Marine Mammals and Sound Workshop July 13th and 14th, 2010

Report to the National Ocean Council Ocean Science and Technology Interagency Policy Committee

Contributing Federal Agencies (in alphabetical order):
Bureau of Ocean Energy Management (BOEM)
Department of Navy (DON)
National Oceanic and Atmospheric Administration (NOAA)

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Executive Summary

The effective understanding, management, and regulation of anthropogenic noise in the marine environment is a critical and challenging goal for all ocean users, especially given that many activities important to the nation's security and economy are also large sound producers (e.g., military training exercises, offshore energy development, commercial shipping). The federal government, academia and other non-governmental organization stakeholders, have made strides in better understanding the effects of anthropogenic noise on marine mammals and, to a lesser degree, how to monitor and mitigate its effects. However, given the breadth and depth of this issue and the scientific uncertainty that still remains in many areas, it is imperative that the management of anthropogenic noise continues to be addressed collaboratively and that input and participation from all stakeholders (both government and non-government) provides the most efficient and effective management approach to conserving and protecting marine mammals.

Workshop Overview

In support of increased stakeholder participation and in following the recommendations of their own 2009 report (JSOST, 2009) on this issue, the U.S. Committee on Ocean Policy Joint Subcommittee on Ocean Science and Technology (JSOST) sponsored a July 13-14, 2010 interactive workshop with governmental and non-governmental stakeholders to solicit input on key issues related to (1) marine mammals and anthropogenic noise effects analysis and (2) monitoring and mitigation measures development. The meeting was organized and co-chaired by the Department of the Navy (DON), National Oceanic and Atmospheric Administration (NOAA), and Bureau of Ocean Energy Management (BOEM). Participants represented the marine mammal research community, including federal government, academic institutions, independent science corporations and organizations, non-governmental organizations, and industry, who had an existing understanding of anthropogenic sound and marine mammals and were active in research, policy development and other fields to address this issue. The agenda allowed for interactive discussions (rather than an emphasis on presentations) with most of the time spent in small discussion groups followed by plenary sessions. Discussions were conducted in four topical areas:

A. Biologically significant effects of sound exposure (baseline data and assessment)

B. Understanding and reducing sound generation and propagation

C. Acoustic behavioral harassment criteria and methodologies for cumulative effects analysis and mitigation

D. Improving monitoring technology and methodologies

Key Messages

This report represents a summary of the collaborative discussions in each of these areas and the primary messages and recommendations derived from the workshop. All participants were provided this report in draft for review and all notes taken during the workshop are posted on-line at: http://www.nmfs.noaa.gov/pr/permits/mammals_sound_workshop.htm.

While consensus was not the end goal, there was convergence on a number of important issues. The key participant messages are summarized below and described in greater detail within the report and its appendices. The online appendices include the summary PowerPoint presentations developed by the Section Chairs, additional comments submitted subsequent to the workshop, and a summary of the post-workshop surveys.

Long-standing recommendations reinforced again at the workshop

- **Create, populate, and maintain a web-accessible, standardized marine mammal database and portal open to all marine mammal researchers.** The database/portal should house all data products from (1) federally-funded marine mammal research and monitoring programs (including, potentially, data used to inform habitat and sound source characterizations), and (2) federally-required marine mammal monitoring data prescribed as a condition of a federal permit or authorization. Participants recommended that the federal government formally charter an interagency working group charged with planning, scoping, and resourcing (i.e., funding) this standardized database/portal.

- **Fill existing gaps in baseline biological information on marine mammals.** Though all acknowledged that this was a priority action, participants were not in consensus regarding how to support fulfilling this need, or precisely how much is needed relative to data on potential impacts. Recommendations included: (1) designating and funding NOAA and the U.S. Fish and Wildlife Service (USFWS) to serve as the primary agencies in charge of resourcing research projects; (2) investigating the feasibility of establishing a third party funding mechanism; (3) implementing a strategic planning and coordinating interagency working group that would ensure cross-agency collaboration and cooperation; and (4) enhancing and expanding existing partnerships.

- **"Fast-track" selected research areas** supported by the federal government such as quieting technologies, obtaining audiograms on sensitive species, acquiring longitudinal data on ambient noise conditions throughout the oceans, continuing and expanding Behavioral Response Studies (BRS), and developing next generation solutions for monitoring technologies.

New ideas produced at the workshop

- Explore instituting a statutory user fee system on noise producers that would fund research and development.

- Use the Navy acoustic ranges at the Atlantic Undersea Test and Evaluation Center (AUTEC), the Southern California Offshore Range (SCORE), and the Pacific Missile Range Facility (PMRF) for algorithm verification and validation (V&V) and the Navy ranges in general for testing newly developed monitoring and mitigation technologies.

Next Steps

Marine mammals and anthropogenic sound is not a new issue, and it is not surprising that the workshop yielded recommendations that for the most part have been heard before (i.e., standardized database and baseline marine mammal research funding needs). Participants (both government and non-government) did acknowledge the need to continue to focus on increased streamlining and partnering and generally think creatively about how to do more with existing resources. Participants also encouraged federal agencies to increase partnering to prevent duplication, maximize coverage and the value of each research dollar invested, and provide open and transparent access to the data by all members of research community.

Aside from these streamlining and leveraging efforts, participants strongly urged the federal government to recognize that increased, strategically-directed federal funding and commitments to the above key recommendations are imperative in achieving effective management of this issue. Further, participants encouraged the federal government (particularly NOAA and the USFWS) to take more of a sustained leadership role in advancing management of this issue by establishing clear and consistent policies and guidance regarding noise impacts; these agencies should also serve as a majority funder (with sufficient appropriations) as well as provide the overarching framework and leadership. Many participants believed that an effective and efficient balance between noise-producing activities and minimized effects to marine mammals will not be achieved without such an increased and long-term commitment by the federal government.

This report will be disseminated to the National Ocean Council (NOC) Ocean Science and Technology (OST) Interagency Policy Committee for review, consideration, and potential implementation. In addition, the report will be provided to the U.S. agencies specifically engaged in conserving and protecting marine mammals and will also be posted on-line at: http://www.nmfs.noaa.gov/pr/permits/mammals_sound_workshop.htm.

With submission of this report to the OST, Workshop sponsors will recommend support for (1) forming a multi-disciplinary working group (with participants from the scientific, regulatory, and regulated communities) charged with planning, scoping, and resourcing a standardized database for marine mammal and acoustic data; (2) convening a strategic planning and coordinating interagency working group for marine mammal research

intended to (a) track progress on research priorities identified in the JSOST report (Southall et al., 2009), (b) investigate the feasibility of establishing a third party funding mechanism for basic marine mammal research and (c) ensure cross-agency collaboration and cooperation; and (3) expand existing federal and non-federal partnerships. Finally, the Workshop sponsors will recommend establishing periodic discussion forums to address important marine mammal and sound issues, especially in light of the quick rate at which data are accumulating in this field. More details on these recommendations are included in the Conclusion section of this report.

Acronyms

ADD	Acoustic Deterrent Devices
AHD	Acoustic Harassment Devices
AIM	Acoustic Integration Model
AIS	Automatic Identification System
AN	Ambient Noise
ANSI	American National Standards Institute
ASA	Acoustical Society of America
AUTEC	Atlantic Undersea Test and Evaluation Center
BCO-DMO	Biological and Chemical Oceanography Data Management Office
BOEM	Bureau of Ocean Energy Management
BRS	Behavior Response Study
dB	decibel
DCL	Detection Classification Localization
DCLD	Detection Classification Localization Density
D-Tag	Digital acoustic recording tag
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESME	Effects of Sound in the Marine Environment Model
FAA	Federal Aviation Administration
GDEM	Generalized Digital Environmental Model
GPS	global positioning system
HITS	Historic Temporal Shipping
Hz	hertz
IMO	International Maritime Organization
IWC	International Whaling Commission
JIP	Joint Industry Programme on E&P (Exploration & Production) Sound and Marine Life
JSOST	Joint Subcommittee on Ocean Science and Technology
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
NEPA	National Environmental Protection Act
NMFS	National Marine Fisheries Service
NRC	National Research Council
NSF	National Science Foundation
NOAA	National Oceanographic and Atmospheric Administration
NOS	National Ocean Service
OBIS-SEAMAP	Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations
OOS	Ocean observing system
OPR	Office of Protected Resources
PAM	Passive Acoustic Monitoring
PBR	Potential Biological Removal
PCAD	Population Consequences of Acoustic Disturbance
PMRF	Pacific Missile Range Facility

PTS	Permanent Threshold Shift
rms	root-mean-square
SAR	Stock Assessment Report
SCORE	Southern California Offshore Range
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SEL	Sound Exposure Level
SONAR	SOund Navigation And Ranging
SPL	Sound pressure level
SPORTS	SONAR Positional Reporting System
TTS	Temporary Threshold Shift
UAV	Unmanned Aerial Vehicles
USFWS	United States Fish and Wildlife Service
VMS	Vessel Monitoring System
V&V	Verification and Validation

Introduction

Sound can be introduced into the marine environment by a variety of human activities, including shipping, commercial and recreational boating and fishing, energy exploration and production, oceanographic research, military operations, construction, and other industrial and transportation activities. Marine mammals rely on sound to communicate, find mates, navigate, detect predators, and to gain other information about their environment critical to survival and reproductive success (Richardson, 1995; Wartzok and Ketten, 1999). Adverse effects to marine mammals from sound exposure have been documented, ranging from minor behavioral modifications to permanent or temporary hearing loss or even mortality, but impacts appear to be species, situation, and context specific (see Richardson, 1995; Wartzok and Ketten, 1999; McCauley *et al*., 2000; Cox *et al*., 2006; Weilgart, 2007; Nowacek *et al*., 2007; Southall *et al*., 2007). Whether, how, and in what specific circumstances human-generated sounds in the ocean affect marine mammals has become an issue of increasing awareness, within scientific and regulatory circles, as well as among the general public.

Aside from the scientific literature, there have been a number of previous efforts to capture the important aspects of this issue and attempt to identify a way forward in both science and management. Some notable examples include:

- Advisory Committee on Acoustic Impacts on Marine Mammals: This group was convened 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 (http://mmc.gov/sound/plenary2/pdf/plenary2summaryfinal.pdf; http://mmc.gov/sound/committee/pdf/soundFACAreport.pdf).
- Joint Subcommittee on Ocean Science and Technology Report: A federal interagency roadmap for focusing and prioritizing research efforts addressing anthropogenic sound (http://www.nmfs.noaa.gov/pr/pdfs/acoustics/jsost2009.pdf).

All of these efforts have added value and advanced our understanding of this issue from scientific and policy perspectives. In some cases, these efforts have focused on priority research items or specific industry or military mitigation or monitoring recommendations. While these approaches and outcomes have been valuable and have advanced how the community addresses noise impacts to marine mammals, there is a need to look holistically at this diverse issue. The goal of this workshop was to bring together topic experts to identify collective priority actions that will advance our understanding of the issue and develop ways of minimizing impacts to marine mammals from anthropogenic sound.

Workshop Process

In early 2009, the Navy and NOAA made a commitment to the Council on Environmental Quality to convene an interactive workshop with governmental and non-governmental stakeholders to solicit input on key issues related to (1) marine mammals and anthropogenic noise effects analysis and (2) monitoring and mitigation measures

development. This goal dovetailed well with the Navy's commitment to pursue the recommendations of JSOST to convene biennial stakeholder meetings to address some of the same issues. This meeting was sponsored by JSOST and facilitated by the Keystone Center www.keystone.org. Following the announcement of the workshop, BOEM (formerly the Minerals Management Service/MMS) joined as a co-chair for the workshop. The workshop was held July 13-14, 2010, at the U.S. Navy Yard in Washington, DC.

The main objectives of the workshop were to:

- Provide an open, transparent, inclusive forum of discussion amongst marine mammal research community stakeholders (i.e., government, academic, and non-governmental),
- Receive scientific input regarding the effects of anthropogenic sound on marine mammals,
- Receive input and encourage creative discussions related to the application of science to management decisions,
- Raise awareness of ongoing marine mammal research activities,
- Receive input regarding current and future research topics, and
- Produce workshop proceedings in a government report to JSOST.

In order to best achieve these objectives, workshop organizers invited members of the marine mammal research community, including federal government, academic institutions, independent science corporations and organizations, and non-governmental organizations, who had an existing understanding of anthropogenic sound and marine mammals and were active in research, policy development and other fields to address this issue. Appendix A contains a list of invited participants and also notes the actual attendees of the workshop.

The agenda for the workshop was organized to allow for interactive discussions (rather than an emphasis on presentations) with most of the time spent in small discussion groups followed by plenary sessions to allow each group to report on their findings. Appendix B contains the final agenda. The agenda was developed by the workshop sponsors and session chairs.

