Report of an International Workshop: Policy on Sound and Marine Mammals, 28–30 September 2004, London, England

Erin Vos and Randall R. Reeves

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Marine Mammal Commission
4340 East-West Highway, Room 905
Bethesda, MD 20814
United States

Joint Nature Conservation Committee
Dunnet House
7 Thistle Place
Aberdeen
AB10 1UZ
United Kingdom

Foreword: A Brief Summary from the Workshop Conveners

The U.S. Marine Mammal Commission (Commission) and the U.K. Joint Nature Conservation Committee (JNCC) sponsored an international policy workshop on sound and marine mammals in London, U.K., 28–30 September 2004. More than 100 participants from more than 20 countries attended. The Commission and JNCC gratefully acknowledge all those who assisted in organizing and carrying out the workshop.

The workshop goals were to:

- Determine the range of efforts to manage, mitigate, and prevent impacts of human-generated sound on marine mammals;
- Determine how various legal and regulatory frameworks have been or could be used to address acoustic impacts on marine mammals;
- Identify cross-boundary or multilateral issues; and
- Identify innovative management strategies and policies that might be incorporated within national and international frameworks.

The workshop included individual and panel presentations as well as small-group and plenary discussion sessions. It focused on promoting contacts and dialogue among expert scientists, industry representatives, policy-makers, and administrators from around world to share information and perspectives about managing the interactions between anthropogenic (human-generated) sound and marine mammals. The organizers did not set out to produce recommendations. Nevertheless, a number of information and institutional gaps, as well as means to address these gaps, emerged as themes from the workshop. We provide our brief summary below.

1. Basis for Concern and State of Knowledge

- Recent mass strandings of beaked whales and other cetacean species have raised international awareness and concern about the impacts on cetaceans from exposure to loud, episodic anthropogenic sounds in low- and mid-frequency ranges.
- Seismic airguns, military sonar, commercial ships, and sound projectors used in large-scale ocean research produce some of the most powerful and pervasive anthropogenic sounds in the oceans.
- Because of the nature of sound propagation in water and the high mobility and wide distribution of marine mammals, managing marine mammal exposures to anthropogenic sound is transboundary in scope and requires international cooperation.
- A wide variety of human activities (e.g., shipping, oil and gas exploration and development, construction, ocean research, and military defense) undertaken by virtually every coastal nation introduce anthropogenic sound into the oceans and seas.
- Different species respond differently to various types and levels of anthropogenic sound. When responses occur, documented effects range from short-term behavioral change to physical injury, stranding, and death.
- In most developing (and many developed) countries, baseline information on marine mammals and underwater sound is far from adequate, and few or no monitoring programs are in place.

- Policy-makers, scientists, and the general public need a better understanding of the effects of sound on marine mammals at both individual and population levels.
- The levels and other characteristics of human-generated underwater sounds from different sources need to be better documented at local, regional, and global levels.
- Scientists and policy-makers need a much better qualitative and quantitative understanding of the mechanisms that link underwater sound to behavioral and physiological responses by marine mammals. Such understanding should include knowledge of dose-response relationships and thresholds of exposure that trigger given effects.
- The biological significance of marine mammal reactions to anthropogenic sounds needs further elaboration. Scientists and policy-makers need to understand the type and scale of effects that would have long-term or irreversible consequences for an individual or a population. Biological significance likely depends, at least in part, on population status. For example, displacement of a few animals belonging to an endangered population could be highly significant, whereas it might be unimportant for a large, healthy population.
- The immediate, acute, or observable effects of underwater sound on marine mammals are important. However, the potential cumulative, synergistic, and long-term effects, although much more difficult to detect, characterize, and measure, may be as important, or even more important, to marine mammal populations.

2. Managing Risk in the Face of Uncertainty

- Risk assessment and environmental impact assessment processes are not used universally, and are not used in relation to some sources of noise. When such tools are used, the potential impacts on marine mammals from anthropogenic sound are frequently overlooked. Use of these tools and consideration of these potential impacts should become routine.
- Best practices in risk assessment and environmental impact assessment involve:
  (a) Recognizing and quantifying risks and uncertainties;
  (b) Incorporating a precautionary approach;
  (c) Assessing potential impacts early in project design so that the results can be used during implementation; and
  (d) Making use of all available relevant data.
- Modifying the spatial and temporal scope of a sound-producing activity may be one of the most effective ways to reduce its risk to marine mammals.

3. Mitigation Strategies

- In managing the risks of sound to marine mammals, strategies must be tailored to particular situations such that appropriate mitigation tools are employed to address particular types and levels of sound and to protect particular species from harm. In other words, a mitigation strategy that is appropriate for one situation may not be appropriate for another: one size does not fit all.
- The most promising mitigation strategies are those that reduce sound output and those that separate sound-generating activities, spatially and temporally, from marine mammals. This separation may be accomplished through, for example, seasonal or year-round avoidance of areas that may include concentrations of marine mammals, areas of

special importance to marine mammals (e.g., locations used for calving/pupping, resting, feeding), or areas used preferentially by species known or thought to be especially vulnerable to harmful effects of particular types of sound (e.g., beaked whales and naval sonar).

- Mitigation strategies that change sound output or constrain operations may be the most expensive or disruptive for the sound producers.
- The shipping industry is a major contributor to the sound budget of the oceans. Shipping is an international enterprise, with many aspects regulated through the International Maritime Organization. Technologies are available for making quieter ships, and the industry's own interests may converge with the conservation imperative to employ those technologies through, for example, a "green shipping" certification initiative. Many ship owners may be willing to work with scientists and conservationists to develop and implement a strategy for managing ship noise, particularly if the risks of ship noise to marine mammals are clearly communicated.
- The effectiveness of many tools currently used to mitigate the effects of human-generated sound on marine mammals (e.g., soft-start/ramp-up, onboard observers to detect marine mammals) is unproven. Monitoring and experimentation should be conducted to test the effectiveness of these and other mitigation techniques.

4. International Cooperation

- Although no existing international legal instrument directly and explicitly addresses underwater sound as a threat to marine mammals, several multilateral agreements contain language that some interpret as applying to this issue (e.g., International Convention for the Regulation of Whaling, United Nations Convention on the Law of the Sea).
- A few multilateral legal instruments and regional bodies are in early stages of addressing this issue. For example, two regional cetacean protection agreements under the Convention on Migratory Species (ASCOBANS and ACCOBAMS) have passed resolutions and commissioned research related to the effects of sound. The North Atlantic Treaty Organization's Undersea Research Centre supports a major program of mitigation and research, focused on reducing the risks to beaked whales from military sonar during research exercises.
- In the absence of an existing international legal instrument with an explicit mandate to address the effects of sound on marine mammals, it will be necessary to decide among three main options for further action:
    (1) Focus on national and/or regional approaches and abandon a global approach;
    (2) Seek to modify or re-interpret an existing international legal framework; or
    (3) Create a new international legal instrument dedicated, at least in part, to this issue.
- Although human-generated underwater sound is a potential problem for marine mammals worldwide, few nations have domestic legal frameworks to address it. Those domestic frameworks that exist (e.g., in the United Kingdom, United States, Brazil, and Australia) tend to be applied unevenly to different sound sources.
- Successfully addressing this issue at all levels—national, regional, and international—will require that the problem be better documented and communicated clearly and credibly, with explicit acknowledgment of both risk and uncertainty.

- The long-term effectiveness of any strategy to address this issue will be enhanced if the solution has a credible scientific basis and is perceived to be culturally sensitive and fair to all stakeholders.

The Commission and JNCC will continue to work on this issue with due regard for the discussions that took place during this workshop. Although international collaboration on research and international cooperation in management efforts are essential, a separate international (global) treaty to address this issue is not considered a viable solution at this time. The effectiveness of international legal instruments depends on the actions of national governments to implement them.

Although a number of multilateral efforts are ongoing, their effectiveness in addressing the effects of human-generated sound on marine mammals remains to be seen. Given the current state of knowledge, advances in this issue are likely to be achieved through national laws and management programs, international collaboration on research, and international coordination of management via regional and industry-based initiatives. We encourage continued international discussion and cooperation, especially on research to reduce scientific uncertainties and on the development of mitigation strategies.

In September 2005, the Commission completed a policy dialogue on the topic of sound and marine mammals involving a 28-member Advisory Committee composed of representatives the major interest groups. Members of the Advisory Committee will submit non-consensus statements to the Commission that provide their views on various topics. Having benefited from the deliberations of this group, the Commission will submit a report to the U.S. Congress, which will contain major findings and recommendations on domestic and international aspects of this issue. The non-consensus statements from Advisory Committee members will be attached to the Commission's report.

This report of proceedings was drafted by Randall R. Reeves and Erin Vos, with assistance from a number of workshop participants, and reviewed and approved by the Commission and JNCC. The authors circulated the draft report to all workshop presenters and topic specialists for comment, but did not seek consensus on each point. The report attempts to portray discussions among workshop participants and the information as it was presented at the meeting. Participants did not formally represent the positions of their employers or home countries. Rather, they informally discussed their own perspectives and experiences. These proceedings do not necessarily reflect the positions of the Marine Mammal Commission, the Joint Nature Conservation Committee, or their respective governments.

December 2005

David Cottingham
Executive Director
U.S. Marine Mammal Commission

Mark Tasker
Head of Marine Advice
U.K. Joint Nature Conservation Committee

Report of an International Workshop: Policy on Sound and Marine Mammals 28–30 September 2004 London, England

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I. Introduction

As an adaptation to their aquatic lifestyle, many marine mammals use sound as a primary means of interacting with their environment. Their use of sound to communicate, navigate, avoid predators, and find food has helped enable cetaceans (whales, dolphins, and porpoises), in particular, to occupy all of the world's seas and oceans as well as some large river systems. However, their dependence on sound has also made them vulnerable to noise associated with human activities. Since the 1970s, with the development and expansion of the offshore oil and gas industry, marine mammal scientists and managers have expressed concern about the biological effects of the underwater sound related to that industry. During the past two decades, such concern has spread to encompass additional human activities. In particular, a series of beaked whale stranding events concurrent with naval activities during the last decade has raised concerns about the potential impacts of military sonar, and studies of increasing ambient noise levels have led to concerns about the potential for shipping activities to have chronic impacts on marine mammals. As major producers of underwater sound, the shipping industry, the oceanographic research community, the oil and gas industry, and the military have come to be viewed as sources of risk to marine mammals.

In his opening remarks to the workshop, David Cottingham, Executive Director of the U.S. Marine Mammal Commission (Commission), emphasized that the meeting's focus was to be on policy rather than science. He outlined the context of this meeting, noting that in 2003 the U.S. Congress had directed the Commission to organize a series of meetings to survey the nature and range of acoustic threats to marine mammals and develop information on how those threats could be addressed.[1] The Federal Advisory Committee on Acoustic Impacts on Marine Mammals (Advisory Committee) was established in December 2003, consisting of 28 members representing the shipping and oil and gas industries, the academic community (including marine mammal scientists and geophysicists), various environmental nongovernmental organizations, the U.S. Navy, and relevant management agencies within the U.S. government. The Advisory Committee was asked to 1) review and evaluate available information on the impacts of human-generated sound on marine mammals, marine mammal populations, and other components of the marine environment, 2) identify areas of general scientific agreement and areas of uncertainty or disagreement related to such impacts, 3) identify research needs and make recommendations concerning priorities for research in critical areas to resolve uncertainties or disagreements, and 4) recommend management actions and strategies to help avoid and mitigate possible adverse effects of anthropogenic sounds on marine mammals and other components of the marine environment.

The congressional mandate directed that the Commission's efforts to address acoustic impacts on marine mammals be international in scope. Although a number of the organizations represented on the Advisory Committee have offices in more than one country and engage in international activities, the Commission decided to investigate directly how the sound issue is (or is not) being addressed outside the United States. It hoped, in the process, to build relationships to improve

[1] Omnibus Appropriations Act of 2003 (Public Law 108-7) directed the Marine Mammal Commission to "fund an international conference or series of conferences to share findings, survey acoustic 'threats' to marine mammals, and develop means of reducing those threats while maintaining the oceans as a global highway of international commerce."

international communication and cooperation. The Advisory Committee supported the idea of a Commission-sponsored international policy workshop and provided valuable advice in the early planning stages. Among the committee's suggestions was that the Commission seek an international partner to co-sponsor the workshop. The Commission approached the U.K. Joint Nature Conservation Committee (JNCC), and in March 2004 the two agencies agreed to collaborate in drafting the agenda, identifying participants, convening the workshop, and producing this report. The Advisory Committee discussed the proposed topics and agenda for the workshop at its plenary meetings in February, April, and July 2004.

A. Goals of the Workshop

The workshop had the following goals:

- To determine the range of existing efforts to manage, mitigate, and prevent impacts of human-generated sound on marine mammals outside the United States.
- To determine the extent to which legal and regulatory frameworks, other than those provided by U.S. domestic laws and regulations, address acoustic impacts on marine mammals.
- To identify cross-boundary or multilateral issues regarding the management and mitigation of acoustic impacts on marine mammals.
- To identify innovative management strategies and policies that might be incorporated within national and international frameworks.

The intent was not to develop recommendations or necessarily to reach consensus on issues. Instead, the focus was on establishing dialogue across international boundaries and on widening the perspectives and strengthening the knowledge base of workshop participants. The workshop conveners and participants made an effort to share information and improve understanding of the range of views on the topics discussed.

B. Workshop Agenda and Procedures

The annotated workshop agenda is given in Appendix 1. The conveners sought to identify and invite individuals from outside the United States and United Kingdom who would have knowledge about and interest in the topic. A diverse group of individuals drawn from industry, military, environmental, academic, regulatory, and other organizations from more than 20 countries attended the meeting (Appendix 2). A majority of participants were from North America or Europe (42 and 41 percent, respectively), with approximately 9 percent of participants from Australia and Asia, 5 percent from South America, and 2 percent from Africa. About 43 percent of participants were employed by government agencies, and about 52 percent were employed by non-governmental entities such as universities or environmental groups. Workshop participants did not formally represent the positions of their employers or home countries; rather, they were asked to discuss informally their perspectives and experiences.

Experts on marine acoustics, marine mammal biology, international law, policy analysis, and environmental impact assessment gave overview presentations. These were supplemented by a series of background papers provided to participants in advance of the workshop (Appendix 3), 27 posters prepared for display during the workshop (Appendix 4), and other materials provided

by participants for distribution at the meeting (IAGC 2004, IAGC no date). In addition, several case studies were presented on the legal and regulatory regimes governing underwater sound and marine mammal protection in specific regions.

C. Organization of the Report

The organization of this report follows the workshop agenda, with each of six topics summarized in turn. To the extent possible, the authors have attempted to eliminate redundancy while recognizing that the topics were often interconnected. All presentations referred to in the report can be found online at http://www.mmc.gov/sound/internationalwrkshp/agenda.html.

The report attempts to portray accurately discussions among workshop participants and the information as it was presented at the meeting. The proceedings recorded in this report do not necessarily reflect the positions of the Marine Mammal Commission, the Joint Nature Conservation Committee, or their respective governments.

II. Topic 1: Overview of Human-Made Sound Sources and Impacts on Marine Mammals

A. Overview of Human-Made Sound Sources in the Marine Environment

John Hildebrand (Scripps Institution of Oceanography, U.S.) provided a brief introduction to acoustics concepts and described sources of human-generated sound and their global distribution in the marine environment. Broad categories of sound were distinguished—continuous vs. intermittent (pulsed) and broadband vs. narrowband. To compare different sounds (e.g., a continuous broadband source and a pulsed narrowband source), the standard approach is to combine pressure, time, and frequency to produce an energy level metric.

Hildebrand described major biological and human-generated components of ambient ocean noise. In general, sounds contributing to ambient noise in the oceans come from natural phenomena such as earthquakes, rainfall, and animal calls, along with anthropogenic activities including shipping, seismic surveys (airguns), and sonar use. Only one good measurement of long-term trends in ambient ocean noise is available: a U.S. Navy Sound Surveillance System (SoSuS) array documented a 10-dB increase in low-frequency (10–1000 Hz) ambient noise in the eastern Pacific Ocean off Point Sur, central California, from 1964 to 2001 (Andrew et al. 2002). Hildebrand considered this increase to be due primarily to shipping, as it seems to correspond to a rapid and consistent upward trend in container ship trades to the United States over the last few decades. As ships pass over the edge of the continental shelf, the low-frequency sounds they produce are transmitted to deep channels and thence can travel over long distances. Nieukirk et al. (2004) illustrated this deep channel phenomenon by reporting that a series of hydrophones along the Mid-Atlantic Ridge have recorded the distant sounds of airguns from seismic vessels almost continuously throughout the year. These sounds are likely coming from deep waters off Europe, Africa, and eastern North and South America.

Hildebrand stressed the value of developing regional and global ocean sound energy budgets and the importance of a long-term monitoring program to track future changes in ambient ocean noise. The most potent individual anthropogenic sound sources in the oceans are underwater nuclear explosions (source levels[2] greater than 300 dB), navy ship shock trials (source levels ~250–300 dB), mid-frequency and low-frequency active sonars (source levels ~200–250 dB), and seismic airguns (source levels ~200–260 dB). A rough annual energy budget might be developed by considering the number of each type of sound source active in a given year, along with individual source characteristics and duty cycles. Hildebrand identified the following priorities for monitoring ocean sound:

- Mapping ocean noise in areas of anthropogenic sound production (e.g., shipping lanes, industrial sites, and navy ranges),
- Initiating long-term ocean noise monitoring,
- Analyzing historic marine anthropogenic noise data,
- Developing global models for ocean noise,

[2] Source and received levels of sound reported in dB re: 1 µPa @ 1 m unless otherwise stated.

- Identifying signal characteristics for anthropogenic noise sources, and
- Determining the relationship between anthropogenic activity level and noise level.

B. Overview of Potential Impacts of Human-Generated Sound on Marine Mammals

In his presentation, Peter Tyack (Woods Hole Oceanographic Institution, U.S.) focused on marine mammals as receivers of sound. The standard model (based on Richardson et al. 1995) for characterizing and managing the effects of sound on marine mammals is to identify zones of influence, with different responses expected at different distances from the sound source, corresponding to lower levels of sound at increasing distances from the source.

Injury from exposure to sound can take several different forms, including auditory and non-auditory physiological damage. Non-auditory physiological damage may occur through blast injury. For example, pinnipeds and odontocetes have been reported killed, and baleen whales seriously injured, from underwater explosions in the wild. In such cases, the actual mechanism of mortality or injury has not been established, but the greatest effects generally occur at boundaries of tissues with different densities, especially gas-liquid interfaces. Acoustically enhanced bubble growth may also play a role in causing non-auditory injury due to sound exposure; Tyack suggested this might be most relevant for prolonged tonal signals and exposures in the immediate vicinity of the source (Crum and Mao 1996). Auditory injuries can be signaled by temporary threshold shifts (TTS) due to system fatigue, or permanent threshold shifts (PTS) that can result either from prolonged or repeated TTS or from brief exposure to very high-intensity sound.

It is important to make a conceptual distinction between injury and the disruption of behavior, as these are different classes of effects. Injury is typically analyzed at the individual level. However, assuming that the focus of conservation is on populations rather than individuals, changes in behavior are of interest not in their own right, but as proxies for estimating the impacts of anthropogenic sound at the population level. Tyack described a variety of ways in which behavior can be affected by sound exposure. Avoidance responses are relatively easy to monitor, and can be viewed as indicative of habitat degradation. However, population-level assessment of such an effect may require estimation of how much habitat is affected, what proportion of the population is affected, and whether avoidance interferes with critical activities. Tyack asserted that one of the best examples of a potentially population-level disturbance effect occurred in Laguna Guerrero Negro in Baja California, an area that was abandoned by gray whales during the 1950s and early 1960s when dredging and commercial shipping activities in the area were intense. When those activities stopped in the mid-1960s, gray whales from other lagoons recolonized Guerrero Negro. Another relevant example comes from the western Arctic, where bowhead whales have shown pronounced avoidance responses to seismic activity associated with the oil and gas industry. Whether such behavioral changes have population-level effects remains unclear. Both of these whale populations—gray whales in the eastern North Pacific and bowhead whales in the western Arctic—have increased in recent years.

The biological significance of behavioral disturbance is of great interest to scientists and resource managers, but the concept is difficult to define. Growth, survival, and reproduction are generally regarded as indicative of biological significance. For example, changes in feeding behavior, stranding, and changes in mating behavior in response to sound exposure might be

regarded as significant impacts. New tools are improving our ability to evaluate the impacts of sound on behavior. For example, digital acoustic recording tags provide sophisticated metrics to estimate the energy cost of diving, which can be incorporated with energy models to investigate the implications of disrupted feeding behavior. A feeding whale needs to take in more energy than it expends, allowing a reserve for growth and reproduction. Tyack observed that controlled exposure experiments are proving highly informative for characterizing and quantifying whale responses to sound.

Apart from overt behavior, effects that are less readily observed and measured might also be biologically significant. For example, male blue whales produce low-frequency calls for reproductive advertisement. Tyack pointed out that because blue (and fin) whale calls might be heard at distances of up to 1,000 km, their mating system(s) could have evolved to depend on breeding advertisement over vast geographical distances, and the increased ambient noise from ship traffic and other sources may have reduced their potential range of communication by an order of magnitude. It is possible that the whales are managing to compensate for such degradation of their acoustic environment, but in any event, this relatively subtle effect would be exceedingly difficult to detect and measure. Cumulative and synergistic impacts further complicate matters, as repeated or multiple exposures to sound, in combination with other factors such as fisheries bycatch or chemical pollution, may lead to more serious effects. The overall impacts of sound on marine ecosystems (of which marine mammals are a part) also merit consideration.

III. Topic 2: Introduction to National and International Legal and Regulatory Frameworks for Marine Mammals and Human-Generated Sound

The central topic addressed in this section of the workshop was the range of national and international laws and regulatory mechanisms governing acoustic impacts on marine mammals.

The session was organized around a series of short presentations, abstracts of which are provided in Appendix 3. A number of posters also addressed aspects of this topic (Appendix 4, note especially posters 4, 15, 23, 26, and 27).

As case studies, each of the presentations was intended to address the following questions:

- Which countries are considered? What are the main sound sources of concern in the country or region? How is the country or region unique?
- How are various countries alike or different in their approaches to protecting marine mammals and/or regulating anthropogenic sound production? How do their systems of government differ?
- What limitations do countries face in dealing with the impacts of sound on marine mammals?

A. European Seas

Mark Tasker (JNCC, U.K.) defined European Seas as a region stretching from the Arctic Ocean, via the northeastern Atlantic (including the North and Baltic Seas), to the Mediterranean and Black Seas. The area encompasses a wide range of habitats, species, and legal jurisdictions. Tasker gave a brief summary of the various frameworks and instruments in Europe under which anthropogenic sound in the marine environment could be managed, including international "regional seas" conventions, international "conservation" agreements, international economic integration organizations, and national laws. Each type of framework has a different geographic and legal applicability.

Existing regional seas conventions and conservation agreements include the Convention for the Protection of the Marine Environment of the Northeast Atlantic (OSPAR, 1992[3]), Convention for the Protection of the Marine Environment and Coastal Region of the Mediterranean (Barcelona Convention, 1976[4]), Convention for the Protection of the Black Sea Against Pollution (Bucharest Convention, 1992[5]), and Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention, 1992[6]). The regional seas conventions generally define "pollution" as substances or energy that cause harm to living resources. Therefore, they arguably have the potential to be used as frameworks for providing protection to marine mammals from the adverse effects of human-generated sound. Most regional seas conventions have a framework under which more detailed agreements or resolutions may be set; as yet, however, none has

[3] See http://www.ospar.org/.
[4] See http://www.greenyearbook.org/agree/mar-env/barcelona.htm.
[5] See http://www.blacksea-commission.org/; http://www.greenyearbook.org/agree/mar-env/bucharest.htm.
[6] See http://www.helcom.fi/.

produced such an agreement or resolution dealing explicitly with marine mammals and human-generated sound. More geographically limited "subregional seas" agreements include the North Sea Conference under OSPAR, the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS, 1992[7]), and the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS, 1996[8]). Other conventions include the North Atlantic Treaty (NAT, 1949;[9] see B, below).

Although no explicit, binding measures in regard to marine mammals and sound have been taken under any of those instruments, a few developments are evident:

- The North Sea Conference is working to produce a "sustainable shipping" component.
- ASCOBANS is committed to working "towards prevention of other significant disturbance, especially of an acoustic nature." ASCOBANS adopted a resolution on ocean noise and marine mammals; has developed guidelines for seismic operations, recreational boating, and whale-watching; and will begin a program requiring member governments to report on sound-generating military activities in 2005. There has also been some discussion of shipping, with research recommended.
- ACCOBAMS prohibits "any kind of cetacean harassment," and is working toward a resolution on human-generated sound. The resolution would call for more research on the effects of sound on cetaceans and the development of guidelines (with the use of sound prohibited until these are in place). Specific resolutions for whale-watching and the use of acoustic harassment devices are also likely.[10]

The major international economic integration organization in the region is the European Union (E.U.). The E.U. operates through Directives, which are implemented by national laws into which the language of a Directive is often simply transposed.[11] Relevant E.U. Directives of potential relevance to management of underwater sound are those on Habitats (92/43/EEC[12]), Environmental Impact Assessment (EIA; 85/337/EEC[13]), and Strategic Environmental Assessment (SEA; 2001/42/EC[14]). The Habitats Directive calls for the creation of protected areas (for seals, bottlenose dolphins, and harbor porpoises), with strict protection of designated species, including prohibitions on indiscriminate killing or deliberate disturbance of cetaceans. The EIA and SEA Directives require a "look ahead" at possible environmental impacts of certain activities (e.g., those of the oil and gas industry). The difference between an EIA and an SEA is that the former concerns an individual activity and is carried out by the proponent, whereas the latter involves license issuance decision-making for multiple activities and is carried out by, or

[7] See http://www.ascobans.org/.
[8] See http://www.accobams.mc/.
[9] See http://www.nato.int/
[10] After this workshop's conclusion, the ACCOBAMS Meeting of Parties in Palma de Mallorca, Spain passed a resolution (MoP2, Resolution 2.16) on anthropogenic ocean noise.
[11] If a Member State fails properly to implement any provision of a Directive by the prescribed deadline, that provision may still be effective through the European Court of Justice's doctrine of "direct effect." This doctrine allows an individual to invoke a non-transposed provision against the Member State if certain conditions are met (e.g., the provision in question must be unconditional and sufficiently precise).
[12] See http://europa.eu.int/comm/environment/nature/nature_conservation/eu_nature_legislation/habitats_directive/index_en.htm.
[13] See http://europa.eu.int/comm/environment/eia/eia-legalcontext.htm.
[14] See http://europa.eu.int/comm/environment/eia/sea-legalcontext.htm#legal.

on behalf of, government authorities. Both Directives allow for public participation, encourage relevant research, and require measures to reduce the effects of harmful activities. E.U. Member States are individually responsible for implementation of the Directives; the timing and mode of compliance varies significantly from one country to another.

Tasker provided a brief overview of relevant national legislation in the United Kingdom, which has sought to implement and apply the E.U. Directives discussed above by means of domestic law. Their implementation, with respect to human-generated sound, has varied across sectors. For the oil and gas industry, guidelines are applied to the use of seismic sound sources and explosives, and full EIA and SEA requirements are in force. For shipping, fisheries, and aggregate extraction sectors, no requirements currently exist. Guidelines and a prohibition on "reckless" disturbance are in place for the tourism industry, while the military sector makes some use of EIA and has received some guidance from the JNCC.

B. North Atlantic Treaty Organization (NATO)

NATO is an alliance of 26 states from Europe and North America that are party to the North Atlantic Treaty of 1949. Michael Carron (Marine Mammal Risk Assessment Program, NATO) reviewed NATO efforts to address the potential impacts of high-intensity sound from military sonar. Those efforts began after Frantzis (1998) called world attention to the 1996 strandings of Cuvier's beaked whales in Greece coincident in space and time with the deployment of military sonar. The NATO Undersea Research Centre convened a bioacoustics panel to investigate the strandings, which in turn initiated the Sound, Ocean, and Living Marine Resources (SOLMAR) project, a multinational, multidisciplinary research project, and established "marine mammal risk mitigation" protocols and tools to protect marine mammals during active sonar tests or experiments. Rules are now in place to reduce the likelihood that NATO forces will conduct naval sonar exercises in close proximity to beaked whales.

NATO's SOLMAR project involves research cruises to study the effects of sound exposure on marine mammal behavior, a crisis response team based in the Mediterranean to investigate cetacean mass strandings, and the development of predictive models of whale distribution (e.g., that of Cuvier's beaked whale). According to Carron, about half of the known mass strandings of Cuvier's beaked whales have been associated with nearby military operations. Except in a few of these cases, no direct link has been established between the military operations and the strandings. The SOLMAR project's goal is to refine and update NATO's mitigation policies to prevent such events. Although it cannot dictate such policies, the project exerts considerable influence on the manner, location, and scheduling of activities by NATO navies, providing advice on all sonar experiments. As such, the existing NATO Undersea Research Centre Marine Mammal and Human Diver Risk Mitigation Instruction establishes the need for environmental scoping studies as part of sonar test plans, requires visual and acoustic watches during tests, sets restrictions for received levels of sound, and establishes a crisis response team. Thus, all NATO active sonar experiments are governed by strict rules and protocols, with even stricter rules imposed for tests planned in regions known or suspected to be beaked whale habitat. Scientists must adhere to instructions and protocols for human and marine mammal risk mitigation. When under NATO control, military units must follow NATO protocols unless either their own nation has stricter rules or protocols, or the host nation imposes stricter rules. When not under NATO

control, military units must follow national or host nation rules and protocols. Because of the organizational complexities of NATO, there are ongoing discussions among member nations concerning the exact risk mitigation protocols that will be used during future NATO exercises.

Following Carron's presentation, attention was called to the fact that Australia's naval forces are engaged in extensive efforts to mitigate the potential effects of their sound-producing activities on marine mammals (see Appendix 4, poster 25).

C. Scientific Committee on Antarctic Research (SCAR)

David Walton (SCAR, U.K.) briefly summarized the Antarctic Treaty System (System). The System was initiated under a 1959 framework agreement (the Antarctic Treaty[15]), which includes 45 sovereign States as Contracting Parties, 28 of which are Consultative (i.e., executive) Parties. The System has since been supplemented by the 1972 Convention for the Conservation of Antarctic Seals,[16] the ecosystem-based 1980 Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR[17]), and the 1991 Protocol on Environmental Protection to the Antarctic Treaty.[18] SCAR is an independent international body set up in 1956 to coordinate science programs and facilitate planning and collaboration. The Antarctic continent is a demilitarized natural reserve where "peace and science" are supposed to prevail. Member States have the right to make inspections of any installations in the System area at any time and the right to conduct scientific investigations anywhere. Under the 1991 Protocol, all activities are subject to environmental impact assessment and monitoring. Agreements within the System are reached by consensus, and implementation depends on national compliance. Walton noted that consensus is often more easily achieved on guidelines than on legal changes, and that overlapping jurisdictions can cause problems. National legislation by Member States may establish more stringent requirements than those of the Treaty System, and in fact, the permitting of activities may involve multiple agencies and governments.

