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STAFF RECOMMENDATION

ON CONSISTENCY DETERMINATION

Consistency Determination No.	**CD-029-10**
Staff:	MPD-SF
File Date:	6/7/10
60th Day:	8/6/10
75th Day:	8/21/10
Commission Meeting:	7/7/10

FEDERAL AGENCY: **National Oceanic and Atmospheric Administration**

PROJECT LOCATION: Southern California (SOCAL) Bight (primarily within U.S. Navy's existing Southern California (SOCAL) Range Complex), northern Santa Barbara Co. to southern San Diego Co. offshore waters (Exhibits 1-2)

PROJECT DESCRIPTION: Marine Mammal Underwater Sound Research, a 5-year research program (commencing in Summer/Fall 2010) studying basic behavior, vocal communication, and biology of various marine mammal species and measuring their reactions to controlled underwater sound exposures (CEEs)

SUBSTANTIVE FILE DOCUMENTS: See page 18.

Staff Recommendation: Concurrence. Motion is on page 10.

EXECUTIVE SUMMARY

The National Oceanic and Atmospheric Administration (NOAA) has submitted a consistency determination for a 5-Year, underwater marine mammal and acoustic research effort in the Southern California Bight (primarily within the U.S. Navy's existing Southern California (SOCAL) Range Complex). The research proposal has been designed to better understand basic diving and vocal behavior in a variety of marine mammal species, to expand the ability to

monitor marine mammal presence and/or density using passive listening sensors, and to study reactions to a variety of controlled underwater sounds, in order to determine the effects on targeted marine mammals of acoustic exposures of mid-frequency (MF) sonar sounds. The research is intended to build on recent controlled exposure experiments (Behavioral Response Studies (BRSs) conducted by many of the same researchers in the Bahamas in 2007-08 and in the Mediterranean in 2009. The primary focus will be on responses of animals to simulated military sonar signals, but it will include other kinds of industrial sounds as well.

The research is clearly intended to improve the currently-limited human understanding of the effects of underwater noise. While the research in intended to expose animals to noise levels that would elicit behavioral impacts, it includes measures to avoid exposing any animals to harmful noise exposures or other impacts (e.g., from tagging animals). NOAA's consistency determination states:

> *… [W]e are intentionally presenting the kinds of sounds that have been known in specific circumstances and conditions to have strong negative, and in fact lethal, consequences for marine mammals. As such, we must be as cautious and vigilant in monitoring and implementing safety protocols to ensure that we can measure the onset of behavioral responses without inducing the strong and potentially harmful adverse effects we are trying to prevent in future operations. We have some reason to be confident that we can accomplish this while still achieving the objectives of the study. As mentioned, similar procedures have been used in the Bahamas (and also recently in Norway…) to obtain important behavioral response data without causing (observed) negative impacts on focal animal groups or others in the area. Sustained visual monitoring as well as follow-up surveys of areas in which experiments were conducted supported this conclusion, as did the sighting of experimental subjects in the Bahamas in subsequent years. We acknowledge that there are potential behavioral responses of focal and incidentally-exposed animals (we are in fact trying to induce them in controlled conditions to understand them) and that we must carefully monitor for such responses and terminate experimental trials if there is indication of any responses that may endanger animals. We also acknowledge that there may be reactions to our research activities that we are not able to observe and monitor in a vast, visually-opaque ocean environment. However, we believe that we have carefully developed such protocols to accomplish this and to reduce the potential of harm to animals through behavioral responses during CEEs* [Controlled Exposure Experiments] *to a very low level. Based on the available data on potential direct harm from sound exposure on marine mammals[1], the probability of this occurring from SOCAL-10 activities is extremely low (and arguably zero). Finally, it is relevant to note that the power of the sound transmissions we will be using for tens of minutes at a time is several orders of magnitude lower than realistic military sources operating in similar areas off California on a regular basis for hours or days in some operations without the same simultaneous monitoring and shut-down mitigation measures proposed for SOCAL-10.*

[1] *Reviewed in Southall et al., 2007 (full reference provided in supporting material).*

The protocols and mitigation measures include: (1) criteria for avoiding certain marine mammals (e.g., neonate calves); (2) safety measures for close approaches and tagging, and (3) specific conditions for sound transmissions during CEEs (e.g., terminating sound transmissions if animals are within 200 meters (m) or when any abnormal behaviors are detected).

The Commission has long supported the notion that regulatory agencies and other entities rely on a paucity of data for making assumptions and extrapolating data and conclusions based on studies on few marine species and primarily on captive animals. Thus, the Commission agrees with NOAA's overall goal of attempting to broaden the currently far too-limited data set on marine mammal hearing thresholds. Additional research, particularly that in the Southern California Bight, should benefit the Commission and other agencies in addressing concerns over underwater anthropogenic noise. The research goals are therefore consistent with the intent and policy language in Section 30230 of the Coastal Act to protect marine resources. A sophisticated and delicate balancing is needed to gather the information will still avoiding adverse effects on the animals being studied. The Commission believes the researchers selected have the necessary experience to be able to accomplish this balancing, and the Commission concludes that the avoidance, monitoring and mitigation measures incorporated into the proposed research, the research will avoid harm and limit acoustic exposures to levels eliciting initial stages of behavioral responses only, thereby protecting both individuals and populations of marine mammals and other potentially affected species. The project is therefore consistent with the marine resource protection policy (Section 30230) of the Coastal Act.

Measures to avoid impacts to fishing, boating, and diving have also been included, and the project is also consistent with the commercial and recreational fishing, recreational boating and diving, and public access policies Sections 30234, 30234.5, 30210 and 30220) of the Coastal Act.

STAFF SUMMARY AND RECOMMENDATION

I. STAFF SUMMARY:

A. Project Description. The National Oceanic and Atmospheric Administration (NOAA) Office of Science and Technology is collaborating with academic, private sector, and civilian military scientists in a 5-Year, underwater marine mammal and acoustic research effort, proposed for the Southern California Bight (primarily within the U.S. Navy's existing Southern California (SOCAL) Range Complex), between the U.S. Mexican offshore waters boundary and (approximately) the Santa Barbara/San Luis Obispo County line (Lat. 35^{o} N) (Exhibits 1-2). The research is largely being funded by the U.S. Navy. The first phase of the research, referred to as SOCAL-10, is currently scheduled to commence in Summer/Fall 2010. The research is also being reviewed by NOAA itself, through a Scientific Research Permit application (under the Marine Mammal Protection Act (MMPA)) to NOAA/NMFS's Office of

Protected Resources (NOAA/ NMFS File No. 14534: "Behavioral Response Studies of Marine Mammals in the Pacific Ocean Using Controlled Sound Exposure: Research Applications to Support Conservation Management.")[2] (See link to NOAA file in footnote below.)

The research proposal has been designed to better understand basic diving and vocal behavior in a variety of marine mammal species, to expand our ability to monitor marine mammal presence and/or density using passive listening sensors, and to study their reactions to a variety of controlled underwater sounds, in order to determine the effects on targeted marine mammals of acoustic exposures of mid-frequency (MF) sonar sounds. The research is intended to build on recent controlled exposure (BRS) experiments conducted (by many of the same researchers) in the Bahamas in 2007-08 and in the Mediterranean in 2009. The proposed research would include essentially the same experimental procedures and protocols to obtain important data while ensuring the safety of exposed animals, but over a larger potential area and time period, as well as including a much greater number of species.

While the primary focus will be on responses of animals to simulated military sonar signals, the results will have implications for assessing potential impacts of other kinds of industrial sounds as well. Also, data obtained on vocal characteristics will contribute to a number of ongoing efforts to detect and track marine mammals. Specifically, the permit application states:

> *Stated broadly, the research to be conducted under this permit with provide empirical measurements of behavior in marine mammals and behavioral changes as a function of sound exposure so that sound producers and regulatory agencies can better understand, minimize, and manage noise impacts on protected species.*

Hypotheses to be tested include: (a) that species differences in vocal behavior can increasingly be used to identify presence and possibly abundance of these species; and (b) that marine mammal behavior will change in a variety of ways based on characteristics and contexts of sound exposure.

NOAA intends the research goals to address the following questions:

> - *What kinds of vocal signals are produced by different species and what are their communicative functions?*
>
> - *How well can acoustic monitoring be used in detecting animal presence of an animal and, in combination with environmental data, estimating distribution and abundance?*
>
> - *How do marine mammals respond to ecologically relevant sounds from other marine mammals, such as a common predator, the killer whale (Orcinus orca)?*

[2] https://apps.nmfs.noaa.gov/preview/applicationpreview.cfm?RecType=Project&RecordID=14534&ProjectID=14534&AppBack=../search/search.cfm&view=110000000110100#Contacts

- How do beaked whales and other marine mammals respond to simulated military sonar and other sounds?

- What are the types and contexts of exposure resulting in different kinds of behavioral responses in different species?

- Are beaked whales particularly sensitive species (Southall et al., 2007), as recent observations seem to indicate (Cox et al., 2006; Boyd et al., 2007; Boyd, 2008)? Are other species particularly behaviorally sensitive to sound exposure?

- Can behavioral responses identified be related to risk factors for significant disruption of behavior or injury?

NOAA articulates three overarching objectives for the research, consisting of:

Objective 1. Identify the types and characteristics of vocal signals produced by different marine mammal species and identify their communicative functions.

Objective 2. How marine mammals respond to the sounds of a common predator, the killer whale (Orcinus orca).[3]

Objective 3. How do marine mammals respond to sonar and other sounds? What are the types and contexts of exposure resulting in different kinds of behavioral responses in different species? Can these responses be related to risk factors for more severe behavioral responses and/or injury? Are there particularly sensitive and generally tolerant marine mammal species with regard to acoustic exposure?

NOAA adds the following more specific research objectives:

(1) Tag a variety of species and obtain baseline behavioral data;

(2) Conduct controlled exposure experiments (CEEs) using similar exposure methodology from previous BRS;

(3) Determine optimal BRS configuration for scaled playback configurations and in realistic/actual military sources in subsequent (2012-15) years; and

(4) Obtain basic biological, behavioral, and foraging ecology data for marine mammals to support (U.S. Navy) range monitoring efforts and/or habitat models.

[3] Note: SOCAL 2010, first phase, research will not include any killer whale sound experiments.

The research will include gathering baseline data, animal tagging, tracking, observing, exposure to playback sounds, active and passive acoustic monitoring, and tissue sampling. The research team is an inter-disciplinary team of scientists selected to conduct the various project functions, including: (1) locating and identifying target species and individuals suitable for tagging; (2) attaching and tracking acoustic tags on individual marine mammals; (3) safely conducting playback experiments with established mitigation measures; and (4) monitoring and tracking focal individuals (and those exposed incidentally, as possible). As described above, the research is intended to build on previous successful but more limited research in the Bahamas and the Mediterranean Sea.

NOAA describes its proposed use of active acoustics in the research as follows:

> *Active acoustics for controlled exposure experiments*
>
> *Controlled exposure experiments for this project will be conducted primarily in summer and Fall in the waters off Southern California within the U.S. Navy's Southern California (SOCAL) Range Complex, and primarily near the vicinity of San Clemente Island (SCI).*
>
> *The sound source for the SOCAL-10 project has been designed for this project to be relatively easy to deploy from a small to mid-size vessel while allowing moderate levels of sound to be presented to test subjects at ranges of several kilometers. The sound source has the following specifications:*
>
> - *Vertical line array of active transducers for projecting mid-frequency, short-duration sounds (see below);*
>
> - *16 transducers driven by individual power amplifiers;*
>
> - *Time-delayed inputs effectively steer the output beam to desired elevation angle;*
>
> - *Estimated maximum source level of >215 dB re 1 mPa @1m within mid-frequency band (2-6 KHz)*
>
> - *Deployable to at least 100 m (cable is 125m);*
>
> - *Two-person, hand-deployable, lightweight configuration for rapid response;*
>
> - *25-50 lb. ballast weight – dry weight of array and ballast is ~125 lb.;*
>
> - *Simple 120VAC, 10A ship power requirements;*
>
> - *All components shock-mounted in rugged, shipping-ready rack (30x48")*

- *Source controlled from remote laptop computer by a single operator;*

A calibrated hydrophone will be used to validate source performance and can be used to provide a degree of passive acoustic monitoring when the ship is stationary. Both the output signal and the receive signal from the hydrophone will be recorded along with an IRIG time signal derived from a GPS satellite. This will allow precise signal reconstruction after the exposure studies.