The agenda was divided into four sessions or topical areas as noted below. Each session then contained numerous small discussion groups[1] that focused on addressing a specific question(s) related to that topic (see Appendix C for the complete list of questions). In addition, discussion groups were encouraged to address any other questions/topics they felt were critical to the session outcomes. Plenary sessions then followed where the small groups reported back to the larger session participants on the outcome of their discussions

[1] Prior to the workshop, participants were asked to choose two of four sessions to participate in during the workshop. The organizers then took these selections and divided participants into the smaller discussion tables (of approximately eight participants each), attempting to diversify the backgrounds within each table (i.e., a mix of government, academic and non-government).

In turn, the session chairs reported overall results to all of the workshop attendees and facilitated a large group discussion period on these outcomes.[2]

Session A. Biologically significant effects of sound exposure: baseline data and assessment
Session Chair: Dr. Brandon Southall (SEA)

(1) Basic Biological Research for Representative Marine Mammal Species
(2) Standardized Marine Mammal and Sound Database(s)
(3) Predictive Tools for Density/Distribution Estimation
(4) Behavioral Response Research for Representative Marine Mammal Species
(5) Non-Behavioral Responses to Sound
(6) Biologically Significant Impacts

Session B. Understanding and Reducing Sound Generation and Propagation
Session Chair: Dr. John Hildebrand (SCRIPPS)

(1) Sound Source Identification and Review
(2) Ambient Noise
(3) Quieting Technologies
(4) Cumulative Contributions of Multiple Sound Sources to Marine Noise
(5) Sound Propagation Prediction Tools
(6) Standardized Marine Mammal and Sound Database(s)

Session C. Acoustic Behavioral Harassment Criteria, Methodologies for Cumulative Effects Analysis and Mitigation
Session Chairs : Ms. Jolie Harrison (NOAA/National Marine Fisheries Service/Office of Protected Resources NMFS/OPR) and Dr. Leila Hatch (NOAA/National Ocean Service NOS/ Stellwagen Bank NMS)

(1) Acoustic Behavioral Harassment Criteria
(2) Masking
(3) Cumulative Impacts Assessment
(4) Mitigation
(5) Monitoring Methods

Session D. Improving Monitoring Techniques (Technology and Methodology)
Session Chair: Mr. Dave Moretti (NUWC Newport)

(1) Algorithms (by category/DCLD)
(2) Processing Hardware
(3) Platforms/sensors (Fixed/Portable)
(4) Information Sharing
(5) Current/Emerging Monitoring Technologies

[2] See http://www.nmfs.noaa.gov/pr/permits/mammals_sound_workshop.htm for verbatim notes from the note takers from each discussion group, comments submitted by notecards on last day of meeting, and session chair PowerPoint presentations for the larger group discussions. In addition, this website also includes a summary and listing of participant feedback on workshop effectiveness.

Workshop Report – Purpose and Objectives

This final report has been written to summarize the main messages derived from the workshop in a transparent and action-oriented manner. To achieve this objective, the workshop organizers summarized small group discussions and session plenary reports in the workshop report and provided verbatim notes and plenary presentations in the on-line appendices (see web address below); allowed for a review and comment on the draft report by all workshop attendees; involved the session chairs at several reviews before finalizing the report; and outlined the next steps after publication of this report to take workshop outcomes beyond mere discussion points into actual action items.

The report is divided into the preceding Executive Summary, chapters that focus on the outcomes of each of the four sessions, and a final summary of main messages and action items[3]. The report appendices (contents outlined in previous section) are accessible at: http://www.nmfs.noaa.gov/pr/permits/mammals_sound_workshop.htm.

[3] Topics presented in the report are listed in no particular order and should not be interpreted as prioritized lists.

Session A – Biologically Significant Effects of Sound Exposure: Baseline Data and Assessment

Six topics were addressed by Session A participants: (1) Basic Biological Research for Representative Marine Mammal Species; (2) Standardized Marine Mammal and Sound Database(s); (3) Predictive Tools for Density/Distribution Estimation; (4) Behavioral Response Research for Representative Marine Mammal Species; (5) Non-Behavioral Responses to Sound; and (6) Biologically Significant Impacts.

First, key recommendations and ideas addressed across all six topics in Session A are highlighted. Then, more specifically for each of the six topics, several key concepts are discussed in greater detail and a general summary of specific issues and recommendations is included in table form.

Key Issues and Recommendations

Baseline Data: There is a **critical** need for baseline biological data on marine mammal distribution, abundance, behavior (in the absence of stressors, to the extent possible), and habitat. Participants commented that these data should be obtained over sufficient time and space to understand seasonal movement patterns and changes that may occur as a function of climate change and human influences. Participants suggested that the responsibility for collecting these data lie largely with NOAA (which needs to be funded at higher levels and emphasizing more comprehensive survey methods than traditional visual surveys to satisfy this need), but that streamlined third-party funding mechanisms are also needed to leverage effort and encourage collaboration. An explicit and regularly assessed plan is needed to prioritize, program and execute the studies necessary to fill these data gaps. Communication between researchers, research program managers, protected resource managers, and even industry representatives needs to be increased and new partnerships explored. Data collected with federal funding or pursuant to federal requirements must be more readily available to the marine mammal community in standardized formats. Finally, while these are identified as critical needs, it is important to remember that research and resource management cannot occur serially, but must inform one another and progress in parallel.

Standardized Database: Participants concluded that NOAA, Navy, and BOEM should jointly create and support a central, on-line portal for authorized users to access standardized marine mammal distribution, behavior, and acoustic databases. As has been identified repeatedly, including by the federal agencies (JSOST report), the lack of funding and coordination for such a database is a major limitation that should be corrected. A permanent federal commitment should be made by the federal government to support the portal and associated databases. Cooperative agreements with academia and industry could also be used to support the effort; expanding existing databases, such as OBIS SEAMAP (Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations) should be considered. Participants did, however, note several areas of concern that need to be addressed in support of a standardized database, including: (1) some datasets are not subject to peer review (but could be identified according to differing

confidence identifiers); (2) given the varying methodologies for surveys there is no existing standardization for monitoring, information, database, etc.; (3) vast volumes of unanalyzed raw data are already available with no resources for analysis; and (4) there will always be some non-compliant data sources.

Biologically Significant Impacts: The primary consideration for determining biological significance should be impacts that can be identified to affect vital rates. At the individual level, this ultimately means changes that affect survivability or current or future reproductive success. At the population level, it is defined as changes or variance in the growth rate. Population size, structure, and range (among other factors), along with changes in the reproductive success of individuals, influence population growth rates. Some key considerations in identifying potential biologically significant impacts (i.e., those that can impact survival and reproductive success) for individuals are: displacement that affects foraging or reproduction, disruption of social bonds, vulnerable individuals, acoustic isolation, chronic exposure, and/or short-term high-energy responses. Understanding the context-dependence of behavioral responses is critical in predicting the likelihood of some of these effects (displacement, etc.); the importance of received sound level is typically overemphasized to the point of being the exclusive factor considered in impact analyses. Participants generally encouraged the continued support of behavioral response studies that consider and report contextual factors of exposure. Well-studied examples of each of these levels of effects may then be used in an integrated and more quantitative approach to assessing biological significance. Also, well-studied species may be used to represent more data-poor species, where appropriate, taking into consideration factors such as: social structure (group size), phylogeny, hearing, foraging ecology, etc., and the decision for which the species is being considered representative.

Topic I. Basic Biological Research for Representative Marine Mammal Species

Participants were asked to identify the most important basic biological data needs required to meet science requirements in the next 2-3 years. The discussions focused on getting recommendations for actions that will (1) advance our understanding and (2) improve management practices on biologically significant effects of exposure to anthropogenic sound. The exercise collected information on why the data are required, who should perform required studies, how long it will take to meet the data requirements, and the consequences of not meeting the data requirements.

Main Ideas

- NOAA, and USFWS for species under their jurisdiction, should be the lead agencies for planning and conducting basic biological research.
- NOAA (and USFWS) should be fully funded to conduct the necessary baseline biological research, but its execution should be conducted through federal-private partnerships.

New Ideas

- To address the perception of a conflict of interest associated with research funding from regulated entities (e.g. the Navy or oil & gas industry), the federal agencies

should conduct a feasibility study that reviews the current agency/industry funding strategies vs. potential separate 3rd party funding mechanisms (and their relative feasibility and cost-benefit assessment).

Specific Issues and Discussion Points

Issues	Discussion Points
Representative species	• Identify relevant species-specific contextual factors (e.g., susceptibility to predation, typical natural history factors such as migration). Consider appropriate factors when determining how to use species information in analysis tools to represent additional species: hearing, foraging and social ecology, phylogeny, group size, conservation status, migratory behavior, population trends, and the decision for why a species is considered representative.
"Baseline Data" definition	• For marine mammals, it must include: basic life history information, important habitat and how it is used, social and acoustic and behavioral ecology, distribution and abundance.
Geographic focus areas	• Concentrate research focus to ecosystems of concern: Arctic, subarctic, coastal & nearshore, high anthropogenic use areas. • Provide a framework to identify hotspots (remembering today's hotspots might not be tomorrow's hotspots). • Need baseline data to understand effects of stressors (remembering that the more data on hand, the more predictive modeling is available for similar areas (with appropriate field verification)). • Data from current stock assessment reports (SARs) can be outdated and limited (http://www.nmfs.noaa.gov/pr/sars/species.htm). • Need to understand the nature and sources of baseline ambient noise (and variance thereof) of an area first, then layer impact assessment over ambient levels (especially for coastal).
Emerging technologies and other available resources	• Use existing ocean observing systems as platforms of deployment for acoustic observation Employ additional research tools including photo-ID, biopsy, tagging, passive acoustic monitoring (PAM).
Who should do the work?	• Regulatory agencies such as NOAA/USFWS must be fully funded to gather necessary baseline data, but must also optimize effort to use the most appropriate tools and teams, which may include federal-private partnerships. • National Marine Sanctuaries are a good starting point for collecting baseline data (already in existence). Also often close to Navy ranges, so data could be compared. • Typically, focus has been on data accumulation and gathering, but much data already exist that has not been shared, integrated, or applied. It is critical to identify barriers and enable sharing and application of data.

Who should pay for the work?	• *Non consensus item:* regulatory decisions should not be based on research funded by permitted entities. • NOAA/USFWS should be funded for work, but also explore 3rd-party funding for contributions from other entities (whether voluntary or required by environmental regulations).
Long-term studies	• Need for ongoing research and long-term studies (more preventative and less reactive). Climate change is an important consideration. • Ensure appropriate budgetary framework is implemented to fully support long-term studies.

Datasets or Efforts that could help

- NOAA National Marine Sanctuaries Program
- Canada's Neptune
- National Science Foundation (NSF) Ocean Observatory Initiative
- NOAA Health and Stranding Program
- Multi-purpose Marine Cadastre Planning
- NOAA Ecological Passive Acoustic Plan
- National Environmental Satellite, Data, and Information Service (NESDIS)

Topic II. Standardized Marine Mammal and Sound Database(s)

Participants considered the proposal to create a standardized marine mammal database(s). All entities holding permits or authorizations requiring marine mammal monitoring would be required to electronically enter any data collected pursuant to the monitoring requirements into a federally-managed database that would be systematically archived, analyzed, and made available to resource managers, researchers, and the public, possibly with different levels of access. Participants considered the logistics needs required to create, maintain and utilize such a database, and how marine mammal data would be integrated with other systematically collected data.

Main Ideas

- NOAA, Navy, and BOEM should jointly sponsor and administer a systematic central portal for authorized users to access standardized data on marine mammal seasonal presence, abundance, and behavior.
- Entities required by resource protection statutes to collect marine mammal information as part of a required monitoring plan, or entities receiving federal funding to conduct marine mammal research should be required to make their data available to the marine mammal community.
- Databases would be required to meet minimum standards, which would need to be developed.

Specific Issues and Discussion Points

Issues	Discussion Points
A *single* global, standardized database is not feasible at this time (but portal possible)	• Data clearance, misuse, potential volume, and propriety issues are important considerations. • Product of the database: raw data vs. more processed end product. • Central portal would be a gateway for authorized users. • Must address different levels of data quality. • Recommend building multiple specialized databases (e.g., seasonal presence, species-specific behavior) linked through a central **portal** (also utilize all or part of some existing databases, which should be listed/evaluated for consideration).
Joint responsibility	• Requires significant, and long-term, financial and logistical commitment, with emphasis on leveraging existing efforts and building collaborations. • Effort should be co-sponsored by the federal government, specifically NOAA, Navy, and BOEM (at a minimum). • These agencies would also serve as gatekeepers establishing standards. • US government needs to commit to long term funding to support the portal and databases. A cooperative agreement between government, academia, and industry could help accomplish this. • Data management should build on existing capabilities, such as exists in the management of satellite and atmospheric data by NOAA and other parts of the federal government.
Business rules	• User guide must be produced with standards for establishing hierarchy of data quality, as well as how data are entered and managed. • Specific consideration should be made to protect the rights of researchers to publish results in a timely manner without their inclusion in the database jeopardizing these efforts. • Ground rules must include timelines for making data accessible. • A vetting process should pre-qualify existing databases.
Database(s) purpose	• Support environmental impact analysis. • Investigate long term trends in the context of impacts from anthropogenic activities. • Support real-time management of critical marine areas.

