Population Consequences of Acoustic Disturbance (PCAD) model "should be developed more fully to help assess impacts of acoustic disturbance on marine mammal populations. Development of such a model will allow sensitivity analysis that can be used to focus, simulate, and direct research..." The U.S. National Research Program should be designed to provide the data needed to populate, refine, and complete the PCAD model developed by the NRC in its 2005 report. This type of risk assessment model not only serves as a framework for identifying existing data gaps, but also ultimately provides the mechanism needed to assess the likelihood that specific acoustic sources will have adverse effects on marine mammal populations. Development of the PCAD model would provide the scientific foundation to move toward the recommendation of NRC (2005) that in the long term management actions regulating "takes" should be based on the concept of Potential Biological Removal (PBR), broadened to include behavioral effects.

Development of the PCAD model is some years in the future, however, and in the interim NRC (2005) recommends determining a de minimus standard for deciding which sound-related activities require authorization for "takes." Although there are substantial gaps in our knowledge concerning the issue of marine mammals and sound, it is still possible using our current knowledge and the framework of risk assessment to "identify activities that have a low probability of causing marine mammal behavior that would lead to significant population effects" (NRC, 2005). For example, activities that result in exposure of only a very small fraction of a population are unlikely to lead to population level effects, except in the case of highly endangered populations where every individual is significant. In another example, activities in which exposure results in only minor behavioral responses that are well within the

range of natural behavioral variability are unlikely to cause biologically significant effects. The fact that we are far from knowing all that we need to know about marine mammals and sound does not mean that we do not know anything. Congress should provide the necessary funding and direct the agencies to work with the scientific community to develop an intelligent decision system for identifying activities that do not reach a *de minimis* standard for biological significance (NRC 2005). Congress should also direct the agencies to develop a PBR-like regime for all forms of "take."

IMPROVED REGULATORY PROCESS

From the perspective of the scientific research community, a related problem is that the current regulatory structure makes obtaining the necessary authorizations for using sound in the sea for scientific research purposes so time-consuming and expensive that it is having a chilling effect on a wide variety of important and valuable uses of sound in the ocean, as well as on the very research needed to improve our understanding of the impacts of underwater sound on marine life and of the environment in which marine animals live. The implications are:

- The permitting and authorization process for scientific use of sound in the ocean urgently needs to be streamlined, so that it is timely, predictable, and assures compliance with all applicable legal requirements.
- The regulatory agencies need to be provided with the necessary resources to fulfill their mandates with oversight to assure that permits are being reviewed and given in a timely manner. Both NMFS and USFWS require additional funding to adequately fulfill their regulatory mandates.

Experimenter holding infant stranded Risso's dolphin while testing hearing using Auditory Evoked Potential (AEP) procedure (Nachtigall et al, 2005).

The various NRC reports and the U.S. Commission on Ocean Policy (2004) all agree that the current regulatory structure requires improvement and make a number of specific recommendations for doing so. NRC (1994), for example, suggests that a set schedule should be established for processing applications for scientific research permits to provide applicants with assurance that applications will be processed within a set period of time. Most research proposals to the federal government take about nine months to be funded. If permit processing had a deadline less than this duration, it would make the permit process much less onerous to research. Recent litigation has increased the burden on NMFS and USFWS for authorizing research, including environmental assessments under NEPA. The agencies must be provided with adequate resources to ensure timely authorizations that can stand up in court. We support the efforts of NMFS to develop general authorization procedures for common research activities, but note the need for this to be combined with streamlined authorization of individual research projects.

Effective protection of marine mammals requires that finite regulatory resources and efforts should be devot-

