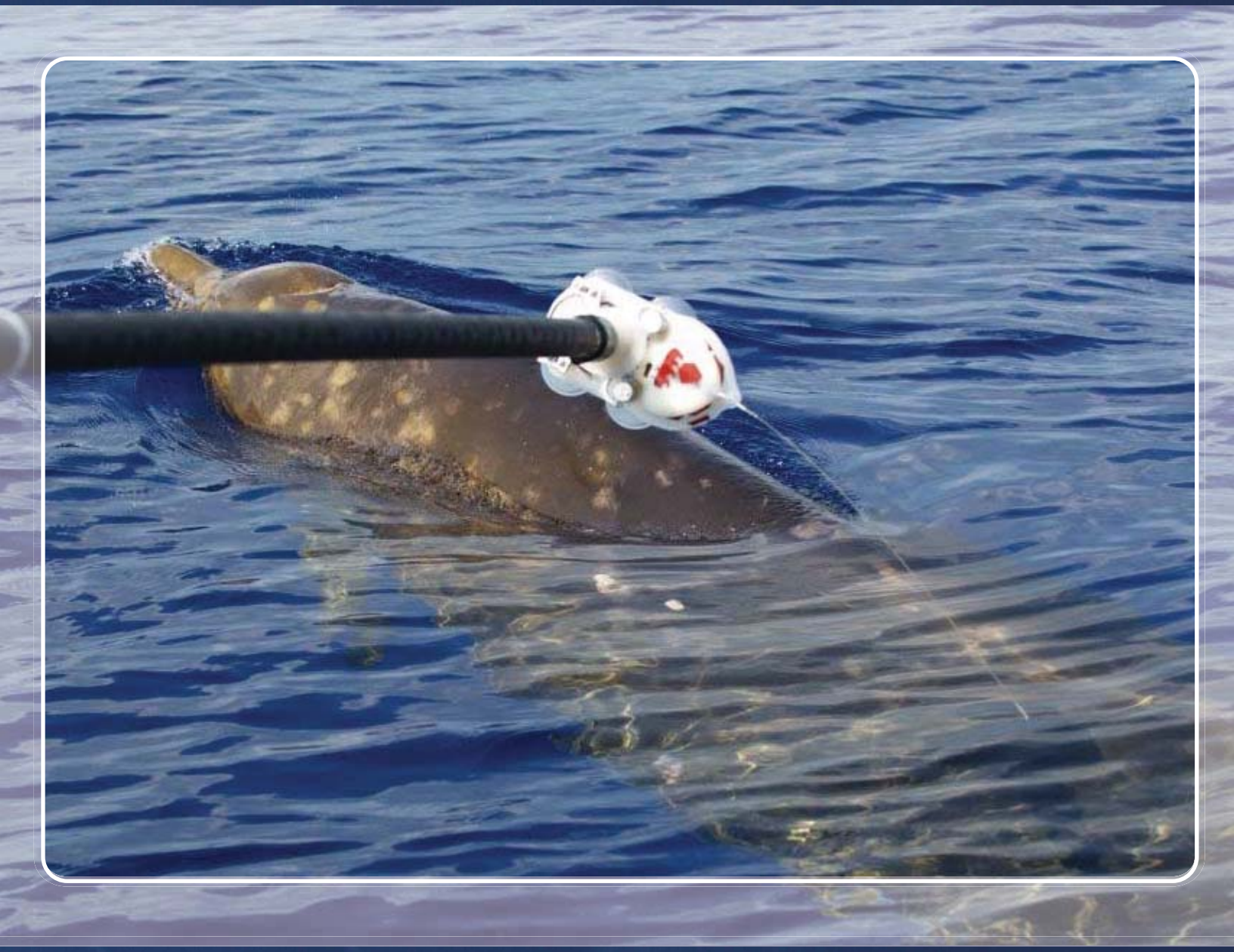
U.S. Navy Marine Mammal Research Program Overview