Datasets or Efforts that could help (directly or as example)

- Ocean Biogeographic Information System – Spatial Ecological Analysis of Megavertebrate Populations (OBIS SEAMAP) is a spatially referenced online database, aggregating marine mammal, seabird and sea turtle data from across the globe. The collection can be searched and visualized through a set of advanced online mapping applications.

- Cornell Bio-Acoustic Resource Network.
- The Biological and Chemical Oceanography Data Management Office (BCO-DMO) was created for NSF-funded research and manages and serves oceanographic biogeochemical, ecological, and companion physical data and information developed in the course of scientific research and contributed by originating investigators.

Topic III. Predictive Tools for Density/Distribution Estimation

This exercise sought to identify what existing or in-development tools might be used to estimate or predict marine mammal density and distribution in the under-surveyed areas of the world's oceans. As in earlier questions, participants were asked to consider standardization and quality control issues.

Specific Issues and Discussion Points

Issues	**Discussion Points**
Available Tools	• Traditional line transect surveys (to increasingly include towed acoustic arrays). • Aerial survey methods. • Small vessel observations, including photo ID and biopsy methods. • Shore surveys (includes opportunistic data such as "platforms of Opportunity" sighting programs and seismic surveys). • Tagging (e.g., long-term satellite tags). • Habitat modeling, satellite data, predictive models using remote sensing and sighting data, SeaWiFS (Sea-viewing Wide Field-of-view Sensor), NOAA buoys. • Remote-deployed acoustic sensors (existing or new systems, leveraging existing efforts particularly those within federal agencies).
Challenges	• Lack of sufficient resources to obtain coverage for all areas. • Baseline data missing for many areas and species. • Estimates often based on small sample sizes. • Large differences in detectability for different species using different methods – some observation methods are entirely ineffective for many species (e.g., visual surveys for some deep-diving cetaceans). Predictive models (e.g., habitat models) may help fill in data gaps but should be ground-truthed, such as having predictions subsequently varied by observational data.
Some tools more likely to yield accurate results	• Many applicable tools/technologies exist but different environments/situations may require different tools. • Nearshore surveys more likely to yield accurate results than offshore surveys. • Use trained Marine Mammal Observers.

	• Robust datasets (higher n) are more likely to yield accurate results. • Areas with good baseline data should be preferentially analyzed to potentially serve as models for understanding less well-studied areas. • Density estimations from PAM are possible in certain applications (http://www.creem.st-and.ac.uk/decaf/outputs).
Standardized applications and acceptance	• Cross-check of predictive models needed before use for management purposes. • Run blind comparison between predictive models for quality control. • Use known species from areas that have been surveyed, predict in unknown areas, and follow up with physical survey for verification. • Implement standardized training program for protected species observers. • Bin data based on confidence factor.
Considered national database for density/ distribution, but had concerns	• Some datasets are not accepted by peer review (though they noted that data could be binned based on differing confidence). • Methodology varies for surveys: no existing standardization for monitoring, information, database, etc. • Vast volumes of raw data available with no resources for analysis. • No money set aside to maintain a national database. • There will always be some non-compliant databases.

Datasets or Efforts that could help (directly or as example)

- Strategic Environmental Research and Development Program (SERDP)
- OBIS SEAMAP

Topic IV. Behavioral Response Research for Representative Marine Mammal Species

Participants were asked to identify the data needs for important behavioral responses to anthropogenic sound. Secondarily, participants were asked to discuss how representative species should be used for predicting behavioral responses.

Main Ideas

- Traditional means of assessing acoustic impacts on behavior have included very simplistic means that rely entirely or almost entirely on received sound levels. There is clear evidence that contextual factors (e.g., behavioral state, proximity to sound source, sound source characteristics and qualities) can be as or more important in determining behavior reactions – these must be integrated into the decision-making process.
- Behavioral reactions most likely to impact survival and reproduction are:
    - Displacement (short or long term, critical habitat, geographic forcing)
    - Social bond disruption (taxonomic variability)
    - Sensitive/vulnerable individuals/populations (critical life stages, critical times of year or locations, unhealthy animals)

    - Acoustic isolation (masking, reproductive success)
    - Chronic exposures (levels and habituation limits, habituation vs. tolerance)
    - Short term high-energy responses (fleeing at ocean surface)
    - Strandings
- Increase funding to support required baseline and applied research; streamline funding mechanisms.
- Increase communications between researchers and program managers.

Specific Issues and Discussion Points

Issues	**Discussion Points**
Behavioral response is poorly understood, context-specific, and highly varied between species	• Context–dependence of behavioral responses is a more important consideration than received level alone. • Conduct long term research to begin to better understand behavioral responses, including cumulative effects. • Ensure field research is verified. • Prioritize applied research; focus on species with known data, high-risk populations, and high-risk locations. • Problem: studies often aren't done in a way to make them comparable to one another.
Defining "representative species"	• This is difficult to define, and potentially more so for behavioral responses than physiological ones, but focus should be on both taxonomic relationships, functional similarities, and potential risk factors. • Often "representative species" are ones where data is readily availbable or are species of concern under the Endangered Species Act (ESA) or the Marine Mammal Protection Act (MMPA). • Group by factors (e.g. behavioral sensitivity, hearing, life history characteristics, predator-prey dynamics, population size and trends, size of range) instead of level of endangerment. • Having better baseline data would help determine what species are comparable and appropriate representatives for one another.
Baseline data and research (participants focused on this even within other identified topics)	• Obtain data for abundance, distribution, and movement patterns; required for density/distribution, behavioral ecology, and behavioral response to sound. • Often research is driven by funding, litigation, and regulatory needs, need to think broader, ultimate goal is species conservation. • These data are also needed for broader applications (e.g., marine spatial planning, ecosystem-based management, and natural resource damage assessment). • Expand beyond the current 2-3 year horizon, shift to ongoing data collection. • Designate NOAA and USFWS as the lead agencies for collecting baseline data. • Increase directed funding for stock assessments, distribution,

	behavioral ecology, predictive habitat modeling, targeted tow-array work. • Fund an effort to standardize and publish analysis of existing data, potentially to include a meta-analysis of multiple behavioral response studies. • Increase opportunities for communication between researchers and managers.
Applied research	• Energetic studies to quantify the costs of various behavioral reactions would be valuable. • Compare noise types: broadband continuous, impulsive, narrow band, etc. • Conduct bottom-up studies that are data rich to support larger-scale multivariate field studies. • Field verification is necessary. • Navy, BOEM, & industry, in coordination with NOAA and USFWS, should conduct targeted research focused on anthropogenic noise and understanding biologically significant effect issues.
Propagation model	• Release a publically available, accepted set of acoustic propagation models to standardize and facilitate the quantification of received sound level into impact analyses.

Topic V. Non-Behavioral Responses to Sound

This question focused on issues relating to the effects of noise on stress response and immune function. Participants were asked to identify the most important data gaps in our understanding of non-auditory tissue damage and to list important studies that are needed. Participants were also asked to consider how these studies might inform management decisions.

Main Ideas

- Need to plan/program/execute studies to fill in data gaps.
- Investigate ways to create new partnerships to start filling important data gaps in our understanding.

Highlights of new ideas

- Evaluate captive animal program data holdings for comparative studies on free-ranging animals.

Specific Issues and Discussion Points

Issues	**Discussion Points**
Advantage compared to behavioral data	• Physiological data can be more objective and tractable than behavioral data.

Priority research areas	• Sublethal physiological responses are potentially important, poorly understood, and may not be observable even with detailed behavioral studies. • Focus on immune function assays, reproductive function, metabolic assays, cardiac rate, gene expression, gene regulation related to stress response. • Need to quantify the relationship between the stressor and the stress response, which can often be difficult. • Continually investigate immune function assays, reproductive function assays, metabolic assays, etc., and explore possibility to share data. • Comparative approach: noisy vs. non-noisy area. • Understanding key elements of auditory fatigue (temporary threshold shift (TTS)/permanent threshold shift (PTS) are far from complete and are still important.
Baseline data gaps	• Focus on filling in missing baseline data needs via partnerships. • Use existing technologies (i.e. Digital Acoustic Recording Tags/D-tags) to obtain data available on behavioral responses that may relate to/interact with physiological impacts. • Increase the number of species studied and sample sizes. • Explore use of fish studies for baseline habitat assessment and predator/prey studies. • Address issues associated with multiple exposures and assessing effects.
Captive study programs	• Provide a level of control that cannot be achieved in field experiments, but must be interpreted with caution given the very different contexts. • Some are concerned that captive subjects are over-trained, i.e., responses are not representative of wild individuals. • Use as control for non-behavior research programs. • Compare captured animals to free-ranging pelagic animals applying biomarkers?

Topic VI. Biologically Significant Impacts

This question explored issues associated with establishing the definition of biologically significant impacts. Participants were asked to propose ways in which this question might be answered for management purposes, to evaluate how well the NRC (2005) recommendations to focus on impacts affecting vital rates (foraging, survival, and reproduction) match available data on behavioral effects, and to identify particular contextual factors about sound exposure more likely to result in biological significance.

Main Ideas

Participants were able to reach consensus on some items. One working group produced the following consensus statement:

> *"At the level of individual animals, changes in current and expected future reproductive success would determine biological significance; at the level of populations, changes in growth rate (lambda or r), variance in growth rate, etc. would determine biological significance. In both cases, the magnitude and direction of the change are biologically tractable; whether the change exceeds some management threshold is a policy decision."*

The groups identified contextual factors that are more likely to result in significant impacts. These factors were broken down into categories that were relevant to the population and individual animal. For population relevancy, the groups noted that population size, insularity, and level of stress response all must be considered in determining biologically significant impacts. For example, the loss of an individual in a small population is probably significant where a one loss in a larger population would not be significant. In an insular or localized population, a localized acoustic stressor may be more of a threat than for a wide-ranging population. Furthermore, a population already stressed by additional factors (e.g., sounds, contaminants, harvest, bycatch, competition or predation risk is more likely to pass a biologically significant threshold. At the individual level, life history stage (juvenile vs. mother with calf vs. male), immune status, and behavioral status (migrating, breeding, feeding) all have contextual influences on biologically significant effects.

Specific Issues and Discussion Points

Issues	**Discussion Points**
Need comprehensive and in-depth methods to assess populations	• Understanding vital rates (foraging, survival, and reproduction) is essential. • Proxy measures can help when marine mammal abundance data are not available (calving rates, mortality, age structure and survivorship). • Best tool is long-term, broad study of known individuals (i.e. monitoring). • Precaution in management is essential due to how long it takes to determine a statistically significant effect.
Highly complex variables	• The marine mammal research community is good at measuring responses but not good at interpreting data, as far as determining biologically significant effects of acute or (particularly) cumulative effects. • Cumulative impacts, including those on marine mammal overall health. • Must analyze both acute and chronic effects. • Life history cycles and overlap with critical seasons and habitat • Psychological impacts *(non consensus item).*

	• Masking impacts on foraging, reproduction, survival may be extremely important in certain areas and for certain species; these have been largely ignored to date in regulatory decision-making. Contextual factors are important to consider, particularly for behavioral responses.
Evaluation processes need improvement	• Focus on those species that have existing models for predicting the effects of acute and chronic effects. • Use "the whole package" tagging/genetics/acoustics etc., to get very full picture of range of effects and concerns. • Continue carefully planned BRS studies for populations and species where enough baseline data exists to appropriately interpret the data.
Validity of NRC (2005) recommendations	• National Research Council (NRC) metrics (foraging, survival, and reproduction) are appropriate for determining biologically significant impacts.
Data availability	• All publicly funded or government required sighting and survey data should be made available through NOAA and BOEM.

<u>Datasets or Efforts that could help (directly or as example)</u>

- Population Consequences of Acoustic Disturbance (PCAD) modeling efforts may be especially useful in developing scientific understanding of biologically significant impacts, as well as their management.

Session B – Understanding and Reducing Sound Generation and Propagation

Six questions were addressed by Topic B participants: (1) sound source identification and review; (2) ambient noise (AN); (3) quieting technologies; (4) cumulative contributions of multiple sound sources to marine noise; (5) sound propagation prediction tools; and (6) standardized marine mammal and sound databases.

First, key recommendations and ideas addressed across all six topics in Session B are highlighted. Then, more specifically for each of the six topics, several key concepts are discussed in greater detail and a general summary of specific issues and recommendations is included in table form. The detailed notes for each of the topics in Session B, as reported by each working group, are included in the on-line appendices at http://www.nmfs.noaa.gov/pr/permits/mammals_sound_workshop.htm.

Key Issues and Recommendations

Marine Mammal and Sound Database: Participants recommended that a federal Interagency Working Group be chartered to plan, scope, and resource a standardized database to house not only marine mammal data (which has been addressed in other sessions), but also sound data (i.e., sound source characterizations, ambient noise measurements, source verification data, temporal-spatial indicators of sound source use, etc.). Additionally, a global ambient noise model that is longitudinally designed to accommodate global changes should be built and housed in or through the standardized database. Related to the sound piece of a standardized database, but also more generally, participants recommended that the government make a decision regarding which federal Agency (or agencies) are responsible for monitoring sound in the ocean and set up mechanisms for interagency cooperation.

