FINAL
OVERSEAS ENVIRONMENTAL IMPACT STATEMENT
AND
ENVIRONMENTAL IMPACT STATEMENT
FOR

SURVEILLANCE TOWED ARRAY SENSOR SYSTEM
LOW FREQUENCY ACTIVE
(SURTASS LFA) SONAR

Volume 1 of 2

Department of the Navy
Chief of Naval Operations
January 2001

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Chief of Naval Operations Instruction 5090.1B

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

Final
Overseas Environmental Impact Statement
and
Environmental Impact Statement

for
Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar
Volume 1 of 2

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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.

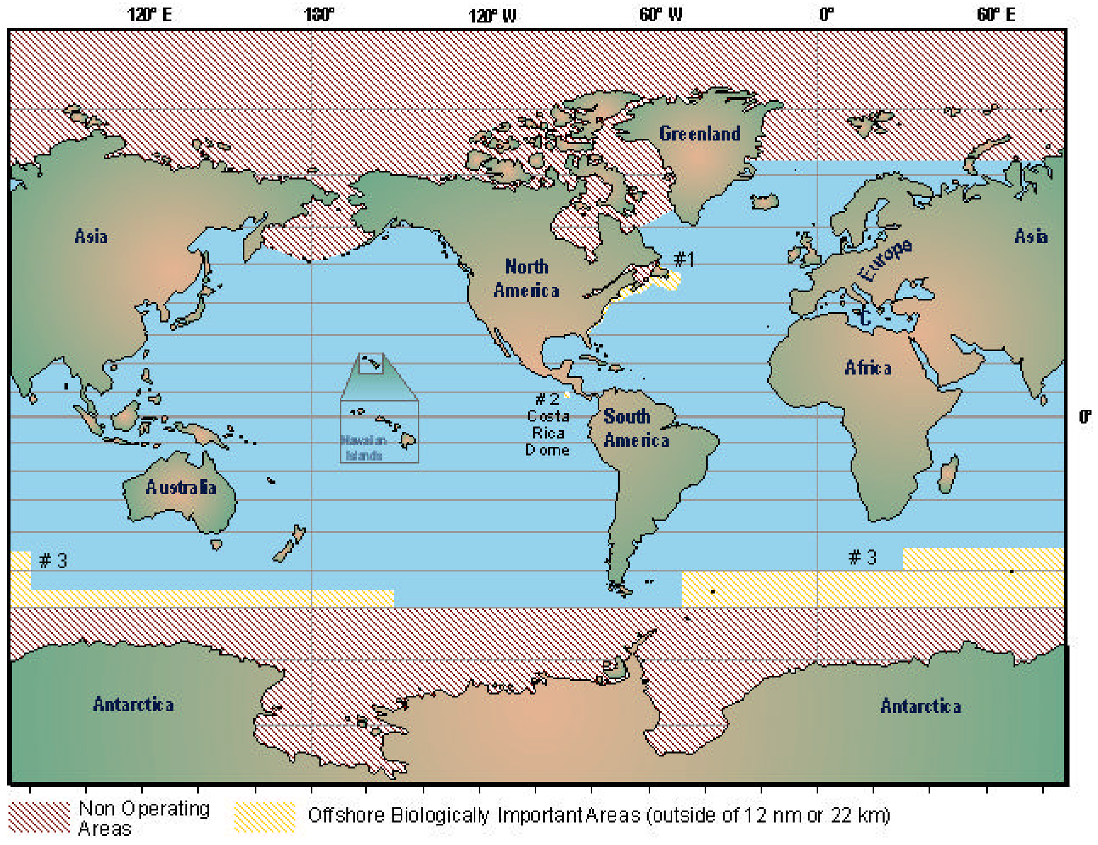

Figure S-1. SURTASS LFA Sonar Potential Operating Areas.

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.

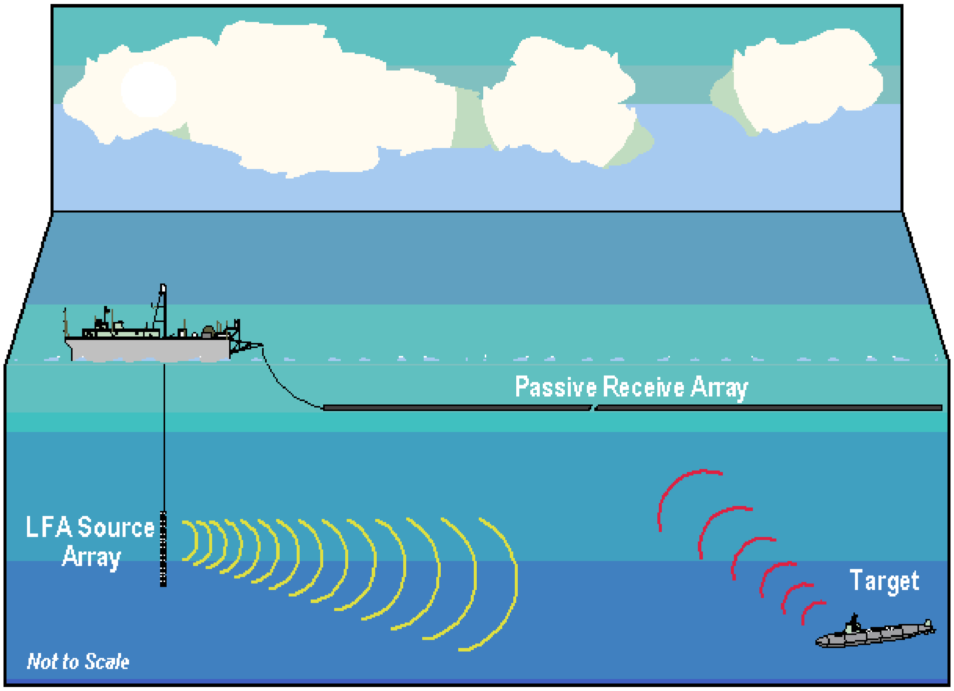

Figure S-2. SURTASS LFA Sonar System.

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.

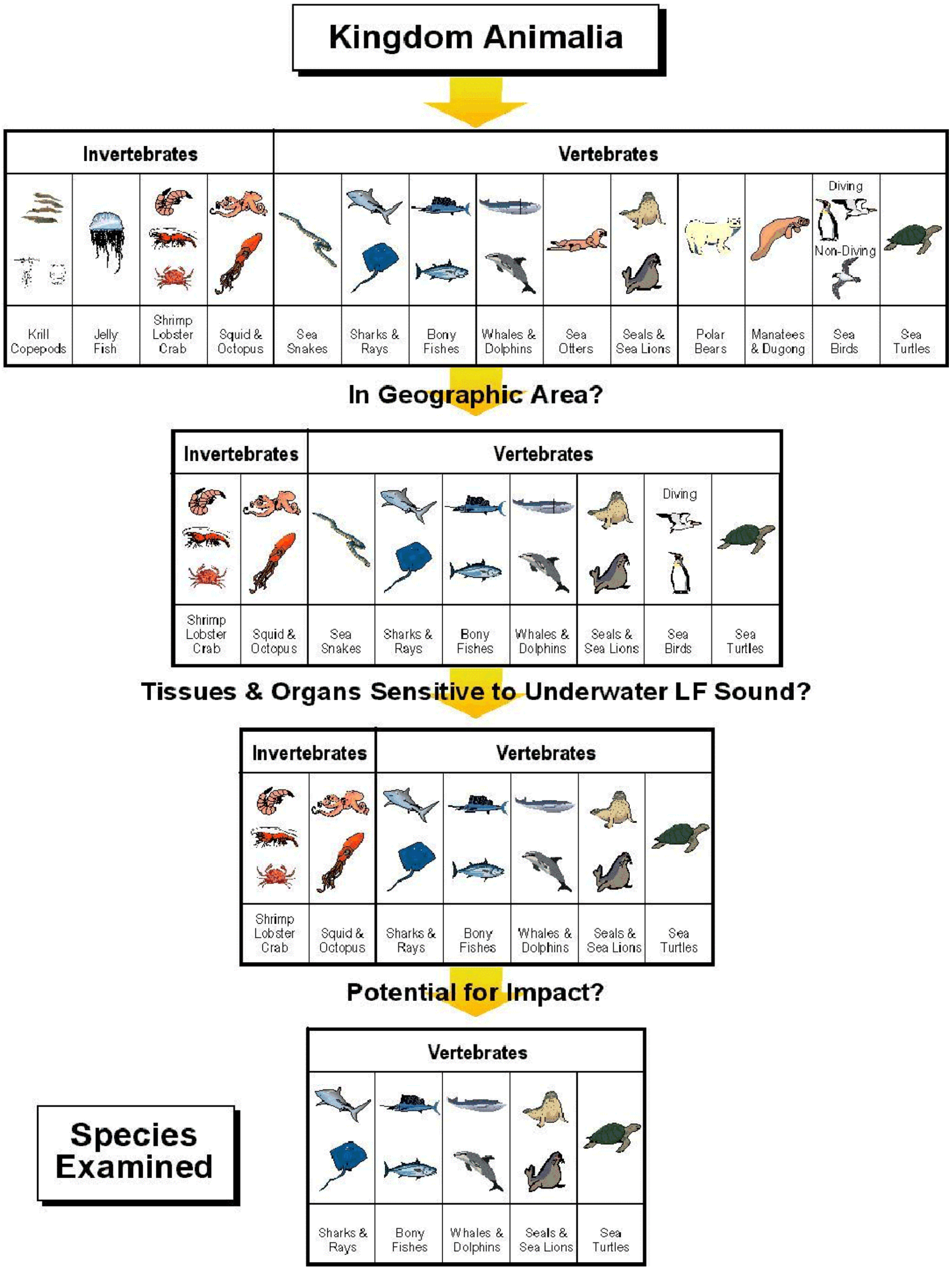

Figure S-3. Species Selection Rationale.

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 ≥ 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.

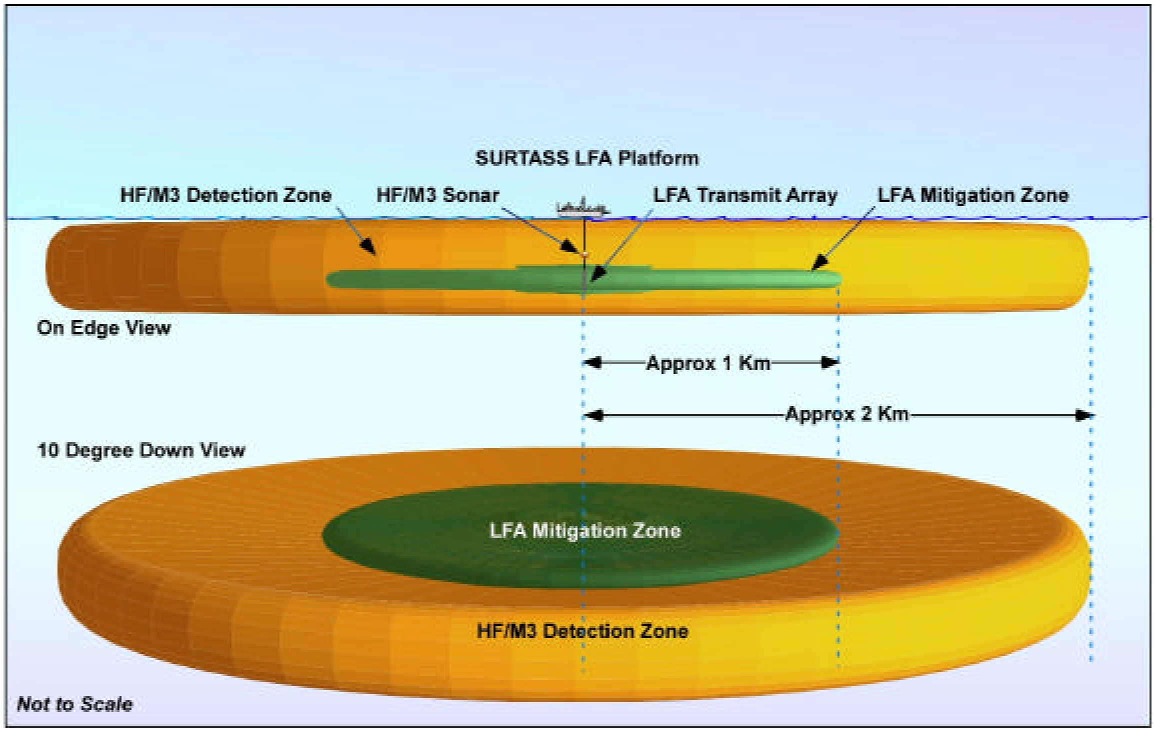

Figure S-4. HF/M3 Sonar Detection and LFA Mitigation Zones.

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:

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

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.

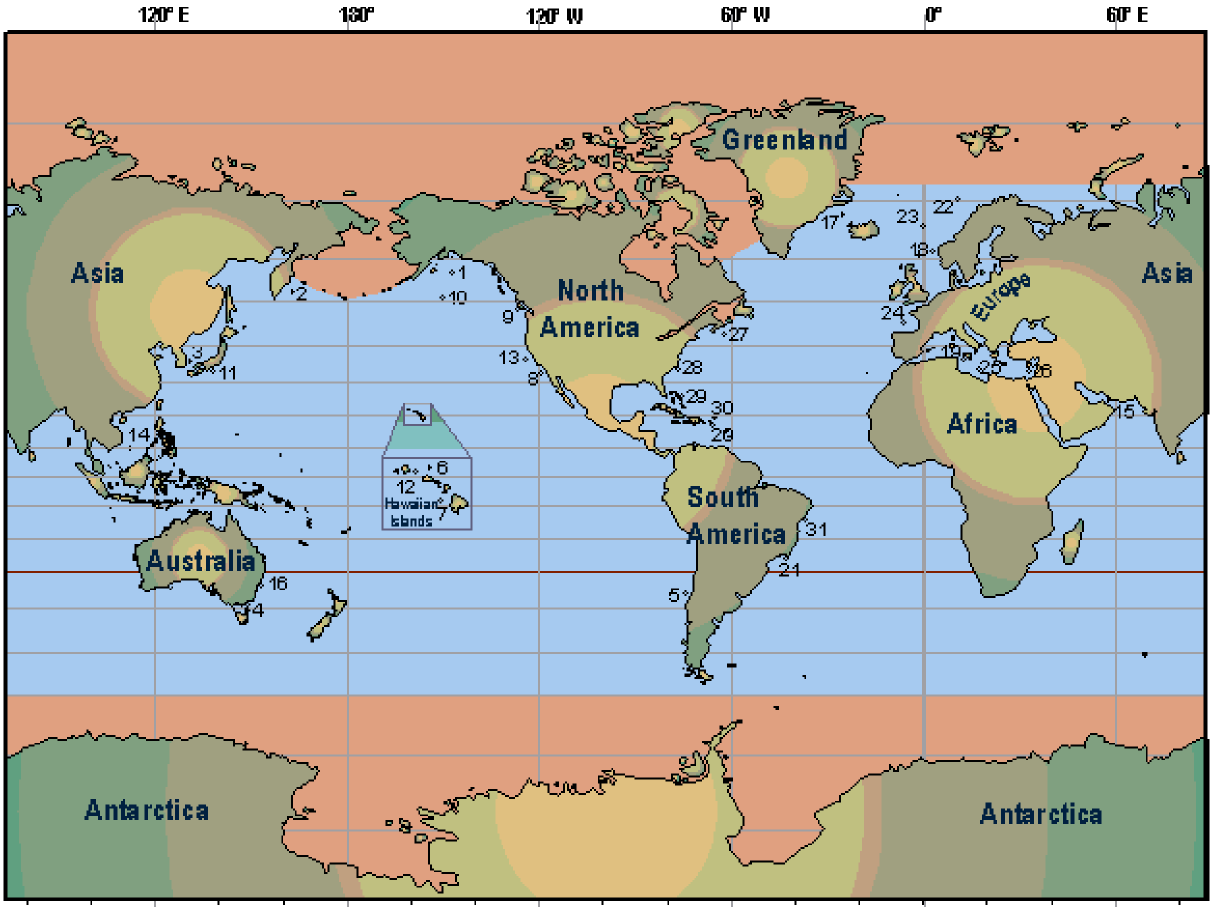

Figure S-5. Acoustic Modeling Sites

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.

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TECHNICAL REPORT ATTACHMENTS

(Incorporated by reference
in accordance with 40 CFR 1500.21)*

TR-1 - Low Frequency Sound Scientific Research Program Technical Report
TR-2 - Acoustical Modeling Results
TR-3 - Summary Report on the Bioeffects of Low Frequency Waterborne Sound

* Available upon request.

ACRONYMS AND ABBREVIATIONS

ABR	Auditory brainstem response
AFSC	Alaska Fisheries Sciences Center
AIM	Acoustic Integration Model
AIP	Air independent propulsion
ANPR	Advance Notice of Proposed Rulemaking
APPS	Act to Prevent Pollution from Ships
ARG	Amphibious Ready Group
ARPA	Advances Research Projects Agency
ASW	Antisubmarine warfare
ASWEX	Antisubmarine warfare exercise
ATOC	Acoustic Thermometry of Ocean Climate
AUTEC	Atlantic Undersea Test and Evaluation Center
BA	Biological Assessment
BARSTUR	Barking Sands Tactical Underwater Range
BO	Biological Opinion
BSURE	Barking Sands Underwater Range Expansion
BUMED	Bureau of Medicine and Surgery
C	Centigrade
CDF	Cumulative distribution function
CEQ	Council on Environmental Quality
CETAP	Cetacean and Turtle Assessment Program
CFR	Code of Federal Regulations
CINCLANTFLT	Commander in Chief, Atlantic Fleet
CINCPACFLT	Commander in Chief, Pacific Fleet
CITES	Convention on International Trade in Endangered Species
CNO	Chief of Naval Operations
COMNAVOCEANCOM	Commander Naval Oceanographic Command
CONOPS	Concept of Operation
CR	Critical ratio
CSI	Cetacean Society International
CW	Continuous wave
CWA	Clean Water Act
CZ	Convergence zone
CZMA	Coastal Zone Management Act
D&T	Development and test
DAN	Divers Alert Network
dB	Decibel(s)
dB(A)	Decibel(s) (A-weighted)
DBDB	Digital Bathymetric Data Base
DD	Destroyer
DDG	Destroyer (guided missile)
DEIS	Draft environmental impact statement
DERA	Defence Evaluation and Research Agency
DoC	Department of Commerce
DoD	Department of Defense
DON	Department of the Navy
DOEIS	Draft Overseas Environmental Impact Statement
DRT	Damage risk threshold
DSB	President's Defense Science Board
D&T	Development and Test

E	Endangered
EEZ	Exclusive Economic Zone
EFH	Essential fish habitat(s)
EIS	Environmental impact statement
EO	Presidential Executive Order
EQ	Equivalent quiet
ESA	Endangered Species Act
ESM	Electronic Support Measures
EVA	Environmental acoustics
F	Fahrenheit
FAO	Food and Agriculture Organization of the United Nations
FBE	Fleet Battle Experiment
FEIS	Final environmental impact statement
FFG	Frigate (guided missile)
FM	Frequency-modulated
FR	Federal Register
FSG	Guided Missile Corvette
ft	Feet
ft/s	Feet per second
FY	Fiscal year
GINSEA	Greenland/Iceland/Norwegian Seas
GRP	Glass reinforced plastic
HESS	High energy seismic survey
HF	High frequency
HF/M3	High Frequency Marine Mammal Monitoring
hp	Horsepower
hr	Hour
Hz	Hertz
IR	Infrared
IRDS	Infrared Detection System
ISSCAAP	International Standard Statistical Classification of Aquatic Animals and Plants
IUCN	International Union for Conservation of Nature and Natural Resources
IWC	International Whaling Commission
JASA	Journal of the Acoustical Society of America
JCS	Joint Chiefs of Staff
JTFEX	Joint Task Force Exercise
JTFS	Joint Task Force Surveillance
kg	Kilogram
kJ/m	Kilojoule per meter
kHz	Kilohertz
km	Kilometer(s)
kph	Kilometer per hour
kt	Knots
Lb	Pound(s)
LF	Low frequency
LFA	Low frequency active
LFAA	Low frequency active acoustic
LFS SRP	Low Frequency Sound Scientific Research Program
LIDAR	Light Detection and Ranging
LLTV	Low Light-Level TV
LOA	Letter of Authorization
LTM	Long Term Monitoring
LWTC	Littoral Warfare Training Complex

m	Meters
MAD	Magnetic Anomaly Detection
MARAD	U.S. Department of Transportation Maritime Administration
MBTA	Migratory Bird Treaty Act
ME	Mitigation effectiveness
MF	Mid frequency
mi	Mile(s) (statute)
min	Minute(s)
MIT	Massachusetts Institute of Technology
MMC	Marine Mammal Commission
MMPA	Marine Mammal Protection Act
MMRP	Marine Mammal Research Program (ATOC)
MMS	Minerals Management Service
MPA	Maritime patrol aircraft
MPRSA	Marine Protection, Research, and Sanctuaries Act
m/s	Meters per second
msec	Millisecond
Mt	Metric ton(s)
NATO	North Atlantic Treaty Organization
NAUI	National Association of Underwater Instructors
NCA	National Command Authorities
NEHC	Navy Environmental Health Center
NEPA	National Environmental Policy Act of 1969
N/M	Not modeled
nm	Nautical mile(s)
NMFS	National Marine Fisheries Service
NMS	National Marine Sanctuary
NOA	Notice of Availability
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPAL	North Pacific Acoustic Laboratory
NRC	National Research Council
NRDC	National Resources Defense Council
NSMRL	Naval Submarine Medical Research Laboratory
NUSC	Naval Underwater Systems Center
NUWC	Naval Undersea Warfare Center
OAML	Oceanographic and Atmospheric Master Library
OAT	Ocean acoustic tomography
OBIA	Offshore biologically important area
OBN	Octave band noise
OEIS	Overseas environmental impact statement
OGC	Office of General Counsel
OIC	Officer in Charge
OMI	Ocean Mammal Institute
ONR	Office of Naval Research
OPAREA	Operations area
OPNAVINST	Chief of Naval Operations Instruction
OV	Observation vessel
P3-C	Maritime patrol aircraft
Pa	Pascal
PADI	Professional Association of Diving Instructors
PBV	Playback vessel
PBR	Potential biological removal
PC	Personal computer
PDR	Periscope Detection Radar

PE	Parabolic Equation
Pers. Comm.	Personal communication
Pers. Obs.	Personal observation
PMRF	Pacific Missile Range Facility
ppt	Parts per thousand
PTS	Permanent threshold shift
R&D	Research and development
RAY	Recent annual yield
RDT&E	Research, development, test, and evaluation
RIMPAC	Rim of the Pacific
RL	Received level
rms	Root mean squared
ROD	Record of Decision
ROPOS	Remotely Operated Platform for Ocean Science
ROV	Remotely operated vehicles
R/V	Research vessel
SACLANT	Supreme Allied Commander, Atlantic Center
SACLANTCEN	SACLANT Undersea Research Centre
SAR	Synthetic Aperture Radar
S/E	Southeast
sec	Second(s)
SH-60R	Antisubmarine Warfare Helicopter
SHAREM	Ship, Helicopter ASW Readiness Effectiveness Measurement
SL	Source level
SOAR	Southern California Acoustic Range
SOC	SURTASS operations center
SOFAR	SOund Fixing And Ranging
SONAR	SOund Navigation And Ranging
SOSUS	Sound Surveillance System
SPAWAR	Space and Naval Warfare Systems Command
SPE	Single ping equivalent
SPL	Sound pressure level
Sq	Square
SRP	Scientific Research Program
SSK	Submarine (diesel-electric)
SSN	Submarine (nuclear-powered)
SSP	Sound speed profile
SURTASS	Surveillance Towed Array Sensor System
SWG	Scientific Working Group
SWTR	Shallow Water Training Range
T	Threatened
T-AGOS	Ocean surveillance ship
TL	Transmission loss
TNT	Trinitrotoluene (dynamite)
TR	Technical Report
TS	Target strength
TTS	Temporary threshold shift
UCSC	University of California - Santa Cruz
UK	United Kingdom
UNCLOS	United Nations Convention on the Law of the Sea
UNOLS	University - National Oceanographic Laboratory System
UN	United Nations
U.S.	United States
USC	United States Code
USEPA	U.S. Environmental Protection Agency

USFWS USNS USW	U.S. Fish and Wildlife Service United States Naval Ship Undersea warfare
WHOI W/m²	Woods Hole Oceanographic Institution Watts per meter squared
VLA	Vertical line array
XBT	Expendable Bathythermograph
yd	Yard
ZOI	Zone of influence
3D 4D	Three dimensional Four dimensional
Symbols	
=	Equal to
≥	Greater than or equal to
>	Greater than
<	Less than
~	Approximately
±	Plus or minus
µ	Micro
Log	Logarithm

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1 PURPOSE AND NEED

This Overseas Environmental Impact Statement (OEIS)/Environmental Impact Statement (EIS) evaluates the potential environmental effects of employment of the Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) sonar. 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]) (JCS, 1997).

It has been prepared by the Department of the Navy (DON) 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 provisions of EO 12114 apply to major federal actions that occur or have effects outside of U.S. territories -- the United States, its territories, and possessions. The provisions of NEPA apply to major federal actions that occur or have effects in the United States, its territories, and possessions. The OEIS/EIS is also intended to augment other environmental reviews associated with using the SURTASS LFA sonar:

- Formal consultation under Section 7 of the Endangered Species Act;
- Potential issuance of authorizations to incidentally take marine mammals pursuant to regulations for implementing the Marine Mammal Protection Act; and
- Consistency determinations under provisions of the Coastal Zone Management Act.

The proposed action is the U.S. Navy employment of the SURTASS LFA sonar. As shown in Figure 1-1 (SURTASS LFA Sonar Potential Areas of Operations), this sonar system would be deployed in the non-crosshatched areas. To reduce adverse effects on the marine environment, areas would be excluded as 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 1-1), and in areas necessary to prevent greater than 145-dB SPL at known recreational and commercial dive sites. The system is a long-range sonar that operates in the low frequency band (below 1,000 Hertz [Hz]) within the frequency range of 100 to 500 Hz, that consists of both active and passive components. Thus, detection does not rely solely on noise generated by the object to be detected. The active array transmits a low frequency (LF) sound pulse that reflects off an object in the water, and the reflected pulse returns in the form of an echo. The passive array receives the return echoes through listening devices (hydrophones).

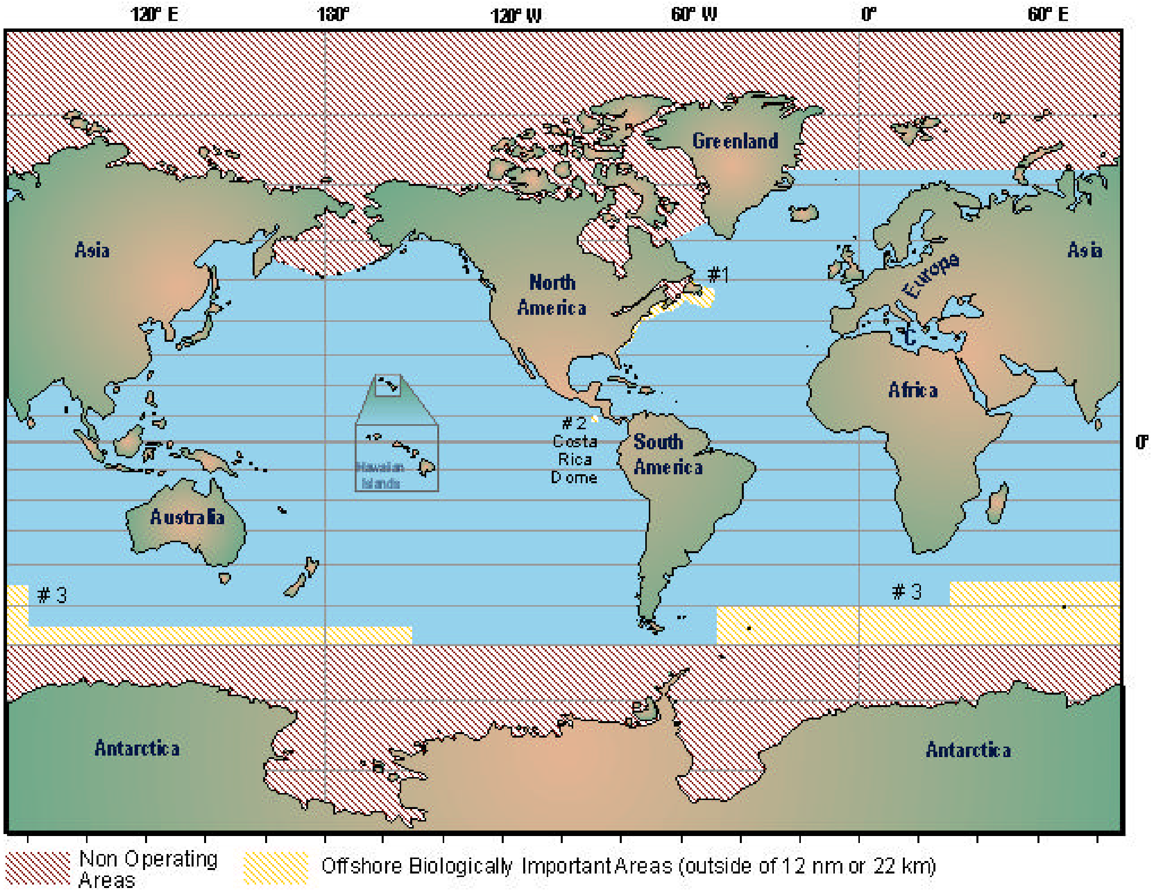


Figure 1-1. SURTASS LFA Sonar Potential Areas of Operations

The purpose of the proposed action is to meet U.S. need for improved capability to detect quieter and harder-to-find foreign submarines at long range. 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.

To meet its long-range detection need, the Navy investigated the use of a broad spectrum of acoustic and non-acoustic technologies to enhance antisubmarine warfare (ASW) capabilities. Of those technologies evaluated, low frequency active sonar was the only system capable of providing long-range detection. Low frequency active sonar is, therefore, the only available technology capable of meeting the U.S. need to improve detection of quieter and harder-to-find foreign submarines at long range.

Since the operation of SURTASS LFA sonar is related to the transmission of sound in the ocean environment, it is important for the reader to have at least an elementary understanding of the science behind the transmission of sound in water. A tutorial on the fundamentals of underwater sound is provided as Appendix B to assist the reader in understanding the technical aspects of this document.

1.1 Background

Geography dictates that the U.S. is a maritime nation, as it shares land borders with only two other nations, while the rest of the world community lies overseas. The U.S. has vital economic, political, and military interests and commitments around the globe. Recognizing this, the National Military Strategy (JCS, 1995) stated that naval forces "…ensure freedom of the seas and control strategic choke points…" The U.S. obtains a majority of its vital resources from overseas trade, more than 90 percent of which comes to the U.S. via merchant shipping. As seen in Figure 1-2 (American Sea Lines of Supply), many of the U.S. sea lines of supply lie near or along vital choke points. Many of these choke points (e.g., Suez and Panama Canals, the Persian Gulf entrance, the Strait of Malacca, and the Straits of Florida) are vulnerable to disruption by surface and submarine forces.

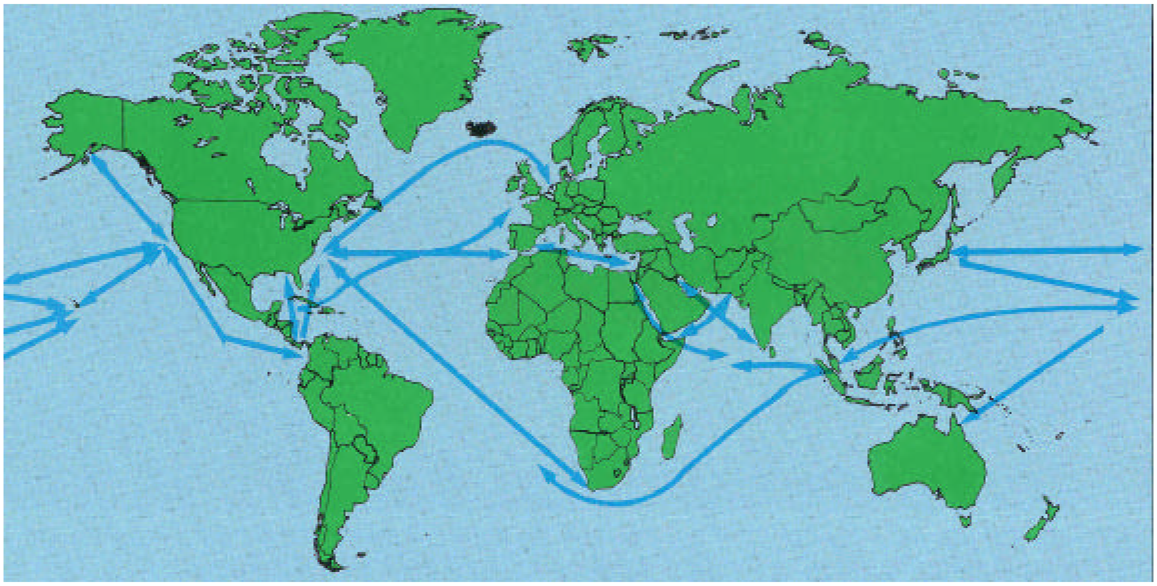


Figure 1-2. American Sea Lines of Supply

1.1.1 The Submarine Threat

The number of countries operating diesel-electric submarines continues to increase and they continue to pose a serious threat to naval operations, in the littoral, as well as in the open ocean (Krause, 1993). Submarines can be used to conduct a broad range of offensive and defensive missions (Naval Doctrine Command, 1997), including:

- Coastal defense;
- Covert surveillance, mining, or attacking of shipping channels and maritime choke points;
- Operation as a self-sufficient platform that can support special operations forces or attack in forward areas (e.g., littoral or "near land" areas of the world); and/or
- Strategic deterrence (e.g., carrying ballistic missiles).

Submarines can accomplish such missions because they possess a number of tactical characteristics that are both dangerous and difficult to counter, including:

- **Stealth** - a submarine is inherently stealthy. This provides a submarine with the dual tactical advantages of opportunity and time for planning an attack with a high probability of success;
- **Lethality** - a submarine can carry highly potent armament (highly destructive torpedoes and cruise missiles) capable of inflicting serious damage to or sinking even the largest ships; and
- **Economy of Force** - a submarine requires fewer operational resources than the resources required to defend against it, as illustrated by the difficulties that the Allied fleet experienced during World War II in defending against a small number of German U-boats in the Atlantic.

An unfriendly nation's aggressive use of even a single submarine has the potential to disrupt operations of U.S. Naval forces and constitutes a threat to U.S. security. The Russian Federation and the People's Republic of China have publicly declared that the submarine is the capital ship of their navies. Many potential adversarial countries have essentially done the same, including Iran and North Korea. A former Indian Navy submarine admiral has commented that developing nations desire submarine forces because they are a most cost-effective platform for the delivery of several types of weapons; they counter surface forces effectively; they are flexible, multi-mission ships; they are covert, and thus can operate with minimal political ramifications; and they can operate without the burden of supporting escorts (JCS, 1995).

Submarines are ideal weapons for states that lack, or cannot afford, the capability to assert sea control in their own (or others') waterspace (Hervey, 1994). As such, they can operate in an opponent's backyard--even in the face of determined sea control efforts, they can conduct stealthy and intrusive operations in sensitive areas, and can be inserted early for a wide range of tasks with a high degree of assured survivability (Chapman, 1993). When equipped with mines, advanced torpedoes, and/or anti-ship, and/or land-attack missiles, a submarine is a potent political weapon. A diesel electric submarine able to penetrate a multinational task force's defenses could undermine efforts to manage coalition politics in a single strike (Canadian Maritime Command, 1997).

The quieting of advanced non-U.S. nuclear submarines and advanced conventional (diesel-electric) submarines operating on battery power is now at parity with U.S. submarines. The U.S. no longer enjoys a comfortable acoustic advantage against the front-line submarines of some other nations. The Russian Federation continues to build new classes of highly capable submarines and to operate its newest vessels outside of home waters, including waters contiguous to the U.S. China is investing heavily in submarine technology, including designs for nuclear attack submarines, strategic ballistic missile submarines, and advanced conventional submarines; the latter through the purchase of KILO-class boats from Russia. China hopes to leap generations of submarine technology in its ambitious buying and building program (NRC, 1997).

The President's National Research Council (NRC) (1997) has projected that by 2035, the U.S. may be seriously and competently challenged by submarines from major powers (Russia and China) or from a number of potentially unfriendly nations. There are currently more than 150 submarines in the navies of potentially unfriendly countries other than Russia. Approximately 45 of these are modern, non-nuclear boats. About 45 more are on order worldwide, principally from German and Russian shipyards. By 2030, it is projected that 75 percent of the submarines in the rest of the world will have advanced capabilities, most likely including air-independent propulsion (AIP) that allows 30 to 50 days of submerged operations without surfacing or snorkeling. When these units are in a defensive mode; that is, not having to travel great distances or at high speed, they have a capability nearly equal to that of the modern nuclear submarine. Quieting technology is expected to proliferate, which will render these submarines difficult to detect, even with the latest ASW passive sonar equipment; and they may be armed with highly capable weapons.

The readiness and proficiency of submarine crews in the rest of the world are improving, and their performance is generally underestimated. Today, high-quality crew training is offered by the countries that export these submarines. Operated competently, these submarines are particularly difficult to find, much less neutralize.

1.1.2 U.S. Navy's Antisubmarine Warfare Mission

The increasing modernization of the world's submarine forces means that America's sea lines of supply are extremely susceptible to reprisals during regional conflicts. In the more unlikely case of global conflict, these maritime supply routes would be even more prone to attack. Thus, a critical cornerstone of the Navy's mission to defend the United States is maintaining the antisubmarine warfare (ASW) capability of its Fleet. This global ASW capability will continue to be a requirement for the U.S. Navy far into the foreseeable future. Critical to accomplishing this mission is detecting increasingly stealthy enemy submarines.

The importance of a strong U.S. global ASW capability is defined in a number of Department of Defense (DoD) documents concerning national security. For example, in *Directions for Defense*, ASW was designated as one of the Navy's core competencies by the report of the Commission on Roles and Missions of the Armed Forces. *Joint Vision 2010* (JCS, 1999), which is an operational warfighting vision from the Chairman of the Joint Chiefs of Staff, presents the concepts that the Chairman views as key to achieving future U.S. national security and national military objectives (JCS, 1999). It recognizes the importance of "full spectrum dominance" -- the ability to fight and decisively win across the full spectrum of conflict, regardless of battlefield conditions or the nature of the conflict.

The Department of the Navy's *2000 Posture Statement*, which discusses the Navy's mission, direction for the future, and the priorities that guide decision-making, relates the special concern of the warfighting concepts and capabilities of potential adversaries—especially anti-access strategies. It goes on to state that dominance in areas such as ASW will be required to ensure control of the seas and access to the battlespace domain under and on the sea (Department of the Navy [DON], 2000).

The National Academy of Sciences (NAS) (1997) reiterates that ASW is one of the Navy's most fundamental core competencies, and it must remain so in the face of a submarine threat that will increase significantly—perhaps even dramatically—in the 21st century. This increase, which is being fueled by the proliferation of advanced submarine quieting, sensors, and processing techniques and technologies, could result in the submarine becoming the dominant threat to the accomplishment of naval missions (NAS, 1997).

The *1998 ASW Focus Statement* of the Chief of Naval Operations (CNO) further emphasizes the importance of ASW in our national security and sets the direction for operational primacy in ASW (CNO, 1998). The statement recognizes that while the nature of the ASW threat has changed, the Navy is committed to excellence in this crucial mission and to the development of new technologies, coupled with innovative operational concepts that will yield a different approach to ASW. The Navy's goal is to have the best-trained ASW force in the world with the right set of tools to prevail in any type of conflict.

SURTASS LFA sonar meets U.S. need for improved capability to detect quieter and hard-to-find foreign submarines at long range, and provides adequate time to react to and defend against potential submarine threats. The Navy has investigated the use of acoustic and non-acoustic technologies to fill this immediate need. Only low frequency active sonar was identified as the system capable of providing the required long-range detection. Thus, SURTASS LFA sonar is critical to the Navy's ASW efforts.

1.1.3 Surveillance and Detection of Submarines

Surveillance of the oceans has been the primary means of detecting enemy submarines. To accomplish this surveillance, surface ships and submarines use the sound-based detection system called SONAR (SOund NAvigation and Ranging) to locate enemy submarines or other underwater objects.

Passive and Active Sonar

Sonar systems can be separated into two broad categories -- active and passive. Active sonars transmit sound energy (a "ping") and locate objects by detecting the reflection of these sound waves returning from the objects in the form of an echo. Passive sonars listen for sound generated by possible targets.

In the past, passive sonars were the dominant sensor used by the Navy for long-range surveillance and initial classification of enemy submarines. Passive sonars have the advantage of silence, in that they do not emit sound that an enemy might detect. Passive sonar was a particularly effective tool of the Navy during the Cold War since the submarines of the former Soviet Union were relatively noisy and could be tracked at long range. The U.S. developed and deployed formidable ASW systems with highly capable passive sonar arrays for broad surveillance of the North Atlantic and North Pacific ocean basins during this period. Geographically fixed systems were known as the Sound Surveillance System (SOSUS) (Tyler, 1992); systems deployed on Naval ships were known as the Surveillance Towed Array Sensor System (SURTASS).

While both these passive sensor systems performed extremely well against the submarine threat of the Cold War years, improvements in, and wide application of, submarine "quieting" technologies in the last decade have caused a significant degradation in their detection effectiveness (Tyler, 1992). These "quieting" technologies, which include hull coatings, sound isolation mounts, and improved propeller design, are increasingly available to forward-fit new submarines or retrofit older submarines, particularly those that are nuclear-powered (Naval Doctrine Command, 1997). In addition, the world's inventory of quieter diesel-electric submarines is increasing.

Other improvements in submarine technology are expected to further reduce submarine noise as well as expand operating ranges and increase periods of submerged operations. For example, the use of air independent propulsion systems minimizes the need for noisy diesel engine operations at or near the surface. In addition, international submarine crews are becoming increasingly proficient at their jobs, allowing them to more intelligently evade detection when submerged.

Shortened detection ranges have been the direct result of increased difficulty in detecting submarines. With current detection ranges in the tens of nautical miles, U.S. forces may have only minutes to respond to a potential submarine threat. This situation is in significant contrast to the margin of safety that was available in the 1970s when U.S. Fleet operating units were able to detect enemy submarines that were hundreds of nautical miles distant.

Over the last decade, Navy research and development (R&D) programs have been challenged to develop an ocean surveillance capability that could effectively detect the presence of quieter submarines at long range. With such a capability, Fleet units would be able to identify submarines underwater, track their routes, predict destinations, and generally maintain an awareness of the tactical situation in the ocean environment. With the information obtained through a long-range surveillance program, U.S. forces would regain the reaction time needed to meet potential undersea threats.

1.2 U.S. Navy Research and Development Initiative

The Navy's submarine detection R&D initiatives of the 1980s considered different technologies to achieve the goal of long-range detection of quiet submarines. One approach focused on the use of conventional (existing) Fleet assets (ASW surface and submarine combatants and aircraft). However, this is considered infeasible from tactical and economic perspectives. The use of a substantially larger number of units may attain a level of wide-area coverage, but the need identified in this OEIS/EIS is for long-range detection. As a result, the use of conventional technologies to accomplish long-range detection of submarines was considered infeasible from tactical and economic perspectives.

Navy R&D programs also considered improvement of passive sonar systems for long range detection. However, even with incremental technological changes, the Navy recognized that its passive sonars would not be sufficient to maintain or exceed the needed long-range detection advantage.

1.2.1 Non-Acoustic Alternative Underwater Detection Technologies

The Navy studied several non-acoustic ASW technologies in the 1980s as potential candidates for use in detecting submarines, including radar, laser, magnetic, infrared, electronic, electric, hydrodynamic, and biologic detection systems. Summary descriptions of these alternative detection technologies are provided in Table 1-1. While these alternative technologies have demonstrated some utility in detecting submarines, they cannot reliably provide U.S. forces with long-range detection (hundreds of nautical miles) and longer reaction times due to a number of critical factors:

- Limited range of detection;
- Meteorological and oceanographic limitations;
- Unique operating requirements; and/or
- Requirement for the submarine to be at or near the surface for detection.

1.2.2 New Active Sonar Technology

With non-acoustic technologies and/or improvements in passive sonars incapable of providing the needed long-range detection, the Navy then focused its research and testing on the new active sonar technologies. The focus of these efforts was to develop more comprehensive information about the acoustic characteristics and long-range detection capabilities of LF active sonar. The Navy focused its investigation on LF because it is well established that LF sounds (below 1,000 Hz) propagate in seawater more effectively and for longer distances than mid (1,000 to 10,000 Hz) and high frequencies (greater than 10,000 Hz). As discussed above, non-acoustic technologies, improvements in passive sonar, and mid- and high-frequency active sonar cannot feasibly meet long-range detection needs.

The Navy's approach to testing and development of a low frequency active acoustic (LFAA) sonar system was two-pronged and involved testing programs to address:

- Critical scientific issues needing resolution before LFAA systems could be realized; and
- Design and development of a deployable LFAA system.

Because the development of an LFAA system was considered a high national priority, the Navy pursued these research efforts in parallel.