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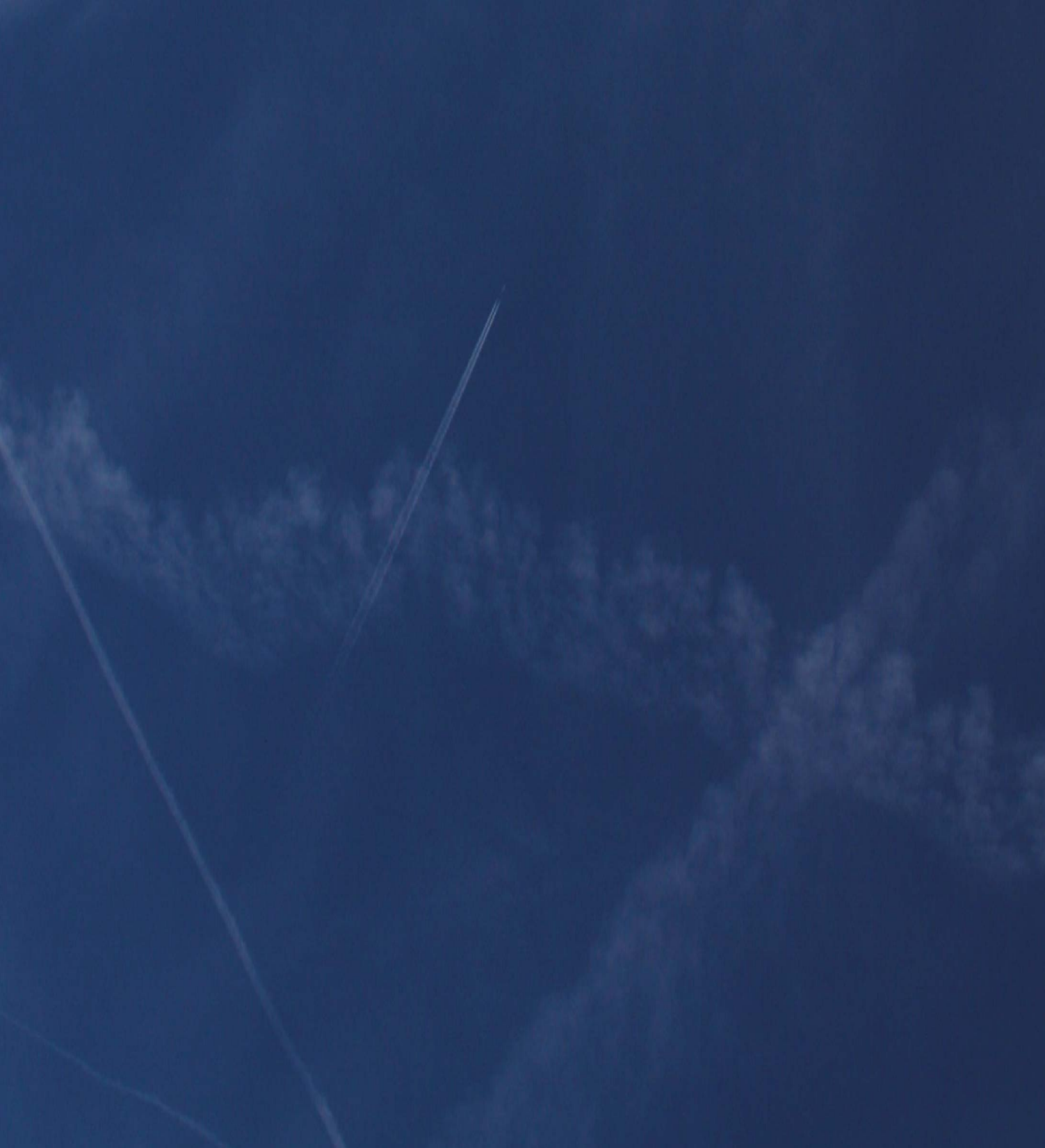

Cover Photo illustrates the application of the Data Tag (DTAG) to a Blainville's beaked whale. The DTAG is a key research tool that provides researchers the ability to observe the behavioral responses of marine animals to sound and their movement in the water column. DTAG's provide depth, pitch, roll and heading of the tagged animal and can record sounds from 80-150 dB re 1 µPa. This tool is a key element in the Behavioral Response Studies conducted on Navy instrumented ranges. Photo Courtesy of Mr. Ari Friedlaender, 2007

TABLE OF CONTENTS

1.0 Introduction

Protection of the natural environment is an integral part of U.S. Navy activities. Sustaining a vibrant and healthy ocean is one of the American values for which Navy Sailors and civilians serve.

A key focus of the Navy's environmental stewardship at sea is the protection of marine species, including marine mammals. In partnership with the National Marine Fisheries Service (NFMS), the Navy develops and implements appropriate science-based monitoring and mitigation measures to protect marine mammals during Navy operations at sea.

Notwithstanding the nation's significant interest in marine mammals, scientific knowledge about their behavior, physiology, population status, distribution and migration is relatively limited. In support of its environmental stewardship goals, the Navy has long supported a robust program of marine mammal research. The Navy's marine mammal research program has historically been funded at more than $20 million annually, making it the largest single contributor to marine mammal research globally. The Navy partners with a host of governmental agencies, academia, private industry and non-governmental organizations (NGO) in developing and executing its marine mammal research program.

The Navy's marine mammal research program invests in basic research on the potential effects of sounds on marine mammals, and develops scientific information that supports Navy preparation of environmental impact statements and associated regulatory processes under the Marine Mammal Protection Act (MMPA), the Endangered Species Act (ESA) and other statutes. The research program also goes beyond legal compliance requirements to support development of improved marine mammal monitoring and detection technology and overall knowledge about marine mammals.