Finally, as noted earlier, NOAA selected the Navy SOCAL Range (Exhibit 2) in part due the potential for combining monitoring efforts with Navy passive acoustic monitoring already in place on the Range, stating:

One of the primary reasons for selecting the initial research area for this program is the presence of significant real-time PAM capabilities available through our collaboration with the U.S. Navy. The combined listening capabilities available on the SCORE range and the proven identification and localization of marine mammals using these sensors will be one of the principal tools used in locating target species and in monitoring real-time responses of animals during controlled exposures. This will be very similar to the use of bottom-mounted, real-time sensors at the AUTEC range in the Bahamas during the 2007-2008 BRS studies in the Tongue of the Ocean. Additionally, where necessary and possible, we propose to deploy hydrophone arrays or sonobuoys from either the WTV or the PBV or both to track vocalizations of marine mammals in the study area. Passive acoustic monitoring of the click sounds of odontocetes can also be used to estimate range to the animal (e.g., Tiemann et al., 2006).

The Navy's instrumented Anti-Submarine Warfare Range (SOAR) is a 670 sq. mi. area directly west of San Clemente Island and southeast of San Nicolas Island, and is the area outlined in red on Exhibit 1 (within the "Offshore" Operational Area for SOCAL-10) .

B. <u>Related Research</u>. NOAA's research is intended to be integrated with and expand on recent research efforts, which it describes as follows:

Other Exploratory Research Associated with Key Objectives

Several authors (e.g., Tyack et al.,2004; Southall et al., 2007) have argued that opportunistic and controlled experimental studies of effects of sound on marine mammals are complementary and are often much stronger in combination. There has been growing interest in the development of tagging and passive acoustic monitoring techniques to monitor the effects of sound-producing activities over the full duration of the activity. There has been increasing recent and ongoing research in these areas and increasing integration among teams working in different areas (including related to the recent BRS project in the Bahamas and monitoring on the AUTEC range using solely the listening sensors during real military sonar training exercises). The experimental

effort described here is intended to similarly contribute to an integrated opportunistic and experimental approach to measuring the behavioral responses of marine mammals in an area where active military sonar is fairly common. For instance, there have been and are ongoing Navy efforts on the SCORE range in southern California to monitor the presence of marine mammals before, during, and after real military training exercises involving the use of mid-frequency sonar (Moretti et al., 2008)). Additionally, researchers from Cascadia have deployed satellite tags ahead of real exercises to track individual movements on a broad scale before, during, and after these operations (J. Calambokidis, pers. comm). These other associated projects will contribute to and be informed by the experimental CEE approach proposed here; many of the same researchers are involved in each of these projects, which will be closely coordinated and cross-pollinated in terms of personnel, results, interpretation, and subsequent modification of experimental approaches.

Additionally, while several specific hypotheses and applied objectives have been specified, much of this research involves topics where so little is known that there are frequent unanticipated discoveries. During the last five years of permitted research by some of the co-investigators included here, the following are some of the unanticipated discoveries:

• Dive behavior and risk of decompression in Cuvier's beaked whales (Zimmer and Tyack, 2008).

• Characteristics and beampattern of echolocation clicks produced by sperm whales (Zimmer et al., 2005a), Cuvier's beaked whale (Zimmer et al., 2005b) and Blainville's beaked whale (Johnson et al., 2006).

• How beaked whales use their echolocation to forage (Johnson et al., 2004; Madsen et al., 2005).

• Beaked and sperm whales can detect echoes from the seafloor and surface for orientation (Zimmer et al., 2005a; Madsen et al., 2005).

• How sperm whales use coda vocalizations to communicate in different phases of the dive cycle (Watwood et al., submitted).

There are several related exploratory research directions related to primary focus of this research program over the next five years. For instance, when more than one animal is tagged simultaneously within a group, it becomes possible to measure the distance between the pairs of tagged animals by timing how long the sound takes to travel from a tagged vocalizing whale to the tagged receiving whale. When more animals are tagged within a group, this may allows one to locate the calls even of animals that are not tagged; this is an exploratory research area for which we plan simultaneously to tag several animals within one group, as possible and appropriate.

Also, the WHOI group is working on a smaller version of the tag that will be suitable for attachment to smaller delphinids which produce a more diverse array of communication signals than sperm and beaked whales. The basic questions to be answered include: what is the effective range of communication, what are the contexts in which animals signal and how do receivers respond, and what are the functions of the calls. While animals will be taken for the research objectives described above, the research is likely to also provide unanticipated results leading to scientific publications on other topics. Finally, new-generation DTAGs are being designed for attachment and recording durations of 2-5 days and include a GPS sensor so that the location of the tagged individuals can be recorded without a ship having to follow the animal continuously. This is expected to enable longer term studies and will involve some changes in experimental methodology, including studying the responses of animals to human activities lasting for up to several days, and for controlled exposure designs that investigate effects of repeated exposures. This question of how the responses of marine mammals change over repeated exposure has been described as a "critical subject for future research" by Southall et al. (2007), and has been identified as a high-priority research objective for U.S. federal agencies involved in this issue (Southall et al., 2009).

This last reference is to a recent interagency task force report entitled: *"Addressing the Effects of Human-Generated Sound on Marine Life: An Integrated Research Plan for U.S. federal agencies. Interagency Task Force on Anthropogenic Sound and the Marine Environment of the Joint Subcommittee on Ocean Science and Technology. Washington, DC."* (Southall, B., Berkson, J., Bowen, D., Brake, R., Eckman, J., Field, J., Gisiner, R., Gregerson, S., Lang, W., Lewandoski, J., Wilson, J., and Winokur, R. 2009.) The executive summary of that report is attached as Exhibit 4.

Finally, NOAA notes:

SOCAL-10 Scientific and Public Impact

SOCAL-10 is committed to openness and transparency of the project and to the timely and effective transmission of results. Open discussions, both in public meetings and through exchange of questions and responses, with conservation interests and other scientists has been a healthy and constructive aspect of the planning of SOCAL-10 and is a process that will continue throughout this project.

Scientific data generated by SOCAL-10 will contribute to a greater understanding of biologically important areas off southern California, as well as how marine mammals dive, communicate, and respond behaviorally to different sounds .

These data will be made available to educational, government, and conservation organizations to increase public awareness and appreciation of these valuable areas and species. The results will also be integrated with ongoing, international efforts to

better understand behavioral responses of marine mammals to sound. SOCAL-10 data will also be made available through scientific presentations and publications in a timely manner, and through various other public outlets to maximize their utility and impact.

C. Federal Agency's Consistency Determination. NOAA has determined the project consistent to the maximum extent practicable with the California Coastal Management Program.

II. Staff Recommendation. The staff recommends that the Commission adopt the following motion:

MOTION*:* **I move that the Commission concur with consistency determination CD-029-10 that the project is fully consistent, and thus consistent to the maximum extent practicable, with the enforceable policies of the California Coastal Management Program (CCMP).**

STAFF RECOMMENDATION:

Staff recommends a **YES** vote on the motion. Passage of this motion will result in an agreement with the determination and adoption of the following resolution and findings. An affirmative vote of a majority of the Commissioners present is required to pass the motion.

RESOLUTION TO CONCUR WITH CONSISTENCY DETERMINATION:

The Commission hereby **concurs** with consistency determination CD-029-10 by NOAA on the grounds that the project is fully consistent, and thus consistent to the maximum extent practicable, with the enforceable policies of the CCMP.

III. Findings and Declarations. The Commission finds and declares as follows:

A. Marine Resources. Section 30230 of the Coastal Act provides:

Marine resources shall be maintained, enhanced, and where feasible, restored. Special protection shall be given to areas and species of special biological or economic significance. Uses of the marine environment shall be carried out in a manner that will sustain the biological productivity of coastal waters and that will maintain healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes.

The Southern California Bight is at the transition zone between two distinct biogeographic coastal provinces: the Oregonian and the Californian. The cold, temperate waters of the California Current flow from northwest to southeast to meet the warmer waters of the northwesterly flowing California countercurrent just south of Point Conception. When the

California Current reaches Point Conception, it flows away from the shoreline, creating a counter-clockwise gyre, the Southern California Eddy. The return flow of this gyre moves to the northeast and north through the southern Channel Islands toward the mainland, before turning toward the northwest.

This mixing of cold and warm water masses affects the distribution of marine fauna and flora and leads to a unique presence of both cold and warm temperature species that thrive in the transition zone and overlap in their distributions, including a broad range of marine mammal species comprised of 43 species of odontocetes (toothed whales), mysticetes (baleen whales), and pinnipeds. Of the 43 marine mammal species, 18 are present year-round, 6 are migratory, and 19 are infrequent or rare, (Dailey *et al*. 1993; Forney and Barlow 1998; Department of the Navy [DoN] 2005; Carretta *et al*. 2007; Barlow and Forney 2007).

Year-round occurring odontocetes are short-beaked common dolphins (*Delphinus delphis*) and bottlenose dolphins (*Tursiops truncatus*). Seasonally occurring (cold water months, Nov. – April) odontocetes are Risso's dolphins (*Grampus griseus*), Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), northern right whale dolphins (*Lissodelphis borealis*), and Dall's porpoise (*Phocoenoides dalli*). Odontocetes occurring less predictably are sperm whale (*Physeter macrocephalus*), killer whale (*Orcinus orca*), Baird's beaked whale (*Berardius bairdii*), short-finned pilot whale (*Globicephala macrorhynchus*), false killer whale (*Pseudorca crassidens*), Cuvier's beaked whale (*Ziphius cavirostris*), and various other beaked whale species (*Mesoplodon spp.*).

Mysticetes in the area include blue, humpback, gray, minke, fin and sei whales. Minke whales (*B. acutorostrata*), fin whales (*B. physalus*), and sei whales (*B. borealis*) are present year-round. Blue (*Balaenoptera musculus*) and humpback (*Megaptera novaeangliae*) whales are usually present in significant numbers in the summer and fall as they migrate through the Southern California Bight. Gray whales *(Eschrichtius robustus)* migrate southward through the region between November - February and northward in April – June.

California sea lions (*Zalophus californianus*) are the most abundant pinniped in the region, with numbers of animals encountered both at sea and ashore on San Clemente Island. Harbor seals (*Phoca vitulina*) and northern elephant seals (*Mirounga angustirostris*) are less abundant but are also found hauled out on San Clemente Island and are observed at sea in the region.

Ten marine mammal species listed as endangered under the federal Endangered Species Act (ESA) are present or possibly present in the area. Those likely to be present are the blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), humpback whale (*Megaptera novaeangliae*), sei whale (*Balaenoptera borealis*), and sperm whale (*Physeter macrocephalus*). These stocks are also consider "strategic" stocks under the ESA, which NOAA states means, in general, "…a stock for which human activities may be having a deleterious effect on the population and it may not be sustainable."

