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pursuant to
Executive Order 12114
and
National Environmental
Policy Act Section 102(2)(C)

Executive Summary
Final
Overseas Environmental Impact Statement
and
Environmental Impact Statement
for
Surveillance Towed Array Sensor System
Low Frequency Active (SURTASS LFA) Sonar

January 2001

Abstract

This Final Overseas Environmental Impact Statement/Environmental Impact Statement (OEIS/EIS) identifies and evaluates the potential environmental impacts of employing the Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) sonar. It has been prepared by the Department of the Navy in accordance with the requirements of Presidential Executive Order (EO) 12114 (Environmental Effects Abroad of Major Federal Actions) and the National Environmental Policy Act of 1969 (NEPA). The Navy currently plans to operate up to four SURTASS LFA sonar systems. At present the Research Vessel (R/V) *Cory Chouest* is the only vessel equipped with SURTASS LFA sonar. The additional SURTASS LFA sonar systems would be installed on board ocean surveillance vessels. Alternatives considered include the No Action Alternative, Alternative 1 (which provides for geographic restrictions and monitoring to prevent injury to potentially affected species), and Alternative 2 (unrestricted operation of the system). Alternative 1 is the Navy's preferred alternative.

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EXECUTIVE SUMMARY

The proposed action is U.S. Navy employment of the Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) sonar in the ocean areas shown in blue in Figure S-1 (SURTASS LFA Sonar Potential Operating Areas) excluding any areas necessary to reduce adverse effects on the marine environment. This would include areas necessary to prevent 180-decibel (dB) sound pressure level (SPL) or greater within 22 kilometers (km) (12 nautical miles [nm]) of land, in offshore biologically important areas during biologically important seasons (see Figure S-1), and in areas necessary to prevent greater than 145-dB SPL at known recreational and commercial dive sites. The SURTASS LFA sonar operational areas are inhabited by marine animals, including birds, fish, sea turtles, and marine mammals.

During employment of the SURTASS LFA sonar system, acoustic signals would be introduced into the water column that could potentially affect the marine environment. As a result, the Navy has prepared this Overseas Environmental Impact Statement/Environmental Impact Statement (OEIS/EIS) to study the potential environmental effects of SURTASS LFA sonar system use.

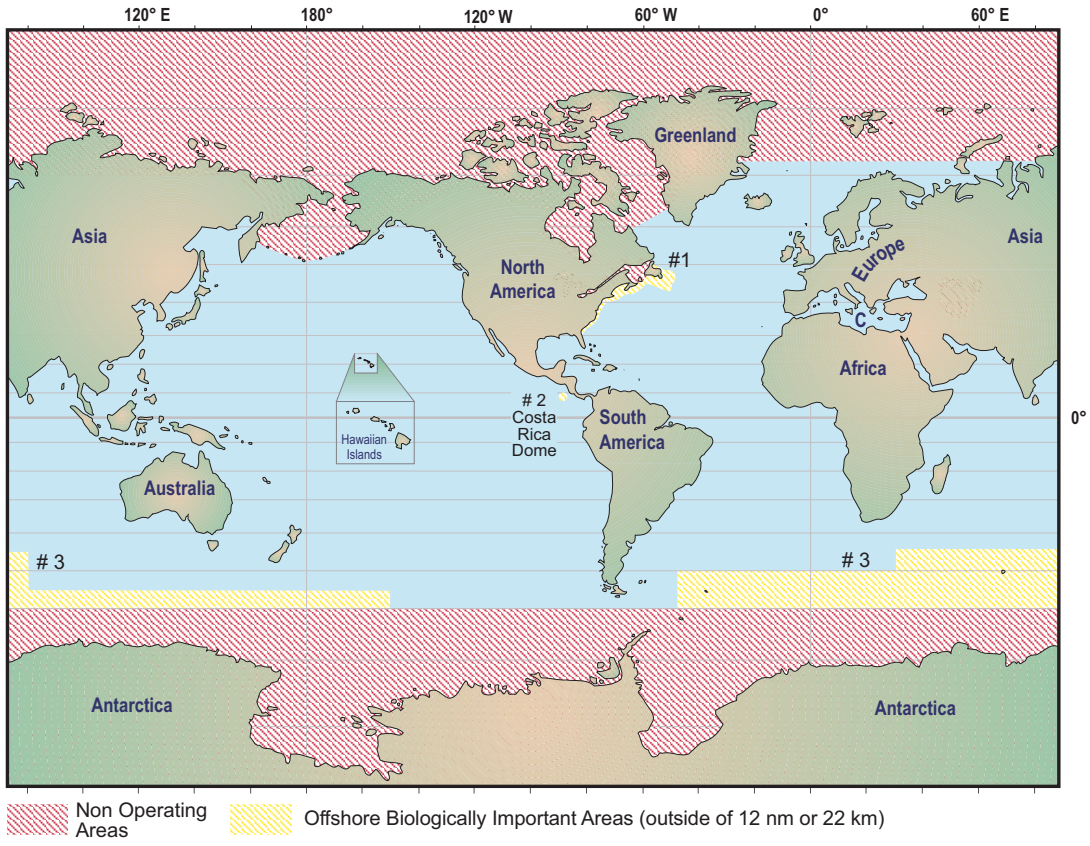

Figure S-1. SURTASS LFA Sonar Potential Operating Areas.

This OEIS/EIS was prepared in accordance with the requirements of Presidential Executive Order (EO) 12114 (Environmental Effects Abroad for Major Federal Actions) and the National Environmental Policy Act of 1969 (NEPA). EO 12114 applies to major federal actions that occur outside the United States, its territories and possessions, while NEPA applies to major federal activities that occur or have effects in the United States, its territories and possessions. The Department of the Navy is the lead agency with the National Marine Fisheries Service (NMFS) of the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) as a cooperating agency.

The results and conclusions of this OEIS/EIS apply only to the SURTASS LFA sonar system and those species that are potentially affected by low frequency (LF) sound in water. They do not apply to other Navy sonar systems.

S.1 Purpose and Need

Submarines can be used for a broad range of offensive and defensive missions, from coastal defense to secret surveillance to stand-alone platforms for special operations forces (e.g., sea-air-land units) or attack on land targets, surface ships or other submarines in both open ocean and littoral or "near land" areas of the world. Nuclear and diesel-electric submarines can accomplish such missions because they are hard to find (they are stealthy), they carry dangerous weapons (torpedoes and cruise missiles), and they provide economy of force (cost-effective weapons delivery).

The world submarine fleet is becoming increasingly quieter; and, since the end of the Cold War, the distance or range of detecting these submarines has been greatly reduced. As a result, in some cases U.S. forces may have only minutes to respond to a potential submarine threat. Such situations could jeopardize U.S. ability to control the sea, land, and air, and hinder follow-on offensive and defensive operations. Eliminating this threat to U.S. security and maintaining the Navy's antisubmarine warfare (ASW) mission into the future were reasons for developing a long-range sonar technology.

To meet the need, the Navy investigated the use of a broad spectrum of acoustic and non-acoustic technologies to enhance ASW capabilities. Of all the technologies evaluated, low frequency active sonar was the only system capable of providing reliable and dependable long-range detection of quieter, harder-to-find submarines. LF sound travels in seawater more effectively and for greater distances than higher frequency sound used by other active sonars. The SURTASS LFA sonar system would meet the Navy's need for improved detection and tracking of new-generation submarines at long range.

The purpose of the proposed action, therefore, is to meet the U.S. need for improved capability to detect quieter and harder-to-find foreign submarines at long range, thereby meeting the Navy's need to maintain the ASW capability of its fleet. This capability would provide U.S. forces with

adequate time to react to, and defend against, potential submarine threats while remaining a safe distance beyond a submarine's effective weapons range.