Walton provided two background documents in advance of the workshop (Appendix 3). His presentation, together with the background documents, provided (a) a review of available information on anthropogenic marine sound and its implications in the Antarctic, (b) suggested mitigation measures, (c) a proposed approach to risk analysis for use in impact assessments prior to issuance of permits for sound-generating activities, and (d) an attempt to establish background levels of underwater sound against which to assess further inputs from human activities. Anthropogenic sound is not explicitly addressed in the System. Although no military exercises or oil and gas industry seismic exploration occurs in Antarctic waters, anthropogenic sound is of some concern in the region. According to Walton, ship traffic, seismic research, and ice breaking are the principal sources of anthropogenic sound in the Antarctic at present. There is some controversy over the extent to which these activities may affect the region's marine mammals.

In discussion, Wolfgang Dinter of Germany's Federal Agency for Nature Conservation, which advises the German Federal Ministry for the Environment, Nature Conservation and Nuclear

[15] See http://www.antarctica.ac.uk/About_Antarctica/Treaty/treaty.html.
[16] See http://www.oceanlaw.net/texts/seals.htm for full text of the Convention.
[17] See http://eelink.net/~asilwildlife/antarctic1980.html for full text of the Convention.
[18] See http://www.antarctica.ac.uk/About_Antarctica/Treaty/protocol.html.

Safety, called attention to several features of the 1991 Protocol that provide a basis for the regulation of potentially harmful underwater sound. These were summarized in a document circulated at the workshop in response to Walton's background documents and presentation (Federal Agency for Nature Conservation/BfN [Germany] 2004). The features include *inter alia* (a) the System's dedication to comprehensive ecosystem protection and (b) a prohibition on taking, or harmfully interfering with, any mammal except under permit. Dinter's further comments on Walton's background documents referred to, *inter alia*, SCAR's information policy on sound and the relation between CCAMLR and the 1991 Protocol with regard to marine environmental protection (SCAR 2002, 2004).

Walton responded that (a) environmental protection is a relatively new aspect of Antarctic Treaty goals (i.e., it was not part of the Agreed Measures but was introduced as part of the 1991 Protocol),[19] (b) there are differences among countries as to how they view jurisdictional limits in implementing the Treaty, and (c) discussion of legalities has often been excessive in comparison with discussion of costs and benefits of various activities. In his view, a risk assessment approach needs to be used more often to evaluate proposed activities in the Antarctic.

D. United States

Douglas Wartzok (Florida International University, U.S.) summarized the legislative and regulatory situation in the United States. He noted that both the Marine Mammal Protection Act (MMPA; adopted in 1972[20]) and the Endangered Species Act (ESA; adopted in 1973[21]) provide a clear and direct basis for protecting marine mammals from the harmful effects of human-generated sound. The National Environmental Policy Act (NEPA, 1969[22]), Outer Continental Shelf Lands Act (OCSLA, 1953[23]), and Coastal Zone Management Act (CZMA, 1972[24]) also have potential applications to this issue. The MMPA mandates an ecosystem-based approach to management and prohibits the "taking" of marine mammals unless explicitly authorized. "Take" means to harass, hunt, capture, or kill, or to attempt to do so. The ESA prohibits "taking" of any threatened or endangered species, where "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to do so. Thus, if the potential impacts of a sound-producing activity were interpreted to constitute taking under either law, the activity would be subject to regulation. The specific regulations and permitting requirements that apply depend on the type of activity. For example, through permits or other authorizations, the MMPA regulates many of the activities that take marine mammals as a result of introducing sound into the marine environment. However, some major economic activities are currently unregulated under the MMPA (e.g., commercial shipping) or regulated by the MMPA under a more liberal set of requirements (e.g., commercial fishing). NEPA requires federal agencies to review potential environmental impacts of activities that they conduct, fund, or permit, and requires the preparation of environmental impact statements (EISs) in certain cases. OCSLA requires reviews

[19] The Agreed Measures on the Conservation of Antarctic Flora and Fauna were adopted in 1964. These Measures address species protection and protected area designation within the Treaty System. (See http://www.oceanlaw.net/texts/antarctic1964.htm.)
[20] See http://www.mmc.gov/legislation/mmpa.html.
[21] See http://www.mmc.gov/legislation/esa.html.
[22] See http://ceq.eh.doe.gov/nepa/regs/nepa/nepaeqia.htm for full text of the Act.
[23] See http://www.csc.noaa.gov/opis/html/summary/ocsla.htm.
[24] See http://coastalmanagement.noaa.gov/czm/czm_act.html.

of all oil and gas leases and development plans in federal waters, and the CZMA requires the federal government to demonstrate consistency between its actions and the coastal zone management program of coastal states with approved programs.

E. Latin America

Monica Borobia (Brazil) indicated that policies and regulatory frameworks concerning marine mammals and sound are either in early developmental stages or have yet to be addressed in most Latin American countries (broadly defined as those in South and Central America, the Caribbean, and Mexico). She cited three main mechanisms available in Latin America to address marine mammal protection and anthropogenic sound production at the national level: (a) general environmental regulations (including directives, licensing guidelines, and action plans), (b) designation of protected areas, and (c) special protection for endemic or threatened species. In addition, most Latin American countries are parties to multilateral agreements such as the International Convention on the Regulation of Whaling (ICRW, 1946[25]), Convention on the Conservation of Migratory Species of Wild Animals (CMS or the Bonn Convention, 1979[26]), Convention on Biological Diversity (CBD, 1992[27]), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 1973[28]), United Nations Convention on the Law of the Sea (UNCLOS, 1982[29]), and International Convention for the Prevention of Pollution from Ships (MARPOL, 1973[30]). Some nations also participate in regional agreements such as the United Nations Environment Programme's Regional Seas Conventions[31] and Associated Protocols on Specially Protected Areas and Wildlife, notably in the Wider Caribbean and South-East Pacific regions where attention to marine mammals, nationally and regionally through action plans and other initiatives or instruments, has been longstanding. As is generally the case with multilateral and regional agreements, implementation is left to the member states and varies widely. There is a general need for increased awareness and capacity (i.e., abilities) with regard to the potential impacts of sound, as well as mobilization and dialogue among various stakeholders in the region.

Borobia offered more specific information related to Brazil's licensing regulations for seismic operations by the oil and gas industry. These began in 1999 and were strengthened in July 2004 by a resolution of the National Environment Council (CONAMA[32]). Initially, a limited, non-specific technical body within the Brazilian Environmental Agency (IBAMA[33]) was responsible for licensing seismic activities, and no specific guidelines were available. Since 1999, IBAMA has worked with industry, local communities, and researchers to review available information regarding socioeconomic issues and the vulnerability of marine resources, and in 2003 the agency issued guidelines for seismic work that consider biologically sensitive areas as well as the need for mitigation measures to protect whales. The guidelines include a prohibition on seismic

[25] See http://www.iwcoffice.org/commission/convention.htm.
[26] See http://www.cms.int.
[27] See http://www.biodiv.org/welcome.aspx.
[28] See http://www.cites.org/.
[29] See http://www.un.org/Depts/los/index.htm.
[30] See http://www.imo.org/Conventions/contents.asp?doc_id=678&topic_id=258.
[31] See http://www.unep.ch/regionalseas/legal/conlist.htm.
[32] See http://www.mma.gov.br/port/conama/index.cfm.
[33] See http://www.ibama.gov.br/.

operations in and near humpback whale calving or mating areas during the months July–November, as well as monitoring programs with land-based and onboard observers. During discussion, Chip Gill of the International Association of Geophysical Contractors called attention to his information paper (IAGC 2004) and abstract (Appendix 4, poster 9) on the questions surrounding humpback whale strandings and seismic activities in the Abrolhos Bank area off Brazil.

The poster by Bolaños-Jiménez et al. (Appendix 4, poster 4) identifies similar initiatives in Venezuela. Under a recent presidential decree, the Venezuelan Ministry of Environment and Natural Resources has been developing terms of reference for environmental impact assessments and various related studies in the oil and gas sector, with an explicit focus on evaluation and regulation of the effects of anthropogenic sound. Moreover, independent and governmental observers working onboard active seismic survey vessels in Venezuelan waters have reported changes in behavior and avoidance reactions by baleen whales.

F. Asia/Pacific Rim

John Wang (FormosaCetus Research and Conservation Group, Taiwan) presented a paper (authored by himself and eight co-authors) that focused on policies and legislation in 13 Southeast Asian countries: China (including Hong Kong), Taiwan, Philippines, Vietnam, Laos, Cambodia, Thailand, Malaysia, Singapore, Brunei, Indonesia, East Timor, and Australia. Although most of those countries confer full legal protection to marine mammals, implementation and enforcement of existing laws are generally lacking, and little effort has been made to assess or manage the potential impacts of human-generated underwater sound in the region. Many sound-producing activities occur in Asian waters. Military naval activity is intense in some parts of the region (e.g., Taiwan Strait), and several of the largest commercial ports and busiest shipping lanes in the world are found there (e.g., Singapore, Hong Kong, Taiwan). In addition, coastal construction activity (e.g., blasting, pile driving) is extensive; blast fishing (although illegal in most countries) still occurs in some places; and offshore oil and gas development is underway in nearly all the countries surveyed. The only one of these classes of potentially harmful activities that is likely to decline in the immediate future is blast fishing; all others are almost certain to increase. According to Wang, the dearth of interest in, and concern about, potential effects of anthropogenic sound on marine mammals in Southeast Asia is due primarily to the lack of regional marine mammal expertise, inadequate funding for local research, and failure of information from the outside to reach Southeast Asia. In addition, the concept of reducing the potential impacts of sound-producing activities is likely to meet resistance, given the implications for the region's economic growth and military interests. Wang argued that more effort is needed to disseminate and exchange information and alert scientists, citizens, and governments of Southeast Asian nations to the issue. He emphasized the importance of culture and politics, and how these affect a nation's attitude toward marine mammal protection.

Australia is an exception to the above generalizations. Marine mammals are protected in Australian waters under the Environment Protection and Biodiversity Conservation Act of 1999.[34] Wang noted that the sanction against "interfering with" any listed species (including five

[34] See http://www.deh.gov.au/epbc/.

"threatened" whale species, nine "migratory" cetacean species, and the dugong) can be interpreted to apply to disturbance or injury from anthropogenic sound. Specifically, offshore seismic operations are subject to guidelines (currently under review) under the Act, including requirements for a 3-km exclusion zone around animals belonging to listed species, onboard visual monitoring to detect whales, soft-start (also known as ramp-up) procedures, and aerial surveys to determine distribution of whales in relation to the area of seismic activity. Seismic operators are not allowed to approach within 20 km of a breeding, feeding, or resting area without further review and mitigation. The Australian military is required under the Act to conduct environmental assessments of its activities, including those that generate sound with potential impacts on marine mammals.

A number of poster presentations addressed related issues in Southeast Asia (Appendix 4, note especially posters 8, 11, 19, and 25).

G. Africa

Policies and regulatory frameworks concerning marine mammals and sound are either non-existent or in early developmental stages in most African countries. The presentation by Ken Findlay (University of Cape Town, South Africa) and Howard Rosenbaum (Wildlife Conservation Society, U.S.) focused on southern Africa, with emphasis on South Africa and Gabon. Forty-five marine mammal species have been documented in the region. To date, concern has centered on areas where baleen whale breeding grounds and offshore oil and gas development sites overlap. Military exercises, academic research surveys, and shipping activities also produce sound in African waters, but their potential impacts have yet to be recognized or addressed. Findlay and Rosenbaum outlined the following options for regulation and environmental management of the offshore oil and gas industry: (a) international conventions and agreements, (b) national legislation and guidelines under oil and gas licenses or production contracts, and (c) industry guidelines through parent companies, operators, or contractors. Relevant international agreements such as UNCLOS, MARPOL, and others exist, but the implementing national governments typically lack enforcement mechanisms and the necessary political will. Two regional conventions may provide relevant frameworks: the Convention for the Protection, Management, and Development of the Marine and Coastal Environment of the Eastern African Region (Nairobi Convention, 1985/1996[35]), and the Convention for Co-Operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region (Abidjan Convention, 1981[36]). However, these Conventions do not explicitly address acoustic impacts on marine mammals at this time.
Although most existing environmental management activities in the region have been carried out by industry (through company policies), Nigeria, Namibia, and Mozambique have adopted domestic laws with environmental guidelines and standards for the oil and gas industry. In addition, South Africa's 2004 Minerals Act requires that environmental management programs be included in all offshore exploration activities, and that seismic surveys incorporate seasonal exclusion zones, observer schemes, operational protocols, reporting, and other requirements for the protection of marine mammals. In Gabon, law 16/93 Relating to the Improvement and Protection of the Environment contains a section that addresses mining and petroleum activities,

[35] See http://hq.unep.org/easternafrica/EasternAfricaNairobiConvention.cfm.
[36] See http://hq.unep.org/easternafrica/AbidjanConvention.cfm.

and industry regulation typically is delegated to the company or contractor involved on the expectation that it will apply the JNCC or International Association of Geophysical Contractors (IAGC) guidelines (JNCC 2004, IAGC 1998). Both the JNCC and IAGC guidelines offer standards to help minimize potential impacts of sound-producing industrial activities, including seismic surveys. Although none of the strategies currently in place deals effectively with issues related to protection of critical marine mammal habitat, the Wildlife Conservation Society is developing a national marine mammal management plan in partnership with the government of Gabon, and in 2002 Gabon declared a nationwide system of protected areas that includes some marine areas. A report entitled "Environmental Impact Assessment and Mitigation of Marine Hydrocarbon Exploration and Production in the Republic of Gabon" provides a review and recommendations for mitigation strategies involving critical marine mammal habitat in Gabon.[37] Table 1 (see page 71) provides a summary of domestic laws and regulations mentioned in the workshop proceedings. The examples provided are a subset of those discussed during the workshop. No attempt has been made to analyze the information as it was presented.

[37] Authored by Findlay, Collins, and Rosenbaum; available from the Wildlife Conservation Society.

IV. Topic 3: Examining International Legal Frameworks

This section of the workshop addressed the following questions: How can the issue of acoustic impacts on marine mammals best be pursued internationally? What would be the key components of an effective international framework? Have sound or acoustic impacts on marine mammals been effectively addressed by international law or institutions? What short- or long-term actions might be taken in international fora to address this issue?

A. Providing an Analytical Framework for International Regulatory Mechanisms and Fora

To help frame discussions of existing and potential future applications of international law and multilateral agreements, Lindy Johnson (National Oceanic and Atmospheric Administration, U.S.) outlined the key considerations and potential options for international or multilateral legal frameworks. She addressed the following questions:

- What steps should be taken to analyze legal frameworks (e.g., instruments and institutions) for their applicability to the issue of acoustic impacts on marine mammals?
- What short- and long-term actions can be taken to address this issue in international fora?

Instead of immediate action through existing international instruments or fora, Johnson advocated an analytical approach that includes questions and assumptions that should be addressed when considering an international legal strategy. She emphasized the importance of (a) clarifying and agreeing on common objectives; (b) framing the issues; (c) defining appropriate solutions, along with strategies to achieve and evaluate them; (d) identifying relevant institutions or instruments; and (e) ensuring stakeholder involvement. In identifying objectives, it is necessary to retain flexibility and creativity, rather than making assumptions about desirable approaches or outcomes (e.g., that a command-and-control regulatory approach is necessarily the best approach, or that sound is preferably viewed as "pollution"). Although it is useful to identify general objectives (e.g., to define potential adverse effects of sound on marine mammals; to develop mitigation strategies to prevent, reduce, or minimize adverse effects of sound on marine mammals), these need to be specified (e.g., in relation to particular types of sound or species of concern) to facilitate appropriate action. As specificity in objectives increases, so do the difficulties of agreeing on achievable goals. Key questions may relate to the sound sources themselves (e.g., are all sources of equal interest, or do some have higher priority?), the biological issues involved (e.g., which ecosystems or species should be considered?), or the options for management (e.g., how can operational measures, research, outreach and education, and information exchange be incorporated?).

Once objectives have been defined, action may be taken using a variety of tools at various levels. National efforts can stress issues within a single jurisdiction and may therefore face fewer constraints and progress more quickly. Actions at the regional level tend to be better focused than international actions, with fewer parties involved in the decision-making process. International efforts tend to involve transboundary issues and a wider variety of stakeholders, making them intrinsically more complex. It is important to take advantage of all types of tools and fora available, including (a) "hard" law (e.g., treaties, regulations); (b) "soft" law (e.g., resolutions, guidelines); (c) research, cooperation, and coordination; and (d) outreach and

education (e.g., information papers). Available instruments for consideration include framework treaties (e.g., UNCLOS); International Maritime Organization (IMO[38]) instruments (e.g., the International Convention for the Safety of Life at Sea [SOLAS, 1974[39]], MARPOL, the Particularly Sensitive Sea Areas [PSSA[40]] provision); conservation treaties (e.g., CBD, ICRW); and regional agreements (e.g., ACCOBAMS). A number of existing instruments could arguably address anthropogenic sound and/or its impacts on marine mammals. However, Johnson reiterated the importance of examining objectives before acting. Furthermore, the precise language of an agreement, its ability to change behavior, its enforceability, its geographic scope, and its comprehensiveness or overlap with other instruments will affect the outcome. In general, existing instruments provide some avenues for progress, but further work is needed if the specified objectives require action.

If no international instrument is available to meet the objectives, two options exist. First, an existing instrument can be amended. This may be easier to accomplish than the second option, but is not likely to produce a comprehensive approach. In addition, procedural issues such as the amendment process deserve serious consideration. Second, a new agreement can be created. This might have the advantage of being more nearly comprehensive (e.g., by addressing various sources of sound in a single instrument), but would require an appropriate international forum that can articulate the need for such an instrument, develop the political will, overcome controversies, engage stakeholders, and provide resources. In deciding on a course of action, it is also important to consider that (a) national governments and international organizations have limited resources and must be convinced that this issue is a priority, (b) international treaties commonly include provisions for sovereign immunity, (c) some sound-producing activities are not currently subject to international oversight, and (d) achieving consensus on an international instrument can drive the results toward a "lowest common denominator," which may not be effective in achieving stated objectives.

When identifying an international forum to address this issue, key considerations include (a) convincing an international organization to take a leadership role, (b) raising the issue's profile within that organization, (c) including interested entities that generally may not be represented on delegations, (d) following the rules of procedure, (e) being sensitive to concerns about timing, and (f) identifying types of actions that are possible. Fora with regularly scheduled meetings can facilitate action on an issue, and non-governmental organizations and industry groups may be willing and able to contribute.

Johnson identified a series of possible next steps for the short and long term. It is important immediately to identify objectives, set priorities, and develop strategies. Mechanisms for information exchange, technology development, and setting research priorities are also key in the short term. In some instances, it may be possible to transfer strategies from land-based policy into the marine context. It is important to look for, and take advantage of, "low-hanging fruit" (i.e., to find opportunities in existing instruments and institutions that allow for progress with

[38] See http://www.imo.org/.
[39] See http://www.imo.org/Conventions/contents.asp?topic_id=257&doc_id=647.
[40] MARPOL resolution A.927(22), Guidelines for the Designation of Special Areas under MARPOL73/78 and Guidelines for the Identification and Designation of Particularly Sensitive Sea Areas. See http://www.imo.org/Environment/mainframe.asp?topic_id=760.

relatively little effort, cost, or controversy). A possible example for further consideration is the development of shipbuilding guidelines. In the long term, it will be important to monitor progress on achievement of the objectives; conduct research and monitoring; based on science, determine possible mitigation techniques; and pursue objectives through appropriate international fora and with various types of tools.

B. Panel Discussion—Components of an Effective International Legal Framework

Panelists:

Lindy Johnson, National Oceanic and Atmospheric Administration, U.S.
Scott Kenney, Department of Defense, U.S.
Elena McCarthy, Woods Hole Oceanographic Institution, U.S.
Daniel Owen, Fenners Chambers, U.K.
Karen Scott, University of Nottingham, U.K.
Jon Van Dyke, University of Hawaii, U.S.

This panel brought together experts with different points of view and different experience and knowledge. Several background documents were relevant to the panel's discussion (Appendix 3), notably those by Owen on the application of marine pollution law to ocean noise (Owen 2003), Scott on international regulation of undersea noise (Scott 2004), and Van Dyke on the precautionary principle in ocean law (Van Dyke 2004).

The discussion was organized around the following questions:

1. Do existing regional and international laws and organizations/institutions address acoustic impacts on marine mammals, or could they?
2. What are the key components of effective regional and international legal/regulatory schemes?
3. What challenges might exist in pursuing this issue internationally? What steps might be possible to further the discussion of this issue in relevant international organizations/institutions and what types of actions could be taken in international fora or through international legal instruments to address the issue?
4. How might multilateral legal and regulatory frameworks develop in the future? What changes might be forthcoming, if any?

Questions 1 and 2:

Scott gave a brief presentation summarizing regional and international laws and organizations/institutions. She noted that although no specific instrument exists to address the sound issue explicitly, a number of institutions have begun to address it, notably the International Whaling Commission (IWC,[41] since 1998), ASCOBANS and ACCOBAMS (see above), the Committee on Environmental Protection within the Antarctic Treaty System (see above), and the OSPAR Commission (see above). Only three instruments currently identify noise directly in their texts: the Helsinki Convention (Article 9 on pleasure craft), the 1991 Arctic Environmental

[41] See http://www.iwcoffice.org/.

Protection Strategy,[42] and ASCOBANS. There are three broad categories of potentially relevant instruments: those that (a) control pollution, (b) conserve wildlife or biodiversity, or (c) invoke specific procedures such as environmental impact assessment or use of the precautionary principle (in terms of habitat or species protection). Examples of (a) include UNCLOS and various regional seas agreements (with minimal implementation, however). Examples of (b) may use general obligations to conserve biodiversity, obligations to establish and regulate activities within special areas, or obligations to protect individual species, and include, *inter alia*, the UNCLOS and the CBD, the E.U. Habitats Directive (see above), and the 1979 Bern Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention[43]). Examples of (c) include the general obligations and procedures for environmental consideration associated with various agreements and laws. Flexibility would be needed to take advantage of new science and new law as they become available.

Van Dyke emphasized the precautionary principle as a meaningful component of international law. Its elements include the following: (a) that studies of effects need to precede potentially harmful activities; (b) that the burden of demonstrating "no significant effect" needs to be placed on the proponents of a potentially harmful activity; (c) that alternative (and potentially less harmful) activities need to be considered; (d) that risks and costs need to be internalized; and (e) that action in the face of uncertainty should take place only slowly, cautiously, and with adequate monitoring. Both UNCLOS and the E.U. Directives incorporate this principle. Van Dyke considered that studies of the effects of high-intensity military sonar are inadequate and therefore its use is not consistent with the precautionary principle. Although military forces may themselves have sovereign immunity, the governments that they represent can be held responsible for damages caused by military activities. In Van Dyke's view, although science is central to risk assessment, values and ethics also play important roles.

Kenney expressed his preference for a universal treaty to address the effects of sound, noting that UNCLOS, for example, was intended to cover all uses of the oceans. He cited Article 15 of the Rio Declaration[44] as containing the most nearly universal definition of the precautionary principle. The focus in that instrument is on threats of serious or irreversible damage, with the provision that lack of full scientific certainty should not delay or prevent signatories from taking steps to prevent harm. In Kenney's view, the precautionary principle includes, or should include, reference to the cost-effectiveness of remedial actions.

Kenney commented that domestic legislation key to the effectiveness of regional or international instruments. UNCLOS, for example, cedes to coastal states the obligation to regulate within their Exclusive Economic Zones (EEZs; usually from shore to 200 nautical miles offshore). Many of the activities that produce anthropogenic sound take place within EEZs, and thus sovereign states should determine how to address their impacts. Coastal states therefore play a pivotal and decisive role in determining the effectiveness of any international instrument.

[42] See http://www.arctic-council.org/en/main/infopage/74/ and http://www.arctic-council.org/files/infopage/74/artic_environment.pdf.
[43] See http://www.oceanlaw.net/texts/summaries/bern.htm.
[44] See http://www.unep.org/Documents/Default.asp?DocumentID=78&ArticleID=1163.

McCarthy acknowledged that cost-benefit analyses are a key component of effective regional or international instruments. For example, ship-quieting technologies may have both sound-reduction benefits and relatively low costs to operators. She also stressed the value of regional temporal zoning, and cited Glacier Bay National Park[45] in Alaska as an example. In the park, vessels without noise-reduction equipment onboard are excluded during the summer when whales (and tour boats) are present. Habitat-based, rather than source-based, management and regulation would emphasize the protection of marine mammals' access to critical resources (e.g., ensuring that whales feeding in a particular area can do so without risk of disturbance). In addition, it is important to retain flexibility in international instruments as science and law evolve over time, and political climates change. Finally, effective regional and international schemes should aim first to protect marine mammals in areas where the greatest threats (i.e., sound-producing activities) are concentrated.

Owen described the existing array of instruments for management of anthropogenic sound in the oceans as a rickety amalgam, rather than a functional network. He urged that those instruments be evaluated in terms of the substantive powers or duties they provide. When thinking about key components of instruments, it is important not to neglect the "behind the scenes" provisions. For example, does the instrument include dispute resolution procedures that are compulsory and binding? Does the instrument offer innovative compliance facilitation mechanisms? How are amendments made? How onerous are threshold conditions for the instrument's entry into force (i.e., is there a realistic prospect that the desired measures will ever come into effect?). How serious are the liability measures (i.e., if a standard is breached, what are the penalties or compensation arrangements?). Owen also called attention to a new instrument—the E.U. Directive on Environmental Liability (2004/35/EC[46])—that may be of relevance.

Johnson embraced the concept of a "rickety amalgam" as particularly fitting. She added that what really matters is political will: with it, an instrument is likely to be effective, but without it, it will certainly not be. It is important to understand how a particular institution or forum functions in order to take advantage of its framework. Among other key components of an effective regime are clarity of objectives, enforceability (if hard law), and effectiveness in changing behavior (if soft law). Monitoring is also required to determine how effective the measures have been in achieving the intended objectives.

The initial presentations by panel members on the first two questions were followed by a brief discussion with the audience of "command-and-control" vs. participatory approaches to implementation. To a considerable extent, the approach must depend on the context in which implementation takes place. It was noted that cultural sensitivity, fairness, and parity are necessary for long-term effectiveness.

Question 3:

McCarthy opened discussion regarding challenges and possible next steps. She identified the following as challenges to pursuing this issue internationally: (a) resistance from user groups (e.g., the oil and gas industry, the military), (b) jurisdictional conflicts (often between agencies

[45] See http://www.nps.gov/glba/.
[46] See http://europa.eu.int/comm/environment/liability/.

within the same country), (c) difficulties in enforcement and monitoring, and (d) scientific uncertainty concerning cause and effect. The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP[47]) might be a good forum to foster discussion at the international level.

Owen noted that "parliamentary time is limited" (i.e., that the issue of potential effects of anthropogenic sound on marine mammals must compete for time and resources with other policy and management priorities, such as land-based pollution). A further challenge arises from problems of interpretation. Does the wording of a particular treaty allow it to be applied to anthropogenic sound? Does the wording of the mandate of a particular international organization allow that organization to address anthropogenic sound? To facilitate timely regulatory action by countries, it is also important to identify when such action may be pursued unilaterally and when it may only be pursued through one or more international organizations.

Johnson reiterated the importance of developing political will and the fact that scientific uncertainties are often used to delay action. Other challenges include (a) a lack of strategic planning, (b) limited resources, (c) difficulties in identifying appropriate fora to address the issues, and (d) the "not me" problem (i.e., a lack of awareness or understanding on the part of sound producers). The immediate priority should be to raise awareness, including at the IMO and United Nations Environment Programme (UNEP[48])[49] and perhaps even trying to get the issue onto the agenda of the United Nations' Open-ended Informal Consultative Process on Oceans and the Law of the Sea (UNICPOLOS[50]). It is important to identify the appropriate forum or fora to address this issue. Johnson's idea about the need to build a "drumbeat" regarding the issue (i.e., to start the process with education and raising awareness) was adopted by some of the other panelists as a useful metaphor.

In Scott's view, investing in multiple fora, rather than in a single, all-embracing one, is the more practical approach. Three steps should be taken in the short term: (a) identify particularly sensitive areas[51] and thus establish geographic priorities for protective measures; (b) seek to incorporate concern about sound in environmental impact assessment processes; and (c) explore use of the Bern Convention, for example, as an instrument for addressing the issue of sound and marine mammals.

Van Dyke lamented the sense of denial and inertia that he believes has characterized the responses of industry, the military, and even much of the scientific research sector. In his view, national security-related issues have been allowed to override environmental concerns. He commended the nongovernmental sector (the Natural Resources Defense Council in particular) for taking the lead and working to ensure that the sound issue is acknowledged and addressed.

[47] See http://gesamp.imo.org/.
[48] See http://www.unep.org/.
[49] E.g., through GESAMP.
[50] See http://www.un.org/Depts/los/consultative_process/consultative_process.htm.
[51] E.g., establish Particularly Sensitive Sea Areas (PSSAs) through the IMO, under MARPOL.

Kenney insisted that the main challenge still lies in the scientific realm, and that a threshold of scientific certainty needs to be reached before the case can be made that anthropogenic sound has a direct connection to harmful effects on marine mammal populations.

Non-panelists made several additional points: (a) the need for parties on all sides to acknowledge uncertainty and to strive for clear communication (e.g., by being precise in their terminology and using standard units when making comparisons); (b) the need for parity in the application of scrutiny and regulation, so that all sectors involved in producing potentially harmful sound are treated in the same way; (c) the importance of public education and of finding a "cultural hook" that will facilitate engagement with the issue in different cultural contexts; and (d) the problem that if major sound-producing countries are not signatories to a particular convention or agreement, that instrument's usefulness as a forum or framework could be limited.

Question 4:

Kenney opened the discussion by stating that the U.S. Navy would continue to spend large amounts of money on research and mitigation related to marine mammals and sound. Although militaries do not want to cause harm to marine mammals, and wish to foster environmental responsibility, the need for some military sonar use will persist. The oceans are important for a variety of human uses (e.g., shipping and trade, oil and gas extraction), and military protection is needed to safeguard those uses.

McCarthy predicted that progress would be very slow and probably occur mainly on a regional or sectoral basis rather than as part of a single, overarching international scheme. The regional seas protocols within UNEP are relatively easy to modify and update, and the sound issue is likely to be incorporated gradually into these and other instruments. Some technological innovations can also be expected, as can novel approaches such as green labeling in the shipping industry (e.g., offering "environment-friendly" certification as an incentive for the use of silencing equipment).

Owen expects increasing overlap in the competence of international instruments and organizations (i.e., multiple agreements establishing similar powers and duties and international organizations with similar functions). He also foresees expanding cooperation and coordination (e.g., through memorandums of understanding), which may in turn improve the effectiveness of various instruments.

Johnson expects domestic and regional measures, or specifically targeted international measures, to emerge first. Addressing the issue on an international basis will require creative thinking. Additionally, it may be difficult to negotiate a single overarching international treaty on this issue, because of the diversity of interests involved and the lack of a forum for bringing these interests together.

Scott sees an international convention on underwater sound as unlikely, and predicts that the issue will continue to be framed mainly in terms of conservation rather than pollution reduction. She identified underwater sound associated with oil and gas development (notably the seismic

profiling component) as a likely initial object of regulatory attention, particularly on a regional basis. She also suggested that shipping noise would be addressed mainly through the IMO.