NOAA specifically selected the project area both due to the large numbers of marine mammals present, as well as the previously described existence of Navy passive acoustic monitoring devices in the area, which increases the opportunities for data-gathering. The Commission understands NOAA's reasoning in selecting this area and attempting to expand on the very limited data points that decision-makers face when attempting to determine impact and damage thresholds in reviewing anthropogenic noise sources. The Commission also acknowledges the particular expertise the researchers bring to bear in designing and carrying out this research. The Commission's concerns over this research are, primarily, the need to avoid impacts from tagging and exposing individual marine mammals to harmful noise levels.

To address these concerns, NOAA has include protocols, monitoring, mitigation, and avoidance measures into the research, including: (1) criteria for avoiding certain marine mammals (e.g., neonate calves); (2) safety measures for close approaches and tagging; and (3) specific conditions for sound transmissions during CEEs (e.g., terminating sound transmissions if animals are within 200 m or when any abnormal behaviors are detected). NOAA summarizes these measures as follows:

> ***Mitigation measures***
>
> *During CEEs the following safety shut down protocols will be used to terminate active sound exposures:*
>
> *- Any marine mammal inside 200m shut-down zone around source vessel during transmissions;*
>
> *- Visual detection from source boat or RHIBs* [rigid-hulled inflatable boats] *of focal group or incidentally exposed marine mammals exhibiting:*
>
> *o Directed, high speed or other abnormal swimming behavior (at surface), especially toward shore;*
>
> *o Unusual and abnormal surface/subsurface behavior involving apparent disorientation and confusion or dramatic changes in group cohesion;*
>
> *- Controlled sound exposures may be conducted with focal groups that include dependent calves that are not neonates (no fetal folds for non ESA listed species). However, if the mother-calf pair begins to become clearly separated during sound exposure (as determined by one of the principal investigators based on the input of trained marine mammal biologists observing the animals), sound transmissions will be terminated.*
>
> *- For beaked whale CEEs on the U.S. Navy SCORE range in SOCAL 10, we would use the same criterion as in BRS 07/08:*

o After animal starts foraging dive, commence exposure soon after animal starts clicking (average vocal time 26 min);

o Terminate exposure when focal group is determined to cease clicking (3 min criteria);

o Subsequent years will likely include options for continuing or initiating exposures during/though surface sequences.

Following CEEs, the following post exposure monitoring will be conducted after sound transmission:

- Source boat and/or RHIB visual teams will maintain visual (and passive acoustic monitoring (PAM), if applicable) monitoring of focal groups for a minimum of one hour post CEE;

- Source boat will maintain visual/VHF radio monitoring of focal animal as long as possible following CEE, but at least on Leg I there will generally not be nighttime tracking of tags/focal animals;

- If there are multiple individuals with tags in a group and the animals stay in the same group, the source boat will stay with them. If the individuals separate, the source boat will go with one and one or both RHIBs will monitor the other.

These measures are described in more detail in Exhibit 6 (Measures to Minimize Effects to Listed Species (excerpted from NOAA's application to NOAA Fisheries, for a MMPA/ESA Research/Enhancement Permit).

Although it considers strandings unlikely, NOAA further provides:

Safety and Stranding Protocols

SOCAL 10 will make every effort to ensure the safe operation of all research vessels and the safety of all personnel. SOCAL 10 will comply with all state and federal international laws and coordinate with state and federal agencies (e.g., California Coastal Commission). The project also includes specific precautionary measures to ensure the safety and welfare of marine mammal subjects [See Exhibit 6]. *As described in detail above, these include criteria for avoiding certain marine mammals (e.g., neonate calves), safety measures for close approaches and tagging, and specific conditions for sound transmissions during CEEs (e.g., terminating sound transmissions if animals are within 200 m or when any abnormal behaviors are detected).*

There is little reason to believe that SOCAL 10 will result in harm to marine mammals, based on safe and successful efforts in BRS 07 08, but it is only responsible to have stranding response protocols. Strandings are common in California and could occur in the same area, even if there is no correlation with SOCAL 10. In coordination with stranding networks, response contingencies are in place to ensure rapid reporting of any stranded marine mammal, facilitate response and investigation, and assess any possible relationship to SOCAL 10.

NOAA concludes:

SOCAL-10 is explicitly intended to increase the understanding of how different marine mammal species behave in the absence and presence of human sounds. We hope to collect a significant amount of baseline (non-exposure) diving and vocal behavior, including in some endangered species such as blue and fin whales, where very little such direct individual measurements are available. As you know, action proponents (including but not limited to the U.S. Navy) that produce sound in the marine environment must assess potential impacts of their activities on protected species and, in the absence of direct information, must use what is available from other species or by approximation. Some of the data we obtain will be directly applicable in increasing the biological accuracy of modeling predictions of impacts by providing direct, baseline measurements of normal foraging, social, and transit behaviors. We will also provide a large amount of visual sighting data, in some cases in conjunction with passive listening sensors that will (as specified in objective #4 above) contribute to the basic understanding and scientific basis for habitat modeling in biologically important areas of southern California. These data, in the absence of deliberate sound exposures, will directly contribute to the scientific basis for responsible use and conservation management of marine resources in these areas.

Our efforts to use controlled sound exposures to experimentally determine the responses of different species of marine mammals are similarly intended to provide sound producing and resource management organizations with direct information on changes in behavior. Currently, the scientific basis for assessing and (hopefully) reducing potential adverse impacts from sound exposure is extremely limited; these assessments often involve extrapolations from captive animals and/or very different situations/species to those being considered. SOCAL-10 will not provide complete answers to these questions and the results must be considered in conjunction with the kinds of opportunistic monitoring during real exercises that is already ongoing. However, the hope and expectation is that we will provide some of the first direct measurements available in several different species of direct and individual behavioral responses to sound, including simulated military sonar. These data will be extremely valuable to those planning and regulating sound producing activities along the California coastline.

> *With regard to potential adverse impacts of our research activities, let me be clear that, in order to obtain these answers, we are intentionally presenting the kinds of sounds that have been known in specific circumstances and conditions to have strong negative, and in fact lethal, consequences for marine mammals. As such, we must be as cautious and vigilant in monitoring and implementing safety protocols to ensure that we can measure the onset of behavioral responses without inducing the strong and potentially harmful adverse effects we are trying to prevent in future operations. We have some reason to be confident that we can accomplish this while still achieving the objectives of the study. As mentioned, similar procedures have been used in the Bahamas (and also recently in Norway…) to obtain important behavioral response data without causing (observed) negative impacts on focal animal groups or others in the area. Sustained visual monitoring as well as follow-up surveys of areas in which experiments were conducted supported this conclusion, as did the sighting of experimental subjects in the Bahamas in subsequent years. We acknowledge that there are potential behavioral responses of focal and incidentally-exposed animals (we are in fact trying to induce them in controlled conditions to understand them) and that we must carefully monitor for such responses and terminate experimental trials if there is indication of any responses that may endanger animals. We also acknowledge that there may be reactions to our research activities that we are not able to observe and monitor in a vast, visually-opaque ocean environment. However, we believe that we have carefully developed such protocols to accomplish this and to reduce the potential of harm to animals through behavioral responses during CEEs to a very low level. Based on the available data on potential direct harm from sound exposure on marine mammals[4], the probability of this occurring from SOCAL-10 activities is extremely low (and arguably zero). Finally, it is relevant to note that the power of the sound transmissions we will be using for tens of minutes at a time is several orders of magnitude lower than realistic military sources operating in similar areas off California on a regular basis for hours or days in some operations without the same simultaneous monitoring and shut-down mitigation measures proposed for SOCAL-10.*

The Commission has long supported the notion that regulatory agencies and other entities rely on a paucity of data for making assumptions and extrapolating data and conclusions based on studies on few marine species and primarily on captive animals. Thus, the Commission agrees with NOAA's overall goal of attempting to broaden the currently far too-limited data set on marine mammal hearing thresholds. Additional research, particularly that in the Southern California Bight, will benefit the Commission and other agencies in addressing concerns over underwater anthropogenic noise. The research goals are therefore consistent with the intent and policy language in Section 30230 of the Coastal Act to protect marine resources. A very sophisticated and delicate balancing is needed to gather the information will still avoiding adverse effects on the animals being studied. The Commission believes the researchers selected have the necessary experience to be able to accomplish this balancing, and the Commission concludes that the avoidance, monitoring and mitigation measures incorporated

[4] See footnote 1, p. 2

into the proposed research, the research will avoid harm and limit acoustic exposures to levels eliciting initial stages of behavioral responses only, thereby protecting both individuals and populations of marine mammals and other potentially affected species. The Commission therefore concludes that the project is consistent with the marine resource protection policy (Section 30230) of the Coastal Act.

B. <u>Public Access/Fishing/Recreational Diving</u>. Section 30210 of the Coastal Act provides:

> *In carrying out the requirement of Section 4 of Article X of the California Constitution, maximum access, which shall be conspicuously posted, and recreational opportunities shall be provided for all the people consistent with safety needs and the need to protect public rights, rights of private property public owners, and natural resource areas from overuse.*

Section 30220 provides:

> *Coastal areas suited for water-oriented recreational activities that cannot readily be provided at inland water areas shall be protected for such uses.*

In addition, aside from the commercial fishing protection afforded under Section 30230, quoted above on page 10, Sections 30234 and 30234.5 underscore the need to protect commercial and recreational fishing opportunities:

> ***30234**. Facilities serving the commercial fishing and recreational boating industries shall be protected and, where feasible, upgraded. Existing commercial fishing and recreational boating harbor space shall not be reduced unless the demand for those facilities no longer exists or adequate substitute space has been provided. Proposed recreational boating facilities shall, where feasible, be designed and located in such a fashion as not to interfere with the needs of the commercial fishing industry.*
>
> ***30234.5.** The economic, commercial, and recreational importance of fishing activities shall be recognized and protected.*

NOAA maintains that the project is consistent with the public access, recreation, and fishing policies of the Coastal Act, stating that:

> *As noted above, SOCAL-10 will explicitly seek to avoid areas of other human activities for our own experimental purposes and data interpretation. Additionally, most fish have hearing ranges limited to the very low frequencies and the mid-frequency sound transmissions in SOCAL-10 are likely to be inaudible to them. As such, we expect that our activities will have very limited or no impact on any commercial or recreational fishing activities.*

> *SOCAL-10 will strive to work in areas as far away from recreational fishing, diving, whale-watching, etc. as possible, as well as the high volumes of noisy commercial shipping in some areas. This is largely to reduce complications in interpreting control and experimental data during exposure studies from other nearby human activities. However, in regard to these provisions, it will have the ancillary benefit of greatly reducing the extent to which our activities may affect these economically and socially important human activities. For much of the project, we will be operating from a commercial diving boat operated from Santa Barbara who will clearly be familiar with recreational diving and fishing operations in the areas we will be working, which should increase our ability to avoid areas of higher human use for these purposes. Finally, while we have proposed to operate as close as 1nm from shore (but no closer than 3nm within the Channel Islands National Marine Sanctuary), we expect to generally be much further out to sea based on the expected distribution of animals from our most likely focal species. This will (to some extent) limit our interactions with some water-oriented recreation activities, particularly recreational diving.*

Concerning potential effects from equipment or debris, NOAA states:

> *Finally, we were asked to address whether SOCAL-10 activities would result in any equipment/debris left in the marine environment following our activities. Most of our research will involve the deployment of archival acoustic tags attached with suction cups that must be retrieved for the data to be obtained. Thus, we will be very motivated to re-acquire these small devices once they detach from the animals with all of the data on their movement, vocal behavior, and sounds to which they were exposed locked inside them. However, there is a very small chance (our tagging team has a near perfect record of retrieval) that some of these devices could be lost. While on the SCORE range near San Clemente we will have the benefit of the U.S. Navy hydrophone array (bottom-mounted) for acoustically-tracking marine mammals. In other areas we will not have this luxury and, in some cases, do plan on deploying remote, expendable, sonobuoys for acoustic monitoring in support of our activities. While these devices are commonly deployed and rarely retrieved in other operations, we will make efforts to retrieve and dispose of these devices, as possible. Additionally, we have informed the Channel Islands National Marine Sanctuary that we would not deploy sonobuoys within the boundaries of the Sanctuary.*

The Commission agrees that with these commitments the research will not adversely affect fishing, recreational boating, or diving. The Commission therefore concludes that the project is consistent with the commercial and recreational fishing, recreational boating and diving, and public access policies Sections 30234, 30234.5, 30210 and 30220) of the Coastal Act.