In addition to the data and comprehensive database recommendations, several topics that could potentially be addressed with a federal policy determination were identified:

- Establish a cross-agency funding/strategic planning framework to fast-track quieting technology research and development efforts.
- Conduct joint behavioral response studies (BRS) to fast-track our ability to analyze cumulative and multiple source exposures.
- Invest in developing databases to support improvements in analyzing sound propagation in heterogeneous environments.
- Focus research on obtaining audiograms for sensitive species.
- Renew focus on recruiting and training for acoustic expertise.

Topic I. Sound Source Identification and Review

Participants evaluated a spreadsheet (see http://www.nmfs.noaa.gov/pr/permits/mammals_sound_workshop.htm) which listed the types of anthropogenic sound contributing to the ocean soundscape, U.S. federal acoustic data holdings, the adequacy of the sound characterization in the data holdings, and whether there are data holdings available outside the federal government that might provide valuable information.

Main Ideas

- Expand/refine/reorganize list of anthropogenic sound sources.
- Provide access to the research community to relevant databases.

New Ideas

- Establish a mechanism for addressing sound exposure from foreign (military) vessels operating in US waters.
- Require all commercial vessels to carry AIS (Automatic Identification System).
- Establish a global ocean ambient sound database.

Specific Issues and Discussion Points

Issues	**Discussion Topics**
Missing or incorrect information in the table provided for review	• Reorganize sound source table in a more coherent fashion. • Table needs to include spatial scale (geographic). • Delete use of "soft" definitions such as 'chronic vs. acute' and replace with 'peak vs. accumulative energy level'. • Establish noise standards for each source.
Data needs for individual sources	• For all categories, include where, when, how, and sound characteristics.
Data needs for broad source types	• Establish a global ocean ambient sound database across the federal agencies. • Refine Large Ocean-going Shipping Category to separate bulk carriers, tankers, container ships etc. Ship speed is also important. • Add all military vessels (U.S. and foreign) by class. • Divide seismic category into large arrays (currently used exclusively for mineral surveys) and small arrays (mostly used in scientific research and small construction operations). • Add mid-size coastal vessels (i.e., tugs, barges). • Add ice management and ice breakers. • Add fishing vessels with Acoustic Harassment Devices (AHD), Acoustic Deterrent Devices (ADD), and seal bomb categories. • Add additional sound category (i.e., multi-beam SONAR, bottom penetrating echosounder).

	• Add categories for navigational SONAR, acoustic modems, fish finder SONAR. • Under construction/industrial, add a subcategory for harbor activities. • Establish specifications for radiated sound (e.g., how much a whale watch boat is allowed to produce). • Develop knowledge on pile driving/ predicting sound channel presence/absence.
Access to relevant datasets	• U.S. Coast Guard's Vessel Monitoring System (VMS) to allow analysis for fishing vessel impacts. • Lloyd's Register and International Maritime Organization (IMO) databases for insured vessels.

Topic II. Ambient Noise

Participants evaluated the state of the science regarding ambient noise (AN) data holdings, requirements for longitudinal studies and data standardization, establishing priority study areas, and how AN data should be used for management purposes.

Main Ideas

- "Ambient Noise" needs to be concisely defined by the community. Workshop attendees noted different definitions, ranging from "all non-anthropogenic sources", "includes shipping and commercial sources", and "every source other than what is regulated".
- Establish a centralized, standardized AN data repository.
- AN data are required longitudinally both temporally and spatially.

Highlights of new ideas

- Extrapolate AN values from Historic Temporal Shipping (HITS) and AIS data.
- Use the Generalized Digital Environmental Model (GDEM) database to build a similar database for AN.
- Have the companies and organizations currently conducting monitoring activities exchange data holdings- the resulting database would be significant.

Specific Issues and Discussion Points

Issues	**Discussion topics**
Need for standardized data collection and housing	• Identify a systematic data format for AN. • Establish a centralized data repository. • Standardize reporting requirements (i.e. power spectrum densities averaged over specific time windows). • Optimize data collection for specific projects/species/sound sources.

	• Establish a standard for measurement procedures (e.g. to reduce artifacts such as flow noise). • Couple AN data with noise modeling.
Longitudinal monitoring	• Needed to support environmental impact assessments comparing operational noise to ambient: o historical o long-term o regional o seasonal o annual • Needed to establish global baseline levels. • Query the Navy to see if it holds releasable AN data.
Data availability	• Establish a centralized database on global AN levels. • Resource sponsors should require researchers and data collectors to make raw and processed data available to the research community.
Prioritized areas of concern	• Areas with high human use including noise and non-acoustic stressors: oil, gas lease areas, major ports, coastal areas with high marine mammal diversity & density/high shipping rates. • Areas of sensitivity based on species at risk.
Ambient noise management context	• AN levels must be measured to determine contribution of proposed actions and to evaluate potential harassment. • Sound propagation and reverberation. • Natural sounds (e.g., lightning, snapping shrimp, wind, rain) • Temporal & spatial components: o Transient or permanent o Distant or close o Moving vs. stationary

Topic III. Quieting Technologies

Participants were asked to consider quieting technologies for anthropogenic noise relating specifically to shipping, seismic, pile driving, and SONAR.

Main Ideas

- A framework for research funding and a coordinated approach is needed, focused on developing technologies that can be applied across the range of sound sources.
- Different strategies of quieting are needed for those sources that produce noise incidental to operations (e.g., shipping) vs. those that produce sound for a particular purpose (e.g., seismic and SONAR).

New Ideas

- Employ a user fee system to fund research and development.

Specific Issues and Discussion Points

Issues	Discussion Topics
Behavioral significance	• Develop technologies that affect duration and frequency content. • Metrics for behavioral significance must be considered to prioritize quieting technology efforts.
Current research funding mechanisms	• Establish a research framework for supporting quieting technologies. • Develop incentive programs to advance this branch of research and development. • Consider noise budget banking (e.g. cap and trade); user fees could be used to fund research.
Alternative technologies	• Joint Industry Programme (JIP) report on reducing noise from oil and gas activities[4]. • As an alternative to seismic air guns, develop marine vibroseis technology (non-impulsive signature but masking could become an issue); Okeanos 2009 workshop[5]. • For SONAR, explore signal modification with lower intensity tradeoffs. • For pile driving, develop bubble curtains and muffling (e.g. cofferdams, pile caps). • For noise from commercial shipping, options are available; incentives might drive more use. Focus on propeller cavitation.

Topic IV. Cumulative Contributions of Multiple Sound Sources to Marine Noise

Participants considered how operators and regulators can better evaluate multiple sources and their cumulative contributions to the marine environment.

Main Idea **-** Physics is available to calculate an accumulated soundfield (if certain temporal and spatial assumptions are made), estimating the exposure of an animal is more difficult, but the biological science is not sufficiently advanced at this time to support the context-specific analysis necessary to predict the animal's response.

[4] http://www.soundandmarinelife.org/Site/Products/NCE07-001_TreatmentsForUnderwaterSoundFromOil.pdf

[5] http://www.okeanos-stiftung.org/assets/Uploads/Airgun.pdf

Specific Issues and Discussion Points

Issues	Discussion Topics
Best available science	• Need to determine how to best evaluate multiple sources and their contribution to the cumulative noise environment. • From a physics application, sum up received levels at the animal. • Extremely complex from a biological perspective: analysis must include behavioral aspects including recovery time, habituation and/or tolerance, sensitivity, context, audiogram, stress response level. Today's state of science does not support this (e.g., difficult to define "representative species"). • Regulator should define metrics (e.g., different metrics may be needed for different situations). • Research audiograms are required on multiple species to advance our understanding of hearing sensitivity.

Topic V. Sound Propagation Prediction Tools

Participants considered sound propagation prediction tools and their availability to resource managers and the public. The group was asked to evaluate their ease of use, output accuracy, and whether the modeling validation was sufficient.

Main Ideas

- Research community needs to focus on recruiting and training new analysts.
- The community should invest in developing databases to support improvements in sound propagation analysis.
- One important note – the quality and quantity of available sound source characterization data directly affect the output quality of any sound propagation model.

Specific Issues and Discussion Points

Issues	Discussion Topics
Analyst expertise and training	• Agencies need to have technical expertise: Focus on recruiting and building analyst capacity. • Platforms such as AIM (Acoustic Integration Model) and ESME (Effects of Sound in the Marine Environment Model require a skilled operator. Further, bothof these models have other primary purposes in addition topredicting sound propagation.
Output quality	• Improve input quality/spatial and temporal data resolution. • Improve modeling in problematic scenarios such as shallow water low frequency propagation, high resolution 3D, rough scattering, reverberation, and impulsive sources.

	• Avoid averaging/use deterministic forecasts or hindcasts. • Invest in databases for full predictive systems.
Verification and Validation	• Improve model outputs in heterogeneous environments by collecting and processing more high quality data.

Topic VI. Standardized Marine Mammal and Sound Databases

Participants considered a proposal to establish a standardized marine mammal database that would systematically archive and serve data to resource managers, researchers, and the public.

Main Idea - Charter a federal interagency working group to plan, scope, and resource a standardized marine mammal and sound database.

Specific Issues and Discussion Points

Issues	**Discussion topics**
Logistical roadblocks (funding, housing, maintenance, standardization, management)	• Charter an interagency working group to determine how to pay for and house, this type of database. • Create ANSI/ASA (American National Standards Institute/Acoustical Society of America)-like standards to characterize sounds from air guns, shallow water industrial activities, and other anthropogenic sound sources.
federal datasets that should be made available	• Need to "mine" older datasets to get more accurate baseline. • Navy SONAR Positional Reporting Systems (SPORTS). • US Coast Guard AIS. • Navy Arctic acoustic measurements from the cold war era (currently classified). • Seismic exploration data from BOEM

Session C – Acoustic Behavioral Harassment Criteria, Methodologies for Cumulative Effects Analysis and Mitigation

Five topics were addressed by Session C participants: (1) Acoustic Behavioral Harassment Criteria; (2) Masking; (3) Cumulative Impacts Assessment; (4) Mitigation; and (5) Monitoring Methods.

First, key recommendations and ideas addressed across all five topics in Session C are highlighted. Then, more specifically for each of the five topics, several key concepts are discussed in greater detail and a general summary of specific issues and recommendations is included in table form. The detailed notes for each of the topics in Session C, as reported by each working group, are included in the on-line appendices at http://www.nmfs.noaa.gov/pr/permits/mammals_sound_workshop.htm.

Key Issues and Recommendations

Several key ideas and recommendations were recorded across the working groups that addressed this topic. Formalizing frameworks to strengthen links between data needs, especially baseline data, and application of data in management contexts figured prominently among the responses. Summarized recommendations included:

Methods for Establishing Behavioral Harassment Criteria: Participants broadly acknowledged that the acoustic behavioral harassment criteria do not determine the overall level of impact- physiological stress and other factors also need to be considered. They also noted the importance of behavioral context (e.g., age, sex, previous experience, behavior at time of exposure) and the acoustic environment (e.g. signal to noise ratio (SNR)) when considering the potential consequences of an acoustic exposure (versus considering received level alone). Different assessment protocols could be used for different exposure types (contexts). The following factors were also considered important in the development of Criteria:

- While the majority of existing behavioral data include sound pressure level (SPL) (and not sound exposure level [SEL]) measurements, the duration of exposure is important in predicting responses to sound and data collectors should be asked to either measure received SEL, or incorporate duration of exposure in another ways, so that the duration metric can be more effectively incorporated in future Criteria.
- Dose curves are considered more likely to realistically predict a marine mammal's response to a sound exposure than a single step function, but dose curves are more difficult to calculate and apply, both for applicants and regulators. A series of step-functions derived from a single dose curve could capture the dose-related nature of a predicted response, while providing a functionally more simple and usable tool.
- One group recommended a Criteria methodology intended to incorporate context by using a matrix that would bin response prediction by: taxa (groups known to respond similarly behaviorally); activity type; and geographic areas.

Incorporating Masking Impacts: Knowledge of existing sound levels, on a regional and seasonal basis, is critical to evaluating the effects of masking on marine mammals. Given that knowledge (which is available only in limited areas), the tools to effectively model masking (via the characterization of the reduction in the available sound space based on an animal's hearing and vocalizations and the sound sources operating in the area) are currently available for use in management decisions. Acknowledging the probable links of masking impacts to vital rates, additional assessment of functional consequences to populations are needed, where possible (e.g., North Atlantic right whales). However, the community cannot, and need not, wait for results from long-term population effect studies to manage the reduction of masking impacts, and conservation efforts should prioritize populations already heavily impacted by multiple stressors and/or where the effects of masking are particularly strong given communication, behavior, or ambient noise (e.g., chronically low SNR).