Table 1-1

Summary of Alternative Non-Acoustic ASW Technologies

Technology	System	Detection Range
Radar	Periscope Detection Radar (PDR) uses low frequency radar to detect submarine periscopes with a potential medium-range (tens of nautical miles) detection capability. Because it must exploit rare opportunities when a submarine's periscope is exposed above the water's surface, the technology is operationally limited.	Medium
	Synthetic Aperture Radar (SAR) allows for the long-range detection of surfaced submarine wakes or periscope "feathers" from satellites and aircraft. This system is of limited operational use because (1) the submarine must either be underway on the surface or at periscope depth with the periscope deployed, and (2) there must be a confluence of near-perfect meteorological and oceanographic conditions (which rarely occur) for the system to function.	Long
Laser	Light Detection and Ranging (LIDAR), only used from aircraft, utilizes a blue-green laser to detect targets during the localization and attack phases of ASW (short-range). The technology is based on a function of water clarity, a factor that is highly variable, particularly in littoral waters.	Short
Magnetic	Magnetic Anomaly Detection (MAD) measures the magnetic anomaly created in the earth's magnetic field by the submarine's metallic (ferrous) materials. It is a good localization and attack sensor (short-range) except in proximity to geologic features (e.g., ore deposits) or manmade iron objects (e.g., shipwrecks) that introduce high background magnetic fields. Although the AN/ASQ-208 digital MAD in use today is far superior to previous systems through the elimination of metallic interference from the aircraft itself, it still suffers from geologic noise and very short detection ranges.	Short
Infrared	Infrared Detection System (IRDS) can detect the exhaust plume from a launched missile and provide the launch platform's location. It can also detect the heat emitted from the snorkel of a diesel-electric submarine charging its batteries. However, infrared detection is limited to "line-of-sight" and, therefore, if deployed from an aircraft or surface vessel, can only provide short- to medium-range detection.	Short to medium
Electronic	Electronic Support Measures (ESM) are passive submarine radar detection and surveillance systems capable of medium-range detection and classification of electronic signals transmitted from threat submarines. However, ESM is limited operationally given that covertly operating submarines would be unlikely to be on or near the surface and even less likely to advertise their presence by operating their radar or transmitting with other electronic equipment.	Medium
Electrical	Electric Field Sensors are stationary sensors that detect *in situ* electric field changes caused by the movement of objects through the water. These sensors require specialized processing to override background noise, are costly, difficult to deploy covertly, and have very short detection ranges.	Very short

Table 1-1 (Continued)

Summary of Alternative Non-Acoustic ASW Technologies

Technology	System	Detection Range
Optical	Low Light-Level TV (LLTV) cameras have proven to be marginally effective, but only when submarines are either on the surface, at periscope depth or, in some cases, just below the surface. Therefore, they are used for short-range localization and attack phases of ASW operations.	Short
Hydrodynamic	This short- to medium-range detection alternative refers to a "hump" at the water's surface from horizontal displacement of internal ocean waves caused by a large, solid object (such as a submarine) moving below the water's surface. The water “hump” can be detected from a high-resolution satellite altimeter, although the submarine must be at a relatively shallow depth, with the satellite almost directly overhead. The presence of a submarine could be inferred from a number of expendable bathythermographs (XBT). However, there must be correct oceanographic conditions to foster internal waves; the submarine must disturb their structure; and the ASW operator must be aware of the presence of internal waves, be in proximity to that area, and at the same time know that a submarine may be in the vicinity. Therefore, the opportunity for use is low.	Short to medium
Biologics	As the submarine travels through the water, it may disturb small bioluminescent sea creatures, sometimes leaving a visible trail. For this detection method to be effective, the submarine must be traveling at speeds greater than 5.5-9.2 km/hr (3-5 knots) at or near the surface, the correct high-density mix of bioluminescent fauna must be present near the sea surface with a low sea state, and a specialized ASW sensor platform must be in proximity. The Navy is no longer pursuing this short- to medium-range technology because opportunity to use this detection methodology was extremely low.	Short to medium

1.2.2.1 Testing Program

In 1987, the Chief of Naval Operations initiated a testing program to more fully evaluate the long-range submarine detection capabilities of LFA sonar. This testing program concentrated its investigative research on resolving fundamental science, engineering, and environmental issues. Phase One of the program involved deep-water tests to enhance the Navy’s understanding of such issues as long-range propagation, as well as bottom, surface, and volume reverberation. These tests also addressed issues such as acoustic waveforms, advanced signal processing techniques, and low-frequency transducer (source) technology. This testing provided the Navy with increased understanding of the acoustic characteristics and limitations of LFA sonar technology, and improved underwater environmental and acoustic propagation loss models (hence, increased ability to predict acoustic performance).

1.2.2.2 SURTASS LFA Sonar Research

The Navy has developed the SURTASS LFA sonar through a systematic research and testing program. The initial phase of the program centered on fundamental technology issues that explored basic science questions (such as reverberation, target strength, propagation and forward scatter), and other issues such as signal processing and system design tradeoffs. The second phase built on the basic science, exploring new scientific and technical issues. The final phase expanded the test and evaluation program to include littoral environments. During each of these phases, the Navy studied issues related to the operation of this system effectively and efficiently in the undersea warfare (USW) environment.

The results of the SURTASS LFA sonar research program expanded the Navy's understanding of LF sound propagation and scattering from the bottom, surface, and ocean volume. The program also contributed meaningful and much needed data to existing oceanographic databases. The results of these environmental acoustic investigations not only directly supported upgrades of Fleet standard models and databases, but they also provided the baseline for SURTASS LFA sonar system performance prediction and analysis capabilities.

1.2.2.3 Evaluation of Different LFA Sonar Configurations

After determining that LFA sonar was the only available technology capable of meeting the U.S. need to improve detection of quieter and harder-to-find foreign submarines at long range, the Navy then considered the secondary question of how LFA technology could be most effectively and efficiently deployed. This led to a range of issues, 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’s consideration of how to most effectively employ LFA sonar technology relied extensively on the system design and analysis conducted during the research program discussed above in Subchapter 1.2.2.2.

The Navy’s evaluation of the different ways in which LFA sonar technology could be configured and employed, while still fulfilling the Navy’s need for long-range submarine detection, led to the following conclusions: 1) four ships would need to be equipped with LFA sonar technology; 2) Navy ships would need to be able to operate LFA sonar technology extensively at various sites located in U.S. and international waters; and 3) LFA sonar technology would need to be capable of operating at source levels of at least 215 dB. The Navy eliminated from further evaluation other LFA sonar technology employment scenarios that did not meet these minimum requirements, because they would not satisfy the Navy’s ASW national defense needs.

1.3 Environmental Impact Analysis Process

The Navy has prepared this OEIS/EIS pursuant to:

- Presidential Executive Order (EO) 12114 (Environmental Effects Abroad of Major Federal Actions); and
- National Environmental Policy Act of 1969 (NEPA).

The Navy is the lead agency for the proposed action with the National Marine Fisheries Service (NMFS) of the Department of Commerce's (DoC) National Oceanic and Atmospheric Administration (NOAA) acting as a cooperating agency. Cooperating agencies have jurisdiction by law or special expertise with respect to certain environmental impacts from a proposed action by another agency. The provisions of EO 12114 apply to major federal actions that may affect the marine environment occurring beyond 22 km (12 nm) from the U.S. shore, in the global commons, or within the territory of a non-participating foreign government. The provisions of NEPA apply to major federal actions that may affect the human and natural environment of the U.S. and within 22 km (12 nm) from shore.

The preparation of this OEIS/EIS enables informed and balanced decision-making regarding the environment and assures public participation. In addition, the OEIS/EIS process is coordinated with the requirements of the Marine Mammal Protection Act and the Endangered Species Act.

1.3.1 Executive Order 12114

Executive Order 12114, signed in January 1979, directs federal agencies to provide for informed decision-making for actions that have the potential to significantly harm the environment outside U.S. territorial waters, including the exclusive economic zone (EEZ), the global commons, and the environment of non-participating foreign nations, or that impact protected global resources. This order furthers the purpose of NEPA, the Marine Protection, Research, and Sanctuaries Act, and the Deepwater Port Act. Procedures for implementing EO 12114 have been published by the Department of Defense (DoD) at 32 Code of Federal Regulations (CFR) Part 187. The Navy has implemented these procedures through Chief of Naval Operations (CNO) Instruction (OPNAVINST) 5090.1B (Environmental and Natural Resources Program Manual), Appendix E. Actions that may be taken during armed conflict are an exemption in EO 12114, so they are not covered in this OEIS/EIS.

1.3.2 National Environmental Policy Act

In 1969, the U.S. Congress passed NEPA, the national charter for environmental planning. NEPA provides for the consideration of environmental issues in federal agency planning and decision- making. The Council on Environmental Quality (CEQ) established guidelines for federal agency implementation of the act (40 CFR Parts 1500 to 1508). OPNAVINST 5090.1B documents the Navy's internal operations instructions on how the department implements the provisions of NEPA.

NEPA requires federal agencies to prepare an EIS for actions that may significantly affect the quality of the human and natural environment. The EIS must provide full disclosure of significant environmental impacts and inform decision-makers and the public of reasonable alternatives, including the No Action Alternative. With respect to full disclosure, the EIS must identify all potential direct and indirect effects that are known, and make a good faith effort to explain the effects that are not known but are "reasonably foreseeable." This includes the agency's responsibility to make informed judgments, and to estimate the potential for future impacts on that basis, especially if trends are ascertainable. However, the agency is not required to engage in speculation or contemplation about future plans that could influence the EIS's analysis of potential direct and indirect effects.

The first step in the NEPA process is the preparation of the formal Notice of Intent (NOI) which is published in the *Federal Register* (FR) and regional and/or local newspapers. The NOI announces the intent of an agency to prepare an EIS (Figure 1-3, The NEPA Process). In addition, the NOI provides an overview of the proposed project and the scope of the EIS, as well as a description of public participation opportunities, the schedule for public scoping meetings, and the location where written comments are received during the scoping period. The NOI for this project was published in the *Federal Register* on July 18, 1996 (FR Vol. 61 No. 139).

Scoping is an early and open process for developing the "scope" of issues to be addressed in the EIS. It is also important for identifying significant or controversial issues related to a proposed action. Through the scoping process, the public helps define and prioritize issues and conveys these issues to the agency through both oral and written comment. The period for public scoping is generally 45 to 60 days in length. Public scoping meetings for this project were held in August 1996.

After scoping, a Draft EIS (DEIS) is prepared. This document provides an assessment of the potential impacts the federal action might have on the human or natural environment. Future environmental conditions with proposed action implementation are compared to current or baseline conditions. The DEIS also informs decision-makers and the public of reasonable alternatives that would avoid or minimize adverse impacts or enhance the quality of the environment. Reasonable alternatives include those that are practical or feasible from a technical and economic standpoint and are based on common sense.

When a draft EIS has been completed, the U.S. Environmental Protection Agency (USEPA) publishes a Notice of Availability (NOA) in the *Federal Register*. The NOA for this Draft OEIS/EIS was published on July 30, 1999 (FR Vol. 64 No. 146). The draft EIS is circulated for review and comment, typically over a 45-day period, to government agencies, interested private citizens, and local organizations, and is available for general review in public libraries and other publicly

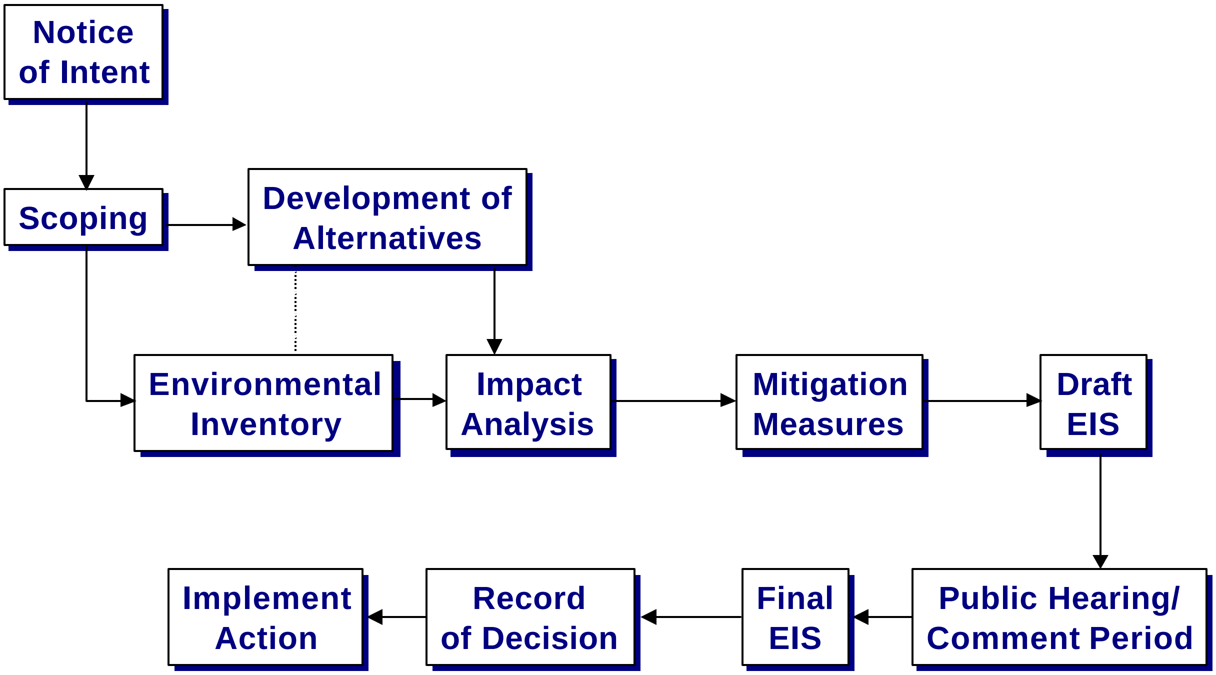


Figure 1-3. The NEPA Process.

accessible locations. This Draft OEIS/EIS was made available for public comment for 90 days, with comments accepted through October 28, 1999. Also, public meetings and hearings were held on the Draft OEIS/EIS as described in Chapter 10.

A Final EIS (FEIS) is then prepared that incorporates, and formally responds to, public comments received on the DEIS. This response can take the form of corrections of DEIS data inaccuracies, clarifications of and modifications to analytical approaches, inclusion of additional data or analyses, modification of the proposed action or alternatives, or simple acknowledgment of a comment. The preferred alternative for implementation is identified in the FEIS, if it was not presented in the DEIS. The FEIS is then circulated for public review for 30 days.

A Record of Decision (ROD) may be issued 30 days after the FEIS has been made available. The ROD identifies all alternatives that were considered, specifying the “environmentally preferable alternative(s)” and the “agency’s preferred alternative.” The latter is the alternative that the agency believes would fulfill its statutory mission and responsibilities, giving utmost consideration to economic, environmental, technical and other factors. The decision-maker may approve the proposal even if is not the environmentally preferable alternative. The ROD also describes the public involvement and agency decision-making process, and presents the agency’s commitments to any mitigation measures. The action can be implemented only after the ROD is signed. The ROD is then published in the *Federal Register*.

1.3.3 Marine Mammal Protection Act/Endangered Species Act

SURTASS LFA sonar may be employed in areas that are inhabited by marine animals, including birds, fish, sea turtles, and marine mammals. Marine mammals are protected under the provisions of the Marine Mammal Protection Act (MMPA) within U.S. territories or on the high seas. In addition, certain species of marine animals are listed as threatened or endangered under the Endangered Species Act (ESA).

Operation of the SURTASS LFA sonar system would introduce acoustic energy into the water that could cause impacts to marine animals. These reactions could be as simple as a temporary change in behavior. However, where the signals have the potential to cause harassment or injury, these disruptions could constitute incidental but unintentional "takings" under both the ESA and MMPA.

1.3.3.1 MMPA

The term "take" as defined in Section 3 (16 United States Code [USC] 1362) of the MMPA and its implementing regulations means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." The term "harassment" means any act of pursuit, torment, or annoyance that has the potential to:

- Injure a marine mammal or marine mammal stock in the wild (MMPA Level A harassment); or
- Disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (MMPA Level B harassment).

If a specified activity will result in a small take of marine mammals (one that will have no more than a negligible impact on the affected stock), the MMPA allows NMFS to authorize the action for a period of five years at a time. Before NMFS can authorize such takings, however, it must publish regulations that set forth, "…(I) permissible methods of taking pursuant to such activity, and other means of effecting the least practicable adverse impact on such species or stock and its habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance; and (II) requirements pertaining to the monitoring of and reporting of such taking." Once these regulations are finalized, NMFS authorizes the activity through a Letter of Authorization (LOA).

NMFS considers its issuance of some small take regulations and MMPA LOAs to be major federal actions, which require preparation of the appropriate NEPA and/or EO 12114 documentation. Accordingly, NMFS has joined with the Navy as a cooperating agency in this OEIS/EIS effort to ensure all information needed for the NMFS permitting process is developed during this OEIS/EIS preparation and public review process.

In August 1999, the Navy submitted an application to NMFS requesting authorization, pursuant to Section 101(1)(5)(A) of the MMPA, for the incidental taking of marine mammals. After NMFS reviewed the application, it published an Advance Notice of Proposed Rulemaking (ANPR) in the *Federal Register* on October 22, 1999 (FR Vol. 64 No. 204). The draft regulations for the proposed action will be prepared after a 30-day comment period and published in the *Federal Register*. A 45-day public comment period would then follow. At the end of this comment period, NMFS would finalize and publish the regulations in the *Federal Register*. NMFS would then determine whether to issue a Letter of Authorization to the Navy for the incidental taking of marine mammals associated with the employment of SURTASS LFA sonar.

1.3.3.2 ESA

Section 3 of the ESA defines “take” as to harass, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct to species listed as threatened or endangered in 50 CFR 402.12(b). The SURTASS LFA Sonar Draft OEIS/EIS served as the basis for the development of the Biological Assessment required under Section 7 of the ESA, and upon its completion and filing with USEPA, the Navy initiated formal consultation with NMFS. The Biological Assessment was submitted to NMFS on October 4, 1999 and constitutes the Navy’s evaluation of the potential effects of the proposed action on species listed or proposed for listing under the ESA, or on critical habitat designated for such species. After review of the Biological Assessment, NMFS will issue a Biological Opinion on the proposed action stating that it has determined it would not be likely to jeopardize the continued existence of listed species under the jurisdiction of NMFS or result in the destruction or adverse modification of critical habitat.

1.4 Analytical Context

In developing the framework for this OEIS/EIS, the Navy recognized that it needed to address the following issues:

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

- Adequacy of scientific information on marine animals - Data regarding the effects of underwater LF sound on marine animals, and in particular marine mammals, are limited. As a result of this limitation, the Navy conducted a series of original scientific field research projects to address the most critical of the data gaps regarding the potential effects of LF sound on the behavioral responses of free-ranging marine mammals. This research effort is referred to as the Low Frequency Sound Scientific Research Program (LFS SRP).

- Analytical approach - Given the data limitations, it was necessary to develop a prudent and conservative approach to the evaluation of potential environmental impacts from SURTASS LFA sonar. A prudent approach was utilized throughout this OEIS/EIS and its supporting studies.

- NEPA disclosure - Under NEPA, the Navy must address the adequacy of scientific information. CEQ regulations implementing NEPA offer protocols for managing situations involving incomplete or unavailable information. The Navy's LFS SRP studies have already helped fill in data gaps on the potential effects of LF sound on marine life, and the ongoing programs and research proposed by the Navy would continue to reduce areas of incomplete information and provide invaluable data that are presently unavailable.

These four topics are addressed in detail in the following material.

1.4.1 Adequacy of Scientific Information On Human Divers

The Navy sponsored research to study the potential effects of LF sound on humans in the water. This research was conducted by teams of independent scientists from universities and from military research laboratories. The research is described below and in Subchapter 4.3.2. 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 the Navy Submarine Medical Research Laboratory (NSMRL) to establish a 145-dB received level (RL) criterion for recreational and commercial divers. The Navy-sponsored studies on human divers included:

- Tests on Navy divers. This research was conducted by the Applied Research Laboratory, University of Texas, from 1993 to 1995 under the direction of NSMRL. In this study, 87 subjects (Navy divers) participated in 437 tests designed to determine the received sound level threshold below which there was no risk of auditory damage. 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 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 to develop guidance for safe exposure limits for recreational and commercial divers who might be exposed to LF sound from 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 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. This study, which is incorporated as Technical Report 3 to this OEIS/EIS, developed guidance

> criteria for human exposure to LF sounds such as those transmitted by the SURTASS LFA sonar system. Results were based on computer modeling and animal and human studies during which subjects were exposed to known levels of LF sound for known periods of time.
>
> Human guidelines were established based on psychological aversion testing. There was only a two percent aversion reaction subjectively judged as "very severe" by divers at a level of 148 dB. NSMRL therefore determined that scaling back the intensity by 3 dB (a 3 dB reduction equals a 50 percent reduction in signal strength) would provide a suitable margin of safety against psychological aversion for divers. Hence, NSMRL set the RL criterion for recreational and commercial divers at 145 dB (see Appendix A).

The Navy's adoption of the 145-dB interim guidance for operation of low frequency underwater sound sources in the presence of recreational and commercial divers is considered a conservative, protective decision. During operation of the SURTASS LFA sonar, the distance from the source to where the RL is 145 dB (the 145-dB sound field) varies from site to site due to the high variability in underwater sound propagation characteristics and deployment protocols. The most reliable method for ensuring that the criterion of 145 dB maximum RL is maintained at known recreational and commercial dive sites involves the application of validated underwater acoustic models of sound propagation using site-specific environmental parameters. Results provide an estimation of sound pressure level (SPL) as a function of range and depth for each specific site (see Subchapters 2.3.2.1 and 5.1.3).

1.4.2 Adequacy of Scientific Information on Marine Animals

Many human activities generate loud underwater sounds, and there is an urgent 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 make convenient subjects in captivity.

- 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 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.

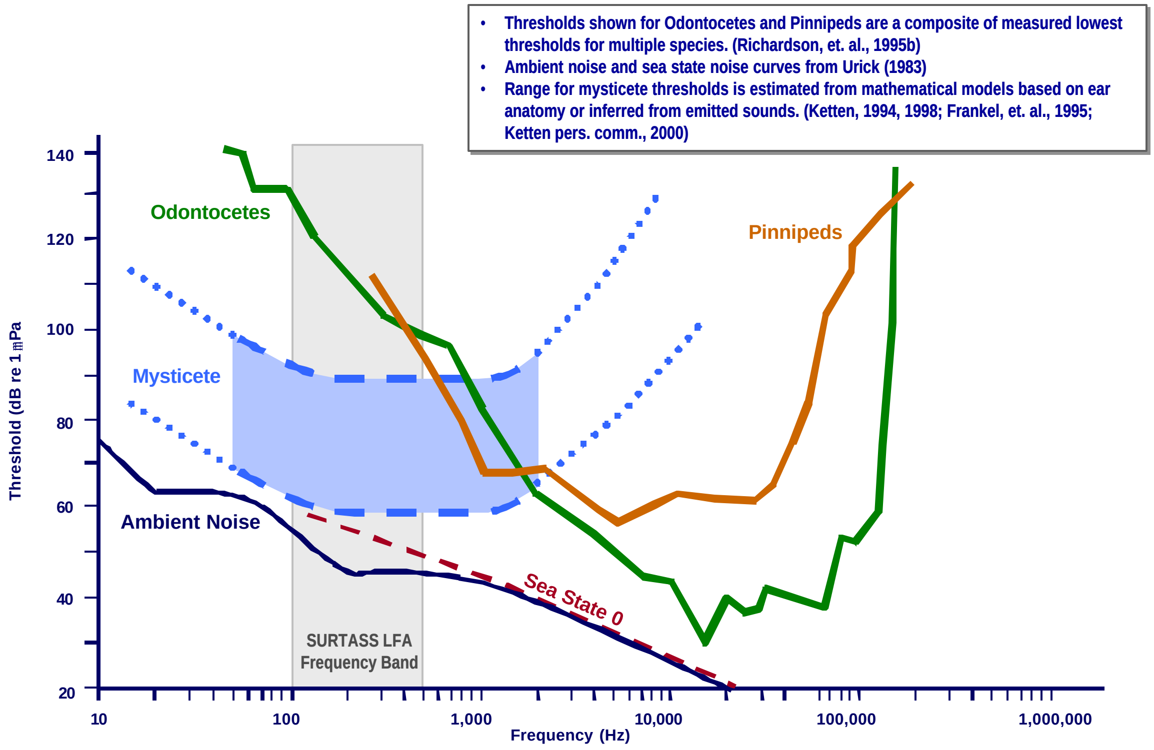
The composite audiogram shown in Figure 1-4 (Marine Mammal Audiograms) uses measured and estimated marine mammal hearing data to illustrate the contention that mysticetes have the best LF hearing of all marine mammals. Studies on pelagic fish and sea turtles indicate that their LF hearing is not as sensitive 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.

One goal of identifying the species most sensitive to LF sound was to produce a model of response that could be applied to other species for which data were lacking. This was also an important element in the selection of species for the LFS SRP research, and was intended to produce estimates of environmental impact that would be conservative when applied to other species.

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

1.4.2.1 Estimating the Potential for Injury to Marine Mammals

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 the survival and reproduction of these animals. Many human activities generate loud underwater sounds, and there is an urgent need for methods of estimating potential risk. The quest for a quantitative assessment of risk potential is complicated by scarce data in two areas. First, direct measured data regarding underwater hearing capabilities of marine mammals are generally limited to a few of the smaller species that can be conditioned for hearing tests in the laboratory. Second, hearing loss due to sound exposure is well studied in humans and other terrestrial animals, but data for marine animals are sparse. These data gaps have prompted the use of various models and extrapolations, in order to provide a rational basis for the assessment of risk potential.



- Thresholds shown for Odontocetes and Pinnipeds are a composite of measured lowest thresholds for multiple species. (Richardson, et. al., 1995b)
- Ambient noise and sea state noise curves from Urick (1983)
- Range for mysticete thresholds is estimated from mathematical models based on ear anatomy or inferred from emitted sounds. (Ketten, 1994, 1998; Frankel, et. al., 1995; Ketten pers. comm., 2000)

Figure 1-4. Marine Mammal Audiograms

Marine Mammal Hearing Thresholds

Assessment of potential risk to a particular species must begin with an estimate of the range of frequencies at which the animal's hearing is most sensitive, and the associated thresholds. The range of sounds produced by a species is generally associated with ranges of good hearing sensitivity, but many species exhibit good hearing sensitivity both above and below the frequency range of sounds they produce. Closely related species of similar body size, vocalization range and ecological habitat are often presumed to have similar hearing. Anatomical models of inner ear function have been used to extend the scope of limited audiometric data (Ketten, 1992, 1994a, 1997, 1998). In Ketten's work, the resonant properties of the basilar membrane provide clues to the probable range of animal hearing. Ketten (1998) delineates marine mammal functional hearing ranges into three categories: 1) infrasonic balaenids (mysticetes) with functional hearing from 15 Hz to 20 kHz, good sensitivity from 20 Hz to 2 kHz, and speculated threshold of best hearing at 80 dB re 1 μPa; 2) sonic to high frequency species with functional hearing range from 100 Hz to 100 kHz with widely varying peak spectra and a minimal threshold commonly at 50 dB re 1 μPa; and 3) ultrasonic dominant species with functional hearing range from 500 Hz to 200 kHz, good sensitivity from 16 kHz to 120 kHz, and minimal hearing threshold commonly at 40 dB re 1 μPa.

The evident difficulties of obtaining measured thresholds for Ketten's first category suggest that an estimation based on a non-direct method of extrapolation be used. Ellison (1997) and Clark and Ellison (2000) propose a general model that estimates lower bounds for hearing sensitivity. This approach assumes that the ambient noise of the environment, combined with general characteristics of vertebrate hearing, create a limit to best hearing. More specifically, the absolute threshold of best hearing can be estimated as:

Best Hearing Threshold = Lowest Ambient Noise Spectra + Critical Ratio

The auditory critical ratio, measured in decibels (dB re 1 Hz) is defined by Richardson (1995b) as the "difference [ratio] between sound power level for a barely audible tone and the spectrum level of background noise at nearby frequencies." The logic in this approach is that evolutionary pressures should select for the most efficient use of the limited dynamic range experienced by the auditory mechanism. Thus, the least detectable sound (i.e., a narrowband signal in dB re 1 μPa) in the frequency band of best hearing should approximate the lowest background noise spectrum level (dB re 1 $\mu Pa^2/Hz$) in that band plus the critical ratio at that frequency. All measured mammalian hearing systems work within a relatively narrow range of critical ratios, on the order of 16 to 24 dB re 1 Hz.

Validation for this approach comes from a comparison of measured results of best hearing thresholds for humans and white whales (beluga: *Delphinapterus leucas*) and their predicted thresholds using the ambient noise and critical ratios method. This comparison revealed remarkable concurrence between the measured and predicted thresholds. For humans, the predicted thresholds were within ± 5 dB of measured thresholds in the 1 – 4 kHz frequency band. For belugas, the predicted thresholds were within ± 5 dB of measured thresholds in the 20 – 70 kHz frequency band, and tended to overestimate threshold levels.

In order to extrapolate this approach to the baleen whales, two assumptions were made: 1) in the region from 100 to 500 Hz, the lower bound of ambient noise spectra (absent shipping noise effects) is on the order of 42 to 46 dB re 1 $\mu Pa^2/Hz$ (Urick, 1983), and 2) the range of mammalian critical ratios is well approximated by 16 - 24 dB re 1 Hz. Given these assumptions, the range of expected thresholds for baleen whales in the 100-500 Hz frequency band is estimated to be in the range of 58 - 70 dB re 1 µPa.

Figure 1-4 illustrates the estimated hearing range for baleen whales from the above method as well as mathematical models based on ear anatomy or inferred from emitted sounds (Ketten, 1994a, 1998; Frankel et al., 1995; Ketten, pers. comm., 2000). Also shown in this figure are composites of the measured lowest thresholds from pinniped and odontocete audiograms (Richardson, et al., 1995b), and an estimate of the lower bound of ambient noise (Urick, 1983).

Human Hearing Loss Studies

Due to the lack of measured data, estimating the point at which marine mammal hearing loss may occur as a function of sound level and duration requires extrapolation. For example, long-term hearing loss in humans is accelerated by chronic daily 8-hour workplace exposure (over time scales on the order of tens of years) to sounds at levels of 85 dB (A) (in air) or greater (*Guide for Conservation of Hearing in Noise*, American Academy of Ophthalmology and Otolaryngology, 1969; Ward, 1997). This result is shown as a function of the expected population percentage affected after 20 years of exposure in Table 1-2. 85 dB (A) is often cited as the level at which hearing loss occurs after workplace exposure over many years, even though it is actually only the 5th percentile point. The 50th percentile point is 20 dB higher (105 dB), and the 90th percentile point is more than 30 dB higher (115 dB). Therefore, the utilization of 85 dB over threshold is conservative.

Table 1-2

Percent of Noise-Exposed Human Population Likely to Develop Hearing Handicap [due to 20 years exposure] as Distinct from Normal Loss of Hearing with Age

Exposure Level at Work in dB(A)	Percent Affected at Age 40 after 20 years of exposure
80	0
85	5
95	21.4
105	49.9
115	83.9

References: *Guide for Conservation of Hearing in Noise*, American Academy of Ophthalmology and Otolaryngology (1969); Ward (1997)

The sound power reference unit dB (A) is the frequency-weighted response matching the human hearing threshold, 0 dB (A) being the nominal threshold of best hearing in young healthy humans. It should be noted that free-field human threshold measurements for binaural hearing (in the best human hearing band: 400 to 8,000 Hz) vary between –10 to + 10 dB re 20 µPa (Beranek, 1954; Harris, 1998) depending on measurement objective and technique used.

For a safe single exposure to very intense sound, Ward (1997) has derived a relationship of maximum safe level vs. exposure duration. Thus, levels higher than this may be viewed as potentially harmful. Simple recoverable temporary threshold shifts (which likely occurred at these intense levels of sound) are not included in this damage category. The relationship provided by Ward scales on a 10 log (duration in seconds) basis. Typical values of maximum one-time safe exposure levels above a nominal best hearing threshold of 0 dB re 20 µPa are 144 dB for 1 second, 124 dB at 100 seconds, 112 dB at 20 minutes, 109 dB at 60 minutes, 106 dB at 2 hours, and 100 dB at 8 hours. If viewed as levels above best hearing threshold, these values can be used to extrapolate and thus infer one-time RL thresholds for single safe exposure for other species.

Ward (1997) also introduces another base reference point of value to extrapolation issues. This reference point is termed equivalent quiet (EQ) and is the level of sound to which humans can be exposed continuously with no expected TTS. The lower level for humans is 70 dB re 20 µPa for sounds less than an octave in bandwidth. It is important to note that the value is comparable but slightly less than the "no effect" level of 80 dB in Table 1-2. An interpretation of this comparison is that repeated but modest levels of TTS (occurring from exposures between 70 and 80 dB above threshold) would have no long-term hearing loss effect. A value to be applied later is the difference in dB for humans between EQ and one-time safe exposure to intense sound (i.e., 74 dB for 1 second [144 dB - 70 dB = 74 dB], 54 dB for 100 seconds [124 dB - 70 dB = 54 dB]). See Temporary Threshold Shift (TTS) discussion below.

Selection of the 180-dB Criterion

For the purposes of the SURTASS LFA sonar analyses presented in this OEIS/EIS, all marine mammals exposed to RLs ≥ 180 dB are evaluated as if they are injured. The following discussion addresses the basis for determination of this value.

Extrapolation to Marine Mammals

If the "dynamic range" between hearing thresholds and problematic exposure levels is the same for marine mammals as for humans, this suggests that potential hearing loss in animals with good LF hearing can be extrapolated from the estimated thresholds shown in Figure 1-4. Selecting 60 dB re 1 µPa as the lower limit of the estimated marine mammal threshold in the 100 to 500 Hz frequency band, the extrapolated human data from Table 1-2 is shown in Table 1-3. For example, adding 60 dB to 80 dB (from first line in Table 1-2) equals 140 dB, as shown in the first line in Table 1-3.

Table 1-3

Percent of Marine Mammal Population (with good LF hearing) Likely to Develop Hearing Handicap (due to long term exposure)

Level in dB re 1 µPa (octave band or narrower band sounds in 100 to 500 Hz band)	**Percent Population Affected after (more than 8 hr/day) long-term (20 yrs) exposure**
140	0
145	5
155	21.4
165	49.9
175	83.9

Table 1-4 provides the equivalent safe one-time exposure levels as a function of duration, based on a 60 dB re 1 µPa best hearing threshold. For example, from the Ward (1997) derivation above, the typical value above a nominal best hearing threshold of 0 dB re 20 µPa is 144 dB for 1 second. Adding 60 dB to this equals 204 dB, as shown in the first line of Table 1-4.

Table 1-4

Duration and Level of Safe One-Time Exposures to Narrowband Sounds in the 100 to 500 Hz Band

Signal Duration	**Safe One-Time Exposure Level in dB re 1 µPa (octave band or narrower band sounds in 100 to 500 Hz band)**
1 sec	204
100 sec (max duration for a single SURTASS LFA sonar ping)	184
20 min	172
60 min	169
2 hr	166
8 hr	160

The selection of 180 dB as the single-ping criterion for the risk continuum approach is in agreement with extrapolation from the human exposure results. A level of conservatism is also inherent in this comparison, as the risk continuum 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

Hastings et al. (1996) studied the effects of intense sound stimulation on the ear and lateral line of the oscar fish (*Astronotus ocellatus*). They found that there was some damage to the sensory hair cells of two of the otolith organs, the lagena and utricle, when the fish were exposed to continuous underwater sound at 300 Hz and 180 dB for one hour. The interpretation of these results was that exposure to a pure tone, high intensity sound continuously for one hour has the potential to damage the ear of fish.

Other studies also suggest that intense sound may result in limited damage to the sensory hair cells in the ears of fish. Cox et al. (1986a, b; 1987) exposed goldfish (*Carassius auratus*), a freshwater fish with specialized and sensitive hearing, to pure tones at 250 and 500 Hz at 204 and 197 dB, respectively, at durations on the order of two hours, and found some indication of hair cell damage. Enger (1981) determined that some ciliary bundles (the sensory part of the hair cell) of the inner ear of the cod (*Gadus morhua*) were destroyed when exposed to sounds at several frequencies from 50 to 400 Hz at 180 dB for 1-5 hours.

Given that the physiology of inner ear hair cells is considered to be similar among vertebrates, and that exposure to 180 dB in water is expected to yield the same shear forces on the inner ears of fish and marine mammals, it seems a valid conclusion that the single-ping 180-dB criterion for SURTASS LFA sonar can be considered to be relatively conservative.

Goldfish in this band have excellent underwater hearing with thresholds in the 60 dB re 1 µPa range (Offutt, 1968). Following the extrapolation based on Ward's (1997) one-time exposure criteria and using a lumped average exposure time of two hours (106 dB from Ward [1997] derivation above) and a threshold of 60 dB, the safe limit would be predicted to be 166 dB (106 dB + 60 dB = 166 dB). Thus, the damage appears to have been caused by levels 14 dB and higher above an extrapolated single continuous two-hour ping guidance criterion (180 dB - 14 dB = 166 dB). Further extrapolation in time would indicate that, for the goldfish, a single 100-second exposure level on the order of 184 dB (see Table 1-4) would have been safe. On this basis, a 100-second duration criterion for SURTASS LFA sonar of 180 dB is conservative.

Temporary Threshold Shift (TTS)

Temporary threshold shifts (TTS) of varying degrees occur naturally on a routine basis in the environment of virtually all animals, including humans. As discussed previously, TTS is not necessarily harmful on a limited basis; however, an organism could miss important low level signals until its normal hearing sensitivity is restored. Further, TTS serves as an indicator that more extensive exposure (above EQ) or significantly louder levels may cause permanent hearing loss. This is demonstrated in Tables 1-2 (humans) and 1-3 (marine mammals with good LF hearing).

Two recent measurements of low-level TTS in marine mammals are discussed below along with the extrapolated relationship of these measurements to the selection of 180 dB as the SURTASS LFA sonar single-ping-exposure-limit for the risk assessment.

Schlundt et al. (2000) documented temporary shifts in underwater hearing thresholds in trained bottlenose dolphins (*Tursiops truncatus*) and white whales (*Delphinapterus leucas*) after exposure to intense one-second duration tones at 400 Hz, and 3, 10, 20, and 75 kHz. Of primary importance to this deliberation are the LF-band tones at 400 Hz. At this frequency, the researchers were unable to induce TTS in any animal at levels up to 193 dB re 1 µPa, which was the maximum level achievable with the equipment being used.

This experiment also provides an additional verification point for the extrapolation of the human data set for hearing effects at best hearing. For both species tested, their best hearing threshold is broadly set at about 40 to 45 dB in the 20 to 75 kHz range. In this band, TTS was reported for levels (varying significantly between individuals) from 182 to 193 dB. Applying the extrapolated one-time safe levels above threshold for one-second duration from Ward (1997), the result (144 dB above threshold) is 184 to 189 dB, providing further validation for the extrapolation technique.

Kastak et al. (1999) documented TTS in three species of pinnipeds exposed to varying levels of octave band noise (OBN) for periods on the order of 20 minutes. OBN center frequencies from 100 to 2,000 Hz were used in these tests, and the results presented in the paper pooled the data from each exposure frequency. The results indicate onset of TTS at mean values of 137, 150, and 148 dB re 1 µPa for the harbor seal, sea lion and elephant seal, respectively, for 20- to 22- minute exposures of OBN. Because of the pooling effect, these data also have variations around the mean on the order of -5 to +10 dB. As described in the account of the test, these levels can be considered to represent the lower level for onset of TTS.

Ward (1997) states that in humans ordinary TTS (i.e., effects lasting longer than two minutes) from narrow-band (octave band or less) sound occurs only at exposure levels in excess of 70 dB above hearing threshold. Due to the long exposure time of the stimulus in these tests, one can infer that the EQ level is closely approximated by the onset levels just described, adjusted for the longest duration (8 hours) in Ward's one-time safe level criteria. The difference between 20-minute and 8-hour exposures is 12 dB (see Table 1-4), thereby yielding extrapolated EQ values of 125 dB (137 dB - 12 dB = 125 dB), 138 dB (150 dB - 12 dB = 138 dB), and 136 dB (148 dB - 12 dB = 136 dB), respectively, for the harbor seal, sea lion, and elephant seal data. Applying the SURTASS LFA sonar 100-second EQ differential level of 54 dB (from the section on Human Hearing Loss Study above) to these values results in single-ping safe exposure levels of 179, 193, and 191 dB, respectively, for the three tested animals. Thus, a 100-second duration for SURTASS LFA sonar of 180 dB should be considered appropriate and, based on Kastak et al. (1999) sea lion and elephant seal data, conservative for these species at least.

For the purposes of this document 180-dB received level is considered as 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 (Knastner, 1998);
- Office of Naval Research Workshop on the Effects of Man-Made Noise on the Marine Environment. Washington, DC, February 9-12, 1998 (Gisiner, 1998); and
- National Marine Fisheries Service (Office of Protected Resources) Workshop on Acoustic Criteria, Silver Spring, MD, September 9-12, 1998.

1.4.2.2 Estimating the Potential for Behavioral Effect

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 disturbed 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.

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 (Malme et al., 1983, 1984). Immediately obvious avoidance responses were expected for levels >140 dB (Richardson et al., 1995b). 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. 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. These scientific results support the conclusion that potential impact on biologically significant behaviors is negligible for SURTASS LFA sonar RLs ≤145 dB. This shifts the level of potential concern from the previous level of 120 dB to levels >145 dB.

The modeled underwater acoustic RLs (Acoustic Integration Model [AIM] analyses results) presented in Subchapter 4.2 of this OEIS/EIS, which were calculated subsequent to the LFS SRP, suggest 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. The data presented as Figures 1-5a through 1-5c (Modeled Received Levels vs. Percentage of Modeled Pings [from AIM Aggregate Data Results] and Probability of Risk (For All Mysticetes, Odontocetes, Pinnipeds [31 sites]) illustrate that the preponderance of all modeled RLs fall below the 155 dB level, which is within the range of exposures studied during the LFS SRP. Thus, it follows that the scientific conclusion based on the LFS SRP research data should encompass the majority of SURTASS LFA sonar operational scenarios.

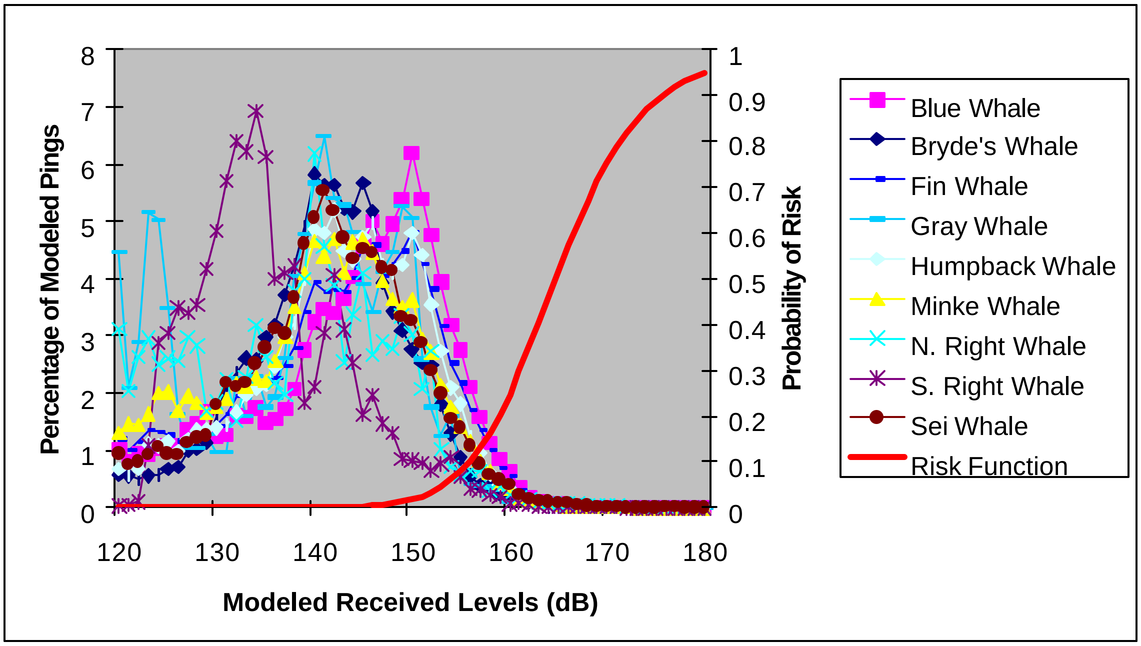


Figure 1-5a. Modeled Received Levels vs. Percentage of Modeled Pings (from AIM Aggregate Data Results) and Probability of Risk (For All Mysticetes [31 Sites])

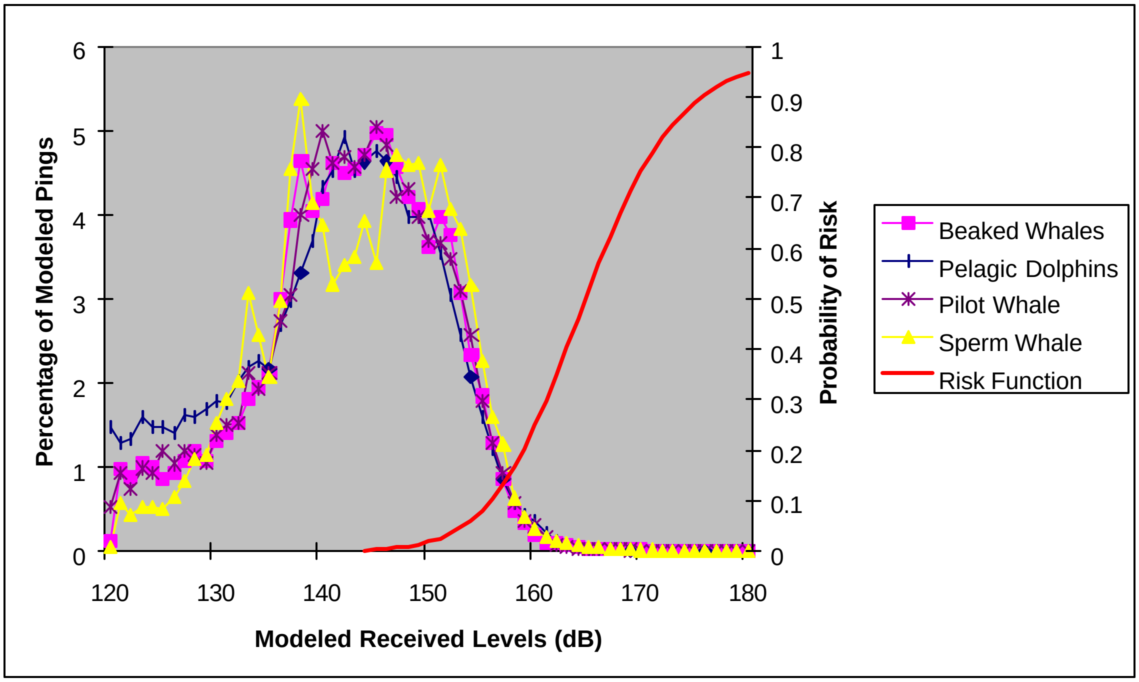


Figure 1-5b. Modeled Received Levels vs. Percentage of Modeled Pings (from AIM Aggregate Data Results) and Probability of Risk (For All Odontocetes [31 Sites])

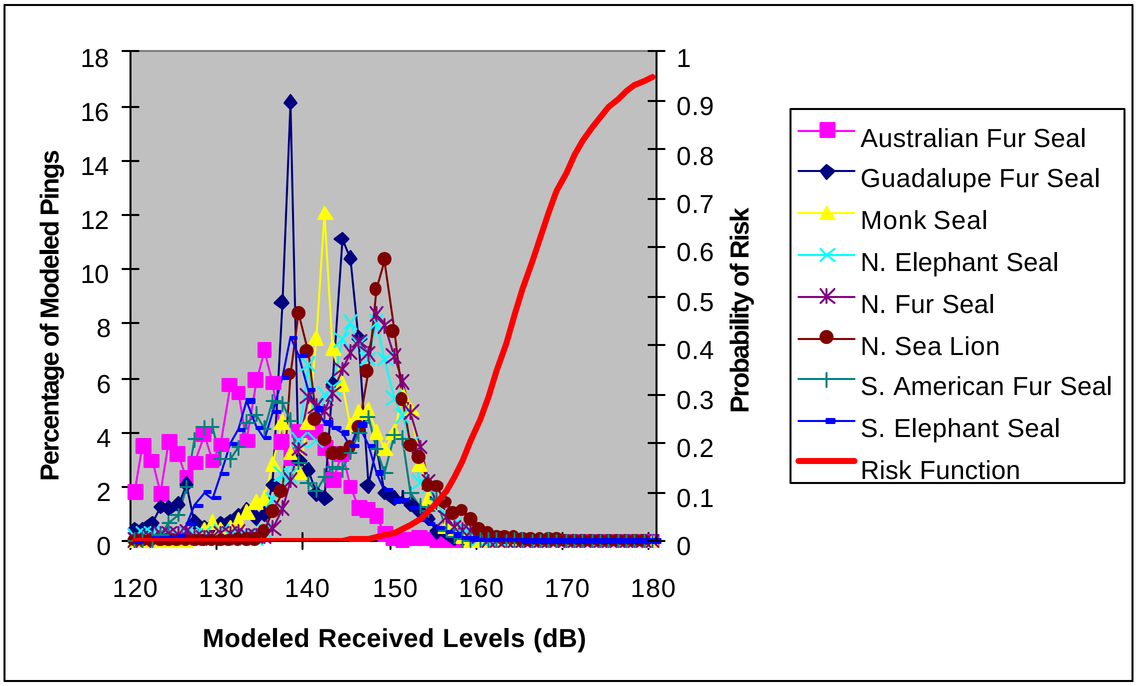


Figure 1-5c. Modeled Received Levels vs. Percentage of Modeled Pings (from AIM Aggregate Data Results) and Probability of Risk (For All Pinnipeds [31 Sites])

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 MMPA reporting requirements. Upon issuance of an LOA by NMFS under the MMPA, the Navy would provide a Long Term Monitoring (LTM) plan.