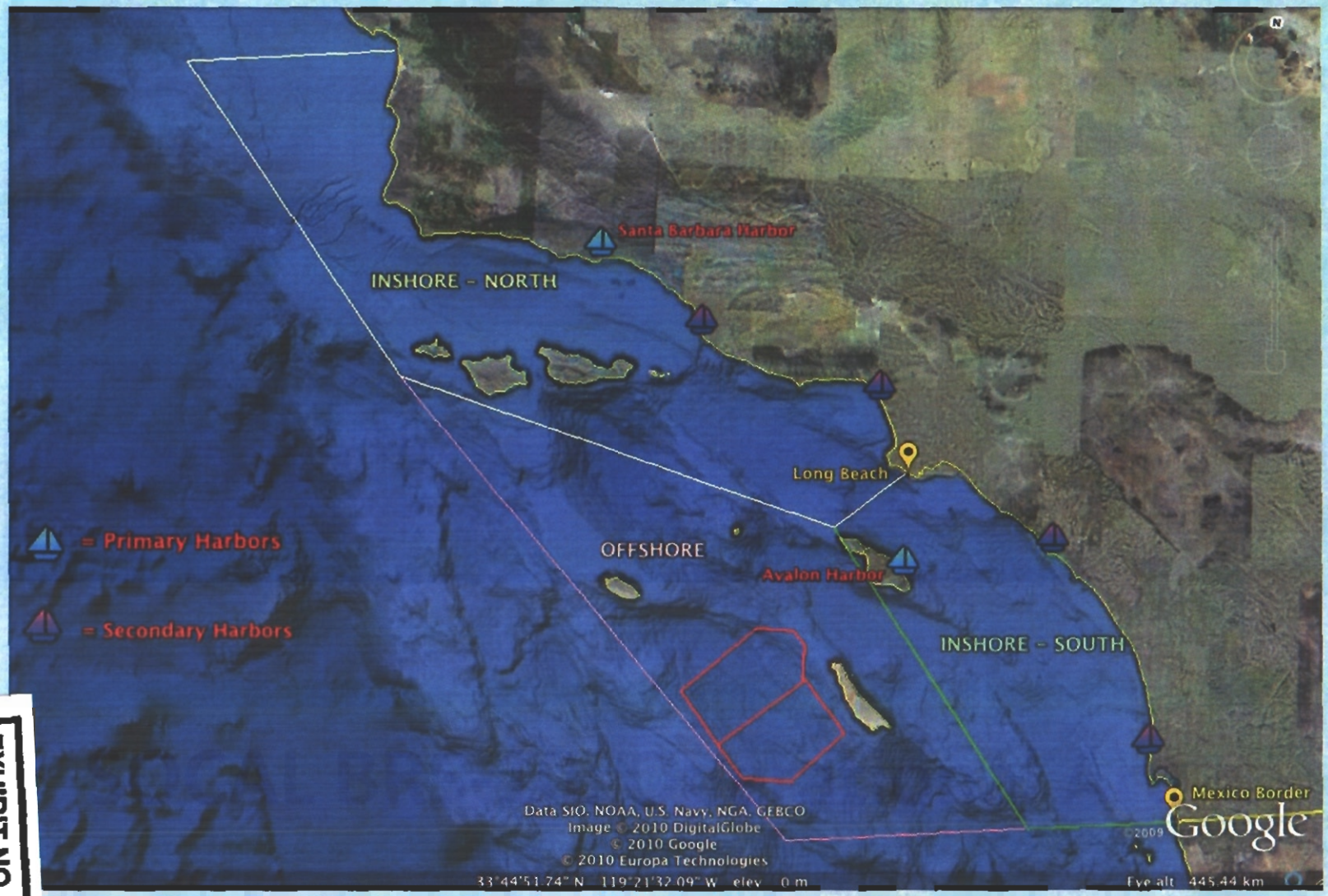
IV. SUBSTANTIVE FILE DOCUMENTS:

1. NOAA Consistency Determination, SOCAL-10 Research
2. NMFS Scientific Research Permit Application (#14534);
3. Supplemental Information for NMFS permit #14534;
4. SOCAL-10 Draft Environmental Assessment;
5. Woods Hole Oceanographic Institute Institutional Animal Care and Use Committee Application for SOCAL-10;
6. SOCAL-10 Public Summary (1-page and 6-page simple summary and FAQs)
7. SOCAL-10 Detailed Public Summary; and
8. SOCAL-10 presentation .pdf presented to the CCC on 13 May
9. Behavioral Response Studies BRS-07-08 (Bahamas) and MED-09 (Mediterranean)
10. "Addressing the Effects of Human-Generated Sound on Marine Life: An Integrated Research Plan for U.S. federal agencies. Interagency Task Force on Anthropogenic Sound and the Marine Environment of the Joint Subcommittee on Ocean Science and Technology. Washington, DC." (Southall, B., Berkson, J., Bowen, D., Brake, R., Eckman, J., Field, J., Gisiner, R., Gregerson, S., Lang, W., Lewandoski, J., Wilson, J., and Winokur, R. 2009.)
11. U.S Navy Consistency Determinations CD-049-08 and CD-086-06 (Navy SOCAL Training Exercises), CD-109-98 (Navy Advanced Deployable System (ADS) Ocean Tests), CD-95-97 and CD-153-97 (Navy, Low-Frequency Active (LFA) Sonar Research, Phases I and II), CD-2-01 (Navy Point Mugu Sea Range testing and training activities), and CD-37-06 (Navy Monterey Bay (MB) 06).
12. USGS Seismic Survey Consistency Determinations No. CD-14-02, CD-16-00 and CD-32-99.
13. NOAA/NMFS Consistency Determination No. CD-102-99 (Pulsed Power Tests).
14. Scripps Institution of Oceanography Consistency Certification CC-110-94/Coastal Development Permit Application 3-95-40, Acoustic Thermometry of Ocean Climate (ATOC) Project and Marine Mammal Research Program (MMRP).
15. Marine Mammal Populations and Ocean Noise: Determining When Noise Causes Biologically Significant Effects, National Research Council, Committee on Characterizing Biologically Significant Marine Mammal Behavior, Ocean Studies Board, 2005.

Exhibits

Exhibit 1 SOCAL-10 Research Area
Exhibit 2 Navy SOCAL Area, and Shipping Lanes
Exhibit 3 Underwater Topography in Area
Exhibit 4 Executive Summary, Interagency Integrated Research Plan
Exhibit 5 Acronyms
Exhibit 6 Measures to Minimize Effects to Listed Species

SOCAL BRS-10: Operational Areas



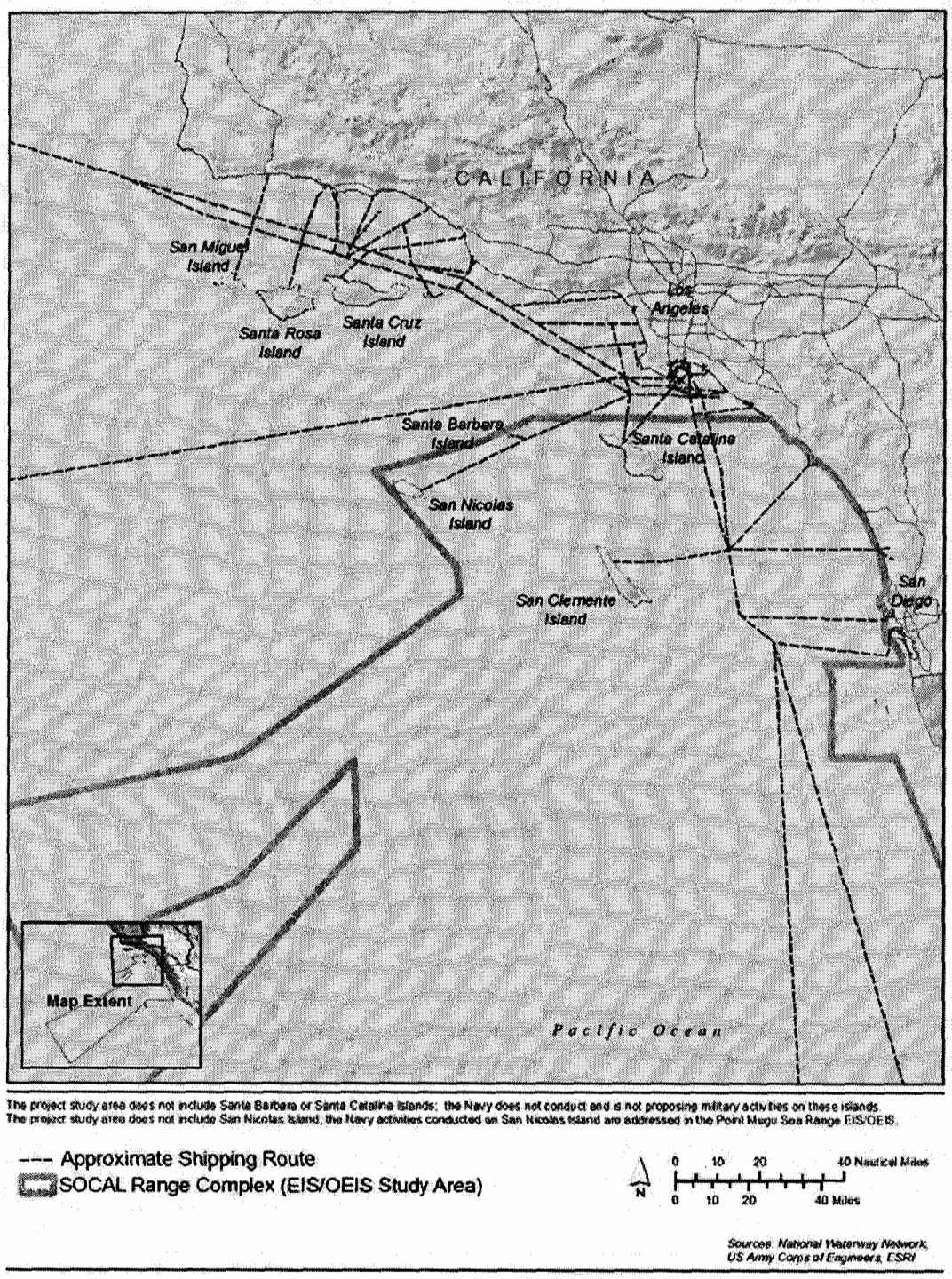


Figure 3-1: SOCAL Range Complex Shipping Routes (DON, 2008)