Assessing Cumulative Impacts: The ability to quantitatively assess cumulative impacts is dependent upon how much data at the individual level are available for translating to vital rates. The participants emphasized that a cooperative, inter-disciplinary approach to hierarchically ordering research needs and then designing methodologies for data collection and analysis, will be critical to understand cumulative impacts. Given the necessary baseline information, multivariate modeling approaches are available and could be applied to well-studied marine mammal species/populations to quantitatively predict cumulative impacts. For example, output could be presented in the form of "an increase of X% in stressor is predicted to result in Y% change in vital rate", or output could be a relativistic ranking of cumulative impacts.

Importance, Prioritization, and Organization of Baseline Data: Baseline data are critical for any sort of impact analyses (sound-based or multi-stressor-based) used to support management decisions, and the participants broadly acknowledged that adequate baseline data are currently lacking in multiple areas (e.g., marine mammal abundance, density, and distribution, sound fields, and additional ecosystem parameters such as prey fields that are critical to understanding marine mammals' life histories). To date, research efforts have not necessarily been geared to address knowledge gaps that would best inform management decisions, and smooth mechanisms for coordination and exchange of information do not yet exist. To address this, federal agencies need to pro-actively and collaboratively plan and prioritize to best fill data gaps. A cooperative effort between the scientific community and government is also needed, since researchers often have interests that do not overlap with the data most urgently needed by regulators or permit applicants. Additionally, care must be taken to not spread limited government support for gathering data too thinly. Fewer more collaborative studies with clear links to management needs across multiple agencies may be more beneficial than more individual studies that address narrowly-defined single agency mandates or focus on questions less clearly linked to resource management or impact assessment.

There was broad agreement that it would be beneficial to establish a universal strategy/framework for data collection and storage that offers better access and utility for meta-analysis (this concept could apply to all data, or data that are specifically required

through regulatory processes). A recommended mechanism for achieving this requirement is to convene a small panel of experts, who would formulate a data collection and storage strategy.

Monitoring Required for MMPA Compliance: Marine Mammal Protection Act (MMPA) Incidental Take Authorizations (ITAs) require a large amount of marine mammal data collection through monitoring. This required data collection has the potential to significantly augment the broader "research needs" referred to above, if managed correctly. However, in the past, NMFS involvement in monitoring plan development prior to the submission of an application has been limited and monitoring plan review has typically been very project-specific. Participants broadly supported the idea of NMFS organizing/convening a nation-wide panel to identify and prioritize monitoring goals (specific to the MMPA regulatory compliance context). These goals would then serve as a planning/reviewing tool for MMPA ITA applicants and regulators.

Topic I. Acoustic Behavioral Harassment Criteria

Participants were asked to think creatively about alternative methods (with their pros and cons) for structuring and implementing acoustic criteria for behavioral harassment, and specifically to consider how to best take contextual issues other than received level into account. Participants chose to additionally address some more specific issues around which disagreement has risen in the past, such as appropriate metrics.

Main Ideas

- Models for assessing behavioral harassment (take) should at the very least consider: 1) amount of time exposed 2) frequency 3) repetition rate of source 4) context of sound source 5) signal characteristics, and 6) predisposition of animal.
- For predicting marine mammal behavioral responses to sound current data availability dictates use of SPL. However, NMFS and BOEM encourage the additional use of SEL in the future and suggest requiring those data be collected.

New Ideas

- To predict behavioral responses, develop a matrix framework that incorporates context by categorizing species, activities, geographic areas to develop a series of step functions based on available literature documenting behavioral links.

Specific Issues and Discussion Points

Issues	**Discussion Points**
Appropriate metrics: SPL root-mean-square (rms) vs. SEL	• Most behavioral data (e.g., historic data) are only available in SPL decibel ($dB_{rms)}$ metric, and not SEL. • SEL considers total acoustic energy accumulation (which reflects the duration of exposure), along with level of exposure. This may be an important consideration for behavioral disturbance. • Use of the SEL metric is not the only way that duration of exposure can be considered in assessment frameworks.

	• In order to have meaningful comparisons (i.e., predict a response in given circumstances based on past observed responses) data need to be in similar metrics. • Future data collections should consider gathering and reporting data in various metrics.
Use of Dose function vs. Step Function[6] based on Received Level	• Using a dose function to predict the varying responses of marine mammals exposed to wide range of acoustic levels is more realistic than using a step Function, which predicts that all individuals will respond in a certain way if exposed above one specific level (the threshold), and will not respond if exposed to any level below the threshold. • Regulators could consider deriving a single continuous dose curve with several step functions binned within the curve to trigger/facilitate regulatory decision-making, compliance, or mitigation. In addition to the fact that literature could potentially be used to support any one step, a series of step functions approximating a dose curve is technologically easier to produce and use (for both applicants and regulators) than a continuous dose curve. • Participants thought that NMFS should move away from using a single step function for predicting MMPA takes. Some participants suggested that NMFS require modeling for takes using a dose function in order to get a permit. • Additionally, as noted in introduction, received level is not the only factor that effects how a marine mammal responds to an acoustic exposure and impact assessments should consider other known contextual factors.
Use of standardized isopleths for different activities/depths/bathymetry vs. estimating sound field project by project.	• Estimation of sound fields need be done on a case-by-case basis, since every project will have different source characteristics; modeling should take into consideration variability of all input types to include depth, bathymetry, season, ship track etc. Alternatively, similarities between sound fields produced exist across certain activity types, given similar enough geographic region/depth. Standardized isopleths would reduce the variance between estimated isopleths that arises through different measurement methodologies and be easier for less sophisticated applicants to calculate.

[6] A dose function depicts risk or probability of behavioral disruption varying over a range of received levels, as opposed to a step function where levels above the threshold result in disruption and levels below the threshold do not (e.g., 120 and 160 dB_{rms}).

Additional factors (other than received level) for consideration in assessments	• Consider at a minimum: time of exposure, duty cycle and pulse length, frequency (in hertz/Hz), peak level, quality (kurtosis or "peakedness" peak level, and context of individual during exposure. Regulators should create guidance parameters for each factor and those collecting data through research or monitoring should try to provide information on as many of these factors as possible. • For permits, applicants should estimate all parameters so that the Regulator can assess which parameter is the most salient variable for that activity. • Both the behavioral context of the individual and ambient noise levels are particularly important in determining behavioral impacts of sound exposure. Consider using different assessment protocols for different exposure types. • Place long-term events with the potential for chronic effects in a different permitting class than short-term events (e.g., different types of exposures may require different assessment protocols). • The more complex exposure models become the more difficult they become to utilize (e.g., increased computation time). • Need to ensure encapsulating complexity in decision-making framework, while also accounting for uncertainty and providing consistent and tractable justification for decisions.
One suggested alternative acoustic behavioral harassment criteria methodology	• Develop a matrix framework categorized by Species or taxa (based on behavioral response similarities such as deep divers), Activity type (e.g., shipping, SONAR, Seismic). Geographic area or distance from shore, which could be surrogate for context, in some cases. • Based on available data, either a step function or dose curve could be applied within each cell of matrix (taxa, activity, geographic) to predict behavioral responses of that taxa in those circumstances. • This framework would help identify data gaps. If data gaps exist (i.e., empty cells in matrix), appropriate representative surrogates would need to be identified to predict responses in those circumstances.

Topic II. Masking

The 'Masking' discussion covered questions on how to quantify the biological consequences of signal masking, particularly as it affects communication, locating prey, avoiding predators, and hearing environmental cues. Participants also discussed how to manage methods for achieving reductions in ambient noise from anthropogenic sources that are changing the acoustic ecology for marine mammals.

<u>Main Ideas</u>

- Good baseline sound budget information for an area is critical to support effective risk analyses.

- Conservation priority should be given to populations already heavily impacted by multiple stressors and/or where effects of masking are particularly strong given communication behavior/ambient noise (SNR) etc.
- Although likely links between masking impacts and vital rates were acknowledged, more assessment is needed of functional consequences for populations where this is possible (e.g. North Atlantic right whales).

Specific Issues and Discussion Points

Issues	**Discussion Points**
How masking effects can be modeled	• Model net background changes in the acoustic environment, across the range of activities (e.g., establish noise budgets), and compare with long-term population trends. • Good baseline information on ambient noise is essential. • Develop an index of ambient noise, based simplistically through sensor-based monitoring. The index could cover both seasonal and longer terms scales. • With a developed index, the environment could be modeled based on forecasted changes in activity levels.
Identify masking hotspots	• Define as areas that currently have high activity levels (e.g., shipping lanes). • Use these hotspots as areas to first advance our understanding of masking.
Identify biological impacts	• Biological impacts include (1) reduction (partial to complete) in environmental perception, (2) reduction (partial to complete) in communication, and (3) annoyance. • Need to consider how the animal perceives a sound and its saliency, which goes beyond simple detection (e.g., hearing). • Need to develop measures that would be used to qualitatively assess individual reproduction, longevity, and survivability. • Need more assessment of functional consequences for populations (e.g., requires long-term studies), however, however protective measures implementation should not be stopped while results for these studies are obtained. • Priority should be for those species/populations already impacted by multiple stressors and/or effects of masking are particularly strong. • Could extrapolate from terrestrial animal studies.
Management recommendations	• Assume that some level of negative impacts from noise exposure is occurring. • Understanding acoustic impacts is logistically difficult and time-consuming through standard scientific experimentation, and waiting to observe negative population trends could result in irreversible harm.

	• Precautionary approach is appropriate. Interim measures might include reducing noise levels from ships and capping ambient anthropogenic noise. • Conservation status of each species and stressors other than sound exposure, in addition to noise (e.g. cumulative impacts) should be considered in predicting risk tolerance.

Topic III. Cumulative Impacts Assessment

The cumulative impacts assessment question was posed to generate discussions on how animal responses can be analyzed within a spatial-temporal context of both acute and chronic stressors. Context in this issue was noted to include noise, chemical pollution, food abundance, mating opportunities, and transient vessel activity. Participants were asked to identify additional data that might be collected in the course of marine mammal research or acoustic monitoring projects that could be used to inform cumulative impact assessments.

Main Ideas

- Multivariate modeling and mapping approaches are available to incorporate noise in relativistic ecosystem models and can quantitatively assess cumulative impacts. However, these efforts are limited by the amount of data available that can be translated from effects on individuals to changes in vital rates.
- NMFS stock assessments should be modified/augmented to include more comprehensive examination of stressors (including previous, but no longer present, exposures).

Specific Issues and Discussion Points

Issues	**Discussion Points**
Cumulative impact definitions	• Use Environmental Protection Agency (EPA) definition, which includes the both single and multiple action analysis of cumulative impacts. EPA (US Environmental Protection Agency) (1999) Consideration of cumulative impacts in EPA review of National Environmental Protection Act (NEPA) documents. Office of Federal Activities (2252A) EPA 315-R-99-002/May 1999 www.epa.gov/compliance/resources/policies/nepa/cumulative.pdf).
Science *and* management	• Science- "what is the effect of stressors?" Management- "how much is too much?". • To determine "how much is too much?" extrapolate from effects measured in well-studied populations, utilize Potential Biological Removal (PBR) framework, or use other relativistic ranking. • Modify NMFS stock assessments to include a more comprehensive examination of stressors (including noise). • Manage ecosystem by regions and populations for survivorship etc. • Context is critical: noise pollution, abundance of food, mate availability, chemical pollution, new transient vessel activity and

	many other things (e.g., natural vs. anthropogenic stressors; chronic vs. acute stressors). The key is how to best integrate (e.g., identify potential connections) all this information to better represent the multi-stressor environment in which an individual is exposed. • Prioritize "unknowns" to complete the life history picture (e.g., migratory species). • Cumulative effects must deal with particular stock or population – what are their temporal and spatial domains? • Stocks cannot be defined by political boundaries – must have global understanding of species. • Management has to decide if unknowns are within realm of acceptable risk and/or employ appropriate precaution. • Look at cumulative in terms of adapting to the future. • Long-term anthropogenic activities need to be monitored over long periods of time to really understand longer-term impacts.
Achievable goals and available data: "models based on well-studied populations"	• Analyze to the individual level for populations where individual encounter histories are used to estimate vital rates such as survivorship and fecundity using the stressors as covariates in a mark-recapture modeling framework. • Use well studied populations as case studies (e.g., elephant seals, resident killer whales, Sarasota dolphins, North American right whales; populations selected for Population Consequences of Acoustic Disturbance [PCAD] working group or International Whaling Commission [IWC] Pollution 2000+ work shop). • For populations that can reasonably use inferences from this model, hold all other variables constant except the stressor of concern. • For populations that cannot reasonably use inferences from this model or are lacking in data, apply multivariate approach to model the effect of the variable with assumed relationship to vital rate. • Output would be an increase of X% in stressor predicted to result in Y% change in vital rate for both modeling approaches. • To address ecosystem-based goals or for data-poor situations, map distribution and stressor intensity in the region or ecosystem and use a qualitative framework (i.e. expert based opinion) to weigh habitat and species vulnerability. Output for this approach would be a relativistic ranking of cumulative impacts (i.e. Halpern et al 2008, Johnson et al Biological opinions).