The Navy's efforts in this regard and its stated intention to conduct LTM (Subchapter 2.4) 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.

1.4.2.3 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.

Masking in fish stocks are discussed in Subchapter 4.1.1.1 (Fish Stocks). Existing evidence supports the hypothesis that masking effects could potentially be significant for fish 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.

Masking in shark stocks is discussed in Subchapter 4.1.1.2 (Shark Stocks). As in bony fishes, masking effects would be most significant for shark species with critical bandwidths at the same frequencies as SURTASS LFA sonar. However, the low duty cycle and maximum 100-second signal transmission window, would lead to only temporary masking, since the intermittent nature of the signal reduces the potential impact. Although long-term effects of masking sounds on sharks have not been studied, these are not expected to be severe because of the limited SURTASS LFA sonar bandwidth (approximate maximum of 30 Hz), and the fact that the signals do not remain at a single frequency for more than ten seconds.

Masking in sea turtle stocks is discussed in Subchapter 4.1.2 (Sea Turtles). For sea turtles, masking effects are potentially significant for those species that have critical hearing bandwidths in the same frequencies as SURTASS LFA sonar. However, masking of this nature would be temporary for the reasons cited above, and also because 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.

As discussed in Subchapter 4.2.7.7 (Potential for Masking) 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.

1.4.3 Analytical Approach

The underwater acoustic analyses described in Chapter 4 incorporate many biological and physical parameters. These parameters allow many situations to be modeled within a common framework. When scientific experts selected the values for these parameters, the best scientific and technical data and information were used, with the goal of selecting the most likely value for each parameter. Each judgment was, however, intentionally tempered by a conservative bias.

The cumulative effect of a series of modestly conservative choices results in a substantial conservative bias in the overall results and percentage of marine mammal stocks potentially affected. For example, suppose ten choices were made, each having a 60 percent chance of being conservative. Next, suppose the model results could be considered correct if at least half of these decisions were correct. The result is a greater than 80 percent chance that the model would be considered correct. This calculation follows from the cumulative binomial distribution (Dixon and Massey, 1969; Zar, 1996); similar considerations hold for the AIM model structure (Subchapter 4.2.2.2) and risk continuum (Subchapter 4.2.5).

This should be contrasted with an approach that would have selected extremely conservative values for each parameter, thereby representing upper bounds of risk contributed by each factor. The collective effect of this alternative strategy would have been a model that radically exaggerated risk by orders of magnitude (10 to 100 times). The OEIS/EIS sought a more realistic scenario, which would reveal conservative but plausible risk estimates, by incorporating a consistent moderately conservative bias.

Conservative Assumptions in Research and Modeling

Where necessary, the analysis relies on conservative procedures and assumptions in research and modeling that were independently developed by the scientific team:

- **Human Diver Hearing:** The comprehensive study conducted by ONR and NSMRL between June 1997 and November 1998 in conjunction with a consortium of university and military laboratories (see TR 3) concluded that the maximum intensity used during testing (157 dB RL) did not produce evidence of physiological damage in human subjects. Furthermore, there was only a two percent aversion reaction subjectively reported as "very severe" by divers at 148 dB RL. NSMRL adopted a very conservative approach and determined that scaling back the intensity by 3 dB (which equates to a 50 percent reduction in signal strength) would provide a suitable margin of safety for commercial and recreational divers. Hence, operation of SURTASS LFA sonar systems would be restricted to 145 dB in known areas of recreational and commercial diving.

- **Diver 145-dB Geographic Restrictions Not Included in Modeling:** In order to facilitate the modeling of potential impacts to marine mammals, the geographic restriction of 145 dB for recreational and commercial dive sites was not included in the AIM analysis. For regions with known recreational and commercial dive sites (predominantly coastal), this is more restrictive, in that its application overrides the 180-dB restriction, usually requiring the SURTASS LFA sonar vessel to operate farther offshore.

- **Use of Baleen Whales as Indicator Species:** As described in Subchapters 1.4.1.1 and 4.2, baleen whales (mysticetes) were selected, after review by an independent, broad group of interested parties, as the marine animals most at risk. Baleen whales were used as indicator species for other marine animals in these studies because they are the animals that are the most likely to have the greatest sensitivity to LF sound, have protected status, and have shown avoidance responses to LF sounds.

- **Site Selection:** For the acoustic modeling, locations covering the major ocean regions of the world were carefully selected to represent reasonable SURTASS LFA sonar employment. Sites were selected to model the highest potential for effects from the use of SURTASS LFA sonar, and incorporated the following factors:

    - Closest operationally plausible proximity to land (from a SURTASS LFA sonar operations standpoint), where biodiversities are high, and/or offshore biologically important areas are present (particularly for animals most likely to be affected);
    - Acoustic propagation conditions that allow minimum propagation loss or transmission loss (TL) (i.e., longest acoustic transmission ranges); and
    - Time of year selected for maximum animal abundance.

- **Use of 180-dB Criterion:** For the purposes of the SURTASS LFA sonar analyses presented in this OEIS/EIS, all marine animals exposed to RLs $\geq$ 180 dB are evaluated as if they are injured. A single-ping RL of 180 dB was assumed for the modeling; this level is considered conservative, as detailed herein.

- **Risk Transition:** The parameter of the risk continuum (for SURTASS LFA sonar) that controls how rapidly risk transitions from low to high values with increasing RL was set at a value that produced a curve with a more gradual transition than curves developed by the analyses of migratory gray whale studies of Malme *et al.* (1984). The choice of a more gradual slope than the empirical data was consistent with other decisions to make conservative assumptions when extrapolating from other data sets.

- **Risk Threshold:** The assumption that risk (for SURTASS LFA sonar) could begin at 119 dB is a practical approximation of the RL below which the risk of a significant change in a biologically important behavior approaches zero. In all three phases of the LFS SRP, most animals showed little to no response to SURTASS LFA sonar signals at RLs up to 155 dB, and those individuals that did show a response resumed normal activities within tens of minutes.

- **Cumulative Exposure:** Another conservative assumption involved the potential effects of cumulative exposure. The analysis assumed that the single-ping equivalent (SPE) level scaled in accordance with previous studies of TTS that dealt with continuous sound, even though SURTASS LFA sonar pings would be separated by 6 to 15 minutes of silence. The 20 percent (maximum) duty cycle of SURTASS LFA sonar transmissions implies that any cumulative exposure would be less than that for continuous sounds.

- **Number of Marine Mammals Potentially Affected:** The acoustic modeling simulations incorporated conservative assumptions regarding the fraction of the regional stock in the area potentially affected by the hypothetical SURTASS LFA sonar operation and their animal movement patterns. Scientific data are typically reported with 95 percent confidence intervals. However, in order to run the acoustic model, an exact number of animals must be specified. Therefore, the upper end of the 95 percent confidence interval was used for stock densities and abundances.

1.4.4 NEPA Disclosure

As previously stated, there are, and may always be, scientific data gaps regarding the potential for effects of LF sound on marine life. However, NEPA does provide guidance for how to proceed under situations with incomplete or unavailable information: CEQ regulations (40 CFR 1502.22) indicate that when an agency is evaluating reasonably foreseeable significant adverse effects on the human environment in an EIS and there is incomplete or unavailable information, the agency shall always make clear that such information is lacking. The term "incomplete information" refers to information that the agency cannot obtain because the overall costs of doing so are exorbitant. The term "unavailable information" refers to information that cannot be obtained because the means to obtain it are unknown.

The regulations further state that (a) if the incomplete information relevant to reasonably foreseeable significant adverse impacts is essential to a reasoned choice among alternatives and the overall costs of obtaining it are not exorbitant, the agency shall include the information in the EIS, and (b) if the information relevant to reasonably foreseeable significant adverse impacts cannot be obtained because the overall costs of obtaining it are exorbitant or the means to obtain it are not known, the agency shall include within the EIS:

- A statement that such information is incomplete or unavailable.

  Discussions of information gaps occur throughout this document, but are particularly discussed in Subchapter 1.4.1, Adequacy of Scientific Information on Human Divers and Subchapter 1.4.2, Adequacy of Scientific Information on Marine Animals. The Navy has, however, endeavored to supply missing information by conducting original research and modeling. The LFS SRP and human diver studies have contributed significantly to addressing the data gaps.

- A statement of the relevance of the incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts on the human environment.

  With regard to incomplete and unavailable information, "reasonably foreseeable significant adverse impacts" includes impacts that have catastrophic consequences, even if their probability of occurrence is low, provided that the analysis of the impacts is supported by credible scientific evidence, is not based on pure conjecture, and is within the "rule of reason." That is, agencies are not required to discuss "remote and highly speculative consequences."

The relevance of incomplete information in evaluating reasonably foreseeable significant adverse impacts from employment of SURTASS LFA sonar on the human environment is deemed moderate. The Navy has undertaken a reasonable search for relevant, current information associated with identified potential effects, and this OEIS/EIS contains a thorough discussion of the significant aspects of the probable environmental consequences of employment of the SURTASS LFA sonar system.

- A summary of existing credible scientific evidence that is relevant to evaluating the reasonably foreseeable significant adverse impacts on the human environment.

  Summaries of such evidence are provided throughout this OEIS/EIS, notably in Chapter 4 and in the discussions on the LFS SRP.

- The agency's evaluation of such impacts, based upon theoretical approaches or research methods generally accepted in the scientific community.

  As demonstrated in this document, not only did the Navy base evaluation of potential impacts on the existing, limited data and use generally accepted approaches and methods in doing so, but it also conducted original research to address many of the data gaps. For instance, the Navy developed the risk continuum analysis (Subchapter 4.2.5) and used acoustic modeling; prepared and executed the LFS SRP (Subchapter 4.2.4, TR 1); prepared and performed studies on human divers (Subchapter 4.3.2.1, TR 3); and has proposed a Long Term Monitoring Program (Subchapter 2.4) that includes further scientific research, which has the additional benefit of the potential for collaboration with other members of the scientific community.

Precedents for Proceeding with the Proposed Action

As stated throughout this section, and the OEIS/EIS as a whole, there are data gaps in what is known about the potential for effects on marine life from LF sound. This lack of information has been dealt with in many ways, including thorough original research, review of the literature, and proposed long term monitoring and research. The limited amount of data on LF sound and marine life is a result, in part, of the difficulties inherent in studying large animals and the unique qualities of the ocean environment.

Precedents for proceeding with the proposed action under these circumstances have been provided by rulings on NEPA documentation, including "frontiers of science" issues for impact analysis.

For instance, in a 1983 Supreme Court decision (on *Baltimore Gas & Electric Co. v. Natural Resources Defense Council*, 475 U.S. 87), the Court ruled on an EIS where the Nuclear Regulatory Commission (NRC) chose to analyze the most probable long-term waste disposal method and then estimate its impacts conservatively, based on the best available information and analysis. The NEPA document contained an expansive discussion of the uncertainties and used known data to extrapolate and identify impacts, resulting in a calculation of resulting consequences. The Court found the approach used by the NRC to be within the realm of "reasoned decision making required by the Administrative Procedures Act." The Court stated that its standard when reviewing was to determine whether the NRC "has considered the relevant factors and articulated a rational connection between the facts found and the choices made."

Further, the Court instructed those conducting review to remember that "…a reviewing court must remember that the NRC is making predictions, within its area of expertise, at the frontiers of science. When examining this kind of scientific determination, as opposed to simple findings of fact, a reviewing court must generally be at its most deferential" (*Baltimore Gas* at 103, relying on *Industrial Union Department v. American Petroleum Institute*, 448 US 607) (1980). It is noted here that the development of this OEIS/EIS and its related research made extensive utilization of professional marine biologists, bioacousticians, environmental physiologists, sensory psychologists, and underwater acoustics experts. The following academic institutions and scientific organizations were involved in the production of this OEIS/EIS: Cornell University (Bioacoustics Research Program), Woods Hole Oceanographic Institution, University of California-Santa Cruz, Bodega Bay Marine Laboratory, University of Miami (Rosensteil School of Marine Sciences), University of Maryland (Department of Biology), Hubbs Seaworld Research Institute, University of Washington, University of Pennsylvania, University of Rochester, University of West Florida, Georgia Institute of Technology, Duke University, National Marine Mammal Laboratory, National Marine Fisheries Service, University of Hawaii, Marine Mammal Commission, Office of Naval Research, and North Carolina State University (Department of Marine, Earth and Atmospheric Sciences).

For this OEIS/EIS, the Navy, as in the case cited above, estimated its potential for impacts conservatively, based upon the best available information and analysis; included an extended discussion of the uncertainties; used known data to extrapolate and identify impacts to calculate resulting consequences; and considered the relevant factors and articulated a rational connection between the facts found and the choices made. Moreover, the Navy also went beyond such extrapolation and calculation, supporting the design and preparation of original research reports. In addition the Navy proposes a Long Term Monitoring Program that will continue to address many of the data gaps. The data produced by this original research has contributed, and will contribute considerably to the body of knowledge in the area of LF sound and the marine environment. In fact, there will be opportunities for collaboration among the Navy and researchers from other government, academic, and private laboratories and industries.

After having given exhaustive consideration to the state of the research, consulted with experts in the field, and conducted original studies, the Navy has satisfied NEPA requirements regarding incomplete and/or unavailable information. The Navy has made every effort to supply information where it was lacking in the literature. Although there are, and may always be, data gaps, courts have ruled that proceeding with a proposed action under such circumstances is acceptable and perhaps even unavoidable.

For instance, the D.C. Circuit, in *Scientists Institute for Public Information Inc. v. Atomic Energy Commission*, 481 F. 2d 1079, stated that "NEPA's requirement that the agency describe the anticipated environmental effects of a proposed action is subject to a rule of reason. The agency need not foresee the unforeseeable, but by the same token, neither can it avoid drafting an impact statement simply because describing the environmental effects of the alternatives to a particular agency action involves some degree of forecasting."

Perhaps, however, the most definitive statement for proceeding with the proposed action comes from the 9th Circuit (in *Jicarilla Apache Tribe of Indians v. Morton*, 471 F. 2d 1275) in the context of what NEPA requires insofar as analyzing all possible scientifically based environmental effects:

> "If we were to impose a requirement that an impact statement can never be prepared until all relevant environmental effects were known, it is doubtful that any project could ever be initiated."

2 DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

This chapter provides a description of SURTASS LFA sonar technology and the alternatives being considered for its employment, including the No Action Alternative. The proposed action is Navy employment of up to four SURTASS LFA sonar systems. This chapter provides a description of the preferred alternative and alternatives to it, including the No Action Alternative and unrestricted operation in the active mode.

2.1 SURTASS LFA Sonar Technology

SURTASS LFA sonar is a long-range, all-weather sonar system that operates in the LF band (below 1,000 Hz) within the frequency range of 100 to 500 Hz, and is composed of both active and passive components (Figure 2-1, SURTASS LFA Sonar System).

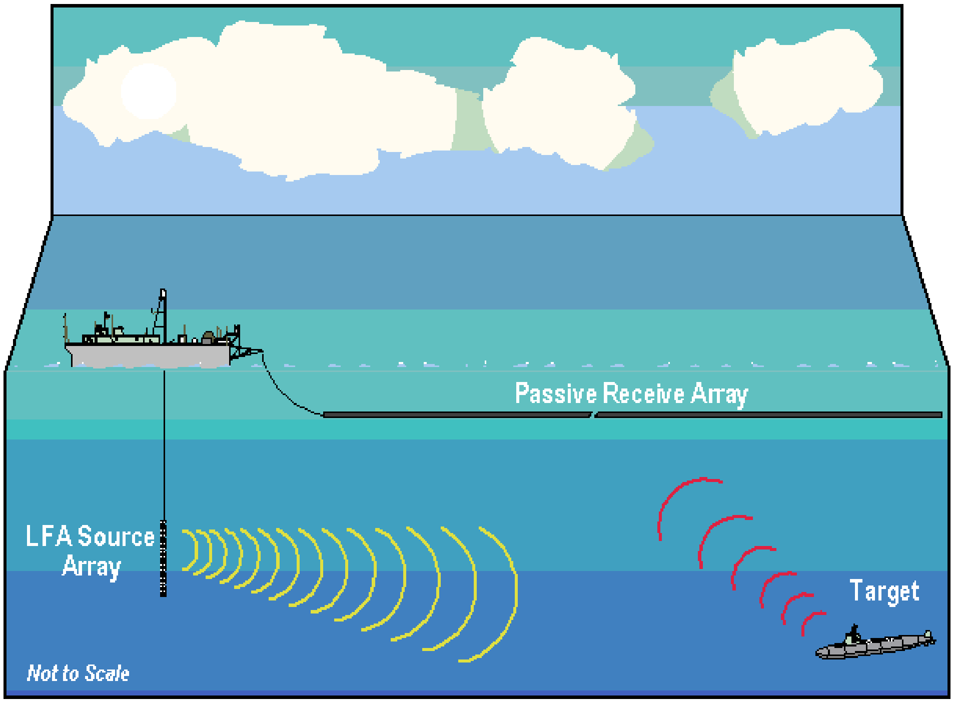


Figure 2-1. SURTASS LFA Sonar System

SONAR is an acronym for SOund NAvigation and Ranging, and its definition includes any system that uses underwater sound, or acoustics, for observations and communications. Sonar systems are used for many purposes, ranging from "fish finders" to military ASW systems for detection and classification of submarines. There are two broad types of sonar:

- Passive sonar detects the sound created by an object (source) in the water. This is a one-way transmission of sound waves traveling through the water from the source to the receiver and is basically the same as people hearing sounds that are created by another source and transmitted through the air to the ear.

- Active sonar detects objects by creating a sound pulse, or "ping," that is transmitted through the water and reflects off the target, returning in the form of an echo. This is a two-way transmission (source to reflector to receiver). Some marine mammals locate prey and navigate utilizing this form of echolocation.

2.1.1 Active System Component

The active component of the SURTASS LFA system, LFA, is an augmentation to the passive detection system, and is planned for use when passive system performance is inadequate. LFA is a set of acoustic transmitting source elements suspended by cable from underneath a ship (such as the Research Vessel [R/V] *Cory Chouest* shown in Photograph 2-1). These elements, called projectors, are devices that produce the active sound pulse, or ping. (The projectors are shown above deck on the R/V *Cory Chouest* in Photograph 2-2.)

Photograph 2-1. R/V *Cory Chouest*

Photograph 2-2. SURTASS LFA Projectors

The projectors transform electrical energy to mechanical energy that set up vibrations or pressure disturbances within the water to produce a ping. This is analogous to a stereo speaker or the earpiece in a telephone handset. The characteristics and operating features of the active component (LFA) are:

- The source is a vertical line array (VLA) of up to 18 source projectors suspended below the vessel. LFA's transmitted beam is omnidirectional (360 degrees) in the horizontal (nominal depth of the center of the array is 122 m [400 ft]), with a narrow vertical beamwidth that can be steered above or below the horizontal.

- The source frequency is between 100 and 500 Hz (the LFA system's physical design does not allow for transmissions below 100 Hz). A variety of signal types can be used, including continuous wave (CW) and frequency-modulated (FM) signals. Signal bandwidth is approximately 30 Hz.

- The source level (SL) of an individual source projector of the SURTASS LFA sonar array is approximately 215 dB. The sound field of the array can never be higher than the SL of an individual source projector.

- The typical LFA signal is not a constant tone, but rather a transmission of various waveforms that vary in frequency and duration. A complete sequence of sound transmissions is referred to as a "ping" and lasts between 6 and 100 seconds although the duration of each continuous frequency sound transmission is never longer than 10 seconds. Figure 2-2 (Comparison of Humpback Whale and SURTASS LFA Sonar Signals) compares an LFA signal with that of a humpback whale. The former is a typical humpback whale song that can be heard in their low-latitude breeding grounds (i.e., Hawaiian Islands). The latter is an LFA sonar-generated FM sweep. This illustrates that both signals are within the same frequency band and have similar ping durations (e.g., humpbacks 12-25 seconds and SURTASS LFA sonar 22 seconds). However, individual sound transmissions are dissimilar (e.g., humpbacks 1-2 seconds long and SURTASS LFA sonar 8 seconds long) and bandwidths are different (e.g., humpbacks 150-250 Hz and SURTASS LFA sonar approximately 30 Hz).

- Average duty cycle (ratio of sound "on" time to total time) is less than 20 percent (20 percent is the maximum physical limit of the LFA system). The typical duty cycle is between 10 and 20 percent.

- The time between pings is typically from 6 to 15 minutes.

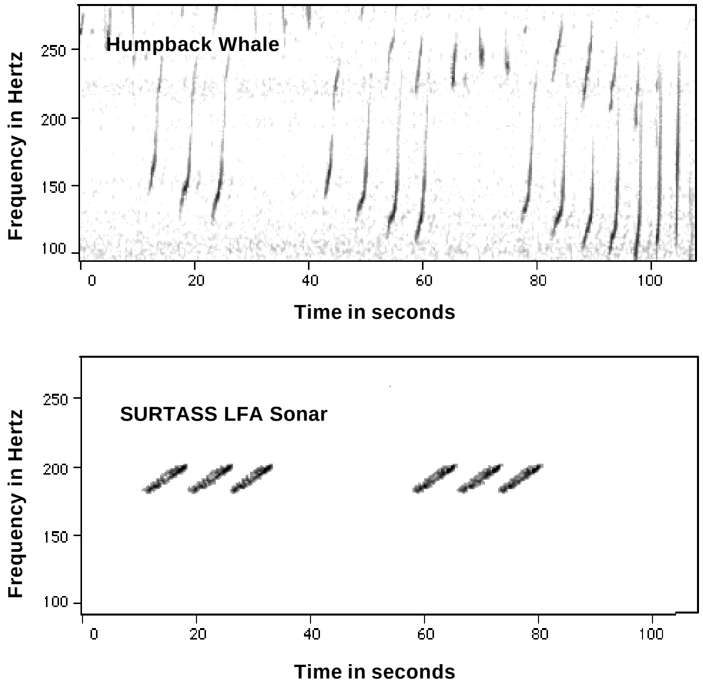


Figure 2-2. Comparison of Humpback Whale and SURTASS LFA Sonar Signatures

Frequency

Sound travels through water as a wave of pressure disturbances propagating through the medium (water). Compressing and relaxing the medium creates pressure disturbances. These disturbances are measured by their number within a given period of time. Frequency, therefore, is defined as the rate of disturbance or vibration, measured in cycles per second. Cycles per second are routinely referred to as the unit of measure of Hertz (Hz). 1000 Hz is usually referred to as 1 kilohertz (kHz). For the purposes of this report, frequency will be characterized in general terms as low, mid, or high. The Navy categorizes these as follows:

Low frequency (LF) sound is below 1000 Hz. Typical underwater LF sounds are the noise made by large ships as well as the vocalizations of a variety of marine animals (see Tables 3.2-3 through 3.2-6). To the human ear in air, 262 Hz sounds like middle C on the music scale (Richardson et al., 1995b). SURTASS LFA sonar transmits sound into the ocean between 100 and 500 Hz.

Mid frequency (MF) sound is 1,000-10,000 Hz. Underwater MF sounds are typically created by marine mammals (primarily odontocetes), precipitation, and ASW tactical sonar.

High frequency (HF) sound is above 10,000 Hz. Underwater HF sounds include those produced by snapping shrimp, echolocation of marine mammals, fish-finder sonars, ship echo sounders (depth finders), and side-scan sonars.

Sonar Performance Parameters

In order to understand the operation of SURTASS LFA sonar, certain operational parameters need to be defined:

Sound Intensity: Sound measurements can be expressed in two forms: *intensity* and *pressure*. The intensity of the sound is the average rate of energy transmitted through a unit area in a specified direction, expressed in watts per square meter (W/m^2). Acoustic intensity is rarely measured directly. Instead, when acousticians refer to intensities or powers, they derive it from ratios of *pressures*. To present sound measurements as ratios of pressures that can be compared to one another, a standard reference pressure needs to be used in the denominator of the ratio. The American National Standard and the international (metric) standard is to use 1 microPascal (µPa) as the reference pressure for underwater sound and 20 µPa as the reference pressure for airborne sound. Once a reference pressure is chosen, a means of relating different pressure ratios to each other is needed. Since our ears respond logarithmically when judging the relative loudness of two sounds, acousticians adopted a logarithmic scale for sound intensities and denoted the scale in decibels (dB). All decibel measurements state the ratio between a measured pressure value and a reference pressure value. The logarithmic nature of the scale means that each 10 dB increase is a ten-fold increase in power; e.g., 20 dB is a 100-fold increase, 30 dB is a 1,000-fold increase. Humans perceive a 10 dB increase in noise as a doubling of sound level, or a 10 dB decrease in noise as a halving of sound level. The phrase "sound pressure level" implies a decibel measure and that a reference pressure has been used as the denominator of the ratio. Comparing decibel values for various noise sources must be done carefully, since those values do not always represent equivalent information. For example, *spectral* values represent the power levels within one-Hertz "slices" whereas *broadband* levels are the total power over a specified bandwidth or portion of the spectrum emitted by a sound source.

Duty Cycle: Duty cycle is the ratio of the time the sound is being transmitted over the single ping cycle, measured in percentage. Ping cycle is equal to the ping duration followed by the period of no active transmissions. In other words, it is the percentage of time that the sound transmitter is on.

Source Level: Source level (SL) is a term for describing the level of the sound produced at the source itself. The standard distance for making this assessment is 1 meter from the source. The term for a source level measurement therefore includes the additional descriptor of the range at which the loudness level was measured. The dB units for SL are therefore given as dB re 1 µPa at 1 m (root mean squared [rms]).

Propagation Loss/Transmission Loss: As the pressure wave, or sound, travels through the water, the associated wavefront diminishes due to the spreading of the sound over an increasingly larger volume and the absorption of some of the energy by seawater. These losses are called propagation or transmission losses (TL). Because TL is based on a ratio of sound level at one location to sound level at another location, it is a pure number and has no units. In the decibel regime, TL is simply described as the dB difference between two points, no reference is necessary.

Received Level: The received level (RL) is simply the level of sound that arrives at the receiver, or listening device (hydrophone). Put simply, the received level is the source level minus the transmission losses, or:

$$RL = SL - TL$$

Because RL is a sound pressure level, its dB units are given in dB re 1µPa (rms).

Reference Pressure for Underwater Sound

All references to underwater sound pressure level in this OEIS/EIS are broadband-level values given in decibels (dBs), and are assumed to be standardized at 1 microPascal at 1m (dB re 1µPa at 1 m [rms]) for source levels (SL) and dB re 1 µPa rms (root mean squared) for received levels (RL), unless otherwise stated.

2.1.2 Passive System Component

The passive, or listening, part of the system is SURTASS. SURTASS detects returning echoes from submerged objects, such as threat submarines, through the use of hydrophones. These devices transform mechanical energy (received acoustic sound wave) to an electrical signal that can be analyzed by the processing system of the sonar. They are analogous to a microphone or the mouthpiece of a telephone handset. The SURTASS hydrophones are mounted on a receive array that is towed behind the ship (Figure 2-1). The SURTASS LFA sonar ship must maintain a minimum speed of 5.6 kilometers per hour (kph) (3 knots [kt]) through the water in order to tow the hydrophone array. The return signals, which are usually below background or ambient noise level, are then processed and evaluated to identify and classify potential underwater threats.

Ambient Noise

Ambient noise is the typical or persistent environmental background noise that is present in the oceans. Ambient noise ranges in frequency from 1 Hz to 100 kHz and is created by a variety of human-made and natural sources, including shipping, wind-generated surface agitation, precipitation, ice, biologics, etc. The level, or loudness, of ambient noise varies with location and season. Ambient noise values are typically given in energy or spectral units (sound power level per unit bandwidth).

2.2 SURTASS LFA Sonar Deployment

Because of uncertainties in the world's political climate, a detailed account of future operating locations and conditions cannot be delineated. However, a nominal annual deployment schedule and operational concept have been developed, using a prudent approach (i.e., higher operational tempo than would nominally be expected) to represent Navy use of the SURTASS LFA sonar. SURTASS LFA sonar operations, including testing of new systems as they come on line, would not be concentrated in specific sites, but would take place within the operational area defined in Chapter 1 (Figure 1-1 [SURTASS LFA Sonar Potential Areas of Operations]). Polar regions are excluded because of the inherent inclement weather conditions, including the danger of icebergs. As shown in Table 2-1, a SURTASS LFA sonar deployment schedule for a single vessel could involve up to 270 days per year at sea (underway). A nominal at-sea mission would occur over a

Table 2-1

Nominal SURTASS LFA Sonar Annual and 30-Day Deployment Schedule

I. Nominal Annual Deployment

30 Days			5 Days	30 Days			5 Days	30 Days			5 Days	30 Days			5 Days	30 Days		
T	Mission Active Operations	T	In-Port Upkeep*	T	Mission Active Operations	T	In-Port Upkeep*	T	Mission Passive Operations*	T	In-Port Upkeep*	T	Mission Active Operations	T	In-Port Upkeep*	T	Mission Active Operations	T

45 Days	30 Days			5 Days	30 Days			5 Days	30 Days			5 Days	30 Days			15 Days
Regular Overhaul*	T	Mission Active Operations	T	In-Port Upkeep*	T	Mission Passive Operations*	T	In-Port Upkeep*	T	Mission Active Operations	T	In-Port Upkeep*	T	Mission Passive Operations*	T	Leave and Upkeep*

Notes: "T" denotes transit periods when there would be no active transmissions; and * denotes that there would be no active transmissions (for operations in SURTASS LFA geographically-restricted areas).

II. Nominal 30-Day Mission

5 Days	9 Days	2 Days	9 Days	5 Days
Transit	Exercise (36 hours active sonar transmissions)	Reposition	Exercise (36 hours active sonar transmissions)	Transit

III. Nominal Annual Summary

Underway on Mission	Days	Not Underway	Days
Transit	90	In-Port Upkeep	50
Active Operations (432 hours transmissions based on a 20% duty cycle)	108	Regular Overhaul	45
Passive Operations	54	Total Not-Underway	95
Reposition	18		
Total Underway	270		
Total Underway/Not Underway			365

30-day period, with two nine-day exercise segments. Sonar operations could be conducted up to 20 hours during an exercise day. Based on a 20 percent maximum duty cycle, the system would actually be transmitting for only a maximum of four hours per day (resulting in 72 hours per mission and 432 hours per year of active transmission time for each SURTASS LFA sonar system in operation). The SURTASS LFA sonar vessel would operate independently of, or in conjunction with, other Naval air, surface or submarine assets. The vessel would generally travel in straight lines or racetrack patterns depending on the operational scenario.

The remaining 12 days of the at-sea mission would be spent in transit or repositioning the vessel. In a nominal year there could be a maximum of nine missions, six of which would involve the employment of SURTASS LFA sonar in the active mode and three of which would employ only the SURTASS in the passive mode. Between missions, an estimated 95 days would be spent in port for upkeep and repair in order to maintain both the material condition of the vessel and its systems and the morale of the crew.

At present, the R/V *Cory Chouest* is the only vessel equipped with SURTASS LFA sonar. The Navy used this system in the testing program described in Chapter 1. It is intended to operate in the Pacific Ocean, but may operate in other parts of the world. The additional SURTASS LFA sonar systems would be installed onboard other ocean surveillance vessels (the second system is expected to be available in Fiscal Year [FY] 2001). These operational systems would be assigned to Fleet commands, and they would be primarily employed in that Naval command's oceanic area of responsibility.

2.3 Alternatives

This subchapter provides a description of the proposed action and alternatives for the employment of SURTASS LFA sonar as shown in Table 2-2. These include the No Action Alternative, Alternative 1 (employment with geographic restrictions and monitoring mitigation), and Alternative 2 (unrestricted operation). Alternative 1 is the Navy's preferred alternative.

NEPA requires federal agencies to prepare an EIS that discusses the environmental effects of a reasonable range of alternatives (including the No Action Alternative). Reasonable alternatives are those that will accomplish the purpose and meet the need of the proposed action, and those that are practical and feasible from a technical and economic standpoint. However, the lead agency is not required to engage in speculation or contemplation about possible future plans that could influence the EIS's analysis of potential direct and indirect effects at some nebulous point in the future. Other alternatives examined but eliminated from further study are discussed in Subchapters 1.2 and 2.3.4.

Table 2-2

SURTASS LFA Sonar Employment Alternative Matrix

Proposed Restrictions/Monitoring	No Action Alternative	Alternative 1 (Preferred)	Alternative 2
Geographic Restrictions	No SURTASS LFA sonar employment	• SURTASS LFA sonar transmitted sound field levels would be below 180 dB within 22 km (12 nm) of the coastline, nor in offshore biologically important areas during biologically important seasons. • SURTASS LFA sonar transmitted sound field levels would not exceed 145 dB at known recreational or commercial dive sites. • Sound Pressure Level (SPL) Modeling.	None
Monitor to Prevent Injury	No SURTASS LFA sonar employment	• Visual Monitoring (bridge watch, daylight only). • Passive Acoustic Monitoring. • Active Acoustic (HF) Monitoring. • Reporting.	None
Note: Decibel (dB) levels are received levels (RL) referenced to 1 µPa (rms).			

2.3.1 No Action Alternative

Under this alternative, operational deployment of SURTASS LFA sonar would not occur. As discussed in Chapter 1 (Purpose and Need), the reduction in radiated noise from nuclear and diesel-electric submarines has reduced the effectiveness of existing passive ASW detection methods. As also discussed in Chapter 1, non-acoustic detection technologies (such as radar, laser, magnetic, infrared, electronic, electric, hydrodynamic, and biological) and high- or mid-frequency sonar cannot provide Naval forces with reliable long-range detection and, thus, do not provide adequate reaction time to counter potential threats.

Under the No Action Alternative, which would foreclose employment of LFA sonar technology, the U.S. Navy's ability to locate and defend against enemy submarines would be greatly impaired. The lack of a long-range submarine detection capability would make it possible for potentially hostile submarines to clandestinely place themselves into position to threaten U.S. Fleet units and land-based targets. Without this long-range surveillance capability, the reaction times to submarines would be greatly reduced and the effectiveness of close-in, tactical systems to neutralize threats would be seriously, if not fatally, compromised.

As discussed in Chapter 1, the purpose of the proposed action is to improve U.S. detection of quieter and harder-to-find submarines at long range. The No Action alternative would not fulfill this purpose.

2.3.2 Alternative 1 (The Preferred Alternative)

Alternative 1 is the Navy's preferred alternative. This alternative proposes the employment of SURTASS LFA sonar technology with certain geographical restrictions and monitoring mitigation to reduce adverse effects on the marine environment (Table 2-2). As discussed in Subchapters 1.2 and 2.3.4, the SURTASS LFA sonar is the only available technology capable of satisfying the purpose of the proposed action—to provide U.S. Naval forces with reliable long-range detection of the new generation of quieter and harder-to-find submarines. 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. The modernization of the world's submarine forces means that America's sea lines of supply are increasingly susceptible to reprisals during regional conflicts. In the more unlikely case of global conflict, these maritime supply routes would be even more prone to attack. Thus, a critical cornerstone of the Navy's mission to defend the United States is maintaining the antisubmarine warfare (ASW) capability of its Fleet. This global ASW capability will continue to be a requirement for the U.S. Navy far into the foreseeable future. Critical to accomplishing this mission is detecting increasingly stealthy enemy submarines.

Unlike Alternative 2 (unrestricted operation), Alternative 1 proposes to apply geographic restrictions and monitoring mitigation. These would reduce the potential for adverse impacts on the marine environment and would provide information to improve the environmental performance of the project in the future.

From an ASW capability standpoint, the operation of the SURTASS LFA sonar proposed in Alternative 1 would provide less extensive submarine detection capability than SURTASS LFA sonar operations under Alternative 2. From a budget standpoint, the monitoring mitigation requirements proposed in Alternative 1 would impose operational costs beyond those in Alternative 2. The reduction in detection coverage and the increase in operational costs, however, are offset by the significant environmental advantages of Alternative 1. Moreover, the operation of SURTASS LFA sonar under the restrictions and requirements proposed in Alternative 1 would still permit the Navy to reasonably fulfill its purpose of providing U.S. forces with reliable, effective, and efficient long-range detection of new-generation submarines.

2.3.2.1 Geographic Restrictions

The Navy would implement geographic restrictions limiting the ocean areas in which the SURTASS LFA sonar would be deployed under Alternative 1. These restrictions would ensure that the sound field:

- Is below 180 dB within 22 km (12 nm) of any coastline and in the offshore biologically important areas that exist outside the 22-km (12-nm) zone during the biologically important season for that particular area (see discussion below). 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. The volume encompassing the 180-dB sound field is designated as the LFA mitigation zone (see Subchapter 2.3.2.2 below). A discussion of the rationale for this restriction is included in Subchapters 4.1 and 4.2, and Technical Report 1.

- Does not exceed 145 dB in the vicinity of known recreational and commercial dive sites. Sites frequented by recreational divers are generally defined as from the shoreline out to the 40-meter (m) (130-feet [ft]) depth contour. A discussion of the rationale for this restriction is included in Subchapter 4.3 and Technical Report 3.

Offshore Biologically Important Areas

Offshore biologically important areas (OBIAs) are defined as those areas of the world's oceans outside of 22 km (12 nm) of a coastline where marine animals of concern (those animals listed under the Endangered Species Act and/or marine mammals) congregate in high densities to carry out biologically important activities. Biologically important areas include:

- Migration corridors;
- Breeding and calving grounds; and
- Feeding grounds.

Figure 2-3 (Offshore Biologically Important Areas) depicts both the intended operational areas for SURTASS LFA sonar (non-crosshatched) and three offshore biologically important areas distinguished by the activities and concentration of marine animals. These have been identified and developed by the Navy and NMFS, with marine biologists that were principal investigators on the Low Frequency Sound Scientific Research Program and/or were members of the SURTASS LFA Scientific Working Group. In addition, inputs from the public during review of the Draft OEIS/EIS were factored into the decision-making process. Details on these offshore biologically important areas are provided in Table 2-3.

The list of OBIAs may be expanded by the Navy in coordination with NMFS. Additional OBIAs may also be proposed and reviewed during the Long Term Monitoring Program (Subchapter 2.4). A process will be instituted through NMFS where an organization/individual can nominate extremely sensitive areas, which are outside of 22 km (12 nm) of the coast, as candidate OBIAs. The nominating organization/individual will be responsible for providing sufficient information to NMFS on the candidate OBIA to allow for a decision by NMFS and the Navy.

Table 2-3

Offshore Biologically Important Areas

Area Number*	Name of Area	Location of Area	Months of Importance	Species
1	200 m isobath of North American East Coast	From 28°N to 50°N west of 40°W	Year Round	northern right whale sei whale humpback whale northern bottlenose whale
2	Costa Rica Dome	Centered at 9°N and 88°W (Longhurst, 1998)	Year Round; no resident stock (Chandler et al., 1999)	blue whale (Chandler et al., 1999) olive ridley sea turtle (Eckert, pers. comm., 2000)
3	Antarctic Convergence Zone	30°E to 80°E: 45°S. 80°E to 150°E: 55°S 150°E to 50°W: 60°S 50°W to 30°E: 50°S (IUCN, 1995)	October through March (IUCN, 1995)	blue whale fin whale sei whale minke whale humpback whale sperm whale killer whale southern bottlenose whale Arnoux's beaked whale Gray's beaked whale strap-toothed beaked wh. Commerson's dolphin Peale's dolphin hourglass dolphin dusky dolphin (IUCN, 1995)
* See Figure 2-3.				

Known Recreational/Commercial Dive Sites

Recreational dive sites are generally defined as sites from the shoreline out to the 40-m (130-ft) depth contour that are frequented by recreational divers, but it is recognized that there are other sites that may be outside of this boundary. SURTASS LFA sonar would transmit such that the received level in known recreational and commercial dive sites would not exceed 145 dB. The rationale for this threshold is provided in Technical Report 3.

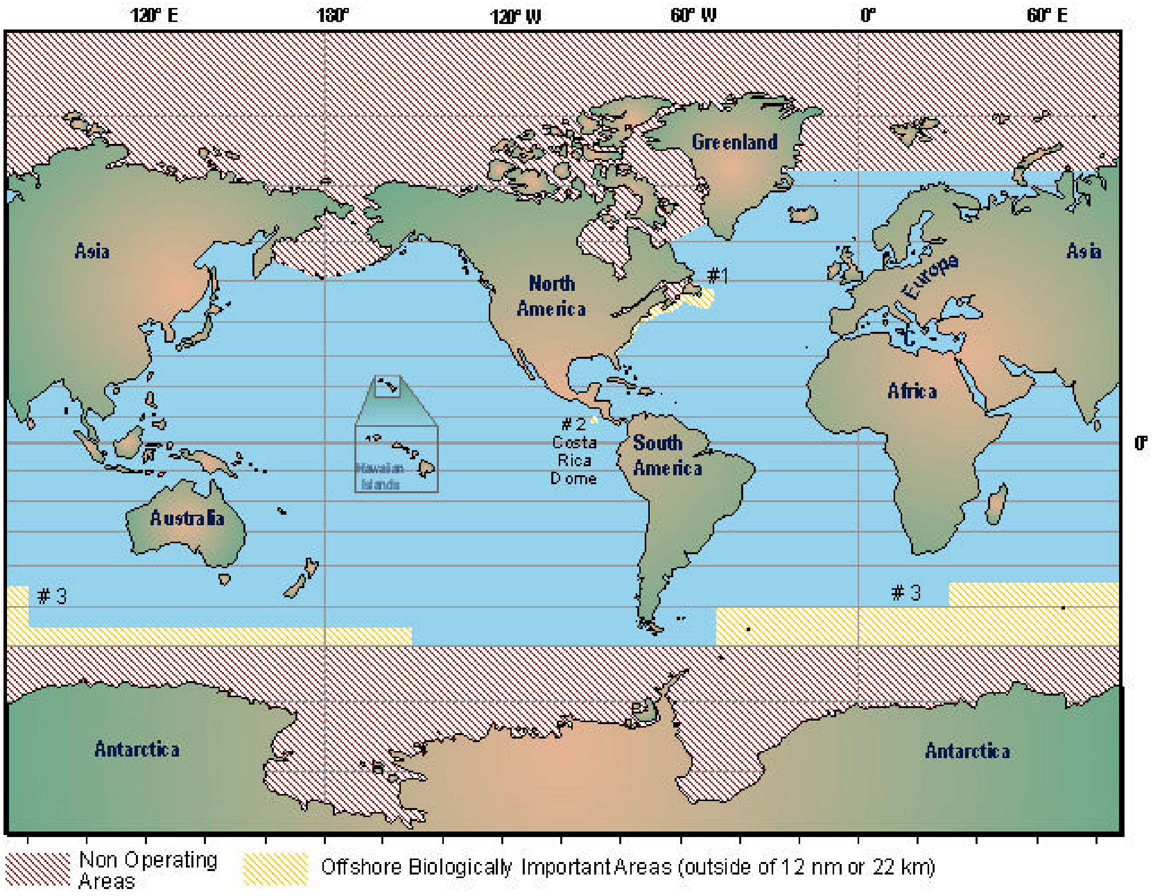


Figure 2-3. Offshore Biologically Important Areas

Sound Pressure Level Modeling

Under Alternative 1, operators of SURTASS LFA sonar would estimate SPLs prior to and during transmission. This SPL modeling would account for the factors affecting the transmission of sound in the ocean. It would be performed by measuring and entering near-real-time environmental inputs (such as sound speed profile [SSP], sea state, water depth, etc.) along with SURTASS LFA sonar operational characteristics into Navy standard acoustic performance prediction models that would then calculate the received levels (RLs) at various ranges and depths. (These models are an integral part of the SURTASS LFA sonar processing system and are discussed in Chapter 4.) This modeling would provide the information necessary for the operator to modify operations, including delay or suspension of transmissions, in order not to exceed the RL criteria for the geographically restricted areas (as previously summarized in Table 2-2).

Acoustic Prediction Models

The U.S. Navy's use of acoustic modeling has been refined since its advent in the 1950s and continues to be employed as part of normal day-to-day ASW operations onboard U.S. Naval ships. This is accomplished by highly trained sonar technicians, who use a variety of measures as input to determine propagation (transmission) loss as part of standard ASW protocols. As a result of broad experience, constantly improving techniques, and the routine nature of ASW training operations, the U.S. Navy is well qualified at determining the underwater propagation of low frequency sound. The Navy's acoustic prediction models are standardized and maintained through the Oceanographic and Atmospheric Master Library (OAML), under the aegis of the Naval Meteorology and Oceanography Command. This will help determine the efficacy of the Navy's acoustic models used for SURTASS LFA sonar operations.

2.3.2.2 Monitoring to Prevent Injury

Implementation of Alternative 1 would also provide for monitoring during operations of the SURTASS LFA sonar to prevent injury to marine mammals (and possibly sea turtles) by making every effort to detect animals within the LFA mitigation zone (180-dB SURTASS LFA sonar source sound field) before and during transmissions. Alternative 1 would also ensure that divers are not within the 145-dB sound field during LF transmissions.

LFA Mitigation Zone

The LFA mitigation zone covers a volume ensonified to a level ≥ 180 dB by the SURTASS LFA sonar transmit array. Under normal operating conditions, this zone will vary between the nominal ranges of 0.75 to 1.0 km (0.40 to 0.54 nm) from the source array ranging over a depth of approximately 87 to 157 m (285 to 515 ft). (The center of the array is at a nominal depth of 122 m [400 ft]). Under rare conditions (e.g., strong acoustic duct) this range could be somewhat greater than 1 km (0.54 nm). Knowledge of local environmental conditions (such as sound speed profiles [depth vs. temperature] and sea state) that affect sound propagation is critical to the successful operation of SURTASS LFA sonar and is monitored on a near-real-time basis. Therefore, the SURTASS LFA sonar operators would have foreknowledge of such anomalous acoustic conditions and would mitigate to the LFA mitigation zone even when this was beyond 1 km (0.54 nm).