EXHIBIT NO. 2
APPLICATION NO.
CD-29-10

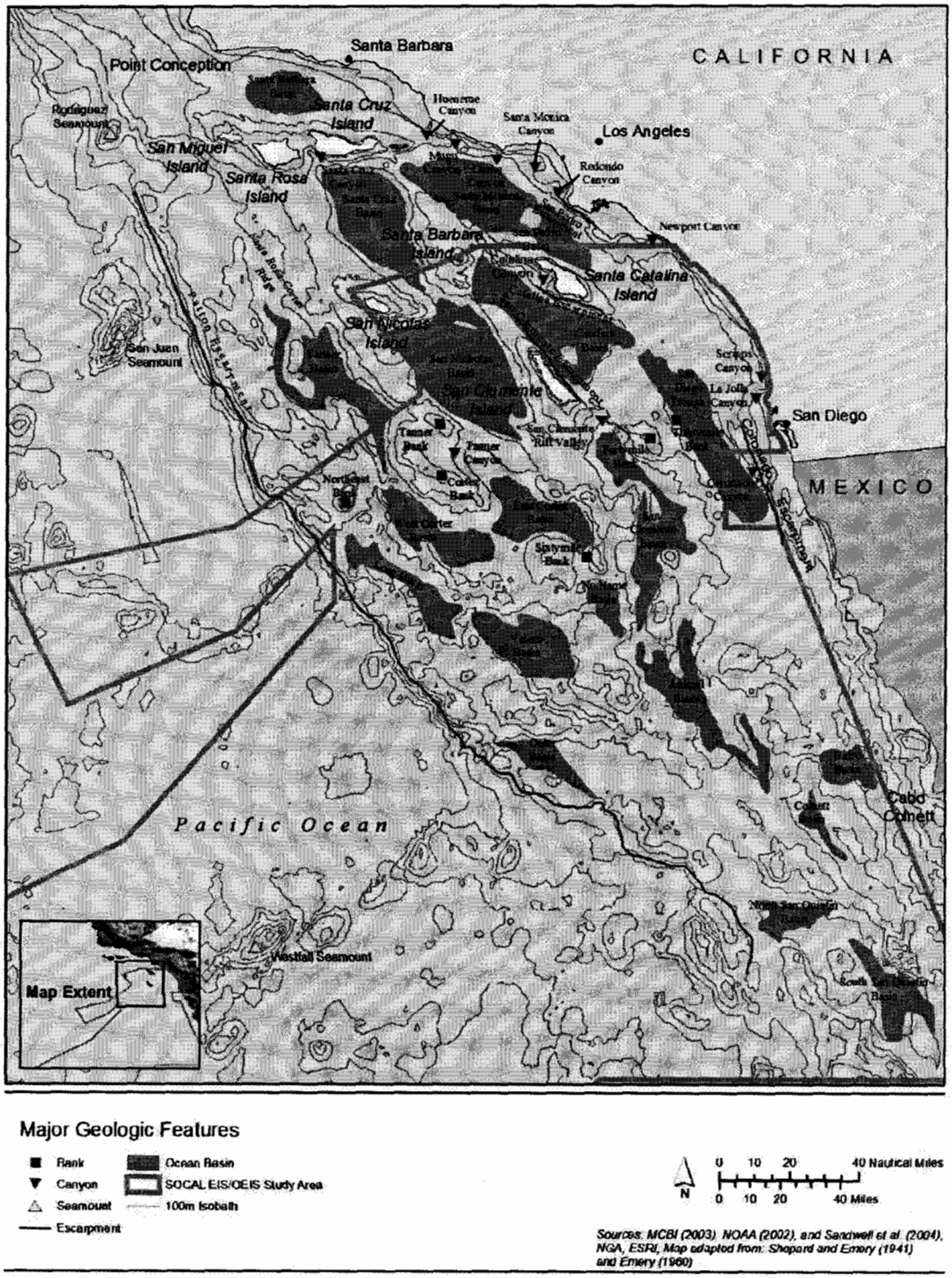
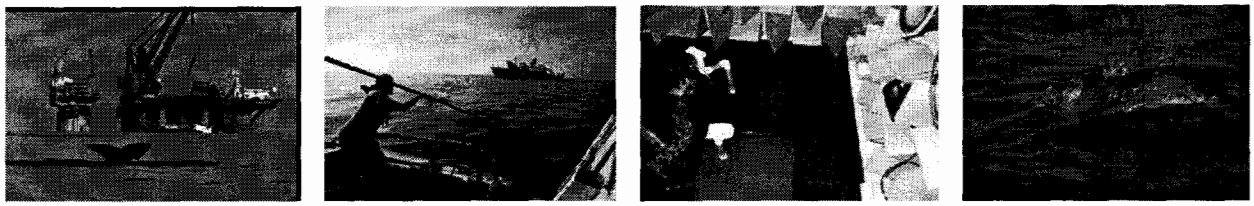


Figure 3-3: Major Geologic Features in the NE portion of the SOCAL Range Complex. (DON, 2008)



"Addressing the Effects of Human-Generated Sound on Marine Life:
An Integrated Research Plan for U.S. Federal Agencies"

A Report of the Joint Subcommittee on Ocean Science & Technology (JSOST)

~ INTERAGENCY TASK FORCE ON ANTHROPOGENIC SOUND AND THE MARINE ENVIRONMENT ~

Contributing Federal Agencies (in alphabetical order):
Marine Mammal Commission (MMC)
Minerals Management Service (MMS)
National Oceanic and Atmospheric Administration (NOAA)
National Science Foundation (NSF)
U.S. Army Corps of Engineers (ACE)
U.S. Coast Guard (USCG)
U.S. Department of Defense, U.S. Navy (USN)
U.S. Department of Energy (DOE)
U.S. Department of State (DOS)
U.S. Fish and Wildlife Service (FWS)

This document should be cited as follows:

Southall, B., Berkson, J., Bowen, D., Brake, R., Eckman, J., Field, J., Gisiner, R., Gregerson, S., Lang, W., Lewandoski, J., Wilson, J., and Winokur, R. 2009. Addressing the Effects of Human-Generated Sound on Marine Life: An Integrated Research Plan for U.S. federal agencies. Interagency Task Force on Anthropogenic Sound and the Marine Environment of the Joint Subcommittee on Ocean Science and Technology. Washington, DC.

Acknowledgements

We appreciate and acknowledge the many scientists and managers from participating federal agencies that contributed to this report

Cover page photo credits (from left to right)
(1) Sperm whale beginning a dive in Mississippi Canyon Block 127 in the Gulf on the 2002 S-tag cruise (photo credit: Christoph Richter, Texas A&M University-Galveston).

(2) Acoustic and behavioral monitoring tag being applied to a pilot whale in Hawai'i by Duke University researcher Doug Nowacek; NOAA's research vessel Oscar Elton Sette is visible in the background (photo credit: NOAA/NMFS Pacific Islands Fisheries Science Center).

(3) Harbor seal participating in behavioral hearing experiments in a specialized anechoic testing chamber at Long Marine Laboratory, University of California, Santa Cruz, CA (photo credit: Brandon Southall, NOAA).

(4) Harbor porpoise (photo credit: Ari Friedlaender, Duke University)

Council on Environmental Quality
Office of Science and Technology Policy
Executive Office of the President
January 13, 2009

Dear partners and friends in the ocean and coastal community:

We are pleased to present this report, ***Addressing the Effects of Human-Generated Sound on Marine Life: An Integrated Research Plan for U.S. Federal Agencies***. This report was developed in response to an Interagency Committee on Ocean Science and Resource Management Integration request for a focused, coordinated Federal science and technology plan from the National Science and Technology Council's Joint Subcommittee on Ocean Science and Technology (JSOST). The JSOST's Interagency Task Force on Anthropogenic Sound and the Marine Environment prepared this report.

Whether and how human-generated sounds in the ocean affect marine life has become an issue of increasing awareness, within scientific and regulatory circles as well as among the general public. Many activities vital to our society, including the actions of many Federal agencies, introduce sound into the marine environment. Consequently, there is much interest and effort involved in understanding associated environmental impacts and, where appropriate and practical, developing ways of minimizing them. A number of Federal agencies are actively engaged in advancing the science and technologies needed to address these challenging issues.

This report provides an explicit interagency roadmap for the next decade to focus and prioritize research efforts addressing this issue. It summarizes collective research efforts by Federal agencies in several key areas and includes a number of specific and prioritized research recommendations regarding future efforts, with particular emphasis on interagency collaboration. Finally, it summarizes some general coordinating actions and means of increasing the transparency and public recognition of ongoing interagency efforts in this field. The findings indicate that many of the challenging scientific, regulatory, and legal issues regarding underwater sound can be addressed with focused, prioritized, and sustained effort coordinated among the Federal agencies. We hope it will be useful to a broad range of interested parties.

Sincerely,

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Chair, Council on Environmental Quality

John H. Marburger III
Director
Office of Science and Technology Policy

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Table of Contents

Report Overview and Summary

The issue of anthropogenic sound[1] and its possible impacts on the marine environment has created unique challenges for virtually all federal agencies conducting, supporting, or assessing operations in the marine environment. These agencies are charged with regulating, supporting, and/or performing activities in the marine environment vital to our nation's health, economy, and security across a wide scope of sectors. Sound (both intentionally produced as a tool or as a by-product of other activities) is an integral part of the activities of these agencies and of many critical human activities, including vessel operation and navigation, offshore minerals exploration, national defense, and scientific research. Federal agencies are challenged with achieving their mission goals in conducting and/or regulating these critical activities while meeting their mandated responsibilities as environmental stewards for the nation. Continuing to develop a scientific basis for determining potential impacts and the appropriate response is an urgent requirement for federal agencies, if they are to continue to achieve their primary missions for our nation in an environmentally safe manner.

There is considerable scientific uncertainty regarding the nature and magnitude of the actual impacts of anthropogenic sound on the marine environment, as well as the most appropriate and effective mitigation measures where effects have been demonstrated or are likely. Societal benefits from the full spectrum of sound-producing activities should be considered along with, and not overshadowed by, any potential negative impacts of those activities. The goal of federally-supported research in this area

1 Within this report, the term "sound" is used to refer to the acoustic energy radiated from a vibrating object, with no particular reference for its function or potential effect. "Sounds" include both meaningful signals and "noise" which may have either no particular impact or may have a range of adverse effects. The term "noise" is only used where adverse effects are specifically described, or when referring to specific technical distinctions such as "masking noise" and "ambient noise."

is to obtain mission-critical data that are used in a timely and effective manner to inform policy guidance, develop targeted mitigation measures, and develop and improve regulatory criteria.

How anthropogenic sound may affect marine life is a new field of study. What began as a simple concern that commercial shipping might affect the long-distance calls of whales (Payne and Webb, 1972) has now evolved into a more complex recognition that various anthropogenic acoustic sources have the potential to adversely affect marine life. Additionally, concerns regarding potential impacts are compromising human applications of sound for important scientific, commercial, and military purposes, particularly where scientific data are lacking or ambiguous. These concerns stem from both an increased understanding of the biological importance of sound to most marine vertebrates (particularly marine mammals and many fish) and a growing appreciation of the value of acoustics as a tool for ocean research, energy development, monitoring ocean health, resource management, military activities, and ship operations. How do we as a society reconcile our growing dependence on sound as a tool for studying, using, and conserving the marine environment with a similarly growing understanding of the potential for unintended adverse environmental consequences? How do we balance the potential negative environmental impacts from the incidental introduction of sound with the benefits of ocean-based commerce, national security, research, or transportation? And most important, how do we regulate these

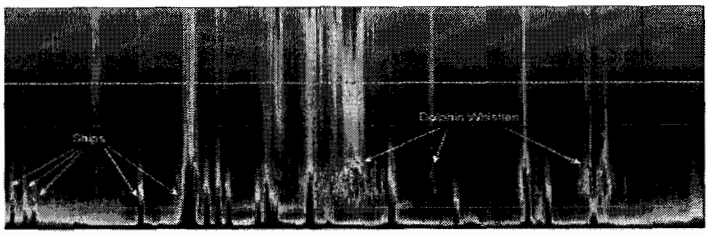

Image courtesy of Dr. John Hildebrand, Scripps Institute of Oceanography

essential human activities in the face of significant scientific uncertainty about adverse effects? Many of these fundamental questions remain to be answered and they clearly require additional scientific data to be adequately addressed.