S.1.1 Public Participation

The public participation program for this OEIS/EIS began with publication of a Notice of Intent (NOI) to prepare an EIS in the *Federal Register* on July 18, 1996. Public scoping meetings were held in Norfolk, Virginia (August 3, 1996); San Diego, California (August 6, 1996); and Honolulu, Hawaii (August 8, 1996).

In addition to conducting the public participation program required by NEPA, the Navy invited representatives of concerned environmental groups, or non-governmental organizations, to an outreach meeting held on January 8, 1997 in Washington, DC. The purpose of this meeting was to provide interested parties with detailed briefings on SURTASS LFA sonar and to exchange views on the EIS process and content. The Navy also invited independent marine biologists, acousticians, and auditory experts to review and discuss a number of key issues related to the potential effects of LFA sonar on marine animals. Additional outreach meetings were held in February 1997, May 1997, October 1997, and June 1998. The outreach meetings provided significant input to the EIS development.

The Navy also organized a Scientific Working Group (SWG) on "The Potential Effects of Low Frequency Sound on the Marine Environment." The group's charter was to provide a forum for scientific discourse among Navy and non-governmental organizations to address the underlying scientific issues needing resolution for development of this OEIS/EIS. Group members included representatives from the Office of Naval Research (ONR), Cornell University, University of Washington, University of California-Santa Cruz, Hubbs Sea World Research Institute, Marine Acoustics, Inc., National Marine Fisheries Service, Naval Submarine Medical Research Laboratory (NSMRL), Marine Mammal Commission, Harvard Medical School, Bodega Marine Laboratory, and Woods Hole Oceanographic Institution. An observer from the League for Coastal Protection represented the public environmental community. Three meetings were held:

- February 1997 in Washington, DC;
- October 1997 at the Naval Postgraduate School, Monterey, California; and
- September 1998 at the Woods Hole Oceanographic Institution in Woods Hole, Massachusetts.

S.1.2 Draft OEIS/EIS

Commencing on July 31, 1999, copies of the Draft OEIS/EIS were distributed to agencies and officials of federal, state, and local governments, citizen groups and associations, and other interested parties (*Federal Register* [FR]Vol. 64 No. 146).

Documents produced for the SURTASS LFA Draft OEIS/EIS were made available for review at 17 public libraries located in many coastal states including Hawaii. The SURTASS LFA Sonar OEIS/EIS Internet website (http://www.surtass-lfa-eis.com) will be available for information purposes until 60 days after publication of the ROD in the *Federal Register* (FR).

A 90-day public review and comment period on the Draft OEIS/EIS occurred through October 28, 1999. During this period, public hearings were held as follows:

- September 29, 1999, in Norfolk, VA;
- October 12, 1999, in San Diego, CA; and
- October 14, 1999, in Honolulu, HI.

Notification for the public hearings was published in the *Federal Register* on September 14, 1999 (FR Vol. 64 No. 177) and in local newspapers. The hearings were conducted in accordance with NEPA requirements and comments were recorded by a stenographer. Transcripts of the hearings are in Appendix F, Volume 2 of the Final OEIS/EIS.

S.1.3 Draft OEIS/EIS Comment and Revisions

Comments on the Draft OEIS/EIS were received from over 1,000 commentors, including federal, state, regional, and local agencies, groups and associations, and private individuals. All comments received were categorized into one or more of 35 broad issues. These issues were further subdivided into more specific comments/questions. Responses to these comments/questions were then drafted and reviewed for scientific and technical accuracy and completeness. The Navy's responses also identify cases in which a specific comment generated a revision to the Draft OEIS/EIS, or when the existing text of the Final OEIS/EIS is deemed an adequate response to a comment, the appropriate chapter, subchapter, and/or appendix is identified.

The Navy received many comments on the Draft OEIS/EIS during the 90-day public comment period. In response to these comments, appropriate updates and revisions to the Final OEIS/EIS have been made. However, no significant new information has been revealed since the publication of the Draft OEIS/EIS. Portions of this Executive Summary have been revised to reflect any changes in the main text of the Final OEIS/EIS.

S.2 Description of Proposed Action and Alternatives

The Navy currently plans to employ up to four SURTASS LFA sonar systems in the blue areas shown in Figure S-1. The word "employment" as used in this document means the use of SURTASS LFA sonar during routine training and testing as well as the use of the system during military operations. This analysis does not apply to the use of the system in armed conflict or direct combat support operations, nor during periods of heightened threat conditions, as determined by the National Command Authorities (President and Secretary of Defense or their duly designated alternates or successors as assisted by the Chairman of the Joint Chiefs of Staff [JCS]).

The proposed system is a long-range, all weather sonar system that operates in the low frequency (LF) band between 100 and 500 Hertz (Hz). It has both active and passive components. Figure S-2 (SURTASS LFA Sonar System) illustrates the proposed system.

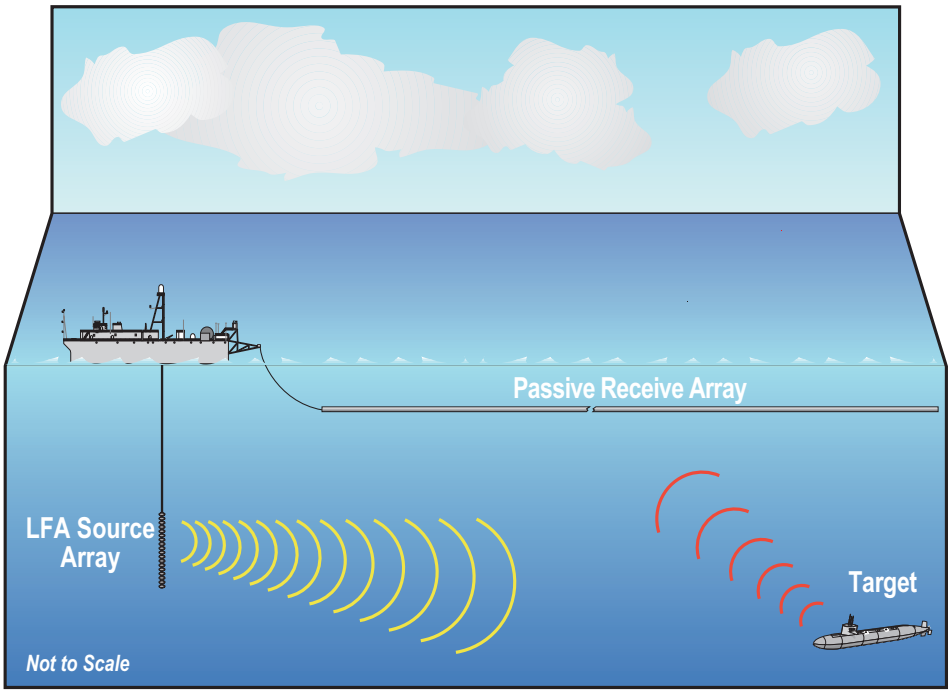

Figure S-2. SURTASS LFA Sonar System.

The active component of the system, LFA, is a set of LF acoustic transmitting source elements (called projectors) suspended by cable from underneath a ship. These projectors produce the active sonar signal or "ping." A "ping" or transmission can last between 6 and 100 seconds. The

time between transmissions is typically from 6 to 15 minutes. The average duty cycle (ratio of sound "on" time to total time) is between 10 and 20 percent. The SURTASS LFA sonar signal is not a continuous tone, but rather a transmission of various waveforms that vary in frequency and duration. The duration of each continuous frequency sound transmission is never longer than 10 seconds. The signals are loud at the source, but levels diminish rapidly over the first kilometer.

The passive, or listening, component of the system is SURTASS. SURTASS detects returning echoes from submerged objects, such as threat submarines, through the use of hydrophones on a receiving array that is towed behind the ship. The SURTASS LFA ship maintains a minimum speed of 5.6 kilometers (km) per hour (kph) (3 knots [kt]) through the water to tow the horizontal line hydrophone array.