Finally, Van Dyke added that clarification and improvement are needed in existing dispute-resolution procedures, liability and compensation regimes, and international and regional procedures.

Non-panelists noted the rapid rate at which new scientific insights are emerging, and also how quickly public awareness of the problems related to sound and marine mammals is expanding (i.e., the "drumbeat" is being heard). Several individuals expressed optimism that mitigation protocols would be developed and that these would spread from national to international contexts, and across sound-source types, as long as public pressure remained strong. It was pointed out, however, that policy-makers would need to be convinced that anthropogenic sound ranks as a high priority relative to other threats to marine mammal populations, and that this may require stronger empirical evidence of harm. Finally, there was discussion about the necessity of recognizing that, particularly in many less developed countries, the strong impetus for resource exploitation is not matched by an effective regulatory infrastructure. Often the capacity is weakest where the need is greatest.

Table 2 (see page 72) provides a summary of multilateral agreements mentioned in the workshop proceedings. No attempt has been made to analyze the information as it was presented during the workshop.

V. Topic 4: Innovative Management, Impact Assessment, and Mitigation Strategies

Among the questions addressed in this section of the workshop were the following: What would be the key components of an effective management scheme for anthropogenic sound and marine mammals? What are, or should be, the goals of management, impact assessment, and mitigation? How can the effectiveness and efficiency of mitigation strategies and impact assessment be evaluated? What roles should regulated groups (e.g., the oil and gas industry, the shipping industry, and the military) and environmental non-governmental organizations play in the development of impact assessment, management, and mitigation strategies?

A. Introduction to Generic Impact Assessment Approaches

Karl Fuller of the U.K.-based Institute for Environmental Management and Assessment gave an overview of basic environmental impact assessment (EIA) in response to the following questions:

- What are the basic steps in environmental impact assessment? What techniques can be used in such analyses?
- What differences exist between countries in their national approaches to risk assessment?

EIA can be defined as a systematic process to predict and evaluate the effects of proposed actions before decisions are made. Fuller described EIA as "best-guess" science, a planning tool, and a vehicle for getting answers in a logical, ordered manner. The general goals of EIA are to guide resource use and improve environmental design, identify mitigation measures, protect human health and safety, safeguard resources and ecosystems, enhance proposed actions, and avoid irreversible harm. Among its benefits are that it provides a common framework for assessing all types of environmental effects, draws on the expertise of appropriate specialists, and ideally presents information in ways that are understandable and that lead to informed decision-making. Acknowledging that EIA should not be seen as a linear series of steps, Fuller identified three key elements that help define the iterative EIA process, as follows:

1. Screening – deciding whether an EIA is needed and appropriate;
2. Scoping – identifying key concerns and determining which of them require focused attention and further investment; and
3. Impact analysis – assessing "baseline" conditions, determining what difference the project will make, analyzing significance of effects, and ensuring that appropriate mitigation measures are in place.

Responsibility for preparing an EIA generally rests with the project proponent. An appropriate regulatory body then has the responsibility to oversee and conduct a review, to make a decision concerning approval or the need for modification and further assessment, and to ensure that the prescribed scenario is effectively delivered.

Special methodological and regulatory challenges can arise in applying the EIA concept to marine contexts, notably that (a) it is difficult to define the extent of the study area; (b) the quantity and quality of baseline data vary, and obtaining such data is expensive; (c) considerable uncertainty exists concerning the responses of organisms to various risk factors; and (d) there is a

lack of reference points for determining the significance of impacts. In marine-based EIAs, there is wide use of secondary data (e.g., extrapolation from one species to another) and geographic information systems, more reliance on models and "worst-case scenario" assessments, and more identification of particularly sensitive areas in order to avoid impacts. The precautionary principle also plays an important role. In any EIA process, risk assessment techniques may be most effective when used in conjunction with other tools, offering opportunities for more systematic management of cumulative effects.

EIA should be integrated with project planning. It is especially important in situations where systematic policies and regulations for protection of the marine environment are lacking. Timing is crucial for an EIA to be effective. That is, it needs to be carried out before initiating a project and before significant investment has been made in infrastructure, licensing, etc. Other important considerations are who decides what questions need to be addressed and how the EIA is funded. For example, Ron Kastelein stated that project proponents in the Netherlands are not allowed to cover more than 50 percent of the cost of an EIA, apparently to avoid conflict of interest. Fuller stressed that providing for meaningful public input is one way to ensure that the right questions are addressed in an EIA.

B. Introduction to Uncertainty and Policy-Making: How Do We Deal With the Unknowns?

John Harwood of the Sea Mammal Research Unit at St. Andrews University (U.K.) discussed the following questions:

- How can scientific uncertainty be addressed when making policy decisions? What can policy-makers do when we don't fully understand the range of impacts from sound?
- Beyond creating models, how can we handle uncertainties like those related to the significance of acoustic impacts?
- How can we define a "precautionary approach," and when/how should such an approach be applied in policy?

Harwood began by drawing a distinction between uncertainties that can and cannot be quantified. Techniques are available for quantifying uncertainty due to measurement error, random variation, and model mis-specification, but Harwood focused on dealing with unquantifiable uncertainties, particularly those due to ignorance. He defined "risk" as the quantifiable probability of a known, undesirable outcome; "pure uncertainty" as uncertainty where possible outcomes are known, but their probabilities cannot be quantified; and "ignorance" as uncertainty where possible outcomes are not known and cannot be quantified. As such, the unknowns in the area of acoustic impacts on marine mammals generally fall into the category of pure uncertainties, rather than ignorance. Harwood's stated goal was to develop a precautionary approach for reducing the potential impacts (risks) of anthropogenic sound in the face of substantial scientific uncertainty.

As currently applied, mitigation measures for acoustic impacts on marine mammals typically attempt to reduce risk by (a) reducing the probability that any individual is exposed to particular levels of sound, (b) avoiding times and areas of high marine mammal abundance, and (c) ensuring that a sound source is not emitting a signal when an animal is within a calculated

"safety zone." However, we generally do not know how effective these techniques are in reducing risk. When experts are unable to agree on a predicted outcome, decision-makers may compare the range of expected outcomes of different scenarios, or look for a risk-averse "minimax" protocol that seeks to minimize the maximum impact. This is one way to implement the precautionary principle.

Harwood emphasized the importance of accounting for uncertainty in models used to estimate or predict risk. He briefly described tools available to evaluate the possible outcomes of different scenarios, and emphasized the importance of applying new data to refine models associated with such tools. The most robust protocol (i.e., most effective across a wide range of scenarios) can be identified, the benefits of current protocols (e.g., soft-starts) can be quantified, and a Bayesian approach can be used to improve weak or subjective information. Bayesian statistical techniques use prior information to interpret observations and accept that many different hypotheses or explanations may be compatible with existing data. Thus, a Bayesian approach may be appropriate for situations of pure uncertainty. It provides an incentive to collect new information, helps identify what new information would be most helpful in reducing risk, and allows for transparency in assumptions made. In practice, such an approach might be applied in a sound exposure model that can be compared to real-world data.

It is useful for policy-makers to have a scenario-based tool for identifying the most robust risk-mitigation approaches. Ideally, such a tool allows sound producers and regulators to determine which techniques reduce risk and by how much. However, risk assessments must account for uncertainties in a precautionary way that creates an incentive to improve understanding of causal mechanisms as well as the accuracy and precision of estimates. Bayesian approaches may be useful for increasing transparency of the decision-making process, incorporating new data, and planning research. An advantage of Bayesian-type models is that they allow for adjustments to increasing or decreasing levels of uncertainty, which may be particularly useful to decision-makers.

C. Introduction to Mitigation Techniques: Options and Effectiveness

Jay Barlow of the National Oceanic and Atmospheric Administration (U.S.) briefly responded to the following questions:

- What constitute state-of-the-art "best practices" in mitigation?
- How do strategies differ for naval sonar, seismic research, shipping noise, and other sound sources? To what extent are mitigation strategies, monitoring technologies, and other techniques transferable across sound sources?
- How could mitigation strategies be made more accessible?
- What are the most promising strategies in development? What can we expect in the future?

His presentation was based on a paper prepared for the Marine Mammal Commission's April 2004 technical workshop on beaked whales (Barlow and Gisiner in review, see Appendix 3). The goal of mitigation can be defined as the minimization of potentially negative effects of anthropogenic sound on marine mammals (from military sonar, airguns, shipping, and fixed sources). Barlow outlined some options for monitoring and mitigating the effects of

anthropogenic sound on beaked whales and stressed the challenges of developing and validating effective methods.

An initial premise is that no realistic prospect exists for eliminating all potentially harmful sound sources from the marine environment, and therefore mitigation is essential. Mitigation can be approached in a number of ways, including:

- Modification or removal of the sound source;
- Avoidance of marine mammal habitat;
- Soft-start or ramp-up of the sound source;
- Detection of marine mammals and consequent modification of the sound source's operations;
- Sound screening (e.g., bubble curtains); and
- Use of aversive alarms to keep or drive marine mammals away from the exposure zone.

The removal of a sound source is generally not feasible, given that many sources serve critical purposes (e.g., national defense, shipping) and alternatives are not readily available. Source modification has more promise, and may include changing training protocols for military sonar use, using ship-quieting technology, or altering signal characteristics. Habitat avoidance (e.g., avoiding critical areas inhabited by certain species) may be an effective way of reducing the potential impacts of a particular risk factor. However, such avoidance requires a good understanding of the animals' distribution, relative abundance, and habitat preferences. Many of the world's navies are investing resources in habitat mapping, but the necessary information is not currently available for most species of marine mammals. Ramp-up (as it is called in the United States) or soft-start (as it is known elsewhere in the world) typically involves initially firing a single airgun in a seismic array and adding others gradually until full operation is reached. It has become a relatively standard procedure throughout the seismic survey industry. The presumption behind this procedure is that the animals of concern (e.g., whales) will detect the sound and respond appropriately (i.e., will move away in time to avoid harm). However, too little is known about animal responses to ramp-up to determine the effectiveness of this mitigation strategy. For example, the animals may move vertically in the water column rather than "away" from an approaching (and ever-louder) sound source.

Another typical approach to mitigation is to place observers onboard a vessel or structure to detect marine mammals, with the expectation that sound-generating activities can be modified in response to a sighting and that a critical separation distance can be maintained between the animals and the sound source. In most U.S.-based seismic and naval operations, the critical distance (safety threshold of exposure) is currently based on an estimated received level of 180 dB.[52] Success of this method depends on the probability that any animal within the critical distance of the sound source will be detected, as well as the appropriate selection of safety thresholds and critical distances. Because visual detection probability depends largely on diving behavior, the deep-diving beaked whales represent a special problem. Mitigation observers from ships or aircraft will detect only a small fraction of the animals that are within their range of vision. Passive acoustic techniques offer some promise for improving detection. However,

[52] The U.S. National Marine Fisheries Service is developing exposure limits specific to species group (e.g., large cetaceans versus pinnipeds in water) and source type (e.g., pulsed or non-pulsed sound).

vocalizations by marine mammals are voluntary and therefore not entirely reliable (i.e., an animal will not be detected by this method if it is not vocalizing). In addition, beaked whales are hard to detect with towed surface hydrophone arrays, largely because they tend to vocalize at depth more than they do at the surface. Some improvement may be achieved using bottom arrays or gliders. The efficiency of visual detection for most or all species can be improved by reducing vessel speed when feasible. Active acoustic detection techniques (e.g., "whale-finding" sonar) are also being investigated and may prove useful in the future, although this technology is somewhat controversial because it involves the introduction of additional sound into the marine environment.

Another mitigation method is the use of bubble screens to dampen sound transmission, but its effective use is limited to some stationary sound-generating sites. Acoustic alarms (e.g., pingers) have been employed successfully to deter toothed cetaceans from the vicinity of gillnets (thus reducing bycatch), but they have not been used to mitigate potential impacts of sound on marine mammals.

During discussion, it was noted that although some mitigation methods may be ineffective with beaked whales, they could be effective with other species that are more readily detected. In response to a question as to why active acoustic detection has not proven useful, Barlow observed that target strength similarities result in numerous false positive results (e.g., fish schools may be difficult to distinguish from marine mammals). Finally, in response to a question of how often shutdowns occur when whales are observed from seismic survey vessels, he answered that they do not occur very often, judging by the limited evidence available from industry records.

D. Issues in Management, Risk Assessment, and Mitigation: Concurrent Small Group Discussions (Session 1)

Following the formal presentations, workshop participants met in four small groups to discuss and elaborate upon assigned subtopics. The goal was to elicit and record the range of opinion within each group and not necessarily to seek consensus.

Group A – Evaluating effectiveness (e.g., criteria for assessing effectiveness and efficiency, techniques for evaluation)

This group addressed the following questions:

- What are the goals of mitigation, management, and monitoring? How should those goals be ranked as priorities?
- How is the effectiveness of mitigation strategies evaluated? To what extent is the effectiveness of existing mitigation techniques understood? What can be done to improve that understanding?

Facilitator: Erin Vos
Topic Specialists: Jay Barlow, John Richardson
Recorder: Colleen Corrigan

The group first identified a range of strategic and operational goals of mitigation, management, and monitoring. An overarching goal is to protect ecosystems, species, populations, and/or individual marine mammals. Priorities for protection may vary, depending on such factors as societal values. For example, management efforts may be driven by a desire to protect rare, endangered, endemic, or especially sensitive species, or by concern about the welfare of individual animals. Management may be focused locally, regionally, or globally. Goals may also vary according to the region, country, or legislative context. Other overarching goals might be to reduce marine mammals' exposure to sound (e.g., by detecting the animals within a zone of impact and modifying operations in response), to prevent or ameliorate impacts, to identify and evaluate threats from anthropogenic sound over the short and long term, and to collect baseline information about the range of "normal" conditions and possible effects. Group members argued that management, mitigation, and monitoring efforts should follow logically from an evaluation and ranking of threats, and should be clearly defined in advance of implementation (e.g., through strategic planning). Furthermore, mitigation should be cost-effective and minimize interference with operational goals of sound producers. To the extent possible, mitigation measures should be specific to particular situations. Many interest groups and the public may believe that "something must be done" and that "every little bit helps." Efforts should consider public appearance and expectation, attempting to address perceptions and misunderstandings through communication, transparency, public participation, and local input (e.g., when defining goals). They should also aim to maximize compliance and effectiveness, and allow for continual improvements (e.g., by collecting data to improve future mitigation and employing other adaptive management strategies).

The varied goals of management, mitigation, and monitoring may lead to conflicts. The group discussed how to set priorities. Suggested strategies included the following:

- Get input from a broad range of stakeholders (i.e., strive for inclusive and extensive communications).
- Listen to experts and solicit information.
- Ensure that surveys are conducted before designing a mitigation approach.
- Apply knowledge from elsewhere.
- Examine species vulnerability (e.g., rarity or endemism, endangered status, sensitivity to sound sources).
- Employ tools of risk assessment and environmental impact assessment.
- Remain sensitive to geographic, national, or cultural differences.
- Consider a range of alternatives, and clarify the rationale for decision-making.
- Consider effectiveness in addressing threats from anthropogenic sound.
- Consider cost-effectiveness.

The group then discussed how to evaluate the effectiveness of mitigation. A basic dichotomy exists between the questions of whether a given mitigation strategy is effective and how well it is being implemented. In other words, ineffectiveness could be due to either an intrinsically flawed strategy or a failure to implement it properly. Keeping this in mind, the group identified key strategies to apply in evaluation:

- Establish a monitoring program.
- Analyze existing monitoring data (e.g., Stone 2003).
- Establish standards for data collection and recording to facilitate analysis and broaden information-sharing.

- Make observations from independent platforms and conduct controlled studies where practicable.
- Solicit external review, including "common sense" and expert evaluations.
- Seek to evaluate the effectiveness of all mitigation measures, both individually and in combination.
- Determine whether goals and objectives are being met.
- Acknowledge the limitations of data that have been collected (e.g., purpose of data collection and reporting).
- Evaluate guidelines, best practices, and standards (e.g., through pre- and post-monitoring and analysis).
- Consider costs and practicalities of implementation.

The effectiveness of current mitigation methods likely varies from one species to another. It is crucial to understand behavioral responses of the animals to underwater sounds (whether unmitigated or mitigated), but such responses are largely unknown. Many methods have the potential to cause unanticipated and undesirable side effects (e.g., soft-start /ramp-up, shut-down, and alarms all may increase total sound exposure). The group specifically discussed what is known about the effectiveness of the following seven basic mitigation methods, as well as what might be done to make them more effective:

1. *Modification of the sound source or how it is used* may work in some cases. For example, ship-quieting technologies (e.g., rubber baffles to reduce vibrations) already exist and might be more broadly applied. However, it would be more cost-effective to incorporate these into newly built ships rather than retrofitting existing ones. Adjusting the source characteristics of seismic airguns may prove difficult, although it may be possible to reduce the high-frequency components, which are not needed to produce survey data. Adjustments to seismic survey design (e.g., using more receivers, adjusting array size) are also possible. Long-term experiments that examine specific conditions are needed to evaluate the costs, effectiveness, and short- or long-term feasibility of such modifications.
2. *Avoiding the generation of sound in areas where, or at times when, the animals are especially sensitive* is a promising approach. In many cases (e.g., certain military and research activities), this is relatively cost-effective and simple, and the potential benefits are significant. In order to improve implementation, population densities and spatial and temporal variations need to be evaluated and baseline data need to be collected. The entire habitat or ecosystem should be considered, along with legal and policy issues. One potential drawback is the challenge of enforcing time-area closures.
3. *Soft-start (ramp-up)* has many proponents, but this strategy is essentially untested. Although it may work well with some species, it may be counterproductive, as it increases the overall amount of sound energy introduced into the environment. Also, some marine mammals may initially be attracted to the relatively low-level start-up sounds, thus increasing their vulnerability as the sound source ramps up. Improvements might be made through more regular or routine application of this technique, or through research on marine mammal behavioral reactions (e.g., context- and species-specific responses).
4. *Detection with avoidance or shutdown* may be an effective strategy for some species (e.g., sperm whales), but detection probabilities need to be improved for other species (e.g., beaked whales). In addition, there are difficulties determining when it is safe to restart operations. Improvements might come from better or more appropriate detection procedures to support

avoidance or shutdown protocols in the presence of marine mammals. It is also important to clarify the goals of monitoring (e.g., whether it is to reduce the number of animals in a safety zone or the percentage of the population being affected), and to understand the effects of sound sources at different ranges.

5. *Acoustic alarms* (e.g., acoustic harassment or deterrent devices) to deter animals and reduce their exposure to dangerous sounds may prove effective in some circumstances, but more information, development, and testing would be needed before this strategy could be widely applied. In particular, there are concerns about whether animals would respond appropriately to the alarms (e.g., move away from, rather than toward, the sound source). More studies are needed on specific species under specific conditions.
6. *Specialized technologies*, such as "whale-finding" sonar, infrared, and radar detection, may be useful, but their effectiveness remains largely untested. Further research and development are needed.
7. *Sound screens* can be effective for stationary sources (e.g., pile-driving), although effectiveness varies according to frequency and other variables. Bubble screens and other devices should be used to reduce exposure, where feasible.

The group agreed that the "habitat avoidance" strategy of restricting sound generation geographically or seasonally offered the most benefits and fewest negative side effects. Reduction of total sound production (e.g., reducing amplitude, improving signal processing, eliminating unnecessary or accidental sound, and using sound-screening mechanisms) also was seen as a promising mitigation strategy. The group also agreed that research is particularly needed on soft-start, marine mammal detection techniques, and acoustic alarms.

Group B – Best practices and emerging techniques (e.g., new applications of technology, research and development, standards for application of mitigation strategies)

This group discussed the following questions:

- What constitutes "best practice" in risk assessment, management, and mitigation? For example, what models are used for risk assessment and what factors are considered in those models? What current standards exist for the application of mitigation strategies? How does this vary for different sound sources and across national boundaries?
- How is scientific uncertainty addressed in management, risk assessment, and mitigation?
- What are the greatest needs in risk assessment, management, and mitigation with regard to marine mammals and sound? What are the most promising strategies currently under development? What innovations can be expected in the future?

Facilitator: Zoë Crutchfield
Topic Specialists: Jim Theriault and Sara Wan
Recorder: Katie Gillham

Risk Assessment
The group described several elements of "best practice" in risk assessment (RA). It is important that precaution is built into RA, and that uncertainties are acknowledged and highlighted. More quantitative RA should be the goal, although the insufficiency of data often limits our ability to do more than place broad confidence limits around quantitative elements and conduct sensitivity

analyses. RA should be part of the design process, not something that takes place after a project is already underway or completed. Finally, all relevant data must be used. It was agreed that a consistent terminology and a common international standard for RA would improve global practices.

Currently available RA models include:

- Acoustic Integration Model (AIM), in which biological information (e.g., distribution, diving behavior), sound source, and environmental acoustic input are combined to yield a decision.
- Effects of Sound on Marine Environment (ESME[53]), which is similar to AIM and is currently being developed as a research project with an emphasis on simulating the effects of anthropogenic sound on the physiological function and behavior of marine mammals. ESME uses a combination of data on animal distribution and diving behavior with sound field calculations to develop exposure criteria. Both AIM and ESME are designed for one or two sources of sound in a relatively small, well-defined area, with a small number of animals subject to exposure.
- Sea Animal Kind Area-dependent Mitigated Active Transmission Aid (SAKAMATA), a naval exercise planning tool that provides the operator with tools for "careful mission planning," implementation of "marine mammal monitoring," and implementation of "ramp-up schemes" (see Appendix 4, poster 2).
- The Protective Measures Assessment Protocol (PMAP[54]), which provides "situational awareness for at-sea training" and is not restricted to acoustic impact awareness, but applies to a wide range of activities.
- GIS Tools (developed by the Canadian Maritime Forces Atlantic's Formation Environment[55]), a toolset to identify risk areas associated with planned training missions in eastern Canadian waters. Similar to PMAP, this tool is not restricted to acoustic impact.
- The Environmental Risk Management Capability (ERMC[56]; being developed for the U.K. Ministry of Defence), which includes a "real-time" shipboard risk assessment system integrated with risk mitigation capability.
- The NATO Undersea Research Centre's current risk management tools, which the Centre plans to move to a Web-based server through the SOLMAR (Sound, Oceanography and Living Marine Resources) project. The focus has been on species in the Mediterranean Sea with a specific interest in sperm whales and Cuvier's beaked whales (see Carron presentation, above).
- A risk matrix, a common and relatively simple tool that considers the probability that an event will happen and the likely consequences when it does.
- Predictive Location Abundance Model, which relies on bathymetry and other oceanographic data to predict where problematic sound exposure is likely to occur.

[53] See http://www.onr.navy.mil/sci_tech/ocean/321_sensing/info_oa_esme.asp.
[54] U.S. Navy's CD-ROM tool that provides operators with environmental data and mitigation guidelines for use during routine training. See http://www.enviro-navair.navy.mil/currents/spring2004/Spr04_Nat_Res_Conference.pdf#search='PMAP percent20marine percent20mammal.
[55] See http://www.navy.forces.gc.ca/marlant/environment/fenv_e.asp?category=1&title=43.
[56] See www.mmc.gov/sound/plenary2/pdf/burt.pdf.

- Bayesian frameworks, which offer the potential to improve risk assessment models (see Harwood presentation, above).

The group identified a number of limitations on the use of RA models. There was no consensus on the utility of models in general: some people have faith in them, but others do not. Models can highlight major gaps in knowledge and help rule out unlikely scenarios, but they are difficult to use for predictive purposes. Most of the RA models currently available in this field suffer in important ways from insufficiency of appropriate data, whether qualitative or quantitative. Uncertainty, even when it can be identified, is difficult to incorporate and quantify, and the quality of results obtained from any model depends on the quality of data available to develop them. When a model is used for decision-making, the decision-makers must be made aware of the assumptions made, the model's limitations, and the (often large) uncertainties surrounding outputs. For example, a model output showing no effect (low risk) does not necessarily mean that there will be no effect; power analysis is essential. A standard question to be clarified is whether data must be collected in advance to provide input for model design, or whether a model can be designed first and data then collected to provide input and testing. Finally, RA tends to be project-specific and does not necessarily incorporate holistic consideration of outcomes (e.g., use of alternative technology).

As a result of those limitations, a number of ongoing needs in RA can be identified:

- The determination of risk acceptability thresholds is essential, as it may influence choices of models to apply.
- There is a need for biological baseline data (e.g., population abundance, distribution, behavior) that include an understanding of the population's historical context (e.g., is it already depleted from some other cause or recovering from depletion). We also need a better understanding of how marine mammals respond when exposed to anthropogenic sound (e.g., behavior when feeding or engaged in activities related to reproduction and nurturing).
- Better information is needed on acoustic oceanography (e.g., currents, sound speed profiles, geoacoustic parameterization, transmission loss). However, it was noted that underwater sound sources will need to be employed to obtain some of this knowledge.
- Better sound source data (e.g., sound profiles, transmission models) are needed.
- There is a need for improved techniques to use the effects on individuals to infer population-level effects. This will depend, in part, on number of individuals affected in relation to total population size.
- An increased ability is needed to account for natural changes and distinguish anthropogenic from non-anthropogenic effects.
- There is a need for thorough and consistent identification and acknowledgement of the range of uncertainties in RA models, as well as any other limitations on their use.

Finally, the group discussed the idea that a choice must often be made between having a risk assessment with many limitations and qualifications, or having no risk assessment at all.

Management
The group identified the following elements of "best practice" in management:

- Well-defined goals, bearing in mind that tolerance of risk is subjective and cultural (e.g., some people consider an effect on a single animal to be excessive; others consider effects of a certain magnitude to be acceptable).
- Recognition of, and accounting for, the distinction between individual- and population-level effects (generally not yet feasible).
- Consideration of cumulative, synergistic, and long-term effects (although it is rarely, if ever, possible to define and quantify these).
- Precautionary measures taken to account for uncertainties.

The group then discussed expected future developments in management. They concluded that no single system can be effective for all sound-generating activities or industries, and that therefore multiple approaches will be needed. Stakeholders (especially national governments) need to be encouraged to participate more actively. This may be especially true in less-developed countries where only nongovernmental organizations have been engaged with the sound issue thus far. Finally, increased transparency is imperative.

Mitigation
The effectiveness of many current mitigation techniques is uncertain, and belief in their effectiveness is often rooted in little more than common sense. Much more work is needed to assess effectiveness of different mitigation strategies, preferably using quantitative measures. Group members regarded seasonal and geographical restrictions as the best mitigation tools for protecting a species or population when its critical habitat has been reliably identified (e.g., seasonal restrictions on seismic survey operations in Brazil to reduce exposure of humpback whales on breeding grounds; see Borobia presentation, above). Measures that modify the source to reduce (or even better, to minimize) the level of sound produced were regarded as promising. To achieve "best practice," the aims of mitigation need to be clearly defined, and mitigation measures designed or selected accordingly. In addition, regulatory measures need to be adaptive so that strategies can be reassessed and adjusted as new information on effectiveness becomes available.

Some participants saw great potential for the use of active, broadband sound (i.e., "whale-finding" sonar) to distinguish between targets and therefore to facilitate the "detection/avoidance/shutdown" strategy. Others cautioned that this tool would itself add sound to the environment. Although the limited targeting potential of passive techniques means that there will always be some need for military active sonar, development of passive techniques for object detection (e.g., submarine surveillance) may decrease the need for active sound sources.

The group concluded that no single approach to mitigation was likely to prove universally applicable, but participants saw signs of convergence toward a suite of best practices.

With regard to shipping, (1) the technology for making ships quieter is already available; (2) political will at national and international levels is needed before major progress can be made to curtail or regulate ship noise; (3) management of shipping requires a means of implementation

(e.g., exerting domestic jurisdiction over traffic in ports and internal waters); and (4) an obvious form of mitigation is to route shipping lanes away from critical habitat.

Several additional themes emerged during this group's discussion:

- When managing acoustic impacts, it is important to define the effects as either episodic (e.g., seismic surveys, sonar, construction) or continuous (e.g., shipping, pipelines, wind farm operations). It is also important to consider that some of the episodic sound sources (e.g., seismic surveys and sonar) are recurrent and increasing, although these sources may not be in precisely the same geographic area.
- In less-developed countries, precautionary mitigation and management are often especially important because so little is known about marine mammal populations and their critical habitat. A combination of precaution and transfer of mitigation technology is needed.
- At some point, decision-makers cannot wait for better information or models. They need to make decisions based on the best data and analysis available at a given time.

Group C – Policy issues in risk assessment and mitigation (e.g., consistency in the application of mitigation strategies, balancing environmental protection with other societal goals)

This group's discussion was guided by the following questions:

- How are practicality, cost, and efficiency balanced in assessing risk and choosing mitigation strategies? What are the goals of existing risk assessment and mitigation mechanisms? How are protection goals balanced against other societal goals?
- How can sound-producing human activities be conducted in the ocean while minimizing the adverse effects on marine mammals?
- How do mitigation strategies differ for naval sonar, seismic research, shipping, and other sound sources? Why? Are such differences desirable?
- To what extent are mitigation and monitoring strategies and technologies transferable across sound sources, and across national boundaries? How could these strategies and technologies be made more accessible to different groups?

Facilitator: Suzanne Orenstein
Topic Specialists: Paul Macnab and Elena McCarthy
Recorder: Randall Reeves

Both risk assessment (RA) and environmental impact assessment (EIA) are intellectual structures, processes, or frameworks that can facilitate determinations of what is at stake from a proposed activity and what information is available for evaluating the risks of that activity. Either process can be viewed as a societal consultation, where it is known that a particular set of activities is planned, and at least something is known about what species occur in or near the action area and what potential environmental impacts may take place. The intent, then, is to establish what is known, what is not known, and what mitigation tools are available to offset any risks that are identified. EIA provides for case-by-case evaluations that highlight information needs to be addressed through surveys or other types of studies.

Defining risk, or impact, is a difficult and inevitably value-laden process involving both scientific and societal considerations. Even when there is approximate agreement on what should be protected (individuals, populations, species, etc.) and the kinds of risk involved (e.g., displacement, change in behavior, physiological damage), establishing the level of impact that is deemed to be biologically significant can be controversial. For the most part, assessment focuses on observable changes in behavior (e.g., of individuals), which are then interpreted as proxies for biologically significant effects. The biological significance of effects may depend on population status. For example, displacement of a few animals belonging to an endangered population could be highly significant, whereas it would be unimportant for a large, healthy population.

The group discussed several issues related to practicality, cost, and efficiency. First, it was agreed that sound-producing activities will not stop, nor will complete knowledge of risks and impacts be attained. Therefore, uncertainty in risk assessment and decision-making is unavoidable. Incorporating the collection of baseline data on underwater sound into ongoing global ocean monitoring programs would be an efficient way to obtain critical data for use in assessing and regulating anthropogenic sound inputs. Second, the group discussed the idea that society must consider the costs of *not* conducting an activity as well as its risks. Some proposed activities or projects might exceed what is necessary in terms of scope, duration, and geographical extent. The group agreed in principle that, whenever possible, serious efforts should be made to pare down the scale of projects, or to modify the sound source to the lowest feasible level needed to achieve the objective. Such a preventative approach can be taken even in cases of uncertainty. Finally, considerable difference of opinion was expressed on the question of whether foreign companies deliberately take advantage of the poor knowledge base and weak infrastructure in less-developed areas, or whether they in fact operate as guests in such areas and are bound only by the prevailing local regulatory regimes.