The most immediate response by U.S. federal agencies has focused on understanding and minimizing the potential adverse effects of their activities, or activities they support or regulate. The current status of science (in terms of exactly what level and types of sound will result in a specific effect) often results in estimates of potential adverse impacts that contain a high degree of uncertainty.

Public perception of threats and scientific analyses of risks may lead to different priorities for acoustic research. There is growing concern by scientific experts in relevant disciplines, that the public and legal focus on a very narrow range of active sources and the predictable agency responses are distorting an appropriate scientific approach to assessing the broader impacts of anthropogenic noise as a global issue (see NRC, 2000; 2003; 2005; Nowacek *et al.*, 2007; Southall *et al.*, 2007). This creates a growing need for both transparency and public and stakeholder outreach as agencies respond to the increasing awareness of sound as an environmental issue.

The laudable aim of minimizing acoustic effects has produced controversy, social tension, and litigation. It has also led to precautionary restrictions, considerable additional costs and delays, not the least of which has been the paradoxical effect of hindering ocean acoustic science essential to understanding not only this issue but also other important environmental issues such as the marine aspects of climate change. These anticipatory restrictions and other precautions imposed through litigative challenges have taken place against a background of considerable uncertainty as to the

nature and extent of impacts from noise exposure. It is this gap, between what should and can be done with scientific confidence and what is currently being done with abundant precaution but demonstrable societal cost, which we seek to reduce through the coordinated federal research strategy depicted here. A summary of key overarching summary points is given below (Box 1).

Box 1 – OVERVIEW OF KEY POINTS

Sound is of vital importance for most marine vertebrates.

Natural and human sounds can have benign (or no) to significant effects on marine life.

Public, media and regulatory attention has focused on known and/or potential adverse impacts of active sonar and seismic systems, but agencies must consider a wider array of sound sources.

Existing data needed to assess and mitigate effects are limited, leading to uncertainty in determining the necessary responses (if any).

Federal research has been largely focused on immediate needs specific to individual agencies.

However, agencies often have common science and technology needs on this issue that could be most quickly and economically met through a coordinated program of effort.

Purpose of Report

As the scope and nature of the issue has expanded, so has the need for increased communication and collaboration across federal agencies[2]. At present, federal agencies have already begun working to develop tools, technologies, and knowledge to provide empirical data on these difficult questions, but these have largely occurred at an agency-specific level. In response, the Interagency Committee on Ocean Science and Resource Management Integration (ICOSRMI) formed an "Interagency Task Force on Anthropogenic Sound and the Marine Environment" within the Joint Subcommittee on Ocean Science & Technology (JSOST). This Task Force was comprised of federal

2 Brief descriptions of the mandates of involved U.S. federal agencies relative to the issue of marine sound, as well as agency representatives contributing to this report are listed in Appendix 1.

agencies most directly involved in this issue with each individual agency providing a representative to participate and speak for their agency perspective. The Task Force was charged with developing a focused, coordinated science and technology plan of action among federal agencies and reporting on this plan through JSOST to ICOSMRI. Therefore, this report represents an overall, interagency (not individual agency) perspective, as determined through the interactions and deliberations of Task Force members.

The recommendations offered within this report provide a strategic vision for integrating, prioritizing and optimizing the science and technology efforts of U.S. federal agencies on marine anthropogenic sound over the next decade. It is based on lessons learned from inter-agency coordination on ocean science issues generally, as well as coordination on pressing research needs regarding this issue specifically. The intent is to promote and develop better scientific understanding, thereby leading to better documentation of effects, less controversy regarding risks, increased scientific certainty underlying policies and regulatory decisions, and effective mitigation efforts where impacts are known or likely. The report is also intended to improve the combined federal effort by increasing inter-agency coordination, planning, and leveraging resources, while reducing redundancy and disproportionate focus in a few areas.

The report is organized into a general overview (this section) that summarizes the key issues and recommendations of the task force, followed by a list of acronyms, five primary chapters, and three detailed appendices. Throughout the report, completed research and specific recommended research actions are given within five general subject categories: (1) Sound Sources and Acoustic Environment; (2) Baseline Biological

Information (Physiology, Distribution, and Abundance); (3) Effects of Sound (Criteria and Thresholds); (4) Monitoring and Mitigation; and (5) Outreach, Education, and Scientific Peer Review. Chapter 1 states the general issue in greater detail than this general overview and provides a sense of the limits to currently available information. Chapter 2 provides an overview of effort to date by federal agencies. Chapter 3 offers specific recommendations for future effort and sets priorities within specific action areas. Chapter 4 considers the opportunities and obstacles for inter-agency coordination. Chapter 5 draws together both general and specific recommendations for a coordinated federal science and technology response to this issue, acknowledging the pragmatic challenges that are known or expected. Appendix I provides a summary of the roles and responsibilities of the participating federal agencies on the marine sound issue; it also includes a list of the agency representatives that contributed to the preparation of this report. Subsequent appendices are more detailed versions of Chapters 2 and 3, providing additional specific information on the current federal effort (Appendix II) and prioritized recommended future federal research and development (Appendix III).

Task Force Conclusions and Recommendations

The Task Force considered both positive and negative outcomes of anthropogenic sound in the marine environment, both through direct use of acoustics for sensing and communication, and through the noise generated as an unwanted, but often unavoidable, aspect of essential human ocean-related activities (*e.g.*, shipping, marine construction, energy exploration and production). Additionally, we note that the scientific understanding and technologies that are needed to enable the federal government to

respond appropriately will, in some cases, be the same tools and technologies required to better execute federal national security and resource management missions. The full extent of research required to address the environmental consequences of anthropogenic marine sound can seem overwhelming. However, some clear, high-priority actions exist that should be undertaken collaboratively among federal agencies for effective action on this issue, including better understanding of the actual impacts of noise, both acute and cumulative.

Of these, the Task Force has identified both specific research action areas and general coordination recommendations which are of the greatest importance to the federal government. Table 1(below) provides an ordinal ranking of these *highest* priority research action areas, their associated suggested timelines (*i.e.*, short-term vs. long-term), and those agencies most likely to have leading/direct interest and/or secondary level of involvement. Each recommended research action area in Table 1 is subjectively categorized by the overall importance and social relevance of the work ("importance") and the relative level of effort required for significant progress ("effort"): (1) High importance/moderate effort; (2) High importance/high effort; (3) Moderate importance/moderate effort; (4) Moderate importance/high effort. [note: additional details regarding the research action areas specified here are given in Chapter 3 and Appendix III].

Table 1 – Overview of Highest Priority Research Recommendations

Prioritized Recommended Federal Research Action Areas	Short or Long-term?	Relative Importance and Level of Effort *	Agencies Involved (see notes below)	General Subject Area(s) (described in Chapter 2)
(1) Improve ability to identify and understand biologically-significant effects of sound exposure in order to improve effectiveness and efficiency of efforts to mitigate risk.	Ongoing and long-term	**High Importance/ High Effort**	NOAA[1] MMC[2] NSF, USN, MMS	Effects of Sound
(2) Hearing, physiological, behavioral, and effects data (*e.g.*, controlled exposure studies) for key species of concern (baleen whales, beaked whales, Arctic & endangered species).	Ongoing and long-term	**High Importance/ High Effort**	USN[1], NOAA[2], NSF, MMS, MMC	Baseline Biological Information, Effects of Sound
(3) Develop new technologies (e.g., acoustic monitoring) to detect, identify, locate, and track marine mammals, in order to increase the effectiveness of detection and mitigation.	Ongoing and short-term	**High Importance/ Moderate Effort**	USN[1], NOAA[1], MMS, NSF, USCG, ACE, DOT, FWS	Sound Sources and Acoustic Environment, Mitigation and Monitoring
(4) Develop and validate mitigation measures to minimize demonstrated adverse effects from anthropogenic noise.	Short-term and long-term	**High Importance/ High Effort**	NOAA[1], MMC[2], USN, MMS, NSF, FWS, USCG, ACE	Mitigation & Monitoring, Effects of Sound
(5) Support the development, standardization, and integration of online data archives of marine mammal distribution, abundance, and movement for use in assessing potential risk to marine mammals from sound-producing activities.	Ongoing	**High Importance/ Moderate Effort**	NOAA[1], USN, FWS, MMS, MMC	Baseline Biological Information
(6) Long term biological and ambient noise measurements in high-priority areas (*e.g.*, Arctic, protected areas, commerce hubs).	Ongoing and long-term	**High Importance/ High Effort**	NOAA[1] USN, MMS	Sound Sources and Acoustic Environment
(7) Test/validate mitigating technologies to minimize sound output and/or explore alternatives to sound sources with adverse effects (*e.g.*, alternative sonar waveforms).	Long-term	**High Importance/ High Effort**	USN[1], NSF[1], MMS, NOAA, MMC, DOE	Mitigation & Monitoring
(8) Explore need for and effectiveness of time/area closures versus operational mitigation measures.	Ongoing and long-term	**Moderate Importance/ Moderate Effort**	MMS[1], NOAA[2], MMC[2], USN, NSF	Mitigation and Monitoring
(9) Develop and improve noise exposure criteria and policy guidelines based on periodic reviews of best available science to better predict and regulate potential impacts.	Ongoing and long-term	**Moderate Importance/ Moderate Effort**	NOAA[1], FWS[1], MMC[2], USN, MMS, NSF	Effects of Sound
(10) Standardize data-collection, reporting, and archive requirements of marine mammal observer programs.	Long-term	**Moderate Importance/ Moderate Effort**	NOAA[1], FWS[1], MMS, NSF, USN, USCG, MMC	Mitigation and Monitoring
(11) Expand/improve distribution, abundance and habitat data for marine species particularly susceptible to anthropogenic sound.	Ongoing and long-term	**Moderate Importance/ High Effort**	NOAA[1], FWS[1], USN, MMC, MMS	Baseline Biological Information

Notes:
* note shading corresponds to four relative importance/effort categories; see text for more detailed explanation
[1] denotes agencies with a leading and/or direct interest on each recommended action
[2] denotes agencies with a secondary level of involvement in each recommended action

Many of the research action areas included in these recommendations are to some extent already being investigated or acted upon by some of the participating agencies in this task force. However, our intention is to focus on those action items and research recommendations that are most likely to remain important for the U.S. federal government, now and over the coming decade. Some of these will require prioritization and action by individual agencies; others will need more concerted inter-agency collaboration.

Perhaps the most important outcome of this report, and of the Task Force generally, is the increased coordination, communication, and planning across federal agencies on this important environmental issue. In order to sustain existing collaborations and enhance further coordination, the Task Force felt it was also imperative to identify the *highest* priority coordination action items. The Task Force feels these actions are critical for the successful implementation of this strategic plan and will ultimately maximize the diverse capabilities and perspectives of the federal agencies. These highest priority coordination action items include:

- **Sustained interagency collaboration and coordination, including:**
  - High-level, inter-agency coordination among individuals with sufficient authority to make timely planning and budget recommendations within their respective agencies; and
  - Program-level, inter-agency coordination among agency subject matter experts and program managers to implement directives and provide technical advice to leadership.