Executive Order 12114 and NEPA require the Navy to evaluate a reasonable range of alternatives to the proposed action. The alternatives evaluated in this OEIS/EIS are the:

- **No Action Alternative** - Operational deployment of SURTASS LFA sonar would not occur;

- **Alternative 1** - (Restricted Operation - the Navy's preferred alternative) use of the system would include geographic restrictions and monitoring to prevent injury to potentially affected species (see S.4.8 below); and

- **Alternative 2** - (Unrestricted Operation) use of the system would involve unlimited use of SURTASS LFA sonar worldwide, with no geographic restrictions or monitoring required, except for the physical limitation of the system (e.g., shallow water depth).

Although NEPA does not require detailed analysis of alternatives that do not fulfill the purpose and meet the need of the proposed action, it does require a brief discussion of why some alternatives were eliminated from detailed study.

The Navy evaluated and tested different detection technologies to determine which of them were capable of meeting the U.S. need to improve detection of quieter and harder-to-find foreign submarines at long range. The detection technologies evaluated and tested by the Navy included radar, laser, magnetic, infrared, electronic, electric, hydrodynamic, biologic and sonar (high-, mid- and low frequency). Of the different technologies evaluated and tested, only LFA sonar proved technically feasible of providing U.S. forces with reliable long-range detection of the new generation, quieter submarines. Because the other detection technologies would not fulfill the purpose of the action proposed, they were eliminated from further study in this OEIS/EIS.

The Navy also evaluated different ways in which LFA sonar technology could be employed, including: 1) the number of ships that might be equipped with LFA sonar technology; 2) the oceanic areas that would support operation of LFA sonar technology; and 3) the source levels at which LFA sonar technology might be employed. The Navy eliminated from further evaluation

all LFA sonar technology employment scenarios that would not fulfill the Navy's primary objective of reliable detection of quieter and harder-to-find submarines at long range. The Navy, therefore, has not provided detailed analysis of such alternatives as reducing the number of ships equipped with LFA sonar technology to a number less than four, extensive additional geographic restrictions on where LFA sonar technology may be operated, or limiting projector source levels to below 215 dB. These alternative LFA sonar employments were eliminated from further analysis because they would not fulfill the purpose and meet the need of the proposed action.

S.3 OEIS/EIS Charter and Team

In carrying out this OEIS/EIS process, the only directive was to obtain the most accurate assessment of potential environmental impacts. To this end, the Navy (the lead agency) adopted a charter made up of five basic principles for the OEIS/EIS team to follow:

- Conduct studies on the potential for effects of LF sound on marine life and human divers;
- Maintain scientific rigor throughout development of the OEIS/EIS;
- Use an independent scientific team to review and edit the OEIS/EIS (i.e., no Navy approval of scientific findings -- acceptance criteria established that included the possibility of a conclusion recommending the No Action Alternative);
- Preserve an "open process" with public engagement (e.g., outreach meetings, SURTASS LFA research vessel cruise, 90-day comment period on the Draft OEIS/EIS, public information meetings, and public hearings) to assure the public that if, after completion of the OEIS/EIS process, SURTASS LFA sonar is deployed, its employment would have no more than a negligible impact on any affected marine animal stocks.; and
- Ensure funding is available for scientific research to address critical data gaps and to furnish a meaningful and understandable document to the public in a timely manner.

The Navy used many assets to develop the OEIS/EIS, including the following:

- **SURTASS LFA Executive Board -** Meetings were held on the order of every three to four months to provide an update on the status of the OEIS/EIS process and receive guidance; members included representatives from the Office of Chief of Naval Operations (CNO), the Navy Office of General Counsel (OGC), the Assistant Secretary of the Navy (Installations and Environment), the Commander in Chief Pacific Fleet (CINCPACFLT), the Commander in Chief Atlantic Fleet (CINCLANTFLT), the Commander Undersea Surveillance, ONR, and the Navy's Space and Naval Warfare Systems Command.

- **Scientific Working Group** - On the potential effects of LF sound on the marine environment. The group members included representatives from the Office of Naval Research (ONR), Cornell University, University of Washington, University of California-Santa Cruz, Hubbs Sea World Research Institute, Marine Acoustics, Inc., National Marine Fisheries Service, Naval Submarine Medical Research Laboratory, Marine Mammal Commission, Harvard Medical School, Bodega Marine Laboratory, and Woods Hole Oceanographic Institution. An observer from the League for Coastal Protection represented the public environmental community.

- **Scientific Research Program Scientists -** Approximately 60 researchers were involved in the Low Frequency Sound Scientific Research Program (LFS SRP) to collect much-needed data on the potential effects of LF sound on baleen whales. These included representatives from Cornell University Bioacoustics Research Program, Woods Hole Oceanographic Institution, Scripps Institution of Oceanography, University of California-Santa Cruz, Bodega Bay Marine Laboratory, Raytheon, Naval Facilities Engineering Service Center, Point Mugu Outer Sea Test Range, Research Vessel (R/V) *Cory Chouest* Military Detachment, and Marine Acoustics, Inc.

- **Cooperating Agency** - Department of Commerce's NOAA/NMFS/Office of Protected Resources.

- **Diver Risk Analysis Team** - A study to develop guidance for safe exposure limits for recreational and commercial divers who might be exposed to LF sound. This research was conducted by scientists from ONR and NSMRL between June 1997 and November 1998 in conjunction with scientists from University of Rochester, Georgia Institute of Technology, Boston University, University of Pennsylvania, Naval Medical Center San Diego, Duke University, Divers Alert Network, and Applied Research Laboratory, University of Texas.

S.4 OEIS/EIS Analysis Process

To meet the charter requirements to study the potential effects of LF sound on marine life and human divers scientifically, the following analytical process was utilized:

- Literature review and determination of data gaps;
- Scientific screening of marine animal species for potential sensitivity to LF sound;
- Scientific research on the effects of LF sound on humans in water;
- Scientific research on the effects of LF sound on marine animals;
- Development of a method for quantifying risk to marine mammals;

- Acoustic modeling;
- Estimation of marine mammal stocks potentially affected;
- Estimation of potential effects on fish and sea turtles; and
- Establishment of mitigation and monitoring to minimize potential for effects to a negligible level.

It is important to note that this analysis is applicable only to the SURTASS LFA sonar with its 6 to 100-second pulse lengths and frequencies between 100 and 500 Hz. It does not apply to other Navy sonar systems.

S.4.1 Literature Review and Determination of Data Gaps

Based on initial literature reviews, it became apparent that there were data gaps concerning the sensitivity of marine animals to LF sound and how sounds similar to SURTASS LFA sonar transmissions could affect them. This initial review did, however, determine that the marine animals most likely to be affected by LF sound were the large baleen whales. Literature reviews also revealed a lack of data concerning the potential effects of LF sound on humans in the water. Thus, the Navy undertook scientific research programs, as described in sections S.4.3 and S.4.4, to address these data gaps.

S.4.2 Scientific Screening of Marine Animal Species for Potential Sensitivity to LF Sound

In order for marine species to be affected by the operation of the SURTASS LFA sonar:

- The animal must be in the geographic area of the SURTASS LFA sonar sound field; and

- The animal must be capable of being physically affected by LF sound.

This selection rationale is demonstrated in Figure S-3 (Species Selection Rationale). The selection started with virtually all marine animal species, including both invertebrates and vertebrates. Based on the above criteria, this list was distilled down to five groups of vertebrates, including sharks and rays, bony fish, whales and dolphins, seals and sea lions, and sea turtles. Virtually all invertebrates were eliminated from further consideration because: 1) they do not have delicate organs or tissues whose acoustic impedance is significantly different from water, and 2) there is no evidence of auditory capability in the frequency range used by SURTASS LFA sonar. Cephalopods and decapods are known to have some sensitivity to LF sound, but have high hearing thresholds (146 dB and above) in the LF range. Based on this they were also eliminated from further evaluation.