When attempting to minimize impacts, information about the species present in an ensonified area is essential. There is a particular need for better data on critical habitat in regions where deliberate sound generation is already occurring or planned (e.g., military activities in the Mediterranean and eastern Asia). In the absence of good information on the animals and the effects of sound exposure, it is preferable to initiate precautionary mitigation while conducting studies to fill the information gaps. Early consultations between sound producers and regulators allow for project modifications when and where possible (e.g., reduce scope, avoid critical habitat). Modification of the scope of an activity or changing the behavior of the operator (sound producer) can be one of the most effective approaches to mitigation. The question of whether sound producers should go beyond the requirements of countries where they operate was controversial. Some participants insisted that outside standards should not be applied to any country; others argued that companies working abroad should be held, at a minimum, to the standards they would face working in their home waters, or even to the highest standards anywhere that such work is undertaken.

The group identified several challenges to successful mitigation:

- Because sound travels, it is difficult to narrow or limit the scope of its effect. This is particularly important to the mitigation of sound that is produced unintentionally (e.g., ship noise).

- Once resources have been invested in a project, product, or type of activity, it becomes less feasible and more costly to make sound-reducing modifications. For example, retrofitting ships with quieting technology is likely to be more challenging than building quieter new ships.
- The great uncertainty surrounding the effectiveness of mitigation measures is a major impediment to their wider acceptance and application.Compliance and enforcement are always challenging.Mitigation strategies should be tailored to the different sound sources and species of concern (i.e., one size does not fit all):
- *Intentionally versus unintentionally produced sound:* Greater control is generally possible when dealing with intentionally generated sound; however, unintentionally produced sound is expendable (*i.e*., lacks a benefit to humans) and therefore may be more amenable to elimination or reduction through technological innovation (e.g., ship design, signal processing). However, the issue of parity arises because deliberately generated sound tends to be more easily monitored and regulated than unintentionally generated sound. Consequently, some sound producers (e.g., military sonar and seismic) feel unfairly targeted by regulation relative to others (e.g., shipping industry).
- *Levels of management:* There is a need for three different "levels" of management or mitigation (i.e., international, national, and private/industrial), the last of which requires more industry engagement and negotiation. The appropriate level of management depends largely on existing legal structures.
- *Prioritization of management efforts:* Priority for mitigation should be assigned according to severity of impact rather than ease of regulation.
- *Engagement of sound producers:* In general, the shipping industry has not yet engaged in this issue, although navies and seismic operators have. The strategies taken for each source type should be adjusted accordingly. For example, most aspects of the shipping industry are regulated internationally (e.g., through international standards), but monitoring and enforcement is typically done at a national level (e.g., through enforcement in territorial waters). The industry is amenable to regulation, silencing technology is available, and quieter ships are more efficient than noisy ones (meaning that economic incentives may converge with environmental objectives). Many ship owners are said to be receptive and willing to work with scientists and conservationists to develop and implement a sound mitigation strategy. The "green ships initiative" was cited as an example.
- *Costs of alternatives:* Cost is a major factor in decisions to employ some sound sources. It may be difficult to identify or develop alternatives to sound-producing activities based on technological limitations or feasibility issues.

The transferability and accessibility of mitigation strategies may vary from one source type to another:

- Most techniques are transferable, but application and enforcement (i.e., legal regimes) may vary with region, country, and context.
- Mitigation guidelines developed by the JNCC for seismic surveys (JNCC 2004) were developed with the U.K. context in mind, but they have been widely used and cited.
- To improve accessibility, issues related to particular strategies need to be articulated in understandable terms. Having good systems in place to serve as models is also a good way to facilitate transference.

- The need for mitigation measures could be placed on the agendas of international fora and raised to the level of policy discussions in an effort to improve consistency and transference.

Other issues related to accessibility and transferability include uncertainty about the effectiveness of some approaches (a major obstacle to transference of tools and techniques), the need for early involvement of key stakeholders in planning and scoping phases, and the desirability of a global biogeographic information system, or universally accessible geo-referenced database on marine mammal distribution, relative abundance, and critical habitat. Duke University's Ocean Biogeographic Information System (OBIS) was cited as an example.[57] However, regardless of how sophisticated the information system itself may be, it cannot compensate for the lack of basic information on marine mammal populations in many regions, including ones where substantial anthropogenic sound inputs already occur.A belief in the feasibility of mitigation underlies virtually all RA and EIA. Expectations regarding the effectiveness of mitigation are often unrealistically high – participants differed in their degree of confidence that mitigation works. In the starkest terms, what one person regards as successful mitigation, another person may regard as imposition of high costs for no return.

Other differences in point of view were expressed on the subject of who should pay for and conduct an EIA. One view was that when companies or their consultants are responsible, they introduce bias, and therefore the responsibility for conducting assessments should be given to independent bodies. Another opposing view was that proponents and regulatory authorities have complementary roles, and that although the former should be responsible for producing the assessment, the latter has the responsibility for review and approval, thus offsetting any bias in the assessment itself.

Further concern was expressed about the extent to which EIA and RA depend on extrapolation (e.g., from well-studied species to poorly studied ones or from animals in one ecological setting to those in another). The credibility attributed to such extrapolations is always a matter of qualitative personal judgment.

Participants with experience in some less-developed countries expressed strong skepticism regarding the effectiveness of EIA. For example, it often takes place in situations where even basic information is lacking, such as what species occur in the affected area or what features of the habitat are biologically important. Institutional capacity, knowledge base, and political will all vary across countries and regions, making EIA variably effective.

The importance of investing resources in research on marine mammal distribution and critical habitat was a consistent theme, especially in reference to areas where the knowledge shortfall is greatest. At the same time, however, it was acknowledged that some of the existing commitments to mitigation are bound to continue, thus precluding reallocation of resources away from them and toward more research. It was also noted that the oil and gas industry already invests significantly more resources in research than in mitigation.

[57] See http://seamap.env.duke.edu/.

Group D – Prioritizing information needs (e.g., identifying information gaps, criteria for setting research priorities)

This group discussed the following questions:

- What information is needed for risk assessment, and how should it be prioritized?
- What are the information needs relative to various mitigation strategies and technologies, and how should those needs be prioritized?

Facilitator: Lee Langstaff
Topic Specialists: Ron Kastelein and Doug Wartzok
Recorder: Victoria Copley

The overall goals of risk assessment and mitigation should be to maximize both protection of the animals and benefits (realized efficiencies) to the sound-producing "users." Risk assessment (RA) provides a way of focusing resources on key concerns.

Risk can be thought of in several ways. For example, it can be a function of hazard in combination with exposure, or of probability combined with consequence (i.e., chance *x* effect). Distinctions can be made between (1) risks to individuals and populations, (2) risks associated with acute, localized high-intensity exposure and dispersed but chronic low-intensity exposure, and (3) risks of short-term and long-term effects. Hazards or effects can be auditory, non-auditory physiological, or indirect (behavioral), and they can be placed in different categories (e.g., directly damaging to hearing capability, forced stranding, or death of individuals; displacement from important habitat; behavioral changes such as separation of mothers and calves or frequent interruption of feeding or nursing leading to energy deficits). With those considerations in mind, the group attempted to construct a multi-dimensional matrix for RA, consisting of (a) category of hazard, (b) probability of occurrence, (c) severity of response, and (d) whether the impact would be on individuals or the population.

Among the types of capabilities and information needed for RA are the following:

- Ability to determine when an effect has occurred. Ideally, one needs to know the probability of being able to make such a determination.
- Ability to assess effects on individuals in relation to size of population. It is generally easier to detect and measure effects on individuals than on populations. Population effects can be measured as changes in demographic parameters (e.g., growth, survival, reproduction).
- Population information (distribution, population structure, abundance, trend, habitat requirements, etc.).
- Organismal information (e.g., foraging, social, and diving behavior; audiograms [hearing profiles] for species or species groups [e.g., beaked whales, baleen whales]).
- Dose-response information on sound exposure of relevant species. For example, we need to understand the levels of exposure (at given frequencies, etc.) at which permanent threshold shifts (PTS), masking (i.e., disruption of an animal's use of sound), behavioral responses, and other effects will occur.
- Understanding of cumulative effects.
- Three-dimensional, broadband source characterization of relevant sound sources.

- Better models of sound propagation, particularly in shallow water.
- Identification of the most important sound sources likely to pose risks to marine mammals.
- Temporal and geographic distribution of anthropogenic sound-generation in the marine environment, including measurements of, and evaluation of trends in, ambient noise.
- Data integration.

The group also thought that a global review of risk management frameworks could be useful.

Methods by which such information could be obtained include the following:

- Captive animal studies in which experimental protocols are used to obtain audiograms, dose-response information, and improved understanding of physiology and energetics. For example, it was suggested that trained animals could be used for studies of supersaturation in tissues during diving. Establishment of a shared captive animal facility for testing and experimentation would help achieve this.
- Access to operational ship time for observation of behavior and for controlled exposure experiments with free-ranging, instrumented animals at sea.
- Examinations of cumulative impact, including the development of better measures and indicators (e.g., neuroendocrine, glucocorticoid).
- Examinations of population-level effects, including the development of better measures (e.g., how changes in the behavior or physiology of individuals translate into changes in vital rates). However, one drawback of focusing on population effects (e.g., through population monitoring) is that once an impact has been detected, it is already too late to prevent such an impact (which is the main goal of mitigation).
- Development and wider availability of affordable technology.
- Improved stranding notification systems and further development of capacity for rapid response. Among the benefits expected from such improvements are auditory brainstem response (ABR) measurements of hearing capabilities, better-quality specimens, and better-controlled pathology investigations.
- Conducting careful, improved examinations of relevant pathology to document physical effects of exposure.
- Examination of mechanisms linking sound exposure to animal responses (e.g., stranding).
- Data collection, data management, and data analysis in less-developed countries. Greater capacity (e.g., facilities, expertise, funding) will be needed to achieve this.

Among the priorities for RA is information that may aid in the following:

- Can lead directly to risk reduction (e.g., describes how a mitigation tool functions, identifies areas or times where sound inputs will not harm marine mammals).
- Allows for extrapolation from one species, situation, or type of exposure/response interaction to other species, situations, or types of interaction.
- Helps establish and clarify cause-and-effect relationships (e.g., whether and how sound exposure leads to stranding).
- Improves understanding of dose-response mechanisms.

- Helps determine if there is a problem, and how large or small it is (e.g., whether a population-level effect is known or expected).
- Addresses regulatory requirements.
- Adds to public awareness and informed concern, including outreach to less-developed countries.
- Adds to capacity for completing the risk matrix described above.

Information needed for mitigation includes the following:

- Clear objectives that are practical, achievable, and auditable. This requires that acceptable risk is defined, and that the mitigation strategy offers potential for reducing risk to the acceptable level.
- Decision analysis models (perhaps adapted from other industries).
- Understanding of the efficacy and efficiency of mitigation measures (e.g., characterizing behavioral responses). These are likely species- and context-specific, which complicates analysis.
- Cost-benefit analyses of mitigation strategies, which will require means to measure both costs and benefits while recognizing that cost and benefit will be perceived and defined differently by various stakeholders.
- Analysis and integration of data already collected, or being collected, from monitoring.
- Better understanding of distribution, abundance, habitat requirements, and temporal use of various habitat areas (e.g., in relation to critical life history times), including habitat modeling.
- Better understanding of acoustic behavior of the marine mammals of concern and the implications for passive acoustic detection systems.
- Improved data and analyses of visual detection (sighting) probabilities so that mitigation efforts involving onboard observers can be evaluated and made more efficient. It was suggested that the analysis presented by Barlow, illustrating the difficulty of detecting beaked whales, should be extended to other species and further refined. His pessimistic conclusion may not apply to all species (e.g., the sperm whale).
- Exposure mapping, especially at the population level, to help determine how acoustic risks contribute to cumulative risks.
- Further development of active sonar detection systems, including improved equipment, better classification algorithms, and more validation trials to test assumptions.
- An operational understanding of the activity for which mitigation is being undertaken.
- Better understanding of how sound sources can be modified and of benefits that might result from signal alteration.
- Better understanding of ancillary effects of various mitigation strategies. For example, quieter ships might increase the incidence of ship strikes on whales.

Priorities for addressing information needs related to mitigation will depend on the perspectives and interests of those setting them. Among the considerations identified by the group were the following:

- Reduction of risk to the animals of concern.
- Ability of noise producers to continue their activities in a precautionary manner.
- Practicality, feasibility, and auditability.
- Scientific credibility.
- Reduction of uncertainty by investing in research and monitoring that will lead to important, relevant insights.
- Immediacy of the need to know whether a given strategy works.
- Matching mitigation strategies to specific, often local, situations.
- Balance between practicality and state-of-the-art standards.
- Optimization of cost-benefit ratio to ensure that good value is realized from investments.
- Conformity with current regulations and laws.
- Acceptability to public and regulators. This requires communication and education strategies. There are commercial and public relations risks that could arise from decisions to mitigate, or from failures to mitigate.

There was some discussion of how best to secure funding for needed studies, including the suggestion that investments in mitigation of unknown effectiveness might be redirected to fund research. However, many conservationists regard existing mitigation measures as appropriately precautionary, and some such measures are entrenched in regulatory regimes regardless of their effectiveness. Rather than redirecting resources away from mitigation measures that have yet to be shown effective, and toward further research to validate effectiveness, new funding likely will be needed to cover the latter. In addition, investment in experimental mitigation is more likely to provide conclusive, relevant information than is additional operational monitoring. For example, experimental protocols outside the normal operational mitigation requirements (e.g., ramp-up) could be integrated into seismic surveys to test effectiveness and refine the approaches.

Lessons might be learned from other fields of risk analysis and mitigation. For example, dose-response curves are regularly developed and used in toxicology. Epidemiological models that mine existing data and conduct correlation analyses also could be instructive. Such approaches might help avoid such problems as the delay of approximately 35 years from the first recorded instances of “atypical” mass strandings of beaked whales to the recognition of an association between such strandings and the deployment of mid-frequency tactical sonar.

E. Plenary Discussion

Lindy Johnson offered a personal summary of this session with the following five points:

- Defining acceptable risk is key to developing precautionary approaches.
- Sound-generating activities are going to continue; therefore the important issue is how those activities can be modified to lessen the risks to marine mammals.
- Early scoping, clear communication and integration of input, and broad stakeholder participation usually help prevent and resolve problems.
- Stakeholders need to be integrated to the greatest extent possible in the search for solutions.

- International solutions may be important, but should not be seen as a replacement for national and regional approaches.

Concern was expressed that chronic exposure of populations to relatively low levels of sound may not be receiving the attention it deserves, in large part because the effects are likely subtle and difficult to detect, measure, or attribute to a particular cause. Indeed, participants generally agreed on the need to seek a balance in managing the effects of both acute and chronic exposure, and effects at both individual and population levels. However, some participants argued that, in a few cases, marine mammal populations are demonstrably increasing in habitats exposed to significant anthropogenic sound, and that this could be interpreted to mean that the population-level effects of present levels of anthropogenic sound are at least tolerable, if not negligible. Although some felt that maximizing the protection of populations is an overarching goal that should be addressed in a more precautionary manner, others felt this goal must be balanced with a second overarching goal: to recognize the needs of sound producers. Balancing the need for protection with the need to avoid undue restrictions requires subjective policy decisions.

It is important not to lose sight of the need to consider potential cumulative, synergistic, and long-term effects. In addition, it should not be forgotten that in most developing (and many developed) countries, baseline information on marine mammals and underwater sound is far from adequate, and few, if any, monitoring programs are in place. One participant stated that, given that the shipping industry is the largest single source of sustained anthropogenic sound in the world's oceans, it should be the highest priority for management.

Differing views were expressed on seasonal or geographical restrictions. Some argued that there needs to be a solid scientific basis for such restrictions, with benefits to the animals clearly identified, and also that flexibility is needed to ensure that a sufficiently large window of time or space exists to allow needed work to take place. Others pointed to the importance of precautionary judgment in interpreting the scientific evidence. Similarly, although some participants expressed strong interest in investigating source-based mitigation strategies, others argued that reductions in sound levels currently being produced could have the unintended effect of greater sound production in the long run (e.g., needing more seismic surveys because of inefficient data collection). In any case, it was reiterated that "one size does not fit all" in the mitigation of impacts.

One participant suggested that risk assessment should be viewed as a means of organizing and ordering how we think about a problem. In some instances, the greatest uncertainties may be characteristics of the marine mammal population rather than the dose-response characteristics of the relevant sounds. Consideration of such factors can aid in setting priorities and developing management strategies.

There was some discussion of the idea that even if current mitigation measures are not proven to be effective for all species of concern, abandonment of those measures would be politically untenable. There is a need for careful evaluation of presently used mitigation protocols; certain measures may work for some species but not others, and certain other measures might be readily improved. Requirements for some mitigation may be justified as precautionary even if it cannot be shown conclusively to be effective. However, this must not preclude continued efforts to measure performance against intent. For example, it may not be possible to demonstrate that a particular

separation distance between an airgun and a whale is “safe” for the whale, but it should be possible to estimate, based on empirical research, the probability of detecting a whale visually within that distance. Such an estimate would help inform an evaluation of the overall effectiveness of this approach to mitigation, as well as efforts to fine tune or improve the approach.

VI. Topic 5: Cross-Boundary Issues and Multilateral Approaches

A. Transboundary Challenges of Addressing Ocean Noise: Several International Focusing Events

Elena McCarthy (Woods Hole Oceanographic Institution, U.S.) addressed the following questions:

- What types of problems arise from the international nature of the issue of acoustic impacts on marine mammals? How can the conflicts be addressed?
- How might international communication and cooperation be improved?

McCarthy introduced this topic with two illustrative case studies that she regards as "focusing events" (i.e., events that brought extensive attention to the issue). One involved the multiple strandings of Cuvier's beaked whales in Greece in 1996, coincident in time and space with NATO sonar deployments (Frantzis 1998). The other was the stranding of two Cuvier's beaked whales in the Gulf of California in 2002, coincident in time and space with seismic research by Columbia University's Lamont-Doherty Earth Observatory (Taylor et al. 2004; see also Richardson et al. poster 22 in Appendix 4). In the Greek event, the ship was owned by 16 NATO Member-States, had an Italian home port, and flew a German flag. Its sonar was owned by the U.S., and its operational area was within Greek waters. In the Gulf of California event, the researchers had received the necessary permits from Mexico, but were sued over whether they had obtained the appropriate authorizations under U.S. law. These examples highlight some of the transboundary challenges posed by anthropogenic sound in the marine environment. Those challenges include (a) jurisdictional and procedural confusion (e.g., regarding where and under what circumstances permits are required); (b) insufficient coordination and communication among government agencies, environmental groups, stranding networks, and other parties; and (c) regulatory inadequacies, often meaning a lack of standards or guidelines for the production of underwater sound. The cases also exemplify the difficulties of establishing cause and effect when the evidence is entirely circumstantial and the mechanism linking stimulus and response is unknown. The absence of an effective multilateral framework can lead to increased operational costs or shutdown, lawsuits, public mistrust, and damaged international relations.

During discussion, it was pointed out that, at least in the Mediterranean, considerable progress has been made since 1996. ACCOBAMS came into force in 2001, and since then stranding networks have been expanding in the region, as has awareness of the importance of rapid response to such events.

Owen speculated about what would happen if regulation of ocean noise developed in a piecemeal fashion. For example, might some researchers using high-intensity sound be tempted to undertake their research in the waters of coastal nations where the regulatory regime is less strict?

Disagreement was evident among workshop participants concerning the standard of evidence that should be met before links between sound exposure and particular impacts on marine mammals are accepted as existing. At one end of the range of opinion were those who believed

that a strong correlation should be sufficient. Others insisted that a mechanism of cause-and-effect (e.g., physiological, behavioral) must be established to explain the link.

B. Consequences of Cross-Boundary Contexts: Concurrent Small Group Discussions (Session 2)

Following the formal presentation, four small groups met to discuss and elaborate upon assigned subtopics. The intention was to elicit and record the range of opinion within each group, and not necessarily to seek consensus.

Group A – Differing regulatory frameworks (e.g., varying degrees of protection, differing mitigation strategies, high-seas activities, enforcement and permitting issues, "not in my backyard" phenomena)

This group's discussion focused on the following questions:

- How do regulations and operational strategies differ between countries and in international waters? For example, to what extent are critical habitats, protected areas, and endangered species and populations reflected in the respective regulatory frameworks? What is the significance of any differences?
- How does the regulation of naval sonar, seismic research, shipping, and other sound sources (e.g., moored vs. ship-based sources) differ? Why? How should sources be differentiated in regulations?
- What problems arise from different national and domestic regulatory regimes? How might such problems be addressed?

Facilitator: Suzanne Orenstein
Topic Specialists: Olaf Boebel and Wolfgang Dinter
Recorder: Colleen Corrigan

Discussions began with the identification of key differences in regulatory and operational strategies, as well as the consequences of differing regimes. Differences can be related to the legal regime, the activity or sound source, and the natural values to be protected. International treaties, regional agreements, and national or domestic laws can result in multiple, and even conflicting, commitments or requirements across jurisdictions at all levels. One example discussed was Germany's position regarding research conducted under the Antarctic Treaty System (see comments by Dinter above, page 10). There is also often a lack of clarity about which rules apply in a given region. For example, the U.S., U.K., and Australian navies apply domestic regulations except when operating in a country with stricter regulations, in which case they adhere to the stricter standards. Meanwhile, oil and gas companies comply with the laws of the country in which they are operating and, in some cases, the laws of the country funding a project or operation hold sway. The extent to which oil and gas companies and seismic operations are subject to home-country regulations or the regulations of the country in which they are working at a given time is not always clear. In addition, cross-jurisdictional problems may arise. For example, it is not unusual for sound sources to be operating (transmitting sound) in one jurisdiction (e.g., on the high seas) while the "receivers" of the sound (e.g., marine mammals) are in another (e.g., within a country's EEZ).

Different instruments at varying levels of jurisdiction or regulation often do not use consistent or standard terminology. For example, the terms *endangered*, *critical habitat*, and *depleted* have specific meanings under U.S. law, and these meanings cannot be transferred directly or unambiguously to other regulatory contexts. Various instruments such as the IUCN—World Conservation Union Red List (a non-regulatory classification system), the Convention on International Trade in Endangered Species of Fauna and Flora (CITES, 1973[58]), and the Convention on the Conservation of Migratory Species of Wild Animals (CMS or the Bonn Convention, 1979[59]) have their own unique categories and criteria for identifying species and populations at risk. These "listing" systems are not interchangeable.

Industry-based initiatives to produce non-regulatory operational guidelines are a responsible first step by industry to reduce or prevent impacts. For example, the International Association of Geophysical Contractors developed voluntary industry guidelines to mitigate seismic operators' interactions with marine mammals (IAGC, no date). IAGC's members represent approximately 70 percent of seismic vessels operating worldwide. The IAGC guidelines may be applied in the waters of countries that have no regulations concerning the potential impacts of their activities. There may be some confusion about the application and enforcement of industry-based initiatives in some cases (i.e., the extent to which operational guidelines constitute binding requirements or voluntary "best practices").

The group described a wide variety of problems associated with these differences in strategy:

- International teams of researchers and other user groups may face multiple, possibly conflicting, standards.
- Obtaining multiple research permits from multiple jurisdictions can be costly and time-consuming, making it a serious obstacle to project planning and implementation.
- Threatened populations and critical habitats in some regions or countries may be left with no form of protection.
- The definitions of terms (e.g., endangered species, critical habitat, and protected area) will likely continue to differ among jurisdictions, between regulatory or non-regulatory instruments, and according to different institutions (e.g., IUCN, CITES, CMS), resulting in confusion and inefficiency. Even *within* treaties and agreements, particular terms may end up meaning different things in different jurisdictions, depending how they are interpreted and implemented by domestic authorities. As a result, the standards of protection or regulation may differ.
- Enforcement and compliance may differ according to local capacities or commitments, leading to unpredictable requirements and inconsistent protective measures.
- With regard to marine sound, it is unclear what standards apply to the shipping industry. In general, shipping is regulated internationally (under the IMO and its Conventions) while compliance is monitored and enforced nationally (through implementation of Conventions by sovereign states). For example, ship construction must comply with the SOLAS Convention; the flag state certifies for compliance. Major structural inspections are required every five years, and minor inspections every two and a half years. Beyond the requirements established under IMO, internal shipboard conditions are regulated by

[58] See http://www.cites.org/.
[59] See http://www.cms.int.

the International Labor Organization (ILO[60]), a U.N. agency that seeks the promotion of internationally recognized human and labor rights. By minimizing shipping noise in accommodation areas and reducing vibration, ILO measures have the added benefit of reducing sound pressure levels beneath the hull. Port states are expected to exert control over construction, maintenance, and working conditions through inspections against a risk matrix that includes performance record, with failures targeted for further inspections. Thus the management of shipping is particularly complex.

- Sovereign national governments maintain authority to impose more stringent regulations than international treaties, meaning that some activities may by prohibited by national authorities even though they are allowed under a broader treaty or agreement.

A number of strategies to address problems associated with differences in domestic, regional, and international regulatory frameworks were discussed as follows:

- Standardization and expanded use of voluntary measures and guidelines (e.g., JNCC 2004, IAGC no date).
- Emphasizing convergence of interests between regulators and sound-producing entities. For example, ship owners with concerns about maintenance and fuel efficiency may see benefits of their own in designing quieter ships.
- Persuading sound producers of the need for action *before* definitive evidence is available (i.e., precautionary approaches) through outreach and education. For example, it might be useful to provide the shipping industry with persuasive (i.e., compelling) evidence of the risks to marine mammals from underwater sound. The industry then needs to be challenged to address design and construction issues, bearing in mind that there is a lag time of approximately four years from initial design to use in the trade. Proposed changes will have a better chance of adoption if they are cost-effective.
- Building the body of scientific evidence related to acoustic impacts. Monitoring ocean noise to characterize, quantify, and determine causes of increasing levels (as recommended by the U.S. National Research Council report in 2003) would help achieve this.
- Easing or eliminating barriers to research and facilitating permitting processes in order to improve efficiency and reduce confusion. This could involve the development and application of broadened or global standards or guidelines. It was suggested that programmatic or general environmental impact assessment could be useful, as could development of a global database of permit requirements in various regions. The Scientific Council on Oceanographic Research (SCOR[61]) was cited as providing a potential mechanism.
- Using existing international frameworks to increase consistency across jurisdictions, industries, and regions. One example might be incorporating necessary modifications to ship design and construction into the terms of the SOLAS Convention. This would require that consideration of acoustic effects and sound production standards be added explicitly to the SOLAS agenda. Another example might be using existing guidelines or agreements under UNCLOS as possible models. For example, the Code of Conduct for

[60] See http://www.ilo.org/public/english/about/index.htm.
[61] See http://www.jhu.edu/~scor/. SCOR was the first interdisciplinary body formed by the International Council for Science (ICSU). It is a non-governmental organization for the promotion and coordination of international oceanographic activities.

Responsible Fisheries (Code)[62] may provide a model for port-state control of vessel activities on the high seas. However, the Code has not been successful in eliminating the widespread problem of illegal, unregulated, and unreported (IUU) fisheries, in part because not all states are signatories and in part because all signatories are not equally rigorous in enforcement. Another possible model is the Straddling Fish Stocks and Highly Migratory Fish Stocks Agreement,[63] which seeks to manage and conserve entire populations or stocks in a holistic manner. A final example might be invoking the environmental management system of the International Organization for Standardization (ISO[64]) to address all sound sources through audit-based certification (i.e., demonstrating reduction in sound generation before being certified). This type of system is either in place or being implemented in the Australian and Canadian naval fleets (ISO 14001 standard). Although the entire U.S. fleet may be too large for immediate implementation, such a system could be applied to individual naval bases.

- Using regional seas agreements under which international standards are implemented by national regulations (e.g., CMS regional agreements like ASCOBANS AND ACCOBAMS).

Some participants considered it important to tailor permitting requirements and processes to different sound sources. Others expressed opinions favoring the idea that all sound sources should be treated similarly (i.e., "parity"). For example, some participants argued that activities producing "transient" sounds should be subject to less stringent regulation than those producing more chronic sound.

A distinction was drawn between performance-based and prescription-based regulation. In the former, the success of mitigation is judged by whether or not marine mammals are negatively affected. In the latter, success is measured by the degree to which sound outputs meet a set of prescribed norms.

A distinction was drawn between sound that is an incidental byproduct of the activity (e.g., ship propellers) and sound that is produced deliberately for a function (e.g., sonars). It was acknowledged that these two types of sound may require different regulatory approaches. Regulatory decisions should be made only after considering the characteristics of the sound.

The shipping industry has recently become subject to international regulation with regard to chemical pollution, anti-fouling agents, and ballast water. Once shippers are convinced that mitigation measures are needed for sound reduction, they can be expected to move ahead with development and implementation. However, in the absence of firm scientific evidence of a significant impact on marine mammals from increased ambient noise in the oceans (e.g., temporary or permanent threshold shifts in hearing, masking of communications), some in the shipping industry will continue to question whether its activities should be regulated or its operations should change with regard to sound production.

[62] See http://www.fao.org/fi/agreem/codecond/codecon.asp.
[63] See http://www.un.org/Depts/los/convention_agreements/convention_overview_fish_stocks.htm.
[64] See http://www.iso.org/iso/en/ISOOnline.frontpage.

Group B – Multilateral agreements (e.g., applications of existing international law; enforcement issues, future actions)

This group discussed the following questions:

- What existing multilateral agreements could be used to address the impacts of sound on marine mammals? Have any actions been taken that are specifically directed at underwater sound or at acoustic impacts on marine mammals?
- What international authorities or institutions should be involved in policy decisions related to this issue? What entities are currently involved in discussions of sound in the oceans?
- What types of future regulatory or non-regulatory actions can or should be considered to address this issue?
- How might concerns about international enforcement be addressed?

Facilitator: Zoë Crutchfield
Topic Specialists: Monica Borobia and Giuseppe Notarbartolo di Sciara
Recorder: Randall Reeves

Differing views exist among legal experts regarding the interpretation of multilateral agreements and international law for the management of sound: strict and narrow interpretation versus flexible and broad. The 1969 Vienna Convention on the Law of Treaties[65] calls for interpretation of instruments in good faith based on ordinary meanings and the original intent of the parties. Further, it states that signatories cannot be bound by provisions when they did not intend to be. Some legal experts consider UNCLOS an example in which the terms "pollution" and "energy" were clearly intended, based on the negotiating history, to mean something other than sound. Other experts point out that UNCLOS was intended to be a comprehensive treaty for the oceans, and therefore it should be interpreted in a flexible manner and sound should be included within the ordinary meaning of "pollution" and "energy." Moreover, UNCLOS explicitly refers to the conservation of whales, and it can therefore be seen as providing a framework for their protection (and that of other marine mammals) from threats that include underwater sound. In general, the group agreed that UNCLOS, given its comprehensive scope, is likely to be the framework treaty most relevant to management of sound in the marine environment and noted that it could feasibly be amended, but recognized the magnitude of such a process. The group also urged that the United States ratify UNCLOS.