A centerpiece of the Navy marine mammal research program is the ongoing Behavioral Response Studies (BRS) being conducted in close collaboration with NMFS, environmental NGOs, and in one theatre with collaborating European governments. BRS studies entail marine mammal tagging, so that their movements can be tracked, followed by exposure to various acoustic stimuli, to observe the behavioral responses of tagged animals. The BRS projects, coupled with other study efforts (i.e., population density estimates, habitat associations, and seasonal occurrence patterns), will allow the Navy to evaluate the potential effects of its operations on marine mammals, and enable the development of appropriate, science-based protective measures to safeguard both individuals and populations.

2.0 U.S. Navy Marine Mammal Research Program

2.1 Major Focus Areas

The Navy marine mammal research program is guided by research and technology development related to understanding the effects of sound on marine mammals, including physiological, behavioral and ecological effects. The program is currently focused on the following general areas:

- Marine mammal ecology and population dynamics demographics
- Criteria and thresholds to measure effects of Navy generated sounds
- Improving mitigation and monitoring techniques
- Sound field characterization

As described below, the Navy's marine mammal research program requirements are periodically reviewed by the Sonar Living Marine Mammal Research Requirements Oversight

Group (SLMRROG) which advises the Assistant Secretary of the Navy (Installations and Environment) (ASN I&E) and the Deputy Chief of Naval Operations (Fleet Readiness and Logistics) (OPNAV N4).

2.2 Navy Marine Mammal Research Program Organizations

Two Navy organizations account for most funding and oversight of the Navy marine mammal research program. These are the Office of Naval Research (ONR) and the Office of the Chief of Naval Operations Environmental Readiness Division (OPNAV N45).

ONR focuses on *basic research* efforts, which is the investigation of initial concepts or fundamental knowledge, and on *applied research*, which brings conceptual developments to a point at which they are mature enough for further development to meet specific Navy needs. Examples of deliverables, which ONR basic and applied research has supported, include acoustic hardware, hearing studies, sound-impact models, databases and animal data loggers (Data Tag (DTAG), B-probe, and others) used to record animal movement. OPNAV N45 funds promising research projects that are refined through a *demonstration and validation* phase. In this phase, researchers determine the utility of the concept to meet actual Navy needs. An example of work undergoing demonstration and validation is the marine mammal monitoring on ranges program (M3R), in which fixed hydrophones are used to track mammals through their vocalizations. Some of the research funded by both ONR and OPNAV N45 is performed solely for the scientific information it develops, and not to support development of a particular system. In this category, research is aimed at improving scientific knowledge about marine mammal behavior and vocalizations, marine mammal physiology, marine mammal bioacoustics, marine ecology and underwater acoustics.

In support of OPNAV N45 and ONR, various universities, small businesses, and Navy laboratories conduct research activities relating to marine mammals. The principal Navy laboratories conducting this research are the Space and Naval Warfare Systems Center, in San Diego, the Naval Undersea Warfare Centers and Naval Surface Warfare Centers located around the country. Other Navy offices sponsor marine mammal research to support their particular needs and/or pursuant to Congressional plus-ups for specific projects. Further information about Navy research and development processes can be obtained by visiting www.onr.navy.mil and www.navy.mil/oceans.

The Navy's overall marine mammal research program is reviewed by the SLMRROG, which is jointly chartered by ASN I&E and OPNAV N4. Refer to Appendix A for the SLMRROG Charter. Chaired by N45, the SLMRROG is comprised of stakeholders within the Navy that have an interest in marine mammal research, including ONR, U.S. Fleet Forces Command, U.S. Pacific Fleet, Navy Systems Commands and the Deputy Assistant Secretary of the Navy (Environment). The purpose of the SLMRROG is to identify Navy research requirements based upon compliance needs and to ensure that research is appropriately funded and focused to fill existing data gaps, so that duplication of effort does not occur. The SLMRROG charter provides that input regarding the Navy marine mammal research agenda will be solicited from regulatory agencies, academia and NGOs. The SLMRROG function is advisory in nature and provides recommendations to the respective marine mammal research program managers at N45 and ONR.

2.3 Partnerships and Other Research Organizations

The partnership between the Navy and NMFS and its parent organization, the National Oceanic and Atmospheric Administration (NOAA) is extremely important. The Navy funds and/or participates in several research efforts with NMFS and NOAA. For example, Navy and NMFS have funded independent research on the effects of Navy training on marine mammals

conducted by Duke University, Woods Hole Oceanographic Institution, and the Scripps Institution of Oceanography. A key BRS effort previously mentioned has been conducted with NMFS at the Navy's Atlantic Undersea Test and Evaluation Center (AUTEC) in the Bahamas, during the summers of 2007 and 2008. Further BRS efforts took place in the Mediterranean Sea in the summer of 2009, and along the Norwegian coast in 2008 and 2009. The Navy will continue to partner jointly with NMFS/NOAA and international agencies to identify and seize upon opportunities for greater cooperation and increased environmental stewardship in support of marine mammal research.