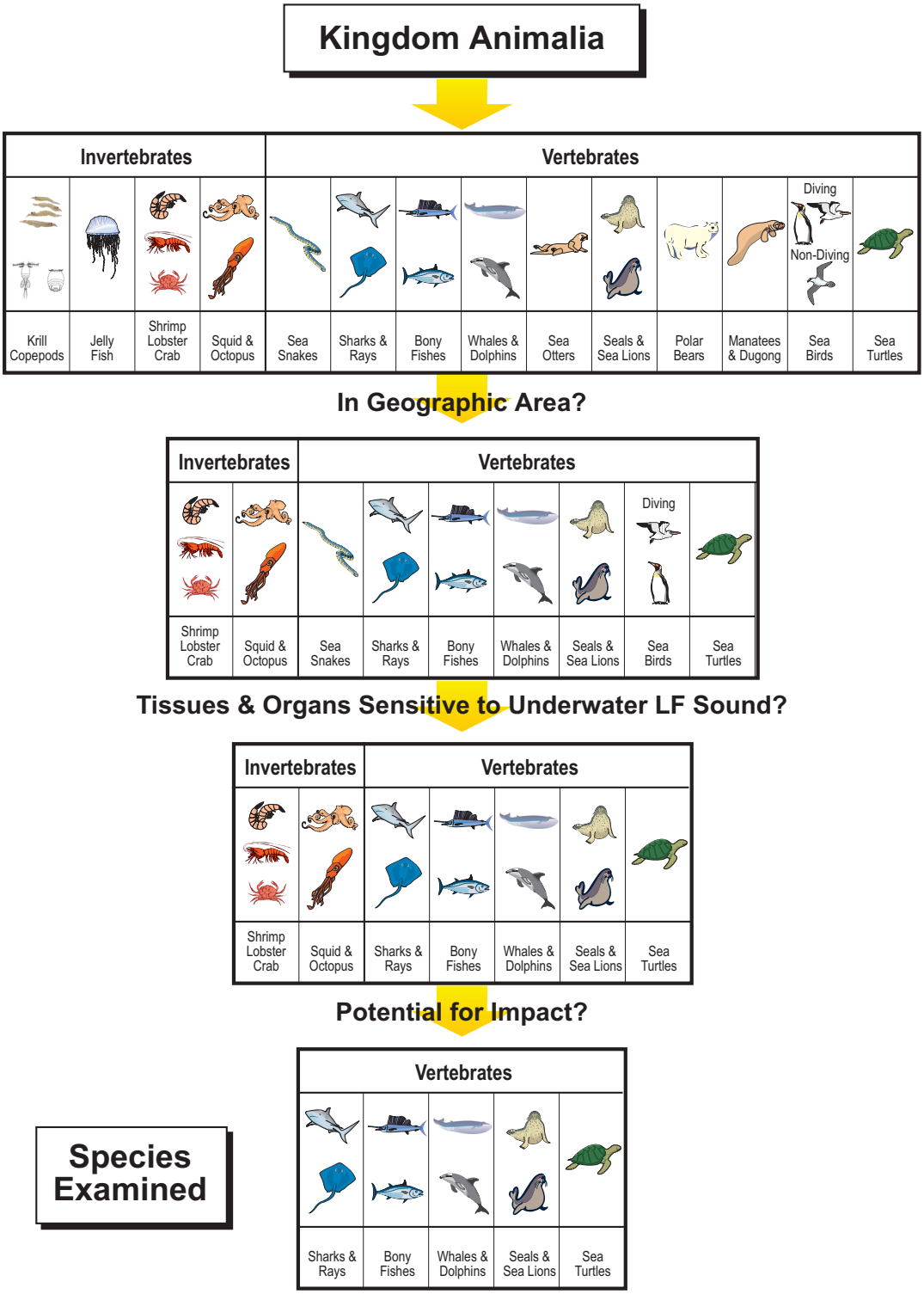

Figure S-3. Species Selection Rationale.

S.4.3 Scientific Research on the Effects of LF Sound on Humans in Water

Data regarding the effects of underwater LF sound on humans are limited. As a result, the Navy sponsored independent scientific research to study the potential effects of LF sound on human divers. The Navy-sponsored studies on human divers included:

- Pursuant to two incidents involving LF underwater sound and human divers, tests on Navy divers were conducted by the Applied Research Laboratory, University of Texas, from 1993 to 1995, under direction of the Navy Submarine Medical Research Laboratory (NSMRL). This research resulted in the establishment of a damage risk threshold of 160 dB received level for 100 seconds or less at a 50 percent duty cycle and cumulative 15 minutes a day. The 160-dB received level (RL) threshold was the maximum level recommended as standard guidance for divers who were equivalent in medical health and fitness to Navy divers.

- A study was conducted to develop guidance for safe exposure limits for recreational and commercial divers who might be exposed to LF underwater sound, such as that generated by SURTASS LFA sonar. This research was conducted by scientists from the Office of Naval Research (ONR) and NSMRL between June 1997 and November 1998 in conjunction with scientists from a number of universities. Human guidelines were established based on psychological aversion testing. NSMRL set the RL criterion for recreational and commercial divers at 145 dB.

Based on results from this research, in conjunction with guidelines developed from psychological aversion testing, the Navy concluded that LF sound levels at or below 145 dB would not have an adverse effect on recreational or commercial divers. This led NSMRL to establish a 145-dB received level (RL) criterion for recreational and commercial divers. The Navy's adoption of the 145-dB interim guidance is considered a conservative, protective decision.

S.4.4 Scientific Research on the Effects of LF Sound on Marine Animals

Many human activities generate loud underwater sounds, and there is a need for better methods for measuring and estimating potential risk. The quantitative assessment of potential risk is complicated by the scarcity of data in several areas:

- Hearing loss due to sound exposure in air is well studied in humans and some other terrestrial animals. Data regarding underwater hearing capabilities of marine mammals are rare and limited to a few of the smaller species that can be conditioned for hearing tests in the laboratory.

- Knowledge of the functions of the sounds produced by most marine mammals is limited.

- Data on the responses of marine mammals to LF sounds are limited.

These data gaps have necessitated the use of various models and extrapolations in order to provide a rational basis for the assessment of potential risk from exposure to LF sounds. To address some of these gaps, the Navy performed underwater acoustic modeling and supported the Low Frequency Sound Scientific Research Program (LFS SRP) to study the potential effect of LF sound on free-ranging marine mammals. This research did not specifically address the issue of LF impact on marine mammal hearing; rather, it focused on the behavioral responses of baleen whales to controlled exposure from SURTASS LFA sonar-like signals.

In general, understanding the mechanics of hearing and the biological functions of sounds for marine mammals has improved considerably over the past decade. Specific information on the effects of most types of human-made underwater noises on marine animals is incomplete, but has also increased in recent years. However, as the environmental evaluation of the SURTASS LFA sonar system progressed, the Navy recognized that additional research was required in several areas to address some basic gaps in scientific knowledge. This included development of a scientifically reasonable estimate of the underwater sound exposure levels that may cause injury to marine mammals and research on the potential effects of LF sound on marine mammal behavior.

While recognizing that not all of the questions on the potential for LF sound to affect marine life are answered, and may not be answered in the foreseeable future, the Navy has combined scientific methodology with a prudent approach throughout this OEIS/EIS to protect the marine environment.

Although there are recognized areas of insufficient knowledge that must be accounted for when estimating the potential direct and indirect effects on marine life from SURTASS LFA sonar, the present level of understanding is deemed adequate to place reasonable bounds on potential impacts.