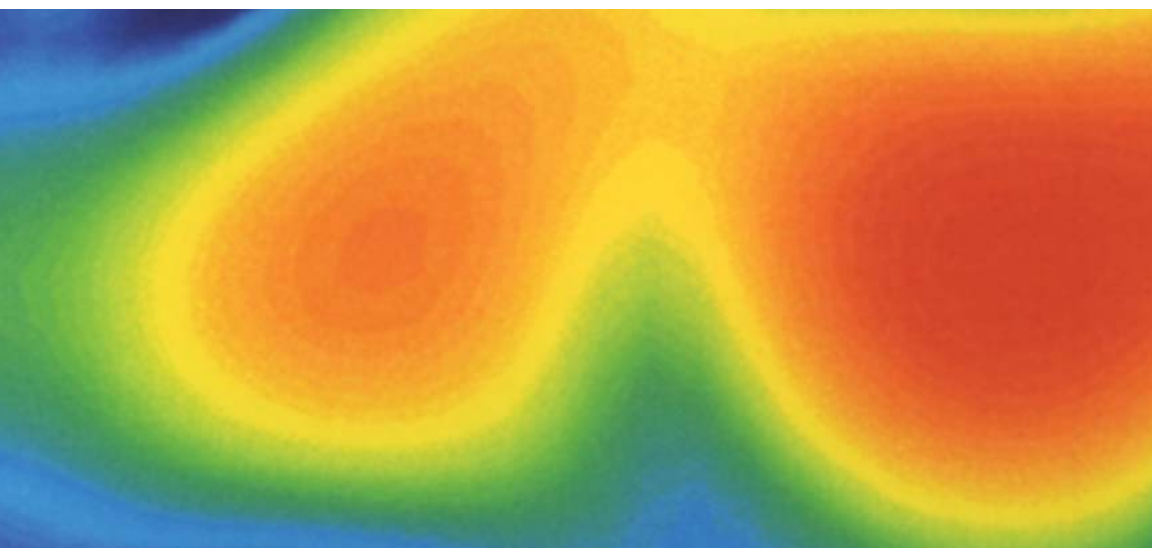
ed to the management of activities with potentially serious impacts on marine mammals, rather than to the management of activities that potentially cause momentary and inconsequential changes in behavior. NRC (2000) concluded that it "does not make sense to regulate minor changes in behavior having no adverse impact; rather, regulations must focus on significant disruption of behaviors critical to survival and reproduction." Unfortunately the Marine Mammal Protection Act has at times been interpreted to mean that any *detectable* change in behavior constitutes harassment that requires permitting (Swartz and Hofman, 1991). The U.S. Commission on Ocean Policy (2004) concluded:

> *Recommendation 20–6: Congress should amend the Marine Mammal Protection Act to revise the definition of harassment to cover only activities that meaningfully disrupt behaviors that are significant to the survival and reproduction of marine mammals.*

The recommendations made in the NRC reports are fully consistent with this recommendation. The need for this redefinition was highlighted in the testimonies of members of the scientific research community during the 2003 Congressional proceedings involving the reauthorization of the MMPA (Ketten, 2003; Tyack, 2003; West, 2003; Worcester, 2003). The Research Caucus urges Congress to make the suggested changes to the definition of harassment.

PUBLIC EDUCATION AND OUTREACH

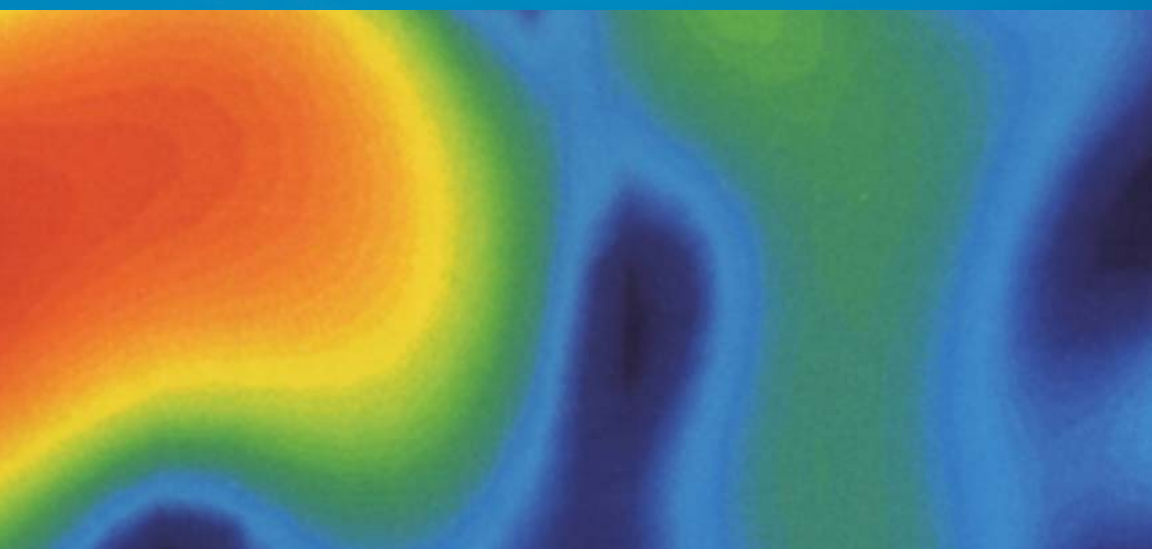
Given the controversy surrounding the issue of marine mammals and anthropogenic sound, it is extremely important that scientifically valid information be readily available to the public. One of the few such sources of scientifically sound information available to the public and the educational community is the *Discovery of Sound in the Sea* web site (www.dosits.org). This web site provides information on the basic science of sound in the sea, on how both animals and people use sound in the sea, and the effects of anthropogenic sound on marine life. One web site is not an adequate program of education and public outreach, however. A more complete, coherent program is needed. The educational efforts should also include programs to educate producers of ocean sound. The educational and outreach program could be included as part of the *U.S. National Research Program on Marine Mammals and Sound* recommended above.