The use of the following three monitoring techniques are proposed:

- Visual monitoring for marine mammals and sea turtles from the SURTASS LFA sonar vessel during daylight hours;
- Use of the passive (low frequency) SURTASS array to listen for sounds generated by marine mammals as an indicator of their presence; and

- Use of high frequency (HF) active sonar to detect/locate/track potentially affected marine mammals (and possibly sea turtles) near the SURTASS LFA sonar vessel and the sound field produced by the SURTASS LFA sonar source array.

Visual Monitoring

Visual monitoring would include daytime observations from the SURTASS LFA sonar vessel for potentially affected species. This monitoring would begin 30 minutes before sunrise, for ongoing transmissions, or 30 minutes before SURTASS LFA sonar is deployed and continue until 30 minutes after sunset or until SURTASS LFA sonar is recovered. Personnel trained in detecting and identifying marine animals would make observations from the vessel. There are two potential visual monitoring scenarios:

- First, should a marine mammal or sea turtle be sighted near, but not within the 180-dB LFA mitigation zone, the following actions would be taken:
    - The observer would notify the Officer in Charge (OIC), who would then notify the operator of the High Frequency Marine Mammal Monitoring (HF/M3) sonar (described later in this section) to determine the range and projected track of the animal.
    - If it were predicted that the animal might pass within the LFA mitigation zone, the OIC would order the delay/suspension of transmissions when the animal entered this zone.
    - If the animal were visually observed within 2 km (1.1 nm) and 45 degrees either side of the bow, the observer would notify the OIC who would order the immediate delay/suspension of SURTASS LFA sonar transmissions.
    - The observer would continue visual monitoring/recording until the animal was no longer seen.
- Second, should a marine mammal or sea turtle be sighted inside the 180-dB LFA mitigation zone, the observer would notify the OIC who would order the immediate delay/suspension of SURTASS LFA sonar transmissions.

Transmissions could commence/resume 15 minutes after there was no further detection by the HF/M3 sonar and there was no further visual observation of the animal within the LFA mitigation zone.

When the SURTASS LFA sonar is deployed, all marine mammal and sea turtle sightings would be recorded and provided as part of the Long Term Monitoring Program (Subchapter 2.4).

Passive Acoustic Monitoring

Passive acoustic monitoring for LF sounds generated by marine mammals would be conducted when SURTASS is deployed. The following actions would be taken:

- If sounds are detected and estimated to be from a marine mammal, the technician would notify the OIC who would alert the HF/M3 sonar operator and visual observers.
- If a sound produced by a marine mammal is detected, the technician would attempt to locate the sound source using localization software.
- If it is determined that the animal would pass within the LFA mitigation zone (prior to or during transmissions), then the OIC would order the delay/suspension of transmissions when the animal was predicted to enter this zone.

The general characteristics of the SURTASS passive horizontal line array used for acoustic monitoring are:

- Array length: 1,500 m (4,920 ft);
- Operational depth: 152 m (500 ft) to 457 m (1,500 ft); and
- Frequency: 0 to 500 Hz.

All contacts would be recorded and provided as part of the Long Term Monitoring (LTM) Program (Subchapter 2.4).

High Frequency Active Acoustic Monitoring

The Navy would conduct high frequency (HF) active acoustic monitoring (through the use of an enhanced HF commercial-type sonar) to detect, locate, and track marine mammals (and possibly sea turtles) that could pass close enough to the SURTASS LFA sonar transmit array to exceed the 180-dB mitigation criterion. This HF Marine Mammal Monitoring (HF/M3) sonar operates with a similar power level, signal type and frequency as HF "fish finder" type sonars used worldwide by both commercial and recreational fishermen.

HF/M3 sonar acoustic monitoring would begin 30 minutes before the first SURTASS LFA sonar transmission of a given mission is scheduled to commence and continue until transmissions are terminated. The startup of the HF/M3 sonar would involve a ramp-up from a source level of 180 dB to ensure there is no inadvertent exposure of local animals to RLs $\geq$ 180 dB. If the operating area is found to be clear, the SL would be increased in 10-dB steps until full power (if required) is attained, at which time the operator would verify the probe pulse steering and surface clutter measurements (see below) and would adjust the HF/M3 sonar controls as necessary.

HF/M3 Sonar, LFA Mitigation Zone, and Sound Propagation

The extent of the LFA mitigation zone (i.e., within the 180-dB sound field) is based on onboard acoustic modeling and environmental data collected *in situ*. Factored into this calculation are SURTASS LFA sonar source physical parameters of tow speed, depth, vertical steering, signal waveform/wavetrain selection, and peak transmit source level (SL).

HF/M3 sonar operating parameters are based on a combination of *in situ* acoustic modeling and active acoustic probe pulse results. Probe pulses are low power (SL < 180 dB) HF signals whose echo characteristics help define the local ocean acoustic environment. They are used to determine the most effective vertical steering angle for the HF/M3 sonar. This entails a tradeoff between near-ocean surface tracking capability and ocean surface clutter reduction.

The HF/M3 sonar and its operating protocols were designed to minimize possible effects on marine animals. The operating procedures provide for the SL to be adjusted to ensure that RLs are below the levels that could potentially cause injury to marine mammals or sea turtles if they approached the HF/M3 sonar.

As shown in Figure 2-4 (HF/M3 Sonar Detection and LFA Mitigation Zones), the HF/M3 sonar is located near the top of the SURTASS LFA sonar vertical line array. The HF/M3 sonar computer terminal for data acquisition/processing/display would be located in the SURTASS Operations Center (SOC). The general characteristics of the HF/M3 sonar are:

- Frequency: 30 to 40 kHz;
- Bandwidth: variable (1.5 to 6 kHz nominal);
- Duty Cycle: 3-4 percent (nominal);
- Nominal Source Level: 220 dB re 1 microPascal at 1 m;
- Pulse Length: variable (10-40 msec nominal);
- Pulse Repetition Rate: set by maximum search range (3-4 sec nominal);
- Source Ramp-Up: five-minute period;
- Detection Volume: 4 equally spaced swept 8º (horizontal) x 10º (vertical) beams making up a 10º (vertical) sector sweep through full 360º (horizontal) around the source (i.e., omnidirectional in the horizontal, 10º vertical beamwidth); nominal time for full 360º sweep 45 to 60 seconds;
- Maximum Detection Range: nominally 2-2.5 km (1.08-1.35 nm).
- Operational Depth Capability: compatible with maximum deployed depth of SURTASS LFA sonar source array;
- Vertical Steering: ±10°; and
- Receiver Gain: 23 dB (nominal vs. omnidirectional noise).

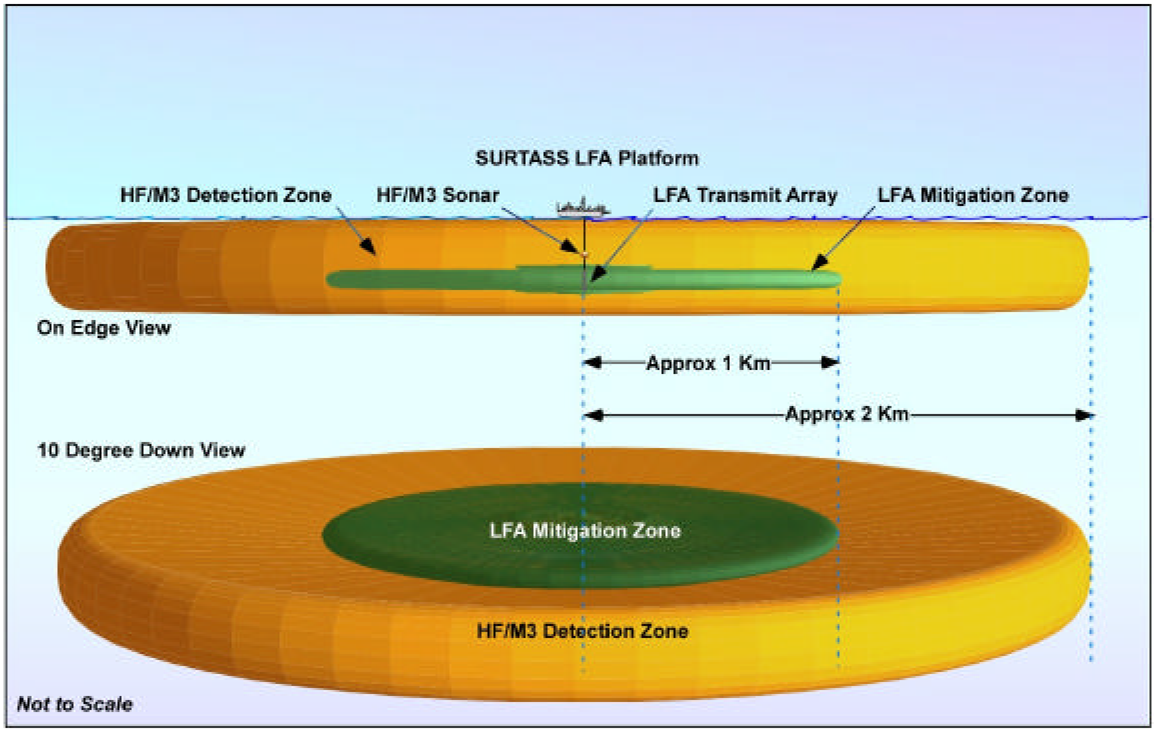


Figure 2-4. HF/M3 Sonar Detection and LFA Mitigation Zones

The HF/M3 sonar would operate continuously while the SURTASS LFA sonar is deployed. Its ping sequence, waveform/wavetrain choice, and PC control station display and signal processing setup are based on the sequence of start-up procedures described above. A remote display from the PC control station would be situated at the SOC Watch Supervisor console, which would be manned 24 hours a day during all SURTASS or SURTASS LFA sonar operations at sea.

Detection of a marine animal by the HF/M3 sonar automatically triggers an alert to the SOC Watch Supervisor, who has the HF/M3 tracking team immediately evaluate the detection. The criteria for evaluating such an alert are detection of a marine mammal or sea turtle whose: 1) projected movement indicates it will enter the LFA mitigation zone, or 2) presence is detected within the LFA mitigation zone. If either of these criteria are met, the Officer in Charge (OIC) would be notified, who then orders the immediate delay/suspension of SURTASS LFA sonar transmissions (if the animal is already in the zone) or does so when the animal enters the LFA mitigation zone, until the animal is determined to have moved beyond this zone. All contacts would be recorded and provided as part of the LTM Program (Subchapter 2.4).

Analysis and testing of the HF/M3 sonar operating capabilities indicates that this system substantially increases the probability of detecting marine mammals within the LFA mitigation zone, and provides an excellent monitoring capability (particularly for medium-large marine mammals) beyond the LFA mitigation zone, out to 2 to 2.5 km (1.08 to 1.35 nm).

HF/M3 Sonar Testing

Qualitative and quantitative assessments of the system's ability to detect marine mammals of various sizes have been verified in several sea trials (Table 2-4). In roughly 170 hours of at-sea testing with artificial targets, six whales have coincidentally been spotted on the surface after strong detections were made in the same general vicinity on the HF/M3 system. Approximately 75 other objects have been detected during testing, which were believed to be marine mammals.

Table 2-4
HF/M3 Sonar Testing

Date	Testing	Location
October 1998	Performance testing of single source/receiver.	NUWC, Seneca Lake, NY
April 1999	Performance testing using complete prototype.	Baja California
February 2000	Calibration of system.	NUWC, Seneca Lake, NY
April 2000	Integration with LFA array on R/V *Cory Chouest.* Engineering trials following installation.	Hawaii
May 2000	Performance testing (HF/M3 sonar only) on R/V *Cory Chouest.*	Hawaii
August 2000	Performance testing with controlled bottlenose dolphins.	Southern California
October 2000	Marine mammal mitigation trials.	Adriatic Sea

For large animals swimming within 200 m (656 ft) of the surface, system performance is relatively insensitive to animal dive patterns and numerous detections are likely before the animal enters the LFA mitigation zone. Single-ping false alarm rates can be held to approximately 1 per 10,000 pings under these scenarios. The ability to track animals via multiple detections virtually eliminates randomly distributed false alarms. The most challenging scenarios are those aimed at detecting small, solitary, fast-diving animals (i.e., moving vertically through the HF/M3 detection zone) in environments with high-clutter characteristics (e.g., shallow waters, downward refracting water column, high sea states).

A dedicated experiment designed to verify the system's detection ability using bottlenose dolphins was conducted off the coast of San Diego in August 2000. This proved to be one of the most challenging possible scenarios, as the tests were conducted with small odontocetes diving vertically through the LFA mitigation zone, in shallow (300 m [984 ft]), downward sound-refracting waters that produced a significantly more acoustically cluttered environment than would be expected under normal SURTASS LFA sonar operating conditions. Trained bottlenose dolphins were commanded to dive one at a time to moored objects 130 to 200 m (426 to 656 ft) below the surface and return, with the HF/M3 system positioned 400 to 1,000 m (1,312 to 3,280 ft) away.

Eleven out of a total of twenty dolphins were detected by the HF/M3 sonar. Given these results, the following factors must be considered for these tests:

- Tests were conducted in a shallow-water, downward sound-refracting environment.
- The bottlenose dolphins had a low target strength (-13 dB).
- The dolphins dove and surfaced vertically through the ensonified region, therefore, they were within the HF/M3 detection envelope for a very short time.
- Environmental conditions during these tests reduced probabilities of detection significantly in comparison to deep-water scenarios (normal SURTASS LFA sonar operations), where system settings (primarily transmitted waveform parameters and projector tilt) can be optimized.
- HF/M3 search zones will typically be at deeper depths than those focused on during these tests, also serving to increase probabilities of detection via advantageous thresholding adjustments to lower clutter fields.

It should be noted that even for this worst-case scenario, the detection rate was 55 percent. This is higher than the 50 percent value that was used in this OEIS/EIS for "active acoustic monitoring" in the calculation of an overall effectiveness estimate for monitoring mitigation (Subchapter 4.2.7.1).

Summary of Statistical Performance

The probability of detecting an animal in the vicinity of the SURTASS LFA sonar depends on several factors, including the single-ping probability of detection, animal behavior, and the HF/M3 sonar scan rate. The single-ping probability of detection used here is defined as the probability of detecting an animal present within the HF/M3 sonar scan beam as a function of range using a single ping.

Figure 2-5 shows the single-ping probabilities of the HF/M3 sonar detecting various marine mammals as a function of range. These curves are based on: 1) the *in situ* measured interference (i.e., backscattering and false targets that cause target-like echoes on the sonar) observed during the August 2000 testing; 2) the *in situ* measured transmission loss (TL) from the August 2000 testing; and 3) the best available scientific data on marine mammal target strength (i.e., the expected ability of a marine mammal to “reflect” acoustic energy). Again, it should be noted that the August 2000 testing occurred in an extremely challenging underwater environment (i.e., shallow water, small and fast targets, high reverberation, and downward-refracting sound propagation), and that deep-water operations would be expected to have higher probabilities of detection for all species at all ranges.

The measured results of the August 2000 testing correspond well with the curves presented in Figure 2-5. For a nominal 800 m (875 yd) range (actual test ranges from the HF/M3 sonar to the dolphins were 366 to 914 m [400 to 1,000 yd]), a probability of detection of 55 percent was

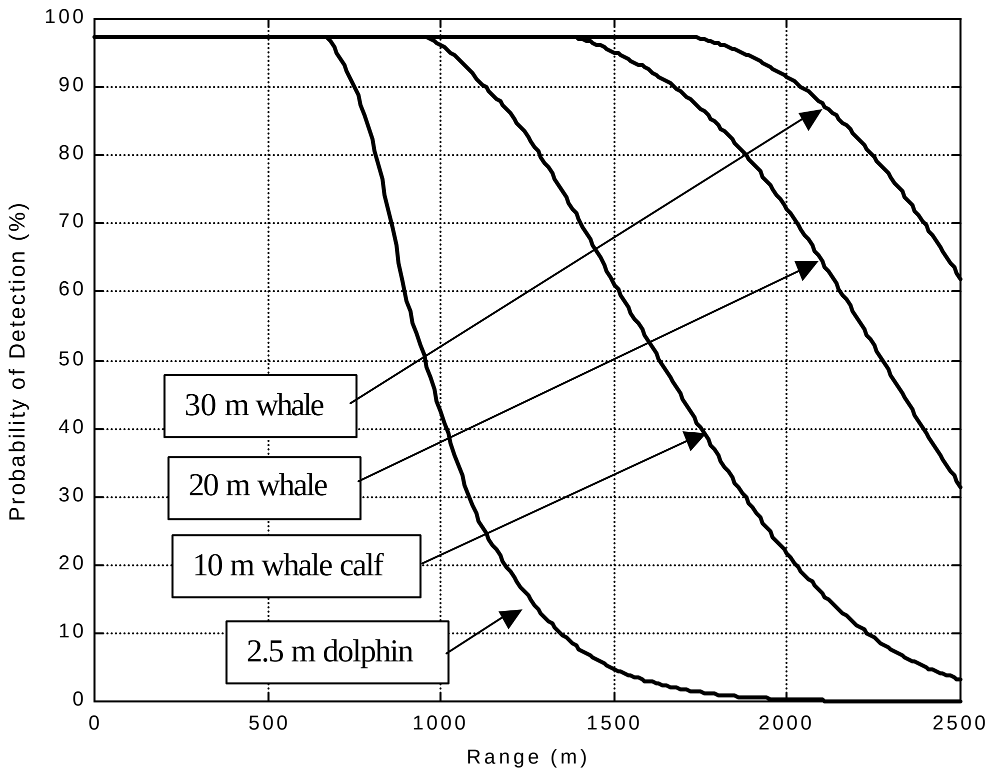


Figure 2-5 Probability of Detecting (on any given ping) Various Marine Mammals Swimming within the Search Beam of the HF/M3 Sonar System

observed. The 2.5 m dolphin curve of Figure 2-5 shows a probability of detection of 55 percent at 930 yd (850 m).

The single-ping probabilities of detection show one facet of the effectiveness of the HF/M3 sonar as a mitigation tool because, in general, any marine mammal that enters the HF/M3 detection zone can be expected to be ensonified multiple times—approximately once every 50 seconds. The number of potential detections depends on the course, speed and depth of the animal in relation to the HF/M3 sonar beam patterns. A realistic scenario that would present a short time period for the animal to be within the HF/M3 detection zone before it entered the LFA mitigation zone would be an animal forward of the SURTASS LFA ship moving toward it. This effectively combines the ship's and the animal's velocities. If the ship is traveling at 1.54 m/s (3 kt) and the animal swims toward the SURTASS LFA sonar at 2.6 m/s (5 kts), it will remain in the 1 to 2 km-radius (3,280 to 6,560 ft) annulus surrounding the HF/M3 sonar long enough to be ensonified approximately 5 times.

From Figure 2-5, it can be seen that for a 2.5 m dolphin, Pd_1 (at 1,000 m) = 43 percent. Using the formula $Pd_N = 1 - (1 - Pd_1)^N$ (DoN, 1998), where N = number of animal ensonifications and Pd_1 = the single-ping probability of detection, it can be seen that for 2 ensonifications, $Pd_2 = 1 - (.57)^2 = 1 - 0.32 = 68$ percent. For 4 ensonifications, probability of detection increases to 90 percent, and for 5 ensonifications, probability of detection approaches 100 percent.

Animal depth can also be addressed using similar probabilistic methodology as was employed to generate Figure 2-5. It is assumed that the LFA mitigation zone can be generally represented as a disk with its vertical dimension from approximately 80 m (262.5 ft) to 160 m (525 ft) depth, extending out to a radius of approximately 1 km (0.54 nm) (see Figure 2-4).

Probabilities of detection for a stationary whale of 20 m length (e.g., a humpback) at various depths and ranges within the LFA mitigation zone are estimated to be from 98 percent (animal at 1 km range and 160 m depth) to 72 percent (animal at 2 km [1.08 nm] range and 160 m depth). Outside of the LFA mitigation zone, probabilities of detection for the same whale are estimated to be from 95 percent (animal at 1.5 km [0.81 nm] range and 200 m [656 ft] depth) to 35 percent (animal at 500 m [1,640 ft] range and 40 m [131 ft] depth). Thus, an animal of this size approaching the LFA mitigation zone from any direction would have an extremely high likelihood of being detected before entering the zone.

The remote possibility exists that a deep and long-diving animal (e.g., sperm whale family, beaked whale family) could approach the LFA mitigation zone without being initially detected by the HF/M3 sonar. It could swim from deep depth upwards into the LFA mitigation zone between HF/M3 sonar beam scans. However, for this to happen, the animal would have to surface within 1 km (0.54 nm) of the SURTASS LFA vessel where it would readily be detected by the HF/M3 sonar and most likely visually detected (during daylight hours). For example, the probability of HF/M3 sonar detection of a 20 m whale within 1 km is greater than 95%. Additionally, using a nominal 15 percent duty cycle for the SURTASS LFA sonar, even if an animal were to avoid the HF/M3 sonar and enter the LFA mitigation zone in this manner, there would be only a 15 percent (i.e., 1 in 6) chance that SURTASS LFA sonar would be transmitting while the animal was in the zone, before it was detected.

2.3.2.3 Reporting

During the routine operations of the SURTASS LFA sonar system, the Navy would record technical and environmental data from visual and acoustic monitoring, ocean environmental measurements (SSP, ambient noise, etc.), and technical operational inputs. This information would be reported as part of the LTM Program discussed in Subchapter 2.4.

2.3.3 Alternative 2

Alternative 2 would involve the unrestricted operation of SURTASS LFA sonar in the active mode as described in Subchapters 2.1 and 2.2. Under this alternative, the Navy would deploy the system with no mitigation measures (e.g., no geographic restrictions or monitoring to prevent injury to marine mammals and sea turtles). In comparison to Alternative 1, Alternative 2 would provide Fleet operators with maximum operational flexibility, would provide maximum submarine detection capability, and would avoid the additional personnel and equipment costs associated with monitoring mitigation. Alternative 2 would be more cost-effective to implement and operate.

Alternative 2 is not the Navy's preferred alternative. Although Alternative 2 would provide more extensive submarine detection capabilities than Alternative 1, and although Alternative 2 would cost less to implement than Alternative 1, Alternative 2 would not be consistent with the CNO's commitment to the protection of the environment and good stewardship of the sea. It also would be inconsistent with the MMPA and ESA if the action would result in the taking of marine mammals and/or species listed as threatened or endangered and taking authority had not been obtained. This alternative is, however, analyzed in order to describe the full operating capability of SURTASS LFA sonar.

2.3.4 Alternatives That Do Not Fulfill the Purpose and Meet the Need

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.

Subchapters 1.2.1 and 1.2.2 discuss the Navy's evaluation and testing of 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.

Subchapter 1.2.2.3 is entitled Evaluation of Different LFA Sonar Configurations. This discusses the Navy's evaluation of 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. Subchapter 1.2.2.3 explains that 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 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.

2.4 Long Term Monitoring Program

The Navy has been instrumental in advancing scientific understanding of the potential effects of LF sound on the marine environment through its three-year Low Frequency Sound Scientific Research Program (LFS SRP), the Marine Mammal Biology Program (a major Office of Naval Research [ONR] initiative since 1993 under ONR Code 335), and the U.S. Navy Marine Mammal Program of the Space and Naval Warfare Systems Command (SPAWAR) Center, San Diego. The LFS SRP is discussed in more detail in Subchapter 4.2 and Technical Report 1.

Although findings from the LFS SRP have not revealed any significant changes to biologically important behaviors of marine mammals in response to SURTASS LFA sonar operations, the Navy and NMFS consider it prudent to continue monitoring of potential effects of the SURTASS LFA sonar. This monitoring would be essential toward providing data to support anticipated MMPA reporting requirements. Upon issuance of LOAs by NMFS under the MMPA, the Navy would provide a detailed Long Term Monitoring (LTM) Program plan that included details on the data collection, processing and reporting elements therein, and how this effort would be coordinated with other applicable NMFS projects. The LTM Program has been budgeted by the Navy at a level of $1M per year for five years, starting with the issuance of the first LOA. One-half of this funding will go to marine environmental research organizations outside of the Navy, to provide scientific and technical support in addressing the pertinent principal objectives of the LTM Program (first, third and fourth objectives), which are discussed below.

2.4.1 Objectives

The principal objectives of the LTM Program for the SURTASS LFA sonar system are to:

- Conduct Navy and independent scientific analyses of the effectiveness of proposed mitigation measures, make recommendations for improvements where applicable, and incorporate them as early as possible, with NMFS concurrence. This includes verification of the HF/M3 sonar performance (including probability of detection curves) by the end of the first full year of SURTASS LFA sonar operations.

- Provide the necessary input data for LOA reports to NMFS on assessment of whether any taking of marine mammal(s) occurred within the LFA mitigation zone (180-dB sound field) during SURTASS LFA sonar operations. This would entail tabular information that includes: date/time; vessel name; LOA area; marine mammals affected (number and type); assessment basis (observed injury, behavioral response, or model calculation); LFA mitigation zone radius; bearing from vessel; whether operations were delayed, suspended or terminated; and narrative.

- Study the potential effects of Navy SURTASS LFA sonar-generated underwater sound on long-term ecological processes relative to LF sound-sensitive marine mammals and sea turtles, focusing on the application of Navy technology for the detection, classification, localization, and tracking of these animals.

- Collaborate, as feasible, with pertinent Navy, academic, and industry laboratories and research organizations, and where applicable, with Allied navy and academic laboratories, on field research efforts to help fill scientific data gaps.

2.4.2 LTM Program Elements

The LTM Program is proposed to include the elements described below. The primary product from the proposed LTM Program would be annual reports submitted to NMFS (public record) that would include the following:

- Summary of the unclassified SURTASS LFA sonar operations during the past year;

- Summary of unclassified plans for the following year;

- Assessment of the efficacy of mitigation measures used during the past year, as well as the value-added from the various LTM elements, with recommendations for improvements (and NMFS concurrence where applicable);

- Synopsis of LOA reports to NMFS on estimates of percentages of marine mammal stocks affected by SURTASS LFA sonar operations. This information (and that from the subsequent report element below) would help confirm the validity of Chapter 4 conclusions, particularly pertaining to adequacy of scientific information; and

- Assessment of any long-term ecological processes that may be exhibiting effects from SURTASS LFA sonar operations, and reports or scientific papers on discernible or estimated cumulative impacts from such operations.

2.4.2.1 Expendable Bathythermograph (XBT) Data Collection

The Navy would collect XBT data from SURTASS LFA sonar vessels while underway as input to the Navy standard acoustic performance prediction model algorithms imbedded in the SURTASS LFA sonar signal processing equipment to determine SPLs. An XBT collects and portrays temperature versus depth data in the water column.

2.4.2.2 LF Ocean Ambient Noise Level Data Collection

Low frequency ocean ambient noise data collection would be carried out automatically in the various ocean basins in which SURTASS LFA sonar would be operated with Navy standard recorders onboard the vessel whenever the SURTASS passive towed array was deployed.

2.4.2.3 Sound Field Modeling

Prior to and during operations, the Navy would model SPLs (see Subchapter 2.3.2.1 and 5.1.3). This SPL modeling would account for the factors affecting the transmission of LFA-generated sound in the oceanic water mass. It would be performed by measuring and entering near real-time environmental inputs (such as sound speed profile based on the XBT data, sea state, water depth, bathymetry, etc.) along with the SURTASS LFA sonar operational characteristics, into the Navy standard acoustic performance prediction models. The models would then calculate the received sound field levels at various ranges and depths.

2.4.2.4 Monitoring

Three monitoring elements, as described for the preferred alternative, would be integral parts of the long-term scientific assessment of the potential effects of SURTASS LFA sonar in the immediate vicinity of the source ship. The data derived from performance of these monitoring elements would be incorporated into the annual report to NMFS as required by the LOAs. These monitoring elements include:

- **Visual monitoring** for marine mammals and sea turtles from the SURTASS LFA sonar vessel during daylight hours on all SURTASS LFA sonar missions;

- **Passive acoustic monitoring** as an indicator of the presence of marine mammals using the SURTASS passive towed array to detect generated sounds; and

- **HF/M3 sonar monitoring**, which would be used to detect marine mammals (and possibly sea turtles) that may pass close enough to the SURTASS LFA sonar's transmit array to potentially be injured, whenever the SURTASS LFA sonar is transmitting. This LTM element includes verification and validation of the HF/M3 sonar's performance envelope and that the effects of the HF/M3 sonar on marine mammals and sea turtles are negligible. In addition, the Navy would explore the possibility of augmenting the HF/M3 sonar with passive HF detection capability for collection of vocalization data from odontocetes (e.g., sperm whales) to broaden the passive data collection effort.

2.4.2.5 Incident Monitoring

This LTM program element comprises two parts: 1) recreational or commercial diver incident monitoring, and 2) marine mammal stranding incident monitoring. The Navy would maintain close coordination with the principal clearinghouses for information on diver-related incidents, namely the National Association of Underwater Instructors (NAUI), Professional Association of Diving Instructors (PADI) and Divers Alert Network (DAN). The Navy would also coordinate with the principal marine mammal stranding networks to correlate analysis of any whale strandings with SURTASS LFA sonar operations.

2.5 Additional Research

There are several opportunities for collaborative research:

- **U.S. Navy and Academic Laboratories -** Collaboration with other Navy oceanographic research laboratories (e.g., ONR, Naval Research Laboratory, Naval Postgraduate School) and CNO-designated U.S. academic establishments (e.g., Woods Hole Oceanographic Institution, Scripps Institution of Oceanography) will occur. When security classification and SURTASS LFA sonar operations scheduling allow, the Navy will encourage cooperative research efforts using SURTASS LFA sonars at sea. This will allow the best qualified marine biologists to address the outstanding critical issues regarding the direct and indirect effects of anthropogenic LF sound on marine mammal stocks.

- **Foreign Navy and Academic Laboratories -** For example, bilateral discussions with the United Kingdom's (UK) Defence Evaluation and Research Agency (DERA) are underway, and working level meetings are planned with the Royal Netherlands Navy with the objective of cooperative efforts on addressing the potential for anthropogenic underwater LF sound to affect human divers, marine mammals and sea turtles.

- **U.S. and Foreign Industry -** There are a variety of research efforts on the effects of LF noise on marine mammals. For example, bilateral discussions are underway with the U.S.'s Western Geophysical and the UK's British Petroleum.

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3 AFFECTED ENVIRONMENT

This chapter provides a generalized overview of the environment that could potentially be affected by Navy employment of the SURTASS LFA sonar system:

- **Acoustic Environment**, including ambient noise in the oceans, physical environmental factors affecting acoustic propagation, and ocean acoustic regimes (Subchapter 3.1);

- **Marine Organisms,** including marine mammals and threatened and endangered species (Subchapter 3.2); and

- **Socioeconomic Conditions**, including commercial and recreational fishing, other recreational activities, research and development, and coastal zone management consistency (Subchapter 3.3).

Because the operation of SURTASS LFA sonar is related to the transmission of sound in the ocean environment, it is important for the reader to have at least an elementary understanding of the science behind the transmission of sound in water. A tutorial on the fundamentals of underwater sound is provided as Appendix B to assist the reader in understanding the technical aspects of this document.

3.1 Acoustic Environment

The only form of energy that travels efficiently within the oceans is sound. Radio and other electromagnetic waves are attenuated in water at a much greater rate than sound. This makes sound, or acoustics, the medium of choice for sensing the ocean environment for both marine organisms and humans. Marine mammals use sound to sense their environment and to communicate among themselves (NRC, 1994). Dolphins, and other toothed whales, utilize echoes from sounds that they produce (echolocation) to locate prey and navigate (NRC, 1994). Humans use acoustics to detect underwater objects, such as submarines or sunken vessels, to conduct depth measurements, and for communications.

The ability to use sound as an effective sensing medium in the ocean is dependent on the level of background noise (ambient noise) as it is related to the signal, or sound, being received, the physical factors of the ocean that affect the speed at which sound travels through water, and the rate at which sound energy is lost. Sound power or intensity loss by the acoustic signal is a result of spreading and absorption. This is referred to as propagation or transmission loss. Water temperature, salinity, and depth/pressure are all factors that affect the density of the water and, therefore, the speed of sound through the water, and thus the water's propagation characteristics.

3.1.1 Ambient Noise

The following discussion is a summary of LF ambient noise within the ocean as it relates to the frequency at which SURTASS LFA sonar would operate (i.e., between 100 and 500 Hz). Ambient noise is the typical or persistent environmental background noise that is present. It does not include “self noise” generated by the listening devices or the vessel on which they are mounted. Ambient noise is directional both horizontally and vertically, meaning that it does not come at equal sound levels from all directions. For more detailed information on oceanic ambient (or background) noise the references listed in the box provide excellent and more comprehensive discussions on the subject.

Ambient Noise in the Ocean - Additional References

Richardson, W.J., C.R. Greene, C.I. Malme, and D.H. Thompson. 1995. *Marine Mammals and Noise.* Academic Press, Inc. San Diego, CA.

Urick, Robert J. 1983*. Principles of Underwater Sound*, 3rd Edition. Peninsula Publishing. Los Altos, CA.

Measurements of ambient noise have been made over frequency ranges from below 1 Hz to 100 kHz. Ambient noise levels and sources vary both in location and season. There are numerous ambient noise sources that are comparable in frequency to SURTASS LFA sonar. Distant shipping noise has been reported by Urick (1983) to be between 20 and 300 Hz, and by Richardson et al. (1995b) to be from 50 to 500 Hz. Biological noise can also be a major contributor of noise in the ocean. Several species of baleen whales, toothed whales, and seals are known to produce underwater sounds between 100 and 500 Hz.

Source levels for selected naturally occurring underwater noises are summarized in Table 3.1-1. This table readily demonstrates that there are numerous natural sources, including certain whales that produce calls as loud as 189 dB. A brief discussion of some of the more significant contributors to ambient noise follows.

3.1.1.1 Wind and Waves

Wind and waves are common and interrelated sources of ambient noise in all of the world’s oceans. All other factors being equal, ambient noise levels tend to increase with increasing wind speed and wave height (Richardson et al., 1995b). Noise generated by surface wave activity and biological sounds is the primary contributor over the frequency range from 300 Hz to 5 kHz. The wind-generated noise level decreases smoothly with increasing acoustic frequency (i.e., there are no spikes at any given frequency).

Table 3.1-1

Natural Sources in the Low Frequencies

Source	Broadband Levels	References
Lightning Strike on Water Surface	~260 dB	Hill, 1985
Seafloor Volcanic Eruption	~255 dB	Dietz and Sheehy, 1954; Northrop, 1974
Sperm Whale	163 - 180 dB	Levenson, 1974; Watkins, 1980a
Fin Whale	155 - 186 dB	Watkins, 1981; Edds, 1988; Watkins, et al., 1987; Cummings & Thompson, 1994
Humpback Whale	144 - 174 dB	Thompson, et al., 1979; Payne and Payne, 1985; Frankel, 1994
Bowhead Whale	128 - 189 dB	Ljungblad, et al., 1982a; Cummings and Holliday, 1987; Würsig and Clark, 1993
Blue Whale	155 - 188 dB	Aroyan et al., 2000; Cummings and Thompson, 1971 and 1994; Edds, 1982; Stafford et al., 1994
Southern Right Whale	172 - 187 dB	Cummings, et al., 1972; Clark, 1982, 1983
Gray Whale	142 - 185 dB	Cummings, et al., 1968; Fish, et al., 1974; Swartz and Cummings, 1978

3.1.1.2 Precipitation

At some frequencies, rain and hail will increase ambient noise levels. Significant noise is produced by rainsqualls over a range of frequencies from 500 Hz to 15 kHz. Large storms with heavy precipitation can generate noise at frequencies as low as 100 Hz and significantly affect ambient noise levels at a considerable distance from a storm’s center. Lightning strikes associated with storms are loud, explosive events that deliver an average of 100 kilojoules per meter (kJ/m) of energy (Considine, 1995). Hill (1985) estimated the source level for cloud-to-water pulse to be 260.5 dB. It has been estimated that over the earth's oceans the frequency of lightning averages about 10 flashes per second, or 314 billion strikes per year (Kraght, 1995).

3.1.1.3 Biological Noises

Biological noises are sounds created by animals in the sea and may contribute significantly to ambient noise in many areas of the oceans. Because of the habits, distribution, and acoustic characteristics of these sound producers, certain areas of the oceans are louder then others. Only three groups of marine animals are known to make sounds (Urick, 1983):

- Crustacea, such as snapping shrimp;
- True fish, such as the drumfish; and
- Marine mammals, including whales, dolphins, and porpoises.

The most widespread, broadband noises from animal sources (in shallow water) are those produced by croakers (representative of a variety of fish classified as drumfish) (100 Hz to 10 kHz) and snapping shrimp (500 Hz to 20 kHz). Sound-producing fishes and crustaceans are restricted almost entirely to bays, reefs, and other coastal waters, although there are some pelagic, sound-producing fish. In oceanic waters, whales and other marine mammals are principal contributors to biological noise. For example, dolphins produce whistles associated with certain behaviors, and the baleen whales are noted for their low frequency vocalizations.

3.1.1.4 Human Activity

Anthropogenic noises that could affect ambient noise arise from the following general types of activities in and near the sea, any combination of which can contribute to the total noise at any one place and time. These noises include:

- Transportation (ship-generated noise);
- Dredging;
- Construction;
- Hydrocarbon and mineral exploration and recovery;
- Geophysical (seismic) surveys;
- Sonars;
- Explosions; and
- Ocean science studies.

Surface shipping is the most widespread source of anthropogenic, low frequency (0 to 1,000 Hz) noise in the oceans (Simmonds and Hutchinson, 1996). At the lower frequencies, the dominant source of this noise is the cumulative effect of ships that are too far away to be heard individually, but because of their great number, contribute substantially to the average noise background. The radiated noise spectrum of merchant ships ranges from 20 to 500 Hz and peaks at approximately 60 Hz. Ross (1976) has estimated that between 1950 and 1975 shipping had caused a rise in ambient ocean noise levels of 10 dB. He predicted that this would increase by another 5 dB by the beginning of the 21st century. It has been estimated that the background ocean noise level at 100 Hz has been increasing by about 1.5 dB per decade since the advent of propeller-driven ships (NRC, 1997).

Table 3.1-2 summarizes source categories and compares source levels for selected sources of LF anthropogenic underwater noise. In the frequency range of SURTASS LFA sonar (between 100 and 500 Hz), there are several of these underwater activities with source levels that are well above ambient noise levels (see below) in most areas of the world. These include icebreaking, seismic surveys, explosives, large oil tankers, and tugs with barges.

Table 3.1-2

Summary and Comparison of Source Levels for
Selected Sources of Anthropogenic LF Underwater Noise

Sound Source (Transient)		**Source Level in dB**
Seismic Survey - Air gun array (32 guns) (Impulsive - Peak)		259[1] Broadband
Explosions (Impulsive)		
0.5 kg (1.1 lb) TNT	Peak	267[1] Broadband
2 kg (4.4 lb) TNT	Peak	271[1] Broadband
20 kg (44 lb) TNT	Peak	279[1] Broadband
4,536 kg (10,000 lb) TNT	Peak	>294[2] Broadband
Ocean Acoustics Studies		
Heard Island Test		220[1] Spectrum Level
ATOC		195[1] Spectrum Level
Vessels Underway		
Tug and Barge (18 km/hour)		171[1] Broadband
Supply Ship (*Kigoriak*)		181[1] Broadband
Large Tanker		186[1] Broadband
Icebreaking		193[1] Broadband

Notes: All dB re 1 µPa at 1 m.

Sources: 1. Richardson et al., 1995b.
2. Urick, 1983.

3.1.1.5 Deep Water Ambient Noise

Urick (1983) provided a discussion of the ambient noise spectrum expected in the deep ocean. Shipping, seismic activity, and weather are primary causes of deep-water ambient noise. Noise levels between 20 and 500 Hz appear to be dominated by distant shipping noise that usually exceeds wind-related noise. Above 300 Hz, the level of wind-related noise might exceed shipping noise. Wind, wave, and precipitation noise originating close to the point of measurement dominate frequencies from 500 to 50,000 Hz. The ambient noise frequency spectrum and level can be predicted fairly accurately for most deep-water areas based primarily on known shipping traffic density and wind state (wind speed, Beaufort wind force, or sea state) (Urick, 1983). For frequencies between 100 and 500 Hz, Urick

(1983) has estimated the average deep water ambient noise spectra to be 73 to 80 dB for areas of heavy shipping traffic and high sea states, and 46 to 58 dB for light shipping and calm seas.

3.1.1.6 Shallow Water Ambient Noise

In contrast to deep water, ambient noise levels in shallow waters (i.e., coastal areas, bays, harbors, etc.) are subject to wide variations in level and frequency depending on time and location. The primary sources of noise include distant shipping and industrial activities, wind and waves, and marine animals (Urick, 1983). At any given time and place, the ambient noise level is a mixture of the above noise types. In addition, sound propagation is also affected by the variable shallow water conditions, including the depth, bottom slope, and type of bottom. Where the bottom is reflective, the sound levels tend to be higher than when the bottom is absorptive.

3.1.2 Environmental Factors Affecting Sound Propagation

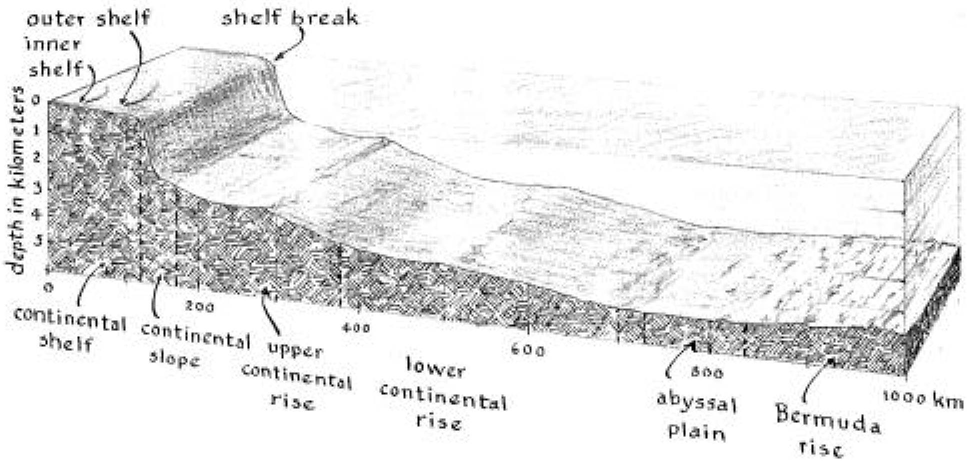
Sound propagation in water is influenced by various physical characteristics, including water temperature, depth, salinity, and surface and bottom properties that cause refraction, reflection, absorption, and scattering of sound waves. The remainder of this section discusses how geology and bottom topography, sedimentation, temperature, salinity, winds and sea state can affect LF sound transmission.

3.1.2.1 Geology and Bottom Topography

The ocean bottom is an effective reflector, refractor, absorber, and scatterer of sound. How the sound is redistributed depends on several factors. First, for the bottom to have any effect, the sound must reach the bottom. Because of the upward refraction of sound waves in the deep isothermal layer, the deepest that the LF sound energy of the SURTASS LFA sonar could reach would usually be about 2,000 m (6,600 ft) before being bent toward the surface. Therefore, any deep ocean bottom areas below 2,000 m (6,600 ft) normally would not affect, or be affected by, the system because the amount of LF acoustic energy reaching this depth would not be significant.

Continental Shelf

The main divisions of the continental margins and the deep ocean basins are the continental shelf, slope and rise, and the abyssal plain. This is shown in Figure 3.1-1 (Typical Ocean Floor for the North Atlantic Basin). The continental shelf is a gently sloping (about 1:1000) deposition surface around the margin of a continent. It extends from the shoreline to the shelf break or shelf edge. At the shelf break, there is usually a marked increase in slope where the shelf edge joins the steeper continental slope. The width of the continental shelf varies from a few kilometers to more than 400 km (220 nm), but the average depth of the shelf break is more uniform, generally averaging about 130 m (427 ft) over most of the world's oceans (Kennett, 1982).



Reference: Gross (1972)

Figure 3.1-1. Typical Ocean Floor for the North Atlantic Basin.

Continental Slope and Rise

At the edge of the continental shelf, the depth falls off rapidly from 100 to 200 m (330 to 660 ft) to 1,500 to 3,500 m (4,900 to 11,500 ft) forming the region known as the continental slope. The regional slope is great (often more than 1:40), although the slope itself is from 50 to 200 km (27 to 108 nm) in width. The continental rise is a zone approximately 100 to 1,000 km (54 to 540 nm) wide, marked by a gentle seaward gradient (1:100 to 1:700) ending in the abyssal plain (Kennett, 1982).

Submarine canyons and deep-sea channels are found in the continental rise and slope. Submarine canyons are steep, V-shaped canyons cutting through the continental slope, rise, and less commonly, the continental shelf. They resemble large canyons on land cut by rivers and are erosion features. There does appear to be a correlation between the larger canyons and large rivers. The sediment is deposited at the base of the continental slope in a number of environments, including deep-sea fans, continental rises, abyssal plains, and trenches.

Deep Ocean Basin

The deep-ocean basin is dominated by several distinct features, including mid-ocean ridges and rises, abyssal plains, seamounts, and marginal trenches as depicted in Figure 3-1.2 (Global Ridge System and Sea Floor). The Mid-Ocean Ridge is a circumglobal undersea mountain range extending over 65,000 km (35,075 nm) in length (Kennett, 1982) forming a series of mountainous features known either as ridges, if they have steep and irregular slopes, or rises, if the slopes are more gentle. This belt of oceanic ridges circles the world and has branches in each of the major oceans. Analogous to the seams of a baseball, the ridge system reaches from the Arctic Ocean southward, bisecting the Atlantic (Mid-Atlantic Ridge) through the Indian Ocean and around the periphery of the Pacific.