Use of Baleen Whales (Mysticetes) as Indicator Species for Other Marine Life

The rationale for using representative species to study the potential effects of LF sound on marine animals emerged from an extensive review in several workshops by a broad group of interested parties: academic scientists, federal regulators, and representatives of environmental and animal welfare groups. The outcome of these discussions concluded that baleen whales (mysticetes) would be the focus of the three phases of the LFS SRP and indicator species for other marine animals in the analysis of underwater acoustic impacts. Mysticetes were chosen because: 1) they were presumed to be most sensitive to sound in the SURTASS LFA sonar

frequency band, 2) they have protected status under law, and 3) there is prior evidence of their avoidance responses to LF sounds.

Analyses presented in this OEIS/EIS support the contention that mysticetes have the best LF hearing of all marine mammals. Studies on pelagic fish and sea turtles indicate that their LF hearing is not as sensitive as that of baleen whales. Deep-diving species such as sperm and beaked whales are presumed not to have LF hearing as good as that of baleen whales. Therefore, all of these groups or species were considered to be at lower risk from LF sound than baleen whales.

The following discussion addresses the three potential areas of impact: injury, behavioral effects, and masking.

S.4.4.1 Estimating the Potential for Injury to Marine Mammals

Given the large number of marine species to be analyzed, the process used to estimate the potential for injury involved identifying the marine species most sensitive to LF sound. This analytical concept simplified the OEIS/EIS analysis by producing a model of response that could be applied to other species for which data were lacking and resulted in estimates of environmental impacts that would be conservative when applied to other species. It was also an important element in the selection of species for the LFS SRP.

Marine mammals rely on hearing for a wide variety of critical functions. Exposure to sounds that permanently affect their hearing ability poses significant problems for their survival and reproduction. Many human activities generate loud underwater sounds, and there is a need for methods of estimating potential risk. The quest for a quantitative assessment of risk potential is complicated by the scarcity of data noted in Subchapter S.4.4 above.

Selection of the 180-dB Criterion

Research is needed to address basic gaps in scientific knowledge on the underwater sound exposure levels that may cause injury to marine mammals. For the purposes of the SURTASS LFA sonar analyses presented in this OEIS/EIS, all marine mammals exposed to RLs $\geq$ 180 dB are evaluated as if they are injured. This determination was based on:

- Estimates of the range of frequencies at which an animal's hearing is most sensitive and the associated thresholds (including an examination of anatomical models of inner ear function).

- Extrapolation from human exposure results. (A level of conservatism is also inherent in this comparison, as the risk continuum [described herein] is based on the lower limit of potential damage, and the human extrapolation is based on the upper level of safety.)

- Comparison to fish hearing studies (because the physiology of inner ear hair cells is considered to be similar among vertebrates, and exposure to 180 dB in water is expected to yield the same shear forces on the inner ears of fish, sea turtles, and marine mammals).

- Recent measurements of low level temporary threshold shift (TTS) in marine mammals.

For the purposes of this document, 180-dB received level is considered the point above which some potentially serious problems in the hearing capability of marine mammals could start to occur. Several scientific and technical workshops and meetings at which the 180-dB criterion were developed are:

- High Energy Seismic Survey (HESS) Team Workshop, Pepperdine University School of Law, June 12-13, 1997;

- Office of Naval Research Workshop on the Effects of Man-Made Noise on the Marine Environment. Washington, DC, February 9-12, 1998; and

- National Marine Fisheries Service (Office of Protected Resources) Workshop on Acoustic Criteria, Silver Spring, MD, September 9-12, 1998.

For injury, an animal would have to be within the 180-dB sound field at the onset of a transmission, the likelihood of which is similar to that of a ship collision with the animal. The probability of either of these events occurring is nearly zero because of the visual and acoustic monitoring that would be utilized whenever the SURTASS LFA sonar is transmitting. See Figure S-4 (HF/M3 Sonar Detection and LFA Mitigation Zones).

S.4.4.2 Estimating the Potential for Behavioral Effects on Marine Mammals

Marine mammals rely on underwater hearing for a wide variety of biologically critical functions. The primary concern here is that exposure to SURTASS LFA sonar signals could potentially affect their hearing ability or modify biologically important behaviors. Biologically important behaviors are those related to activities essential to the continued existence of a species, such as feeding, migrating, breeding and calving. An individual exposed to LF sound levels high enough to affect its hearing ability could potentially have reduced chances of reproduction or survival. If stocks of animals are exposed to high levels that affect hearing ability, then significant portions of a stock could potentially experience lower rates of reproduction or survival.

Given that a LF sound source is loud and can be detected at moderate to low levels over large areas of the ocean, the concern would be that large percentages of species stocks could be exposed to moderate-to-low received sound levels. If animals are affected at these moderate-to-low exposure levels such that they experience a significant change in a biologically important behavior, then such exposures could potentially have an impact on rates of reproduction or survival.

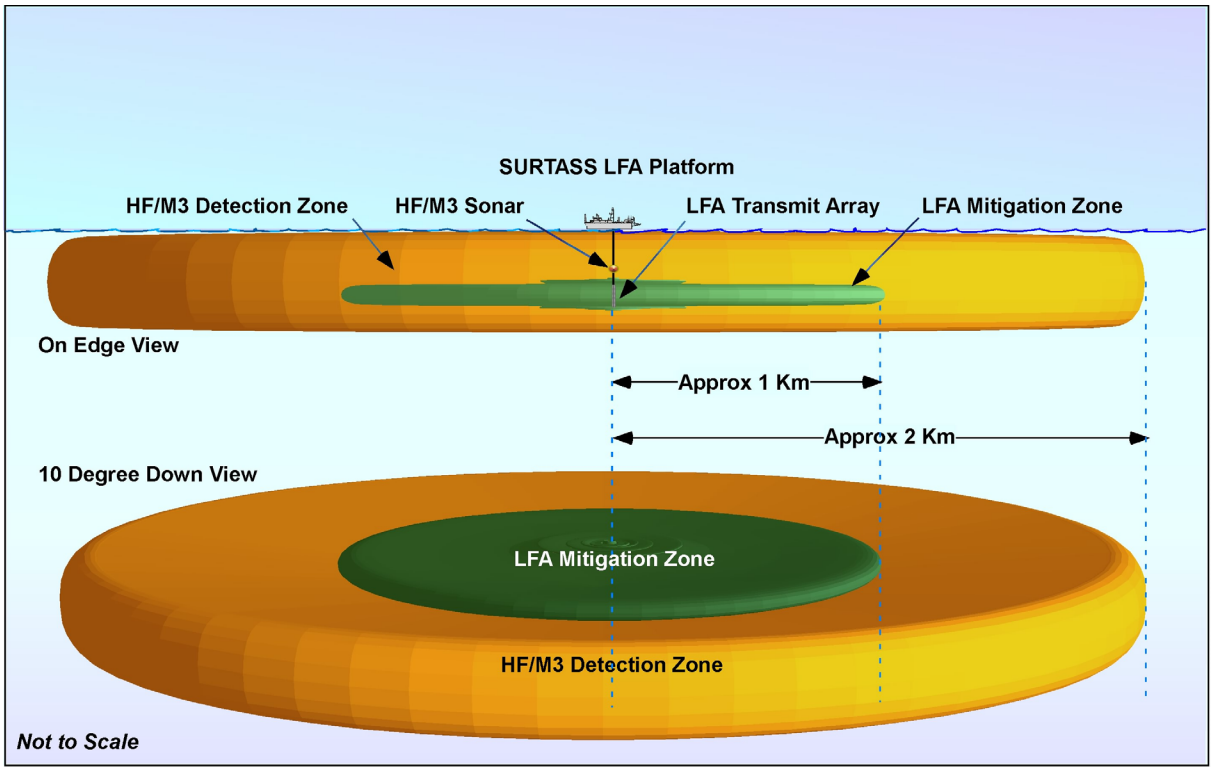

Figure S-4. HF/M3 Sonar Detection and LFA Mitigation Zones.