Topic IV. Mitigation

The "Mitigation" discussions examined typically employed measures such as exclusion zones, monitoring, power-down/shutdown, and ramp-up, which are used to avoid exposing animals to sound levels associated with TTS, PTS, and severe behavioral responses. Participants were asked to consider whether these measures are thought to be effective, how studies to measure mitigation measure effectiveness might be designed, how standard

measures used today might be improved, what potential effects today's measures miss, and the pros and cons of focusing mitigation measures primarily on avoiding very high levels/close distance versus avoiding other less severe impacts that are more widespread. Participants also considered how to best incorporate information about noise exposure into management decisions, and how to design studies that investigate suspected associations such as SONAR and stranding events.

Main Ideas

- Early in planning (e.g., initial scoping/site planning, Marine Spatial Planning etc.) is often the best time to incorporate spatial and temporal modifications and technology advances (quieting) to minimize and/or avoid marine mammal harassment.
- Need better access to propagation modeling tools to get better predictions of noise exposure and need more source verification in field to support modeling.
- Need new tools in addition to visual detection, including passive acoustic, to improve mitigations like shut-downs in response to presence of animals (i.e., real time, localization).

Specific Issues and Discussion Points

Issues	**Discussion Points**
Evidence that current mitigation measures work	• Need to start by compiling information on what types of mitigation are available (e.g., geographic/temporal vs. source-based mitigation). • Expand on known evidence for baleen whale horizontal avoidance of seismic activity.
How to design effectiveness studies	• For ramp-up: determine orientation and range of animals before and after ramp-up procedures; experimental studies. • For Mitigation monitoring: have multiple monitors observe/report independently (without consulting each other), compare end result, and allow scientists to assess reports. • Ship movement towards shore potentially herding animals: tag animals and use a global positioning system (GPS) to track animal and ship movement; test ship movement toward and away from shore.
Improve/augment measures	• Need new tools in addition to visual detection, including passive acoustics (e.g., real time detection and localization). • Explore using active acoustic measures to detect animals (evaluate effectiveness of detecting animals within safety zone and evaluate effectiveness of limiting impacts to animals). • In addition to increasing tools for mitigation, there also needs to be increased training on effectively utilizing these tools (e.g., need skilled users).
Acoustic exposure conditions of concern	• Migration corridors (where source is in corridor matters [e.g., center of corridor vs. edge). • Sounds that simulate sounds associated with a direct threat (e.g.

	killer whale in beaked whale habitat). • Need to further identify what these are.
General issues	• Raw monitoring data (not just reports) should be publicly available. • Monitoring (i.e., data collection/reporting) should be standardized. • Monitor before, during, and after activities. • Near-source real time mitigation must be balanced with long-term planning mitigation. • Early in planning is the best time to incorporate spatial and temporal modifications or technological advances (e.g., use of quieting technologies) to minimize and/or avoid marine mammal harassment. • Range/orientation to ship should be recorded on monitored animals.

Topic V. Monitoring Methods

The monitoring methods question was designed to explore how monitoring studies, as required by the MMPA (vs. the broader research discussed above), should be designed and prioritized in order to better understand acoustic signatures and acoustic behavior or sources and species, and to provide information that will help fill identified data gaps.

Main Ideas

- NMFS should organize a nation-wide panel to prioritize monitoring goals (for regulated entities) that includes all groups and agencies that will use the data after the fact or regulate.
- In order to detect or identify any sort of impact or change that might result from a stressor, baseline information is first needed. Baseline research should be proactively pursued by all (not just as requirement of NOAA) and agencies should collaborate to identify and fill data-gaps.

Specific Issues and Discussion Points

Issues	**Discussion Points**
Standardized protocols, recording, reporting	• Establish standardized monitoring protocols, recording procedures, and reports. • Ensure baseline data are collected for comparison (e.g., best way to identify change). • Institute longitudinal studies to identify and document trends and responses to specific activities. • Agency collaboration would probably yield existing baseline databases that could be used for monitoring studies (e.g., nation-wide program or region-specific effort). • Acoustic Monitoring is cost effective and has great potential, but

	should be used in conjunction with visual monitoring. • Monitoring should be viewed as a proactive approach and not just a required activity.
Information needs	• Use acoustic monitoring to develop comprehensive baseline data; incorporate into existing Ocean Observing System (OOS) databases. • Perform regional, focused studies and incorporate results into a nationwide ongoing study building towards a complete baseline dataset. • Build some fine-scale study of specific populations. • Better propagation models/tools are needed to get a better prediction of noise exposure. Source level verification and model validation in the field are needed to support models/tools. Focus should be on activities where opportunities are present to gather information. • Ensure appropriate surrogate site selection in order to get sound stock assessments.
Programmatic needs	• Sound propagation from shipping sources: develop a monitoring program to assess areas where coastal shipping noise levels have elevated to a point of having an environmental impact. • Improve current understanding of anthropogenic sources to bound options for regulation improvement. • Build cooperative efforts with industry to establish long term efforts associated with the commercial and industrial activities.
Need for national monitoring strategy	• NMFS should convene a panel of experts to design a national monitoring strategy. • Establish a common language and ensure consistency in use. • Include members of the groups and agencies which will be using the data and regulating the activities.

Session D – Improving Monitoring Techniques/Technology and Methodology

Five topics were addressed by Session D participants: (1) algorithms by category; (2) processing hardware; (3) platforms/sensors; (4) information sharing and (5) current and emerging monitoring technologies.

First, key recommendations and ideas addressed across all five topics in Session D are highlighted. Then, more specifically for each of the five topics, several key concepts are discussed in greater detail and a general summary of specific issues and recommendations is included in table form. The detailed notes for each of the topics in Session D, as reported by each working group, are included in the on-line appendices at http://www.nmfs.noaa.gov/pr/permits/mammals_sound_workshop.htm.

Key Issues and Recommendations

Several key ideas and recommendations were recorded across the working groups that addressed this topic. Data needs and database housing/serving figured most prominently among the responses. The summarized recommendations for this included:

General Monitoring Issues: Participants noted that the available technology drives new science and acknowledged that there are some very real technology limitations for monitoring applications, such as the aging satellite infrastructure and the inability to process information real-time at the recording level. That said, they recommended hosting a focused workshop convened for engineers and researchers to explore "out of the box" options and next generation solutions (e.g., consider recruitment outside the field). Specifically, participants identified the importance of advancing the science of passive acoustic monitoring (PAM) to identify behavioral responses, abundance, and density and to improve PAM data analysis for efficiencies in processing and forming multi-dimensional analysis. Also, they stressed the need to engage with the federal Aviation Administration (FAA) regarding opening up U.S. air space for unmanned aerial vehicle (UAV) monitoring flights.

Detection, Classification, Localization, and Density (DCLD) Algorithm Development: Participants recommended establishing and populating a standardized database containing different species' sounds (vocalization library) and all other federally 'collected' monitoring data. This sharing, standardizing, and centralizing of data would help expedite the development of vocalization algorithms, as well as the development of platforms and sensors. The data in this database (and that should be included in monitoring requirements for regulated entities) would include vocalization, environmental, behavioral, and seasonal data holdings. Participants further recommended using Navy acoustic ranges at AUTEC, SCORE, and PMRF for algorithm verification and validation (V&V) and Navy ranges in general for testing new V&V technologies.

Topic I. Algorithms by Category/DCLD

Participants were asked to evaluate the current status of detection, classification, localization, and density (DCLD) algorithm development. Issues discussed included basic data requirements, validation requirements, and information sharing.

Main Ideas

- Data requirements should include the vocalization/vocalization usage library and environmental, behavioral, and seasonal data holdings;
- Use the Navy acoustic ranges at AUTEC, SCORE, and PMRF for algorithm Verification &Validation (V&V);
- Consider using "fake" whales (e.g. gliders equipped withacoustic recorders) to test exposure levels at Navy ranges as an alternative V & V method; and
- Establish a national, standardized database containing all the different species' sounds to focus and speed up progress in algorithm development.

Specific Issues and Discussion Points

Issues	**Discussion Points**
Data requirements	• No set of algorithms that can replace a good analyst. • Obtain a better understanding of vocalizations and vocalization usage in order to apply to density estimation and probability of detection. • Build a confidence assessment for end users to use with the algorithm. • Improve processing speeds. • Develop density algorithms to match the developmental state of the Detection, Classification, and Localization algorithms. • Obtain test and training data in all different environmental settings, behavioral states, group size, and seasons. • Obtain tagged animal and visual observations for density estimations.
Verification and validation	• Use Navy ranges for V & V testing of new technologies. • Use mark/recapture method with "fake" whale duplicating known exposure properties (acoustic, infrared, etc.).
Information sharing	• Continue biennial DCL workshop series. • Explore Mobysoft database as a mechanism for sharing. • Build a national, standardized database that contains all the different sounds that each species makes.

Topic II. Processing Hardware

Participants discussed the current hardware gaps in monitoring technologies.

Main Idea - Convene a workshop with engineers and researchers to explore "out of the box" options and next generation solutions.

Specific Issues and Discussion Points

Issues	Discussion Points
Battery/bandwidth/size issues	• Hold a subject matter expert workshop to bring in a diverse group of researchers/engineers to work on tags, platforms, and other hardware. • Explore the NSF Industry Research Grants mechanism as a possible development framework.

Topic III. Platforms/Sensors (Fixed/Portable)

Participants discussed current gaps in processing platforms and sensors, summarized current available platforms and sensors, and identified priorities for future development.

Main Ideas

- Acknowledgement of technology limitations (e.g. the aging satellite infrastructure, inability to process information real-time at the recording level).
- Consider the need for data sharing and comprehensive database housing to speed up development of platforms and sensors.
- Consider the use of Navy ranges for V&V testing of new technologies.

Specific Issues and Discussion Points

Issues	Discussion Points
Goals with separate requirements and considerations	• Long-term: health of population. • Short-term: monitoring/mitigation.
Satellite transmission infrastructure	• Spearhead US/international effort to revamp the satellite infrastructure to expand the ability to collect data.
Information sharing	• Formulate a mechanism to advise research community on what datasets are available for analysis.
Hardware capability	• Develop real-time processing capability at recorder level. • Develop commercial replacement for military sonobuoy receivers.
V&V	• Use Navy ranges for V&V testing of new technologies.
Interagency prohibitions	• Work with the FAA to increase ability to employ UAVs in US air space for monitoring purposes.

Topic IV. Information Sharing

Working group participants were asked to suggest methods of improving information dissemination and sharing.

Main Idea - Develop a national, cross-agency database program serving up all federally collected monitoring data.

Specific Issues and Discussion Points

Issue	Discussion Points
Information disclosure requirements	• Require information disclosure by resource sponsors and regulators. • Establish a gatekeeper institution to ensure consistency, data integrity, archiving, standardization, and maintenance.

Topic V. Current and Emerging Monitoring Technologies

Participants evaluated current systems that can be used to inform management, and make current systems more cost effective, available, and efficient. Participants also evaluated systems for covering large spatial and temporal scales, generating archival data to inform time/area closures and other pre-set mitigation measures. Finally, participants evaluated the costs and benefits of using active acoustics for mitigation and monitoring.

Main Ideas

- Further develop PAM to identify behavioral responses, abundance, and density.
- Develop PAM data analysis for efficiencies in processing and forming multi-dimensional analysis.

Specific Issues and Discussion Points

Issues	Discussion Points
PAM limitations	• Need to develop capability to interpret PAM data for behavioral response (e.g., currently PAM is useful in presence/absence). • Develop PAM data analysis processes to better assimilate, integrate, and present findings. • Develop PAM technologies to improve efficiencies, effectiveness, and availability. • Develop PAM data analysis to enable abundance and density determinations • Develop programs to successfully integrate a range of modalities to give a multi-dimensional picture of what is happening with marine mammals in their environment.

Using active acoustics to detect mammals for implementing mitigation or monitoring measures	• Complete required studies on effectiveness and impacts (need to weigh costs vs. benefits). • Establish a cross-agency method that will effectively integrate multiple stakeholder funds, goals, and technologies.
Additional considerations	• Technologies need to be validated. • Need to successfully integrate multiple technologies to get a multidimensional picture. • Consider ancillary tools: prey mapping. • Gliders in addition to acoustics can provide important environmental information. • Monitor area from cradle to grave (e.g., life of an oil field).

Conclusions

Primary Messages Gained from Workshop Participants

Several key ideas and recommendations were produced by the workshop. One recommendation in particular was repeatedly endorsed: build and populate a standardized, web-accessible, database of marine mammal presence, density, behavior and human impact data. This database (or, potentially, portal to several databases) would contain all of the data collected from both: (1) federally-funded marine mammal research and monitoring programs (including, potentially, data used to inform either habitat or sound source characterizations); and (2) federally-required marine mammal or sound source characterization data collected pursuant to monitoring prescribed as a condition of a federal permit or authorization. This database should be built using existing systems (e.g. OBIS SEAMAP), and should be made freely available to the marine mammal research community. The call for an open database is not a new idea and many participants have been pursuing this concept for some years. However, to truly advance this needed goal, and recognizing that it should not be conducted by a single agency, participants suggest that the federal government formally charter an interagency working group charged with planning, scoping, and resourcing this standardized database/portal for marine mammals and acoustic data.