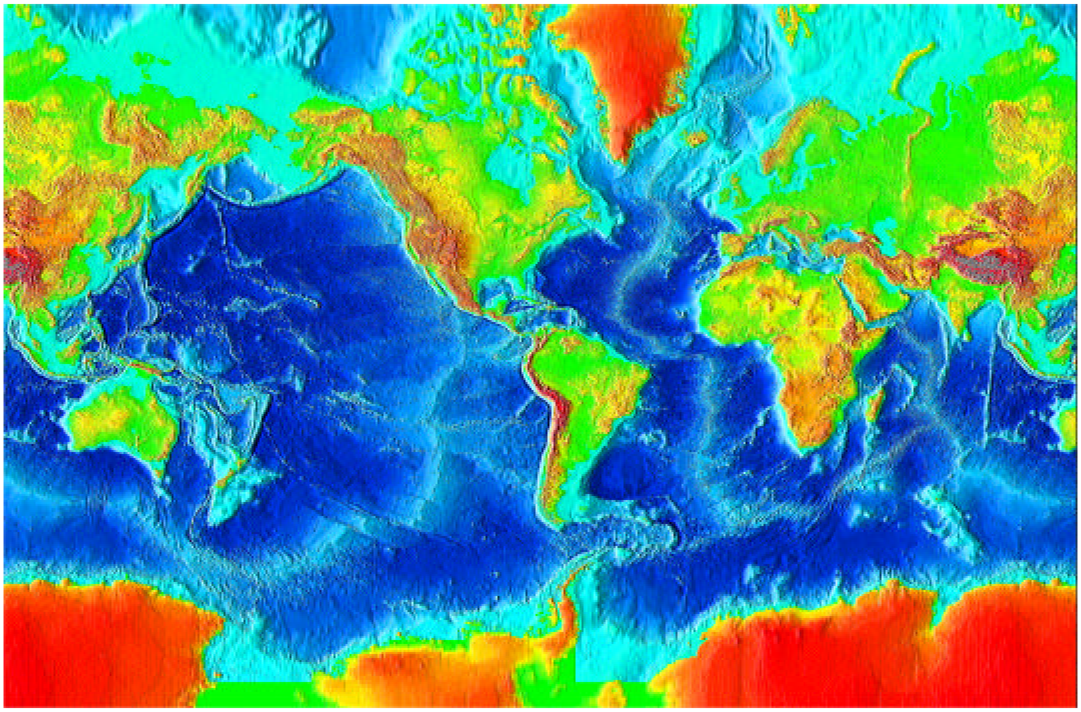


Figure 3.1-2. Global Ridge System and Sea Floor.

Dominating the Atlantic geology, the rift valley (the central cleavage) has been traced from Iceland southward through the Atlantic and around into the Indian Ocean. The system of mountains is entirely volcanic and is composed of lava with a basaltic composition characteristic of the ocean basin crust. The depth of the ridge crest varies between 2,100 and 3,700 m (6,890 and 12,140 ft) and consists of extremely rugged relief with broad, rugged flanks. A central rift valley, 1 to 2 km (3,300 to 6,600 ft) deep and from one to a few tens of kilometers wide, lies along the axis of the ridge.

Abyssal plains are formed by the accumulation of sediment deposited by turbidity currents, which have built up deposits over 1,000 m (3,300 ft) thick. The formation of the abyssal plains is largely a function of sediment availability and topography adjacent to sediment-source areas. They generally occur at depths between 4,000 and 6,000 m (13,100 to 19,700 ft) and are characterized by slopes of less than 1:1000. Abyssal hills are small, sharp-featured volcanic hills that rise less than 1,000 m (3,300 ft) above the abyssal plains. They are shaped by the basalt floor beneath them, but are covered by transported sediment. Seamounts, by contrast, are volcanic mountains with an elevation of greater than 1,000 m (3,300 ft).

Marginal trenches are narrow, steep-sided troughs roughly parallel to continental margins at the seaward base of a continental platform. The deepest portions of the world's oceans are found in these trenches. The Challenger Deep of the Marianas Trench has a depth of 11,034 m (36,200 ft), the greatest ocean basin depth known (Kennett, 1982).

3.1.2.2 Sedimentation

To effectively predict how certain sounds would react with the bottom, it is necessary to know sediment density, thickness, and type. The majority of the ocean bottom is covered by sediment deposits made up of unconsolidated accumulations of particles transported to the oceans by rivers, glaciers, and wind mixed with the remains of marine organisms. Deep-sea sediments are those deposited at depths greater than about 500 m (1,640 ft) and are dominated by biogenic (fossil) components and pelagic clays, although terrigenous sediments (land source) are widespread in some deep-sea basins.

Where LF sound interacts with the bottom, the sound transmissions experience what is referred to as bottom loss. When sound interacts with the seafloor, the energy is generally reflected at the sediment-water interface or partially transmitted into the sediment. The energy transmitted into the sediment is refracted, usually upward, or absorbed. The energy refracted upward from the sediment can potentially reenter the water. Energy absorption is dependent on the composition of the sediment. Sediments high in calcium (calcareous sediments) tend to absorb more sound energy than those low in calcium minerals.

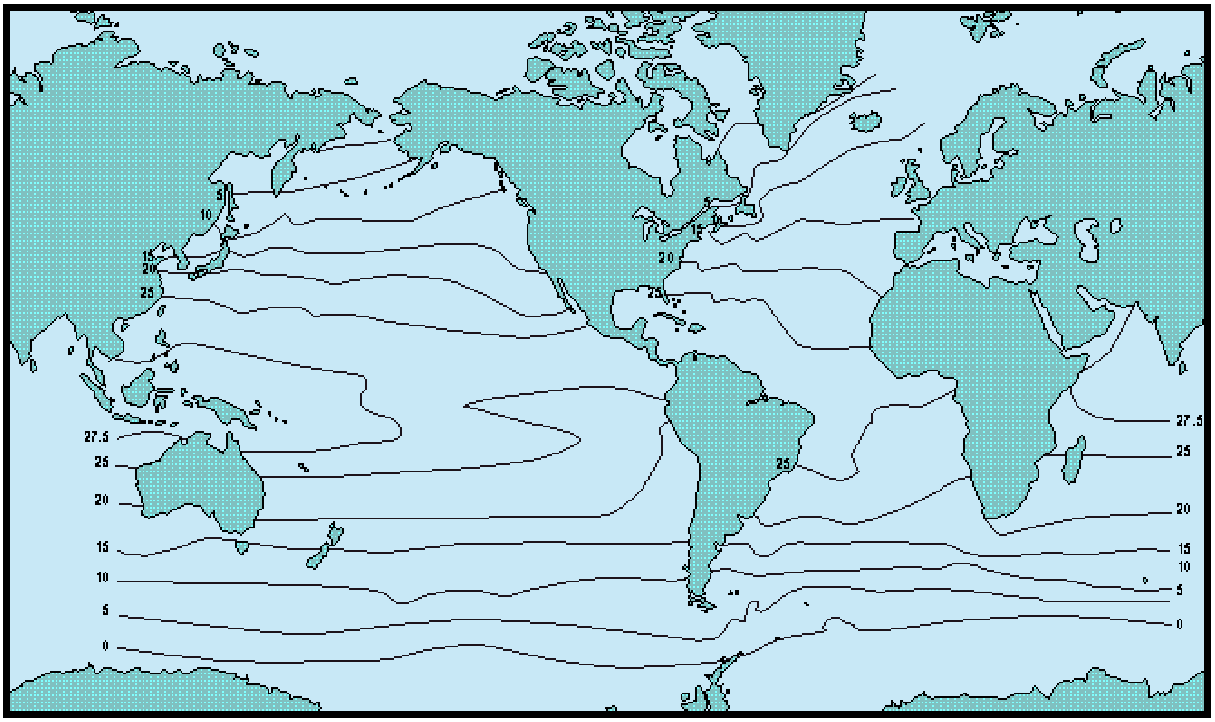
Most of the deep ocean sediments and much of the coastal sediments can be more simply defined as mud or ooze. Near the water-sediment interface, this mud has a density very close to that of the overlying water. Because of this, it tends to be transparent to LF sound. As the depth increases, so does the density of the sediment. This causes the sound to be refracted upward and eventually back into the water. If the sound waves strike the underlying oceanic bedrock before they begin to refract upward, then they would be reflected. This is defined as the acoustic bottom, or basement.

In areas where sediments are thicker than 2,000 m (6,600 ft), LF sound energy usually would not reach acoustic bottom. However, there are certain areas of the open oceans, such as the mid-ocean ridges and seamounts, where LF transmissions could exhibit bottom interaction characteristics.

3.1.2.3 Temperature and Salinity

Water temperature and salinity are important because they affect the sound speed within the water column. This sound speed profile (SSP), as it varies with water depth, is a critical parameter in determining sound transmission loss in the ocean.

The distribution of temperature is approximately zonal, with lines of constant temperature running roughly east-west and temperatures decreasing away from the equator. One exception to this is along the eastern boundaries of the oceans where upwelling occurs, bringing cold subsurface waters to the surface. This is demonstrated in Figure 3.1-3 (Yearly Average Surface Temperature of the Ocean [ºC]).



Reference: Williams et al. (1968)

Figure 3.1-3. Yearly Average Surface Temperature of the Ocean (°C).

The salinity distribution is basically zonal as well, although it does not occur in as sharp a contrast as the temperature distribution. Lowest surface salinity occurs five degrees north of the equator (average 34.54 parts per thousand [ppt]), while the highest values appear in the regions of high evaporation and low precipitation at latitudes 25°N (average 35.79 ppt) and 20°S (average 35.69 ppt). A second zone of low salinity occurs in each hemisphere at latitudes 40°N (average 34.54 ppt) and 50°S (average 33.99 ppt) (Duxbury, 1971).

The vertical distribution of salinity is not as simple as that of temperature. Density is the principal factor responsible for determining the position of a water mass vertically in the water column, and density is determined chiefly by temperature. Water of higher temperatures is generally found in upper waters, and colder waters are found in the deeper layers. Salinity variations are not sufficient to overcome this process. Thus, it is possible to have either high or low salinity water in upper waters. In the equatorial, tropical and subtropical regions, however, there is a marked salinity minimum at 600 to 1,000 m (1,970 to 3,300 ft) with salinity increasing to 2,000 m (6,600 ft). Deep waters (approximately 4,000 m [13,100 ft] or so) have a relatively uniform salinity of 34.6 to 34.9 ppt.

3.1.2.4 Winds and Waves

The ocean surface either reflects or scatters sound waves. If the sea surface were perfectly smooth, like a mirror, then all of the sound impinging upon it would be reflected back into the water. When the sea is rougher, some of the sound energy is scattered and less is reflected. Because of the longer wavelength of LF sound, there are smaller surface losses because the sea surface appears smoother in relationship to the longer sound wave.

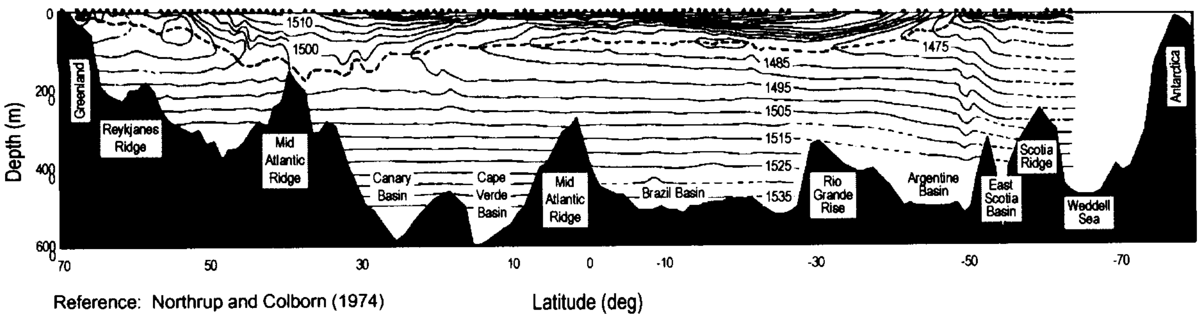
3.1.3 Ocean Acoustic Regimes

The oceans are not homogeneous, that is, they do not have the same physical characteristics throughout their four-dimensional structure (the fourth dimension being time or season). Sound speed in water varies with water density. Water density is affected primarily by depth, temperature, and to a lesser degree, by salinity. Thus, the speed of sound in water varies with depth (a plot of sound speed versus water depth is known as a sound speed profile [SSP]). As sound speed changes due to environmental conditions of the water, the sound rays bend, or refract, either toward or away from the surface. Under certain conditions sound rays may become trapped in a duct and create a sound channel. This is discussed in more detail in Subchapter 3.1.3.2. It is this refraction, coupled with the reflection from the surface and interaction with the bottom that makes it difficult to predict how sound travels in water. See Appendix B for more detailed information on sound speed in the ocean.

As an example of how sound speed varies within the oceans, two figures are provided for the Atlantic Ocean (other major oceanic areas would be similar):

- Figure 3.1-4 (North-South Section of Sound Channel Structure in the Atlantic -- 30.5ºW Meridian) demonstrates how sound speed varies with latitude and depth for the Atlantic Ocean (Northrup and Colborn, 1974). Sound speeds are measured in meters per second, and the heavy dashed line shows the approximate depth of the sound channel axis (axis of minimum sound speed). It can be seen that sound speed generally increases with depth, and is variable nearer to the surface.

- Figure 3.1-5 (Deep Channel Sound Axis Contours for the Atlantic Ocean) demonstrates the location of the sound channel, or the axis of minimum sound speed, by depth at contour intervals of 200 m (660 ft) (Northrup and Colborn, 1974). It can be seen that the depth of the sound channel is nearest to the surface at the poles.



Reference: Northrup and Colborn (1974)
Units = meters/second

Figure 3.1-4. North-South Section of Sound Channel Structure in the Atlantic – 30.5° W Meridian.

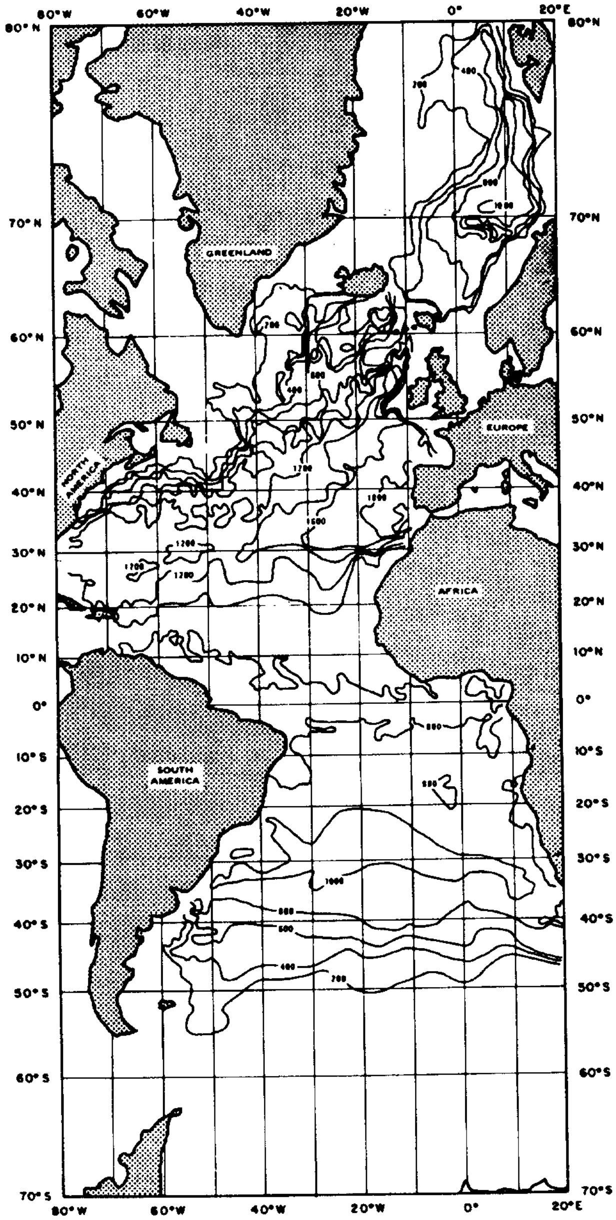
Based on the characteristics of the SSPs for specific areas of the oceans, sound propagation for those areas can be predicted. These predictions are generally grouped by the physical effects that the SSP has on acoustic propagation. Despite the complexity of the ocean environment these effects can be organized into the following three groups, which are referred to as ocean acoustic regimes:

- Deep water convergence zone (CZ);
- Surface duct; and
- Shallow water bottom interaction.

Table 3.1-3 shows a generalized summary of these acoustic regimes for most of the world's oceanic areas.

Deep Water Convergence Zones

Convergence zones (CZ) are special cases of the sound-channel effect occurring in deep water. The existence of CZs depends on the SSP and the depth of the water. Due to downward refraction at shorter ranges, sound rays leaving the near-surface region are refracted back to the surface because of the positive sound speed gradient produced by the greater pressure at deep



Reference: Northrup and Colborn (1974)
Units = meters

Figure 3.1-5. Deep Channel Sound Axis Contours for the Atlantic Ocean.

Table 3.1-3

Generalized Summary of Oceanic Regimes

Oceanic Areas/Season	Deep Water CZ Regime	Near-Surface Duct Regime	Shallow Water Bottom Interaction Regime
North Pacific			
Summer	South of 45° N Latitude	North of 45° N Latitude	Bottom interaction in depths shallower than 1,800 to 2,000 m (5,900 to 6,600 ft)
Winter	South of 45° N Latitude	North of 45° N Latitude	Bottom interaction in depths shallower than 1,800 to 2,000 m (5,900 to 6,600 ft)
South Pacific			
Summer	North of 45° S Latitude	South of 45° S Latitude	Bottom interaction in depths shallower than 1,800 to 2,000 m (5,900 to 6,600 ft)
Winter	North of 45° S Latitude	South of 45° S Latitude	Bottom interaction in depths shallower than 1,800 to 2,000 m (5,900 to 6,600 ft)
North Atlantic			
Summer	South of 40° to 45° N Latitude	North of 45° N Latitude mixture of CZ and ducted	Bottom interaction in depths shallower than 2,000 m (6,600 ft) including areas over the Mid-Atlantic Ridge
Winter	South of 40° to 45° N Latitude	North of 45° N Latitude mixture of CZ and ducted with higher percentage of ducted	Bottom interaction in depths shallower than 2,000 m (6,600 ft) including areas over the Mid-Atlantic Ridge
South Atlantic			
Summer	10° to 50°S Latitude	South of 50° S Latitude mixture of CZ and ducted	Bottom interaction in depths shallower than 2,000 m (6,600 ft) including areas over the Mid-Atlantic Ridge
Winter	10° to 50°S Latitude	South of 50° S Latitude mixture of CZ and ducted with higher percentage of ducted	Bottom interaction in depths shallower than 2,000 m (6,600 ft) including areas over the Mid-Atlantic Ridge
North Central Indian			
Summer	Not applicable	Ducted	Bottom interaction in depths shallower than 1,800 to 2,000 m (5,900 to 6,600 ft) including above the Ninetyeast Ridge
Winter	Not applicable	Ducted	Bottom interaction in depths shallower than 1,800 to 2,000 m (5,900 to 6,600 ft) including above the Ninetyeast Ridge

Table 3.1-3

Generalized Summary of Oceanic Regimes

Oceanic Areas/Season	Deep Water CZ Regime	Near-Surface Duct Regime	Shallow Water Bottom Interaction Regime
South Central Indian			
Summer	Not applicable	Ducted	Bottom interaction in depths shallower than 1,800 to 2,000 m (5,900 to 6,600 ft) including above the Ninetyeast and Broken Ridges.
Winter	CZ north of 25° S Latitude	Duct south of 25° S Latitude	Bottom interaction in depths shallower than 1,800 to 2,000 m (5,900 to 6,600 ft) including above Ninetyeast and Broken Ridges
Western Mediterranean			
Summer	Weak CZ	Half channel ducting	Very little bottom interaction; only when shallower than 1,800 to 2,000 m (5,900 to 6,600 ft)
Winter	Weak CZ	Half channel ducting	Very little bottom interaction; only when shallower than 1,800 to 2,000 m (5,900 to 6,600 ft)
Central Mediterranean			
Summer	CZ and weak CZ	Surface ducting	Very little bottom interaction; only when shallower than 1,800 to 2,000 m (5,900 to 6,600 ft)
Winter	CZ and weak CZ	Some surface ducting to south	Very little bottom interaction; only when shallower than 1,800 to 2,000 m (5,900 to 6,600 ft)
Eastern Mediterranean			
Summer	CZ and weak CZ	Not applicable	Very little bottom interaction; only when shallower than 1,800 to 2,000 m (5,900 to 6,600 ft)
Winter	CZ and weak CZ	Surface ducting	Very little bottom interaction; only when shallower than 1,800 to 2,000 m (5,900 to 6,600 ft)

ocean depths. These deep-refracted rays often become concentrated at or near the surface at some distance from the sound source through the combined effects of downward and upward refraction, thus causing a CZ.

CZs may exist whenever the sound speed at the ocean bottom, or at a specific depth, exceeds the sound speed at the source depth. Depth excess, also called sound speed excess, is the difference between the bottom depth and the limiting, or critical, depth. (See Appendix B for more detailed information on CZs.)

3.1.3.1 Acoustic Ducting

There are two types of acoustic ducting:

- **Surface Ducts** - Usually, the top layer of the ocean is well mixed, meaning that it has a constant value for temperature and salinity. Because of the effect of depth (pressure), surface layers exhibit a slightly positive sound speed gradient, and sound emitted from a source within this layer will be refracted upward and surface-reflected. Because this characteristic causes much of the sound to remain, or be trapped, in this layer, the surface layer is often called a duct, surface duct, or surface channel. In surface ducts, the maximum range of propagation (i.e., how far the sound can travel) depends upon the SSP, sound frequency, the bottom slope, and depth. As a general rule, surface duct propagation will improve as the surface layer depth increases. Sound trapped in a surface duct can travel for relatively long distances. In cloudy, windy ocean areas throughout the world, the near surface water is very often isothermal enabling surface ducting. In midwinter the isothermal surface layer is usually several hundred feet deep, except in tropical waters, where the depth varies from 15 to 150 m (50 to 500 ft) depending on ocean currents and other environmental factors. In the very high latitudes, the surface layer may extend down to the ocean bottom in winter months.

- **Sound Channels** - Variation of sound velocity with depth causes sound to travel in curved paths. A sound channel is a region in the water column where sound speed first decreases with depth to a minimum value, and then increases. Above the depth of minimum value, sound is refracted (bent) downward; below the depth of minimum value, sound is refracted upward. Thus, much of the sound starting in the channel is trapped, and any sound entering the channel from outside its boundaries is also trapped. This mode of propagation is called sound channel propagation. This propagation mode experiences the least transmission loss along the path, thus resulting in long-range transmission. Sound channels are a typical feature of the open ocean at depths around 1,000 m (3,280 ft) at the mid-latitudes to near the surface in polar regions (Gross, 1972).

3.1.3.2 Shallow Water Bottom Interaction

Reflections from the ocean bottom can extend propagation ranges. The effect of bottom bounce is to return some of the sound energy that has been carried downward by refraction back into the water column, enabling longer-range transmission. At low frequencies, some energy penetrates the seafloor and within this layer is refracted back to the boundary between the water and the seafloor, and is then returned to the water column. At low frequencies this refraction within the seafloor, not reflection, is the predominant mechanism for energy return.

Major factors affecting bottom-bounce transmission include water depth, angle of incidence, frequency, bottom composition, and bottom roughness. A flat ocean bottom produces the greatest accuracy in estimating range and bearing in the bottom bounce mode. In shallow water, LF sound rays, which are refracted from the bottom, may then be reflected from the surface creating a ducted acoustic environment. However, the effectiveness of these shallow water ducts is highly variable dependent on the water depth, type of bottom, bottom topography, weather conditions, etc.

For SURTASS LFA sonar transmissions between 100 and 500 Hz, bottom interaction would generally occur in areas of the ocean where depths are between approximately 200 m (nominal minimum water depth for SURTASS LFA sonar deployment) and 2,000 m (660 and 6,600 ft).

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3.2 Marine Organisms

3.2.1 Species Screening

In order for LF sound to have an effect on an animal, the animal must be able to sense LF sound, and/or some organ or tissue must be capable of changing sound energy into mechanical effects. To achieve this change, the organ or tissue must have an acoustic impedance different from water, where impedance is the product of density (kg/m^3 [lb/yd^3]) and sound speed (m/sec [ft/sec]). Thus, many organisms would be unaffected, even if they were in areas of LF sound, because they do not have an organ or tissue with acoustic impedance different from water or cannot sense LF sounds. These factors immediately limit the types of organisms that could be adversely affected by LF sound.

Based on these considerations, a detailed analysis of only those organisms in the world's oceans that meet the following criteria has been undertaken:

- Does the proposed SURTASS LFA sonar geographical sphere of acoustic influence overlap the distribution of this species? If so,

- Is the species capable of being physically affected by LF sound? Are acoustic impedance mismatches large enough to enable LF sound to have a physical effect or can the species sense LF sound?

In other words, to be evaluated for potential impact in this OEIS/EIS, the species must: 1) occur within the same ocean region and during the same time of year as the SURTASS LFA sonar operation, and 2) possess some sensory mechanism that allows it to perceive the LF sounds or possess tissue with sufficient acoustic impedance mismatch to be affected by LF sounds. Species that did not meet these criteria were excluded from consideration. The evaluation process is summarized visually in Figure 3.2-1 (Species Selection Rationale). For example, phytoplankton and zooplankton species do have acoustic impedance differences from seawater due to tiny gas bubbles. However, Medwin and Clay (1998) have calculated resonance frequency ranges from 7 to 27 kHz at 100 m (328 ft). Because of the lack acoustic impedance mismatches at low frequencies, the SURTASS LFA sonar pulse essentially would pass through them without being detected. Therefore, they do not have the potential to be physically affected by the operation of SURTASS LFA sonar, and so they were not evaluated for potential impacts (Croll, et al. 1999).

In cases where direct evidence of acoustic sensitivity is lacking for a species, reasonable indirect evidence was used to support the evaluation (e.g., there is no direct evidence that a species hears LF sound but good evidence that the species produces LF sound). In cases where important biological information was not available or was insufficient for one species, but data were available for a related species, the comparable data were used. Additional special attention was given to species with either special protected stock status or limited potential for reproductive replacement in the event of mortality.

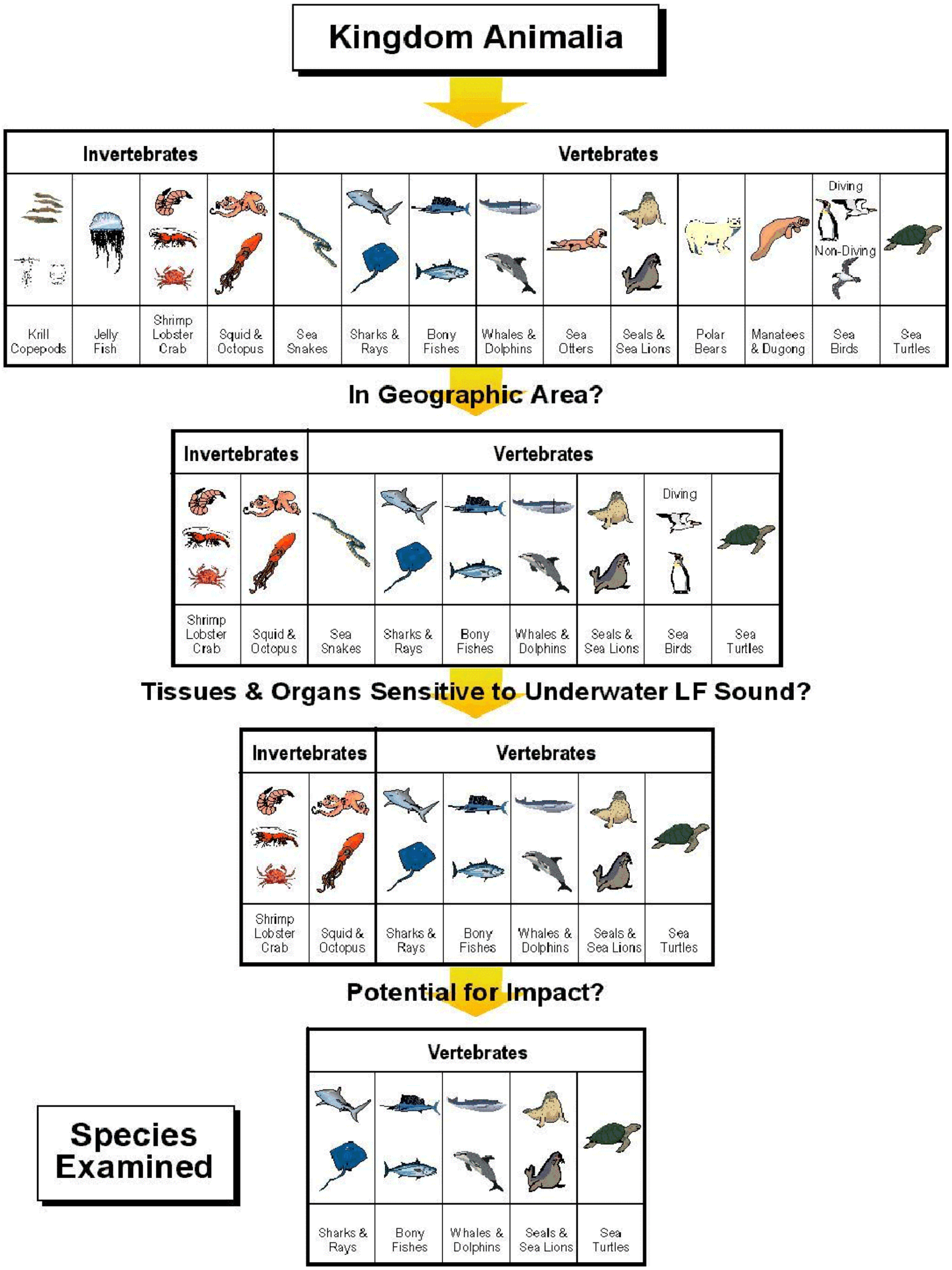

Figure 3.2-1. Species Selection Rationale.

3.2.1.1 Invertebrates

Virtually all invertebrates can be categorically 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 capabilities in the frequency range used by SURTASS LFA sonar. Siphonophores and some other jelly plankton do have air-filled bladders, but because of their size, they do not have a resonance frequency close to the low frequencies used by SURTASS LFA sonar.

Among invertebrates, only cephalopods (octopus and squid) and decapods (lobster, shrimp, and crab) are known to sense LF sound (Offutt, 1970; Budelmann and Young, 1994). Based on Budelmann and Young's measurements, the cephalopod threshold for hearing for far-field sound waves is estimated to be 146 dB. The hearing threshold for the American lobster has been determined to be approximately 150 dB -- in the LF range of SURTASS LFA sonar (Offutt, 1970). Given these high levels of hearing thresholds, SURTASS LFA sonar operations could only have a lasting impact on these animals within a few tens of meters from the source. Therefore, the fraction of the cephalopod and decapod stocks that could possibly be found in the water column near a vessel using SURTASS LFA sonar would be extremely small. Cephalopods and decapods, therefore, have been eliminated from further consideration because of their poor LF hearing.

3.2.1.2 Vertebrates

Vertebrates, especially those species whose bodies contain air-filled cavities (e.g., lungs or sinuses), offer an acoustic impedance contrast with water and have specialized organs for hearing; hence, they are potentially susceptible to the operation of SURTASS LFA sonar.

Fishes

In general, fishes perceive sound in the 50-2000 Hz band, and peak sensitivity lies below 800 Hz. Of the estimated 27,000 fish species only a small percentage have been studied in terms of audition or sound production. No fish species are known to be deaf. Of those studied, many fishes produce sounds and/or hear in the LF band. Hearing or sound production is documented in 247 species comprising 58 families and 19 orders. Although there are diverse morphological and physiological mechanisms of hearing in fishes, hearing capabilities seem relatively homogenous within orders (Popper and Fay, 1993). Consequently, potential SURTASS LFA sonar effects are considered by fish order for this analysis, except for the Perciformes, which is analyzed by family. Of the 19 orders of fishes with sound production, those that would be found inshore in shallow waters (within 22 km [12 nm] of the coast) have been eliminated from evaluation because they would not occur where the SURTASS LFA sonar would be operating. The fish orders with sound production that do occur in pelagic (oceanic) waters where they might encounter SURTASS LFA sonar are Heterodontiformes, Lamniformes, Anguilliformes, Albutleiformes, Clupeiformes, Salmoniformes, Gadiformes, Pleuronectiformes, Beryciformes, Scorpaeniformes, and the Perciformes families Pomacentridae, Labridae, Lutjanidae, Serranidae, Sciaenidae, Scombridae, and Haemulidae. These are the fish groups evaluated for potential impacts in this OEIS/EIS.

Seabirds

There are more than 270 species of seabirds in five orders, and each order has species that dive to depths exceeding 25 m (82 ft). There are few data on hearing in seabirds and even less on underwater hearing. Studies with other species have shown that birds are sensitive to LF sounds in air. While it is likely that many diving seabirds can hear LF sound, there is no evidence that seabirds use sound underwater. Seabirds that can occur in areas where SURTASS LFA sonar may operate are generally shallow divers. In addition, seabirds spend a very small fraction of their time submerged, and they can rapidly disperse to other areas if disturbed. Therefore, there would be no impact to seabirds, including those that may be threatened or endangered. For these reasons, seabirds have been excluded from further evaluation.

Sea Snakes

Sea snakes are excluded because they primarily inhabit inshore waters, and there is no evidence of sensitive hearing in the LF band in these species.

Sea Turtles

There are seven species of marine turtles, six of which are listed as either threatened and/or endangered under the ESA. The green turtle (*Chelonia mydas*) is listed as threatened everywhere except Florida and the Pacific coast of Mexico, where they are endangered. The loggerhead turtle (*Caretta caretta*) is listed as threatened. The hawksbill (*Eretmochelys imbricata*), Kemp’s ridley (*Lepidochelys kempi*), and leatherback (*Dermochelys coriacea*) are listed as endangered species. The olive ridley (*Lepidochelys olivacea*) is threatened everywhere except the Mexican breeding stocks, which are listed as endangered. The flatback turtle (*Natator depressus)* is unlisted and is restricted to nearshore waters off Australia. Consequently, it is excluded from further analysis. It is likely that all species of sea turtles hear LF sound as adults (Ridgway et al., 1969; O’Hara and Wilcox, 1990). Therefore, the other six species of sea turtles are considered for evaluation because they hear LF sound, occur in pelagic water, and/or dive deeply.

Baleen Whales (Mysticetes)

All 11 species of baleen whales produce LF sounds. Sounds may be used as contact calls, for courtship displays and possibly for navigation and food finding. Although there are no direct data on auditory thresholds for any mysticete species, anatomical evidence strongly suggests that their inner ears are well adapted for LF hearing. Therefore, sound perception and production are assumed to be critical for mysticete survival. For this reason all mysticete species are considered sensitive to LF sound. However, only those that occur within the latitudes of proposed SURTASS LFA sonar operations are considered. This excludes the bowhead whale (*Balaena* *mysticetus*) that occurs only in Arctic waters, north of the area where the system would operate. Included for consideration are the remaining ten baleen whale species: blue (*Balaenoptera musculus*), fin (*Balaenoptera physalus*), minke (*Balaenoptera acutorostrata*), Bryde's (*Balaenoptera edeni*), sei (*Balaenoptera borealis*), humpback (*Megaptera novaeangliae*), northern right (*Eubalaena glacialis*), southern right (*Eubalaena australis*), pygmy right (*Caperea marginata*), and gray (*Eschrichtius robustus*) whales.

Toothed Whales (Odontocetes)

There are at least 70 species of odontocetes (some species classifications are under study, and the exact number of beaked whales is not known) including dolphins, porpoises, beaked whales, "blackfish"[1] (long-finned pilot, short-finned pilot, pygmy killer, false killer, and melon-headed whales), killer whales, and sperm whales. A number of these species inhabit ocean areas where SURTASS LFA sonar might operate–especially pelagic dolphins, beaked whales, sperm whales, "blackfish" and killer whales. Many species are known to use HF clicks for echolocation. All odontocete species studied to date hear best in the mid- to high-frequency range, and so are less likely to be directly affected by exposure to LF sounds than mysticetes. Like mysticetes, odontocetes depend on acoustic perception and production for communication, food finding, and probably for navigation and orientation.

The following species of odontocetes do not meet the screening criteria described at the beginning of this subchapter, and thus are eliminated from further evaluation:

- Arctic specialists in the family Monotontidae including *Monodon monoceros* (narwhal) because SURTASS LFA sonar would not be employed in their range in the Arctic.

- Porpoise species (except the *Phocoenoides dalli*, [Dalls' porpoise] and *Phocoena phocoena* [harbor porpoise]) in the family Phocoenidae because they are coastal species with ranges well inshore of the areas where SURTASS LFA sonar would be employed, including: *P. spinipinnis* (Burmeister's porpoise), *P. sinus* (vaquita), *Neophocaena phocaenoides* (finless porpoise), and *Australophocaena dioptrica* (spectacled porpoise).

- Dolphin species in the following families: Pontoporiidae (*Lipotes vexillifer* [Chinese river dolphin], *Pontoporia blainvillei*, [franciscana]); Iniidae (*Inia geoffrensis* [boto/Amazon river dolphin]); and Platanistidae (*Platanista gangetica* [Ganges River dolphin] and *P. minor* [Indus River dolphin]). They are eliminated because they are river dolphins that may enter coastal waters, but their ranges are well inshore of the areas where SURTASS LFA sonar would be employed.

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[1] "Blackfish" include the pygmy killer whale, melon-headed whale, false killer whale, short-finned pilot whale, long-finned pilot whale and killer whale. (from *Whales, Dolphins and Porpoises*, Carwardine, 1995). However, for this analysis, killer whales will be considered separately.

- Dolphin species in the family Delphinidae that occur in shallow, coastal waters well inshore of the areas where SURTASS LFA sonar would be employed and are not known to hear sounds in the range of the system. This group includes *Sotalia fluviatilis* (Tucuxi/boto), *Oracella brevirostris* (Irrawaddy dolphin), *Sousa chinensis* (Indo-Pacific humpbacked dolphin), S*ousa teuszii* (Atlantic humpbacked dolphin), and *Sousa plumbea* (Plumbeous dolphin).

Odontocetes that are further analyzed in this document are those species that have the potential to be found in deeper, offshore waters where SURTASS LFA sonar might operate. This includes pelagic dolphins, coastal dolphin species that also occur in deep water, beaked whales, killer whales, sperm whales, long-finned and short-finned pilot whales, pygmy killer whales, false killer whales, melon-headed whales, and belugas.

Seals, Sea Lions, and Walruses (Pinnipeds)

The suborder of Pinnipeds consists of “eared” seals (family Otariidae), “true” seals (family Phocidae), and walruses (family Odobenidae).

There are 14 species of otariids including sea lions and fur seals. They are found in temperate or sub-polar waters. Several of these species are listed as special status (northern sea lion, northern fur seal, and Guadalupe fur seal). All 14 species are further analyzed in this document.

There are 18 species of phocids, or “true” seals, nine of which occur in polar oceans or inland lakes and can therefore be excluded. The remaining nine phocid species, including two monk seal species that are listed as endangered, merit further evaluation. These include the Hawaiian and Mediterranean monk seals (*Monochas monachus* and *M. schauinslandi*); the northern and southern elephant seals (*Mirounga angustirostris* and *M. leonina*); the gray seal (*Halichoerus grypus*); three species in the genus *Phoca*: the ribbon, harbor, and spotted seals (*P. fasciata, P. vitulina,* and *P. largha*); and the hooded seal (*Cystophora csistata*).

The walrus can be excluded from further analysis since it is a polar species.

Polar Phocids Excluded from Further Analysis

ringed (*Phoca hispida*)
baikal (*P. sibirica)*
Caspian (*P. caspica*)
harp (*P. groenlandica*)
bearded (*Erignathus barbatus*)

crabeater (*Lobodon carcinophagus*)
Ross (*Ommatophoca rosii*)
leopard (*Hydrurga leptonyx*)
Weddell (*Leptonychotes weddelli*)

Mustelids

Two of the six species of otters in the world inhabit ocean waters: the sea otter (*Enhydra lutris*) and the chungungo (*Lutra felina*). The activities of both species occur almost exclusively in shallow waters. Therefore, these species are not considered for further evaluation.

Sirenians

The world's three manatee species (West Indian [*Trichechus manatus*], Amazonian [*T. inunguis*], and West African [*T. senegalensis*]) and one dugong species (*Dugong dugon*) are primarily fresh water and estuarine species. Therefore, they are eliminated from further evaluation.

3.2.2 Fish

3.2.2.1 Background

Two classes of fish are considered for this OEIS/EIS: Chondrichthyes (cartilaginous fishes including sharks and rays) and Osteichthyes (bony fishes). The bony fishes comprise the largest of all vertebrate groups with over 27,000 extant species (Nelson, 1994). The distribution of fishes is extremely wide, with different species being adapted to a diverse range of abiotic and biotic conditions.

Pelagic fish live in the water column, while demersal fish live near the bottom. Table 3.2-1 provides a listing and a general discussion of the pelagic and demersal fish orders, which are of particular importance because of their demonstrated responses to LF sounds, protected status, and/or commercial importance. It is likely, however, that many other fish species produce and/or use sound for communication, but data are not available on additional species.

3.2.2.2 Hearing Capabilities, Sound Production, and Detection

A fish's octavolateralis system senses sound, vibrations and other forms of water displacement in its environment. The octavolateralis system is comprised of two main components: 1) the inner ear; and 2) the lateral line. A fish uses this system not only to detect sound and vibration, but also to orient itself in three-dimensional space. The ear, lateral line and their central pathways functionally interact to detect signals (Coombs et al., 1989). Both the ear and lateral line use sensory hair cells for signal detection.

Table 3.2-1

Selected Fish Orders

Fish Order	Common Name (representative of order)	Pelagic or Demersal	Hearing Characteristics
Heterodontiformes	Bullhead sharks	Demersal	The horn shark, *Heterodontus francisci*, reportedly hears from 20-160 Hz (Kelly and Nelson, 1975).
Lamniformes	Pelagic sharks	Pelagic	Hearing range for the bull shark, *Carcharhinus leucas*, reportedly is 100-1400 Hz (Kritzler and Wood, 1961) while the lemon, *Negaprion brevirostris,* hears from 10-640 Hz (Banner, 1967) and hammerhead shark, *Sphyrna lewini*, from 250-750 Hz (Olla, 1962). Data from shark attraction experiments suggest hearing up to 1500 Hz in a number of species, although these data are not quantified and need to be repeated.
Anguilliformes	Eels	Demersal	*Anguilla anguilla* hearing upper audible limit 300 Hz with best hearing at about 100 Hz at 95 dB (Jerko et al., 1989).
Albuleiformes	Bonefishes	Pelagic and demersal	The bonefish (*Albula vulpes*) hears from 50-700 Hz (Tavolga, 1974).
Clupeiformes	Herrings/shads/sardines/ anchovies	Pelagic	Maximum hearing sensitivity for Pacific herring (*Clupea harengus pallasi*) is reportedly 125-500 Hz (Croll et al., 1999), Pacific sardine (*Sardinops sagax*) max sensitivity at 63-500 Hz (Sonalysts, 1995). Spotted shad (*Clupanodon punctatus*) max sensitivity 125-500 Hz (Sorokin et al., 1988). All of these data are highly suspect and most other clupeiforms are able to detect sounds to over 3 kHz (Popper pers com) although some species can detect sounds to over 180 kHz (Mann et al., 1998, Popper pers. Comm.).
Salmoniformes	Salmons/trouts/ chars	Pelagic	Some species are able to detect sounds from 30 Hz to about 400 Hz (Hawkins and Johnstone, 1978; Knudsen et al., 1992).
Gadiformes	Cods/hakes/haddock/ pollock	Pelagic and demersal	Hearing range of the cod (*Gadus morhua)* is 10-500 Hz (Chapman and Hawkins, 1973), while that of the haddock (*Melanogrammus aeglefinus*) is from 30-470 Hz. Pollack (*Pollachius polachius*) hears about the same range of sounds (Chapman, 1973). The ling (*Molva molva*) reportedly detects sounds from 40-550 Hz (Chapman, 1973).
Pleuronectiformes	Flounders/sole/ halibut	Demersal	*Pleuronectes platessa* and *Limanda limanda* can detect sounds up to 200 Hz (Chapman and Sand, 1974), while *Pleuronectes* is able to detect sounds as low as 30 or 40 Hz (Karlsen, 1992).

Table 3.2-1

Selected Fish Orders

Fish Order	Common Name (representative of order)	Pelagic or Demersal	Hearing Characteristics
Beryciformes	Squirrelfish	Pelagic and demersal	One species of squirrelfish (*Myripriste kuntee*) can detect sounds between 100-3,000 Hz with most sensitivity between 300-2000 Hz, while another (*Adioryx xantherythrus*) can only detect to about 1000 Hz (Coombs and Popper, 1979) and the dusky squirrelfish (*Holocentrus vexillaris*) detects sounds from 100-1200 Hz (Tavolga and Wodinsky, 1963). Large variability in hearing capabilities within this group of fishes.
Scorpaeniformes	Searobbins	Demersal	Slender searobbin (*Prionotus scitulus*) detects sounds from 100-600 Hz, with best sensitivity from 200-400 Hz (Tavolga & Wodinsky, 1963).
Perciformes (note, this is such a diverse group of fishes that they are broken down by taxonomic family)	Tunas (Scombridae)	Pelagic and demersal	Yellowfin tuna (*Thunnus albacares*) hearing range 50-1100 Hz with most sensitive hearing between 300 and 500 Hz (Iverson, 1967). This species has much better sensitivity than another tuna, the kawakawa (*Euthynnus affinis*) that has the same hearing range (Iverson, 1967).
	Damselfishes (Pomacentridae)	Demersal	Various species in this family (genus *Eupomacentrus*) can detect sounds from 100 to 1,200 Hz, with best hearing from 300-600 Hz (Myrberg and Spires, 1980)
	Wrasses (Labridae)	Pelagic and Demersal	Very diverse group and not likely that data for one species represent variation in hearing likely to be found. However, blue-head wrasse (*Thalassoma bifasciatum*) can detect sounds from 100-1200 Hz, with best sensitivity from 200-600 Hz (Tavolga & Wodinsky, 1963).
	Sea basses (Serranidae)	Pelagic and demersal	Only data are for the red hind (*Epinephelus guttatus*) which can hear from 100-1000 Hz, with best sensitivity from 200-400 Hz (Tavolga and Wodinsky, 1963).
	Snappers (Lutjanidae)	Pelagic and demersal	Schoolmaster (*Lutjanus apodus*) hears from 100-1000 Hz, with best sensitivity from 200-600 Hz.
	Drums (croakers) (Sciaenidae)	Pelagic and demersal	One member of this group, the chubbyu (*Equetus* acuminatus) hears from 100-2000 Hz, with best hearing from 200-1000 Hz (Tavolga and Wodinsky, 1963). However, there is broad diversity in ear structure in members of this family, suggesting that there is also broad diversity in hearing (Popper, Pers. Comm.)

Table 3.2-1

Selected Fish Orders

Fish Order	Common Name (representative of order)	Pelagic or Demersal	Hearing Characteristics
	Grunts (Haemulidae)	Demersal	Blue-striped grunt (*Haemulon sciurus*) hears from 75-1000 Hz, with best hearing from 75-800 Hz (Tavolga and Wodinsky, 1963).