The Navy also collaborates with over 30 universities and institutions, with private industry, conservation agencies, independent researchers, and other world navies in developing and sharing information about the ocean, the species in it, and the potential effects of human activities. Some of the universities, institutions, and companies in which the Navy collaborates include the following:

- Bahamas Marine Mammal Research Organization
- Boston University
- Cascadia Research Collective
- Cornell University
- Duke University
- Elizabeth City State University
- Marine Acoustics Inc.
- Marine Mammal Research Consultants
- Mount Sinai Medical College
- New England Aquarium
- Scripps Institution of Oceanography
- University of California Santa Cruz
- University of Aberdeen
- University of California San Diego
- University of Hawaii
- Stanford University
- NOAA Southwest Fisheries Science Center
- NOAA National Marine Mammal Lab
- Oregon State University
- Texas A&M University
- University of California Davis
- University of Maryland
- University of Queensland
- University of Southern Mississippi
- University of St. Andrews
- Woods Hole Oceanographic Institution
- Norwegian Navy
- Netherlands Navy
- Royal Canadian Navy
- Royal Navy

2.4 Research Requirements

The Navy Marine Mammal Research Program is focused primarily on development of information needed for compliance with applicable environmental laws, in particular the Marine Mammal Protection Act (MMPA), the Endangered Species Act (ESA) and the National Environmental Policy Act (NEPA). In addition to a broad range of basic knowledge and technology development, research needs are identified during the development of environmental compliance documents, during adaptive management and other discussions with regulatory agencies and other stakeholders, and in the review of post-exercise marine mammal monitoring reports. The Navy implements a rigorous requirements identification process to ensure funded research projects continue to meet the Navy's needs. A listing may be found in Appendix B.

3.0 Current Research

This section describes the Navy's four research focus areas and examples of current projects.

3.1 Marine Mammal Ecology & Population Dynamics

This focus area includes research on integrated ecosystems; sensor and tag development; marine mammal diving and stress physiology, and the population structure of beaked whales in the vicinity of Navy training ranges. Research projects in this area are designed to improve our understanding of the behavior, patchiness or variability in movement and abundance of organisms over space and time, in marine ecosystems in areas where the Navy conducts testing and training activities. Patterns of biota in the ocean have significant impacts on population dynamics, trophic interactions, community organization and stability, as well as cycling of elements. This research provides a biological baseline to be used when assessing potential effects. Other efforts include addressing key behavioral and community ecology attributes of different species such as population dynamics; habitat associations; predator-prey relationships; and foraging, resting and social behaviors. For research projects in this focus area, top priority is given to the Navy operating areas included in the Hawaii Range Complex, Southern California Range Complex, the Atlantic Fleet Active Sonar Training study area and the AUTEC Range in the Bahamas. Priority is also given to threatened and endangered species.

In addition, the Navy has had a long-term interest in both the invention and early stage technology development of new marine mammal sensing capacity with the goal of improving our understanding of the behavior, distribution and movements of these animals. Recent advancements in sensor technology and the on-going miniaturization of electronics components offer great opportunities to increase our capacity to monitor marine mammals. However, attaching sensors or tags to cetaceans is particularly problematic and continues to be one of the greatest technical challenges hampering research efforts. Navy's objective is to facilitate research through the development of attachment mechanisms covering short, medium and long-term time durations; development of broad sensor suites into tags; and improving accessibility of sensors, tags and attachments to the research community.

Navy's objective in physiology research is a better understanding of the gas management and kinetics (stores and use) in marine mammals, and the mechanisms by which marine mammals control their dive response. The rare mass strandings of marine mammals in relation to naval exercises using mid-frequency active (MFA) sonar systems have multiple hypotheses. One theory is that strandings may be related to gas-bubble disease or decompression sickness (DCS). There is a need to develop technologies and models to test this hypothesis by measuring partial pressure of blood gases, examining the interplay between lung volume and gas exchange within different body compartments, and imaging the kinematics of gas exchange during lung collapse in diving marine mammals. This research will provide a novel understanding of the mechanism(s) for bubble formation in stranded marine mammals exposed to Navy sonar, and lead to advances in the study of decompression illness (DCI), N_2 narcosis, and O_2 toxicity in human divers, as well.

Example projects underway in this focus area include:

- Using animal tagging and passive acoustic monitoring to study behaviors and distributions of animals relative to key environmental properties (biotic and abiotic).

- Improving technologies associated with digital tags used to track marine mammals in the wild. This includes better attachment mechanisms for short, medium, and long-term applications; increasing the sensor suites built into tags to provide a greater variety and volume of data; and improving the uploading and downloading of data using satellites.

- Models are being developed at NMFS Southwest Fisheries Science Center, Scripps Institute of Oceanography, and Duke, and St. Andrews Universities that will provide density estimates based on habitat preference data.

- A Spatial Decision Support System being developed at Duke University to predict probability of animal occurrence based on species-specific preferences related to physical oceanography, biological availability, and other variables.