- **Enhanced communication and coordination on the marine sound issue with private sector interests and with the governments of other nations to reduce duplication of effort and advance a consistent scientific response.**
- **Continued efforts to streamline research permitting involving acoustic sources.**
- **Development of a biennial forum for information transfer to report on the results of inter-agency research to various stakeholders (*e.g.*, federal and state government agencies, industry, academia, public, educators, media, and environmental groups).**

ACRONYMS AND ABBREVIATIONS

AAM	Active Acoustic Monitoring
ABR	Auditory Brainstem Response
ADC	Analog-Digital Converter
ATOC	Acoustic Thermometry of Ocean Climate
AUTEC	U.S. Atlantic Undersea Test and Evaluation Center
BEQ	Bachelor Enlisted Quarters
BRS	Behavioral Response Study
CA	Close Approach
CDFG	California Department of Fish and Game
CEE	Controlled Exposure Experiment
CETAP	Cetacean and Turtle Assessment Program
CFR	Code of Federal Regulations
CI	Confidence of Intervals; Co-Investigator
CINMS	Channel Islands National Marine Sanctuary
CITES	Convention on International Trade in Endangered Species
cm	centimeter(s)
CV	Coefficient of Variation
dB	decibel(s)
DDT	Dichloro-diphenyl-trichloroethane
DOC	Department of Commerce
DON	Department of the Navy
EA	Environmental Assessment
EFH	Essential Fish Habitat(s)
EIS	Environmental Impact Statement
EKG	Electrocardiogram
ESA	Endangered Species Act
Et seq	Et sequencial
FAO	Fisheries and Agriculture Organization
FEIS	Final Environmental Impact Statement
FF	Focal Follow
FM	Frequency Modulated
FMP	Fishery Management Plan(s)
FOEIS	Final Overseas Environmental Impact Statement
FONSI	Finding of No Significant Impact
FR	Federal Register
ft	feet
FWS	Fish and Wildlife Service
Gb	Gigabyte(s)
GOMEX	Gulf of Mexico
HMS	Highly migratory species
hr	hour
Hz	Hertz
IACMST	Inter-Agency Committee on Marine Science and Technology (United Kingdom)
ICW	Intra-Coastal Waterway
IUCN	International Union for Conservation of Nature and Natural Resources
JASA	Journal of the Acoustical Society of America
kHz	kiloHertz
km	kilometer(s)
km/hr	kilometer(s) per hour
kt	knot(s): nautical mile(s) per hr
LF	Low Frequency

m	meter(s)
Mb	Megabyte(s)
MBTA	Migratory Bird Treaty Act
MF	Mid-Frequency
mi	mile(s) (statute)
MICA	Mesure de l'Impact des Catures Accessoires
min	minute(s)
MMA	Marine Managed Area(s)
MMC	Marine Mammal Commission
MMPA	Marine Mammal Protection Act
MPA	Marine Protected Areas
MSL	Mean Sea Level
NATO	National Oceanic and Atmospheric Administration
NEO	NOAA Executive Order
NEPA	National Environmental Policy Act of 1969
NMFS	National Marine Fisheries Service
NMS	National Marine Sanctuary
NURC	NATO Undersea Research Centre (formerly SACLANTCEN)
NUWC	Naval Underwater Warfare Center
OEIS	Overseas Environmental Impact Statement
OPAREA	Operational Area
OPR	Office of Protected Resources
OV	Observation and tracking Vessel
Pa	Pascal
PAM	Passive Acoustic Monitoring
PB	Playback
PBV	Play Back Vessel
PCB	Poly-Chlorinated Biphenyls
Pers. Comm.	Personal Communication
ppt	parts per thousand
psu	Parts per thousand salinity units
PTS	Permanent Threshold Shift
RDT&E	Research, Development, Test and Evaluation
RL	Received Level
rms	root mean squared
SACLANTCEN	Supreme Allied Commander, Atlantic: Undersea Research Centre
SAG	Surface Action Group
SARA	Canada's Species at Risk Act
SCANS	Small Cetaceans in the North Sea
SCB	Southern California Bight
SCI	San Clemente Island
SCIUR	San Clemente Island Underwater Range
SCORE	Southern California Offshore Range
sec	Second(s)
SEL	Sound Exposure Level
SL	Source Level
SOAR	Southern California Anti-Submarine Warfare Range
SOCAL	Southern California
SONAR	SOund Navigation And Ranging
SPE	Society of Petroleum Engineers
SPL	Sound Pressure Level
Spp	Species
SRP	Scientific Research Permit

TAG	Tag Attachment Vessel
TL	Transmission Loss
TOTO	Tongue of the Ocean
TTS	Temporary Threshold Shift
U.S. or US	United States
U.S.C.	United States Code
UN	United Nations
USFWS	United States Fish and Wildlife Service
WHOI	Woods Hole Oceanographic Institution
WTV	Whale Observation/Tag tracking Vessel

Symbols	
=	Equal to
/	Divided by
+	Plus
≥	Greater than or equal to
>	Greater than
<	Less than
~	Approximately
±	Plus or minus
μ	Micro (10^{-6})
Log	Logarithm

Measures to Minimize Effects to Listed Species:

This project includes a large number of co-investigators because of the complex set of different skills required in each of several different field sites. Each co-investigator will be responsible for a specific research activity on a cruise, often leading a team. Their roles are specified in the plan for each cruise well ahead of time, and during the cruise the actions of their teams are coordinated in daily planning with a designated scientist in charge of each cruise.

The three different activities under the permitted research that could affect animals are close approach, tagging, and playback.

Close Approach

We plan to use relatively small, quiet boats for tag attachment. In our experience, the approach with minimal risk of harm or disturbance uses a small boat with inflatable soft sides, powered by motors that are as silent as practicable. Slightly larger tagging boats may be required for some of the species to be tested in the SOCAL BRS program than, for instance, in the Bahamas BRS, but the same general approaches will be followed. We pre-position the boat relatively close to where we think the whales will surface, approach and maneuver slowly around the whales, and break off and find another group if the whales show signs of disturbance. Whether or not disturbance is observed, we limit the number of close approaches to any one group to three within a day.

Tagging

Two methods are common for deploying tags on cetaceans at sea, using a pole or launching the tag from a cross-bow or rifle. There are settings where using a launcher may allow the tag to be attached from farther away, reducing the potential for harassment during the tagging approach, but in our experience, there is greater control with attaching the tag to the whale using a pole. Tags can also be attached with suction cups or a harness that does not break the skin, or with an invasive attachment that penetrates the tissue to anchor the tag. Our tags use a non-invasive suction cup attachment to reduce the risk of pain and infection. The current DTAG package has an array of 4 60mm diameter suction cups made from medical grade silicone. Before deployment the cups are cleaned and sterilized using the following protocol to reduce the risk of any infectious agent being present and to prevent contamination of any thin layer of skin that may adhere to the tag after release.

- Rinse the cups with distilled water.
- Use a tooth brush and detergent to clean the surface of the cups.
- Rinse the soap off the cups using more distilled water.
- Sterilize the cup by rinsing it with ethyl alcohol.
- Rinse the cup a final time with distilled water.
- Cover the suction cups with latex gloves or other sterile covering to prevent contamination.

If the tag does bother the whale, this attachment also reduces the duration of the problem, as the whale can relatively easily dislodge and remove the tag by rapid movements. The duration of attachment of these non-invasive tags is suitable for the design of the playback experiments or other research protocol. The suction cup tag is set to release after a duration that is set by the scientific goals of tagging, and the tag does not remain attached for longer than necessary.

The proposed research uses tags that, while attached, continuously monitor the behavior of cetaceans. This technique requires CA for photo-identification and for tag attachment, and these CAs and tag attachments may require some brief and necessary disturbance, but the tagging reduces the potential for disturbance during the subsequent focal follows (FF). FFs of tagged animals can be conducted farther from the focal whale than would otherwise be required to monitor the behavior of untagged animals. The goal of the FFs is to operate the observation vessel in such a way that it has no effect on the subjects.

Playback (PB)

The plan for the playback experiments is to determine behavioral responses of whales exposed to received sound levels well below those thought to pose a potential for direct physical injury using methods that can identify the onset of a response and can safely help to define behavioral reactions that if prolonged or exaggerated might start to pose a risk. The playback experiments covered in this application include measures to minimize the potential for injury by establishing conservative maximum received levels of sound at the whale, based upon extensive research and upon current regulatory criteria (NMFS 2005a;

Southall et al., 2007). For beaked whales, where the potential for physical injury from exposure may possibly occur at relatively lower levels as a function of behavioral responses, explicit mitigation and monitoring protocols will be used to ensure that physical harm does not occur. Specifically, the protocols calls for the level of playback not to exceed the level at which disruption of behavior is first detected.

The sound playback experiments are designed to elicit measurable behavioral responses, but they are of short duration on the order of tens of minutes at about 10% duty cycle and unlikely to cause adverse reactions or prolonged disturbance. The basic goal of the sound playback experiments of anthropogenic sounds to beaked and other whales covered in this permit is to determine the lowest exposure of short transmissions of transient underwater sounds that predictably elicit behavioral responses from subjects. Our studies are designed in such a way as to minimize exposure of animals to sounds louder than is required to elicit identifiable behavioral reactions in this range of received levels (RLs). The results of playback experiments to beaked whales (Boyd et al. 2007; Boyd, 2008) have demonstrated clear behavioral responses to sound exposures currently viewed by regulatory policy as unlikely to pose an adverse impact. While these behavioral responses differ from baseline behavior, there is no indication of adverse effect.

The primary features we will control in our PB experiments are the duration and RL (SPL) of sound at the test subject. We will model or measure underwater sound propagation in order to predict exposure at the animal. We will control exposure at the animal by controlling the SL of the source and the distance between the source and the whale. The playback protocol for establishing the level at which an animal starts to respond to a playback calls for starting the PB with a SL yielding a low RL at the animal; relatively near the ambient noise level. While monitoring for potential reaction, the RL increases in a ramp-up procedure until the subject responds or the target exposure level is reached. This measure minimizes exposure beyond the level required to elicit a reaction, and it minimizes the potential for disturbance, given the importance of detecting reactions in the target RL range. We then follow the animal post-exposure, and rely on the tag and on vessel based observations to document return to baseline behavior. Subjects are photo-identified, and later identifications will be checked for re-sightings.

Maximum received level for sound playbacks is designed to minimize the potential for pain or injury. The maximum exposure level for playback is designed to minimize the potential that animals are exposed to sounds that might cause physiological harm or injury. Over the past few years several experiments have defined sound exposures that cause a temporary decrease in the sensitivity of hearing (TTS for temporary threshold shift) in captive dolphins and seals (Ridgway et al., 1997; Kastak et al., 1999; Schlundt et al., 2000) using Sound Exposure Level as the criterion for evaluating exposure in terms of auditory injury. Ridgway et al. (1997) and Schlundt et al. (2000) found it took exposure to single 1-sec tonal signals above 190 dB re 1 µPa2-s SEL to obtain TTS in dolphins and beluga whales for most frequencies. These experiments exposed animals to sounds with Sound Pressure Levels well above the 180 dB exposure limit for playback with no sign of injury even though subtle and fully reversible effects on hearing were measured under controlled conditions.

Given that our exposures will be below the level indicating a potential for direct injury from exposure, we also take into account the regulatory situation in selecting a maximum exposure level for playbacks. NMFS currently applies the following acoustic criterion for injury "In the absence of species-specific data on auditory impacts for marine mammals, a received sound pressure level of 180 dB re 1 ?Pa (rms) or greater has been used by NMFS as a threshold for concern about temporary and/or permanent hearing impairment (Level A Harassment)." (NMFS 2004, 67537). NMFS currently applies the following acoustic criterion for level B harassment "In the absence of scientific, species specific information for marine mammals in the GOM, a received sound pressure level of 160 dB re 1 ?Pa (rms) has been used by NMFS as the threshold indicator of potential concern about disturbance of marine mammals in the wild through disruption of behavioral patterns, including but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (Level B Harassment)." (NMFS 2004, 67538). The SURTASS LFA FOEIS/EIS (Department of the Navy 2001) assumes a continuum of risk from low near 120 dB to high near 180 dB SPL, with an assumed MMPA Level A injury take for all exposures above 180 dB SPL. In this policy context, NMFS OPR in its cover letter of 25 July 2001 for the first amendment to permit no. 981-1578, quoted comments from the Marine Mammal Commission pointing out how important it is to test whether exposures to RLs up to 180 dB SPL may cause disturbance:

The experimental protocol uses a maximum received level for all sounds except airguns of 160 dB SPL.