Workshop participants also identified a critical need to fill existing gaps in baseline biological information on marine mammals. Multiple discussions focused on "who" should fund and "who" should perform baseline research. Several high level recommendations were produced, including: designating and funding NOAA and the USFWS to serve as the primary agencies in charge of resourcing research projects; investigating the feasibility of establishing a third party funding mechanism; implementing a strategic planning and coordinating interagency working group that would ensure cross-agency collaboration and cooperation; and, enhancing and expanding existing partnerships.

New Ideas

Marine Mammals and Anthropogenic Sound is not a new issue, and it is not surprising that the workshop yielded recommendations that for the most part have been heard before. Nevertheless, some new ideas were generated. Two such ideas were to: (1) explore instituting a statutory user fee system on noise producers that would fund research and development, and (2) use the Navy acoustic ranges at AUTEC, SCORE, and PMRF for algorithm verification and validation and the Navy ranges in general for testing newly developed monitoring and mitigation technologies.

Recommendations for Fast Track Programs

Workshop participants were particularly coherent in recommending focused attention to selected research areas. These include fast tracking research on quieting technologies, obtaining audiograms for sensitive species, acquiring longitudinal data on ambient noise

conditions throughout the oceans, continuing and expanding behavioral response studies where baseline data is available, and developing next generation solutions for monitoring technologies.

Challenges

The two main issues identified at the workshop (a standardized database/portal and baseline marine mammal research funding needs) are a focus for a reason: they represent serious challenges. In developing a national database, the following issues must be addressed: standardization of metadata and database protocols; variability in data quality and collection techniques; ; consideration of proprietary and confidential data, and resource availability for maintaining and fielding a national database. Regarding funding for research, the federal government is currently in an extremely tight fiscal environment. Though this workshop report highlights the need for studies and can be used to support research funding requests, stakeholders should focus on streamlining and improving current efforts as well as be creative to accomplish studies with existing resources. Partnerships with private research organizations and industry will likely remain important, and increasingly so in the immediate future, but these can be implemented within the context of a federal research strategy. Agencies should increase capacity by evolving today's relationships into comprehensive partnerships focused on preventing duplication, maximizing coverage, maximizing the value of each research dollar invested, and providing open and transparent access to the data by all members of research community.

Moving Forward

Dissemination of the Workshop Report: These workshop proceedings will be presented to the National Ocean Council (NOC) Ocean Science and Technology (OST) Interagency Policy Committee for review, consideration, and potential implementation. In addition, the report will be provided to the U.S. agencies specifically engaged in conserving and protecting marine mammals, including but not limited to NOAA, BOEM, DON, NSF, USFWS, the Marine Mammal Commission, U.S. Coast Guard, U.S. Army Corps of Engineers, the U.S. Geological Survey, and the National Science Foundation, All federal resource managers responsible for funding and designing marine mammal research programs within the government, and for implementing and ensuring compliance with the federal statutes that protect marine mammals (e.g. MMPA, ESA, NMSA), will receive the report.

With this submission, the sponsors of this Workshop will recommend forming a multi-disciplinary working group (with participants from the scientific, regulatory, and regulated communities) charged with planning, scoping, and resourcing a standardized database for marine mammal and acoustic data. Planning will include the identification and consideration of existing tools and efforts that are already being used or underway. For example, an informal interagency group with representatives from the U. S. Navy, Marine Mammal Commission, NODC, USGS, NSF, ONR, and BOEM is working to develop improved archiving of marine biological data at NODC and OBIS-USA with cooperation with OBIS-Seamap (or similar capability). The group is concentrating on the

standardization of the forms and formats of the data and metadata, which presently vary widely. The ultimate goal is to make secondary use of large quantities of archived data easier. Of note, and one of the reasons why a panel would be beneficial, the efforts of this informal interagency group do not currently address acoustic data. Separately, OBIS-SEAMAP recently (2011) received funding from NSF to standardize passive acoustic data and metadata. Discussions are being conducted with producers and users of other kinds of marine biological data identify archiving standards.

Convening Federal Strategic Planning and Coordinating Interagency Working Group: Additionally, the sponsors of this Workshop will recommend to the NOC OST the formation of a strategic planning and coordinating interagency working group for marine mammal research that will do the following: (1) continue to track progress on and specify in more detail the research priorities identified in the JSOST report (ref); (2) investigate the feasibility of establishing a third party funding mechanism for basic marine mammal research; (3) ensure cross-agency collaboration and cooperation; and (4) expand existing federal and non-federal partnerships.

Establishing Periodic Discussion Forums: Last, participants discussed the likely usefulness of holding regular, biennial, interdisciplinary, collaborative Workshops to address important marine mammal and sound issues, which was also a recommendation of the JSOST report (one practical idea would be to convene a standard working meeting prior to Marine Mammal Society biennial meetings). Because of the quick rate at which data are accumulating in this field, the sponsors of the workshop generally support that idea, but are also open to a more targeted approach that would better focus the specific issue(s) to be addressed at a given Workshop and would schedule them as needed (perhaps not exactly biennially).

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Appendix A- Workshop Participants

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Mr.	Ryan	Wulff	NOAA
Dr.	Robert	Bonde	US Geological Service Southeast Science Ctr
Dr.	Robyn	Angliss	NMFS/Alaska Fisheries Science Ctr/Natl Marine Mammal Laboratory
Mr.	Kyle	Baker	NMFS Southeast Region

Appendix B- Agenda for the National Marine Mammals and Sound: Science and Application Workshop

13 July 2010:

0830 - 0840 Welcome Remarks The Honorable Ms Pfannenstiel (Navy)
0840 - 0850 Welcome Remarks Ms. Medina (NOAA)
0850 - 0910 Ocean Policy Overview: Climate Change Task Force and Interagency Collaboration RADM Titley (Navy)
0910 - 0955 Keynote summarizing the issues- Dr. Chris Clark (Cornell)

0955 - 1015 Break

1015 - 1115 Workshop Topic Introductions
1015 Session A Dr. Brandon Southall (SEA)
1030 Session B Dr. John Hildebrand (SCRIPPS)
1045 Session C Ms. Jolie Harrison (NOAA NMFS OPR) and Dr. Leila Hatch (NOAA NOS Stellwagen Bank NMS)
1100 Session D Mr. Dave Moretti (NUWC Newport)
1115 - 1145 Q&A
1145 - 1155 Workshop ground rules and orientation Mike Hughes, Keystone Center

1155 - 1300 Lunch

1300 - 1700 (*individual groups determine best breaktimes within 4-hr session*)
Session A: Biologically significant effects of sound exposure: baseline data and assessment.
Session B: Understanding and Reducing Sound Generation and Propagation
1300- 1305 Topic Introduction (Dr. Southall, Dr. Hildebrand)
1305- 1615 Facilitated working group exercises (Mr. Hughes, Ms. Shapiero)
1615- 1700 Session debrief

1700 - 2000 Icebreaker/Information Sharing Session
1800- Oral Presentations

14 July 2010:

0800 - 1200 (*individual groups determine best breaktimes within 4-hr session*)
Session C: Acoustic Behavioral Harassment Criteria, Methodologies for Cumulative Effects Analysis, and Mitigation
Session D: Improving Monitoring Techniques (Technology and Methodology).
0800- 0805 Topic Introduction (Ms. Harrison, Mr. Moretti)
0805- 1115 Facilitated working group exercises (Mr. Hughes, Ms. Shapiero)
1115- 1200 Session debrief

1200 - 1300 Lunch

Report-out times below tentative, will be solidified based on material from groups
1300 - 1350 Plenary Session A Report Out/Discussion
1350 - 1440 Plenary Session B Report Out/Discussion

1440 - 1500 Break

1500 - 1550 Plenary Session C Report Out/Discussion
1550 - 1640 Plenary Session D Report Out/Discussion

1640 - 1700 Concluding remarks Mr. Schregardus (Navy DASN) and Jim Lecky (NOAA NMFS OPR)

Appendix C- Discussion Questions for Marine Mammal and Sound Workshop

Instructions for Discussion Sessions

As a reminder, you will be seated in an assigned group of 7 or 8 people that will include scientists and policy folks from both governmental and non-governmental groups. Each table will have a designated recorder who is not a workshop participant.

In the interest of ensuring that every question gets addressed by at least one group:
For sessions A and C, each table will be given one required question from the list, and then each table will choose 1 or 2 additional questions to address.
For sessions B and D, each table will be given two required questions from the list, and then each table will choose 1 or 2 additional questions to address.

Once you are discussing a question, if there are facets of the issue at hand that you think are important to explore in this forum that are not addressed in the question, please feel free to pursue them and report back to the group.

In order to ensure adequate discussion time for the chosen questions, we will also ask that you please choose the questions that the group will be addressing at the beginning of the discussion period and identify a tentative amount of time for the discussion of each.

Question Topic Overview

A. Biologically significant effects of sound exposure: baseline data and assessment

(1) Basic Biological Research for Representative Marine Mammal Species
(2) Standardized Marine Mammal and Sound Database(s)
(3) Predictive Tools for Density/Distribution Estimation
(4) Acoustic Behavioral Response Research for Representative Marine Mammal Species
(5) Non-Behavioral Responses to Sound
(6) Biologically Significant Impacts

B. Understanding and Reducing Sound Generation and Propagation

(1) Sound Source Identification and Review
(2) Ambient Noise
(3) Quieting Technologies
(4) Cumulative Contributions of Multiple Sound Sources to Marine Noise
(5) Sound Propagation Prediction Tools
(6) Standardized Marine Mammal and Sound Database(s)

C. Acoustic Behavioral Harassment Criteria, Methodologies for Cumulative Effects Analysis and Mitigation

(1) Acoustic Behavioral Harassment Criteria
(2) Masking
(3) Cumulative Impacts Assessment
(4) Mitigation
(5) Monitoring Methods

D. Improving Monitoring Techniques (Technology and Methodology)

(1) Algorithms (by category/DCLD)
(2) Processing Hardware
(3) Platforms/sensors (Fixed/Portable)
(4) Information Sharing
(5) Current/Emerging Monitoring Technologies

Question Topic Detail

A. Biologically significant effects of sound exposure: baseline data and assessment (Session Chair- Southall)

(1) Basic Biological Research for Representative Marine Mammal Species

Many reports have listed areas where we are missing important *basic* physiological, behavioral (baseline), density/distribution, and longitudinal life history data for representative marine species (such as common species) and key species (ESA-listed and sound sensitive species, i.e., those that seem to react to sound at comparatively lower received levels or are historically more likely to be associated with strandings).

- What are the most important basic biological data needs for better understanding and management of biologically significant effects of exposure to sound that need to be met in the next 2-3 years? Why? Who should perform these studies, what are the cost estimates and how will they be funded?
- How long is it likely to take to meet these most important data needs at a level of resolution/certainty required for management, i.e., can they be accomplished with one discrete study or will they necessitate long-term governmental support to be useful to management (show variation over seasons/larger areas etc.)?
- If these essential data gaps were not bridged in the near future due to lack of funding or governmental investment, what are some options for resource agencies to manage species conservatively in the face of the specific types of uncertainty that these data gaps generate?

(2) Standardized Marine Mammal and Sound Database(s)

There have been many discussions about creating a standardized marine mammal database and requiring that all parties/agencies holding permits or authorizations be required to electronically enter any data collected into that government-run database. This data could then be systematically archived, analyzed, and made available to resource managers, researchers, and the public. Without getting into a discussion of who should fund this and which government agency would house it (although, with the intent of informing these issues) please consider the questions below.

- What are some of the logistical needs to make this happen (e.g., data clearance/proprietary issues, communication among agencies with access to data and/or expertise in managing data etc.)?
- As a potential user of this database, how would you use this resource if it existed (e.g., all visual sightings made during construction projects in Puget Sound over 10 years, sound source verification data from Arctic oil and gas seismic vessels) in research and/or environmental impact assessment contexts?
- How could these types of data be integrated with (or used in meta analyses with) more standardized or systematically collected data to inform understanding of distribution, abundance, and/or behavior?
- In light of your responses to the last 3 bullets, list the high-priority issues that need to be taken into consideration in the development of a standardized database to maximize its utility.
- Some government agencies may have existing but currently under-utilized datasets that could be made available to aid in the analysis of biologically significant effects of sound exposure. List any these datasets (of marine mammal data) that you are aware of, by agency, and indicate what type of data (e.g., basic information on distribution or abundance, data on potential effects, sound source characterization data) is contained in the dataset, as well as the general format and standardization of raw and metadata.
- What needs to happen to make the data more readily available (e.g., are certain protocols existing, or necessary to design)?

(3) Predictive Tools for Density/Distribution Estimation

- What existing tools (or tools in development) can be effectively used to estimate/predict marine mammal density and distribution for under-surveyed areas of the world's oceans?
- What oceanographic, biological, and other environmental features (if any) are effectively considered in these predictive tools?
- Can we systematically identify specific sets of circumstances in which the use of these sorts of tools would be expected to be either more or less likely to result in accurate results?
- What should be done to achieve standardized applications and acceptance for these tools?

- What are the pros and cons of incorporating such tools into a standardized national system that would be applied in management decisions (such as the one contemplated for housing all marine mammal monitoring data).