Low Frequency Sound Scientific Research Program

Knowing that cetacean responses to LF sound signals needed to be better defined using controlled experiments, the Navy helped develop and supported the three-year LFS SRP beginning in 1997. The LFS SRP was designed to supplement the limited scope of data from previous studies. This field research program was based on a systematic process for selecting the marine mammal indicator species and field study sites, using inputs from several workshops involving a broad group of interested parties (academic scientists, federal regulators, and representatives of environmental and animal welfare groups). In designing the LFS SRP, the Navy chose to minimize the potential of risk to animals that were the subject of the study by limiting the exposure of subject animals to a maximum RL of 160 dB.

The LFS SRP produced new information about responses to LF sounds at RLs from 120 to 155 dB. The scientific research team explicitly focused on situations that promoted high RLs, but were seldom able to achieve RLs above 155 dB due to the motion of the whales and

maneuvering constraints of the LF source vessel. Controlled experimental tests were performed in three phases, involving the following species and settings:

- Phase I: Blue and fin whales feeding in the Southern California Bight (September – October 1997);
- Phase II: Gray whales migrating past the central California coast (January 1998); and
- Phase III: Humpback whales off Hawaii (February – March 1998).

Relevance of LFS SRP for Risk Assessment and Quantifying Potential Impacts to Marine Mammals

Prior to the LFS SRP, the expectation was that whales would begin to show avoidance responses at RLs of 120 dB. Immediately obvious avoidance responses were expected for levels >140 dB. The LFS SRP experiments detected some short-term behavioral responses at estimated RLs between 120 – 155 dB. In the Phase II research, avoidance responses were sometimes obvious in the field when the LF source was in the gray whale migration path. Although several behavioral responses were revealed through later statistical analysis, there was no significant change in a biologically important behavior detected in any of the three phases. Most animals that did respond returned to normal baseline behavior within a few tens of minutes.

The modeled underwater acoustic RLs, which were calculated subsequent to the LFS SRP, have demonstrated that the range of exposure levels for subject animals during the LFS SRP covered an important part of the RL range that would be expected during actual SURTASS LFA sonar operations. Thus, it follows that the scientific conclusions based on the LFS SRP research data should encompass the majority of SURTASS LFA sonar operational scenarios.

Long Term Monitoring

Findings from the LFS SRP did not reveal any significant change in a biologically important behavior in marine mammals, and the risk analysis estimated very low risk. However, the Navy considers it prudent to continue monitoring for potential effects of the SURTASS LFA sonar. This monitoring would provide additional data to support the resolution of unresolved scientific issues, and respond to anticipated Marine Mammal Protection Act (MMPA) reporting requirements. Upon issuance of a Letter of Authorization (LOA) by NMFS under the MMPA, the Navy would provide a detailed Long Term Monitoring (LTM) plan. The Navy's efforts in this regard and its stated intention to conduct LTM concurrently with the operation of SURTASS LFA sonar will contribute to the body of scientific knowledge on the potential effects of human-made underwater LF sound on marine life.

S.4.4.3 Masking

Masking is the concealment or screening of a sensory process. In the marine environment and the context of this OEIS/EIS, this refers to biologically important sounds being masked, or screened, by louder noises, or sounds within the same frequency band. With regard to masking in marine mammals, any masking effects would be temporary and are expected to be negligible, because the SURTASS LFA sonar bandwidth is very limited (approximately 30 Hz), signals do not remain at a single frequency for more than ten seconds, and the system is off at least 80 percent of the time.

Masking effects could potentially be significant for fish and sea turtles that have best hearing at the same frequencies of SURTASS LFA sonar. However, given the 10-20 percent duty cycle and maximum 100-second signal duration, masking would be temporary. Additionally, the 30-Hz (approximate maximum) bandwidth of SURTASS LFA sonar signals is only a small fraction of the animal's hearing range (most fish sounds have bandwidths >30 Hz), and the geographical restrictions imposed on SURTASS LFA sonar operations would limit the potential for masking of sea turtles in the vicinity of their nesting sites.

S.4.5 Development of a Method for Quantifying Risk to Marine Mammals

In assessing the potential risk of SURTASS LFA sonar transmissions to marine mammals, two questions must be addressed:

- How does risk vary with repeated exposure?
- How does risk vary with RL?

These questions have been addressed by developing a function that translates the history of repeated exposures into a RL for a single exposure with a comparable risk. The measurement parameters for determining exposure were RL in decibels, length of the signal (ping), and number of pings received.

S.4.5.1 Variation of Risk with Repeated Exposure (Single Ping Equivalent)

There is a very limited basis for determining the potential effects of repeated exposures for marine mammals. It has been postulated that the risk threshold is lowered by 5 dB for every ten-fold increase in the number of sounds in the exposure, or, the single ping equivalent (SPE) level would be:

$$SPE = L + 5 \log_{10}(N)$$

Where: L = received level in decibels
N = number of exposures

In this process, the SPE RL would be larger than the maximum RL of any single ping in a sequence. Also, the SPE for a sequence consisting of a single loud ping and a long series of softer pings could be almost the same as the level of the single loud ping. For example, using the above formula, 100 pings at 170 dB would be equivalent to one ping at 180 dB.

S.4.5.2 Variation of Risk with RL (Determination of Risk Function)

Previous studies have based the definition of biological risk to marine mammals on a single received sound level threshold for individual species. For example, temporary threshold shift (TTS) values have been used as a threshold. However, this approach sets a threshold under which any RL value below the threshold is considered risk-free, and any value above it has been considered certain to cause adverse responses by marine mammals.

In contrast, the widely adopted approach to assessing biological risk is to use a smooth, continuous function that maps RL to risk, where risk is a probability function. Scientifically, this acknowledges that individual animals vary in sensitivity, so if an entire stock were exposed to a given level of sound, effects, if any, would be observed in a percentage of the stock rather than the entire stock. In order to represent this probability (or risk), the function should have values near zero at very low RLs, and values near one for very high RLs.

The risk continuum, developed by marine biologists specifically for the SURTASS LFA sonar analysis, estimates that 95 percent of the marine mammals exposed to a single ping at 180 dB RL could incur a significant change in a biologically important behavior. This is the first of three conservative assumptions underlying the OEIS/EIS risk continuum. The second assumption is that the risk of a significant change in a biologically important behavior could begin at 119 dB RL. The third assumption is that the parameter of the risk continuum that controls how rapidly risk transitions from low to high values with increasing RL is set at a value that produced a more gradual slope than empirical data.

S.4.6 Acoustic Modeling

After deriving population estimates from the most recent NMFS stock assessment reports and other pertinent references, this analysis modeled the species considered to potentially be the most vulnerable to LF sound. Since it was infeasible to model every potential operating site in the world, 31 acoustic modeling sites were developed for the major ocean regions (North and South Pacific oceans, Indian Ocean, North and South Atlantic oceans, and the Mediterranean Sea). These locations, as shown in Figure S-5 (Acoustic Modeling Sites), represent reasonable sites for each of the three major underwater sound propagation regimes where SURTASS LFA sonar would be employed (deep-water convergence zone propagation, near surface duct propagation, and shallow water bottom interaction propagation). The underlying geographic restriction influenced the location of the sites (i.e., SURTASS LFA sonar would not impose sound pressure levels (SPLs) $\geq$ 180 dB within 22 km [12 nm] of any coastline).

The Navy's standard acoustic performance prediction transmission loss model was used to estimate LF acoustic propagation loss (referred to as transmission loss), and, in turn, provided these data as primary input to the Acoustic Integration Model (AIM). Next, the population distribution, abundance, density, general movement and diving profile data of potentially affected marine mammals were determined for all sites and entered into AIM. AIM was then used to simulate acoustic exposure for each sonar ping for each animal during a hypothetical SURTASS LFA sonar mission.