As a starting point for discussion, the group attempted to develop a non-exhaustive list of multilateral instruments that might be used to address the effects of sound on marine mammals:

- Marine mammal conservation instruments and institutions that explicitly refer to the issue of anthropogenic sound:
  - ASCOBANS (1992, Baltic and North Seas and, more recently, the north-east Atlantic), which deals with small cetaceans, includes a preamble containing reference to noise disturbance and explicitly refers to "prevention of other significant disturbance, especially of an acoustic nature" in its annex (see discussion under VI.A. European Seas)

[65] See http://www.un.org/law/ilc/texts/treaties.htm.

  - ACCOBAMS (1996, Black Sea, Mediterranean Sea and contiguous Atlantic area), which prohibits "any kind of cetacean harassment," does not explicitly mention human-generated sound, but is working toward a resolution that would do so. [66]
  - The ICRW (1946), which established the IWC and has as a primary goal the conservation of whale stocks, is a global instrument that applies to some large cetaceans but is unlikely to develop a major role in this issue because of its narrow scope. The Convention itself does not explicitly mention human-generated sound, but recent non-binding whale-watching guidelines specifically mention noise disturbance, and a 2004 resolution on western gray whales refers to noise disturbance from oil and gas industry-related activities.
- Conservation instruments and institutions that have referred to the issue of anthropogenic sound but do not deal with marine mammals explicitly:
  - SOLAS (1974) deals with ship design, construction, and equipment, including aspects related to sound production.
  - The Convention on Transboundary Environmental Impact Assessment (Espoo Convention, 1991[67]) applies to the transboundary maritime context and includes the Protocol on Strategic Environmental Assessment (2003);
  - The Particularly Sensitive Sea Areas (PSSA) provision under MARPOL and the IMO is a global scheme that mentions noise. To apply the PSSA concept, a companion legal instrument for the associated protective measure would be needed.
  - The Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention, 1992), a regional agreement that deals with conservation of the Baltic Sea area, contains reference to human-generated sound in Article 9 relating to pleasure craft.
  - The Declaration on Protection of the Arctic Environment's Arctic Environmental Protection Strategy (1991) is a "soft law" regional agreement that includes sound as one of six environmental concerns.
- Five instruments that include a general obligation to prevent pollution or conserve biodiversity[68] and are sufficiently broad in their current form as to apply to sound-producing activities:
  - UNCLOS (1982) is a global framework instrument that includes biodiversity conservation and pollution prevention obligations.
  - CBD (1992) is a global instrument that includes biodiversity obligations, EIA provisions, obligations to protect special habitats, and the Jakarta Mandate on Coastal and Marine Biological Diversity (Jakarta Mandate[69]), which addresses the sustainable use of marine resources;
  - CMS (1979) is an instrument that is global in scope and includes annexes on cetaceans, sirenians, and pinnipeds and a resolution on wind farms;

[66] After this workshop's conclusion, the ACCOBAMS Meeting of Parties in Palma de Mallorca, Spain passed a resolution (MoP2, Resolution 2.16) on anthropogenic ocean noise.
[67] See http://www.unece.org/env/eia/eia.htm.
[68] See the Joint Web Site of the Biodiversity Related Conventions, http://www.biodiv.org/convention/partners-websites.asp.
[69] See http://www.biodiv.org/programmes/areas/marine/default.asp.

    - OSPAR (1992) is a regional convention that defines pollution similarly to UNCLOS and has biodiversity provisions, some of which include specific protocols on biodiversity and on offshore oil and gas development.
    - The Barcelona Convention (1976, amended 1995) is a regional convention that defines pollution similarly to UNCLOS and has biodiversity provisions, some of which include specific protocols on biodiversity and on offshore oil and gas development.
- Instruments and institutions that are potentially applicable to the management of sound but that would require amendment:
    - MARPOL currently applies to "substances" but includes strategies that are appropriate for interpretation that encompasses sound.
    - IMO could develop a convention to deal with the issue of human-generated sound as it did for the issues of ballast water and anti-fouling substances.

Although it was noted that NATO had taken action to mitigate the impacts of naval activities by member countries, the group did not discuss it in detail.

The group identified a number of international actions have been taken that specifically relate to sound:

- ASCOBANS has adopted ten resolutions related to sound, calling for applied research and the development of guidelines. ASCOBANS has developed guidelines for seismic operations, recreational boating, and whale-watching, and will begin a program related to sound-producing military activities in 2005. There has also been some discussion of shipping, with research recommended.
- IWC has produced non-binding whale-watching guidelines that specifically mention noise disturbance, and a 2004 IWC resolution on disturbance of gray whales near Sakhalin Island, Russia, refers to noise disturbance from seismic surveys and other oil and gas industry-related activities.
- CMS has adopted a non-binding resolution on wind farm noise.
- The Offshore Protocol[70] of the Barcelona Convention states that all activities, including seismic surveys, in the Protocol Area are subject to review. By implication, this refers to the potential for disturbance from anthropogenic sound.

In addition, the U.N. Straddling Fish Stocks and Highly Migratory Fish Stocks Agreement introduced the concept of supplementing flag-state control by allowing third parties to board and inspect a fishing vessel suspected to be in violation. This may serve as a useful precedent.

The group identified a number of entities and institutions that are, or should be, involved in policy discussions of the sound issue:

- UNICPOLOS, which addresses only two issues per year. Underwater sound has not yet found its way onto the agenda (although a joint presentation on the issue has already been made by the Ocean Institute, Natural Resources Defense Council, and Silent Oceans). If

[70] Protocol for the Protection of the Mediterranean Sea against Pollution Resulting from Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil, 1994; not yet in force. See http://www.greenyearbook.org/agree/mar-env/barcelona.htm.

it proves impossible to get sound on the UNICPOLOS agenda, the issue could possibly be addressed instead through the U.N. General Assembly.
- The Jakarta Mandate of CBD, with its references to conservation of critical habitat.
- IMO, for universal guidelines on ship construction.
- OSPAR, whose competence concerns "noxious substances." Annex 5 is especially relevant. Parties are supposed to consider all of pollution, thus potentially including sound. OSPAR has already expressed interest in the issue.
- Regional fishery organizations, with a concern for conservation of fish stocks that could extend to interest in the effects of sound on those species.
- Scientific expert groups such as the Intergovernmental Oceanographic Commission (IOC[71]) of the United Nations Educational, Scientific and Cultural Organization (UNESCO[72]), GESAMP, Global Assessment of the State of the Marine Environment[73] (coordinated by UNEP), and IUCN.
- Defense treaty organizations such as NATO.
- Various other governmental and intergovernmental fora including (but are not limited to) the International Seabed Authority,[74] UNEP, Antarctic Treaty Consultative Meetings,[75] North American Commission for Environmental Cooperation[76] under the North American Free Trade Agreement (NAFTA[77]), Asia Pacific Economic Cooperation (APEC,[78] which has marine environment and fisheries working groups), European Union,[79] Council of Europe,[80] and Arctic Council.[81]
- Nongovernmental organizations representing environmental or industry interests (e.g., whale watching, oil and gas, shipping).

Avenues for implementing future regulatory or non-regulatory actions include creating one or more new treaties, and amending or reinterpreting existing instruments, regional agreements, and national laws. Various approaches that might facilitate such actions include the following:
- Adopting guidelines or regulations through the IMO. Port states could prohibit entry and docking by vessels that do not meet those guidelines. However, this could have the effect of shifting the problem to areas with less stringent controls, with no net benefit for conservation (e.g., the requirement for double-hulled tankers).
- Increasing efforts by the international ocean monitoring community to place more hydrophones in the water and provide better baseline data on ambient noise.
- Building on opportunities for cooperative action to refine mitigation methods and encourage compliance provided by the fact that some stakeholders (e.g., the seismic

[71] See http://ioc.unesco.org/iocweb/index.php.
[72] See http://www.unesco.org.
[73] See http://www.unep.org/DEWA/water/MarineAssessment/.
[74] See http://www.isa.org.jm/.
[75] See http://www.scar.org/treaty/meetinglist.html.
[76] See http://www.cec.org/home/index.cfm?varlan=english.
[77] See http://www.nafta-sec-alena.org/DefaultSite/index.html.
[78] See http://www.apecsec.org.sg/apec.html.
[79] After this workshop's conclusion, the European Parliament passed a resolution on the environmental effects of high intensity active naval sonars. (European Parliament Resolution on the environmental effects of high-intensity active naval sonars, PE 347.527. Oct. 28, 2004.)
[80] See http://www.coe.int/DefaultEN.asp.
[81] See http://www.arctic-council.org/.

industry, the military) are already engaged in mitigation efforts. Partnership arrangements involving nongovernmental organizations, government agencies, and industry can provide training, workshops, and other "capacity-building" opportunities.

- Preparing and circulating information papers in international fora (e.g., the IMO, UNICPOLOS, meetings or conferences of the parties of relevant instruments noted above).
- Passing resolutions in appropriate organizations.
- Developing the "green ships" initiative within the shipping industry.
- Inserting underwater noise guidelines into the approval criteria on projects funded by institutions such as the World Bank[82] and the Global Environmental Facility.[83]
- Further developing voluntary initiatives and refining guidelines or codes of conducts within sound-generating industries (e.g., research, oil and gas development).
- Standardizing regular reporting as a key to ensuring compliance (although reporting obligations themselves often are not met).
- Using dispute resolution mechanisms to encourage compliance. This may work in some cases, but some disputes are nevertheless likely to drag on for long periods of time without resolution.
- Establishing a clearinghouse, or central repository of information, on the known and potential effects of sound on marine mammals. This may facilitate awareness raising, exchange of experiences, and the incorporation of sound into environmental impact assessments at the national or regional level.

Actions to mitigate the effects of underwater sound can range from guidelines and codes of conduct to binding treaties. As a general principle, the broader the geographical scope of a measure, the higher the threshold of proof needed to justify regulation. In other words, a globally binding measure would probably need to be buttressed by conclusive evidence of cause and effect. There is some disagreement about the conclusiveness of scientific information currently available on the effects of sound on marine mammals.

Participants differed on the question of whether a given action should be binding (regulations) or non-binding (guidelines, hortatory resolutions). Views sometimes even differ within an industry or interest group. For example, in the shipping industry, American shippers may prefer globally binding regulations, but the U.S. merchant marine is relatively small and does not have decisive influence on the industry overall. The shipping industry may prefer guidelines or codes of conduct (e.g., industry-developed voluntary measures) rather than regulations.

A distinction was made between enforcement (which can accompany regulations and implies liability) and compliance (which is essentially voluntary in the case of non-binding guidelines). Compliance is difficult to monitor in the case of activities at sea, but relatively easy to monitor in the shipping industry through port-state inspections. A need that can arise in enforcement proceedings is for an ability to specify sound sources (i.e., acoustic "fingerprints"). In instances where treaty measures have no threat of penalties, chastising mechanisms may exist to provide incentives to comply. It is crucial that the standards of compliance be clearly stated.

[82] See http://www.worldbank.org/.
[83] See http://www.gefweb.org.

As involved parties become more comfortable with guidelines and convinced of their utility, these may become recommended (and even implemented) practices and procedures. As a result, states may become more willing to sign treaties and thus entrench the guidelines as binding measures. Some non-binding measures (e.g., guidelines, capacity building, information dissemination) can be pursued alongside regulations to make them better understood and more widely accepted.

In the short term, when it comes to multilateral agreements and international law, regional agreements probably offer more feasible options for addressing underwater sound than international instruments because they tend to be more specific to a region's biological characteristics, socioeconomic realities, and implementation capacities.

The proliferation of environmental treaties and agreements since the Earth Summit in Rio de Janeiro in 1992,[84] and indeed since the Stockholm Conference in 1972,[85] has led to "agreement fatigue," a reluctance of some countries to sign onto more instruments and an insistence on improved implementation of those that exist. In some instances, resource limitations are a serious obstacle to further development of international or even regional legal instruments.

Group C – Marine mammal research coordination (e.g., setting priorities among research agendas, stranding response programs, permits)

This group focused on the following questions:

- How can information from around the world be incorporated in the policy-making process at national, regional, and international levels?
- What are the challenges to marine mammal research coordination, and what problems arise from a lack of such coordination?
- How could scientists better inform policy-makers on issues related to marine mammals and sound? What challenges does the scientific community face? What challenges do policy-makers face?

Facilitator: Lee Langstaff
Topic Specialists: Mardi Hastings, Bill Perrin, and Lorenzo Rojas-Bracho
Recorder: Eunice Pinn

Scientists and policy-makers often fail to understand each other's language and needs, resulting in mutual incomprehension and, sometimes, mistrust. If science is to be used optimally to inform policies and laws, scientific findings and their limitations need to be interpreted accurately into non-technical terms and communicated effectively to policy-makers. For their part, policy-makers need to be receptive to scientific input and avoid the temptation to ignore or knowingly misinterpret it. Science-based policy tends to be difficult to formulate and implement, even in the best of circumstances.

[84] See http://www.un.org/geninfo/bp/enviro.html.
[85] See http://www.unep.org/Documents/Default.asp?DocumentID=97.

The group identified several challenges to communication and coordination between scientists and policy-makers, as follows:

- Scientists' involvement in policy-making can impinge on scientific objectivity.
- The results of hypothesis-driven science are not always easy to match with the types of questions asked by policy-makers and managers.
- Honest answers to scientific questions include descriptions of the associated uncertainties, while policy-makers often expect, and sometimes need, unqualified advice from scientists.
- The timescales of science and policy are often mismatched, as many scientific questions require long-term studies for definitive answers, while policy decisions often need to be made quickly.
- Scientific pronouncements can have serious implications for policy if misused, misinterpreted, or taken out of context. Conversely, good science, properly interpreted and communicated, can have a positive influence on policy. Scientists need to be aware of the weight given to their statements and qualify what they say accordingly.
- Scientists are often dismayed by the loss of precision and accuracy that occurs when scientific concepts are translated into non-technical terms and conveyed to a non-technical audience.
- The general state of "information overload" makes it increasingly difficult to transmit non-sensationalist messages to a wide audience. Competition for reader, viewer, or listener attention prompts media to release information prematurely and to opt for sensational, rather than considered and balanced, reporting.
- Misunderstandings often arise as a result of the lack of standardized methods, units, and terminologies, even among scientists.
- Scientific research is intrinsically a "bottom-up," or curiosity-driven, process, but most funding is made available on a "top-down" basis, through contracts and grants to seek answers to specific questions. The results of such work are often viewed with suspicion and considered biased toward the sponsor's desired outcome, even when safeguards against conflict of interest are in place.
- Access to scientific expertise is not uniform around the world, and is affected by geography, politics, and economics. Language barriers and shortages of technically trained people make it difficult in some regions and countries to inform and shape public policy with scientific knowledge.
- Scientific literature (e.g., technical journals) is often expensive to obtain, and it cannot be assumed that just because a study is published, it is widely available to policy-makers.
- In many countries and regions, marine mammal conservation is not a priority; it may not even be on the policy agenda. Concerned scientists may thus face barriers as they attempt to influence policy decisions.
- Military and industrial sound producers are often reluctant, unwilling, or unable to provide key information on their activities. Even when they are willing to release information, the onus may remain on researchers to formulate their requests in particular ways to elicit all of the relevant data.
- Policy-makers usually need to be responsive to a variety of stakeholders, and the scientific community is seen as only one of several stakeholder groups. Thus "scientific opinion" may be given no more weight than that of other groups.

- Staff turnover in government agencies or industry offices can result in the loss of institutional memory and make it difficult for other stakeholders to keep track of whom to contact concerning particular issues.

Coordination of research is always a challenge, but is necessary to avoid duplication of effort and increase the chances of consistency and completeness of information on national, regional, and international scales. Specific challenges to coordination and cooperation include the following:

- Difficulty of identifying common objectives, given the volatility of national priorities and frequent non-transparency or ambiguity of agendas.
- The fact that permitting processes may differ between countries, and multiple permit requirements can add time and expense to collaborative projects. Further, procedures for obtaining permits may change, leading to further delays and confusion.
- Language, cultural, and other differences among researchers from different countries, contexts, or disciplines.
- Lack of standardized methods, units, and terminologies.
- The fact that in most countries and regions, marine mammal conservation is not a priority.
- The tendency of existing international collaborations to involve the same core group of countries or individuals, which reinforces imbalance in scientific and technical capacity.
- Lack of access to key information from certain types of sources (e.g., the military, industries).

The group was not able to identify and agree on specific ways to overcome these challenges, but noted that SCOR might provide a mechanism to improve coordination and facilitate international collaborations.

A number of possible mechanisms for improving the linkages of science to policy and law were identified, as follows:

- Professional organizations, including nongovernmental organizations, can use science-based position papers and press releases to influence and drive the policy process.
- Just as policy-makers need to better understand the positive potential and limitations of science, scientists need to become better acquainted with the policy process and thus with the needs and constraints faced by policy-makers. In fact, project designs and methods can sometimes be selected or shaped to increase the likelihood that the findings will meet the needs of policy-makers. Medical science and some other sciences may provide useful models of this process.
- Scientific advice should clearly delineate options for action and describe the probable consequences for each option.
- Interim or intermediate reporting of research results may facilitate timely policy decisions. However, policies then need to be flexible and adaptive to allow adjustments when final results become available.
- In the U.K., policy-makers refer specific questions to groups of scientific specialists, often without revealing the motives behind the questions. This is a slow and protracted process but generally successful.
- Professional science communicators can play an important role in translation between technical and non-technical audiences.

- Scientific advisory support to policy-makers, whether through staff positions for scientists or standing advisory boards (e.g., the Marine Mammal Commission's Committee of Scientific Advisors), can help ensure that scientific information is conveyed to policy-makers in a timely, accurate, and understandable fashion.
- Articles or commentaries by scientists (or professional science communicators) in major newspapers and news magazines can be an efficient way of disseminating key information.
- Better use can be made of the Internet (e.g., the MARMAM e-mail list server,[86] electronic access to journals) to achieve centralized information sharing.
- Transference of scientific knowledge and advice across international boundaries may be accomplished through internships or scientific extension/exchange programs.
- Provision of non-English abstracts in relevant languages by scientific journals and other publications is a relatively easy way of increasing and expanding access to scientific information.
- International bodies such as ASCOBANS and ACCOBAMS facilitate exchange of information among national representatives, scientists, and nongovernmental organizations. In that regard, these agreements might provide models for other regions.
- Programs initiated and sponsored by professional organizations can help offset the technically disadvantaged positions of some regions or countries (e.g., by providing scholarships and fellowships, offering free or subsidized memberships, and funding attendance at international meetings and conferences). Professional organizations can facilitate courses and training workshops to help build capacity in those regions or countries.
- The IOC has employed a capacity-building specialist to provide a strategic review of data exchange and ocean research funded by the IOC. Comments on this review have been requested from the 129 member countries.
- Any effort to standardize methods, units, and terminologies can be expected to improve communications between scientists and policy- and lawmakers. Standardization, however, should not be allowed to stifle originality and prevent the development of improved methods.
- One way of addressing the problem of bias (perceived or real) in sponsored research is to establish independent scientific panels to review such work.
- As a way of enhancing the quality of scientific analyses and facilitating access to the results, some programs require researchers to publish their findings in peer-reviewed journals as a condition of funding. Project budgets need to be adjusted accordingly to make this feasible.
- Some journals have a mechanism for making full data sets that underlie a published study available electronically to anyone interested in conducting further analyses. Making "raw" data available in this way, with due consideration for the proprietary interests of those who designed and conducted the original study, can improve credibility and encourage scientific discourse.

[86] See http://whitelab.biology.dal.ca/marmam.htm.

Group D – Improving Regulatory Capacity (e.g., strategies to enhance abilities of governments to create, implement, and enforce laws and regulations concerning underwater sound)

Facilitator: Erin Vos
Topic Specialists: Michael Jasny and Mark Tasker
Recorder: Victoria Copley
This group discussed the following questions:

- What are the greatest needs of countries seeking to improve their ability to deal with the impacts of anthropogenic sound on marine mammals? What are the greatest needs in dealing with these impacts internationally?
- What can be done to improve various national or domestic management and regulatory regimes?
- What can be done to improve international or multilateral management and regulatory regimes?

The group began by focusing on what is needed to improve regulatory capacity at the national level. Although the nature and level of needs vary widely from country to country, all require additional political will and better technical, scientific, and management capacity to address sound-related issues. Countries with no suitable management regime may desire one but lack the necessary institutional capacity and resources. In some cases, countries with no management regime may have little or no interest in developing one (e.g., due to suppression, resistance, corruption, or prioritization of other issues). Few, if any, countries that do have management regimes in place have sufficient capacity to address the sound issue in a comprehensive manner. Six major categories of need apply to all countries, especially in the developing world. For each category, several tools and actions were identified that could improve management and regulatory regimes, as described below.

1. At the national level, there is a need for *greater institutional capacity for policy development, oversight, and enforcement*. National administrations need to build expertise in science and policy. For example, mechanisms to provide funding for students might help increase the number of individuals trained to work on sound issues, and job-swap, secondment, or partnership programs could facilitate the transfer of relevant skills and knowledge across governments and institutions. In addition, training programs could be created, or specific topics could be built into existing courses. Such efforts in skill development and sensitization to the sound issue must be accompanied by the creation of outlets for the use of those skills and opportunities to express any heightened awareness. Otherwise, they are likely to cause frustration and disillusionment. National and regional meetings and regular interdisciplinary conferences could help create communication networks and enhance public awareness. These, in turn, could be expected to reduce institutional fragmentation and build political will.
2. The *development of incentives to comply with existing laws and guidelines and to reduce sound production voluntarily* is another area of need at the national level. In general, incentives can be produced by addressing multiple societal values concurrently, considering both conservation and socioeconomic goals. Solutions to sound-related issues may be linked to solutions to other conservation problems, as

well as to economic benefits. It is important to make solutions attractive, or at least tolerable, to user groups (i.e., those that introduce sound into the marine environment). For example, some sound-producing industries may see public relations benefits in developing more environment-friendly practices (e.g., "quiet" cruise ships). Such groups can capitalize on consumer choices in cases where a well-educated or conservation-minded public exists. Financial incentives may be created through tax relief programs and subsidies. It may also be possible to create government markets for new "quieting" technologies. Education and increased public awareness play a key role in creating and communicating incentives for sound reductions.

3. There is a need for more *effective and efficient mitigation and monitoring options that are affordable in a national context*. Long-term approaches to mitigation can produce economies of scale and thereby improve efficiency, while short-term approaches that focus on "low-hanging fruit" (i.e., issues that are relatively easy to address) may also be worth pursuing. It is important to maintain flexibility and creativity as protocols are being developed, as this will maximize effectiveness while avoiding unnecessary expenditures or efforts. For example, seasonal restrictions are best applied in a manner that reflects the dynamics of the natural systems involved. Cumulative impacts (a concept often overlooked in mitigation schemes) should be addressed by placing various types of sound exposure into a wider context of animal health, reproduction, and survival. Coordination of mitigation efforts through a single "gatekeeper" entity (e.g., to complete strategic cumulative impact assessments and to develop ambient noise budgets) may improve coordination and transparency.
4. National regulatory capacity can be improved by *better communication and coordination, heightened awareness about sound-related issues, and education and information-sharing efforts*. For example, central clearinghouses can make information widely available, educational materials can aid policy-makers, and intergovernmental strategy-sharing can enhance management efforts. The development of public awareness and political will may require a stronger conservation ethic (e.g., a shift in cultural values). In all efforts, culturally sensitive approaches that make concerns relevant to the affected parties are likely to be more effective and sustainable. For example, it may be more effective to address the impacts of underwater sound on marine mammals through integration with existing programs to conserve sea turtles in the Caribbean, rather than by creating new, entirely separate marine mammal initiatives in that region. An understanding of local culture is vitally important in effective management.
5. *Capacity for oversight, enforcement, and compliance* is important at both national and international levels. In some cases, enforcement is complicated by a lack of clarity in existing laws or guidelines (e.g., legal definitions of harassment). Where existing regulations can be clarified, it may be useful to standardize these and broaden their application. Barriers to ratification and implementation of legal measures may need to be addressed to allow this. There is a general need to develop competency in authorities charged with implementing existing laws. Financial and human resources often limit government capacity. In such cases, education and training programs may help. There is also a need to enhance compliance where laws or guidelines exist. Both incentives ("carrots," e.g., financial rewards; see additional discussion above) and consequences or threats ("sticks," e.g., procedural or criminal litigation, financial

penalties) should be employed when appropriate. Stronger monitoring and reporting requirements may also help, and monitoring by citizen groups and other users can enhance enforcement capacity. User groups themselves may be more inclined to comply if they have a clear understanding of the problem. Stakeholder participation in policy development and management, as well as education and other efforts to build political will, can also help. Finally, many believe that sound-producing operators working abroad have an obligation to adhere to their own country's standards when these are more stringent than those of the host country.

6. Finally, a need at both national and international levels is to *clarify jurisdictional issues and delineate responsibilities between and within governments*. For example, some low-frequency sounds propagate many hundreds of miles and cross multiple jurisdictional boundaries, but the relevant authorities and institutions often lack the capacity to coordinate and cooperate in management. Source-specific and region-centered research, as well as improved dissemination of information, may improve understanding of sound propagation and clarify to managers what types and levels of sound are "significant." Integrated approaches to management and law (e.g., a single national agency to address marine issues) can improve coordination and communication and streamline management processes. It is also important to improve understanding of the laws that determine jurisdictional boundaries, clarifying ambiguities and educating stakeholders.

In addition to the two national/international issues discussed above (numbers 5 and 6), the group identified five categories of actions and tools to improve regulatory capacity at the international level, as described below.

1. There is a need to *develop multilateral instruments and guidelines* to deal with the issue of sound and marine mammals. It may be possible to use existing legal regimes and frameworks to do so (e.g., by expanding existing conventions and agreements to incorporate sound or encouraging additional governments to join). Sound can and should be considered an aspect of habitat quality and therefore merits consideration in ecosystem approaches to management. Sound should be explicitly included in international guidelines and agreements.
2. Another area for improvement is in the *use of experience and knowledge to shape and inform best practices in permitting, mitigation, or other aspects of management*. For example, the JNCC's guidelines for seismic operations, existing industry-defined standards, or sets of standards developed in other jurisdictions might be applied more widely. Improved dissemination of information, job swaps, secondment programs, and model programs also may help.
3. *Broad stakeholder participation* is another key to improving international regulatory capacity. A variety of formal and informal processes might be employed to achieve this throughout all phases of policy-making and management.
4. *Better liability and enforcement mechanisms in existing international law* are desirable. These might require statutory changes or legal challenges leading to judicial interpretations.
5. Finally, *international use of monitoring and adaptive management* would enhance regulatory capacity.

C. Small Group Reporting and Plenary Discussion

One participant urged others not to assume anthropogenic sound is a threat to marine mammals without more compelling scientific evidence. Citing the recent U.S. Commission on Ocean Policy's report as confirmation that marine resources should be available for multiple uses,[87] he pointed out that off California, where low-frequency sound levels have increased by 10 dB over the last 40 years, gray whale populations also have increased. Most notably, the eastern North Pacific population of gray whales is believed to have recovered to a level close to carrying capacity, despite the documented increase in ambient noise. Another participant elaborated on this point, suggesting that even if one accepts that anthropogenic sound is a problem, the resources committed to address it may be currently misallocated. In other words, relative to other threats (e.g., bycatch in fisheries), is it appropriate to force the industry to spend such large sums on the sound issue?

Several participants expressed disappointment that the very existence of a problem is still a matter of debate. They suggested it was simplistic to infer from the evidence of population increase for some marine mammal populations that exposure to anthropogenic sound poses no threat. If the best available scientific opinion indicates that there is a problem, a precautionary approach would be to accept the need for corrective action (mitigation) while at the same time pursuing focused research to improve understanding of the nature and magnitude of the problem.

Common themes from the group reports and ensuing discussion included that (a) both short- and long-term goals and objectives need to be defined and clearly articulated; (b) outreach and education should begin immediately; (c) management of sound should be tailored appropriately to the type of activity involved, and (d) given that the shipping industry has its own economic (energy-conservation) reasons to move toward quieter ships, there may be opportunities for cooperative action.

Table 2 (see page 72) provides a summary of multilateral agreements mentioned in the workshop proceedings. No attempt has been made to analyze the information as it was presented during the workshop.

[87] See http://www.oceancommission.gov/.

VII. Synthesis, Summary, and Future Directions

Mark Tasker provided a personal synthesis to initiate the workshop's final plenary discussion. His presentation is summarized below.

The overall goal of policy is to reduce and further control anthropogenic sound in the world's oceans. The greatest concern is loud low- and mid-frequency sound, the most significant sources of which are shipping, seismic survey operations, and military sonar.

Views differ concerning the relative and absolute significance of sound as a risk factor for marine mammals. Some participants likened the current debate on this issue to the early stages of the controversy over global warming. It is important, however, to continue to seek greater agreement on the environmental effects of underwater sound because any action to manage sound will cost resources. Given that resources are limited, any allocation to address one sound source could have implications for the amount available to address others. Thus, to some extent at least, attention and investment devoted to the sound issue may divert resources away from other conservation issues. At all stages, it is important that cultural choice be respected.

As highlighted in the seven case studies of efforts made in various jurisdictions (Section VI), several challenges must be overcome to regulate ocean sound, including the following:

- The issue was not viewed as significant until recently and even now some stakeholders question its importance.
- Few existing laws or multilateral legal instruments explicitly address the issue, and none focus on it.
- Underwater sound cannot easily be constrained within the borders of countries or other jurisdictional units, so it is by nature transboundary.
- Many nations and a wide variety of stakeholders (shipping industry, oil and gas industry, research community, military, etc.), all with differing priorities, contribute to anthropogenic sound in the oceans.

Rapidly growing awareness of the problem of sound and marine mammals on the part of those involved in sound-generating activities creates opportunities for action. It may be possible in the near future to build on the following:

- The military has sophisticated technological capabilities and financial resources.
- The seismic survey industry has been developing guidelines for mitigation.
- The shipping industry is awakening to the need to address this problem.
- Treaties exist to control and reduce marine pollution, potentially including sound.
- Laws and conventions exist for nature conservation, with some potential for regulating sound.

A number of "next steps" were identified during the workshop. For mitigation, some techniques (e.g., geographical or temporal shifts in sound production to accommodate marine mammal needs) are effective in reducing and preventing impacts. A better understanding of other techniques is needed. For education and outreach, materials and campaigns need to be carefully crafted and culturally sensitive, and public input is therefore essential. The primary aim should be to ensure that the issue is widely debated and placed on relevant agendas. Educational efforts

need to be grounded in accurate reporting, with uncertainties explicitly acknowledged. In research, there needs to be a balance of top-down and bottom-up approaches.

Various user groups are at different stages. Tasker believes that the military has made good progress but needs to be more transparent. The seismic industry has guidelines, but those may need to be open for comments and modification (e.g., those in the U.K. are posted on a website for input from interested parties). Industry should be encouraged to continue development and testing of mitigation approaches (noting the considerable investment that has already been made). The shipping industry and ship designers should be challenged to develop quieter technology.

In terms of legal frameworks, it is necessary to consider scale and transboundary aspects. In general, it will be necessary to choose between prescriptive and performance-based models, but the latter is preferable. It was agreed that sound should be incorporated as an element to be considered in environmental impact assessments.

Internationally, the creation of a new treaty on sound and marine mammals would be hard to deliver. Acceptable risk is a cultural choice, and thus universality may be difficult to achieve. However, numerous treaties and other instruments are available, UNICPOLOS offers a way into the U.N. system, and useful lessons may be learned from the climate change debate.