Vibrations are perceived with sensory hair cell receptors of the ear and the lateral line. The lateral line is actually divided into two parts, the canal system and the free neuromasts. The sensory hair cells of the lateral line are arranged in small groups called neuromasts. The neuromasts of the canal system are spaced evenly along the bottom of canals that are located on the head and extending along the body. The free neuromasts are distributed over the surface of the body. The specific arrangement of the lateral line canals and the free neuromasts vary with different species (Coombs et al., 1992). The pattern of the lateral line canal suggests that the receptors are laid out to provide a long baseline to enable the fish to extract information about the direction of the sound source relative to the animal. The latest data suggest that the free neuromasts detect water movement (e.g., currents), whereas the receptors of the lateral line canals detect hydrodynamic signals. By comparing the responses of different hair cells along such a baseline, the fish should be able to use the receptors to locate the source of vibrations (Montgomery et al., 1995; Coombs and Montgomery, 1999). Moreover, the lateral line appears to be most responsive to relative movement between the fish and surrounding water (its free neuromasts are sensitive to particle velocity; its canal neuromasts are sensitive to particle acceleration). The ear and the lateral line overlap in frequency range to which they respond. The lateral line appears to be most responsive to signals ranging from below one Hz to between 150 and 200 Hz (e.g., Coombs et al., 1992), while the ear responds to frequencies from about 20 Hz to several thousand Hz in some species (Popper and Fay, 1993). The specific frequency response characteristics of the ear and lateral line varies among species and is probably related, at least in part, to the life styles of the particular species.

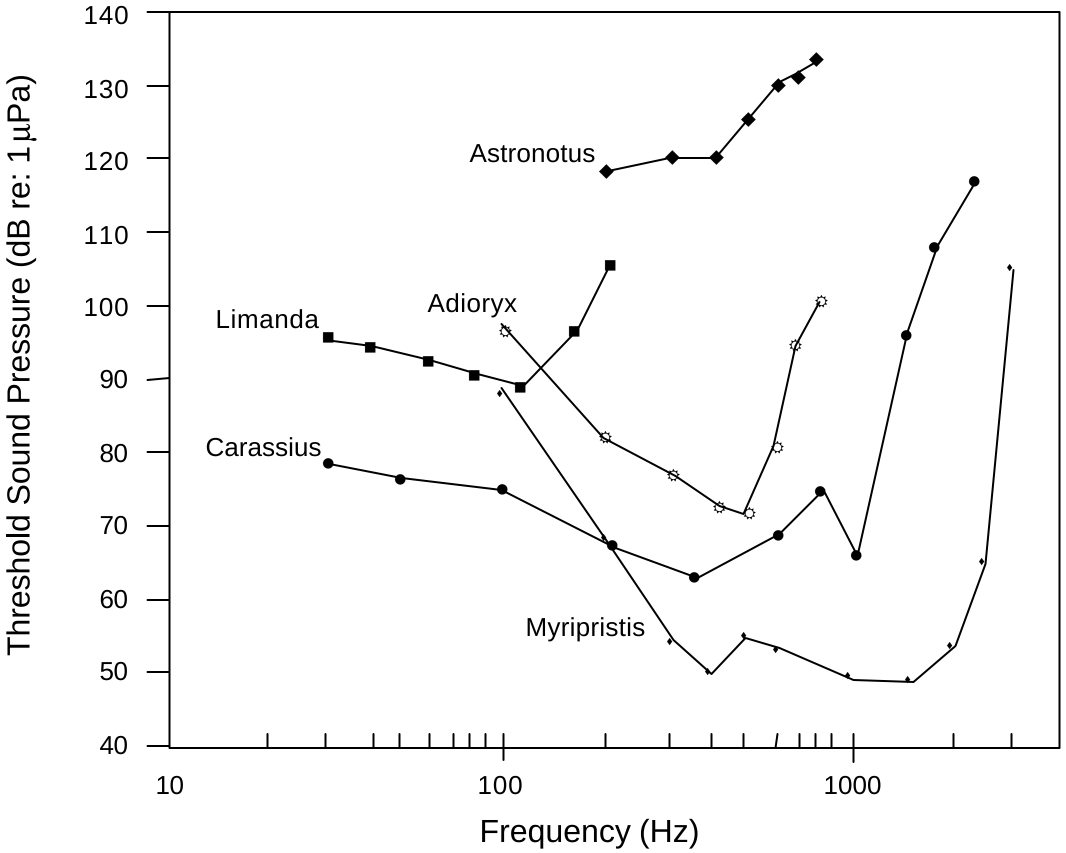
The inner ear in fishes is located in the head just behind the eye and there is no apparent feature on the head of fish, or an opening that indicates its location. The ear in fishes is generally similar in structure and function to the ears of other vertebrates. It consists of three semicircular canals that are used for detection of angular movements of the head, and three otolithic organs that respond to both sound and changes in body position (Schellart and Popper, 1992). The sensory regions of the semicircular canals and otolith organs contain many sensory hair cells. In the otolith organs, the ciliary bundles, which project upward from the top surface of the sensory hair cells, contact a dense structure called an otolith (or ear stone). It is the relative motion between the otolith and the sensory cells that results in stimulation of the cells and responses to sound or body motion. The precise size and shape of the ear varies in different fish species (Popper and Coombs, 1982; Schellart and Popper, 1992).

Hearing is better understood for bony fishes than other fish, such as sharks and jawless fishes (class Agnatha) (Popper and Fay, 1993). Fish with specializations that enhance their hearing sensitivity have been referred to as hearing "specialists;" whereas, those that do not posses such capabilities are termed "nonspecialists." Popper and Fay (1993) suggest that in the hearing specialists, one or more of the otolith organs may respond to sound pressure as well as to acoustic particle motion. The response to sound pressure is thought to be mediated by mechanical coupling between the swim bladder (the gas-filled chamber in the abdominal cavity that enables a fish to maintain neutral buoyancy) or other gas bubbles and the inner ear. With this coupling, the motion of the gas-filled structure, as it expands and contracts in a pressure field, is brought to bear on the ear. In nonspecialists, however, the lack of a swim bladder, or its lack of coupling to the ear, probably results in the signal from the swim bladder attenuating before it gets to the ear. As a consequence, these fishes detect little or none of the pressure component of the sound (Popper and Fay, 1993).

The vast majority of fishes appear to be non-specialists (Schellart and Popper, 1992), and only a few specialists are known to inhabit the marine environment (although lack of knowledge of specialists in the marine environment may be due more to lack of data on many marine species, rather than on the lack of their being specialists in this environment). Although data are limited, it appears that the majority of hearing specialists are found in fresh water. Some of the better known marine hearing specialists are found among the Beryciformes (i.e., soldierfish and especially Holocentridae, which includes the squirrelfish), and Clupeiformes (i.e., herring and shad). Even though there are hearing specialists in each of these taxonomic groups, most of these groups also contain numerous species that are nonspecialists. In the family Holocentridae, for example, there is a genus of hearing specialists, *Myripristis*, and a genus of nonspecialists, *Adioryx* (Coombs and Popper, 1979).

Audiograms have been determined for over 50 fish (mostly fresh water) and three shark species (Fay, 1988a). An audiogram plots auditory thresholds (minimum detectable levels) at different frequencies and depicts the hearing sensitivity of the species. It is difficult to interpret audiograms because it is not known whether sound pressure or particle motion is the adequate stimulus and whether background noise determines threshold. The general pattern that is emerging indicates that the hearing specialists detect sound pressure with greater sensitivity over a wider bandwidth (up to 3 kHz) than the nonspecialists. Also, the limited behavioral data available suggest that frequency and intensity discrimination performance may not be as acute in nonspecialists (Fay, 1988a).

Behavioral audiograms are presented for two hearing specialists (Pacific sardine and squirrelfish), two nonspecialists that have a swim bladder (another squirrelfish and an oscar), and one nonspecialist without a swim bladder (lemon sole) (Figure 3.2-2). Popper and Fay (1993) state that threshold values are expressed as sound pressure levels because that quantity is easily measured, although this value is strictly correct only for the fishes that respond in proportion to sound pressure. It is uncertain if the thresholds for the oscar and lemon sole should be expressed in terms of sound pressure or particle motion amplitude. In comparing best hearing thresholds, hearing specialists are similar to most other vertebrates, when thresholds determined in water and air are expressed in units of acoustic intensity (i.e., Watts/cm^2) (Popper and Fay, 1993).



Two hearing specialists: *Carassius auratus* (goldfish)(Fay, 1969) *and Myripristis kuntee* (squirrelfish)(Coombs and Popper, 1979); two hearing nonspecialists having a swimbladder, *Adioryx xantherythrus* (another squirrelfish)(Coombs and Popper, 1979), and *Astronotus ocellatus* (the Oscar)(Yan and Popper, 1992); and a nonspecialist without a swimbladder, *Limanda limanda* (lemon sole)(Chapman and Sand, 1974)

Figure 3.2-2. Behavioral Audiograms

The specialists whose best hearing is in the LF register (i.e., below 1000 Hz) appear well adapted to this particular range of frequencies, possibly because of the characteristics of the signals they produce and use for communication, or the dominant frequencies that are found in the general underwater acoustic environment to which fish listen (Schellart and Popper, 1992; Popper and Fay, 1997, 1999). The region of best hearing in the majority of fishes for which there are data available is from 200 Hz up to 500-800 Hz. Most species, however, are able to detect sounds to well below 200 Hz, and often there is good detection in the LF range of sounds. It is unlikely that as data are accumulated for additional species, investigators will find that more species are able to detect LF sounds fairly well (Popper, pers. comm., 2000).

As for sound production in fish, Myrberg (1980) states that members of more than 50 fish families produce some kind of sound using special muscles or other structures that have evolved for sound production, or by grinding teeth, rasping spines and fin rays, burping, expelling gas, or gulping air. Sounds are often produced by fish when they are alarmed or presented with noxious stimuli (Myrberg, 1981). These emanations are usually intense and have a sudden onset, like signals used by both terrestrial and aquatic animals to startle one class of receivers (e.g., nearby predators). Some of these sounds may involve the swim bladder as an underwater resonator. Sounds produced by vibrating the swim bladder may be at a higher frequency (400 Hz) and the swim bladder drumming muscles are correspondingly specialized for rapid contractions (Zelick et al., 1999). Sounds also accompany the reproductive activities of numerous fish species, and the current data suggest that males are the most active producers. Sound activity often accompanies aggressive behavior in fish, usually peaking during the reproductive season. Those benthic fish species that are territorial in nature throughout the year often produce sounds regardless of season, particularly during periods of high-level aggression (Myrberg, 1981).

3.2.2.3 Sharks

Sharks are also of interest because of their LF sound detection ability, a capability that is particularly important for detecting sounds that are produced by potential prey (Nelson and Gruber, 1963; Myrberg et al., 1976; Nelson and Johnson, 1976; Myrberg, 1978). There are hearing data on very few species, and several studies have found that they may be sensitive to both sound pressure and to particle velocity or displacement. In general, sharks hear only a narrow range of frequencies and their hearing capability is not very good (Banner, 1967; Nelson, 1967; Kelly and Nelson, 1975). Although almost nothing is known about the function of the lateral line system of sharks, it is likely that this system, like in fishes, responds to LF hydrodynamic stimuli.

Several studies of LF sound effects on sharks have occurred during the last four decades. Behavioral evidence indicates that certain LF sound signals, particularly in the 20 to 80 Hz range, can attract sharks (Popper, 1977). Hammerhead sharks have been found to be able to detect sounds below perhaps 750 Hz, with best capability from 250 to 275 Hz (Olla, 1962). Kritzler and Wood (1961) reported that the bull shark responded to signals at frequencies between 100 and 1,400 Hz, with the band of greatest sensitivity 400 to 600 Hz.

Lemon sharks responded to sounds varying in frequency from 10-640 Hz, with the greatest sensitivity at 40 Hz. However, the lowest frequency may not accurately represent the lower limit of lemon shark hearing due to the energy production limitations of the shark test pool. The sharks may have responded at higher frequencies, but not enough energy could be produced to elicit attraction responses (Nelson, 1967). Banner (1972) reported that lemon sharks he studied responded to sounds varying from 10 to 1,000 Hz. In a conditioning experiment with horn sharks, Kelly and Nelson (1975) discovered the sharks responded to frequencies of 20 to 160 Hz. The lowest particle motion threshold was at 60 Hz.

Researchers have also discovered several shark species that appear to exhibit withdrawal responses to broadband noise (500-4,000 Hz). The oceanic silky shark (*Carcharhinus falciformis*) and coastal lemon shark (*Negaprion brevirostris*) withdrew from an underwater speaker playing LF sounds (Myrberg et al., 1978; Klimley and Myrberg, 1979). Lemon sharks exhibited withdrawal responses to broadband noise raised 18 dB at an onset rate of 96 dB/sec to a peak amplitude of 123 dB re 1 micro Pascal (RL) from a continuous level, just masking broadband noise (Klimley and Myrberg, 1979). Myrberg et al. (1978) reported that a silky shark withdrew 10 m (33 ft) from a speaker broadcasting a 150-600 Hz sound with a sudden onset and a peak sound pressure level of 154 dB. These sharks avoided a pulsed LF attractive sound when its sound level was abruptly increased by >20 dB. Other factors enhancing withdrawal were sudden changes in the spectral or temporal qualities of the transmitted sound. Klimley (unpublished data) also noted the increase in tolerance of lemon sharks during successive sound playback tests. Myrberg (1978) has also reported withdrawal response from the pelagic whitetip shark (*Carcharhinus longimanus*) during limited testing.

Animals are known to eventually change their behavior when a given stimulus has no consequence. Such animals learn to ignore irrelevant stimuli. Such learning, known throughout the vertebrates and many invertebrates, is termed habituation. Those species of sharks that have been studied showed habituation to intense sound after a varying number of trials when immediate withdrawal was the demonstrated response (Myrberg, pers. comm., 29 November 1999).

Fay (1988a) summarized the results of hearing studies of the horn, lemon and bull shark. Within the 100-500 Hz frequency band, the lemon shark exhibits best hearing, with hearing thresholds down to 90 dB. Next best is the bull shark with thresholds down to 100 dB. The horn shark has much poorer hearing capability in this LF band, with thresholds at 130-140 dB.

One caveat with all data collected with sharks is that they are generally obtained from studies of a single animal, and it well known that sound detection ability (and bandwidth) varies considerably among different, and even among members of the same species. Moreover, it is known that hearing ability changes with age, health, and many other variables. Thus, while these thresholds (and all of those reported for sharks) give an indication of the sounds they detect, it would be of great value to replicate these analyses using modern methods and several animals. A similar observation may be made for some fish studies, but generally those are done with several animals and are replicated far more than is possible with the larger and more difficult-to-handle sharks. However, for the most part, data for an individual fish species (including sharks) can often be accepted as being generally reliable for that species.

The effect of pulse intermittency and pulse-rate variability on the attraction of five species of reef sharks to LF pulsed sounds was studied at Eniwetok Atoll, Marshall Islands in 1971 (Nelson and Johnson, 1972). The species of shark tested were: gray reef, blacktip reef, silvertip, lemon and reef white tip. Nelson and Johnson (1972) concluded from these tests that the attractive value of 25-500 Hz pulsed sounds is enhanced by intermittent presentation, and that such intermittency contributes more to attractiveness than does pulse-rate variability. All tested sharks exhibited habituation to the sounds during the course of the experiment.

3.2.2.4 Threatened and Endangered Fish Stocks

The following fish have been listed by NMFS as threatened (T) or endangered (E) under ESA:

Threatened and Endangered Fish Stocks

- Coho salmon (*Oncorhynchus kisutch*)(T): central California coast, northern California/southern Oregon, and Oregon Coast;
- Chinook salmon (*Oncorhynchus tshawytscha*)(E): North Pacific Ocean basin;
- Sockeye salmon (*Oncorhynchus nerka*)(E): North Pacific Ocean basin;
- Cutthroat trout (Umpqua River)(*Oncorhynchus clarki clarki*)(E): U.S. and Canadian coastal zone from southeast Alaska to northern California (within 18.5 km [10 nm] of coast);
- Steelhead trout (*Oncorhynchus mykiss*)(T): Washington, Oregon, and North California coastal and inland waters;
- Shortnose sturgeon (*Acipenser brevirostrum*)(E): U.S. and Canadian North Atlantic Ocean coast;
- Gulf sturgeon (*Acipenser oxyrinchus desotoi*)(T): U.S. Gulf of Mexico coasts from Mississippi River to Tampa Bay; and
- Totoaba (*Cynoscion macdonaldi*)(E): Gulf of California.

Fish that are federally or state listed as endangered, threatened or protected retain that status only in estuarine or near-shore waters, not in the open ocean, where SURTASS LFA sonar would operate.

3.2.3 Sea Turtles

3.2.3.1 Background

Sea turtles are marine reptiles well adapted for life in the sea. Their streamlined bodies and flipper-like limbs make them strong swimmers able to navigate across the oceans (e.g., leatherbacks and loggerheads). When they are active, they must swim to the ocean surface to breathe every few tens of minutes (Keinath, 1993). When they are resting, they can remain underwater for much longer periods of time. With the exception of the leatherback sea turtle (*Dermochelys coriacea*), which is primarily a temperate species, sea turtles dwell in tropical waters, ranging into temperate zones in the summer (Ernst et al., 1994).

Distribution of sea turtles is throughout all oceans; however, for most species, their distribution is limited by temperature. Most sea turtle species prefer water temperatures above 18º C, but can survive in waters as cool as 10º C (50º F). This means that most sea turtle distribution is limited between 40ºN and 35ºS, although during warmer seasons this range is substantially expanded. The exception to this distribution is the leatherback, which is found from 71ºN to 65ºS, and seems to prefer water temperatures between 14º and 16º C (57º and 61º F) for foraging, but also spends extended periods in tropical waters for breeding.

Hawksbills, greens, olive ridleys and Kemp's ridleys are generally coastal species, although it is likely that the young of some or all of these species can be found in the open ocean. Nevertheless, because of the incorporation of geographic mitigation measures, the fact that a small fraction of ocean volume would make up the LFA mitigation zone, and that the criterion developed for the potential for injury to marine mammals is a reasonably conservative estimate for possible injury to sea turtles, it is unlikely that any sea turtle stock would experience significant impacts.

Although they live most of their lives in the ocean, adult females return to their natal beaches in order to lay eggs. The females come ashore two or more times a season to lay a hundred or more eggs in a deep nest cavity dug with the hind flippers. After filling the nests, the adult females return to the sea and generally remain near the nesting area until they have deposited their last clutch of eggs for the season.

Hatchlings, upon emerging from their nests, rely on the lighter horizon over the sea to find the ocean. After entering the water, both magnetic orientation and the oncoming direction of sea swell guide them away from shore (Ernst et al., 1994). All marine turtle species will then remain pelagic for many years and may travel through a large range of habitats before returning to coastal environments to reside. Once in coastal waters (excluding the leatherback), juvenile turtles continue to grow and move among developmental environments until maturity, when their pattern of movements becomes more regular, with turtles moving between foraging and breeding areas (Wyneken, 1997).

The protected status (with respect to the U.S. Endangered Species Act [ESA] and the Convention on International Trade in Endangered Species [CITES]), and other attributes of the sea turtles species selected for study are summarized in Table 3.2-2. Following is a brief summary of each species.

The **leatherback turtle** (*Dermochelys coriacea*) is the largest, most pelagic, and most widely distributed of any sea turtle from 50°N to 35°S (Eckert, pers. comm., 1998). It is also considered by most authorities to be the most endangered of the sea turtles due to the rapid decline in global population during the last 15 years (Eckert, pers. comm.). Leatherbacks are distributed from 71°N (Barents Sea) to the Antarctic Convergence (based on recent satellite tracking data from South Africa). Recent data indicate that there may be important migratory corridors and habitats used by the species in the Pacific Ocean (Morreale et al., 1996; Eckert, 1999). Current information indicates that the leatherback prefers water temperature between 14-16°C (57-61°F) for foraging, though it exhibits extraordinary thermal tolerance and is often observed in much colder water. It feeds primarily on jellyfish and is a deep, nearly continuous diver (Eckert et al., 1996). It rarely stops swimming and individuals have been monitored swimming in excess of 13,000 km (7,014.8 nm) per year (Eckert, 1998; Eckert, 1999; Eckert, pers. comm.). It is endangered according to the ESA and CITES. Although it has not been subject to significant commercial exploitation, its global population size is declining, due most likely to incidental mortality associated with open ocean fishing. It has been speculated that females use LF sound associated with surf to orient toward nesting beaches in turbid water (Mrosovsky, 1972).

The **green turtle** (*Chelonia mydas*) is widespread throughout tropic and temperate seas. There are a number of morphologically distinct stocks, one of which is the black turtle in the Eastern Pacific (Pritchard, 1997). Hatchlings and young turtles are pelagic and omnivorous, but juveniles and adults forage on benthic algae and sea-grasses. They are, therefore, primarily coastal as juveniles and adults, but make long pelagic migrations between foraging and breeding areas (Bjorndal, 1997; Pritchard, 1997). Population sizes are not known, but they appear to be declining, at least since the 1950s, and are considered threatened by the ESA everywhere except Florida and the Pacific Coast of Mexico, where they are endangered. They are also protected by CITES.

The **loggerhead turtle** (*Caretta caretta*) is a large, widespread turtle that feeds primarily on benthic invertebrates (Ernst et al., 1994; Bjorndal, 1997). Loggerhead turtles reside and nest in subtropical to temperate areas (e.g., North Carolina to Florida, Oman, Northeastern Australia, Japan) and in some stocks, they have long cross-basin migrations between feeding and nesting areas. They are listed as threatened under the ESA and are protected by CITES. The primary threat to their populations is incidental capture by commercial trawlers and longline fishing nets. As hatchlings they undertake long developmental migrations. Turtles hatched in Japan cross the Pacific to spend some years living off the U.S. and Mexican coasts. Hatchlings on the eastern coast of the U.S. cross the Atlantic before they return to the coastal waters near where they were hatched (Wyneken, 1997).

Table 3.2-2

Information Summary for Selected Turtle Species

Species	Protected Status	Distribution	Abundance/ Population	Diving Behavior	Travel Speeds
Leatherback Turtle (*Dermochelys coriacea*)	ESA endangered; CITES protected	- Tropical and temperate pelagic waters; - May aggregate at concentrations of jellyfish and areas of coastal upwelling; - Most significant nesting areas: Mexico, Costa Rica, Trinidad, Surinam/French Guyana, Indonesia, Culebra, Puerto Rico, and St. Croix U.S. Vi.	- Recent global population estimates for mature female turtles: 26,200-42,900; - Total adult population probably double above, but total population unknown; - Gulf of Mex: 5 turtles per 1,000 sq km	- Routinely dive to 50-84 m, regularly exceed 200 m; - Typical durations: 9-15 min; - Maximum dive time 37 min.; - Maximum depth >1000 m; - Dive and swim throughout day and night	- During long movements or migration: 45-65 km per 24 hours; - Average swim speed: 2.21 kph (0.614 m/s); -- Hatchlings: 30cm/sec below surface
Green Turtle (*Chelonia mydus*)	ESA threatened everywhere except FL and Pac. Coast of Mexico where listed as endangered; CITES protected	- Green turtles found throughout tropics; - Breeds on tropical beaches throughout the world	- Recent population estimates not available; - Consensus that numbers have been declining since 1950s	- Routinely dive to 20 m; - Average dive time > 40 min.; Maximum dive time of 66 min	- 0.95 km/ hr and have been measured at 1.4-2.2 kph; - Adults sedentary; though migrations cover distances greater than 100 km
Loggerhead Turtle (*Caretta caretta*)	ESA threatened; CITES protected	- Tropical and subtropical waters of the Atlantic, Pacific, and Indian Oceans; - Relatively solitary except when aggregating on food concentrations or near nesting beaches; - About 88% of all nesting occurs on beaches in the S/E U.S., Oman, and Australia	- Estimated population size for S/E U.S. is 30,000-35,000 nesting females; - Estimated 250,000 females worldwide; - Estimated total population over 500,000 worldwide.	- Routinely dive to 9-22 m; - Average dive time 17-30 min.; - Maximum recorded dive is 233 m	1.2-1.7 km/ hr and have been measured at 0.02 - 3.01 kph

Table 3.2-2

Information Summary for Selected Turtle Species

Species	Protected Status	Distribution	Abundance/ Population	Diving Behavior	Travel Speeds
Hawksbill Turtle (*Eretmochelys imbricata*)	ESA endangered; CITES protected	- Worldwide tropical waters; - Hatchlings pelagic, but older juveniles and adults live in clear shallow waters over reefs	Population estimates not available	- Routinely dive to 7-10 m; - Average dive time 56 min.; - Dive during day and night	0.74 kph
Olive Ridley Turtle (*Lepidochelys olivacea*)	ESA threatened (Mexican population endangered);CITES protected	- Worldwide tropical waters; - While large juveniles and adults reside primarily within 100 km of the coast, and aggregate in large concentrations in coastal waters during the nesting season, olive ridleys will often range far out to sea (>100 km) in certain areas of the world (e.g. Eastern Tropical pacific and Indian Ocean).	Most abundant sea turtle, though population estimates not available	- Average dive time 29-54 min.; - Maximum recorded dive is 290 m	1.2-3.6 km/ hr
Kemp's Ridley Turtle (*Lepidochelys kempi*)	ESA endangered; CITES protected	Primarily in Gulf of Mexico	Most rare sea turtle in the world, though population estimates not available	- Routinely dive to 50 m; - Average dive time 13-18 min.;	1.0-1.4 km/ hr

Source: Croll et al., 1999.

The **hawksbill turtle** *(Eretmochelys imbricata)* is a tropical, primarily near-shore reef dwelling turtle that feeds on benthic sponges (Witzell, 1983). Hawksbill turtles nest in a number of scattered tropical locations, usually under coastal vegetation. There are very few sites where females concentrate for breeding. Some adults make long migrations between feeding and nesting areas, but juveniles are relatively sedentary on shallow reefs (Bjorndal, 1997). They are listed as endangered under the ESA and are protected by CITES.

The **olive ridley turtle** (*Lepidochelys olivacea*) is the most abundant sea turtle. It is found throughout the tropics, but is concentrated around several very limited nesting beaches in Costa Rica, Mexico, and India (Musick and Limpus, 1997). The global population is protected by CITES and is listed as threatened under the ESA everywhere except the Mexican breeding stocks, which are listed as endangered. Olive ridleys are omnivorous, feeding on a wide variety of animals and algae from diverse marine habitats.

The **Kemp's ridley turtle** (*Lepidochelys kempi*) is the rarest sea turtle. It is listed as endangered under the ESA and is protected by CITES. Kemp's ridley turtles are found primarily in the Gulf of Mexico and, to a lesser extent, along the Atlantic coast of the United States as far north as Long Island, New York (Musick and Limpus, 1997). They feed primarily on crabs (Bjorndal, 1997). Kemp's ridley turtles nest primarily at Rancho Nuevo Mexico in the Gulf of Mexico (only rarely has significant nesting been observed at any other beaches). There are consistent reports of large concentrations of mating adults at sea, suggesting breeding aggregations well offshore (NRC, 1990).

3.2.3.2 Turtle Hearing Capabilities and Sound Production

Data on turtle sound production and hearing are few (Croll et al., 1999). The few studies completed on the auditory capabilities of sea turtles also suggest that they could be capable of hearing LF sounds. These investigations examined adult green, loggerhead, and Kemp's ridley sea turtles (Mrosovsky, 1972). There have been no published studies to date of olive ridley, hawksbill, or leatherback sea turtles. It has been suggested, albeit based on data from just a few species, that all species can hear LF sound as adults (Ridgway et al., 1969; O'Hara and Wilcox, 1990; Bartol et al., 1999).

Ridgway et al. (1969) used airborne and direct mechanical stimulation to measure the cochlear response in three specimens of green sea turtle, and concluded that they have a hearing range of about 60 to 1000 Hz, but hear best between 200 and 700 Hz, with sensitivity falling off considerably below 200 Hz. The maximum sensitivity for one animal was 300 Hz, and for another 400 Hz. At the 400-Hz frequency, the turtle's hearing threshold was about 64 dB in air. At 70 Hz, it was about 70 dB in air. Bartol et al. (1999) measured the hearing of juvenile loggerhead sea turtles using auditory evoked potentials. Auditory brainstem response (ABR) recordings from LF tone burst indicated the range of hearing to be from at least 250 to 750 Hz. The lowest frequency tested was 250 Hz.

3.2.4 Cetaceans (Mysticetes)

Cetaceans (whales and dolphins in the order Cetacea) are highly modified mammals found in all the world's seas and oceans. There are two suborders of cetaceans: baleen whales, or Mysticeti; and toothed whales, or Odontoceti. The mysticetes, or baleen whales, include the largest animal ever to live on earth, the blue whale, which can reach 30 m (100 ft) in length and 145,000 kilograms (kg) (160 tons) in weight. Mysticetes are distinguished by possessing keratinous baleen plates in their mouths that are used to strain small food organisms from seawater. The mysticetes include four families containing 11 species (see text box below).

Mysticetes

Family: Balaenopteridae (Rorquals)
- Blue whale (*Balaenoptera musculus*)
- Fin whale (*B. physalus*)
- Bryde's whale (*B. edeni*)
- Sei whale (*B. borealis*)
- Minke whale (*B. acutorostrata*)
- Humpback whale (*Megaptera novaeangliae*)

Family: Balaenidae (Right whales)
- Bowhead whale (*Balaena mysticetus*)
- Northern right whale (*Eubalaena glacialis*)
- Southern right whale (*E. australis*)

Family: Eschrichtiidae
- Gray whale (*Eschrichtius robustus*)

Family: Caperea
- Pygmy right whale (*Caperea marginata)*

Cetacean species vary considerably in size from harbor porpoises at less than a meter (3 ft) to the blue whale. The general description of cetaceans in this section is taken from Leatherwood and Reeves (1983) and Castello (1996).

The sense of hearing is highly developed in all cetacean species studied to date. It is assumed that mysticete species rely heavily on sound for communication and sensing of their environment (Norris, 1969; Watkins and Wartzok, 1985). All mysticetes produce LF sounds, and several are known to use sound for communication (Clark, 1982; Tyack, 1982).

Many cetacean populations have been reduced by intensive hunting conducted over the last several hundred years. An International Union for Conservation of Nature and Natural Resources (IUCN) report (Reeves and Leatherwood, 1994) found that cetacean populations today are threatened by hunting, incidental capture in commercial fishing nets as bycatch, culling operations as a consequence of perceived competition with humans for marine resources, pollution, and habitat loss and degradation.

Cetaceans are generally long-lived, although the smallest species have a life expectancy of less than 10 years. Mature female cetaceans give birth to a single calf every few years, though the smallest species may calve annually. Age at first reproduction ranges from a few years in the smaller species to more than a decade in some of the larger species. Long maturation intervals and low annual reproductive capacity limit their capacity to recover from depressed population levels.

Social systems range from relatively solitary (e.g., Bryde’s whale) to more social (e.g., humpback and right whales) (Gambell, 1985b; Stewart and Leatherwood, 1985; Tershy, 1992). Whales may congregate during certain activities, for instance while foraging on feeding grounds, or during certain times of the year, for instance during mating periods. These social contexts influence the distribution of animals, and might influence the manner in which they respond to disturbance.

Cetaceans have evolved to exploit virtually all productive marine, estuarine, and many riverine habitats. Cetacean distributions are roughly correlated with that of their prey, and they are often associated with fertile continental shelves, ocean fronts, upwelling areas, or water mass convergence zones. Many cetaceans feed upon fish, squid or crustaceans in pelagic waters. Many species undergo seasonal north-south migrations that track peaks in prey availability, but others may reside year-round in areas bounded by tens of kilometers.

3.2.4.1 Mysticete Acoustic Capabilities

All species of baleen whales produce some form of LF sound below 400 Hz (Thompson et al., 1979; Watkins and Wartzok, 1985; Clark, 1990; Edds-Walton, 1997). From the perspective of potential acoustic impact from anthropogenic LF sounds, mysticetes can be divided into the following two general categories based on considerations of water depth, frequency band in which most species produce sound, and predicted frequency band of best hearing:

- **Pelagic Species -** The pelagic category contains the five of six rorqual species. Pelagic species are found extensively in the open ocean throughout the year. Their breeding or calving areas are not known but are believed to be offshore. They occasionally feed along shelf edges and dive to depths of at least 300 m (1,000 ft). They produce very LF, repetitive sounds with most sound energy in the 15-200 Hz band.

- **Coastal Species -** The coastal species category (gray, humpback, southern right, northern right, and pygmy right whales) are primarily found in coastal areas except when migrating. They breed and calve in traditional shallow water areas. They produce highly variant, complex mixtures of sounds spanning approximately the 30-5,000 Hz frequency band, but the majority of sound energy is in the 80-400 Hz band.

Sound is the primary modality for such necessary behaviors as communication, for example as contact calls (Clark, 1983; Clark, 1989), and in male mating displays (Tyack, 1981).

No direct measurements of auditory thresholds in mysticetes have been made. It is generally believed that their auditory systems are well adapted for hearing at frequencies below 400 Hz (Fleischer, 1976, 1978; Ketten et al., 1993; Ketten, 1994a), and they likely hear best in the frequency range of their calls. For this reason the mysticete species described here are considered sensitive to LF sound.

Table 3.2-3 summarizes information on the protected status as designated by the ESA, CITES, and the IUCN. Also included in the table are data on the distribution, abundance, diving behavior, sound production and hearing of the ten mysticete whale species being evaluated for potential impacts.

3.2.4.2 Pelagic Mysticete Species

The **blue whale** occurs in all oceans of the world. The species is currently divided into two forms: *Balaenoptera musculus* (found in the Southern Hemisphere, the North Atlantic and the North Pacific Oceans), and *B. m. brevicauda* (the pygmy blue whale, found in the sub-Antarctic Indian Ocean and the southeast Atlantic Ocean) (Clapham and Brownell, 1996). They are primarily pelagic but are found along shelf areas during feeding (Yochem and Leatherwood, 1985). The global population estimate is about 11,200-13,000 individuals (Maser et al., 1981; U.S. Department of Commerce, 1983) with some stocks at extremely low levels as a result of commercial whaling. Blue whales are currently endangered under the ESA and protected under CITES, and classified as endangered by the IUCN.

Blue whales feed almost exclusively on euphausids, or krill, with dive depths tracking the depths of prey schools (Rice, 1978; Croll et al., 1999). Generally, blue whales make 5-20 shallow dives at 12-20 second intervals followed by a deep dive of 3-30 minutes (Mackintosh, 1965; Leatherwood et al., 1976; Maser et al., 1981; Yochem and Leatherwood, 1985; Strong, 1990; Croll and Tershy, pers. obs.). Croll and Tershy (pers. obs.) found that the dive depths of blue whales foraging off the coast of California during the day averaged 132 m (433 ft) with a maximum recorded depth of 204 m (672 ft) and a mean dive duration of 7.2 minutes. Nighttime dives are generally less than 50 m (165 ft) in depth (Croll and Tershy, pers. obs.; Croll et al., 1999). Important foraging areas include the edges of continental shelves and ice edges in polar regions (Yochem and Leatherwood, 1985; Reilly and Thayer, 1990). Swimming speeds during feeding are in the 0-6.5 kph (0-3.5 kt) range.

Traditionally, it was assumed that distribution and movement patterns consisted of seasonal migrations between higher latitudes for foraging and lower latitudes for mating and calving (Mackintosh, 1965; Lockyer, 1984). More recent data indicate that some summer feeding takes.

Table 3.2-3

Information Summary for Mysticetes

Species	Protected Status	Distribution	Abundance	Diving Behavior	Underwater Hearing/ Sound Production
Blue Whale (*Balaenoptera musculus*)	ESA endangered; CITES protected; IUCN endangered	- All oceans along edge of continental shelf in temperate and tropical zones - Higher latitudes in summer, lower latitudes in winter	Global estimates: 11,200 to 13,000	- 5-20 shallow dives at 12-20 sec intervals followed by a deep dive of 3-30 min - Avg. dive depth: 132 m; recorded maximum dive of 204 m	- No hearing data available; - Vocalizations are primarily in the 10-100 Hz range
Fin Whale (*Balaenoptera physalus*)	ESA endangered; CITES protected; IUCN endangered	- All oceans - Higher latitudes in summer, lower latitudes in winter	- 20,000 in N. Pacific - 103,000 in Southern Hemisphere; - 13,000 in N. Atlantic - 3,500 in Mediterranean	- 5-20 shallow dives of 13-20 sec duration followed by a deep dive of 1.5 to 15 min - Dive depths: 100 m-200 m typical; 300 m max	- No hearing data available - Sounds produced primarily in the 15-200 Hz range
Bryde's Whale (*Balaenoptera edeni*)	IUCN- Data deficient species	- Tropical and subtropical; - Primarily between 40° N and 40° S latitudes	- Data unavailable for most regions - In Western N. Pacific: 10,000 - 49,000	- Dive as long as 20 min - Surface as often as every minute	- No hearing data available - Sounds produced primarily in the 70-245 Hz range
Sei Whale (*Balaenoptera borealis*)	ESA endangered; CITES protected; IUCN endangered	- All oceans but concentrated in temperate zones; - Higher latitudes in summer, lower latitudes in winter	- 14,000 in N. Pacific - 37,000 in Southern Hemisphere - 13,500 in N. Atlantic	- 5-20 shallow dives at 20-30 sec intervals followed by a deep dive of 15 min - Dive depths inferred from diet probably don't exceed 100 m	- No hearing data available - Calls have only been recorded twice - consisted of phrases in the 1.5-3 kHz range
Minke Whale (*Balaenoptera acutorostrata*)	IUCN - lower risk/near threatened species	- All oceans - Higher latitudes in summer, lower latitudes in winter	- Most recent est. in N. Pacific: 17,000-28,000 - 200,000 in Southern Hemisphere - NE Atlantic: 86,000-113,000	- Surface once or twice before sounding - Dive depths probably less than 300 m (1,000 ft) based on diet	-No hearing data available - Many types of sound pulses produced from 60-20,000 Hz: Clicks from 3.3 kHz-20 kHz and moans, clicks and grunts from 60-140Hz.

Table 3.2-3

Information Summary for Mysticetes

Species	Protected Status	Distribution	Abundance	Diving Behavior	Underwater Hearing/ Sound Production
Humpback Whale (*Megaptera novaeangliae*)	ESA Endangered; CITES protected IUCN endangered	- All oceans - Nearshore feeders and breeders	- 1,400-2,100 in N. Pacific - 13,000-15,000 in Southern Hemisphere - 8,000-13,000 in the N. Atlantic	- Dives time: 2-5 min - Because prey is above 300 m (1,000 ft) dive depths are likely above that	- No direct data on hearing available. Modeling suggests sensitivities between 40 and 16,000 Hz. - Sounds produced primarily in the 20 Hz to 10 kHz range
Gray Whale (*Eschrichtius robustus*)	ESA - Western Pacific Population listed as Endangered; Eastern Pacific population delisted.	Usually in coastal N. Pacific, however during summer feeding seasons may be found far off coast.	26,600 Eastern N. Pac. Stock.	-Avg dive times: 4-5 min -Dive to less than 80 m	-No hearing data available -Produce sounds from 15 Hz-20 kHz
Northern Right Whale (*Eubalaena glacialis*)	ESA Endangered; CITES protected; IUCN Endangered	Primarily in temperate and subpolar waters of Northern Hemisphere	- N. Pacific and N/E Atlantic populations nearly extinct; - N/W Atlantic: 295-300	- Dive as deep as 306 m - Avg. dive depth is 7.3 m - Avg. dive time is 7 min	- No hearing data available - Moans less than 400 Hz; calls similar to S. Right Whale but few data
Southern Right Whale (*Eubalaena australis*)	ESA Endangered; CITES protected; IUCN - lower risk/ conservation dependent	Throughout Southern Hemisphere	Worldwide estimates: 1,500-3,000	- Not regarded as deep divers (prey just below surface) - Max. dive time: 20 min.	- No hearing data available - Produce sounds from 40-5,000 Hz
Pygmy Right Whale (*Caperea marginata*)	IUCN - lower risk/least concern species	Known only in temperate waters of S. Hemisphere	No data available	Does not seem to be a deep or prolonged diver, but, spends little time at the surface	- No hearing data available - One juvenile produced pulses between 60 and 300 Hz

Source: Richardson et al., 1995b; Croll et al., 1999; Rugh, et al, 1999.

place at low latitudes in "upwelling-modified" waters (Reilly and Thayer, 1990), and that some whales remain year-round at either low or high latitudes (Yochem and Leatherwood, 1985; Clark and Charif, 1998). Swimming speeds during migration are between 5-33 kph (2.7-17.8 kt) (Lockyer, 1981; Gagnon and Clark, 1993).

Calving and mating occur in late fall and winter (Millais, 1906; Mackintosh and Wheeler, 1929; Nishiwaki, 1952; Tomilin, 1957). Specific breeding areas are unknown and mating is assumed to occur in pelagic waters some time during the fall and winter when blue whales are in middle latitudes.

Blue whales produce a variety of LF sounds in a 10-100 Hz band (Cummings and Thompson, 1971; Edds, 1982; Thompson and Friedl, 1982; Alling and Payne, 1991; McDonald et al., 1995; Clark and Fristrup, 1997; Rivers, 1997; Ljungblad et al., In Press; Stafford et al. 1998, 1999a, 1999b). The most typical signals are very long, patterned sequences of tonal infrasonic sounds in the 15-40 Hz range. Estimated source levels are as high as 188 to 190 dB (Cummings and Thompson, 1971; NRC, 1997) In temperate waters, intense bouts of long, patterned sounds are very common from fall through spring, but these also occur to a lesser extent during the summer in high latitude feeding areas. Short sequences of rapid frequency-modulated (FM) calls in the 30-90 Hz band are associated with animals in social groups (Clark, pers. obs.; McDonald, pers. comm.; Moore et al., 1999). The seasonality and structure of long, patterned sounds suggest that these are male song displays for attracting females and/or competing with other males. The context for the 30-90 Hz calls suggests that they are communicative but not related to a reproductive function.

There are no data on hearing sensitivity for blue whales. In a study of the morphology of the auditory mechanics, Ketten (1994a) hypothesized that the blue whale has excellent LF hearing.

The **fin whale** is widely distributed and is found in all oceans of the world in pelagic and coastal areas. Most populations appear to be recovering from commercial whaling, and the global population estimate is about 100,000-150,000 (Maser et al., 1981; U.S. Department of Commerce, 1983). They are currently endangered under the ESA and protected under CITES, and classified as endangered by the IUCN.

Fin whales feed primarily upon planktonic crustaceans, but also take fish and squid (Gambell, 1985a; Piatt et al., 1989; Piatt and Methven, 1992). Generally, fin whales make 5-20 shallow dives 13-20 seconds in duration followed by a deep dive of 1.5 to 15 minutes (Gambell, 1985a; Strong, 1990; Croll and Tershy, pers. obs). Croll and Tershy (pers. obs.) recorded dive depths of 100-200 m (330-660 ft), with maximum depths of 300 m (1,000 ft) (Panigada et al., 1999). Dive depths and duration were significantly shorter at night than during the day, presumably in response to the daily vertical migrations of prey schools. Foraging areas tend to occur along continental shelves with productive upwellings or thermal fronts (Gaskin, 1972; Sergeant, 1977; Nature Conservancy Council, 1979). They tend to avoid tropical and pack ice waters (Meredith and Campbell, 1988), with the northern limit set by ice and the southern limit by warm water of approximately 15°C (60°F) (Sergeant, 1977).

Like blue whales, it is assumed that distribution and movement patterns consist of seasonal migrations between higher latitudes for foraging and lower latitudes for mating and calving (Mackintosh, 1965; Lockyer, 1984). Recent data indicate that some whales remain year-round at high latitudes (Clark and Charif, 1998) and other areas such as the Gulf of California (J. Urban, UABCS, La Paz, BCS. Mexico, pers. comm.), migrating only short distances of 100-200 km (53.9-107.9 nm) (Agler et al., 1993). Swimming speeds can be very high, with average rates between 9-12 kph (5-7 kt) (Ray et al., 1978; Watkins, 1981). Calving and mating occur in late fall and winter (Millais, 1906; Mackintosh and Wheeler, 1929; Nishiwaki, 1952; Tomilin, 1957). Specific breeding areas are unknown and mating is assumed to occur in pelagic waters, presumably some time during the winter when whales are in mid-latitudes.

Fin whales produce a variety of LF sounds, primarily in the 15-200 Hz band (Watkins, 1981; Watkins et al., 1987; Edds, 1988; Thompson et al., 1992;). The most typical signals are long, patterned sequences of short duration (0.5-2 seconds) infrasonic pulses in the 18-35 Hz range (Patterson and Hamilton, 1964; Watkins et al., 1987). Estimated source levels are as high as 186 dB (Patterson and Hamilton, 1964; Watkins et al., 1987; Thompson et al., 1992; McDonald et al., 1995). In temperate waters intense bouts of long, patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high-latitude feeding areas (Clark and Charif, 1998). Short sequences of rapid FM calls in the 20-70 Hz band are associated with animals in social groups (Clark, pers. obs.; Watkins, 1981; Edds, 1988; McDonald et al., 1995). The seasonality of the bouts of patterned sounds suggests that these are male reproductive displays (Watkins et al., 1987), while the individual counter-calling data of McDonald et al. (1995) suggest that the more variable calls are contact calls.

There are no data on hearing sensitivity for fin whales. In a study of the morphology of the mysticete auditory mechanics, Ketten (1994a) hypothesized that the fin whale has excellent LF hearing.

The **Bryde's whale** is found in low densities throughout the tropical and subtropical waters of the world (Omura, 1959). They are most commonly encountered in waters warmer than 15-20°C (60-70°F), between 40°N and 40°S latitudes. Population estimates for most regions are not available. In the western North Pacific, estimates range from 10,000 (Best, 1975) to 49,000 (Ohsumi, 1978). Nishiwaki (1972) speculated that due to this species' limited migration and confined distribution, the total world population is likely to be relatively small. They are currently classified as a data deficient species by the IUCN.

Bryde's whales feed primarily on schooling fish (i.e., sardines, herring, pilchard, mackerel) and euphausids (Best, 1960; Nemoto and Kawamura, 1977; Cummings, 1985a; Tershy, 1992; Tershy et al., 1993). Tershy (1992) reports that Bryde's whales increased feeding around dawn and dusk. Cummings (1985a) reports that Bryde's whales come to the surface as often as every minute and dive for as long as 20 minutes. Dive depths are not known but are assumed to be similar to those of blue and fin whales.

Best (1960) reported that Bryde’s whales breed throughout the year off South Africa, and Tershy et al. (1990) reported Bryde’s whale calves present throughout the year in the Gulf of California. Best (1975) also reported that the offshore population off South Africa breed only in the fall. Data on the speed of travel are not available, but are assumed to be similar to those of blue and fin whales (Croll and Tershy, pers. obs.). There is some evidence that Bryde’s whales remain resident in areas throughout the year, migrating only short distances (Best, 1960; Tershy, 1992).