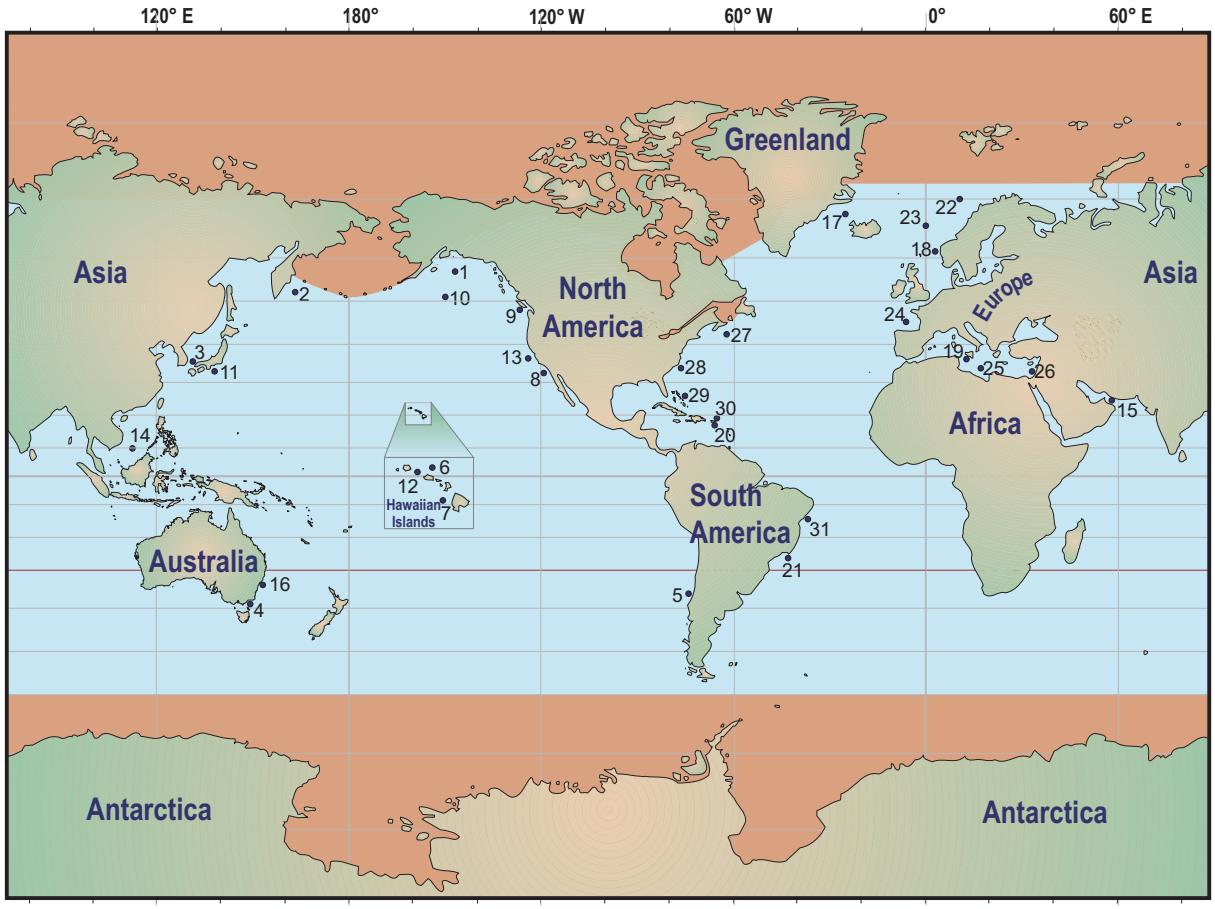

Figure S-5. Acoustic Modeling Sites

S.4.7 Estimation of Marine Mammal Stocks Potentially Affected

To estimate the percentage of marine mammal stocks potentially affected on a yearly basis, the typical annual operating schedule was correlated to the modeled sites. A conservative prediction from the modeling of the annual estimates of percentages of marine mammal stocks potentially affected by SURTASS LFA sonar operations can be seen in Tables S-1 and S-2 for the Pacific/Indian oceans and Atlantic Ocean/Mediterranean Sea, respectively. Since marine mammal stocks are reproductively isolated decreases in one stock cannot be replaced by animals from other stocks. Therefore, to accurately assess the potential effect of SURTASS LFA sonar, each stock was examined independently.

The percentages estimate the portion of the stock potentially affected by Alternative 1 (with geographic and monitoring mitigation). These values were corrected to account for the percentage of animals affected in relation to the area's stocks.

To understand Tables S-1 and S-2, it is important to recognize that the marine mammals included within such percentages would be affected only for brief periods of time, when the SURTASS LFA sonar was operating near them and, then, only when the sonar was actually transmitting (less than 20 percent of the time). The percentages given in the tables do not represent continuous effect on animals. The annual estimates of the percentages of marine mammal stocks potentially affected presented in Tables S-1 and S-2 consist mostly of possible significant changes in biologically important behavior with almost no chance of injury.

Under Alternative 2, there would be no geographic restrictions or monitoring mitigation. Two case studies presented in this OEIS/EIS demonstrate that there is a potential for increased effects without geographic restrictions and monitoring mitigation. Clearly, Alternative 1 is superior to Alternative 2 as a reduced risk selection.

Table S-1

Annual Estimates of Percentages of Marine Mammal Stocks Potentially Affected
(Alternative 1 - With Geographic and Monitoring Mitigation, Pacific/Indian Oceans)

Stock Areas	Eastern North Pacific	Western North Pacific	South Pacific	Indian
Species				
blue whale	8.36	6.27	0.32	N/M[1]
fin whale	1.03	1.07 (0.03)[2]	0.29	N/M[1]
sei whale	N/M[1]	N/M[1]	0.16	N/M[1]
Bryde's whale	N/M[1]	0.33	0.08	0.02
minke whale	0.72	1.16	N/M[1]	N/M[1]
humpback whale	2.58	3.29 (0.21)[2]	4.44	0.20
gray whale	3.43	5.30	N/M[1]	N/M[1]
n. right whale	4.13	N/M[1]	N/M[1]	N/M[1]
s. right whale	N/M[1]	N/M[1]	1.38	N/M[1]
sperm whale	0.16	N/M[1]	0.32	0.03
beaked whale	1.27	1.65	0.56	0.01
pilot whales	0.10	0.16	N/M[1]	0.01
pelagic dolphins	0.15	0.89 (0.01)[2]	0.11	0.01
N. elephant seal	12.41	N/M[1]	N/M[1]	N/M[1]
S. elephant seal	N/M[1]	N/M[1]	0.07	N/M[1]
N. sea lion	9.93	0.19	N/M[1]	N/M[1]
N. fur seal	0.09	5.21	N/M[1]	N/M[1]
Australian fur seal	N/M[1]	N/M[1]	1.12	N/M[1]
S. American fur seal	N/M[1]	N/M[1]	0.73	N/M[1]

1. N/M = Not Modeled. This species was not modeled in this stock area.
2. ( ) = Annual estimate of percentages of marine mammal stocks affected by injury.

Table S-2

Annual Estimates of Percentages of Marine Mammal Stocks Potentially Affected
(Alternative 1 - With Geographic and Monitoring Mitigation, Atlantic Ocean/Mediterranean Sea)

Stock Areas	Eastern North Atlantic	Western North Atlantic	South Atlantic	Mediterranean Sea
Species				
blue whale	16.39	16.06	0.85	N/M[1]
fin whale	0.64	1.77	0.41	7.69
sei whale	3.92	5.54	N/M[1]	N/M[1]
Bryde's whale	N/M[1]	0.57	0.58	N/M[1]
minke whale	0.46	8.08	0.28	6.75
humpback whale	3.12	7.12	1.80	N/M[1]
N. right whale	N/M[1]	2.52	N/M[1]	N/M[1]
sperm whale	0.41	N/M[1]	N/M[1]	13.40
beaked whale	5.31	2.33	0.11	10.82
pilot whales	0.99	0.62	N/M[1]	8.62
pelagic dolphins	0.83	0.94	0.03	12.37
1. N/M = Not Modeled. This species was not modeled in this stock area.				