However, this upper limit is not consistent with that proposed by the Navy (i.e. 180 dB SPL). The difference in these limits seems significant (a hundred-fold change in the intensity) and an informed judgment on the effects of SURTASS LFA or similar systems requires a measure of response to these levels. If a received sound level of 160 dB SPL or less is sufficient to cause significant behavioral changes, then the need to increase the received level to 180 dB SPL is not apparent. However, if changes observed at a received level of 160 dB SPL are deemed insignificant, then additional testing at higher exposure levels seems necessary.

The maximum RL above which we will not expose animals in order to avoid exposures that might enter the range of possible harm to the auditory system is 180 dBrms re 1 μPa; this is a quite precautionary level based on recent data regarding possible direct injury from sound exposure in marine mammals (see Southall et al., 2007). For the relatively short underwater sound transmissions we propose, we believe that a maximum exposure level of 180 dB SPL is conservative based upon TTS data. Southall et al. (2007) set SPL and SEL criteria for injury in cetaceans. The SPL criterion is 230 dB re 1 μPa peak, which is well above the proposed maximum of 180 dB. This criterion is higher than the maximum Source Level proposed for the permitted research, so it would be physically impossible to expose animals to levels near the predicted injury SPL level. However, the risk of injury varies as a function of duration as well as SPL, and Southall et al. (2007) also include a Sound Exposure Level criterion which is a function of SPL and duration. This SEL criterion is 198 dB re 1 μPa2-s, weighted by the hearing of the animal subject. Conservatively, we ignore this weighting, and calculate that the subject would have to be exposed to about a minute of continuous exposure at the peak SPL of 180 dB to exceed the SEL limit (SEL = SPL + 10 log duration in seconds = 180 + 10 log ~60). The signals being transmitted typically just involve a few seconds of sound every few tens of seconds, so to accumulate a minute of exposure would take more than ten minutes. Since this sound pressure level of 180 dB occurs less than 100m from the source, the odds of this duration of exposure are very low. We will also add a margin of error for safety in each experiment to account for the possibility that the acoustic models used to predict RL at the animal have some error margin. This margin of error will be validated by comparison of estimated levels with those measured initially, and during the course of the PB by RLs measured at the animal by the tag. This maximum exposure level will not allow the experiments to exceed the 180 dB threshold currently set by NMFS for injury, but it does allow testing of levels above 160 dB as advocated by the Marine Mammal Commission if changes seen at 160 are deemed insignificant. This compromise minimizes the potential for injury while testing the relevant range of RLs for changes in behavior.

The threshold for pain for sounds is usually considered to occur above the sound exposures that produce threshold shifts, and several other considerations suggest that the maximum exposure criteria here protect against the potential that the playbacks could cause pain. The threshold for pain for sounds is usually considered to occur 140 dB above the C-weighted threshold for hearing (Kryter, 1994, p 53). Most odontocete cetaceans whose audiograms have been measured have best hearing at frequencies above 10 kHz with the lowest thresholds near 40-50 dB. Hearing thresholds below 10 kHz are typically 60 dB or higher. This would suggest a pain threshold above 180 dB for sounds at the frequencies of best hearing, and well above 180 dB for sounds below about 10 kHz for most odontocete species. The two audiograms for beaked whales suggest that they are even less sensitive to sounds in this frequency range (Cook et al., 2006; Finneran and Houser, 2008). Ketten (2002) suggests a threshold of pain and discomfort for marine mammals at an exposure level of 182 dB re 1 μPa. All of these analyses suggest that the maximum exposure level selected for this permit minimizes the potential for pain.

Necessary vs. unnecessary disturbance

Marine mammals are exposed to an increasing number of loud underwater anthropogenic sound sources. One of the main obstacles to minimizing the risk of adverse impacts of these exposures concerns our ignorance of which levels of which kinds of sound may cause disturbance in which species. The key for the proposed work with anthropogenic stimuli is to test for safe behavioral responses that may indicate potential for disturbance that is useful to inform policy-makers to protect these species. We will therefore intentionally expose animals to underwater anthropogenic sounds in order to test how animals respond and what exposure is required to elicit the response. All of this field research takes place in a broader policy context, in which interest and concern may focus on specific exposure ranges for specific taxonomic groups and for specific sound sources. The US Marine Mammal Commission hasstrongly urged setting the upper threshold for exposure studies up to the level treated by policymakers as likely to disturb but not above the threshold for injury. If disturbance is detected and verified at levels below this,

the series of PB experiments probably need not go to higher RLs, but only document the level at which disturbance starts. Hence, the appropriate maximum level for PBs may need to go higher if no disturbance is detected within the regulated range, assuming that there is minimal potential for physiological effects, or permanent effects on hearing. However, we propose to not expose animals to levels above those treated as safe by regulatory agencies but will include exposures above the threshold used by regulators to predict behavioral disruption. (in this case, up to the 180 dB injury level but above the 160 dB level B harassment threshold).

What will be done to avoid or minimize disturbance?

The design of the playback studies designed to test whether specific acoustic exposures of anthropogenic sound cause behavioral disruption does not necessarily mean that we must continue increasing exposure until we detect significant disturbance of a biologically important behavior. Our protocol calls for starting PBs of anthropogenic signals to a focal animal at the lowest RLs thought to pose a potential for an identifiable behavioral reaction. We will increase the exposure until it has been determined that behavioral response or disruption of behavior has been observed. Even if we have not detected such a response, we will limit exposure to levels below those thought to pose a risk of injury (in this case, below 180 dB SPL). The maximum exposure level we propose for our PBs is a RL at the animal of 180 dB SPL. We plan playbacks to last up to several tens of minutes of regular exposures of transient sounds with duty cycles of about 10% up to several times over a day to test whether normal behavior may soon resume, even during exposure, and we plan to follow post-exposure behavior carefully to monitor for how long it may take to return to baseline. In the past few years, we have increasingly succeeded with 18 hr tag attachments, a duration that would allow for a 4 hour pre-exposure period, several exposures over a period of 4-5 hours and up to 9 hours post-exposure. WHOI researchers are currently working on a new version of the DTAG, which should allow for attachment durations of up to 3-5 days, enabling longer term monitoring and likely modifications to exposure methodologies. The key for minimizing disturbance is to limit exposure to the minimum required for a behavioral response or disruption of behavior, to wait until the animal returns to baseline before initiating another playback, and to use the minimum number of stimuli required to meet the scientific objective.

What will be done if evidence of disturbance is observed?

Close Approach
During CAs for tagging, some animals may show avoidance or other reactions. If an animal shows a strong attempt to avoid the approaching tagging vessel, or shows a moderate (e.g., hard tail flicks or trumpet blows) or strong reaction (e.g., continuous surges, tail slashes, numerous trumpet blows, agonistic behavior), as judged by the Weinrich et al. (1991) classification we will break off the CA and select a different subject. If after three CAs, we are not able to attach a tag, we will also select a different subject for tagging.

Playback
The purpose of the PB experiments involving anthropogenic sounds is both to detect disturbance reactions and to determine how exposure may affect the ability of exposed animals to achieve the goals of their activities. If we obtain evidence of an identifiable behavioral reaction during a PB, we will not increase the RL at the subject, but may maintain exposure at that level for a pre-determined period of time (depending on the target species, type of reaction, and when it occurs during the animal's dive + surface sequence). After exposure and assuming we can identify and move the observation vessel close enough, we will continue to follow the focal animal with both visual observation and acoustic monitoring. This observation and listening along with data from the tag will monitor how long it takes it to return to baseline behavior. If there is any sign of prolonged responses that might pose a risk of injury (e.g., panicked flight toward shallow water), we will suspend PBs, and communicate with NMFS (OPR) to develop a protocol to ensure that future PBs would limit exposure to levels below those likely to expose animals to any such risk.

Monitoring Effects of Activities

Observers will carefully monitor for changes in behavior during CA, tagging and PBs. Visual observation from both the tagging vessel and the larger observation vessel coupled with passive acoustic monitoring

from the larger vessel when practicable, will provide detailed evidence on behavior of the animals post CA or tagging. Animals will be photo-identified whenever possible during the CA in order to determine when the same individual is sighted later. The attachment of the tag is videoed whenever possible to document any possible reactions. One the animal is tagged, the tag itself is capable of providing very detailed data on behavioral responses.

Visual observation of the movement patterns of animals with relatively short dive times, such as most delphinids, can serve as a useful indicator of avoidance reactions or changes in surface/dive behavior during a PB. For animals such as beaked whales with potentially long dive times, passive acoustic monitoring of vocalizing animals serves as a good criterion of disturbance. Disturbance of beaked whales can be judged during a dive if they cease vocalizing in response to a PB or if passive tracking indicates disturbance of normal dive behavior. It has proved possible at AUTEC to conduct combined acoustic/visual follows of beaked whales in which a small observation vessel is sent by acoustic monitors to a location where beaked whales are heard. The monitors radio the OV when the whales stop clicking and start ascent, and the OV often sights the whales after their ascent. Then, when the whales start their descent, the OV radios the acoustic monitors either on the OV or using the SCORE hydrophones, who pick up the clicks as the whales start to echolocate at the start of a foraging dive. This kind of visual/acoustic follow can be used for real-time monitoring. We will provide several methods for such passive acoustic monitoring from the large ship, including a towed array, an array that can be deployed when the ship is dead in the water, rapidly deployable individual hydrophones and sonobuoys, including broadband sonobuoys that can detect frequencies of beaked whale clicks and the existing listening devices on the Navy's SCORE range.

Animal disturbance indicators will include, but not be limited to: 1) click cessation for more than 2 min during a foraging dive; 2) premature ascent; 3) abnormally short or long surface time period; 4) abnormal number and/or frequency of hard tail flicks/slaps or trumpet blows; 5) continuous surges or tail slashes; and 6) panicked flight. After each PB is completed, the primary criteria for disturbance from the acoustic stimuli will come from data from the archival acoustic tags. We will compare the pre-exposure baseline for each individual subject to the exposure condition using data on vocalizations, dive pattern, fluke strokes, orientation, and acceleration.

The archival acoustic tags, which offer the ability to monitor acoustic and motor behavior, will provide more detailed data on potential disturbance reactions and return to baseline than has been possible in the past for cetacean studies. The DTAG offers a direct means to measure acoustic and motor behavior. By simultaneously recording the sound at the animal, together with behavioral responses, the connection between sound and response or other behavior can be made directly. Specific advantages of an acoustic tag are:

1. The sound level at the animal (i.e., RL) is measured directly. There is no reliance on transmission loss models to estimate RL.
2. There are no time alignment errors when correlating sound exposure and behavioral response.
3. It is also possible to measure subtle and short-duration responses; e.g., vocalizations, fluke stroke frequency and amplitude, ensuring that almost any potential movement response will be documented.

An acoustic recording tag also provides information on the vocalization rate and types of vocalizations produced by individuals of known species, and often of known age/sex. Acoustic recording tags have been demonstrated on such diverse species as elephant seals, dolphins, and right whales. The elephant seal tag used a hard drive to record low-bandwidth sound and pressure (e.g., Burgess et al., 1998; Costa et al., 2003). A major discovery made with this tag was that the ventilation and heart rate of the host animal can be recorded acoustically (Le Boeuf et al., 2000), obtaining a response measure familiar from its wide use on terrestrial species. This result has been duplicated using the DTAG with dolphins, and demonstrated heart rate responses to noise (Miksis et al. 2001). Similar acoustic records from DTAGs on beaked whales have been able to record heart rate when the whale is at the surface, but unfortunately, to date it has not been possible to sample heart rate continuously throughout the dive cycle. The new version of DTAG will also include sensors to detect EKG signals.

Alternatives