SUMMARY

The recommendations given above are not new. Fundamentally the same recommendations were made by the scientific community in the National Research Council reports (1994b, 2000, 2003, 2005), in testimony to Congress (Ketten, 2003; Tyack, 2003; West, 2003; Worcester, 2003), and in published papers (e.g., Tyack *et al.*, 2003/04; Worcester and Munk, 2003/04). Fundamentally the same recommendations were made by the U.S. Commission on Ocean Policy (2004). It is time for action if we are to develop the knowledge needed to effectively protect marine mammals from the threats facing them.

Image Below: Forward-looking sonar systems provide a three-dimensional picture of the ocean depths and any submerged obstacles ahead of a vessel. These systems are able to detect marine animals that are in the water. This is an example from a 1998 test involving northern right whales. The range to the animal is about 50 meters and the water depth is approximately 40 meters. The colors indicate target strength, ranging from red (strongest) to blue (weakest). Image courtesy of Jim Miller, University of Rhode Island.



APPENDIX. RESEARCH PRIORITIES

Risk assessment methodology provides a framework to prioritize different research needs. We suggest differentiating between specific research projects likely to resolve critical management issues in a well-defined time and longer term research programs that are highly relevant to management but that require regular sustained funding over long periods to provide basic support for management decisions. We set priorities for targeted projects, but list with no prioritization the longer term areas requiring increased support.

The research area with the greatest uncertainty and the greatest opportunity for directing management decisions in the next decade involves effects of sound on marine mammals. There are a variety of areas where targeted research programs would be likely to resolve critical uncertainties within a 5–10 year period. These should be the top priority research recommendations.

Of special immediate concern is research to understand the one case where exposure to underwater sound has been related to mortalities – the relation between mid-frequency sonar and mass strandings of beaked whales (Cox *et al.,* 2005). We recommend a directed research program to decrease response times for experts in pathology to study stranded animals associated with sound, to standardize data collection and reporting from strandings associated with sound, and to determine, where possible, any human activities coinciding with the stranding that might be involved in the event. This program should also support rigorous scientific studies to test all feasible hypotheses of mechanisms consistent with the observed traumas. If new mid-frequency sonar signals can be designed to reduce impact on beaked whales while retaining the military sonar function, cooperative analyses of these alternate signals should be a high priority and should be conducted employing combined expert analysis of potential behavioral and physiologic responses to the new source characteristics. Questions have been raised about the effect of low frequency sonar and airguns on beaked whales, but the evidence for an association with stranding is much weaker for these sources. Therefore, testing these signals should be a lower priority, but to assure all impacts are considered and because of the value of comparisons from responses to non-traumatic sources, some funding should be devoted to these as well as other common man-made sound sources such as conventional fish finding and research sonar, noise associated with construction, shipping, etc.

Another area of immediate importance involves research to evaluate untested assumptions used in current management. Of high importance is testing whether different marine mammal species avoid intense sources such as airguns at ranges sufficient to prevent injury and to test the effectiveness of ramp up as a mitigation tool. Determinations of level of impact depend critically upon such untested assumptions, but these can be tested within five years using existing methods through a focused research program.

Most monitoring and mitigation plans rely heavily on visual observers to sight marine mammals. There is a low probability of sighting many species under most conditions. Recent work has demonstrated that passive acoustic monitoring can enhance monitoring efforts, and there has been preliminary research on new techniques such as whalefinding sonar and radar. A high priority for improving the effectiveness of mitigation efforts involves research to test the effectiveness of these different methods and how to optimally integrate them. Such an effort should have the goal of improving the effectiveness of monitoring by an order of magnitude within 5–10 years.