- Mapping prey fields to better understand the distributions of marine mammal species in their habitats.

- Studies using satellite tags to track beaked whales off Hawaii, SOCAL and AUTEC.

- Development of tag attachments covering short, medium and long-term durations.

- Investigating the relative vulnerability of marine mammals to acoustically mediated trauma from emboli formation by evaluating key environmental, behavioral and physiological factors involved in the movement of gases at the whole animal and tissue levels.

3.2 Criteria and Thresholds to Measure Effects of Navy Generated Sounds

Research projects in this focus area are designed to determine what constitutes biologically significant behavioral responses to Navy-generated sound on individuals with respect to disruption of natural behavioral patterns, ascertaining the short and long-term effects of such disruptions and documenting avoidance behaviors. Navy's goal is to understand how marine mammals hear, produce sounds and are affected by anthropogenic sounds in the marine environment. Projects have focused on: looking at the anatomy of hearing; creating audiograms to determine the frequency-dependent sensitivity of marine mammals hearing; determining threshold shifts; comparing behavioral psychophysical responses with auditory evoked potentials; creating models of marine mammal hearing; and examining the automatic gain control mechanisms in odontocete echolocation.

The primary objective of hearing related research is to safely study responses of beaked whales and other species to naval and other anthropogenic sounds to understand the causal chain of events leading from sound exposure to 'biologically significant' behavioral reactions to risks of stranding. Recent research efforts focused on defining and characterizing behavioral effects of sound exposure on tagged whales (with a focus on beaked whales but including other cetaceans), and measuring the exposure required to elicit responses that are safe but indicate potential for risk.

The issue of 'biologically significant' behavioral responses of marine mammals to acoustic exposure is an area of interest because 'biologically significant' responses include short-term and long-term stress response to acoustic exposure. Diving mammals demonstrate a level of conscious control over the intensity of the dive response and modify it according to the demands of the particular dive type. A startle reaction may cause an animal to react to threats with a general discharge of the sympathetic nervous system, priming the animal for fighting or fleeing. In a diving animal, a startle response could potentially result in a suite of physiological conflicts: increased heart rate instead of suppressed heart-rate, increased oxygen requirements of muscles for flight and vasodilation at depth. It is hypothesized that unexpected exposures to loud noises could produce a startle response and cause a temporary lapse in active control of physiological functions. When coupled with potential rapid ascents or descents, exposures could hypothetically affect normal diving patterns (e.g., dive duration and depth) potentially making animals more susceptible to direct auditory damage, resonance of gas containing spaces, and/or increased risk of decompression sickness or acoustic enhancement of bubble formation and growth. Prolonged or chronic exposure to stress may result in effects including immune system suppression, reproductive failure, accelerated aging and slowed growth.

Navy's objective in stress physiology research is a better understanding of the relationship between the startle response and dive response in marine mammals. Further, we are interested in developing a theoretical framework that can assist in conceptualizing and ultimately measuring the cumulative effects of multiple stressors on individual animals.

A major hurdle with marine mammal conservation and management is to know if and when measurable short term responses of marine mammals result in 'biologically significant' or meaningful effects on individuals and/or their populations. The 2005 National Research Council report presented the Population Consequences of Acoustic Disturbance (PCAD) model, which is a heuristic model that defines several levels of potential effects of anthropogenic sound on marine mammals ranging from behavioral effects, to effects on life functions (e.g. feeding, breeding, migrating), to effects on vital rates (e.g. adult survival, reproduction), to population level effects. Between each of these levels are 'transfer functions', most of which are poorly understood. Navy's objective is to transform the conceptual PCAD framework into a more formal model structure and improve our understanding of transfer functions, whether theoretical or empirical, which might help to guide research and management efforts and to project how marine mammals may respond to alternative future scenarios of anthropogenic sound.

Example projects underway in this focus area include:

- Development of portable Auditory Evoked Potential equipment so scientists can measure the brain's responses to sounds electronically, allowing the hearing range to be conducted on an opportunistic basis in the field. Knowing the hearing range of different species of marine mammals is important to understanding the effects of different sound sources as many animals will have different, frequency-dependent sensitivities. Gathering data using trained, captive animals was done in the past, but many species, particularly large endangered whales and beaked whales cannot be maintained in captivity.

- The 2009 BRS in the western Mediterranean Sea is taking what was learned in the previous BRS efforts and applying the research to marine mammals believed to have limited exposure to sonar and other Navy-generated sound. These studies investigate responses of cetaceans to simulated naval sonar, playbacks of killer whale vocalizations and other man-made sounds to better understand the causal chain of events that lead from the reception of sound to biologically significant behavioral reactions.

- Upgrading the current acoustic effects model to better estimate the potential to expose marine mammals to significant levels of acoustic energy and to assess the effects of sound sources on other marine animals.

- Development of medium to long-term data collection tags designed to record heart, respiration and fluke rates. These data can be used to evaluate the energy expended by a marine mammal during normal behavior and behavior altered by the exposure to Navy-generated sound.