Following Tasker's synthesis, additional points were made by other participants:

- Opportunities exist (e.g., in the shipping industry) to take advantage of the convergence in interests between the sound producers, who for economic reasons want to make vessels quieter, and those who are pushing for regulation and reduction of anthropogenic sound in the oceans.
- Mid-frequency sound (e.g., that of some military sonars) is as much of a concern for marine mammals as low-frequency sound. Regulatory attention needs to be given to both frequency and intensity of sound.
- Source-based mitigation is at least as effective as time/area shifts in operations, and more investment is needed in research and development directed at source modification.
- The necessary research and development for effective mitigation will take considerable time; in the meantime, precautionary management measures are warranted.

In considering what should happen next, participants made the following suggestions:

- With regard to the shipping industry, a compelling case needs to be made that ship noise has adverse effects on marine mammals. The industry must then be challenged to address the problem. The SOLAS convention provides a possible route of access for influencing the shipping industry to move toward quieter operations.
- It is important to distinguish between short- and long-term goals, and to pursue them in tandem.
- Outreach and education should be pursued via information papers circulated in appropriate fora.
- From the perspective of the seismic industry, it was noted that (a) internal educational programs are ongoing; (b) seismic survey vessels provide platforms for obtaining scientifically relevant data (effort and sighting report forms, including periods in non-

operational mode); (c) most future production of oil and gas will come from countries in which government-owned companies predominate, and as a rule, these companies are less environmentally responsible than companies that are publicly owned and accountable for their actions; (d) the idea of systematically soliciting public input and vetting the IAGC guidelines (per the U.K. example) would be welcomed by the industry; and (e) references to the potential effects of seismic activities that appear in educational and outreach materials must be accurate and include appropriate reference to scientific uncertainties.

- U.S. naval forces are investing substantially in research, and a Navy representative encouraged non-military researchers to contribute to naval priorities, especially modeling.
- Nongovernmental organizations (a) expressed their interest in and commitment to further awareness and education on this issue; (b) emphasized the value of a participatory framework in which NGOs work cooperatively with government agencies, regional bodies, and industries to improve mitigation efforts (e.g., guidelines); and (c) characterized their failure to engage in a broad inter-NGO dialogue as a glaring omission in their strategy on ocean sound to date.
- Scientists involved in acoustics research in the marine environment indicated that they wish to (a) establish scientific priorities for sound-generating research, (b) diversify the funding base for their research, and (c) develop outreach efforts that are accurate and that improve public understanding of their work.
- A suggestion was made that sound-generating research should be avoided if possible and that solid justification should be required before permits are issued for such research. A code of conduct for sound-generating ocean research is being developed in Germany.
- Scientists studying the effects of sound on marine mammals need to (a) identify priorities and key information gaps, (b) establish international and interdisciplinary collaborations, (c) publish their results in the peer-reviewed literature, and (d) improve their communication with non-scientists.
- An internationally funded and administered mechanism for investigating mass strandings of cetaceans is desirable (e.g., to achieve complete necropsies of dead animals and obtain as much relevant information as is feasible from live animals).

The workshop goals of (a) describing the range of existing management and mitigation approaches and (b) exploring and describing cross-boundary issues were largely met. The goal of identifying strategies and solutions to policy questions that might be transferable across national boundaries was met only partially. It might be useful to hold further meetings as offshoots of this workshop, focusing on some of the technical issues identified in London. Such meetings might include more case studies in which the entire management process is tracked from problem identification, to directed research, to management decision-making, to implementation.

Table 1. Selected Examples of Domestic Laws and Regulations Mentioned
The examples provided are a subset of those discussed during the workshop. No attempt has been made to analyze the information as it was presented.

Country	Sound Sources Potentially Addressed	Relevant Laws or Means of Regulation	For additional information
Brazil	Seismic survey activities	Resolution 305 of the National Environment Council (CONAMA), July 2004	http://www.mma.gov.br/port/conama/index.cfm
Gabon	Seismic survey activities	Law 16/93 Related to Improvement and Protection of the Environment	
South Africa	Seismic survey activities	2004 Minerals Act	http://www.dme.gov.za/home.asp?menu=publications/guideline_documents.htm
United Kingdom	All activities with potential to kill or disturb cetaceans and other designated species	Wildlife and Countryside Act 1981; Conservation (Natural Habitats &c.) Regulations 1994	http://www.jncc.gov.uk/page-1377
United States	All activities with potential to "take" marine mammals, with some exceptions	1972 Marine Mammal Protection Act; 1973 Endangered Species Act; 1969 National Environmental Protection Act; 1972 Coastal Zone Management Act; 1953 Outer Continental Shelf Lands Act	http://www.mmc.gov/legislation/ http://ceq.eh.doe.gov/nepa/regs/nepa/nepaeqia.htm http://coastalmanagement.noaa.gov/czm/czm_act.html http://www.csc.noaa.gov/opis/html/summary/ocsla.htm

Table 2. Summary of Multilateral Agreements Mentioned
The agreements summarized below are those mentioned in the workshop proceedings, a subset of those discussed during the workshop. No attempt has been made to analyze the information as it was presented.

Agreement Abbreviation	Agreement Name	Date Signed	Date Entered into Force	For more information
Abidjan Convention	Convention for Co-Operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region	1981	1984	http://hq.unep.org/easternafrica/AbidjanConvention.cfm
ACCOBAMS	Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area	1996	2001	http://www.accobams.mc/
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas	1992	1994	http://www.ascobans.org/
Barcelona Convention	Convention for the Protection of the Marine Environment and Coastal Region of the Mediterranean	1976	1978	http://www.greenyearbook.org/agree/mar-env/barcelona.htm
Bern Convention	Bern Convention on the Conservation of European Wildlife and Natural Habitats	1979	1982	http://www.oceanlaw.net/texts/summaries/bern.htm
Bonn Convention (also known as CMS)	Convention on the Conservation of Migratory Species of Wild Animals	1979	1983	http://www.cms.int/
Bucharest Convention	Convention for the Protection of the Black Sea Against Pollution	1992	1994	http://www.blacksea-commission.org/ http://www.greenyearbook.org/agree/mar-env/bucharest.htm
CBD	Convention on Biological Diversity	1992	1993	http://www.biodiv.org/
CCAMLR	Convention on the Conservation of Antarctic Marine Living Resources	1980	1982	http://www.greenyearbook.org/agree/mar-liv/ccamlr.htm http://eelink.net/~asilwildlife/antarctic1980.html
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora	1973	1975	http://www.cites.org/
EIA Directive	Council Directive of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment	1985 (amended 1997)	1985	http://europa.eu.int/comm/environment/eia/full-legal-text/85337.htm
Espoo Convention	Convention on Transboundary Environmental Impact Assessment	1991	1997	http://www.unece.org/env/eia/eia.htm

Agreement Abbreviation	Agreement Name	Date Signed	Date Entered into Force	For more information
Habitats Directive	Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora	1992	1992	http://europa.eu.int/comm/environment/nature/nature_conservation/eu_nature_legislation/habitats_directive/index_en.htm
Helsinki Convention	Convention on the Protection of the Marine Environment of the Baltic Sea Area	1992	2000	http://www.helcom.fi/ http://www.greenyearbook.org/agree/mar-env/helsinki.htm
ICRW	International Convention on the Regulation of Whaling	1946	1948	http://www.iwcoffice.org/commission/convention.htm http://www.greenyearbook.org/agree/mar-liv/icrw.htm
Jakarta Mandate	Jakarta Mandate on Coastal and Marine Biological Diversity (under CBD)	1995	(not applicable)	http://www.biodiv.org/programmes/areas/marine/default.asp
MARPOL	International Convention for the Prevention of Pollution from Ships	1973	1983	http://www.imo.org/Conventions/contents.asp?doc_id=678&topic_id=258
NAFTA	North American Free Trade Agreement	1992	1994	http://www.nafta-sec-alena.org/DefaultSite/index.html
Nairobi Convention	Convention for the Protection, Management, and Development of the Marine and Coastal Environment of the Eastern African Region	1985	1996	http://hq.unep.org/easternafrica/EasternAfricaNairobiConvention.cfm http://www.greenyearbook.org/agree/mar-env/nairobi.htm
NAT	North Atlantic Treaty	1949	1949	http://www.nato.int/ http://www.nato.int/docu/basictxt/treaty.htm
Offshore Protocol (under the Barcelona Convention)	Protocol for the Protection of the Mediterranean Sea against Pollution Resulting from Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil	1994	Not yet entered into force	http://www.greenyearbook.org/agree/mar-env/barcelona.htm
OSPAR	Convention for the Protection of the Marine Environment of the Northeast Atlantic	1992	1998	http://www.ospar.org/ http://www.greenyearbook.org/agree/mar-env/ospar.htm
Rio Declaration	Rio Declaration on Environment and Development	1992	(Not applicable)	http://www.unep.org/Documents/Default.asp?DocumentID=78&ArticleID=1163
SEA Directive	Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment	2001	2001	http://europa.eu.int/comm/environment/eia/sealegalcontext.htm#legal
SOLAS	International Convention for the Safety of Life at Sea	1974	1980	http://www.imo.org/Conventions/contents.asp?topic_id=257&doc_id=647
UNCLOS	United Nations Convention on the Law of the Sea	1982	1994	http://www.un.org/Depts/los/index.htm

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APPENDIX 1: Annotated Workshop Agenda

28–30 September 2004
Holiday Inn Kings Cross/Bloomsbury, London, England

The Marine Mammal Commission and Joint Nature Conservation Committee are sponsoring an international policy dialogue related to the effects of human-generated sound on marine mammals. The workshop results will be used to inform the deliberations of the Commission's Advisory Committee on Acoustic Impacts on Marine Mammals, and ultimately, policy-makers in the United States Congress and around the world.

Goals:

- Describe the range of international efforts in management and mitigation related to marine mammals and sound, considering the extent to which established legal and regulatory frameworks address acoustic impacts on marine mammals on a global scale
- Explore and describe cross-boundary/multilateral issues regarding the management and mitigation of acoustic impacts on marine mammals
- Identify innovative management strategies and solutions to policy questions that might be transferable to national and international frameworks

Expected Products: (all background documents, abstracts, posters, and presentations can be found at http://www.mmc.gov/sound/internationalwrkshp)

- Set of brief background documents
- Collection of abstracts and posters related to international policy for sound and marine mammals
- Workshop report that informs the Marine Mammal Commission's Advisory Committee on Acoustic Impacts on Marine Mammals and can be incorporated into a report to U.S. Congress.

Day 1: Tuesday, 28 September 2004

0900-0930 **Welcome and Introduction –** David Cottingham, U.S. Marine Mammal Commission

0930-1030 **Topic 1: Overview of Human-Made Sound Sources and Impacts on Marine Mammals** (Session Chair: Mark Tasker)

0930-1000 (with Q&A) **Overview of Human-Made Sound Sources in the Marine Environment** – John Hildebrand, Scripps Institution of Oceanography and U.S. Marine Mammal Commission Committee of Scientific Advisors

1000-1030 (with Q&A) **Overview of Potential Impacts of Human-Made Sound on Marine Mammals** – Peter Tyack, Woods Hole Oceanographic Institution, U.S.

1030-1100 **Break**

1100-1420 (with lunch) **Topic 2: Introduction to National and International Legal and Regulatory Frameworks for Marine Mammals and Human-Made Sound** (Session Chairs: Lee Langstaff and Suzanne Orenstein)

Theme: What is the range of national and international laws and regulatory mechanisms governing acoustic impacts on marine mammals?

- Which countries are considered in this case study? What are the main sound sources of concern in the region/country? How is this region/country unique?
- How are those countries alike or different in their approach to protecting marine mammals and/or regulating anthropogenic sound production? How different are their government systems?
- What limitations do these countries face in dealing with the impacts of sound on marine mammals?

1100-1200 **Case Study Presentations** (20 minutes each, including Q&A)

- **European Seas** – Mark Tasker, U.K. Joint Nature Conservation Committee
- **North Atlantic Treaty Organization (NATO)** – Mike Carron, NATO Undersea Research Centre, Italy
- **Scientific Committee on Antarctic Research (SCAR)** – David Walton, British Antarctic Survey, U.K.

1200-1300 Lunch

1300-1420 **Continue Case Study Presentations** (20 minutes each, including Q&A)

- **United States** – Douglas Wartzok, Florida International University and U.S. Marine Mammal Commission Committee of Scientific Advisors
- **Latin America** – Monica Borobia, Independent Environmental Consultant, Brazil
- **Asia/Pacific Rim** – John Wang, FormosaCetus Research and Conservation Group and National Museum of Marine Biology and Aquarium, Taiwan
- **Africa** – Howard Rosenbaum, Wildlife Conservation Society, U.S., and Ken Findlay, University of Cape Town, South Africa

1420-1615 Topic 3: Examining International Legal Frameworks (Session Chair: Mark Tasker)

Theme: How can the issue of acoustic impacts on marine mammals best be pursued internationally? What are the key components of an effective international framework? Has sound or acoustic impacts on marine mammals been effectively addressed by international law or institutions? Are there short or long-term actions that could be taken in international fora to address this issue?

1420-1440 (with Q&A) **Providing an Analytical Framework for International Regulatory Mechanisms and Fora** – Lindy Johnson, U.S. National Oceanic and Atmospheric Administration Office of International Environmental Law

- What steps can be taken to analyze existing legal frameworks, examining their applicability to the issue of acoustic impacts on marine mammals
- What steps can be taken to analyze potential short- and long-term actions that could be pursued in international fora to address this issue?

1440-1500 Break

1500-1615 **Panel Discussion – Components of an Effective International Legal Framework**

1. Do existing regional and international laws and organizations/institutions address acoustic impacts on marine mammals, or could they? (10 minutes)
2. What are the key components of effective regional and international legal/regulatory schemes? (15 minutes)
3. What challenges might exist in pursuing this issue internationally? What steps might be possible to further the discussion of this issue in relevant international organizations/institutions and what types of actions could be taken in international fora or through international legal instruments to address the issue? (25 minutes)
4. How might multilateral legal and regulatory frameworks develop in the future? What changes might be forthcoming, if any? (25 minutes)

Panelists:

Lindy Johnson, U.S. National Oceanic and Atmospheric Administration
Scott Kenney, U.S. Department of Defense
Elena McCarthy, Woods Hole Oceanographic Institution, U.S.
Daniel Owen, Fenners Chambers, U.K.
Karen Scott, University of Nottingham, U.K.
Jon VanDyke, University of Hawaii, U.S.

1615-1700 Topic 4: Innovative Management, Impact Assessment, and Mitigation Strategies (Session Chair: David Cottingham)

Theme: What are the key components of an effective management scheme related to anthropogenic sound and marine mammals? What are the goals of management, impact assessment, and mitigation? How are the effectiveness and efficiency of mitigation strategies and impact assessment evaluated? What roles do regulated communities and environmental NGOs play in the development of impact assessment, management and mitigation strategies? What can we conclude about effective management, impact assessment, and mitigation strategies?

1615-1635 (with Q&A) **Generic Impact Assessment Approaches** – Karl Fuller, Institute of Environmental Management and Assessment, U.K.

- What are the basic steps taken in Environmental Impact Assessment? What techniques can be used in such analyses?
- What differences exist between countries in their national approaches to risk assessment?

1635-1655 (with Q&A) **Uncertainty and Policy-Making: How Do We Deal With the Unknowns?** – John Harwood, Sea Mammal Research Unit, University of St. Andrews, U.K.

- How can scientific uncertainty be addressed when making policy decisions? What can policy-makers do when we don't fully understand the range of impacts from sound
- Beyond creating models, how can we handle uncertainties like those related to the significance of acoustic impacts?
- How can we define a "precautionary approach," and when/how should such an approach be applied in policy?

1700 **Adjourn**

1900 **Conference Dinner: Holiday Inn Kings Cross**

Day 2: Wednesday, 29 September 2004

0900-1400 **Continue Topic 4: Management Strategies, Risk Assessment, and Mitigation** (Session Chair: David Cottingham)

0900-0910 **Announcements and Instructions**

0910-0940 Mitigation Techniques: Options and Effectiveness – Jay Barlow, U.S. National Marine Fisheries Service

- What constitute state-of-the-art, “best practices” in mitigation?
- How do strategies differ for naval sonar, seismic research, shipping noise, and other sound sources? To what extent are mitigation strategies, monitoring technologies, and other techniques transferable across sound sources?
- How could mitigation strategies be made more accessible?
- What are the most promising strategies in development? What can we expect in the future?

0940-1130 (with break) **Issues in Management, Risk Assessment, and Mitigation: Concurrent Small Group Discussions (facilitated):**

- **Group A: Evaluating effectiveness** (criteria for assessing effectiveness and efficiency; techniques for evaluation; etc.)
  Topic specialists: Jay Barlow, U.S. and John Richardson, Canada
  - What are the goals of mitigation, management, and monitoring? How should we prioritize those goals?
  - How is the effectiveness of mitigation strategies evaluated? To what extent do we understand the effectiveness of existing mitigation techniques? What is needed to improve our understanding?

- **Group B: Best practices and emerging techniques** (new applications of technology; research and development; standards for application of mitigation strategies; etc.)
  Topic specialists: Jim Theriault, Canada and Sara Wan, U.S.
  - What constitute state-of-the-art, "best practices" in risk assessment, management, and mitigation? For example, what models are used for risk assessment and what factors are considered in those models? What current standards exist for the application of mitigation strategies? How does this vary for different sound sources and across national boundaries?
  - How is scientific uncertainty best dealt with in management, risk assessment, and mitigation?
  - What are the greatest needs in risk assessment, management, mitigation and mitigation in this field? What are the most promising strategies in development? What innovations can we expect in the future?

- **Group C: Policy issues in risk assessment and mitigation** (consistency in the application of mitigation strategies; balancing environmental protection with other societal goals, etc.)
  Topic specialists: Paul Macnab, Canada and Elena McCarthy, Italy/U.S.
  - How are issues of practicality, cost, and efficiency balanced in assessing risk and choosing mitigation strategies? What are the goals of existing risk assessment and mitigation mechanisms? How are protection goals balanced with other societal goals?
  - How can sound-producing human uses of the ocean be carried out while minimizing adverse effects on marine mammals?
  - How do mitigation strategies differ for naval sonar, seismic research, shipping noise, and other sound sources? Why? Are such differences desirable?
  - To what extent are mitigation and monitoring strategies/technologies transferable across sound sources, and across national boundaries? How could these strategies and technologies be made more accessible to different groups?

- **Group D: Prioritizing information needs** (identifying information gaps; criteria for prioritizing research; etc.)
  Topic specialists: Ron Kastelein, Netherlands and Douglas Wartzok, U.S.
  - What are the information needs for risk assessment, and how should we prioritize those needs?
  - What are the information needs related to mitigation strategies and technologies, and how should we prioritize those needs?

1130-1330 Lunch and Poster Session

1330-1415 (with Q&A) **Small Group Reports:** Report back to full group with list of lessons/guidance drawn from presentations and discussions

1415-1500 **Plenary Discussion and Synthesis**

1500-1515 Break

1515-1700 Topic 5: Cross-Boundary Issues and Multilateral Approaches (Session Chair: Mark Tasker)

1515-1545 (with Q&A) **The Transboundary Challenges of Addressing Ocean Noise: Several International Focusing Events** – Elena McCarthy, Woods Hole Oceanographic Institution, U.S.

- What types of problems arise from the international nature of the issue of acoustic impacts on marine mammals? How can we best address conflicts that arise?
- How might we improve international communication and cooperation related to this issue?

1545-1700 **Consequences of Cross-Boundary Contexts: Concurrent Small Group Discussions (facilitated):**

- **Group A: Differing regulatory frameworks** (varying degrees of protection; differing mitigation strategies; high seas activities; enforcement and permitting issues; "not-in-my-backyard" [NIMBY] phenomena; etc.)
  Topic specialists: Olaf Boebel, Germany and Wolfgang Dinter, Germany
  - How do regulations and operational strategies differ between countries and in international waters? For example, to what extent are critical habitats, protected areas, and endangered species/populations reflected in the respective regulatory frameworks? What is the significance of these differences?
  - How does the regulation of naval sonar, seismic research, shipping noise, and other sound sources (e.g., moored vs. ship-based sources) differ? Why? What approach to differentiation between sources in regulation would be most useful?
  - What problems arise from differing national/domestic regulatory regimes? How might these problems be addressed?

- **Group B: Multilateral agreements** (applications of existing international law; enforcement issues; future actions; etc.)
  Topic specialists: Monica Borobia, Brazil and Giuseppe Notarbartolo di Sciara, Italy
  - What existing multilateral agreements could be applied in the management of impacts from sound on marine mammals? Have any actions been taken that are specifically directed at sound or acoustic impacts on marine mammals?
  - What relevant international authorities/institutions should be involved in policy decisions related to this issue? What entities are currently involved in any discussion of sound in the oceans?
  - What types of future regulatory or non-regulatory actions can or should be considered to address this issue?
  - How could we address concerns about international enforcement?

- **Group C: Marine mammal research coordination** (prioritizing research agendas; stranding responses; permits; etc.)
  Topic specialists: Mardi Hastings, U.S., Bill Perrin, U.S., and Lorenzo Rojas-Bracho, Mexico
  - How can we use information from around the world in the policy-making process at national, regional, and international levels?
  - What are the challenges to coordinating marine mammal research, and what problems arise from a lack of coordination?
  - How could scientists better inform policy-makers on issues related to marine mammals and sound? What challenges does the scientific community face? What challenges do policy-makers face?

- **Group D: Improving regulatory capacity** (strategies to enhance a governmental regime's ability to create, implement, and enforce laws and regulations on this issue; etc.)
  Topic specialists: Michael Jasny, Canada and Mark Tasker, U.K.
  - What are the greatest needs for countries seeking to improve their ability to deal with the impacts of anthropogenic sound on marine mammals? What are the greatest needs in dealing with these impacts internationally?
  - What can be done to improve various national/domestic management and regulatory regimes?
  - What can be done to improve international/multilateral management and regulatory regimes?

1700 **Adjourn**

1900-2230 **Reception: Tower Bridge**

Day 3: Thursday, 30 September 2004

0900-1200 **Continue Topic 5: Cross-Boundary Issues and Multilateral Approaches**

0900-1030 **Continue Concurrent Small Group Discussions and Prepare Reports**

1030-1100 **Break**

1100-1145 (with Q&A) **Small Group Reports**: Report back to full group with list of lessons/guidance drawn from presentations and discussions

1145-1315 **Plenary Discussion and Synthesis**

1315-1415 **Lunch**

1415-1600 **Topic 6: Synthesis, Summary, and Future Directions** (Session Chair: Mark Tasker)

Plenary Discussion

1. How have we addressed the goals of the workshop?
2. What are our major findings?
3. What are the key components of the workshop products? How could we structure a useful workshop report?
4. Where do we go from here?

1600 **Adjourn**

APPENDIX 2: Workshop Participants

*indicates workshop organizer [%]indicates speaker or panelist [#]indicates topic specialist
[^]indicates facilitator or recorder [&]indicates poster presenter

Name	Organization	Country
Acebes, Jo Marie	World Wildlife Fund - Philippines	Philippines
Ainslie, Michael	TNO Physics and Electronics Lab	Netherlands
Barlow, Jay[% #]	National Marine Fisheries Service	United States
Bauch, Linda	American Petroleum Institute	United States
Bird, Richard	Ministry of Defence	United Kingdom
Bjørge, Arne	Institute of Marine Research	Norway
Bloor, Philip	Department of Trade and Industry	United Kingdom
Boebel, Olaf[# &]	Alfred Wegener Inst. for Polar and Marine Research	Germany
Bolaños-Jimenez, Jaime[&]	Ecological Society SEA VIDA	Venezuela
Borobia, Monica[% #]	Independent Environmental Consultant	Brazil
Boyd, Ian	St. Andrews Univ. Sea Mammal Research Unit	United Kingdom
Burkhardt, Elke	Alfred Wegener Inst. for Polar and Marine Research	Germany
Burt, Claire	Defence Science and Technology Lab	United Kingdom
Caldwell, Jack	Industry Consultant	United States
Campbell, Alyssa	Marine Mammal Commission	United States
Carron, Mike[%]	Marine Mammal Risk Assessment Program, NATO	Italy/U.S.
Connolly, Niamh	European Science Foundation	France
Copley, Victoria[^]	English Nature	United Kingdom
Corrigan, Colleen*[^]	U.S. Fish and Wildlife Service	United States
Cottingham, David*	Marine Mammal Commission	United States
Crowe, Alice	American Petroleum Institute	United States
Crutchfield, Zoë*[^]	Joint Nature Conservation Committee	United Kingdom
Dalton, Penny	Consortium for Oceanographic Research and Education	United States
Decker, Cynthia	Office of the Oceanographer of the Navy	United States
Dinter, Wolfgang[#]	Federal Agency for Nature Conservation	Germany
Dolman, Sarah	Whale and Dolphin Conservation Society	Australia
dos Santos, Manuel	Unidade de Investigacao em Eco-Etologia	Portugal
Evans, Peter	Sea Watch Foundation	United Kingdom
Fernández, Antonio[&]	University de Las Palmas de Gran Canaria	Spain
Findlay, Ken	University of Cape Town	South Africa
Ford, Lee-Ann[&]	Linking Individuals for Nature Conservation	Taiwan
Fuller, Karl[%]	Inst. of Environmental Mgmt. and Assessment	United Kingdom
Gentry, Roger	National Marine Fisheries Service	United States
Gill, Chip[&]	Int'l Association of Geophysical Contractors	United States
Gillespie, Douglas	International Fund for Animal Welfare	United Kingdom
Gillham, Katie[^]	Scottish Natural Heritage	United Kingdom
Gordon, Jonathon	Sea Mammal Research Unit	United Kingdom
Green, Marsha[&]	Ocean Mammal Inst./Albright College	United States
Harwood, John[%]	St. Andrews Univ. Sea Mammal Research Unit	United Kingdom
Hastings, Mardi[# &]	Office of Naval Research	United States
Haun, Jeff	Office of Naval Research – Global	United States/U.K.
Heskett, Erin	International Fund for Animal Welfare	United States
Hildebrand, John[%]	Scripps Institution of Oceanography and Marine Mammal Commission	United States

Hinchliffe, Peter	International Chamber of Shipping	United Kingdom
Hodgson, Amanda[&]	James Cook University	Australia
Jackson, Graham	Defence Science and Technology Lab	United Kingdom
Jansen, Frans	Dept. of Weapon and Communication Systems	Netherlands
Jasny, Michael[#]	Natural Resources Defense Council	Canada
Jepson, Paul	Zoological Society of London	United Kingdom
Johnson, Lindy[%]	National Oceanic and Atmospheric Administration	United States
Kahn, Benjamin	APEX Environmental	Australia
Kastelein, Ron[# &]	Sea Mammal Research Company	Netherlands
Kaveney, Tom	Department of the Environment and Heritage	Australia
Kenney, Scott[%]	Department of Defense	United States
Ketten, Darlene	Woods Hole Oceanographic Inst/Harvard University	United States
Künitzer, Anita	Federal Environmental Agency	Germany
Kvadsheim, Petter[&]	Norwegian Defence Research Establishment	Norway
LaBelle, Bob	Minerals Management Service	United States
Langstaff, Lee[^]	Facilitator	United States
Lucke, Klaus[&]	University of Kiel	Germany
Ludwig, Stefan	Federal Armed Forces Underwater Acoustic & Marine Geophysical Research Institute	Germany
Lueber, Sigrid[&]	ASMS OceanCare	Switzerland
Lusseau, David[&]	Lighthouse Field Station	United Kingdom
Macnab, Paul[#]	Bedford Institute of Oceanography	Canada
McCarthy, Elena[% #]	Woods Hole Oceanographic Institution	Italy/U.S.
Melton, Rodger	Exxon Mobil	United States
Nachtigall, Paul	University of Hawaii	United States
Notarbartolo di Sciara, Giuseppe[%]	Tethys Research Institute	Italy
Orenstein, Suzanne[^]	Facilitator	United States
O'Sullivan, Christine	Independent Environmental Consultant	Jamaica
Owen, Daniel[%]	Fenners Chambers	United Kingdom
Padovani, Bernard	Compagnie Générale de Géophysique	France
Parsons, Chris[&]	University Marine Biological Station	United Kingdom
Pavan, Gianni[&]	Universita' degli Studi di Pavia	Italy
Penney, Kyle[&]	Department of National Defence	Canada
Perrin, Bill[#]	National Marine Fisheries Service	United States
Pinn, Eunice[^]	Joint Nature Conservation Committee	United Kingdom
Plé, Jean-Pierre	U.S. Department of State	United States
Purdy, Mike	Lamont-Doherty Earth Observatory	United States
Reeves, Randall[^]	Okapi Wildlife Associates/IUCN	Canada
Reynolds, Joel	Natural Resources Defense Council	United States
Richardson, John[# &]	LGL Ltd.	Canada
Rigg, Caroline	Dept. for Environment, Food and Rural Affairs	United Kingdom
Rojas-Bracho, Lorenzo[#]	National Institute of Ecology	Mexico
Rose, Naomi	Humane Society of the United States	United States
Rosenbaum, Howard[%]	Wildlife Conservation Society	United States
Sandeman, Liz	Marine Connection	United Kingdom
Schoennagel, Chuck	Minerals Management Service	United States
Scott, Karen[%]	University of Nottingham	United Kingdom
Stone, Frank	Office of the Chief of Naval Operations	United States
Storrie, Jamie	English Nature	United Kingdom
Tackett, Bruce	Exxon Mobil	United States
Tasker, Mark*[% #]	Joint Nature Conservation Committee	United Kingdom

Theriault, James[# &]	Defence Research & Development Canada Atlantic	Canada
Tirpak, Elizabeth	U.S. Department of State	United States
Tomaszeski, Steven	Office of the Chief of Naval Operations	United States
Tougaard, Jakob[&]	Denmark National Environmental Research	Denmark
Trinder, Colin[&]	Department of Defence	Australia
Tyack, Peter[%]	Woods Hole Oceanographic Institution	United States
van der Sman, Peter	Shell Oil	Netherlands
Van Dyke, Jon[%]	University of Hawaii	United States
Vicente, Elio	Zoomarine-Mundo Aquatico	Portugal
Vos, Erin* [^]	Marine Mammal Commission	United States
Walton, David[%]	British Antarctic Survey	United Kingdom
Wan, Sara[# &]	California Coastal Commission	United States
Wang, John[%]	FormosaCetus Research & Conservation Group	Taiwan/Canada
Ward, Nathalie	Eastern Caribbean Cetacean Network	St. Vincent/Grenadines
Wartzok, Douglas[% #]	Florida International University and Marine Mammal Commission	United States
Weilgart, Lindy	Dalhousie University	Canada
Wieting, Donna	National Marine Fisheries Service	United States
Wilson, Judy[&]	Minerals Management Service	United States
Womersley, Mark	BMT-Singapore	Singapore
Worcester, Peter	Scripps Institution of Oceanography	United States
Wysocki, Roger	Department of Fisheries and Oceans Canada	Canada

OTHER CONTRIBUTORS
(presented posters in absentia)

Name	Organization	Country
André, Michel[&]	Universitat Politècnica de Catalunya	Spain
Benders, F.P.A[&]	TNO Physics and Electronics Lab	Netherlands
Kendall, James[&]	Minerals Management Service	United States
Morrissey, Ron[&]	Naval Undersea Warfare Center	United States

APPENDIX 3: Abstracts and Descriptions of Workshop Background Documents

The Marine Mammal Commission and Joint Nature Conservation Committee collected a series of briefings on the topics listed below. These background papers were intended to give broad summary overviews of the issues, and were provided to participants prior to the workshop and posted on the Marine Mammal Commission's website. (Please note that distribution of these papers does not constitute endorsement by the Marine Mammal Commission and Joint Nature Conservation Committee.) These documents are now available online at http://mmc.gov/sound/internationalwrkshp/backgroundpapers.html.