Based on limited sound recordings, Bryde’s whales are known to produce a variety of short-duration (0.2 to 1.5 second), FM sounds in the 70-245 Hz band (Cummings, 1985a; Edds et al., 1993). Source levels were estimated at 156 dB. The function of the sounds produced by Bryde’s whales is unknown, but sounds are assumed to be used for communication. There are no data on hearing sensitivity for the Bryde’s whale. By comparison to what little is known about Balaenopterid auditory mechanics, it is assumed that they have excellent LF hearing (Ketten, 1994a).

The **sei whale** is broadly distributed, is primarily found in temperate zones of all oceans, and does not venture as far into polar waters as blue, fin, or minke whales. Allen (1980) estimated the abundance of sei whales as 14,000 for the North Pacific and 37,000 for the Southern Hemisphere populations. Sigurjonsson (1995) estimated the North Atlantic population size at approximately 13,500 individuals. Sei whales are currently endangered under the ESA protected under CITES, and classified as endangered by the IUCN.

As with other members of the family Balaenopteridae, sei whales are assumed to migrate to higher latitudes where they feed during the late spring through early fall and then migrate to lower latitudes where they breed during the fall through winter. Whalers considered the sei whale to be one of the fastest whale species; however, records of the movement speeds of sei whales are not available.

In the North Pacific, sei whales can be found during the summer from California to the Gulf of Alaska, across the Bering Sea and off the coasts of Korea and Japan. During the winter, centers of abundance move south to around 20°N (Gambell, 1985a). In the eastern North Pacific sei whales have been reported during the summer between 35-55°N. Little is known of stock separation, but three stocks are recognized (Leatherwood and Reeves, 1983). Less is known of the distribution of sei whales in the North Atlantic. In the eastern North Atlantic, they are believed to reside off Nova Scotia and Labrador during the summer and to winter as far south as Florida (Leatherwood and Reeves, 1983). In the western North Atlantic, they are found in the Denmark Strait, the Norwegian Sea, and in the vicinity of Great Britain where they mostly feed during the summer. In the winter months they are found off Spain, Portugal, and northwest Africa (Gambell, 1985a).

Generally the movements of sei whales in the Southern Hemisphere are similar to those of fin and blue whales (Gambell, 1985a), except they do not migrate as far south. Their main summer concentrations are between 40-50°S. In the winter, sei whales are present off Brazil, the east and west coasts of South Africa, and Australia. Open ocean wintering grounds are not known (Gambell, 1985a).

Sei whales feed predominantly on copepods in the higher latitudes and predominantly on schooling fish in the lower latitudes (Jonsgård and Darling, 1977; Rice, 1977; Nemoto and Kawamura, 1977; Kawamura, 1994; Sigurjonsson, 1995). Sei whales make shallow dives of 20-30 m (65-100 ft) followed by a deep dive up to 15 minutes in duration (Gambell, 1985a). The depths of sei whale dives have not been well studied; however, the composition of their diet suggests that they rarely perform dives in excess of 100 m (330 ft). No specific breeding areas are known, although mating presumably occurs some time when sei whales are at lower latitudes during the fall and winter.

Few sounds have been recorded from sei whales. Knowlton et al. (1991) and Thompson et al., (1979) recorded rapid sequences of FM pulses in the 1.5-3.0 kHz range near groups of feeding sei whales during the summer off eastern Canada. There are no data on hearing sensitivity for sei whales. By comparison to what little is known about Balaenopteran auditory mechanics, it is assumed that the sei whale has excellent LF hearing (Ketten, 1994a).

The minke whale is found throughout all oceans of the world. As with other balaenopterids, minke whales migrate to higher latitudes where they feed during the late spring through early fall and to lower latitudes where they breed during the fall through winter. Minke whales are widespread and abundant in the North Atlantic (Stewart and Leatherwood, 1985). They have been commercially exploited since at least 1923 (Kellogg, 1931), but global populations appear to be healthy. Minke whales are listed as IUCN lower risk/near threatened species.

When traveling, minke whales surface once or twice before sounding (Horwood, 1981) and are thus easily missed. Because they feed on small schooling fish near the surface, dive depths are likely to be relatively shallow (less than 300 m or 1,000 ft). Normal swimming speed has been reported as 6.1 kph (3.2 kt) (Lockyer, 1981). During migration, speeds of up to 25.9 kph (14 kt) have been observed (Lockyer, 1981). Folkow and Blix (1993) radio-tagged four minke whales and reported that surfacing rates were significantly higher during the day than at night. Markussen et al. (1992) modeled the activity budget of minke whales and assumed that 6 hr/day is spent in resting or sleeping, 14 hours per day is spent swimming at 6.1 kph (3.3 kt), and 4 hours per day is spent swimming at 25.9 kph (14 kt).

Breeding appears to take place during the winter in warmer waters, but little is known of breeding areas (Kasamatsu et al., 1995). Kasamatsu et al. (1995) also suggested that breeding populations are relatively dispersed in open waters.

Minkes produce a variety of sounds, primarily in the 80-5,000 Hz range. In the Northern Hemisphere, sounds recorded include “grunts,” “ thumps,” and “ratchets” from 80-850 Hz and pings and clicks from 3.3-20 kHz. Most sounds during the winter consist of 10-60 second sequences of short 100-300 microsecond pulses (Winn and Perkins, 1976; Thompson et al., 1979; Mellinger and Clark, 2000). Sounds recorded in the Southern Hemisphere include “whistle series, clanging bell series, clicks, screeches, LF grunts, and FM modulated sweeps” (Schevill and Watkins, 1972; Leatherwood et al., 1981). The function of the sounds produced by minke whales is unknown, but they are assumed to be used for communication. There are no data on hearing sensitivity for the minke whale. Analysis of the inner ear of minke whales suggests that they have excellent LF hearing (Ketten, 1994a).

3.2.4.3 Coastal Mysticete Species

The humpback whale occurs worldwide. It is a coastal species that travels over deep pelagic waters during migrations between higher latitude feeding areas and lower latitude breeding areas. Almost all feeding occurs during the late spring through early fall in mid-to-high-latitude areas in shallow coastal waters or near the edge of a continental shelf. Calving takes place in shallow waters in isolated tropical areas from late fall through late winter. Breeding is assumed to take place in or near these calving areas during the same period. Data indicate that not all animals migrate during the fall from summer feeding to winter breeding sites and that some whales remain year-round at high latitudes (Christensen et al., 1992; Clapham, et al. 1993).

Humpback whales were severely over-hunted in the early 1900s and protected from all commercial hunting in 1966. Since then most populations have shown significant recovery. Existing population estimates vary from ocean to ocean (see Table 3.2-3). Population estimates for the North Pacific range from 1,407 (Baker and Herman, 1987) to 2,100 (Darling and Morowitz, 1986), but these are probably underestimates given increases in other populations. Estimates for the Southern Hemisphere south of 30ºS are on the order of 13,000-15,000 (Butterworth et al., 1993). The best estimate for the North Atlantic population is 10,600 (Smith et al., 1999). Humpback whales are endangered under the ESA, protected under CITES, and classified as endangered by the IUCN.

Maximum recorded swimming speeds are 27 kph (15 kt) (Tomilin, 1957). Estimated speed during migration is about 8 kph (4.3 kt) (Chittleborough, 1953), while an average minimum speed of 4.7 kph (2.6 kt) has been calculated from photo-identification data. A tagged whale in the western North Atlantic traveled 260 km (140 nm) between two foraging areas with an average minimum speed of 5.6 kph (3 kt) (Croll, et al., 1999), and other tagged humpbacks have moved more than 100 km/day (54 nm/day) (Watkins et al., 1978, 1981).

Humpback whales have well-defined breeding areas in tropical waters near usually isolated islands. In the North Pacific there are breeding grounds around the Mariana Islands, Bonin, Ogasawara, Okinawa, Ryukyu Island, and Taiwan; around the main Hawaiian Islands; off the tip of Baja California; and off the Revillagigedo Islands. In the North Atlantic there are breeding areas near the West Indies and Trinidad in the west, and the Cape Verde Islands and off northwest Africa in the east.

Because most humpback prey is likely found above 300 m (1,000 ft), most humpback dives are probably relatively shallow and less than five minutes in duration. Humpbacks eat a wide variety of small schooling prey including schooling fish and euphausids (krill), which they capture using a variety of prey-concentrating techniques. The deepest recorded humpback dive was 240 m (790 ft) (Hamilton et al., 1997). Dives on feeding grounds ranged from two to five minutes in the North Atlantic (Croll, et al., 1999). In southeast Alaska average dive times were 2.8 minutes for feeding whales, 3.0 minutes for non-feeding whales, and 4.3 minutes for resting whales (Dolphin, 1987). In the Gulf of California, humpback whale dive times averaged 3.5 minutes (Strong, 1990).

Humpbacks produce a great variety of sounds in a range from 20 Hz to 10 kHz. During the breeding season males sing long, complex songs, with frequencies in the 25-5,000 Hz range and intensities with mean source levels of 165 dB (broadband rms) (Frankel, 1994). The songs appear to have an effective range of approximately 10-20 km (06-12 nm). Social sounds in the breeding areas extend from 50 Hz to more than 10 kHz with most energy below 3 kHz (Tyack and Whitehead, 1983; Richardson et al., 1995b). Feeding groups produce distinctive sounds ranging from 20 Hz to 2 kHz (Thompson et al., 1986). These sounds are attractive and appear to rally animals to the feeding activity (D'Vincent et al., 1985; Sharpe and Dill, 1997). There are no direct data on hearing sensitivity for humpback whales. In a study of the morphology of auditory mechanics, Ketten (1994a, b) hypothesized that humpbacks have excellent LF hearing.

The **gray whale** is probably the most coastal of all the mysticetes. Gray whales are confined to the shallow waters of the continental shelf from the Bering and Chukchi seas south to southern Japan in the west and the tip of Baja California in the east. Every year most of the population makes a large north-south migration from high latitude feeding grounds to low latitude breeding grounds. They generally dive to the bottom in shallow waters less than 80 m (260 ft) deep to feed primarily on benthic amphipods. Average dive times of foraging whales are 4–5 minutes (Rice and Wolman, 1971). The eastern Pacific stock of gray whales was listed as endangered under the ESA, but has recently been de-listed. The western Pacific stock is extremely low and is still listed as endangered by the ESA.

Most gray whales in the eastern Pacific mate or give birth during the winter in or near the shallow water lagoons along the west coast of Baja California (Scammon, 1874), where they have migrated from summer feeding grounds in the Bering Sea. The timing and main migratory paths are well known (Jones et al., 1984). Migrating gray whale adults travel about 6–8 kph (2-4.3 kt). Radio-tagged adults traveled about 85 km/day (46 nm/day) during the northern migration. Daily distance traveled was greater farther north than it was in Baja California and Southern California (Mate and Harvey, 1984).

Gray whales produce a variety of sounds from 15 Hz to 20 kHz (Dahlheim et al., 1984; Moore and Ljungblad, 1984). The most common sounds are knocks and pulses in frequencies from <100 Hz-2 kHz. The source level for some of these sounds is as high as 185 dB (Cummings et al., 1968). The rate of sound production in gray whales may be related to social activities -- they were relatively silent when dispersed across summer feeding grounds, made slightly more sounds when migrating, and generated the most sounds when on their winter breeding/calving grounds (Dahlheim, 1987; Dahlheim and Ljungblad, 1990; Crane and Lashkari, 1996). There are no data on hearing sensitivity for gray whales. In a study of the morphology of auditory mechanics, Ketten (1994a) hypothesized that gray whales have good LF hearing.

Northern and southern right whales occur in the Atlantic and Pacific oceans as well as off the southern bight of Australia. The global population is estimated at less than 3,000 animals, making right whales the most endangered large whale in the world. Several of the stocks are nearly extinct or extremely endangered. From late winter to fall they breed and give birth in temperate shallow areas, migrating into higher latitudes where they feed in coastal waters during the winter through fall. Right whales are endangered under ESA, protected under CITES, and classified as endangered by the IUCN.

Right whales feed primarily on copepods but sometimes on euphausids (krill) along coastal areas (Omura, 1958; Omura et al., 1969). They have been known to occasionally move offshore into deep water, presumably for feeding (Mate et al., 1997). They typically feed by surface skimming but will on occasion dive through the water column to reach deeper layers of food (Jefferson et al., 1993). Northern right whales dive as deep as 306 m (1,000 ft) (Mate et al., 1992). In the Great South Channel, average dive times were nearly two minutes; the average dive depth was 7.3 m (24 ft) and the maximum at 85.3 m (280 ft) (Winn et al., 1994). On the outer continental shelf of the U.S., the average northern right whale diving time was about 7 minutes (CETAP, 1982). Six northern right whales tracked by satellite had average swim speeds of 1-3.5 kph (0.5-1.9 kt); average speeds in breeding areas ranged from 0-4 kph (0-2.2 kt) (Mate et al., 1997). Southern right whales are not regarded as deep divers since they find their prey near the surface, and maximum submergence times are about 20 minutes (Leatherwood and Reeves, 1983).

Southern right whales produce a great variety of sounds in the 40-5,000 Hz range, and sounds are used for communication over distances of up to 10 km (5.3 nm) (Payne and Payne, 1971; Cummings et al., 1972; Clark, 1980; 1982; 1983). Maximum source levels for right whale calls have been estimated at 172-187 dB (Cummings et al., 1972; Clark, 1982). Sounds are used as contact calls and for mediating a range of social activities (Clark, 1982, 1983). Females produce sequences of wild screams and roars that appear to attract males into highly competitive mating groups (Clark, 1982). Northern right whales produce calls similar to southern right whales, but little information is available except that they produce LF moans below 400 Hz (Watkins and Schevill, 1972; Thompson et al., 1979; Spero, 1981). There are no data on hearing sensitivity for right whales. In a study of the morphology of auditory mechanics, Ketten (1994a) hypothesized that right whales have excellent LF hearing.

The **pygmy right whale** is the least known baleen whale. It is confined to waters between 30°S and 60°S, where it feeds on copepods. There are no detailed data on abundance, fine scale distribution, breeding, or movements. It has been observed in Tasmania throughout the year (Leatherwood and Reeves, 1983). It occurs during the southern winter in South Africa, particularly between False Bay and Algoa Bay (Evans, 1987). Sounds produced by one temporarily captive juvenile were from 60 to 300 Hz (Dawbin and Cato, 1992). There is some evidence for an inshore movement in spring and summer, but no long-distance migration has been documented (Leatherwood and Reeves, 1983). Breeding areas are unknown. Mating and calving seasons are unknown, but are believed to be protracted (Ross et al., 1975; Lockyer, 1984; Baker, 1985). The pygmy right whale does not seem to be a deep or prolonged diver; however, it apparently spends little time at the surface (Leatherwood and Reeves, 1983). It is not federally listed under the ESA. However, the IUCN lists it as a lower risk/least concern species.

3.2.5 Cetaceans (Odontocetes)

The odontocetes, or toothed whales, comprise about 70 species of marine mammals. They feed mainly on squid and fish. Odontocetes often forage in groups, and coordinated foraging behavior, such as herding prey, has been observed. There is evidence that this coordination is mediated by acoustic contact (Richardson et al., 1995b). Odontocetes share with the mysticetes the characteristics ascribed to all cetaceans in Subchapter 3.2.4.

Odontocete social systems range from solitary (e.g., pygmy and dwarf sperm whales) to highly social (e.g., sperm whales and killer whales) (Mann et al., 2000). Complex social structures are well documented in several species (e.g., killer whales, sperm whales, pilot whales), where extended family groups exist and family bonds may be maintained over decades (Bigg et al., 1990; Connor et al., 1998). Many odontocete species are gregarious and may be found in groups of 3 to 3,000 (Wade and Gerrodette, 1993; Evans, 1994) and may be very vocal during social interactions such as mating and sexual activity, dominance interactions, and maternal behaviors (Richardson et al., 1995b). There is increasing evidence that certain sounds serve to identify individuals (Caldwell et al., 1990; Sayigh et al., 1990; Sayigh et al., 1993: in, Richardson et al., 1995b). These social structures influence the distribution of animals, and might influence the manner in which they respond to disturbance.

Most species of odontocetes are known to produce sounds (mostly in the mid-to high-frequency range), and several are known to use sound for communication (Norris and Dohl, 1980; Tyack and Clark, 1998; Weilgart and Whitehead, 1990). Odontocetes studied have been found to echolocate by using echoes from their own HF and ultrasonic pulses to determine the direction, range and characteristics of objects in the water (review in Richardson, et al., 1995b; Au, 1993, 1997). This is the basis for the general assumption that all odontocetes use echolocation to find food, to navigate, and to orient, although empirical data are limited.

Most odontocetes produce a wide variety of sonic and ultrasonic sounds. These sounds can be categorized as:

- **Tonal whistles** - Most odontocete whistles are narrowband sounds that exhibit frequency modulation, with most of their energy below 20 kHz. Narrowband LF calls as low as 300 to 900 Hz have been recorded from bottlenose dolphins off eastern Australia (Schultz et al., 1995 in: Richardson et al., 1995b). Whistles vary widely, in terms of frequency patterns, duration, repetition of patterns, etc.

- **Clicks and other pulsed sounds** - These sounds are of very short duration, and some may be used in echolocation. Echolocation pulses are generally directional, forward-projecting sounds of high intensity and frequency. Each pulse is very brief, typically 50 to 200 microseconds in duration (Au, 1993, in: Richardson et al., 1995b). Sperm whale clicks are repeated at rates of 1-90 per second (Watkins and Schevill, 1977; Watkins et al., 1985; both in: Richardson et al., 1995b). In killer whales, the pulse repetition rate for echolocation clicks is 6-18 clicks per second (Ford and Fisher, 1982, in: Richardson et al., 1995b).

- **Rapid bursts of pulsed sounds** - Many killer whale social sounds are examples of this category, with energy in the frequency band between 500 Hz and 25 kHz. Other odontocetes produce burst-pulsed sounds, which are often described with terms like cries, grunts, and barks.

Richardson et al. (1995b) reviewed the limited research on hearing ranges in odontocetes. Of the eight species studied (which did not include the sperm or beaked whales), the low end of the range was measured in bottlenose dolphins (40-75 Hz). The hearing range of at least some individuals of all eight of the species tested extended up to 80-150 kHz. However, for the species studied, hearing was most sensitive and acute in the frequencies of 10-100 kHz.

Table 3.2-4 provides specific information on the protected status (according to the ESA, CITES, and IUCN), distribution, abundance, diving behavior, sound production and hearing of odontocetes. For the purpose of this OEIS/EIS, odontocetes are discussed further below in terms of groups of species, or "guilds," with common ecologic and demographic characteristics:

- Deep Divers;
- Large Pelagic Odontocetes;
- Small Pelagic Odontocetes; and
- Small Coastal Odontocetes.

Table 3.2-4

Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior	Underwater Hearing/Sound Production
Sperm whale (*Physter macrocephalus*)	ESA endangered; CITES protected	- All oceans - Females and young males: tropical and temperate waters; adult males: polar waters - Most abundant in areas of steep topographical relief	Estimates vary from several hundred thousand worldwide to almost 2 million; recent survey estimates 39,200 in eastern temperate N. Pacific between W. Coast and Hawaii	- Typical dives last 40 min and descend to 400 m, followed by 8 min rest at surface - Maximum recorded dive duration of 2 hr; maximum recorded dive depth of 3,000 m	- Produce sounds from <0.1 kHz to 30 kHz - Produce clicks as high as 180 dB. - Good hearing sensitivity above 2.5 kHz; lower limit of hearing probably 100 Hz
Pygmy and dwarf sperm whale (*Kogia* species)	IUCN-lower risk, least concern species	Deep waters of all temperate, subtropical, and tropical seas	- Worldwide population size unknown - Thought to be abundant	- Probable deep divers; dwarf sperm whale recorded diving for 43 min - Median dive time of 8.6 min with 1.2 min at surface	- Produce sounds from 1.3 kHz to 200 kHz - Best underwater hearing from 90-150 kHz from auditory brainstem response study
N. and S. bottlenose whales (*Hyperoodon* species)	IUCN-lower risk/conservation dependent species	- Northern found in North Atlantic only - Southern south of 20°S - Cold temperate to subarctic for both	- Worldwide population sizes unknown - Estimated 600,000 Beaked Whales, most Southern Bottlenose, are present south of the Antarctic Convergence in January	- Known as deep divers - Maximum dive times of 70 min recorded for both species; maximum depth of 1,454 m for northern -Southern dive time averages 25 min	- Northern Bottlenose Whale produce sounds from 0.5 kHz to 30 kHz - No hearing data available
Baird's and Arnoux's beaked whales (*Berardius* species)	IUCN-lower risk, least concern species	Deep waters of all temperate, subtropical seas	- Worldwide population size unknown - Baird's population in NW Pacific estimated to be 5,870; 38 off California	- Known as deep divers; - Baird's max recorded dive time of 67 min; and average 20 min off Japan - Arnoux's dive 35-60 min, maximum 70, off Antarctic	- Baird's Beaked Whales produce sounds from 12 kHz to 134 kHz - No hearing data available

Table 3.2-4

Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior	Underwater Hearing/Sound Production
Cuvier's beaked whale (*Ziphius cavirostris*)	IUCN-data deficient species	- Offshore waters of all oceans - More common in subtropical and temperate than tropical and subpolar regions	- Worldwide population size unknown - 20,000 in E. tropical Pacific	- Known as deep divers - Dive times: 30-40 min	No published data available
Beaked whale (*Mesoplodon* species)	IUCN-data deficient species	- All oceans; most species, but not all, found in tropical to temperate waters	- Worldwide population size unknown - Estimates of 25,300 in E. tropical Pacific Estimates of 250 off California;	- Known as deep divers - Dive times: 20-45 min	- Hubb's Beaked Whales produce sounds from 0.3 kHz to 80+ kHz - One Blainville's Beaked Whale produced sounds from <1 kHz to 6 kHz - No hearing data available
Shepherd's beaked whale (*Tasmacetus shepherdi*)	IUCN-data deficient species	- Not well known - Thought to have a circumpolar distribution in cold temperate seas of S. Hemisphere	No data available	No data available	No data available
Longman's beaked whale (*Indopacetus pacificus*)	IUCN-vulnerable	- Most poorly known of all marine mammals - Believed to be limited to Indo-Pacific region	No data available	No data available	No data available
Beluga *Delphinapterus leucas)*	Cook Inlet stock proposed Candidate Species under ESA; IUCN - vulnerable species	- Circumpolar ranging into subarctic coastal waters - Summer, coastal waters and river estuaries - Winter, offshore in pack ice and polynyas	Worldwide abundance of ~100,000; Western Greenland abundance 12,000-14,000.	- Deep divers - Recorded dive duration of 15 min. at 647 m depth	- Produce sounds from 0.26 – 20 kHz - Echolocation clicks from 40-60, 100-120 kHz - Hearing threshold is 1 kHz

Table 3.2-4

Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior	Underwater Hearing/Sound Production
Killer whale (*Orcinus orca*)	IUCN-lower risk/conservation dependent	All oceans	- Worldwide abundance of 100,000 - Estimate of 8,500 in E. tropical Pacific	- Spend 70% of time in upper 20 m - Dive to 100 m or more during foraging - Maximum dive of 265 m - Dive duration as long as 10 min	- Produce sounds from 0.1 kHz to 85 kHz - Hear sounds from <0.5 kHz to 105 kHz
False killer whale (*Pseudorca crassidens*)	IUCN-data deficient species	Worldwide tropical to warm temperate, deep, offshore waters	- Worldwide population unknown - Estimate of 39,800 in E. tropical Pacific	No data available	- Produce sounds from 4 kHz to 130 kHz - Hear sounds from <1.0 kHz to 115 kHz
Pygmy killer whale (*Feresa attenuata*)	IUCN-data deficient species	Oceanic tropical to subtropical waters	- Worldwide population unknown;- - Estimate of 38,900 in E. tropical Pacific	Adult captive male avg. dive time 26 sec	No data available
Melon-headed whale (*Peponocephala electra*)	IUCN-lower risk/least concern species	Oceanic tropical waters	- Worldwide population unknown - Estimate of 45,400 in E. tropical Pacific	No data available	- Produce sounds from 8 kHz to 40 kHz - No hearing data available
Pilot whale (*Globicephala* species)	Short-Finned Pilot Whale: IUCN-lower risk/conservation dependent; Long-finned: lower risk/least concern	Worldwide, deep ocean, from sub-polar to tropical waters	N/E Atlantic: 778,000 Long-Finned Pilot Whales; N/W Pacific: 53,000 Short-Finned Pilot Whales: E. Tropical Pacific, 160,000 Short-Finned Pilot Whales	- Deepest dive recorded as 610 m	- Long-Finned Pilot Whales produce sounds from 0.5 kHz to 18 kHz -Short-Finned Pilot Whales produce sounds from 0.28 kHz to 100 kHz - No hearing data available

Table 3.2-4

Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior	Underwater Hearing/Sound Production
Risso's dolphin (*Grampus griseus*)	IUCN-data deficient species	Deep oceanic and continental slope waters from the tropics through the temperate regions	- Worldwide population unknown - In N/W Atlantic, ranges from 3,500 in summer to 350+ in winter - Estimate of 175,800 in E. tropical Pacific	No data available	- Produce sounds from 0.1 kHz to 65 kHz - Hear sounds from 0.75 kHz to 100 kHz
Common dolphin (*Delphinus delphis*)	Common Dolphins are IUCN-lower risk/least concern species	Occur worldwide in temperate to tropical oceans along continental shelf and bank regions	No data available	- Deepest dive recorded of a Common Dolphin is 260 m - Majority of dives are to 9-50 m	- Produce sounds from 0.2 kHz to 150 kHz - Hear sounds from <5 kHz to 150 kHz
Fraser's dolphin (*Lagenodelphis hosel*)	IUCN-data deficient species	Deep, tropical and subtropical oceanic waters around the world	- Worldwide population unknown - Estimate of 289,300 in E. tropical Pacific	No data available	- Produce sounds from 4.3 kHz to 40 kHz - No hearing data available
Rough-toothed dolphin (*Steno bredanensis*)	IUCN-data deficient species	Deep oceanic tropical to subtropical waters	- Worldwide population unknown - Estimate of 145,900 in E. tropical Pacific	No data available	- Produce sounds from 0.1 kHz to 200 kHz - No hearing data available

Table 3.2-4

Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior	Underwater Hearing/Sound Production
Dolphins (*Stenella* species)	-Clymene and Atlantic Spotted Dolphins are listed as IUCN-data deficient species -Striped, Pantropical Spotted, and Spinner Dolphin are IUCN-lower risk/ conservation dependent species	-Pantropical Spotted and Spinner Dolphins: tropical waters worldwide -Striped Dolphins: tropical and warm temperate waters around the world -Atlantic Spotted Dolphins: only in the tropical and warm-temperate Atlantic Ocean -Clymene Dolphins: only in the tropical and subtropical Atlantic Ocean	No data available	Spotted Dolphins dive to depth of 100 m and can dive for as long as 3 min	- Produce sounds from 0.1 kHz to 160 kHz - Hear sounds from <10 kHz to >100 kHz
Bottlenose dolphin (*Tursiops truncatus*)	IUCN-data deficient species	Distributed worldwide in coastal and oceanic temperate, tropical, and subtropical waters	No data available	- Deepest recorded dive is 535 m - Dive up to 10 minutes	- Produce sounds from 0.05 kHz to 150 kHz - Hear underwater sounds from 0.15 kHz to 135 kHz
Dolphins (*Lagenorhynchus* species)	Peale's and Dusky Dolphins-IUCN data deficient species; Atlantic White-Sided, White-Beaked, Hourglass and Pacific White-Sided Dolphins:IUCN lower risk/least concern species-	Primarily inhabit coastal temperate and cold areas; however, they also occur in deep, offshore waters	No data available	- Not regarded as deep divers - Based on feeding habits, Pacific White-Sided Dolphins dive to 120 m - 76 of Atlantic White-Sided Dolphin foraging dives last less than 1 minute	- Produce sounds from 0.06 kHz to 325 kHz - Pacific White-Sided Dolphins hear sounds from 0.5 kHz-135 kHz

Table 3.2-4

Information Summary for Odontocetes

Species	Protected Status	Distribution	Abundance	Diving Behavior	Underwater Hearing/Sound Production
Right whale dolphin (*Lissodelphis* species)	- Northern Right Whale Dolphin: IUCN-lower risk/least concern species; - Southern Right Whale Dolphin: IUCN data deficient species	Inhabit deep, offshore waters in the North Pacific and between the Subtropical and Antarctic Convergence Zones	No data available	- Feed on mesopelagic fishes and appear capable of deep dives, but no data available - Both species dive for a maximum of 6 min	- Northern Right Whale Dolphins produce sounds from 1 kHz to 40 kHz - No hearing data available
Dolphins (*Cephalorhynchus* species)	-Commerson's, Black, and Heaviside's Dolphins-IUCN data deficient species; -Hector's Dolphin-IUCN vulnerable	All species live in coastal temperate waters of the Southern Hemisphere	- Total population of Hector's Dolphins estimated at 3,400 - No data available for other species	- All four species appear to be brief divers - Heaviside's avg. dive < 20 m and < 2 min - Hector's dives< 2 min	- Produce sounds from 0.32 kHz to >150 kHz - No hearing data available
Porpoise (*Phocoenoides* species)	Dall's: IUCN-lower risk/conservation dependant Harbor: Gulf of Maine stock candidate species under ESA	Dall's: - Exclusively found in the N. Pacific - Continental shelves to deep water Harbor: - Coastal cool waters in N.Pac., N. Atl., Black Sea, Med.	Dall's: Population is estimated to be 1.4 to 2.8 million porpoises Harbor: - Alaska est. 29,744 - Calif., Ore., Wash, BC est. 64,951 - G. of Maine/Bay of Fundy est 54,300	Dall's: Dive as deep as 275 m and as long as 8 min Harbor: Shallow, frequent dives	Dall's: - Produce sounds from 0.04 kHz to 160 kHz - No hearing data available Harbor: - Produces clicks at 100 dB - Hearing range 1 to 100 kHz - best hearing 10 to 100 kHz

Source: Based upon compilation of research prepared by the Institute of Marine Sciences, University of California-Santa Cruz (Croll et al., 1999). Hearing and sound production information also gleaned from Richardson et al. (1995b).

Odontocete Deep Divers

Family: Physeteridae	
Physeter macrocephalus	Sperm whale
Family: Kogiidae	
Kogia breviceps	Pygmy sperm whale
Kogia simus	Dwarf sperm whale
Family: Ziphiidae (Beaked Whales)	
Hyperoodon ampullatus	Northern bottlenose whale
Hyperoodon planifrons	Southern bottlenose whale
Berardius bairdii	Baird's beaked whale
Berardius arnuxii	Arnoux's beaked whale
Ziphius cavirostris	Cuvier's beaked whale
Mesoplodon species	14 species
Tasmacetus shepherdi	Shepherd's beaked whale
Family: Monodontidae	
Delphinapterus leucas	Beluga or white whale

3.2.5.1 Odontocete Deep Divers

Species in this group are typically found in deeper ocean waters and are all pelagic, deep divers that feed primarily on squid (Croll et al., 1999). Their distribution varies, with the largest of the group, the sperm whale, distributed throughout the world. Others are more restricted in their distribution, such as the northern bottlenose whale that is found only in the North Atlantic. Most of the beaked whale species in the family Ziphiidae are poorly known and little studied.

Some members of this group dive more than a 1,000 m (3,280 ft) below the surface. **Sperm whales**, the largest odontocetes and probably the deepest cetacean divers, have been recorded diving to depths of more than 3,000 m (9,800 ft) with dives lasting as long as two hours (Clarke, 1976; Watkins et al., 1985). Typical sperm whale foraging dives last about 40 minutes and descend to about 400 m (1,300 ft), followed by eight minutes rest at the surface (Gordon, 1987; Papastavrou et al., 1989).

These deep diving species have the longest maturation interval and among the lowest reproduction rates of all cetaceans. The sperm whale has been the most studied of this group. The sperm whale is a seasonal breeder, with a prolonged breeding season extending from late winter through early summer. Females are sexually mature at 7 to 13 years (Rice, 1989), and then give birth about every four to six years (Best et al., 1984) while males mature at 18 to 21 years. Gestation lasts 14 to 15 months, and calving season is between November and March in the Southern Hemisphere (Klinowska, 1991 in: Simmonds and Hutchinson, 1996). They can live up to 60-70 years (Rice, 1989).

The frequency range of sperm whale clicks is from less than 100 Hz to 30 kHz, with most energy at 2-4 kHz and 10-16 kHz (Watkins and Schevill, 1977; Watkins et al., 1985, both in: Richardson et al., 1995b). Large male sperm whales show stable peaks in click spectra at 400 Hz and 2 kHz; females show less stable peaks at 1.2 and 3 kHz. However, detectable energy has been found up to 15 kHz (Goold and Jones, 1995). Peak pressure levels of clicks have been recently measured at up to 223 dB (Møhl et al., 2000). Watkins and Schevill (1975) reported that sperm whales have good hearing sensitivity above 2.5 kHz and are known to be sensitive to changes in their acoustic environment (Watkins and Schevill, 1975; Watkins et al., 1985). There are more recent suggestions that they can hear at higher frequencies based on auditory brainstem response of a neonatal sperm whale (Carder and Ridgway, 1990). Ketten (1994b) stated that because of its size, the sperm whale might be expected to have good LF hearing; however, the inner ear resembles that of most dolphins and is adapted for ultrasonic reception. Base on inner ear anatomy, she predicted that the functional lower limit of sperm whale hearing would be near 100 Hz. This is consistent with measurements of evoked response data from one stranded sperm whale (Gordon et al., 1996).

The **pygmy and dwarf sperm whales** are small, relatively solitary, apparently deep-diving, whales that live in temperate to tropical deep waters from 60°N to 40°S around the world. They are especially common along continental shelf breaks (Evans, 1987; Jefferson et al., 1993). Very little is known about any aspect of their biology, although they are thought to be relatively abundant. Based on their geographic distribution and the habitat of their preferred prey, it is likely that both species are deep divers. In the Gulf of California, dwarf sperm whales dive for as long as 43 minutes (Breese and Tershy, 1993). Surface behavior of *Kogia* species in the Gulf of California consisted of resting at the surface for approximately one minute, followed by a brief dive of less than three minutes (Willis and Baird, 1998). In the same area, 59 dive intervals of *Kogia* species indicated a median dive time of 8.6 minutes and a median resting time at the surface of 1.2 minutes; dives up to 25 minutes and resting periods at the surface of up to 3 minutes were common (Willis and Baird, 1998).

There are no data on sound production in the wild for either pygmy or dwarf sperm whales. Recent recordings from captive pygmy sperm whales indicate that they produce sounds between 60 and 200 kHz with peak frequencies at 120-130 kHz (Santoro et al., 1989; Carder et al., 1995). Thomas et al., (1990a) recorded a LF sweep ascending sound, heard singly or in pairs, between 1.3 and 1.5 kHz from a captive pygmy sperm whale. An auditory brainstem response study indicates that pygmy sperm whales have their best underwater hearing range between 90-150 kHz (Carder et al., 1995).

Northern bottlenose whales are the largest of the species in the family Ziphiidae, and the second largest of all the toothed whales. These whales are a cold temperate-to-subarctic species found in the North Atlantic, mostly seaward of the continental shelf in water deeper than 1,000 m (3,300 ft) (Leatherwood and Reeves, 1983; Jefferson et al., 1993). **Southern bottlenose whales** are thought to be found south of 20°S, with a circumpolar distribution (Leatherwood and Reeves, 1983; Jefferson et al., 1993).

Dives of more than 60 minutes have been recorded for both southern and northern bottlenose whales (Jefferson et al., 1993). Recently, northern bottlenose whales have been recorded diving for as long as 70 minutes and as deep as 1,454 m (4,770 ft) (Hooker and Baird, 1999). After a long dive, northern bottlenose whales usually remain at the surface for ten minutes or more, blowing at regular intervals before making another dive (Leatherwood and Reeves, 1983). Southern bottlenose whales have been observed diving from 11-46 minutes, with an average duration of 25.3 minutes (Sekiguchi, et al., 1993). Northern bottlenose whales produce echolocation-type clicks between 8-12 kHz, whistles between 3-16 kHz, and clicks between 500 Hz and 26 kHz (Winn et al., 1970b). Off Nova Scotia, predominant sounds are click series and trains ranging from 2-20 kHz (Hooker and Whitehead, 1998).

Beluga or white whale *(Delphinapterus leucas)* habitat is north circumpolar ranging into the subarctic. Belugas inhabit the east and west coasts of Greenland and in North America extending from Alaska across the Canadian western arctic to Hudson Bay (Sergeant and Brodie, 1969a). Occasional sightings and strandings occur as far south as the Bay of Fundy (Atlantic). In the Pacific, belugas summer in the Okhotsk, Chukchi, Bering, and Beaufort seas, the Anadyr Gulf, and off Alaska. They are commonly found in Cook Inlet year round (Hansen and Hubbard, 1998; Rugh et al., 1998).

Based on the best available information, NMFS has determined that the Cook Inlet stock of belugas has declined to a level that is considered depleted under the MMPA (FR Vol 65 No. 105). However, because the stock is not in danger of extinction nor is it likely to become so in the near future, they have determined that listing of the Cook Inlet stock of belugas under the ESA is not warranted as of 22 June 2000 (FR Vol. 65, No. 121). This beluga stock will continue to be included on the list of candidate species under the ESA (FR Vol 64 No. 120). This stock, located within south-central Alaska, is genetically and geographically isolated from the other Alaskan stocks of belugas. The stock includes all belugas occurring in the waters of Cook Inlet, Kachemak Bay, Kamishak Bay, Chinitna Bay, Tuxedni Bay and freshwater tributaries to these waters (FR Vol. 64 No. 201). Because this stock is not located within the proposed operational area for SURTASS LFA sonar, there is no potential for it to be affected by the proposed action.

Seasonal movements of belugas include moving into coastal waters and river estuaries during summer, and wintering off-shore in pack ice and polynyas (Sergeant and Brodie, 1969b). They are Arctic species; and, therefore, the only potential area that belugas could potentially be affected by SURTASS LFA sonar transmission would be in the Greenland Sea. The population estimate for this species may be in the vicinity of 60,000 (Braham, 1984).

The beluga is not a fast swimmer, with maximum bursts estimated at 20 kph (10.7 kts) and normal cruising speeds in the range of 6-9 kph (3.2-4.9 kts) (Brodie, 1989). Studies on diving capabilities of trained belugas in open ocean conditions by Ridgway et al. (1984) demonstrated a capacity to dive to depths of 647 m (2,123 ft) and remain submerged for up to 15 min.

Belugas produce whistles in the 0.26 – 20 kHz range and vocalizations in the 0.5 – 16 kHz range (Schevill and Lawrence, 1949; Sjare and Smith 1986a, b). Predominant echolocation frequencies for this species occur in ranges of 40-60 kHz and 100-120 kHz and at levels of 206-225 dB (Au et al., 1985, 87; Au, 1993). Belugas have been reported to react strongly and at long distances to the noise from ships and icebreaking in the deep channels of the Canadian high Arctic during the spring (Richardson et al., 1995b). They also exhibit apparent habituation as evidenced by their tolerance of boats in various areas after their extreme sensitivity to the first icebreaker approach of the year (Richardson et al., 1995b).

Both the **Baird's and Arnoux's beaked whales** are deep-water temperate and sub-tropical species that are likely distributed throughout most of the world's oceans. Like other deep-water species, they appear to be most abundant at areas of steep topographic relief such as shelf breaks and seamounts. Baird's beaked whales were recorded diving for an average of 20 minutes in 30 dives off Japan, with a maximum dive of 67 minutes (Kasuya, 1986). Arnoux's beaked whales dove for 35-65 minutes and a maximum of 70 minutes when diving from narrow cracks or leads in sea ice near the Antarctic Peninsula (Hobson and Martin, 1996). Baird's beaked whales have been recorded producing sounds between 12.1-134 kHz with dominant frequencies between 23-24.6 and 35-45 kHz (Dawson et al., 1998).

Cuvier's beaked whale is one of the most abundant and widespread species in the family Ziphiidae. They are found in deep, offshore waters of all oceans, from 60°N to 60°S (Jefferson et al., 1993), but are more common in subtropical and temperate waters than in the tropical and subpolar waters of their range (Evans, 1987). Dives up to 40 minutes duration have been recorded, and they typically are found in groups of two to seven (Heyning, 1989; Jefferson et al., 1993). They usually travel at a pace of 5-6 kph (2.7-3.2 kt) (Houston, 1991). No sound or hearing data are available.

The 12 species in the genus ***Mesoplodon*** are deep-diving but poorly studied, pelagic whales that are distributed throughout the world's oceans between 72°N and 60°S (Leatherwood and Reeves, 1983; Jefferson et al., 1993; Carlstrom et al., 1997). New species have been described as recently as 1997, and undescribed species may still exist. *Mesoplodon* species are most commonly seen as single individuals or pairs, sometimes trios. Dives over 45 minutes have been recorded for some species in this genus (Jefferson et al., 1993). **Blainville's beaked whales** (*M. densirostris*) dive for 20 minutes or longer (Leatherwood et al., 1988). A young beaked whale, apparently a Blainville's beaked whale, produced chirps and whistles below 1 kHz up to 6 kHz (Caldwell and Caldwell, 1971b, in: Richardson et al., 1995b). **Hubb's beaked whale** (*M. carlhubbsi*) has been recorded producing whistles between 2.6-10.7 kHz, and pulsed sounds from 300 Hz-80 kHz and higher with dominant frequencies from 300 Hz-2 kHz (Buerki et al., 1989; Lynn and Reiss, 1992, both in: Richardson et al., 1995b). Little is known of the other species in this genus.

Like most members of the beaked whale genus *Mesoplodon*, very little is known about two other beaked whale species: **Shepherd's beaked whale** and **Longman's beaked whale**. Longman's beaked whale is perhaps the most poorly known of all marine mammals (Jefferson et al., 1993).

It is believed that Longman's beaked whale is limited to the Indo-Pacific region (Leatherwood and Reeves, 1983; Jefferson et al., 1993). Recent groups of whales sighted in the equatorial Indian and Pacific oceans have tentatively been assigned to this species (Ballance and Pitman, 1998; Pitman et al., 1998). Pitman et al. (1998) reported that groups of Longman's beaked whales had a mean size of 18.5 whales per group, a large average for a beaked whale.

Information Regarding Strandings of Beaked Whales

Two papers have suggested that beaked whales tend to strand when there are naval operations offshore. Simmonds and Lopez-Jurado (1991) reported on four mass strandings of *Ziphius cavirostris* between 1985-1989 in the Canary Islands. All of these mass strandings involved *Ziphius* stranding at the same time as other beaked whale species. Local people reported that naval ships were observed from shore near the stranding sites during three of the four mass stranding events, and these were the only times that such military maneuvers were observed from 1985-1989. No data were provided on the acoustic signals transmitted by the naval ships; however, it is very unlikely that any sonar transmissions would have involved frequencies below 1 kHz. Frantzis (1998) reported on another mass stranding of 12 or more *Ziphius cavirostris* sighted along 38 km (20.5 nm) of coastline on 12-13 May 1996 in the Kyparissiakos Gulf in Greece. There was no external sign of injury or disease in any of these juvenile whales, and many had recently been feeding.

In searching for a potential cause of these strandings, Frantzis (1998) noted a warning had been issued to mariners indicating that a test of a NATO low frequency sonar called LFAS was being conducted in the gulf at the same time as the strandings. Frantzis (1998) presented data on the number of strandings analyzed by half-year from 1992-1996, and stated that no mass strandings or LFAS tests had occurred in the Ionian Sea since 1981, except during the four-day period 11-15 May 1996. Frantzis (1998) concluded that the probability of this association of the mass stranding and the sonar exercise was <0.07. The statistical analysis was not described in the paper, but it appeared to treat each four-day period during the 16.5 years from 1981 – 1997 as an independent event during which strandings and sonar tests could be counted. The probability of the mass stranding occurring during the four known days of sonar testing was then simply calculated by dividing the four days by the number of days in 16.5 years = 0.066%.

The Frantzis (1998) article stimulated the North Atlantic Treaty Organization (NATO) Supreme Allied Commander, Atlantic Center (SACLANT) Undersea Research Centre (SACLANTCEN) that conducted the sonar tests to convene panels to review the data, and to develop an environmental policy. The report of these panels (SACLANTCEN, 1998) presented more detailed acoustic data than were available for beaked whales stranded in the Canary Islands. The NATO sonar transmitted two simultaneous signals lasting four seconds and repeating once every minute. The simultaneous signals each were broadcast at source levels of just under 230 dB re 1 µPa at 1 m. One of the signals covered a frequency range from 450-700 Hz and the other one covered 2.8-3.3 kHz. The *Ziphius* strandings in the Kyparissiakos Gulf occurred during the first two sonar runs on each day of 12 and 13 May 1996. The close timing between the onset of sonar transmissions and the first strandings suggests closer synchrony between the onset of sonar transmissions and the strandings than was presented in Frantzis (1998). However, the Bioacoustics Panel convened by NATO was unable to reach a definitive conclusion due to the lack of evidence of direct physical injury because no viable tissue samples suitable for laboratory analysis were recovered from any of the animals. Their official finding was "An acoustic link can neither be clearly established nor eliminated as a direct or indirect cause for the May 1996 strandings."

The Simmonds and Lopez-Jurado (1991) and Frantzis (1998) papers served an important function to alert marine mammalogists and the public of coincidences of rare strandings with military operations. However, two problems prevent stronger inference. The papers do not have the appropriate design for statistical analysis of conditional probability, and no such correlative study can provide evidence for causation. Both papers started with stranding events and then looked for some other rare event that might coincide. This strategy is useful to identify coincidences, but is not appropriate for a statistical analysis of conditional probability concerning two independent events. Both papers suggested that naval sonars may have caused these strandings, but neither performed a systematic survey of naval or sonar exercises. SACLANTCEN (1998) attempted a correlative study relating all tests of the NATO sonar with Italian and Spanish stranding records. SACLANTCEN (1998) reported that the same NATO sonar described in Frantzis (1998) was used in six sonar tests in the Mediterranean near the Spanish or Italian coasts; five additional low frequency sonar tests were conducted by NATO in the Mediterranean from 1981-1992 using source levels below 215 dB re 1 µPa at 1 m. The SACLANTCEN (1998) review of Italian and Spanish stranding records revealed no other coincidence of beaked whale strandings near the time and place of these sonar tests.

These papers raise concern about the effects of noise on beaked whales, but they provide no guidance as to what exposures may be dangerous and which are safe. Correlative studies cannot prove causation; all of these reports agree on this issue. Simmonds and Lopez-Jurado (1991) stated: "Very little is known about the biology of *Ziphius*, so the reason for the unusual strandings can only be the subject of speculation." Frantzis (1998) agreed: "Little is known about whales' reactions to LFAS; to obtain definitive answers, more information needs to be gathered." The Bioacoustics Panel convened by NATO stated: "Behavioral responses to acoustic transmission must be taken into consideration as a possible cause for strandings: therefore, acoustic characteristics that induce behavioral changes or physical damage to marine animals should be determined."