- A multi-disciplinary working group will translate PCAD model transfer functions into a formal mathematical model structure to better identify 'biologically significant' or meaningful behavioral effects on individuals and/or their populations.

3.3 Improving Monitoring Techniques

Research projects in this focus area are designed to determine the observation, detection and classification measures required to develop effective monitoring and mitigation procedures. Navy's goal is to improve marine mammal monitoring capabilities over current methods by developing new and adapting existing technology such as passive acoustics, radar and others.

Navy is developing signal-processing algorithms for detection, classification and localization of marine mammals. Ultimately, Navy's objective is to adapt those algorithms for use on a variety of fixed, towed, floating and profiling platforms. For example, over the last several years the Navy has adapted the use of ocean gliders for marine mammal monitoring with the desired capability of persistent, autonomous passive acoustic monitoring of an area for marine mammal presence to provide timely, reliable, accurate and actionable information to support marine mammal mitigation.

Example projects underway in this focus area include:

- The development and testing of new hardware platforms and signal processing algorithms for detection, classification, and localization of marine mammals.

- Developing radar, as well as hardware and the associated signal processing algorithms for passive detection, classification and localization of marine mammals.

- Improving technologies for passive acoustic monitoring (PAM). PAM research is concentrating on understanding the limitations of "behavioral ecology," knowing that during any time period, many of the animals are quiet or do not emit sound sufficient for detection. PAM is also concentrating on understanding the significance of variability of vocalization patterns between species, an essential step in the quest for automatic classifiers that can differentiate species without requiring a person in the loop.

3.4 Sound Field Characterization

Research projects in this area focus on developing protocols and a model for predicting how sound propagates in water. Acoustic signal characteristics are many and varied, and within their entirety produce the sound field. Sound field characteristics include frequency, content, rise-time, pressure and particle velocity, time series, zero-to-peak and peak-to-peak amplitude, and mean squared duration and repetition rate.

Example projects underway in this focus area include:

- Developing transmission loss models that propagate acoustic energy through the air/sea boundary.

- Developing models to predict the transmission of acoustic energy from multiple small shots and large explosions in a shallow water environment.

- Developing models to account for surface glinting in high frequency transmission loss.

- Developing protocols for when to use coherent (e.g., sonar) and incoherent (e.g., explosives) transmission loss models.

- Integrating the latest propagation models into a standard Navy process. The Navy Effects Model (NEMO) is being developed to provide a consistent methodology for environmental planners to use when analyzing the potential for acoustic effects from Navy operations.

4.0 Future Research

This section describes potential future projects in the Navy's four research focus areas. Whether these projects are carried out depends on a number of factors, most importantly, whether these projects continue to meet the Navy's most important research needs.

4.1 Marine Mammal Ecology & Population Dynamics

Future potential projects in this focus area may be used to broaden the approach of previous studies that attempted to correlate sighting data with multiple physical ocean variables to one that supports true abundance predictions. Habitat studies have the ultimate goal of defining where marine mammals of various species are most likely to be, based on the physical ocean qualities that generate a food source at the correct trophic level. Other potential projects in this focus area will expand on previous feasibility demonstrations to explore the merits of various data collection techniques. The newest vehicles for potentially monitoring a large ocean area over medium lengths of time are unmanned underwater vehicles, (e.g., sea gliders, wave gliders, and mini sailboats with attached data sensors). These unmanned vehicles have the capability to move in some general programmed direction while continually transiting through various depth strata.

Potential efforts in this focus area include:

- Begin collecting multi-year, seasonal oceanographic data with marine mammal sighting and acoustic detections to determine the correlations of oceanographic variables that can best predict marine mammal presence. Results from this study would provide an indicator for the location of both the resident and migrating marine mammal populations.

- Development of methodology to be used in predictive marine mammal abundance modeling. Predictive modeling is advancing the ability to forecast, within reasonable parameters, the expectation that animals of a given species will be within a region of interest during different times of the year and what their abundance might be.

4.2 Criteria and Thresholds to Measure Effects of Navy Generated Sounds

The Navy anticipates a continuing need to investigate and understand the potential cause and effect of operationally relevant sound on beaked whales and other species of interest. Potential projects in this focus area may include studies monitoring behavior, evaluating acoustic models and utilizing computer simulation programs to better understand the effects of sound energy on all aspects of marine mammal physiology. Examples include the following:

- Conduct a BRS in the Southern California Operating Area (SOCAL) and elsewhere. SOCAL BRS would be conducted over the next five years following the generally successful methodology used to expose marine mammals safely to sonar-like signals, killer whale calls and random noise in the BRS projects completed at AUTEC in 2007 and 2008 and in the western Mediterranean Sea in 2009. BRS efforts currently are underway in Norwegian waters and the Mediterranean. This will be the largest effort in this focus area.