(4) Behavioral Response Research for Representative Marine Mammal Species

As we can see by looking at the Southall et al. (2007) compilation of data, we are missing important pieces of information showing how specific marine mammal groups (representative marine species: such as common species and key species: such as ESA-listed and sound sensitive species) respond to specific types of sound sources/activities (not to mention in different contexts or at what different received levels).

- What are the most important specific behavioral response to anthropogenic sound data needs for better understanding and management of biologically significant effects that need to be met in the next 2-3 years? Why? Who should perform these studies, what are the cost estimates and how will they be funded?
- How long is it likely to take to meet these most important data needs at a level of resolution/certainty required for management, i.e., can they be accomplished with one discrete study or will they necessitate long-term governmental support to be useful to management (areas achieve threshold sample sizes, repeat experiments, alter ecological/environmental conditions etc.)?
- If these essential data gaps were not bridged in the near future due to lack of funding or governmental investment, what are some options for resource agencies to manage species conservatively in the face of the specific types of uncertainty that these data gaps generate?
- How should representative species best be used for predicting the behavioral responses of other species based on the information we have in-hand? For example, should this concept be based on taxonomy, hearing sensitivity (by frequency), or similarities in life history?
- What are the most important laboratory/captive based experiments and/or theoretical modeling (i.e. no field component) projects needed, and why?

(5) Non-Behavioral Responses to Sound

- Should there be an increased focus on the effects of noise stress and immune function studies? If yes, keeping in mind both acute and long-term exposures, what are the most important studies that should be conducted and why?
- What are the most important data gaps in our understanding of how to best assess specific types of non-auditory tissue damage in animals exposed to anthropogenic sound? Why and, separately, will they directly inform current management decisions?
- What are the most important data gaps in our understanding of how to best assess auditory tissue fatigue/damage in animals exposed to anthropogenic sound? Why and will they directly inform current management decisions?

(6) Biologically Significant Impacts

- What is a biologically significant impact (to an individual or a population)? How is it quantitatively identified?
- How do we realistically and consistently determine which effects may be discounted as insignificant in a decision-making context?
- How well do the NRC recommendations regarding effects on foraging, survival, and reproduction match the available data on behavioral effects? Are these the correct criteria for the determination of biologically significant impacts?
- Are there particular contextual factors about sound exposure (e.g., similarity of sounds to those of predators) that are more likely to result in biologically significant impacts?

B. Understanding and Reducing Sound Generation and Propagation (Session Chair-Hildebrand)

(1) Sound Source Identification and Review

- Please refer to the attached spreadsheet which lists: types of anthropogenic sound that contribute notably to the soundscape; U.S. acoustic data sets that can help characterize sound fields affected by these sounds (broadly, e.g., shipping lanes); the agency/organization that holds those datasets, whether or not the specific sources have been specifically characterized, and the reference: Is anything missing or incorrect?
- What are the most important data needs (and why?), each, for characterizing acoustically: individual sources and understanding broad use of the source type?
- Are there similar data sets available outside of the U.S. Government that would provide valuable sound field characterization information? Is there sufficient reason to push for releasing this data?

(2) Ambient Noise

- What acoustic datasets are available for measured ambient noise? What are the needs for longitudinal measurements of ambient noise? How should we standardize collection of that data? How do we prioritize the areas in which ambient noise measurements are most needed? What are the important uses of ambient noise data in a management context?

(3) Quieting Technologies

- Different groups are working on ways to quiet shipping noise and quieter alternatives to seismic airguns for oil and gas surveys. Are there other activity types in which economically feasible improvements have been/could be made to reduce the amount of energy introduced into the water to accomplish the given goal (i.e., quieter ways to build a pier or detect an enemy submarine)?

(4) Cumulative Contributions of Multiple Sound Sources to Marine Noise

- How do we best evaluate multiple specific sources and their cumulative contributions to marine noise?

(5) Sound Propagation Prediction Tools

- What tools are currently available (or will be available in near future) to resource managers and the public to model sound propagation? How do these tools compare in ease of use and accuracy of output? Have they been validated?

(6) Standardized Marine Mammal and Sound Database(s)

There have been many discussions about creating a standardized marine mammal database and requiring that all parties/agencies holding permits or authorizations be required to electronically enter any data collected (which will sometimes include sound source verification information and could also include other sound source information) into that government-run database. This data could then be systematically archived, analyzed, and potentially made available to resource managers, researchers, and the public. Without getting into a discussion of who should fund this and which government agency would house it (although, with the intent of informing these issues) please consider the following:

- What are some of the logistical needs to make this happen (e.g., data clearance/proprietary issues, communication among agencies with access to data and/or expertise in managing data etc.)
- As a potential user of this database, how would you use this resource if it existed (e.g., all visual sightings made during construction projects in Puget Sound over 10 years, or the sound source verification data for seismic air guns in the Arctic) in research and/or environmental impact assessment contexts?
- How can we standardize source characterization and measurements (at least within certain large frequency bands) so that comparisons among sources are meaningful in the context of evaluating impacts to marine mammals?
- For example, the ASA Standards Committee S12/Working Group 47 has produced a document, "American National Standard Quantities and Procedures for Description and Measurement of Underwater Sound from Ships- Part 1: General Requirements" (ANSI/ASA S12.64-2009/Part 1), and similar efforts are under way within the International Standards Organization (ISO/TC8SC2) regarding the characterization of underwater noise, specifically for merchant ships. Should the ANSI standards be adopted as a standard for sound source verification (SSV) test when vessel noise is involved? Or should we wait for the ISO standards and make a decision which one is the most appropriate to be used in addressing shipping noise? Why?
- Are there other existing standards that we should consider adopting? What are the pros and cons of doing so?
- Are there existing datasets describing specific propagation environments (e.g., SVP, boundary condition, transmission loss spectra, etc.)? Is the information accessible to researchers and resource managers?

- Some government agencies may have existing but currently under-utilized datasets that could be made available to aid in the analysis of biologically significant effects of sound exposure. List any of these datasets (of sound source characterization or propagation data) that you are aware of, by agency, and indicate what type of data (e.g., basic information on distribution/abundance, data on potential effects) is contained in the dataset, as well as the general format and standardization of raw and metadata. What needs to happen to make the data more readily available (e.g., are certain protocols existing, or necessary to design)?

C. Acoustic Behavioral Harassment Criteria, Methodologies for Cummulative Effects Analysis and Mitigation (Session Chairs – Harrison and Hatch)

(1) Acoustic Behavioral Harassment Criteria

- Thinking outside of any boxes (i.e., do not limit thoughts based on questions below), what are some alternative methods (with their pros and cons) for structuring and implementing acoustic criteria for behavioral harassment? For example: Dose/response curve versus step function based on received level; Estimating sound fields on a project-by-project basis vs. setting up standard isopleths for different activity types/depths/bathymetry; If dose/response curve, how derive? – LOGIT, etc.; Quantitatively, and more comprehensively, incorporating the consideration of additional contextual factors such as distance from the source, directionality/predictability of source movement (i.e., additional factors beyond received level).
- Classifying general categories of noise differently, for example (1) impulse; (2) non-impulse continuous (such as drilling or any source that is continuously run for an appreciable duration at one location); and (3) non-impulse transient (such as vibratory pile driving, shipping, or any source that runs intermittently or runs continuously but does not stay at one location) – OR, maybe it should be by activity type instead of these broader categories? OR, sounds classified as predators?
- Acknowledging the large role that context of exposure plays, how should hearing sensitivity (by frequency) be quantitatively taken into account in predicting marine mammal *behavioral* responses to sound?

(2) Masking

- How can we quantify the biological (fitness) consequences of signal masking in order to understand the costs of noise interference with communication, the locating of prey, predator avoidance and hearing environmental cues in marine animals? How should we seek to manage relatively lower level (below current exposure thresholds) changes in ambient noise resulting from regular human activities that are, nevertheless, changing the acoustic ecology for marine animals that rely on sound to live?

(3) Cumulative Impacts Assessment

- How do we integrate information about how animals are responding to noise with information about how they are responding to the more realistic multi-stressor environments that they are exposed to either during a short-term permitted activity and/or in the increasingly urbanized coastal ocean?
- Context is critical, and context is not just noise, it is pollution, abundance of food, mate availability, chemical pollution, new transient vessel activity and many other things. How do we integrate noise with information about the full environment the animal is exposed to in order to evaluate effects effectively?
- Please recommend a framework for considering the interaction of multiple stressors (acute and chronic) in the context of conservation management decisions.
- What additional data can be being collected when doing marine mammal research or monitoring of sound effects that could be used to inform cumulative impact assessments? Which of these additional data collection efforts would be easy, medium, or difficult? Inexpensive, medium, or expensive?

(4) Mitigation

- Regarding typical basic mitigation measures (i.e. exclusion zones, monitoring of exclusion zones, power-down or shutdown within exclusion zones, or ramp-up) intended to avoid exposing animals to sound levels associated with TTS, PTS, or more severe behavioral responses: What evidence is available indicating these measures are effective at accomplishing the goal above? How would you design a study to evaluate the effectiveness of current mitigation measures? Are you aware of real-time ways to improve/augment these measures to better accomplish the above goal using methods or technologies that are available today and considering the characteristics/goals of the proposed activity?
- What kinds of potential effects (e.g., auditory masking from chronic sound sources) may conventional approaches miss in terms of mitigation
- Based on existing evidence, what are the pros and cons of focusing mitigation measures primarily on avoiding exposure to very high levels (at close distances) that would likely be associated with more severe impacts versus avoiding other kinds of impacts that may be less immediately severe but more widespread?
- How do we best incorporate information about noise exposure into siting/ocean use decisions in general? For example, based on the existing evidence, what characteristics of marine mammal use would suggest that an area should be considered for limiting sound-producing activities, (e.g., breeding/calving, feeding, high density, etc.). What information exists to support the effectiveness (in terms of reducing quantity or severity of effects) of limiting activities in these scenarios?
- For the purposes of both better analysis and mitigation development, is there evidence of specific acoustic exposure conditions that have been linked to more adverse effects (e.g., the way that the Navy has generally characterized the steep bathymetry and multiple vessel factors that have been present in most of the stranding events that have been associated with naval exercises)? Or, if scientists suspect such an association, but

supporting data are limited, how could we design a study to answer these sorts of questions?

(5) Monitoring Methods

- How should we design and prioritize monitoring studies, in the context of regulated activities, to both: 1) better understand the acoustic signatures and acoustic behavior of sources and species, respectively associated with the authorized activity and area, and, as appropriate and needed, 2) provide information that will help fill broader identified data gaps (background noise variation in a region, animal distribution/density in a region, response of species to sources of different types under different conditions etc.) or 3).
- What is the most important type of information that monitoring programs should gather? Why?
- Describe how the focus should shift in different circumstances (e.g., for long term activities vs. short term, for activities in areas with little available marine mammal baseline information vs. areas with substantial information).
- Describe some methods/study designs that could be used to efficiently gather the data prioritized above (specify method, not just technology used). Estimate how long these methods take to implement (from deployment of equipment through analysis of data and finalization of reports) and compare how much they cost, grossly (low, medium, high – or some other system).
- Should NMFS convene a panel of experts to design a national monitoring strategy specifically targeted at filling some of the data gaps identified in this workshop? Focus of this group would be to recommend methodologies pursuant to a wide array of regulated activities that would take into consideration varying resources (money, capacity and infrastructure) among regulated parties while ensuring consistency in overall approach and goals among monitoring programs. Why or why not?

D. Improving Monitoring Techniques (Technology and Methodology) (Session Chair-Moretti)

(1) Algorithms (by category/DCLD)

- What are the basic requirements?
- Given these perceived requirements, what are the areas (by category/DCLD) that require significant improvement?
- What basic data are required for development?
- What methods can be used to verify performance?
- Suggested methods for data gathering?
- Isolate current shortfalls in methods and technology.
- How can the necessary data be most efficiently shared across organizations and between developers?

(2) Processing Hardware

- What are the areas of need for processing hardware?
- What are the current gaps in processing hardware?

(3) Platforms/sensors (Fixed/Portable)

- Summarize the perceived requirements
- Summarize the current available platforms and sensors.
- What are the current gaps in processing platforms and sensors? Priorities?

(4) Information Sharing

- Suggest methods of improving the dissemination/sharing of information (algorithms/hardware/methodologies).

(5) Current/Emerging Monitoring Technologies

- What technologies are available now or near future for real-time vs. archival data collection from monitoring/mitigation systems (PAM, active acoustics, radar, infrared imaging, underwater gliders, etc.)?
- What systems can be used now to inform real time management and how can they be improved (i.e., make them more cost effective, more available, more efficient etc)?
- What are the most effective systems for covering long time series and large spatial scales and generating archival data to inform time/area closures or other pre-set mitigation designs and how can those be made more cost effective/available?
- What are the anticipated benefits and drawbacks of using active acoustic methods for detection of marine mammals for mitigation implementation or monitoring (e.g., avoiding certain effects, but potentially creating an acoustic impact) – what are the existing studies?