Of longer term importance is research to test whether there is a hazard from currently unregulated sources of sound. The potential effect of low frequency ship noise on animals sensitive to low frequencies is perhaps of highest importance here, since ship noise has increased global ambient noise and is relevant for endangered baleen whales. We know that shipping has

elevated average noise levels ten to 100 fold in the frequency range at which baleen whales communicate, but we have no evidence whether this poses a risk of adverse impact. A 5–10 year research program focused on studying the effective ranges of communication in these whales (especially calls used for breeding), studying effects of shipping noise on communication, and studying whether they have mechanisms to compensate for increased noise could help resolve this uncertainty. These studies should be balanced with continued research on risk factors for ship collision in baleen whales, which is known to be a significant hazard for some populations, and involves lack of response or insufficient response to the sound of oncoming ships.

High frequency sound travels less far than low frequency, but the increase in high frequency sources such as acoustic devices designed intentionally to harass marine mammals creates a priority for studying the impacts of these devices on coastal toothed whales that use high frequencies. The few studies on these impacts suggest strong avoidance responses at low received levels. We recommend continued funding for studies of the impact of these sources on toothed whales, especially porpoises and river dolphins.

Another area that may not yield immediate results, but will be critical to improve judgments of biological significance of disturbance was highlighted by the NRC 2005 report. There are few if any models or methods available to calculate the effect specific disturbances will have on vital rates of individual animals. If policy is to move towards population analysis of the consequences of acoustic disturbance, there must be new funding to start a completely new area of research on this topic.

Summary of research priorities for focused projects in order of priority

1. Study effects of mid-frequency sonars (and airguns and alternate sources) on odontocete whales (with focused effort on beaked whales where possible).
2. Test assumptions about which species avoid intense sound sources enough to avoid adverse impact, including testing ramp-up.
3. Develop new methods to monitor, detect, and/or predict the presence of marine mammals and test their effectiveness
4. Test effects of low frequency shipping noise on baleen whales, which are presumed to use low frequencies.
5. Test effects of high frequency sound sources designed to affect marine mammals on coastal species specialized for high frequencies.
6. Develop new modeling and empirical efforts to link changes in behavior and physiology to vital rates of individuals.
7. Tie controlled laboratory data to expanded field tests.

Summary of research projects requiring sustained funding to reduce important uncertainties.

These are important, but are judged less likely to provide rapid resolution of management problems. They are therefore not ranked in priority.

- Design acoustic sensing for ocean observation networks capable of monitoring ambient ocean noise levels and trends on global, regional, and local scales.
- Survey the status, abundance, and distribution of marine mammals globally to develop an improved capability for assessing the exposure of marine mammals to sound producing activities.
- Develop a broadly accessible data base of results from strandings with standardized necropsies capable of detecting most causes of death.
- Support the development of more sophisticated methods to sample behavior and physiology of marine mammals both in the laboratory and in the wild.
- Support long term field studies of baseline behavior for selected marine mammal populations.

REFERENCES

Cox, T. M., T. J. Ragen, A. J. Read, E. Vos, R. W. Baird, K. Balcomb, J. Barlow, J. Caldwell, T. Cranford, L. Crum, A. D'Amico, G. D'Spain, A. Fernandez, J. Finneran, R. Gentry, W. Gerth, F. Gulland, J. Hildebrand, D. Houser, T. Hullar, P. D. Jepson, D. Ketten, C. D. MacLeod, P. Miller, S. Moore, D. Mountain, D. Palka, P. Ponganis, S. Rommel, T. Rowles, B. Taylor, P. Tyack, D. Wartzok, R. Gisiner, J. Mead, and L. Benner (2005). Report of a workshop to understand the impacts of anthropogenic sound on beaked whales, *J. Cetacean Res. Management*, 31 pp. (submitted).

Environmental Protection Agency (1992). *Framework for Ecological Risk Assessment,* U.S. Environmental Protection Agency, Risk Assessment Forum, Washington, D.C.

Harwood, J. (2000). Risk assessment and decision analysis in conservation, *Biological Conservation,* 95, 219–226.

Ketten, D. R. (2003). Testimony of Darlene R. Ketten, Ph.D., on Environmental Legislative Proposals to the Subcommittee on Readiness and Management Support, Senate Armed Serviced Committee, 1 April 2003. (http://armed-services.senate.gov/statemnt/2003/April/Ketten.pdf).