- Explore and evaluate finite element models, magnetic resonance imaging and computer simulation. These models use the measurements of the physical properties derived from small samples of tissue and organs that are collected from live animals using biopsy darts or dead beached animals during necropsies. Once the key physical properties are measured, they are incorporated into the finite element model and run through computer simulation. The results provide graphic representations of the energy flow (i.e., sound) through the auditory pathway and the associated effects on the surrounding tissue. The end product will be the ability to take electronic scan data and convert it directly to tissue density and other variables that can then be used in simulation to determine physiological effects of any sound source.

- Expand the Temporary Threshold Shift (TTS) experiments conducted over the past decade because there are several variables that influence the onset and degree of TTS, and masking of hearing ability. This will lead to a more complete understanding of how exposures to different Navy sound sources might result in TTS in certain scenarios.

- Address the limitations of the current dose-response function that is used to assess behavioral effects of marine mammals' exposure to Navy-generated sound.

4.3 Improving Monitoring Techniques

The Navy uses various monitoring techniques before, during and after exercises to record the behavior and movement of marine mammals. The Navy would like to explore options, techniques or tools to improve current monitoring and mitigation efforts. Fieldwork would primarily take place at the AUTEC undersea range in the Bahamas and the SCORE undersea range off southern California. The purpose of using these facilities is the availability of passive acoustic monitoring tools, specifically bottom mounted and deployable sensors to collect data on species that are both resident and transient on these ranges. In addition, satellite tags would be used to the track movement of these animals on a wider scale. Results from this effort would provide information on how "normal" behavior is defined on these ranges. When "normal" behavior has been defined, then in future projects, individual animal behavior would be monitored for comparison during underwater sound-emitting events to determine if there is a change in behavior as a result of the sound exposure. Other aspects of monitoring systems the Navy would like to explore further involve automating the data collected through passive monitoring, validating data sets of vocalizing mammals detected during passive monitoring and developing baseline information on resident and transient species in certain geographic areas.

4.4 Sound Field Characterization

The Navy is developing the Effects of Sound in the Marine Environment (ESME) Workbench. The ESME Workbench is a software simulation system that will serve as a publicly available educational and basic research tool for the marine mammal research community. In the longer term, ESME could be used by environmental planners who need to assess the potential impact of Navy-generated sound on marine mammals.

Future goals of this project could include:

- Finalize ESME software architecture and develop capability for simulating and analyzing 3D sound fields produced by fixed sources.

- Add capacity to simulate moving sound sources and to do acoustic footprint analysis.

- Integrate moving sound source with animal behavior model provided by Biomimetica, Inc. and provide analysis tools for dynamic simulation output.

- Implement simulation of moving mammalian sound sources with fixed and moving receivers and provide tools for animal detection analysis.

- Add capacity for simulating single explosive sources, create and test prototype ESME data portal.

- Add capacity for simulating multiple explosive sources integrated with animal behavior model and complete fully featured ESME data port.

- Integrate the ESME Workbench simulation system with the Navy's NEMO process, utilizing aspects of ESME to provide processing, simulation and interface improvements.

5.0 Summary

Over the next five to ten years, the Navy expects its research will provide the information required to improve data collection technology and develop better methods to enhance our understanding of the short, medium and long-term effects of anthropogenic activities on living marine resources. These tools will enable the Navy to meet and optimize its training and testing objectives in an environmentally responsible manner, and to provide regulatory agencies and the Navy with sufficient, scientifically defensible information to assess, monitor and mitigate the effects of Navy-generated sound on marine mammals.

Appendix A SLMRROG Charter

CHARTER

FOR THE

SONAR AND LIVING MARINE RESOURCES RESEARCH OVERSIGHT GROUP (SLMRROG)

1. Purpose: Establish the Navy Sonar and Living Marine Resources Research Oversight Group (SLMRROG) and define its functions and responsibilities.

2. Background: In recent years Navy has dedicated nearly $100M to research on the effects of sonar on marine mammals. Research has been sponsored by a number of different commands, examining a host of different issues, without overall Navy-wide coordination. Given the critically important need for timely research in this area to support Navy environmental compliance and stewardship, a coordinated program is needed to ensure that the highest priority Navy needs are addressed, that research projects meet the needs identified, and that there is no redundancy throughout the Navy in projects undertaken. A single group is needed to perform these functions.