- **Sources of Anthropogenic Sound in the Marine Environment** (provided by John Hildebrand)

John Hildebrand. 2004. Sources of Anthropogenic Sound in the Marine Environment.
This paper describes the various sources of human-generated sound and their global distribution. It also discusses the need for a long-term monitoring program to track future changes in ocean noise.

- **Marine Acoustic Technology and the Environment** (provided by David Walton)

Scientific Committee on Antarctic Research. 2002. Marine Acoustic Technology and the Environment. Working Paper WP-023, XXV ATCM. 2 pp.
Working Paper 23 was presented by SCAR at XXV Antarctic Treaty Consultative Meeting in September 2002 in Warsaw. This was in response to a request from Treaty Parties for a review of available scientific information on anthropogenic marine acoustic noise and its implications. The paper provides an overview of relevant literature compiled from a workshop meeting and makes some recommendations about mitigation measures.

Scientific Committee on Antarctic Research. 2004. SCAR Report on Marine Acoustic Technology and the Antarctic Environment. Information Paper IP-078, XXVII ATCM. 17 pp.
Information paper 78 was presented by SCAR to XXVII Antarctic Treaty Consultative Meeting in July 2004 in Cape Town. The paper reviews new information available since 2002 and provides a risk analysis approach that can be used for environmental impact assessment in advance of permitting any marine activities that will produce underwater noise. It also attempts to establish the levels of background sound against which anthropogenic noise should be judged.

- **International Regulation of Undersea Noise** (provided by Karen Scott)

Karen N. Scott. April 2004. International Regulation of Undersea Noise. International and Comparative Law Quarterly vol. 53, pp 287–324.
This paper surveys a selection of global and regional instruments which directly or indirectly impact upon the regulation of undersea noise. In its conclusion, this paper attempts to identify further measures that might be taken in order to expedite the development of a comprehensive global legal framework for the regulation of marine acoustic pollution.

- **The Application of Marine Pollution Law to Ocean Noise** (provided by Daniel Owen)

Daniel Owen. 2003. The Application of Marine Pollution Law to Ocean Noise. Annex 1 in Oceans of Noise: A WDCS Science Report. M. Simmonds, S. Dolman, and L. Weilgart, eds. Pp 94–129.
This excerpt from the Whale and Dolphin Conservation Society's 2003 report addresses the application of marine pollution law to the regulation of ocean noise. (Full report available at http://www.wdcs.org)

- **The Evolution and International Acceptance of the Precautionary Principle** (provided by Jon Van Dyke)

Jon M. Van Dyke. 2004. The Evolution and International Acceptance of the Precautionary Principle. In Bringing New Law to Ocean Waters, D.D. Caron and H.N. Scheiber eds. Pp 357–379.
This paper examines how the precautionary principle has been used in recent multilateral treaties and in decisions by international tribunals and national courts, and then summarizes the current content and understanding of this principle.

- **Whales, Submarines, and Active Sonar** (provided by Jon Van Dyke)

Jon M. Van Dyke, Emily A. Gardner, Joseph R. Morgan. 2004. Whales, Submarines, and Active Sonar. 18 Ocean Yearbook 330–63.
This paper summarizes the current scientific understanding of the effect of low frequency active sonar and other loud sounds in the ocean on marine mammals and other marine creatures. It then examines the Navy's justifications for using active sonar and examines how the principles and institutions of international environmental law apply to this new form of ocean pollution.

- **Mitigation and Monitoring** (provided by Jay Barlow and Robert Gisiner)

J. Barlow and R. Gisiner. In review. Mitigating, Monitoring, and Assessing the Effects of Anthropogenic Sound on Beaked Whales. Submitted to the Journal of Cetacean Research and Management.
This paper was originally prepared for the Marine Mammal Commission’s April 2004 technical workshop on beaked whales. It reviews options for mitigating and monitoring the potential impacts of human acoustic activity on beaked whales, providing an analysis of the challenges inherent in developing effective methodologies.

APPENDIX 4: Workshop Poster Abstracts

POSTER SESSION

Wednesday, 29 September 2004

List of Abstracts (Alphabetical by First Author)

1. **M. André, E. Delory, and M. van der Schaar**
   A Passive Mitigation Solution to the Effects of Human-Generated Sound on Marine Mammals

2. **F.P.A Benders, S.P. Beerens, and W.C. Verboom**
   SAKAMATA: A Tool to Avoid Whale Strandings

3. **Olaf Boebel, Horst Bornemann, Monika Breitzke, Elke Burkhardt, Lars Kindermann, Holger Klinck, Joachim Plötz, Christoph Ruholl, and Hans-Werner Schenke**
   Risk Assessment of *ATLAS HYDROSWEEP DS-2* Hydrographic Deep Sea Multi-beam Sweeping Survey Echo Sounder

4. **Jaime Bolaños-Jiménez, Luis Bermúdez-Villapol, Alejandro Sayegh, Janin N. Mendoza M., and Clemente Balladares**
   Evaluation and Management of the Noise Impact on Marine Mammals in Venezuela—Legal and Technical Aspects

5. **Antonio Fernández, Manuel Arbelo, Pascual Calabuig, Carrillo Manuel, Mariña Mendez, Eva Sierra, Pedro Castro, José Jabber, and Antonio Espinosa de los Monteros**
   "Gas Embolic Syndrome" in Two Single Stranded Beaked Whales

6. **Antonio Fernández, Pedro Castro, V. Martín, T. Gallardo, and Manuel Arbelo**
   New Beaked Whale Mass Stranding in Canary Islands Associated with Naval Military Exercises (Majestic Eagle 2004)?

7. **Antonio Fernández, Manuel Arbelo, Eva Sierra, Mariña Méndez, F. Rodríguez, and P. Herráez**
   Pathological Study of a Mass Stranding of Beaked Whales Associated with Military Naval Exercises (Canary Islands, 2002)

8. **Lee-Ann Ford**
   A Nation Without Mercy

9. **Chip Gill**
   Further Analysis of 2002 Abrolhos Bank, Brazil Humpback Whale Strandings Coincident with Seismic Surveys

10. **Marsha L. Green**
    Underwater Noise Pollution: Impacts on Marine Life & Recommendations for International Regulatory Action

11. **Amanda Hodgson**
    The Behavioural Responses of Dugongs to Two Noise Sources: Boats and Pingers

12. **R.A. Kastelein, W.C. Verboom, N. V. Jennings, S. van der Heul, and R.J.V. Triesscheijn**
    The Influence of Acoustic Emissions for Underwater Data Transmission on the Displacement of Harbor Porpoises (*Phocoena phocoena*) in a Floating Pen and Harbor Seals in a Pool

13. **James Kendall, Pat Roscigno, and Cleve Cowles**
    Snapshot of MMS Research on Cetaceans and Anthropogenic Presence

14. **Petter H. Kvadsheim, Erik Sevaldsen, and John K.Grytten**
    Active Sonar and the Marine Environment

15. **Sigrid Lüber**
    Undersea Noise Pollution—A Challenge for Science, Governments and the Civil Society

16. **Klaus Lucke, Wolf Hanke, and Guido Dehnhardt**
    ABR Responses in Two Species of Marine Mammals

17. **D. Lusseau, J.E.S. Higham, S.M. Dawson, and E. Slooten**
    Multi-scale Impact Assessments Can Help Detect Impact, Infer its Mechanism and Consequences and Provide Tools for Management

18. **Ron Morrissey, Nancy DiMarzio, Susan Jarvis, David Moretti, and Mardi Hastings**
    Passive Acoustic Marine Mammal Monitoring Technology for Navy Ranges

19. **E.C.M. Parsons and S. Hung**
    Noise Pollution Case Study: Cetaceans in Hong Kong

20. **G. Pavan, M. Manghi, C. Fossati, and M. Priano**
    Tools for Underwater Noise Monitoring, Marine Mammals' Surveys, and Implementation of Acoustic Risk Mitigation Policies

21. **Kyle Penney and James A. Theriault**
    Environmental Stewardship: Maritime Forces Atlantic's Marine Mammal Impact Mitigation

22. W.J. Richardson, M. Holst, W.R. Koski, M.A. Smultea, and M. Rawson
Marine Mammal Monitoring and Mitigation During Recent Seismic Surveys for Geophysical Research

23. James A. Theriault and Gary Fisher
Canadian Environmental Legislation Impacting to Sonar R&D

24. Jakob Tougaard, Jacob Carstensen, Henrik Skov, Jonas Teilmann, and Oluf D. Henriksen
Effects from Pile Driving Operations on Harbour Porpoises at Horns Reef Offshore Wind Farm, Monitored by T-PODs and Behavioural Observations

25. Colin Trinder
Whales and the WAXA: Defence Sponsored Whale Research off the West Coast of Australia

26. Sara Wan
Regulatory Authority of the States Over Acoustic Activity, With Emphasis on California

27. Judy Wilson
A Regulatory Agency Perspective on Anthropogenic Noise and Marine Mammals

A Passive Mitigation Solution to the Effects of Human-Generated Sound on Marine Mammals

M. André, E. Delory, and M. van der Schaar

Laboratory of Applied Bioacoustics
Technical University of Catalonia (UPC)

Abstract
Acoustic and physical interactions between human activities and coincident cetacean occurrence have become a threat to marine mammal conservation. Although we do not yet fully understand under what circumstances exposure to loud sounds will cause harm to cetaceans, scientific evidence indicates that such high intensity sounds can cause lesions in acoustic organs, severe enough to be lethal. The use of active acoustic solutions, i.e. acoustic deterrents and active sonar, in areas of interest (shipping, military exercises, gas exploration, etc.) to prevent unfortunate interactions is either range-limited and intrusive or ineffective on cetaceans, specially on those already highly tolerant to noise. An alternative solution based on passive detection, classification and localization has been therefore considered. Here, we introduce a time and cost effective minimal solution applied to sperm whales - but applicable to other cetacean species - to an automatic real-time 3D whale localization. The 3D localization is based on the acoustic signal arrival time-delays and the assumption that sound propagation can be modeled by straight rays, resolving both the azimuth and elevation on a short aperture tetrahedral array of passive sensors and the source distance from the time arrival on a distant fourth hydrophone (wide aperture array). With this configuration, the 3D localization algorithm calculates the whale's position within a 3000m deep and 2500m radius cylinder with an estimated 200m maximum distance error. The system further integrates the tracking of acoustically passive whales by a sperm whale click-based ambient noise imaging sonar. A simulation tool for 3D acoustic propagation was designed to simulate a bi-static solution formed of an arbitrary number of active acoustic sources, an illuminated object, and a receiver all positioned in 3D space with arbitrary bathymetry. Detection and bearing estimates could be performed for silent whales at ranges of 1500m from a 4m diameter array of 32 hydrophones, in a simulated scenario where on-axis click source and ambient noise levels were respectively 200dBrms re 1µPa @1m (full bandwidth) and 60 dBrms re 1µPa in the 1-10kHz band. While an ambitious synthesis of many advanced acoustic technologies, the benefit is an efficient, non-intrusive system which could continuously 3D track cetaceans in areas of interest, therefore mitigating the impact of artificial sound sources on marine mammal populations.

SAKAMATA: A Tool to Avoid Whale Strandings

F.P.A Benders, S.P. Beerens and W.C. Verboom

TNO Physics and Electronics Laboratory,
P.O. Box 96864, 2509 JG The Hague,
The Netherlands
E-mail: frank.benders@tno.nl

Abstract
World-wide a concern exists about the influence of man-made noise on marine life, and particularly of high power sonar. Most concern lies with marine mammals that use acoustics for hunting, communication and/or navigation. This concern is fed by recent strandings of whales that could be related to military sonar transmissions and seismic explorations. Especially sonars that use audible frequencies are harmful for these mammals. However, little is known about the exact influence of active sonar on marine mammals and therefore many countries apply the *precautionary principle*. In practice this means that mitigation measures are defined for the use of active sonars. Implementation of such mitigation measures is no sinecure. Background knowledge (presence of mammal species and their hearing sensitivity and behaviour, acoustic conditions) is often lacking. Therefore historical and *in situ* information must be used. TNO-FEL has developed SAKAMATA, a tool that supports the implementation of mitigation measures in an effective way.

Risk Assessment of *ATLAS HYDROSWEEP DS-2* Hydrographic Deep Sea Multi-beam Sweeping Survey Echo Sounder

Olaf Boebel, Horst Bornemann, Monika Breitzke, Elke Burkhardt, Lars Kindermann, Holger Klinck, Joachim Plötz, Christoph Ruholl, and Hans-Werner Schenke

Alfred Wegener Institute for Polar and Marine Research
P.O.Box 12016, 27515 Bremerhaven, GERMANY
E-mail: oboebel@awi-bremerhaven.de

Abstract
The hull-mounted *Atlas Hydrographic* multibeam deep-sea echosounder *Hydrosweep DS-2* is installed on several research vessels (e.g. R/V *Maurice Ewing,* R/V *Meteor,* R/V *Polarstern*) to carry out bathymetric surveys of the sea floor. At full ocean depth (3000 to 11000m water depth), the instrument usually operates in "Deep Sea II" mode. In this mode, three short (24, 12 and 24ms) sound pulses of 15.5 kHz are successively emitted, ensonifying a port-, centre- and starboard beam, respectively. This pattern repeats itself at regular intervals of typically 15 seconds. The resulting swath covers an area of approximately twice the local water depth along the profile line.

The sound pressure level (SPL) capable of causing a temporary threshold shift (TTS) is calculated on the basis of experimentally derived TTS threshold levels and the 3-dB exchange rate, resulting in a critical SPL of 203.2 dB_{RMS} rel. 1µPa. For this calculation, a conservatively estimated effective pulse length of 60 ms, i.e. the sum of the three pulses, is used. Then the corresponding region is derived from the *Hydrosweep DS-2* beam pattern. Again a conservative approach selects the maximum SPL of each of the three consecutive pulses for every direction. The resulting critical region is heart-shaped and bounded by a box of 43 m depth, 46 m width athwartship and 1 m (sic!) width fore-and-aft.

Subsequently, regions where reception of multiple pings could lead to a TTS are determined for increasing numbers of assumed ensonifications. Finally the region where potential critical behavioural responses may occur is determined, assuming a sound pressure level commensurate with results from the Bahamas 2001 stranding event.

For cruising ships (R/V *Polarstern* particularly), the study concludes that the risk of causing a TTS to marine mammals is conservatively estimated to be less then 1 percent of the risk of a collision between the ships-hull and the animal by comparing the relevant volumes and cross-sections. The risk of causing a permanent threshold shift (PTS) will be smaller, though quantification thereof is difficult. For ships on station (zero velocity), the non-zero risk of ensonifying a marine mammal at TTS levels obviously exceeds the risk of collision, as the latter becomes zero. In this later situation, mitigation methods such as a shut down of *Hydrosweep* on station when whales are observed within a certain mitigation radius could serve to eliminate any remaining risks.

Evaluation and Management of the Noise Impact on Marine Mammals in Venezuela—Legal and Technical Aspects

Jaime Bolaños-Jiménez,[1] Luis Bermúdez-Villapol,[2] Alejandro Sayegh,[2] Janin N. Mendoza M.,[3] and Clemente Balladares [4]

[1]SEA VIDA, A.P. 162, Cagua, Aragua, Venezuela 2122
E-mail: sea_vida@yahoo.es

[2]Centro de Investigación de Cetáceos (CIC)

[3]Ministerio del Ambiente y de los Recursos Naturales, Dirección de Calidad Ambiental, Dirección de Calidad de Aguas (DGCA – MARN).

[4]Ministerio del Ambiente y de los Recursos Naturales, Oficina Nacional de Diversidad Biológica (ONDB – MARN).

Abstract

In Venezuela, the legal and regulatory framework includes a series of instruments related to the conservation of natural ecosystems. Accordingly, the Venezuelan State's duties include assuring the conservation and sustainable use of ecosystems and natural resources, as well as to increase both the quality of the human life and of the environment. In a general sense, no specific regulations have been promulgated for the protection of marine mammals. Nevertheless, based on such instruments as the "*National Constitution*", "*Organic Law of Environment*", "*Environment Criminal Act*", and "*Biological Diversity Act*", the Venezuelan State is providing a reference for the protection of the marine habitat and species, including the obligation to prevent, mitigate or correct environmental impacts of economic activities. On the other hand, the Presidential Decree 1257 that deals with "*Guidelines on environmental evaluation of potentially degrading activities*" provides a more specific foundation for evaluating and regulating the impact of sound on cetaceans. Two kinds of activities are considered of special interest for taking into account for conservation and management purposes: 1) oil and gas exploration/production and 2) maritime traffic. On the basis of the above-mentioned Decree, since 2002 the Ministry of Environment and Natural Resources (MARN) authorities have included the evaluation of the effect of sound on cetaceans in the Terms of Reference of Environmental Impact Assessments, Specific Environmental Assessments and Baseline Studies related to the oil industry offshore activities.

Up to the present, the presence of independent observers and MARN officers on board vessels during two seismic surveys reached 1264 hs of effort and yielded 117 cetacean sightings. According to this preliminary results, behavioral changes and/or avoidance reactions have been observed only in mysticetes. Though no research effort is being made currently on the effect of other sources of human-generated sound on these species, specific regulations are being developed jointly by the MARN and non-governmental organizations.

"Gas Embolic Syndrome" in Two Single Stranded Beaked Whales

Antonio Fernández, Manuel Arbelo, Pascual Calabuig,[1] Carrillo Manuel,[2] Mariña Méndez, Eva Sierra, Pedro Castro, José Jabber, and Antonio Espinosa de los Monteros

University of Las Palmas de Gran Canaria, Veterinary School, Institute for Animal Health, Unit Histology and Pathology, Arucas, Gran Canaria, Canary Islands, Spain
E-mail: afernandez@dmor.ulpgc.es

[1] Centro Recuperación Fauna. Cabilido Insular de Gran Canaria

[2] Tenerife Conservación

Abstract

Introduction:

Lesions consistent with in vivo bubble formation in beaked whales have been recently described in **Nature** by Jepson and col. and Fernández and col. A decompression-like syndrome has been postulated to happen in whales in response to sonar exposure. Gas embolism "in vivo" is difficult to determine some time after death. This report presents a systemic "gas bubble" embolism in two fresh single stranded beaked whales.

Material and Methods:

One adult female and one old male beaked whale stranded on the coasts of Gran Canaria and Tenerife in 2003 and 2004 respectively. Both animals were necropsied around 4 to 8 hours after death. A routine necropsy for whales was carried out by pathologists from the Unit of Histology and Pathology (Institute of Animal Health-Veterinary School-University of Las Palmas de Gran Canaria). A routine histological study was also performed in all the sampled organs, as well as a microbiological study.

Results and discussion:

Both animals showed massive gas bubbles in the portomesenteric system, involving changes in the liver. Gas bubbles were seen macroscopically and microscopically in the venous system, including intestines, liver, lymph nodes, lung, kiney, heart and brain. Although a test of nitrogen content of the gas is now underway, the pathological picture is very similar to an acute massive systemic gas embolism in DCS in humans. It is not known if these cases were associated with sonar activities.

Conclusion:

The present results found in two very fresh beaked whales restate and reinforce the "systemic gas embolism" in beaked whales, a new pathologic entity to be described in cetaceans, with special attention to deep, long duration diving species like beaked whales, which seem to be more susceptible of suffering this embolic syndrome.

Jepson and cols. **Nature** 425:575-576(2003).
Fernandez and cols. **Nature** doi:101038/nature 02528 (2004).

New Beaked Whale Mass Stranding in Canary Islands Associated with Naval Military Exercises (Majestic Eagle 2004)?

Antonio Fernández,[1] Pedro Castro,[1] V. Martín,[2] T. Gallardo,[3] and Manuel Arbelo[1]

[1]University of Las Palmas de Gran Canaria, Veterinary School, Institute for Animal Health, Unit Histology and Pathology, Arucas, Gran Canaria, Canary Islands, Spain. E-mail: afernandez@dmor.ulpgc.es

[2]Sociedad para el estudio de los cetáceos en las Islas Canarias (SECAC)

[3]Cabildo Insular de Fuerteventura

Abstract

Four beaked whales (*Ziphius cavirostris*) stranded in Lanzarote and Fuerteventura (Canary Islands). The first animal stranded the 21st and the last the 28th of July. During the previous week (11th–16th July 2004) an international military naval exercises (Majestic Eagle 2004) took place between the Canary Islands and Morocco. The corpses were autolytic, lacking part of the body in some cases. A necropsy was carried out on 3 out of 4 animals. The last beaked whale that stranded the 28th was not possible to sample. The necropsied animals showed abundant content of aliment in the stomach with, in same cases, large non-digested squids. No macroscopic findings were recorded due to advanced autolysis, but samples from different organs, except the central nervous system, were taken for histology. Samples were processed for routine histological study and also for detecting fat emboli. This report presents epidemiological data and pathological data from this new beaked whale mass stranding associated with naval exercises.

Pathological Study of a Mass Stranding of Beaked Whales Associated with Military Naval Exercises (Canary Islands, 2002)

Antonio Fernández, Manuel Arbelo, Eva Sierra, Mariña Méndez, F. Rodríguez, and P. Herráez

University of Las Palmas de Gran Canaria, Veterinary School, Institute for Animal Health, Unit Histology and Pathology, Arucas, Gran Canaria, Canary Islands, Spain
E-mail: afernandez@dmor.ulpgc.es

Abstract

A study of the lesions of beaked whales in a recent mass stranding in the Canary Islands following naval military exercises provides evidence of the possible relationship between anthropogenic, acoustic (sonar) activities and the stranding and death of marine mammals. Fourteen beaked whales were stranded in the Canary Islands close to the site of an international naval exercise (Neo-Tapon 2002) held on 24 September 2002. Strandings began about 4 hours after the onset of the use of mid-frequency sonar activity. Eight Cuvier's beaked whales (*Ziphius cavirostris*), one Blainville's beaked whale (*Mesoplodon densirostris*) and one Gervais' beaked whale (*M. europaeus*) were necropsied and studied histopathologically. No inflammatory or neoplastic processes were noted, and no pathogens were identified. Macroscopically, whales had severe, diffuse congestion and hemorrhage especially around the acoustic jaw fat, ears, brain, and kidneys. Gas bubble-associated lesions and fat embolism were observed in vessels and parenchyma of vital organs. This *in vivo* bubble formation associated with sonar exposure may have resulted in modified diving behavior that caused nitrogen super-saturation in excess of a threshold value normally tolerated by the tissues (as occurs in decompression sickness). Alternatively, a physical effect of sonar on *in vivo* bubble precursors (gas nuclei), the activation level of which may be lessened by nitrogen gas super-saturation of the tissues, may explain the phenomenon. Both mechanisms might also work together to augment and maintain bubble growth. Exclusively or in combination, these mechanisms might initiate the embolic process. Severely injured whales died, were killed by predators, or became stranded and died due to a more severe cardiovascular collapse during beaching. The present study demonstrates a new pathologic entity in cetaceans. This syndrome that is apparently fostered by exposure to mid-frequency sonar particularly affects deep, long duration, repetitive diving species like beaked whales.

A Nation Without Mercy…

Lee-Ann Ford

Linking Individuals for Nature Conservation, Taiwan
E-mail: lincngo@yahoo.ca

Abstract
Taiwan is an economically thriving nation with only 1 percent of the population living below the poverty line. Slightly smaller that the states of Delaware and Maryland combined; this tiny island supports a population of 22,749,838 people. With one of the largest commercial shipping industries in the world, Taiwan has proven itself to be an economic success and an environmental failure.

A booming economy has resulted in an environmental catastrophe. Taiwan's complicated international status has led to a lack of international environmental agreements. These agreements have been signed but never ratified; due to this status, Taiwan escapes monitoring for its actions, or perhaps of equally importance, its inactions.

Due to expense and inexperience, the government refuses make marine conservation a serious issue on its agenda. Conditions such as water pollution from industrial emissions, raw sewage, and low-level radioactive waste, and large-scale modification of shoreline habitat have been unable to motivate the central government to recognize and address the environmental issues that threaten the marine life of this island.

Guilty of being the principal culprit behind Asia's commerce in endangered wildlife, no mercy or compassion is shown for the flora and fauna within Taiwan itself. Still, Taiwan continues to operate without consequence.

Even though, the Wildlife Conservation Law was passed in 1989 and was designed to be comparable to the regulations of CITES, the marine mammal populations of Taiwan continue to suffer from unmonitored military exercises. Government regulations do not allow the conservationist to interfere with military exercises or measure their impacts.

The Taiwanese government presents itself as a democratic, responsible government that is determined to put an end to the illegal trade of endangered species and promises to protect its depleting marine mammal populations; nothing could be further from the truth.

Further Analysis of 2002 Abrolhos Bank, Brazil Humpback Whale Strandings Coincident with Seismic Surveys

Chip Gill

International Association of Geophysical Contractors
2550 North Loop West Suite 104
Houston, TX 77092
E-mail: chipgill@iagc.org

Abstract
A paper, "Are seismic surveys responsible for cetacean strandings? An unusual mortality of adult humpback whales in Abrolhos Bank, northeastern coast of Brazil" (Engel et al. 2004), was presented to the 2004 International Whaling Commission Scientific Committee. It presented strandings data for the northeastern coast of Brazil, the areas where seismic surveys were conducted in 2002, and an overview of the IBAMA efforts to establish guidelines for the seismic activities in the Brazilian coast. While the paper concluded that a scientific correlation between increased adult humpback strandings and seismic surveys along the east coast of Brazil can not be established, the authors nevertheless suggest that seismic surveys be suspended offshore from the Abrolhos Bank region (Bahia and Espírito Santo States) during the humpback whale breeding season from July to November.

The geophysical industry has compiled data on all seismic surveys conducted off the Brazilian coast from 1999 to 2003. It has further conducted an independent analysis of this seismic activity over a 5 year period around the 2002 season as well as the location of the 8 adult humpback whale mortalities noted in Engel et al. 2004 relative to coincident seismic activity. In this poster session the geophysical industry will present details of these data and analyses and will examine the major premises of Engel et al. 2004 against them. It will offer an examination of the scientific literature quoted in Engel et al. 2004 in support of its conclusions as well as how this literature was used, and will draw conclusions about what lessons the 2002 humpback mortalities should offer managers considering mitigations of seismic activity.

Underwater Noise Pollution: Impacts on Marine Life & Recommendations for International Regulatory Action

Marsha L. Green

Albright College, Ocean Mammal Institute, Ocean Noise Coalition
PO Box 14422, Reading, PA 19612; Phone: 610-670-7386
E-mail: mlgreen@pacifier.com

Abstract
Anthropogenic noise is a form of pollution that poses significant threats to marine mammals, fish and other ocean wildlife including displacement, injury and mortality. The use of technologies that produce intense underwater noise pollution may be in breach of Article 194(1) of the UN Convention on the Law of the Sea which requires States to take all measures necessary to prevent, reduce and control pollution of the marine environment and Articles 204-206 which require States to assess potentially negative impacts on the environment.

Acoustic energy is not restricted by national boundaries and there is growing consensus that undersea noise pollution should be regulated by responsible international institutions The Scientific Committee of the International Whaling Commission in July 2004 issued a strong statement of concern about intense underwater noise stating that there is compelling evidence that marine mammal populations worldwide are potentially threatened especially by intense military sonars and air guns used in geophysical research and oil and gas exploration. They asked that noise exposure standards be included in national and international ocean conservation plans.

The Scientific Committee to ACCOBAMS issued a formal recommendation on "Man-Made Noise" urging extreme caution in using intense acoustic devices and the 2003 meeting of ASCOBANS passed a resolution affirming their commitment to apply the Precautionary Principle to ocean noise.

NATO representatives met with MEP's, scientists and NGO's in October 2003 to receive petitions signed by 70 environmental groups in Europe and North America, representing memberships of 8.3 million people, and consider requests for regulatory action on underwater noise pollution. NGO's gave a presentation on Intense Underwater Noise Pollution at the Fifth UN Informal Consultative Process on Oceans and the Law of the Sea in June 2004 discussing science, legal aspects and political activities urging international regulation of ocean noise. NGO's worldwide are forming an International Coalition for Ocean Noise Management.

The Behavioural Responses of Dugongs to Two Noise Sources: Boats and Pingers

Amanda Hodgson

James Cook University

Abstract

The objectives of this project were to determine the risk disturbance from boats and pingers (acoustic alarms) through direct observations of dugong (*Dugong dugon*) behaviour. To observe dugongs I developed the blimp-cam; this consists of a helium-filled balloon (blimp) with a mounted video camera. I assessed the behavioural responses of dugongs to opportunistic and experimental boat passes in Moreton Bay, Australia. The feeding and travelling behaviour during 4.5 min focal follows was not affected by the experimental boat passing, the number of passes made, whether the pass was continuous or included a stop and restart, or the individual's position in the herd in relation to these three factors. However, individual dugongs were significantly less likely to remain feeding if a boat passed within 50 m. Feeding herds often responded to boats by performing mass movements, which on average lasted 2 min. During the time of year my study was conducted, boat traffic may disturb dugongs for 0.8 to 6 percent of the time they spend feeding. This level of disturbance presents minimal risk of displacing dugongs from my study site where seagrass beds are large enough for dugongs to move and recommence feeding immediately. The response to an array of two 10 kHz pingers (acoustic alarms designed to reduce entanglement in fishing nets) was also observed. Pinger noise did not significantly affect the rate of dugong movement away from the focal arena surrounding the pingers, the orientation of these dugongs, or the presence or absence of feeding plumes. The results from these pinger experiments suggest dugongs are unlikely to be displaced from important habitat areas by pingers.