Nachtigall, P. E., M. E. Yuen, T. A. Mooney, and K. A. Taylor (2005). Hearing measurements from a stranded infant Risso's dolphin (Grampus griseus). *J. Experimental Biology,* 208, 4181–4188.

National Marine Fisheries Service (2000). Annual Report to Congress: 1999-2000. Administration of the Marine Mammal Protection Act of 1972. National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA Fisheries), Silver Spring, Maryland, 105 pp. (http://www.nmfs.noaa.gov/prot_res/readingrm/MMPAannual/1999_2000_mmparep.pdf)

National Research Council (1983). *Risk Assessment in the Federal Government: Managing the Process,* National Academy Press, Washington, D.C., 191 pp.

National Research Council (1993). *Issues in Risk Assessment,* National Academy Press, Washington, D.C., 374 pp.

National Research Council (1994a). *Science and Judgment in Risk Assessment,* National Academy Press, Washington, D.C., 672 pp.

National Research Council (1994b). Low-Frequency Sound and Marine Mammals: Current Knowledge and Research Needs, National Academy Press, Washington, D.C., 75 pp.

National Research Council (2000). *Marine Mammals and Low-Frequency Sound: Progress Since 1994,* National Academy Press, Washington, D.C., 146 pp.

National Research Council (2003). *Ocean Noise and Marine Mammals,* National Academy Press, Washington, D.C., 192 pp.

National Research Council (2005). *Marine Mammal Populations and Ocean Noise: Determining When Noise Causes Biologically Significant Effects,* National Academy Press, Washington, D.C., 126 pp.

Payne, R., and D. C. Webb (1971). Orientation by means of long range acoustic signaling in baleen whales, *Annals of the New York Academy of Sciences,* 188, 110–141.

Read, A. J., P. Drinker, and S. Northridge (2003). By-catches of marine mammals in U.S. fisheries and a first attempt to estimate the magnitude of global marine mammal by-catch. IWC paper number SC/55/BC, 12 pp.

Richardson, W. J., C. R. Greene, Jr., C. I. Malme, and D. H. Thomson (1995). *Marine Mammals and Noise,* Academic Press, Inc., San Diego, California, 576 pp.

Swartz, S. L. and R. J. Hofman (1991). Marine mammal and habitat monitoring: Requirements; principles; needs; and approaches. Report prepared for the U.S. Marine Mammal Commission, August 1991. PB91-215046. p. 2–3.

Tyack, P., J. Gordon, and D. Thompson (2003/04). Controlled exposure experiments to determine the effects of noise on marine mammals, *Marine Technology Society Journal,* 37, 41–53.

Tyack, P. (2003). Testimony of Peter Tyack, Ph.D., on H.R. 2693, Marine Mammal Protection Act Amendments of 2003, to the Subcommittee on Fisheries Conservation, Wildlife, and Oceans, Committee on Resources, U.S. House of Representatives, 24 July 2003. (http://resourcescommittee.house.gov/108cong/fish/2003jul24/tyack.htm)

U.S. Commission on Ocean Policy (2004). *An Ocean Blueprint for the 21st Century: Final Report of the U.S. Commission on Ocean Policy,* U.S. Commission on Ocean Policy, Washington, D.C., 522 pp.

West, R. D. (RADM Ret.) (2003). Testimony of RADM Richard D. West, USN, Ret., President, Consortium for Oceanographic Research and Education, on SR-428, The Marine Mammal Protection Act, to the Subcommittee on Oceans, Fisheries, and Coast Guard, Senate Committee on Commerce, Science, and Transportation, 16 July 2003. (http://commerce.senate.gov/hearings/testimony.cfm?id=862&wit_id=2380)

Worcester, P. F. (2003). Testimony of Peter F. Worcester, Ph.D., on H.R. 2693, Marine Mammal Protection Act Amendments of 2003, to the Subcommittee on Fisheries Conservation, Wildlife, and Oceans, Committee on Resources, U.S. House of Representatives, 24 July 2003. (http://resourcescommittee.house.gov/108cong/fish/2003jul24/worcester.htm)

Worcester, P. F., and W. H. Munk (2003/04). Commentary: The experience with ocean acoustic tomography. *Marine Technology Society Journal,* 37, 78–82.

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