3. Membership. The SLMRROG will be chaired by OPNAV N45 and will report to ASN (I&E) and OPNAV N4. Membership will consist of representatives from the following organizations:

a. ASN (I&E)
b. ASN (RD&A)
c. OPNAV N45, N874, N3/N5
d. Fleet Forces Command
e. COMPACFLT
f. NAVSEA
g. NAVAIR
h. ONR
i. SPAWAR
j. Naval Postgraduate School
k. Navy Deputy, NOAA
l. Navy Sonar Integrated Coordinating Group (ICG)

4. Functions and Responsibilities: The SLMRROG will meet at least quarterly to perform the following functions:

a. Identify and prioritize Navy research requirements pertaining to the effects of sonar activities on living marine resources, taking into account needs identified in the preparation of environmental compliance documents, during

litigation, and as identified by the fleet. The SLMRROG will solicit suggestions from regulatory agencies, academia, and non-governmental organizations in developing the research requirements.

b. Review all Navy research programs pertaining to the effect of sonar activities on marine mammals (including efforts undertaken pursuant to Congressional plus-ups, Small Business Innovative Research (SBIR) topics, Strategic Environmental Research and Development Program (SERDP) projects, and Operations and Maintenance, Navy (O&M,N) funded efforts) to ensure that these efforts address an identified need and do not duplicate previously completed or on-going research efforts. Unnecessary or duplicative research and all high priority needs that are not being addressed will be brought to the attention of OPNAV N4 and the Secretariat.

c. Report on the activities of the Group at each quarterly meeting of the Maritime Sustainability Executive Steering Group (ESG).

B. J. PENN
Assistant Secretary of the Navy
(Installations and Environment)

7/30/08

M. K. LOOSE
Vice Admiral, CEC, U.S. Navy
Deputy Chief of Naval Operations
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Appendix B Listing of Research Requirements

TABLE ONE: Navy's Research Requirements and Priorities	
Priority	**Requirement**
	Marine Mammal Ecology & Population Dynamics
High	(1) Determine the distribution and abundance of marine mammal species at spatial and temporal scales relevant to Naval training activities and with respect to: a. priority Navy operating areas such as HRC, SOCAL, AFAST, and AUTEC b. priority order of federal listed species, beaked whales, and other species and populations of concern (hereafter priority species) c. geographic and seasonal estimates of density with known variance. d. Predictive habitat models (in cases where density cannot be estimated)
Med	(2) Identify and describe the key behavioral and community ecology attributes of priority species to include: a. population dynamics (sex structure, vital rates, and reproductive ecology) b. habitat associations (oceanographic features & prey field structure dynamics) c. predator-prey relationships d. foraging, resting, and social behaviors.
	Criteria and Thresholds to Measure Effects of Navy-Generated Sound
High	(3) Determine biologically significant behavioral responses from Navy sound sources on individuals representing marine mammal species of concern with respect to: a. significance defined as disruption of natural behavior patterns, including, but not limited to migration, and surfacing to a point at which such behavioral patterns are abandoned or significantly altered b. ascertaining short-term (tactical scale) effects of behavioral responses c. determining long-term effects of behavioral responses and how individual vital rates may affect the population d. detecting and describing avoidance behaviors e. determining effects of Navy sound sources on the instantaneous versus the sustained stress in the stress budget of individuals and populations f. investigating threshold responses that approach but do not exceed significance and the sound levels associated with such thresholds.
High	(4) Identify the mechanism(s) that result in injury to or mortality of marine mammals from exposure to Navy-generated sound with respect to: a. various frequency and amplitude spectra b. physiological state of the animal c. specific physiological and behavioral reactions d. potential of mid-frequency active sonar to cause directly or indirectly decompression sickness (bends).
Med-High	(5) Determine the physiological effects on living marine resources (fish stocks, including larvae, turtles, etc.) of: a. active sonar, including high and low frequency sonars b. impulsive sound sources and explosions.

TABLE ONE: Navy's Research Requirements and Priorities	
Priority	**Requirement**
Med	(6) Identify or develop methods and tools to produce audiograms and masked hearing thresholds for those marine mammal species for which hearing measurements do not currently exist with respect to: a. priority species b. age or sex differences.
Low	(7) Determine the fate of priority species upon their death with respect to: a. physiology of the organism that may predispose them to sink upon dying b. current evidence that they do or do not sink to the bottom of the ocean when they die c. decomposition rates of the bodies under different environmental conditions d. based on the above, determine the portion of animals that die at sea and are found on the beach.
Improving Monitoring Techniques	
High	(8) Determine what real time observation, detection, and classification measures are required to develop effective monitoring and mitigation procedures. a. Means to detect whether priority species have been affected by Navy sounds. b. Means to measure significance of these effects. c. Mean to test the effectiveness of mitigation measures.
High	(9) Identify, research, and develop enabling science and technologies whose potential impacts are significant breakthroughs in the capacity to: a. collect and interpret basic species ecological and population data, as well as associated environmental/habitat data b. observe and interpret behavioral responses to natural and anthropogenic stimuli, with a focus on naval sounds c. detect and classify marine mammals under various environmental conditions in real time d. use and assess for effectiveness various mitigation techniques.
Sound Field Characterization	
Med	(10) Continue to develop and improve an acoustic effects model incorporating a wide range of acoustic sources, specific propagation, and associated predictions of potential effects to living marine resources, consistent with regulator requirements and applicable to individuals, groups, and populations.
Low	(11) Evaluate if active sonar signal alteration can reduce the potential effects of active sonar on priority species.