The Influence of Acoustic Emissions for Underwater Data Transmission on the Displacement of Harbor Porpoises (*Phocoena phocoena*) in a Floating Pen and Harbor Seals in a Pool

R.A. Kastelein,[1*] W.C. Verboom,[2] N. V. Jennings,[3] S. van der Heul,[1] and R. J.V. Triesscheijn[1]

[1]Sea Mammal Research Company (Seamarco), Julianalaan 46, 3843 CC Harderwijk, The Netherlands
[2]TNO-TPD, Department of Noise and Vibration, Stieltjesweg 1, 2628CK Delft, The Netherlands
[3]School of Biological Sciences, University of Bristol, Woodland Road, Bristol, BS8 1UG, United Kingdom
*Corresponding author. Tel.: + 31-341-456252.
E-mail: Researchteam@zonnet.nl (R.A. Kastelein)

Abstract
To prevent grounding of ships and collisions between ships in shallow coastal waters, an underwater data collection and communication network is currently under development: Acoustic Communication network for Monitoring of underwater Environment in coastal areas (ACME). Marine mammals might be affected by ACME sounds since they use sounds of similar frequencies (around 12 kHz) for communication, orientation, and prey location. If marine mammals tend to avoid the vicinity of the transmitters, they may be kept away from ecologically important areas by ACME sounds. The most abundant marine mammal species that may be affected in the North Sea are the harbor porpoise and the harbor seal. Therefore, as part of an environmental impact assessment program, two captive harbour porpoises and nine harbour seals were subjected to four sounds, three of which may be used in the underwater acoustic data communication network. The effect of each sound was judged by comparing the animals' positions and respiration rates during test periods with those during baseline periods. Each of the four sounds could be made deterrent by increasing the amplitude of the sound. Both the porpoises and the seals reacted by swimming away from the sound source. The porpoises increasing their respiration rate slightly, but the seals' respiration rate remained the same. From the sound pressure level distribution in the enclosures, and the distribution of the animals during test sessions, discomfort sound pressure level threshold were determined for each sound. The acoustic discomfort threshold is defined as the boundary SPL between the areas that the animals generally occupied during the transmission of the sounds and areas that they generally did not enter during transmission. In combination with information on sound propagation in the areas where the communication system may be deployed, the extent of the 'discomfort zone' can be estimated for several source levels. The discomfort zone is defined as the area around a sound source that animals are expected to avoid. Based on these results, source levels can be selected that have an acceptable effect on harbor porpoises and harbor seals in particular areas. The source level of the communication system should be adapted to each area (taking into account bounding conditions created by narrow channels, sound propagation variability due to environmental factors, and the importance of an area to the affected species). The discomfort zone should not prevent porpoises and seals from spending sufficient time in ecologically important areas (for instance resting, breeding, suckling, and feeding areas), or routes towards these areas.

Snapshot of MMS Research on Cetaceans and Anthropogenic Presence

James Kendall,[1] Pat Roscigno,[2] and Cleve Cowles[3]

[1] Minerals Management Service
Headquarters
(703) 787-1717

[2] Minerals Management Service
Gulf of Mexico Region
(504) 736 -2752

[3] Minerals Management Service
Alaska Region
(907) 271-6617

Abstract
Initially, the Environmental Studies Program (ESP) addressed broad, general information needed to assess OCS activity compliance with the National Environmental Policy Act; that is, baseline studies or surveys. However, more specific information needs pertaining to those species given protection under the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA) began to develop. In the early ESP years, many baseline studies/surveys of protected and endangered species were conducted to develop an understanding of populations, abundance and distributions, and preferred areas for feeding, breeding and birthing. These studies helped address issues pertaining to space conflict and multiple use. Concurrent with this baseline work, research needs associated with the "potential" effects of oil and gas and marine minerals activities began to evolve. These later concerns surrounded potential impacts from sources other than oil spills and drilling discharges, such as noise and disturbance. By the mid-1980's, studies on the effects of noise on marine mammals were initiated in our Alaska and Pacific OCS Regions. In 1987, MMS sponsored a comprehensive literature review of the effects of noise, particularly focusing on the oil and gas industries. In 1992, the Office of Naval Research (ONR) provided core funding to convert this MMS report into an expanded publication: "Marine Mammals and Noise" published by Academic Press (1995).

Featured in the poster are two MMS studies which address the issues of anthropogenic presence, noise and endangered whales. The "Bowhead Whale Aerial Survey Project" is a 20 plus year effort to understand the bowhead migration and potential impacts from anthropogenic presence. The other featured study is the "Sperm Whale Seismic Survey" a multi-phased effort to get snapshot and broad views of the presence and use by sperm whales of the deep waters of the Gulf of Mexico - areas of exploratory oil and gas activities.

Active Sonar and the Marine Environment

Petter H. Kvadsheim, Erik Sevaldsen, and John K.Grytten

Norwegian Defense Research Establishment (FFI), Maritime Systems Division, Horten, Norway.

Abstract

A study of the effects of active sonar transmissions on fish and marine mammals in Norwegian waters has been launched, following ordering of new frigates by the Royal Norwegian Navy (RNoN). The objective of the study is to produce a set of recommended rules for naval sonar operations in Norwegian waters based on scientific grounds. The project includes studies of physiological and behavioral effects of sonar signals on fish and marine mammals, as well as development of a decision aid system to assure responsible operation of naval sonars within Norwegian waters.

Undersea Noise Pollution—A Challenge for Science, Governments and the Civil Society

Sigrid Lüber

ASMS OceanCare
CH-8820 Waedenswil – Switzerland
Phone: +41-1-780 66 88
E-mail: slueber@asms-swiss.org

Abstract
A growing body of evidence indicates that undersea-noise pollution can have various adverse impacts on marine life and thus constitutes a severe threat to the marine organisms and ecosystems. The intense and widespread undersea noise is an issue of increasing importance and has already been addressed by several international institutions (including IWC, IMO, ASCOBANS and ACCOBAMS).

In 2002 ASMS OceanCare founded the European Coalition for Silent Oceans and commissioned a legal analysis on the use of low frequency active sonar (LFAS) by Dr. Alexander von Ziegler, a Swiss expert in sea law. In his expert report entitled "The use of LFA Sonar under International Law" A. von Ziegler concluded that the use of LFAS violates four of the most important general principles of customary law (sovereignty over natural resources and the responsibility not to cause damage to the environment of other states or of areas beyond the limits of national jurisdiction, principle of preventive action, principle of sustainable development, precautionary principle) as well as the obligations deriving from several international conventions. In 2003 the expert report has been distributed to the relevant conventions and to the ministers of defense, foreign affairs and environment of all NATO and UN states. Reactions from numerous ministers showed concern.

Various petitions against the use of military sonar systems have been handed over to the European Parliament and to NATO. The fatal effects of sonar technology have been discussed with the NATO representatives, who since are looking into alternative methods and have intensified efforts to protect marine mammals from the hazardous effects associated with sonar tests. At the 5th UN conference on "Oceans and the Law of the Sea" an NGO delegation presented an overview of the scientific aspects, the legal arguments, and the political activities aiming at placing Ocean Noise under intergovernmental regulation.

ABR Responses in Two Species of Marine Mammals

Klaus Lucke,[1,2] Wolf Hanke,[1] and Guido Dehnhardt[1]

[1] University of Bochum, General Zoology & Neurobiology, ND6/33, 44780 Bochum, Germany

[2] Science and Technology Centre Westcoast, Christian-Albrechts-University Kiel, Hafentoern, 25761 Buesum, Germany

Abstract

Plans exist to built numerous offshore wind farms in the North and Baltic Sea, comprising several thousand windmills. The sound emitted during the construction (225+dB re 1µPa) as well as the operation of the windmills is considered to have potentially negative impact on marine mammals. Therefore an audiometric study on harbour porpoises and harbour seals has been initiated within the framework of the research projects MINOS. This study comprises measurements of the absolute hearing threshold of both species in captivity as well as of harbour seals in the wild. These data are prerequisite as a baseline for a subsequent resilience test (TTS test) of the animal's auditory system. The measurement of auditory brainstem response (ABR) is being used in this study. This method is a common tool to investigate the auditory abilities of vertebrates including humans. So far measurements have been conducted on a wild and a captive harbour seal with wideband signals at 4kHz, a male harbour seal with narrow band tone bursts of 0.125 to 16kHz, a male harbour porpoise with tone bursts of 0.3 to 2kHz and amplitude-modulated sounds of 2kHz to 22.4kHz. Thresholds were determined using a correlation technique as well as regression analysis. The resulting audiograms are in accordance with the shape of behavioural audiograms, although thresholds are shifted to higher values. Further animals are currently measured for their absolute hearing threshold and TTS measurements are in preparation. In addition, the responses of seals to broad-band click stimuli was measured comparatively on the captive and on wild animals. ABR waveforms and hearing thresholds were similar to those of the captive individual. It can be concluded that ABR measurements can become a tool for an ecological survey programme with wild-caught animals if more experience is gathered regarding the precise assessment of auditory thresholds under suboptimal conditions.

Multi-scale Impact Assessments Can Help Detect Impact, Infer its Mechanism and Consequences and Provide Tools for Management

D. Lusseau,[1,2] J.E.S. Higham,[3] S.M. Dawson,[4] and E. Slooten[2]

[1] University of Aberdeen
School of Biological Sciences
Lighthouse Field Station
George Street
Cromarty, IV11 8YJ, UK
E-mail: d.lusseau@abdn.ac.uk

[2] University of Otago
Department of [2]Zoology, [3]Tourism, and [4]Marine Sciences
PO Box 56
Dunedin, New Zealand

Abstract
Boat traffic, and particularly the traffic associated with the tourism industry, generates a significant proportion of the noise to which cetaceans are exposed because of the overlap between coastal cetacean habitat and this activity. Interactions with vessels are chronic intermittent stressors for cetaceans, but the long-term consequences of these impacts are often difficult to detect due to methodological issues. We report on the framework of a study conducted in Doubtful Sound, New Zealand which assessed the effects of boat interactions on bottlenose dolphins (*Tursiops* spp.). We tested whether the presence of boats, their type, and their behaviour, affected the diving pattern of individuals, the behavioural events observed in groups of dolphins as well as the behavioural state of these groups. We therefore looked for various short-term reactions at the individual and group levels. Combining the effects observed at these two ecological levels allowed us to infer both the mechanisms by which vessel interactions were impacting the dolphins and the long-term biological cost of these interactions for individuals and the population. We found that dolphins were more sensitive to boat presence when they were resting or socialising. We also showed that boats misbehaving increased the effect size of the impact, especially for females. We proposed a multi-level reserve to mitigate these effects based on the dolphins' spatial behavioural ecology. Adapting the management of boat interactions to reduce exposure, either spatially or temporally, during sensitive behavioural states is likely to be an efficient mitigation tool. We think that this framework could be readily applied to other situations where the detection and mitigation of anthropogenic impacts on animals is required.

Passive Acoustic Marine Mammal Monitoring Technology for Navy Ranges

Ron Morrissey,[1] Nancy DiMarzio,[1] Susan Jarvis,[1] David Moretti,[1] and Mardi Hastings[2]

[1]Naval Undersea Warfare Center, Newport, Rhode Island, USA

[2]Office of Naval Research, Arlington, Virginia, USA

Abstract

The Office of Naval Research (ONR) program, Marine Mammal Monitoring on Navy Ranges (M3R), has leveraged the infrastructure of U.S. Navy undersea ranges to develop a set of tools for passive detection and localization of marine mammal calls. Widely-spaced, bottom mounted omni-directional hydrophones are used to monitor animal calls over broad spatial and temporal scales. The tools are designed for use with diverse calls including clicks, sweeps, and whistles. Call frequency can vary from 50 Hz to 50 kHz. Calls are detected, precisely time-tagged using a GPS reference, and detection reports generated. Calls are divided in to 2 broad classes, clicks and "everything else." The Time Difference of Arrivals (TDOA) between a master hydrophone and those surrounding are calculated. For clicks, this is done directly using a data association algorithm. For all other calls, a 2-D spectrogram cross correlation is first performed. A hyperbolic tracking algorithm is then used to localize the calls. 3-D tracks are obtained for repetitively vocalizing animals. Included in the tool set are real-time displays that allow simultaneous monitoring of all range hydrophones. For installations such as the Atlantic Undersea Test and Evaluation Center (AUTEC), up to 82 hydrophones covering an area of over 500 square nautical miles are utilized. Displays for receiver detection statistics, individual receiver output spectrograms, and X-Y geo tracking displays are provided. The current detection algorithm runs on a massively parallel Digital Signal Processor (DSP). A replacement processor based on commodity Linux cluster technology is under design. This processor will reduce the cost of hardware by up to a factor of 10, making the tools affordable for a diverse set of applications.

Noise Pollution Case Study: Cetaceans in Hong Kong

E.C.M.Parsons [1-2] and S. Hung [3-4]

[1] Department of Environmental Science & Policy, George Mason University, 4400 University Drive, Fairfax, Virginia, USA. (E-mail: ecm-parsons@eathlink.net)
[2] University Marine Biological Station, Millport, Isle of Cumbrae, Scotland.
[3] University of Hong Kong, Pokfulam, Hong Kong SAR, China (E-mail: kyhung@attglobal.net)
[4] Hong Kong Cetacean Research Project, 12 Kak Tin Kung Miu Village, Tai Wai, Hong Kong.

Abstract

Hong Kong has two resident species of cetacean: the Indo-Pacific humpback dolphin and finless porpoise. However, Hong Kong is one of the busiest ports in the world, with approximately half a million oceanic and river-going vessels travelling through its waters every year, including over 10,000 transits by high speed ferries through the area of greatest humpback dolphin abundance. This shipping traffic will eventually increase, as new regular shipping routes to Hong Kong from mainland China have been proposed. Studies have demonstrated changes in dolphin behaviour in response to boat traffic, including avoidance of fast vessels.

In 1995 a sanctuary was established by the Hong Kong government around the islands of Sha Chau and Lung Kwu Chau, an area important for resident humpback dolphins. However, over 200 vessels can surround this sanctuary area at any time, and the Urmston Road shipping channel is located immediately to the north of the sanctuary. The sanctuary itself was a measure to mitigate, and compensate, for the construction of a temporary aviation fuel receiving facility off Sha Chau, the construction of which incorporated pile driving and additional boat traffic. A bubble curtain was used to try to mitigate the noise produced by the pile driving.

Adjacent to the sanctuary in the south is Chek Lap Kok airport, which when at full capacity will have over 700 planes descending and taking off daily, directly over the sanctuary and other critical dolphin habitat. The airport itself is constructed from an island which was an area frequently used by dolphins, prior to the infilling of the surrounding waters and the demolition of the island itself in 1993 to produce the airport platform; all activities involving high noise input into cetacean habitat.

In addition, there are increasing numbers of dolphin-watching vessels specifically targeting areas of high dolphin abundance. A recent land-based study demonstrated that longer dolphin dive times, and shorter periods at the surface, were recorded when dolphin-watching boats were present. Recently, small motorized boats have also been reported chasing dolphins at high speed to the south of the sanctuary area.

Cetaceans in Hong Kong are exposed to high levels of anthropogenic contaminants, their food supply is depleted, and there is evidence of some anthropogenic mortality and injury through fisheries by-catch and ship-strikes. Noise is adding another, potentially major, anthropogenic stressor to already impacted populations.

Tools for Underwater Noise Monitoring, Marine Mammals' Surveys, and Implementation of Acoustic Risk Mitigation Policies

G. Pavan,[1,2] M. Manghi,[1] C. Fossati,[1] and M. Priano [1]

[1]CIBRA- Centro Interdisciplinare di Bioacustica e Ricerche Ambientali dell'Università di Pavia, Italia.

[2]Università IUAV di Venezia, Italia
E-mail: gpavan@cibra.unipv.it

Keywords: Underwater acoustic monitoring, acoustic risk mitigation, marine mammals and noise, passive acoustics

Abstract
The concern that man-made acoustic signals can affect marine mammals has increased over the past few years, mainly within the context of low-frequency active sonars and seismic surveys. Whether it is in support of acoustic risk mitigation measures, or in the larger context of environmental monitoring, recent years have seen an increasing use of underwater passive acoustics.

Passive acoustics is a powerful tool to be used for (a) expanding knowledge about marine mammals' behaviour, ecology and distribution; (b) monitoring underwater noise; (d) monitoring critical habitats; (e) evaluating the effects of sound exposure on animals' behaviour; (f) implementing mitigation policies by detecting animals within or approaching a possibly dangerous sound exposure area.

To support the Acoustic Risk Mitigation Policies being developed by many national and international civil and military organizations a PC based Sound Analysis Workstation was designed and extensively tested to provide an affordable and flexible tool for wide band acoustic detection and monitoring. It provides detection, processing, storage and plotting capabilities and can be used for both wide area surveys and local monitoring needs.
In many years of extensive use it has been demonstrated the importance of broadband detection, continuous 24/24h monitoring and integration of visual cues to maximize detection capabilities.

The package includes software for 1) recording and analyzing sounds received by up to 8 wide band sensors, 2) manage a sonobuoys' radio receiver, 3) recording and distributing NMEA navigation data, 4) logging and classification of acoustic contacts, 5) logging visual contacts, 6) sharing data among a network of PCs, 7) plot georeferenced data on a GIS.

The research has been carried out within the NATO Undersea Research Centre's SOLMAR Project with ONR Grants N00014-99-1-0709, N00014-02-1-0333, and N00014-03-1-0901.

Environmental Stewardship: Maritime Forces Atlantic's Marine Mammal Impact Mitigation

Kyle Penney[1] and James A. Theriault[2]

[1]Formation Environment, Natural Resources Office,
Maritime Forces Atlantic,
Halifax, NS Canada
E-mail: kpenney@forces.gc.ca

[2]Defence R&D Canada – Atlantic,
P.O. Box 1012,
Dartmouth, NS Canada B2Y 3Z7
E-mail: jim.Theriault@drdc-rddc.gc.ca

Abstract
The Canadian Department of National Defence has a policy of environmental stewardship. In being mindful of the potential impact related to its operations, Maritime Forces Atlantic has undertaken an Environmental Assessment of its training activities in the Atlantic Operating Areas, created the framework of an Environmental Management System, created computer-based environmental risk assessment tools, and has drafted a "Standard Operating Procedure" on the observation of marine mammals and reptiles. This poster will present a brief overview of the effort.

Marine Mammal Monitoring and Mitigation During Recent Seismic Surveys for Geophysical Research

W.J. Richardson,[1] M. Holst,[1] W.R. Koski,[1] M.A. Smultea,[1] and M. Rawson[2]

[1] LGL Ltd., environmental research associates, POB 280, King City, Ont. L7B 1A6, Canada
E-mail: wjr@lgl.com

[2] Lamont-Doherty Earth Observatory of Columbia University, POB 1000, Palisades, NY 10964, U.S.A.

Abstract

The R/V *Maurice Ewing*, operated by Lamont-Doherty Earth Observatory of Columbia University, conducts academic marine seismic surveys sponsored by the U.S. National Science Foundation. In autumn 2002, a beaked whale stranding occurred in Baja California when the *Ewing* was operating its largest airgun configuration (20 guns; 8600 in^3) nearby. No causal link was confirmed. However, subsequent *Ewing* seismic surveys have included progressively more stringent monitoring and mitigation measures under provisions of Incidental Harassment Authorizations issued by the U.S. National Marine Fisheries Service (NMFS). ***Monitoring*** includes visual observations by trained marine mammal observers during all daytime airgun operations and during nighttime ramp-ups, when allowed. Starting in 2004, a towed hydrophone array is monitored day and night for cetacean calls when the larger airgun configurations are used. ***Pre-cruise mitigation*** includes selecting the smallest airgun array consistent with the geophysics objectives and, where possible, adjusting plans to avoid seasons and/or locations of special concern for marine mammals, sea turtles, and most recently fisheries. ***Mitigation during cruises*** includes ramp-ups, plus power-downs (to one small airgun) or shut-downs when mammals and (recently) sea turtles are detected within a "safety radius": the 180 dB re 1 µPa (rms) distance for cetaceans and sea turtles, and the 190 dB radius for pinnipeds. Specific rules determine when airgun operations can resume after a shut-down or power-down. ***Acoustic measurements*** showed that the safety radii are greater in shallow than deep water. Recently, depth-dependent safety radii have been applied, and other mitigation measures have been more stringent in shallow waters. ***Conclusions:*** No one monitoring or mitigation measure is entirely effective in detecting marine mammals or avoiding their exposure to strong airgun sounds. However, different monitoring and mitigation techniques can be complementary. In judiciously chosen combinations, they can substantially reduce the likelihood of biologically-significant effects. These benefits have costs to the seismic operator.

Canadian Environmental Legislation Impacting to Sonar R&D

James A. Theriault and Gary Fisher

Defence Research and Development Canada – Atlantic
P.O. Box 1012, Dartmouth, NS
Canada B2Y 3Z7

Abstract
Defence Research and Development Canada (DRDC) Atlantic has a number of projects which require the transmission of acoustic energy. Because of potential adverse environmental affects, a number of Canadian laws and Department of National Defence (DND) policies impact on these research activities. In particular the Fisheries Act, the Oceans Act, the Canadian Environmental Assessment Act (CEAA), the Canadian Environmental Protection Act (CEPA), and the Species at Risk Act (SARA) influence the operation of research trials. Under CEAA research activities on CFAV Quest within Canadian waters are exempt from the requirement to carry out an environmental impact assessment; however, DND policy requires that the assessment be carried out. This poster provides an overview of the relevant legislation and policies together with a description of DRDC Atlantic's approach to addressing the various concerns in its EA process.

Effects From Pile Driving Operations on Harbour Porpoises at Horns Reef Offshore Wind Farm, Monitored by T-PODs and Behavioural Observations

Jakob Tougaard,[1] Jacob Carstensen,[1] Henrik Skov,[2] Jonas Teilmann,[1] and Oluf D. Henriksen[1,3]

[1]National Environmental Reseach Institute, Frederiksborgvej 399, DK-4000 Roskilde, Denmark

[2]DHI Water and Environment, Agern Allé 11, DK-2970 Hørsholm, Denmark

[3]Stavnsbjerg Allé 55, DK-2730 Herlev, Denmark

Abstract
The world's largest offshore wind farm was build on Horns Reef in the Danish North Sea in 2002. It consists of 80 2 MW wind turbines, mounted on steel monopile foundations. The monopiles were driven into the seabed with a hydraulic hammer, a procedure generating high underwater noise levels (not quantified). Underwater acoustic alarms (AQUAmark pingers and seal scrammer) were deployed prior to each pile driving operation in order to deter marine mammals from the vicinity of the operation and hence protect them from excessive sound exposure.

Reactions of harbour porpoises was monitored by visual surveys from ship and by acoustic dataloggers (T-PODs), both inside and outside of the wind farm.

Average time from end of each pile driving operation to the first porpoise encounter recorded by the T-PODs increased significantly from the average time between encounters in periods without pile driving (from 50 minutes to close to 300 minutes). Average interval between first and second encounter after end of pile driving was not significantly larger than outside pile driving periods, indicating return to levels normal for the construction period as a whole.
Observations from ship surveys showed a significant change in surface behaviour on days with pile driving at distances up to 10 nautical miles from the wind farm. The most frequent behaviour changed from non-directional movement (presumably associated with feeding) to directional movement on days with pile driving operations.

Both data sets points to a strong and immediate effect of the pile driving operations (caused by AQUAmark pingers and seal scrammers and impact sounds from the hydraulic hammer), followed by a rapid recovery to the situation normal for the construction period. This normal situation was not undisturbed, as other, less noisy activities took place during the entire period, as well as a general high level of ship traffic during construction.
A separate, ongoing study will address permanent effects from the construction and operation of the wind farm.

The study was supported financially by the Danish National Energy Authority.

Whales and the WAXA: Defence Sponsored Whale Research off the West Coast of Australia

Colin Trinder

Director of Environmental Stewardship, Department of Defence
BP-2-B029, CANBERRA, ACT, 2600, Australia
Ph: 61 2 6266 8067
Fax: 61 2 6265 3794
E-mail: mailto:colin.trinder@defence.gov.au

Abstract
The Western Australia Exercise Area (WAXA), situated near Perth, Western Australia, is one of the primary maritime exercise areas of the Australian Defence Force (ADF). The waters of the WAXA are used extensively by ships, submarines and aircraft of the ADF, and shared with merchant shipping, commercial fishing and recreational activities such as whale watching.

Parts of the WAXA are also an important migration route for the humpback whale (*Megaptera novaeangliae*) and an aggregation area for the blue whale (*Balaenoptera musculus*). In recognition of the periodic presence of these threatened species in the WAXA, the Australian Department of Defence has sponsored and coordinated an extensive research program into the status and habits of blue whales in the WAXA. This research has been conducted in collaboration with leading researchers and government regulatory authorities.

In a wider context, Defence has also undertaken an exhaustive review of all activities carried out at sea and the way in which these activities may have an impact upon all aspects of the environment, including marine mammals. Coupled with the specific knowledge gained from the WAXA blue whale research program, Defence has developed a range of standard environmental risk mitigation measures which are employed by all ADF units operating at sea.

This poster will:

- Describe relevant geographical and biophysical features of the WAXA, including the status of marine mammals and blue and humpback whales in particular.
- Describe Defence activities in the WAXA, including history of use.
- Outline the planning and conduct of ADF activities to minimise risks to marine mammals.
- Describe Defence-sponsored whale research in the WAXA.
- Describe liaison and consultation undertaken by Defence with regulatory authorities, researchers and other stakeholders regarding protection of marine mammals.

Regulatory Authority of the States Over Acoustic Activity, With Emphasis on California

Sara Wan

California Coastal Commission
Member, Advisory Committee on the Affects of Sound on Marine Mammals
310-456-6605 (voice)
310-456-3380 (fax)
E-mail: Lwan22350@aol.com

Abstract
In the United States the Federal Coastal Zone Management Act (CZMA) designates management authority to States over federal waters off shore of the States, once a state's coastal management program is certified by the federal government. The CZMA gives state coastal management agencies regulatory control (federal consistency review authority) over all federal activities and federally licensed, permitted or funded activities affecting the coastal zone (regardless of whether they occur within, landward or seaward of the coastal zone boundary), if the activity affects the land or water uses or natural resources of the coastal zone. In California the California Coastal Commission (CCC) is the designated coastal management agency. The regulations and the regulatory processes in California under the federal CZMA and under State law (the California Coastal Act) will be discussed with respect to underwater acoustic activities. Policy evolution over the past two decades will also be examined, as well as comparisons and contrasts with procedural and policy positions taken by other states.

In addition, the discussion will include examples of mitigation requirements imposed by the States on activities that produce sound, including seismic surveys for oil and gas, geologic investigations and other research, pier and platform decommissioning, naval activities, etc.

A Regulatory Agency Perspective on Anthropogenic Noise and Marine Mammals

Judy Wilson

Minerals Management Service
381 Elden Street MS 4042
Herndon, VA 20170 USA
E-mail: Judy.wilson@mms.gov

Abstract
MMS administers about 7,500 active leases on 40 million acres of the Outer Continental Shelf (OCS). The OCS makes a significant contribution to the national energy supply, providing 25 percent of the natural gas and 30 percent of the oil produced in the United States. The MMS carries out its mission of managing OCS mineral resources through a variety of efforts: estimating national OCS energy resources; assessing environmental impacts; funding research to assess and manage impacts of activities and to monitor changes in the quality and productivity of the marine environment; leasing OCS acreage; analyzing and permitting proposed actions; inspecting operations; enforcing statutory and regulatory requirements; and providing scientific and technical assistance to other nations.

The MMS protected species program involves complying with the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA); analyzing impacts; designing mitigation, monitoring guidelines and management approaches; and providing information necessary for promulgating regulations; and identifying, funding, and participating in research necessary for the protection and enhancement of protected species and their habitat.

MMS has focused two programmatic environmental analyses (under the National Environmental Policy Act [NEPA]) on noise producing activities (seismic surveys and explosive removals of offshore structures). The programmatic environmental assessments characterize activities and the environment in which they occur, document potential environmental impacts and mitigation measures, and evaluate proposals.

To avoid or reduce the potential impacts of noise MMS, implements mitigation measures (based on NEPA analyses, ESA consultations, and MMPA collaboration) through a variety of mechanisms including regulations (30 CFR Part 250 - Oil and Gas and Sulphur Operations in the Outer Continental Shelf) that implement provisions of the OCS Lands Act (U.S. Code Title 43, Chapter 29, Subchapter III), lease stipulations, and notices to lessees (which clarify requirements addressed in our regulations).

APPENDIX 5: List of Relevant Acronyms and Abbreviations

Abidjan Convention	Convention for Co-Operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region, 1981
ABR	auditory brainstem response
ACCOBAMS	Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area, 1996
AIM	Acoustic Integration Model
APEC	Asia Pacific Economic Cooperation
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas, 1992
Barcelona Convention	Convention for the Protection of the Marine Environment and Coastal Region of the Mediterranean, 1976
Bern Convention	Bern Convention on the Conservation of European Wildlife and Natural Habitats, 1979
Bonn Convention	Convention on the Conservation of Migratory Species of Wild Animals, 1979 (also known as CMS)
Bucharest Convention	Convention for the Protection of the Black Sea Against Pollution, 1992
CBD	Convention on Biological Diversity, 1992
CCAMLR	Convention on the Conservation of Antarctic Marine Living Resources, 1980
CITES	Convention on International Trade in Endangered Species of Wild Flora and Fauna, 1973
CMS	Convention on the Conservation of Migratory Species of Wild Animals, 1979 (also known as the Bonn Convention)
CONAMA	Conselho Nacional do Meio Ambiente (Brazilian National Environmental Council)
CZMA	Coastal Zone Management Act (U.S.), 1972
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIA Directive	Council Directive of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment (E.U.), 1985 (amended 1997)
ERMC	Environmental Risk Management Capability, U.K. Department of Defence
ESA	Endangered Species Act (U.S.), 1973
ESME	Effects of Sound on Marine Environment, U.S. Office of Naval Research
Espoo Convention	Convention on Transboundary Environmental Impact Assessment, 1991

GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
Habitats Directive	Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (E.U.), 1992
Helsinki Convention	Convention on the Protection of the Marine Environment of the Baltic Sea Area, 1992
IAGC	International Association of Geophysical Contractors
IBAMA	Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renovaveis (Brazilian Environmental Agency)
ICRW	International Convention on the Regulation of Whaling, 1946
ICSU	International Council for Science
ILO	International Labor Organization
IMO	International Maritime Organization
IOC	Intergovernmental Oceanographic Commission (under UNESCO)
ISO	International Organization for Standardization
IWC	International Whaling Commission
Jakarta Mandate	Jakarta Mandate on Coastal and Marine Biological Diversity (under CBD)
JNCC	Joint Nature Conservation Committee
MARPOL	International Convention for the Prevention of Pollution from Ships, 1973
MMPA	Marine Mammal Protection Act (U.S.), 1972
NAFTA	North American Free Trade Agreement
Nairobi Convention	Convention for the Protection, Management, and Development of the Marine and Coastal Environment of the Eastern African Region, 1985/1996
NAT	North Atlantic Treaty, 1946
NATO	North Atlantic Treaty Organization
NEPA	National Environmental Policy Act (U.S.), 1969
NGO	non-governmental organization
OBIS	Ocean Biogeographic Information System, Duke University
OCSLA	Outer Continental Shelf Lands Act (U.S.), 1953
Offshore Protocol	Protocol for the Protection of the Mediterranean Sea against Pollution Resulting from Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil, 1994 (under the Barcelona Convention)
OSPAR	Convention for the Protection of the Marine Environment of the Northeast Atlantic, 1992

PMAP	Protective Measures Assessment Protocol, U.S. Navy
PSSA	Particularly Sensitive Sea Area (provision under MARPOL and IMO)
PTS	permanent threshold shift
RA	risk assessment
Rio Declaration	Rio Declaration on Environment and Development, 1992
SAKAMATA	Sea Animal Kind Area-dependent Mitigated Active Transmission Aid
SCAR	Scientific Committee on Antarctic Research (under the Antarctic Treaty)
SCOR	Scientific Council on Oceanographic Research
SEA	Strategic Environmental Assessment
SEA Directive	Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment (E.U.), 2001
SOLAS	International Convention for the Safety of Life at Sea, 1974
SOLMAR	Sound, Ocean, and Living Marine Resources
SoSuS	Sound Surveillance System, U.S. Navy
TTS	temporary threshold shift
UNCLOS	United Nations Convention on the Law of the Sea, 1982
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICPOLOS	United Nations' Open-ended Informal Consultative Process on Oceans and the Law of the Sea