S.4.8 Estimation of Potential Effects on Fish and Sea Turtles

S.4.8.1 Fish

For purposes of analysis, fish were categorized into two groups -- bony fish and sharks. Direct effects on the ears and lateral lines of fish (organs that are involved in detection of sound and hydrodynamic stimuli) were considered. Effects on these organs could lead to temporary hearing loss and masking of behaviorally relevant signals that could keep fish from pursuing normal activities. Existing research on hearing responses is limited to only a few species and there are almost no data that are useful in determining which sound pressure levels (SPLs) cause temporary or permanent injury.

The criterion applied here for SURTASS LFA sonar is that the risk of physical harm or injury to fish would be no greater than that for marine mammals, and this is likely to be a conservative estimate. Therefore, a fish or shark would have to be inside the LFA mitigation zone (180-dB sound field) during the time that the sonar was operating to possibly incur injury.

The analysis concludes that potential effects on fish, including sharks and some prey species for marine mammals, would not be significant under either Alternative 1 or 2 due to several factors:

- Small number of SURTASS LFA sonar systems to be deployed;
- Geographic restrictions imposed on system employment;
- Narrow bandwidth of SURTASS LFA sonar active signal (approximately 30 Hz);
- Slowly moving ship, coupled with low system duty cycle, mean fishes and sea turtles would spend less time in the LFA mitigation zone (180-dB sound field); further, with a ship moving in two dimensions and animals moving in three dimensions, the potential for animals being in the sonar transmit beam during the 20% (or less) time the sonar is actually transmitting is very low; and
- Small size of the LFA mitigation zone (180-dB sound field) relative to fisheries provinces and open ocean areas. Due to the lack of more definitive data on fish and sea turtle stock distributions in the open ocean, it is infeasible to estimate the percentage of a stock that could be located in a SURTASS LFA sonar operations area at a potentially vulnerable depth, during a sound transmission. Therefore, it is assumed that the stocks are evenly distributed.

S.4.8.2 Sea Turtles

Most sea turtle species reside primarily in coastal areas and, in a geographic sense, are generally considered to be temperate zone animals, as they are rarely found in waters with temperatures below 16°C (61°F). Although they are thought to be capable of hearing LF sound, there is very little information on their behavioral or physiological responses to it.

The criterion applied here for SURTASS LFA sonar is the same as that for fish -- that the risk of physical harm or injury to sea turtles would be no greater than that for marine mammals, and this is likely to be a conservative estimate. Therefore, a sea turtle would have to be inside the LFA mitigation zone during the time that the sonar was operating to possibly incur injury.

For Alternative 1, sea turtle encounters with SURTASS LFA sonar would be limited and not significant due to the five factors described in S.4.8.1. Thus, it is unlikely that individual animals or a significant portion of any sea turtle stock would experience adverse effects on movements, migration patterns, breathing, nesting, breeding, feeding, or other normal behaviors. Any potential effects due to masking would be minor and temporary. Moreover, given the fact that sea turtles are comparable in size to that of a small marine mammal, the visual monitoring and active acoustic monitoring proposed under Alternative 1 would further reduce the risk of sea turtles encountering the SURTASS LFA sonar system.

Unlike Alternative 1, under Alternative 2 there would be no geographic restrictions or monitoring mitigation. Alternative 2 would, therefore, likely expose a greater number of sea turtles to higher sound levels of SURTASS LFA sonar, and would not provide information to help improve the environmental performance of the SURTASS LFA program going forward. As a result, the potential for harm or behavioral effects to sea turtles would be greater under Alternative 2 than under Alternative 1. For both alternatives the potential impact due to masking would be temporary.

S.4.9 Mitigation and Monitoring

Alternative 1 (the Navy's preferred alternative) incorporates mitigation measures into operation of the SURTASS LFA sonar. The objective of these mitigation measures is to avoid injury to marine mammals and sea turtles near the SURTASS LFA sonar source and to recreational and commercial divers in the coastal environment. This objective would be met by Navy adherence to the following restrictions on SURTASS LFA sonar operations:

- SURTASS LFA sonar-generated sound field would be below 180 dB (RL) within 22 km (12 nm) of any coastlines and in offshore areas outside this zone that have been determined by NMFS and the Navy to be biologically important (see Figure S-1, SURTASS LFA Sonar Potential Operating Areas);

- When in the vicinity of known recreational or commercial dive sites, SURTASS LFA sonar would be operated such that the sound fields at those sites would not exceed 145 dB (RL); and

- SURTASS LFA sonar operators would estimate SPLs prior to and during operations to provide the information necessary to modify operations, including the delay or suspension of transmissions, in order not to exceed the 180-dB and 145-dB sound field criteria.

In addition, the following monitoring to prevent injury to marine animals would be required when employing SURTASS LFA sonar:

- Visual monitoring for marine mammals and sea turtles from the vessel during daylight hours by personnel trained to detect and identify marine mammals and sea turtles;

- Passive acoustic monitoring using the low frequency SURTASS array to listen for sounds generated by marine mammals as an indicator of their presence; and

- Active acoustic monitoring using the High Frequency Marine Mammal Monitoring (HF/M3) sonar, which is a Navy-developed, enhanced high frequency (HF) commercial sonar, to detect, locate, and track marine mammals, and to some extent sea turtles, that may pass close enough to the SURTASS LFA sonar's transmit array to enter the 180-dB sound field (LFA mitigation zone).

S.5 Conclusion

In summary, under Alternative 1, the potential impact on any stock of marine mammals from injury is considered negligible, and the effect on the stock of any marine mammal from significant change in a biologically important behavior is considered minimal. However, because there is some potential for incidental takes, the Navy is requesting a Letter of Authorization (LOA) from NMFS for the taking of marine mammals incidental to the employment of SURTASS LFA sonar during training, testing and routine military operations under the Marine Mammal Protection Act (MMPA), and is consulting with NMFS under Section 7 of the Endangered Species Act (ESA). NMFS considers the issuance of some small take authorizations and MMPA LOA to be major federal actions. Accordingly, it has joined with the Navy as a cooperating agency in the preparation of the OEIS/EIS to ensure that all information needed for the NMFS permitting process has been identified in the development of this document.

Further, any momentary behavioral responses and possible indirect impacts to marine mammals due to potential impacts on prey species are considered not to be biologically significant effects.

Finally, any auditory masking in mysticetes, odontocetes, or pinnipeds is not expected to be severe and would be temporary.

Under Alternative 2, the Navy could conduct SURTASS LFA sonar operations anywhere in the world within the system's physical limitations (e.g., not in very shallow water). Even though Alternative 2 is more operationally flexible and cost-effective for the Navy to implement and operate, it is not the Navy's preferred alternative due to its potential adverse effects to marine animals and human divers. Its implementation would not be consistent with the CNO commitment to the protection of the environment and good stewardship of the seas.

The No Action Alternative would avoid all environmental effects of employment of the SURTASS LFA sonar. It does not, however, support the Navy's stated priority ASW need for long-range underwater threat detection. The implementation of this alternative would allow potentially hostile submarines to clandestinely threaten U.S. Fleet units and land-based targets. Without this long-range surveillance capability, the reaction times to enemy submarines would be greatly reduced and the effectiveness of close-in, tactical systems to neutralize threats would be seriously, if not fatally, compromised.