On March 15, 2000 a number of marine mammals, including beaked whales, stranded in the Bahamas. The U.S. Navy launched an in-depth investigation of this phenomenon with scientists from NOAA's National Marine Fisheries Service and others to determine the possible cause of the strandings. The investigation has focused on a transit of seven ships and three submarines through the area of the Northwest New Providence Channel during the morning and afternoon of March 15th in an effort to determine if any action by these vessels could have created an environment hazardous to marine mammals, and particularly beaked whales. The Navy is reviewing acoustic, oceanographic, biological and environmental data to determine whether these transit activities may have had a role in the strandings. At the time of the publication of this OEIS/EIS, preliminary analysis indicated that one submarine sonar and five of the seven ship sonars were in use during the transit, and their operating frequencies and power settings were part of the investigation. Each sonar was a standard, mainframe mid-frequency (3 to 5 kHz) sonar of the type commonly found on surface combatants and submarines in most of the world's navies. They operated with standard power outputs and modes.

The SURTASS LFA sonar program has focused on the issue of the potential for LF sound impacts on all marine animals, including beaked whales. It has been confirmed that SURTASS LFA sonar was not involved in any of the events. Moreover, the LFS SRP made systematic evaluation of the animals most likely to be potentially affected by LF sound. Current evidence would suggest that while beaked whales may be sensitive to frequencies above SURTASS LFA sonar, there is little evidence that they are more sensitive to LFA sounds than the species selected as subjects for the LFS SRP. Thus, even if the investigation ultimately concludes that the mid-frequency sonars in use during the transit caused or contributed to the strandings, such a conclusion would not appear to present any significant new information relevant to the proposed deployment of SURTASS LFAS sonar.

3.2.5.2 Large Pelagic Odontocetes: Killer Whales and "Blackfish"

Species in this group frequent offshore, pelagic waters. The **killer whale** is perhaps the most cosmopolitan of all marine mammals, found in all the world's oceans from about 80°N to 77°S (Leatherwood and Dahlheim, 1978). However, they appear to be more common within 800 km (430 nm) of major continents in cold temperate to subpolar waters (Mitchell, 1975). The killer whale is the largest member of the family Delphinidae and one of the best-studied species. They have perhaps the most diverse food habits of any marine mammal, feeding on fishes, cephalopods, pinnipeds, sea otters, whales, dolphins, seabirds, and marine turtles (Hoyt, 1981; Gaskin, 1982; Jefferson et al., 1991). They have low reproductive rates.

Large Pelagic Odontocetes: Orcas and "Blackfish"

Family: Delphinidae	
Orcinus orca	Killer whale (orca)
Pseudorca crassidens	False killer whale
Feresa attenuata	Pygmy killer whale
Peponocephala electra	Melon-headed whale
Globicephala macrorhynchus	Short-finned pilot whale
Globicephala melas	Long-finned pilot whale

The deepest dive recorded by a killer whale is 265 m (870 ft), reached by a trained individual (Ridgway, 1986). In the Bering Sea there is some suggestion that killer whales prey on fish at water depths of 200-300 m (660-990 ft) or more (Yano and Dahlheim, 1995a and b). In southern

British Columbia and northwestern Washington State, killer whales spend more than 70 percent of their time in the upper 20 m (66 ft) of the water column; but they dive to 100 m (330 ft) or more, with a maximum recorded dive of 201 m (660 ft) (Baird et al., 1998). Dive durations recorded range from 1 to 10 minutes (Norris and Prescott, 1961; Lenfant, 1969; Baird et al., 1998). Swimming speeds usually are 6-10 kph (3.2-5.4 kt), but they can achieve speeds up to 40 kph (22 kt) (Lang, 1966).

Killer whales have perhaps one of the most stable and cohesive animal societies, in which sound production plays an essential role. Their signals carry information regarding geographic origin, individual identity, pod membership, and activity level. As they use stealth for hunting marine mammal prey, hearing is critical to success (Thomas et al., 1981; Hoelzel and Osborne, 1986; Bain, 1989) Killer whales produce sounds as low as 100 Hz and as high as 85 kHz with dominant frequencies at 1-20 kHz (Schevill and Watkins, 1966; Diercks et al., 1971, 1973; Evans, 1973; Steiner et al., 1979; Awbrey et al., 1982; Ford and Fisher, 1983; Ford, 1989). Killer whales hear underwater sounds in the range of <500 Hz to 105 kHz (Bain et al., 1993). Their best underwater hearing occurs at 15 kHz, where the threshold level is 34 dB (Hall and Johnson, 1972).

False killer whales are found in tropical to warm temperate zones in deep, offshore waters from 60°S to 60°N living in groups ranging from 18 to 89 whales (Stacey et al., 1994; Odell and McClune, 1999). Reproductive rates are low. They swim at an estimated speed of 3 kph (1.6 kt) (Brown et al., 1966). No data are available on diving. False killer whales produce sounds from 4-130 kHz, with dominant frequencies at 4-95 kHz, 25-30 kHz, and 95-130 kHz (Busnel and Dziedzic, 1968; Kamminga and Van Velden, 1987; Thomas and Turl, 1990). Underwater audiograms indicate that the false killer whale hears down to below 1 kHz to up to 115 kHz (Johnson, 1967; Awbrey et al., 1988; Au et al., 1993). More recent audiograms obtained for the false killer whale (Au et al., 1997) confirm previous measurements indicating hearing thresholds of 140 dB at a frequency of 75 Hz, 108 dB at a frequency of 1 kHz, and 70 dB at a frequency of 5 kHz.

Pygmy killer whales and **melon-headed whales** are poorly-known, small odontocetes. Pygmy killer whales inhabit oceanic tropical waters around the world from about 40°S to 40°N (Caldwell and Caldwell, 1971a; Ross and Leatherwood, 1994). The melon-headed whale has a similar distribution as the pygmy killer whale, but most records are from 20°S to 20°N (Jefferson and Barros, 1997).

Melon-headed whales feed on mesopelagic squid found down to 1,500 m (4,920 ft) deep, so they appear to feed deep in the water column (Jefferson and Barros, 1997). Melon-headed whale sounds are low level, with maximum source levels estimated at 155 dB for whistles and 165 dB for click bursts. Individual click bursts of 0.1 to 0.2 seconds with 40 or more clicks at repetition rates up to about 1,200/second have frequency emphases between 20 and 40 kHz. Dominant frequencies of whistles are 8-12 kHz, with both upswept and downswept frequency modulation (Watkins et al., 1997).

Pilot whales, including the short-finned and long-finned, are relatively large, deep-water, oceanic species that occur in temperate and subpolar zones as well as warm temperate to tropical waters of the world. Long-finned pilot whales occur in temperate and subpolar zones from 20° to 75°N and from 5° to 70°S, excluding the North Pacific (Nelson and Lien, 1996). Short-finned pilot whales are found in temperate to tropical waters of the world from 50°N to 40°S (Leatherwood and Dahlheim, 1978). They have low reproductive rates (Sergeant, 1962; Kasuya and Marsh, 1984; Martin et al., 1987; Kasuya et al., 1988; Bloch, 1994) and are considered deep divers, feeding on fish and squid. A short-finned pilot whale was recorded as diving to 610 m (2,000 ft) (Ridgway, 1986). Sound productions of the gregarious pilot whales are correlated with behavioral state and environmental context (Taruski, 1979; Weilgart and Whitehead, 1990). Long-finned pilot whales produce sounds as low as 500 Hz and as high as 18 kHz, with dominant frequencies between 1-11 kHz (Schevill, 1964; Busnel and Dziedzic, 1966a; Taruski, 1979; Steiner, 1981; McLeod, 1986). Short-finned pilot whales produce sounds as low as 280 Hz and as high as 100 kHz, with dominant frequencies between 2-14 kHz and 30-60 kHz (Caldwell and Caldwell, 1969; Fish and Turl, 1976; Scheer et al., 1998). No hearing data are available.

3.2.5.3 Small Pelagic Odontocetes

Species in this group occur in deeper, offshore waters. The group includes dolphins and one pelagic porpoise species as shown below.

Small Pelagic Odontocetes

Family: Delphinidae	
Grampus griseus	Risso's dolphin
Delphinus delphis	Common dolphin (short beaked)
Delphinus capensis	Common dolphin (long-beaked)
Lagenodelphis hosei	Fraser's dolphin
Steno bredenansis	Rough-toothed dolphin
Stenella attenuata	Pantropical spotted dolphin
Stenella clymene	Clymene dolphin
Stenella coeruleoalba	Striped dolphin
Stenella frontalis	Atlantic spotted dolphin
Stenella longirostris	Spinner dolphin
Tursiops truncatus	Bottlenose dolphin
Lagenorhynchus acutus	Atlantic white-sided dolphin
Lagenorhynchus albirostris	White-beaked dolphin
Lagenorhynchus australis	Peale's dolphin
Lagenorhynchus cruciger	Hourglass dolphin
Lagenorhynchus obliquidens	Pacific white-sided dolphin
Lagenorhynchus obscurus	Dusky dolphin
Lissodelphis borealis	Northern right whale dolphin
Lissodelphis peronii	Southern right whale dolphin
Family: Phocoenidae	
Phocoenoides dalli	Dall's porpoise

Risso's dolphin is a medium-sized odontocete that inhabits deep oceanic and continental slope waters from the tropics through the temperate regions from 55°S to 60°N (Leatherwood et al., 1980; Jefferson et al., 1993). They feed on squid species found more than 400 m (1,300 ft) deep, but they may be taking them when they are closer to the surface at night. Groups of Risso's dolphins average between 6 and 63 individuals, but groups can reach up to 2,000 (Braham, 1983; McBreanty et al.; 1986, Kruse, 1989; Wade and Gerrodette, 1993; Miyashita, 1993).

Risso's dolphins produce sounds as low as 100 Hz, with dominant frequencies at 2-5 kHz and at 65 kHz (Watkins, 1967; Au, 1993). Published audiograms for Risso's dolphins indicate hearing at frequencies as low as 75 Hz (Johnson, 1967). More recent audiograms obtained on Risso's dolphin (Au et al., 1997) confirm previous measurements and demonstrate hearing thresholds of 140 dB at a frequency of 75 Hz, 127 dB at a frequency of 1 kHz, and 70 dB at a frequency of 4 kHz.

The two **common dolphin species, the short-beaked and long-beaked**, are distributed worldwide in temperate, tropical, and subtropical oceans, primarily along continental shelf and bank regions from about 66°N to 55°S (Evans, 1994). They are the most abundant species in the eastern tropical Pacific (Wade and Gerrodette, 1993). The deepest dive recorded for these species is 260 m (850 ft) (Evans, 1971); however, the majority of dives are 9-50 m (30-165 ft) (Evans, 1994). Common dolphins can be found in groups that reach thousands of individuals; however, the basic social unit may be less than 30 dolphins (Evans, 1994). In the North Pacific, females reach sexual maturity at around eight years and males at 10.5 years (Ferrero and Walker, 1995) with a mean calving interval of 1.3 to 2 years (Gaskin, 1992).

Common dolphins produce sounds as low as 200 Hz and as high as 150 kHz, with dominant frequencies at 0.5-18 kHz and 30-60 kHz (Caldwell and Caldwell, 1968; Popper, 1980; Au, 1993; Moore and Ridgway, 1995). The maximum peak-to-peak source level of common dolphins is 180 dB (Popper, 1980). Based on auditory brainstem responses, common dolphins hear underwater sounds in the range of <5 kHz to 150 kHz (Popov and Kishin, 1998). The best underwater hearing of the species occurs at 65 kHz, where the threshold level is 53 dB (Popov and Kishin, 1998).

Fraser's and rough-toothed dolphins are poorly known. Both occur in deep, oceanic tropical and subtropical waters around the world and appear to be relatively abundant in certain areas (Jefferson and Leatherwood, 1994). Fraser's dolphin is not known to produce LF sounds; recorded sounds have ranged from 4.3 kHz to more than 40 kHz (Leatherwood et al., 1993, in: Richardson et al., 1995b; Watkins et al., 1994). The diving habits of both species are unknown. Rough-toothed dolphins produce sounds as low as 100 Hz to as high as 200 kHz, but most sounds are concentrated at the higher frequencies (Popper, 1980; Miyazaki and Perrin, 1994; Richardson et al., 1995b). Clicks have durations of 50-250 microseconds with peak energy at 25 kHz; whistles last 100-900 microseconds and have a maximum energy at 2-14 kHz and at 4-7 kHz (Busnel and Dziedzic, 1966b, in: Richardson et al., 1995b; Norris and Evans, 1967; Norris, 1969; Popper, 1980). The same individuals can produce both broad-spectrum clicks and whistles at frequencies of 3-12 kHz (Watkins et al., 1994).

The five species of ***Stenella* dolphins** -- the **pantropical spotted, clymene, striped, Atlantic spotted, and spinner** -- inhabit coastal and oceanic tropical and subtropical waters worldwide from 40°S to 40°N (Perrin and Gilpatrick, 1994; Perrin and Hohn, 1994). Radio-tagged pantropical spotted dolphins have been recorded diving to a maximum depth of 100 m (330 ft) (Scott et al., 1993) for as long as 3.4 minutes (Leatherwood and Ljungblad, 1979). They are very gregarious, and groups can vary from dozens to thousands depending upon the species and the geographic area (Miyashita, 1993; Wade and Gerrodette, 1993; Suarez-C. et al., 1994; Jefferson, 1995; Acevedo-Gutierrez and Burkhart, 1998). Pantropical spotted dolphins become sexually mature at about 10 to 11 years for females and 12 to 15 years for males (Chivers and Myrick, 1993) with calving about every three years (Perrin and Hohn, 1994). Sexual maturity in the other four species is reached at these ages or earlier. Calving intervals vary in the other species from 2 to 4 years. These five species are fast swimmers with the spinners being one of the most aerial cetaceans (Norris and Dohl, 1980; Norris et al., 1994).

Dolphins of the genus *Stenella* produce sounds as low as 100 Hz and as high as 160 kHz with dominant frequencies at 5-60 kHz, 40-50 kHz, and 130-140 kHz (Busnel et al., 1968; Caldwell and Caldwell, 1971b; Caldwell et al., 1973; Popper, 1980; Watkins, 1980b; Steiner, 1981; Zanardelli et al., 1990; Mullin et al., 1994; Norris et al., 1994; Wang Ding et al., 1995; Au et al., 1998; Ketten, 1992; Richardson et al., 1995b). Peak-to-peak source levels as high as 210 dB have been measured (Au et al., 1998). Based on auditory brainstem responses, striped dolphins hear underwater sounds equal to or louder than 120 dB in the range of <10 kHz to >100 kHz. The best underwater hearing of the species appears to be at 50-70 kHz, where the threshold level is 30-40 dB (Popper, 1980).

The much-studied and generally abundant **bottlenose dolphin** is distributed worldwide in temperate to tropical waters. They occur in very diverse habitats ranging from rivers and protected bays (Scott and Chivers, 1990; Sudara and Mahakunlayanakul, 1998) to oceanic islands and the open ocean (Scott and Chivers, 1990). The deepest dive recorded for a bottlenose dolphin is 535 m (1,755 ft), reached by a trained individual (Ridgway, 1986). They are found in groups ranging up to 5,000, but median group size as calculated from many studies is about 11 (Saayman and Tayler, 1973; Lear and Bryden, 1980; Jones, 1988; Scott and Chivers, 1990; Miyashita, 1993; Félix, 1994; Acevedo-Gutierrez, 1997; Acevedo-Gutierrez and Burkhart, 1998).

Reproduction rates vary among stocks with females reaching sexual maturity at an average of 12 years (but as early as 3.5 years and as late as 14 years possible). Males reach maturity at an average of 11 years, but vary from 9 to 20 years. Calving occurs every 1.3 to 2 years (Perrin and Reilly, 1984; Kasuya, 1985).

Bottlenose dolphins produce sounds as low as 50 Hz (Johnson, 1967 in: Richardson et al., 1995b) and as high as 150 kHz with dominant frequencies at 0.3-14.5 kHz, 25-30 kHz, and 95-130 kHz (Popper, 1980; McCowan and Reiss, 1995; Schultz et al., 1995; Richardson et al., 1995b). Each individual bottlenose dolphin has a fixed, unique FM pattern, or contour, whistle composed of similar, repetitive elements called loops (Caldwell et al., 1990). They hear underwater sounds in the range of 150 Hz to 135 kHz (Johnson, 1967; Ljungblad et al., 1982b). Their best underwater hearing occurs at 15 kHz, where the threshold level is 42-52 dB (Sauerland and Dehnhardt, 1998). Target discrimination experiments have shown that bottlenose dolphins can discriminate the shape, size, material composition and internal structure of targets from their echoes at ranges of approximately 100 m (330 ft), depending upon the size of the targets (Au, 1997).

The dolphins in the genus *Lagenorhynchus* -- the **Atlantic white-sided**, **white-beaked**, **Peale's**, **hourglass**, **Pacific white-sided,** and **dusky dolphins** -- primarily inhabit coastal temperate and cold waters; but they also occur in deep, offshore waters. The taxonomy of this genus is currently under review (IWC, 1997). They feed on nearshore, epipelagic, and mesopelagic fish and squid. They are not regarded as deep divers. Based on feeding habits, it is inferred that Pacific white-sided dolphins dive to at least 120 m (395 ft) (Fitch and Brownell, 1968). A satellite-tagged Atlantic white-sided dolphin dove an average of 38.8 seconds, with 76 percent of dives lasting less than one minute; the dolphin was submerged 89 percent of the time (Mate et al., 1994a). Species in this genus produce sounds as low as 60 Hz and as high as 325 kHz with dominant frequencies at 0.3-5 kHz, 4-15 kHz, 6.9-19.2 kHz, and 60-80 kHz (Popper, 1980; Richardson et al., 1995b). Pacific white-sided dolphins hear underwater sounds in the range of about 500 Hz to 135 kHz (Tremel et al., 1998).

The finless **northern and southern right whale dolphins** inhabit deep, offshore waters in the North Pacific and between the Subtropical and Antarctic Convergence zones. They feed primarily on mesopelagic fishes and appear capable of deep dives (Jefferson et al., 1994). Northern right whale dolphins dive as long as 6.25 minutes (Leatherwood and Walker, 1979). Southern right whale dolphins dive as long as 6.5 minutes (Cruickshank and Brown, 1981). Northern right whale dolphins produce sounds as low as 1 kHz and as high as 40 kHz or more, with dominant frequencies at 1.8 and 3 kHz (Fish and Turl, 1976; Leatherwood and Walker, 1979).

Dall's porpoise is found exclusively in the Northern Pacific between 32° and 62°N, primarily in continental shelf and slope waters, although they also inhabit deep waters more than 1,000 km (520 nm) offshore (Morejohn, 1979; Jefferson, 1988, 1990; Jefferson et al., 1993). They are relatively deep divers, diving to 275 m (900 ft) and for as long as eight minutes (Ridgway, 1986; Hanson et al., 1998). Dall's porpoises are usually found in small groups, although aggregations of several thousand are seen at times (Scheffer, 1949; Sullivan and Houch, 1979; Jefferson, 1988, 1990). Males become sexually mature from 4-6 years and females from 3.5-4.5 years. The mean calving interval is about three years for the Japanese stock (Kasuya, 1978). They are thought to be one of the fastest small cetaceans, and they may reach speeds of 55 kph (30 kt) for quick bursts (Leatherwood and Reeves, 1986).

Dall's porpoises produce sounds as low as 400 Hz and as high as 160 kHz (Ridgway, 1966; Evans, 1973; Awbrey et al., 1979; Evans and Awbrey, 1984; Hatakeyama and Soeda, 1990; Hatakeyama et al., 1994). They can emit LF clicks (0.04-12 kHz) (Evans, 1973; Awbrey et al., 1979). Their maximum peak-to-peak source level is 175 dB (Evans, 1973; Evans and Awbrey, 1984 in: Richardson et al., 1995b). No hearing data are available.

3.2.5.4 Small Coastal Odontocetes

The dolphin species in this group are usually seen within sight of land and are shallow divers. The dolphins in the genus *Cephalorhynchus* do, however, produce LF sounds, and so are included for evaluation of potential impacts.

Small Coastal Odontocetes

Family: Delphinidae (Dolphins)	
Cephalorhynchus commersonii	Commerson's dolphin
Cephalorhynchus eutropia	Black or Chilean dolphin
Cephalorhynchus heavisidii	Heaviside's dolphin
Cephalorhynchus hectori	Hector's dolphin
Family: Phocoenidae (Porpoises)	
Phocoena phocoena	Harbor porpoise

The four species of *Cephalorhynchus* dolphins are small, found in temperate coastal waters in the Southern Hemisphere, travel in small groups, and are brief divers (Goodall et al., 1988; Goodall, 1994a and 1994b; Sekiguchi et al., 1998). A **Heaviside's dolphin** made relatively shallow and short dives; close to 81 percent of dives were less than 20 m (66 ft); 86 percent of dives lasted less than two minutes; and the maximum recorded dive was 104 m (340 ft) (Sekiguchi et al., 1998). The average long dive of **Hector's dolphins** lasts 89 seconds and is followed by an interval of 54 seconds in which the dolphin breathes (Slooten and Dawson, 1994).

Dolphins of this genus produce sounds as low as 320 Hz and higher than 150 kHz, with dominant frequencies all above 800 Hz (Watkins et al., 1977; Watkins and Schevill, 1980; Kamminga and Wiersma, 1981; Sho-Chi et al., 1982; Evans and Awbrey, 1984; Dawson, 1988; Evans et al., 1988; Dziedzic and De Buffrenil, 1989; Dawson and Thorpe, 1990; Au, 1993).

The maximum peak-to-peak source level for the genus ranges from 160 dB for the **Commerson's dolphin** to 163.2 dB for the Hector's dolphin (Richardson et al., 1995b). The **Black or Chilean dolphin** is restricted to the shallow, coastal waters of Chile, the Straits of Magellan and the channels of Tierra del Fuego. It is one of the smallest of all cetaceans (adult weight 30-65 kg [65-145 lb]) and as many as 4,000 animals have been seen traveling together

(Carwardine, 1995). The **Harbor porpoise** is found in cold temperate and sub-arctic coastal waters (usually under 200 m [655 ft] depth) of the northern hemisphere, with most sightings within 10 km (6 nm) of land. When feeding, it rises for breath at 10-20 second intervals, about four times in a row, than dives for two to six minutes.

3.2.6 Pinnipeds (Sea Lions, Fur Seals, and Hair Seals)

The natural history of pinnipeds is summarized by Gentry (1998). Pinnipeds are globally distributed aquatic mammals with some specializations for terrestrial life. The suborder includes the true seals (family Phocidae), eared seals (family Otariidae), and the walrus (family Odobenidae). Because walruses are not found where SURTASS LFA sonar operations could occur, they will not be discussed further.

True seals swim with undulating motions of the rear flippers driven by back muscles, and move caterpillar-like on land. Otariids swim with their foreflippers and move on all fours on land. On average, pinnipeds are larger than other mammals, ranging from 50 to 2,000 kg (23 to 900 lb). The otariids retain more extensive ties with land. Otariids suckle and mate on land while phocids suckle on land but mate at sea.

All pinnipeds produce single, precocious young on land and males play no role in raising offspring. While otariid females feed during lactation (making regular trips to sea to forage), phocid females generally fast while suckling. Because of this strategy, otariids can only rear young in limited sites near extremely productive marine areas. Due to the limited number of such sites, a situation arises where males can monopolize mates by defending the few pupping sites. This leads to the polygynous breeding system found in most pinnipeds. Generally, the restriction for otariids in finding productive offshore foraging areas adjacent to pupping sites leads to more extreme polygyny in otariids than phocids. Most pinnipeds gather to bear young and breed once a year. This is facilitated by delayed implantation.

Pinnipeds are generally high-level consumers taking fish, cephalopods and crustaceans. Phocids are often benthic feeders; fur seals tend to feed on small surface-schooling fish; sea lions tend to specialize on large or adult stages of higher trophic-level species found over continental shelves. While a few species (e.g., monk seal, Galapagos fur seal, Galapagos sea lion) are found at low latitudes in tropical or sub-tropical waters, most species are found in temperate or polar waters. Foraging regions are often associated with ocean fronts or upwelling zones.

Pinniped visual systems are adapted to low light levels, consistent with feeding at depth or at night. However, the eye structure also allows for visual acuity in air. The ears of otariids are similar to carnivore ears while phocid ears are more water-adapted. Individuals of both groups produce aerial sounds, and many also produce underwater sounds. Airborne vocalizations have been associated with territoriality and dominance displays and mother-pup recognition. The context and function of subsurface sounds is not clear. Many appear to be socially important as they are often produced during the breeding season (e.g., harbor seals). Thus, many species must be able to hear well both above and below the water. Sensitivity to sounds at frequencies above 1 kHz has been well established. Fewer studies have examined sensitivity to LF sound. However, several generalizations may be made:

- The dominant frequencies of the sounds produced by hooded seals are below 1000 Hz (Schevill et al., 1966; Terhune and Ronald, 1973; Ray and Watkins, 1975).
- Audiograms for ringed, harbor, and harp seals demonstrate hearing to at least as low as 760 Hz, the hearing threshold is flat from 1-50 kHz between 65 and 85 dB (Møhl, 1968a; Terhune and Ronald, 1972, 1975b; Terhune, 1981).
- In a recent study, Kastak (1996) found hearing sensitivity decreased in three species of pinniped's (California sea lion, harbor seal, elephant seal) for frequencies below 64 kHz, but the animals are still able to hear sounds below 100 Hz.

3.2.6.1 Otariids

The family Otariidae includes the sea lions and fur seals. Fur seals tend to feed on small surface-schooling fish; sea lions tend to specialize on large or adult stages of higher trophic-level species found over continental shelves. The otariids include 14 extant species in seven genera (Table 3.2-5). Most otariids are found in temperate or sub-polar waters. Tropical species are generally located in regions of locally high productivity. Since many otariids spend the majority of their time in coastal regions, they are unlikely to be affected by SURTASS LFA sonar operations.

Several species that are listed as special status are discussed in more detail below (Northern sea lion [*Eumetopias jubatus*], Northern fur seal [*Callorhinus ursinus*], and Guadalupe fur seal [*Arctocephalus townsendi*]).

Otariid sounds are used to defend territories and secure mates on traditional terrestrial rookeries. In-air vocalizations are part of the displays used to establish and defend territories, attract females, and form and maintain the mother-pup bond. Males of at least two species (Juan Fernandez fur seal and California sea lion) use underwater sound to defend aquatic territories (Croll et al., 1999).

The underwater sounds of otariid species other than California sea lions have not been studied extensively. However, their hearing abilities are believed to be intermediate between the Hawaiian monk seal and other phocids. The HF cut-off is between 36 and 40 kHz. Sensitivity to low frequencies underwater also seems intermediate between 100 Hz and 1 kHz. Among the otariids, fur seals have their most sensitive underwater hearing at about 60 dB, at frequencies

Table 3.2-5

Information Summary for Otariids

Species	Protected Status	Distribution	Abundance	Diving Behavior	Hearing/Sound Production
S. American fur seal *(Arctocephalus australis)*	CITES protected	Pelagic distribution unknown; breeding on South American islands from Peru to Uruguay	69,000	Diving depth from 40 to 170 m.	No data available
New Zealand fur seal *(A. forsteri)*	CITES protected	Pelagic distribution unknown; breeding New Zealand Islands and Mainland and Australian Islands.	52,500	Unknown	No data available
Galapagos fur seal *(A. galapagoensis)*	CITES protected	Pelagic distribution unknown; breeding on Galapagos Islands.	27,000	Unknown	No data available
Juan Fernandez fur sea *(A. philippii)*	CITES protected	Pelagic unknown; breeding on Juan Fernandez Islands.	6,300	Unknown	Produces clicks from 100 to 200 Hz.
S. African and Australian fur seals *(A. pusillus)*	CITES protected	Coastal residents of SE Australia, Tasmania, South Africa, Namibia.	1,100,000 South African; 25,000 Australian	Unknown	No data available
Guadalupe fur seal *(A. townsendi)*	ESA - threatened IUCN - vulnerable species CITES protected	Pelagic distribution unknown; breeding on Guadalupe Island.	7,400 (in 1993)	Shallow divers foraging within 30 m of the water column.	Little is known about underwater sound production and hearing.
Subantarctic fur seal *(A. tropicalis)*	CITES protected		2,000,000	Unknown	No data available
N. fur seal *(Callorhinus ursinus)*	IUCN - vulnerable species	Pelagic distribution Bering Sea, to 35°N in W Pacific, to 33°N in E Pacific; 48-100 km offshore; Breeding Pribilof Islands, Commander Islands.	1,320,000	Forage in upper 100 m of water column. Max recorded depths from 207 to 230 m.	Underwater hearing range from 500 Hz to 40 kHz with best hearing at 5 kHz w/ threshold of 50-60 dB.

Table 3.2-5

Information Summary for Otariids

Species	Protected Status	Distribution	Abundance	Diving Behavior	Hearing/Sound Production
N. sea lion *(Eumetopias jubatus)*	ESA - Population west of 144°W longitude is endangered; remaining population is threatened.	Pelagic distribution North Pacific, shore to continental slope; Breeding North Pacific Islands, Hokkaido-central California.	39,031 - Western U.S. stock 30,403 - Eastern U.S. stock	Feed in water column at relatively shallow depths. Deepest dives to 277 m.	Little is known about underwater sound production and hearing. They produce clicks and growls.
Australian sea lion *(Neophoca cinerea)*		Shallow waters off Australia, non-migratory; breeding western and southern Australian islands and mainland between 28° and 36° South.	5,000	Deepest dive to 92 m.	No data available
S. American sea lion *(Otaria byronia)*		Coastal resident; near shore and near surface. Breeding Uruguay to Peru.	300,000	Forage in shallow water - less than 300 m in depth.	No data available
Hooker sea lion *(Phocarctos hookeri)*		New Zealand offshore to 600 km; breeding New Zealand and Aukland Islands.	6,000	Unknown	No data available
California sea lion *(Zalophus californianus)*		Males migrate north near shore and females disperse near shore; breeding islands and remote mainlands Southern California to Mexico and Galapagos.	160,000	Feed at relatively shallow depths of 26 to 74 m; max recorded dives to 376 m.	Hearing: HF cutoff is between 36 and 40 kHz and LF sensitivity is between 100 and 1000 Hz.
Antarctic fur sea (*Arctocephalus gazella)*	CITES protected	Pelagic 61°S to the Antarctic Convergence; breeding on S. Georgia, S. Shetland, S. Sandwich, Kergulen, McDonald, Heard, Vouvel, and Marion Islands.	1,800,000	Average dives of 30 to 40 m; max dives may exceed 250 m.	No data available

Source: Based upon compilation of research prepared by the Institute of Marine Sciences, University of California-Santa Cruz (Croll et al., 1999); Reeves et al. (1992); and Richardson et al. (1995b).

between 4 kHz and 17 to 28 kHz (Moore and Schusterman, 1987 and Babushina et al., 1991, both in: Richardson et al., 1995b).

The **northern sea lion** *(Eumetopias jubatus*) (also known as the Steller sea lion) is widely distributed throughout the North Pacific. Populations have dramatically declined in recent years, due to declines in prey species in the northern portion of its range. Breeding generally occurs during May through June. Males are sexually mature at three to eight years, and physically mature at ten to eleven years. Females sexually mature at two to eight years, with the average age of first pregnancy at 4.9 years. They give birth each year thereafter. Gestation is 11 months, and pups are generally weaned by the end of their first year (Reeves et al., 1992). Based on recent biological information, NMFS reclassified the northern (Steller) sea lion as two distinct stock segments under the ESA. The stock west of 144° W longitude was reclassified as endangered, and the threatened listing is being maintained for the remaining stock (FR Vol. 62 No. 86). More than 50 northern sea lion rookeries and even more haulout sites have been identified.

Northern sea lion underwater sounds have been described as clicks and growls (Poulter, 1968, in: Richardson et al., 1995b). Otherwise, little is known about underwater sound production and hearing in northern sea lions.

Guadalupe fur seals *(Arctocephalus townsendi)* were once believed extinct from over harvest in the 18th and 19th centuries. Since a remnant stock was discovered on Guadalupe Island, Mexico, the species has recovered to over 7,400 individuals in 1993. Currently the species only breeds on Guadalupe Island. Guadalupe fur seals are shallow divers, foraging within the upper 30 m (100 ft) of the water column. The stock of Guadalupe fur seals returns to Guadalupe Island to breed during the summer, and again in the fall-winter to molt (Reynoso, 1994). Female Guadalupe fur seals give birth to single pups in June. It appears that the individuals are faithful to the same breeding site from year to year (Reeves et al., 1992). Nothing is known about the age at sexual maturity or longevity (Croll et al., 1999). Little is known about underwater sound production and hearing in Guadalupe fur seals.

Northern fur seals (*Callorhinus ursinus*) were commercially exploited for over 250 years. In spite of the cessation of commercial harvest, populations generally declined from 1956 to 1983. The reasons for the decline are not fully understood. Since 1984, populations have remained relatively stable. Northern fur seals are widely distributed across the North Pacific in November and December, and are generally associated with the continental shelf break in the North Pacific between Japan and southern California at other times. They forage primarily in the upper 100 m (345 ft) of the water column. Maximum recorded dive depths of breeding females, which increases between early and late lactation (Goebel, 1998), is 207 m (680 ft) in the Bering Sea, and 230 m (755 ft) in southern California.

Males are sexually mature at four to five years, and physically mature at eight to nine years. Females sexually mature at four to five years, as well, and produce pups each year thereafter

(Reeves et al., 1992). Males rarely breed for more than one year (Reeves et al., 1992; Gentry, 1998). Mating takes place during the summer and is brief. Males arrive at breeding grounds in May and June, while females arrive in July and early August (Gentry, 1998).

3.2.6.2 Phocids

Phocids are generally benthic feeders. While a few species (e.g., monk seals) are found at low latitudes in tropical or sub-tropical waters, most species are found in temperate or polar waters where productivity is higher. Foraging regions are often associated with ocean fronts or upwelling zones.

The phocids include 18 extant species in ten genera. Many phocids are confined to Arctic/Antarctic waters or inland lakes and so would not be affected by SURTASS LFA sonar operations. Nine species occur in non-polar waters and are discussed below. They are the Mediterranean and Hawaiian monk seals (*Monachus monachus* and *M. schauinslandi*); the northern and southern elephant seals (*Mirounga angustirostris* and *M. leonina*); the gray seal (*Halichoerus grypus*); three species in the genus *Phoca*: the ribbon, harbor, and spotted seals (*P. fasciata, P. vitulina,* and *P. largha*); and the hooded seal (*Cystophora cristata*).

All of the phocid species discussed below occur in pelagic waters, dive for their food, and breed on land or pack ice. The monk seals are rare and protected as endangered species. The Mediterranean monk seal is the most endangered of all pinnipeds; it is on the verge of extinction due to competition with commercial fisheries, habitat destruction, pollution, human disturbance, and harassment by fishermen. The other species have large, in some cases expanding, populations. All species of true seals discussed here are likely capable of producing and hearing LF sound underwater. There is little evidence on the responses of seals to LF sounds.

According to Richardson et al. (1995b), phocid seals have essentially flat underwater audiograms for mid to high frequencies (1 kHz to 30 to 50 kHz), with thresholds between 60 and 85 dB (Møhl, 1968a; Terhune and Ronald, 1972, 1975a; Terhune, 1981, 1989; Terhune and Turnbull, 1995). Above 60 kHz, phocid sensitivity to underwater sound is poor (Richardson et al., 1995b) and frequency discrimination minimal (Møhl, 1968a, 1968b in: Richardson et al., 1995b). Thus, the functional HF limit for this species, based on testing to date, is about 60 kHz (Schusterman, 1981, in: Richardson et al., 1995b). Hawaiian monk seals have their best underwater hearing at 12 to 28 kHz (Thomas et al, 1990b).

Most phocid seal calls seem to be associated with mating, mother-pup interactions, and territoriality; thus, underwater calls may not be very important for species such as gray seals and elephant seals that perform these activities on land. Some species produce strong underwater sounds that may propagate for long distances (Ray, et al., 1969; Watkins and Ray 1977). Other species produce faint and infrequent underwater sounds (Schevill et al., 1963, in: Richardson et al., 1995b).

Phocids probably hear underwater sounds at frequencies up to about 60 kHz. Calls between 90 Hz and 16 kHz have been reported, but for some species, other LF sounds may have been missed. Source levels have been estimated for at least five species. However, it is difficult to determine the range of a seal calling underwater, especially under ice, so reliable estimates of source levels are rare (Richardson et al., 1995b).

Most phocids are confined to Arctic and Antarctic waters, and would not occur within the operating area of the SURTASS LFA sonar. Six species occur in non-polar waters. Table 3.2-6 provides summarized information on the protected status (with respect to ESA, CITES, and IUCN), distribution, abundance, diving behavior, and travel speeds of these six phocid species. Pertinent details on species of specially protected status follow.

Mediterranean and Hawaiian monk seals are the two surviving monk seal species and are very rare. The main conservation problems are past and current exploitation, interactions with commercial fisheries (Croll et al., 1999), and toxins (such as ciguatera poisoning) (Gilmartin et al., 1980), and anthropogenic noise.

Mediterranean monk seals (*Monachus monachus)* are in imminent danger of extinction and are protected as endangered species throughout their range. They are found in several fragmented and now isolated stocks throughout their former range in the Mediterranean and Black Seas, and the Atlantic coast and offshore islands of North Africa. Mediterranean monk seals tend to stay close to their haul-out areas and forage in coastal waters for fish, octopus, and crustaceans. They are less social than other pinnipeds and have a lower potential rate of population growth. Mediterranean monk seals forage in water less than 70 m (230 ft) deep.

Mediterranean monk seals become sexually mature at about five to six years, and live to 20 or 30 years (Reeves et al., 1992). Many females do not produce pups every year. They give birth and rear their pups in isolated caves throughout their range (Reeves et al., 1992).

There are no data on hearing of Mediterranean monk seals.

Hawaiian monk seals (*M. schauinslandi)* are found almost exclusively on the Leeward Islands where they occasionally move among islands and atolls. They are listed as endangered under the ESA throughout their range. They forage in deep water and dive to at least 490 m (1,608 ft) (Reeves et al., 1992). Hawaiian monk seals probably have the lowest reproduction rate of all pinnipeds. Their rookeries are primarily located on the Leeward Islands of French Frigate Shoals, Pearl and Hermes Reef, Kure Atoll, and Laysan and Lisianski islands (Croll et al., 1999). Hawaiian monk seals mature at age five, and only about 54 percent of the females give birth every year (Johanos et al., 1994).

Hawaiian monk seals have their most sensitive hearing at 12 to 28 kHz. Below 8 kHz, their hearing is less sensitive than other pinnipeds. HF sensitivity drops off sharply above 30 kHz. (Thomas et al., 1990b)

Table 3.2-6

Information Summary for Phocids

Species	Protected Status	Distribution	Abundance	Diving Behavior	Hearing/Sound Production
Hawaiian monk seals *(Monachus schauinslandi)*	ESA endangered; CITES protected	Found primarily on the Leeward Chain of the Hawaiian Islands, especially Nihoa, Necker, French Frigate Shoals, Pearl and Hermes Reef, KureAtoll, Laysan, and Lisianski.	More than 1,500 and population appears to be increasing slowly.	Hawaiian monk seals dive to 490 m and stay submerged for 20 min.	Hawaiian monk seals have most sensitive underwater hearing from 12 to 28 kHz; Hearing is less sensitive than other pinnipeds below 8 kHz and drops off sharply above 30 kHz. -No sound production data available
Mediterranean monk seals (*Monachus monachus)*	ESA endangered; CITES protected	Found in several fragmented and isolated populations throughout former range: Mediterranean and Black Seas, Atlantic coast, and offshore islands of N. Africa	Less than 500 – fragmented into a number of isolated populations	Mediterranean monk seals forage in water primarily less than 70 m.	No hearing data available on Mediterranean monk seals.
Ribbon, harbor, and spotted seals (*Phoca* species)		- Ribbon and Spotted: pack ice breeding species that rarely enter N. Pacific; - Harbor seals: subarctic and temperate waters of Northern Hemisphere	- Ribbon: 240,000; - Harbor: 500,000; - Spotted: 200,000	- Ribbon: No data; - Harbor: dive to more than 500 m for up to 30 min/avg. dives 17-87 m; - Spotted: dive to at least 300 m	-Ribbon : Vocalize at 0.1 –7.1 kHz; -No hearing data available; -Harbor: Vocalize at <0.1 kHz; hear sounds from 1-180 kHz; -Spotted: Vocalize at <0.1 kHz; no hearing data available
Gray seal (*Halichoerus grypus*)		- Found only in N. Atlantic; - Three populations: Baltic Sea, E/N Atlantic, and W/N Atlantic	- Worldwide: 200,000 - Baltic: 2,500-3,000 - E/N Atl: ~86,000 - W/N Atl: 85,000 - 115,000	- Avg. dive time: 1.8-2.5 min.; - Max time: 9.1-27.5 min.; - Max. depth: 400 m	-Underwater hearing from 2-90 kHz; -Vocalize at 0.1-16 kHz

Table 3.2-6

Information Summary for Phocids

Species	Protected Status	Distribution	Abundance	Diving Behavior	Hearing/Sound Production
Northern and Southern elephant seals (*Mirounga angustirostris* and *M. leonina*)	Southern elephant seals are CITES protected.	Northern elephant seals: throughout the NW Pacific; southern elephant seals: circumpolar between 40° and 62° South	Northern: 130,000; Southern: 400,000	- Both dive deep, long, and continuously; - Northern: max. depths are 1,503 m and max. times 68 min.; - Southern: max. depths are 1,403 and max. time 120 min.	-Hearing range from less than 0.075 kHz to 6.4 kHz; -Produce low frequency sounds on breeding colony
Hooded seal (*Cystophora cristata*)		North Atlantic north of St. Lawrence ice floes and deep offshore waters.	Canada: approximately 400,000	- Believed to feed at depths greater than 200 m.	- Males produce LF underwater "grung," "snort," and "buss."

Source: Based upon compilation of research prepared by the Institute of Marine Sciences, University of California-Santa Cruz (Croll et al., 1999)

Ribbon and spotted seals only occasionally venture south from the Arctic into the North Pacific.

Harbor seals are widely distributed in subarctic and temperate waters along the margins of both the North Atlantic and North Pacific oceans. These *Phoca* species are relatively abundant, have a broad diet, make no clear long-distance migrations, and are seasonally monogamous or mildly polygynous breeders. They have all been hunted commercially or in an attempt to reduce population sizes (Croll et al., 1999).

Ribbon seals breed on pack ice throughout the Bering, Chukchi, and Okhotsk seas (Riedman, 1990), while harbor seals breed on pack ice, islands, offshore rocks, isolated mainland beaches, log booms, and other surfaces throughout their range (Riedman, 1990). Spotted seals also breed on pack ice throughout their range (Reeves et al., 1992).

No diving data are available for ribbon seals. Harbor seals dive to more than 500 m (1,640 ft), although average dive depths are 17 to 87 m (56 ft to 285 ft) (Eguchi and Harvey, 1995). Adult spotted seals dive to at least 300 m (1000 ft) (Reeves et al., 1992).

Female ribbon seals are sexually mature at two to five years, males at three to five years. About 95 percent of the females give birth every year. Mortality before sexual maturity is about 58 percent, but longevity is about 20 to 30 years (Reeves et al., 1992). Harbor seals are sexually mature at three to six years, males at three to seven years. Mortality before sexual maturity can be as high as 55 percent (Reeves et al., 1992). Female spotted seals become sexually mature at three to four years, and give birth about every year. Males mature at four to five years (Reeves et al., 1992).

Watkins and Ray (1977) indicate that underwater sounds produced by the ribbon seal range between 100 Hz and 7.1 kHz, with source levels up to 160 dB. Summarizing the work of several authors, Richardson et al. (1995b) indicate a variety of sounds produced by harbor and spotted seals, including clicks, "bubbly" growls, groans, grunts, and creaks. The frequencies of these sounds range from below 100 Hz to over 150 kHz.

Gray seals (*Halichoerus grypus)* occur in three stocks in the North Atlantic. They are relatively abundant and their population is increasing in many parts of their range, but decreasing in the Baltic Sea. They forage on a number of fish species, and dive to a maximum depth of 400 m (1,300 ft). Gray seals are polygynous, and very gregarious at haul outs, but more solitary at sea. Females reach sexual maturity at four to five years. Males can reach sexual maturity at age eight, but generally are between 12 and 18 (Platt et al., 1975). Gary seals breed on drifting ice and offshore islands throughout their range.

Gray seals produce sounds at 0.1 to 16 kHz, with predominant frequencies between 100 Hz and 4 kHz, and again at 10 kHz. Sound frequencies as high as 30 and 40 kHz have been reported

(Schevill et al., 1963; Oliver, 1978). Gray seals have underwater hearing ranging from 2 kHz to 90 kHz, with best hearing between 20 kHz and 50 to 60 kHz (Croll et al., 1999).

Northern and southern elephant seals (*Mirounga angustirostris* and *M. leonina)* are large, highly polygynous seals that have recovered from severe over-exploitation. They dive deep and frequently to feed on mesopelagic squid, and fish such as sharks and hake, and they make long migrations between foraging and breeding areas. Maximum dive depths are 1,503 m (4,931 ft), with average dive depths of about 500 m (1,640 ft). Both species were hunted nearly to extinction in the late 1800s, but with regulation have made remarkable recoveries. However, some stocks of the southern elephant seal are declining due to unknown factors (Laws, 1994; Hindell et al., 1994).

Both species of elephant seal are gregarious at breeding colonies, but solitary at sea. The males maintain harems. Male mating is highly skewed, with as few as five out of 180 males being responsible for 90 percent of the copulations (Le Boeuf and Laws, 1994). Northern elephant seals breed on about 16 islands and mainland rookeries from central Baja, Mexico to central California (Stewart et al., 1994). Southern elephant seals breed on 14 colonies around the Antarctic Convergence, between 40^o and 62°S (Laws, 1994).

While elephant seals have not been thought to produce LF sounds underwater, Burgess et al. (1998) detected 300 Hz pulses on an acoustic recording from a juvenile female elephant seal between 220 to 420 m (722 to 1,378 ft) dive depths. The mean frequencies of airborne calls of northern elephant seals range from 147-334 Hz for adult males (Le Boeuf and Peterson, 1969; Le Boeuf and Petrinovich, 1974) and 500-1000 Hz for adult females (Bartholomew and Collias, 1962). Because elephant seal hearing sensitivity has been shown to be greater underwater (Kastak, 1996), it may be inferred that this species would be sensitive to human-produced LF sound. However, experimental releases of northern elephant seals with attached dive recorders, into areas where LF sounds were being broadcast (e.g., Acoustic Thermometry of Ocean Climate [ATOC]), indicate that these sounds did not cause any short-term changes in dive behavior associated with (ATOC) transmissions.

Hooded seals (*Cystophora cristata*) are found in the North Atlantic, primarily north of the Gulf of St. Lawrence and prefer thick, drifting ice floes or deep offshore waters (Wynne and Schwartz, 1999). They are also found in the Davis and Denmark Straits and the Greenland, Norwegian, and Barents seas (Reeves et al., 1992). They are relatively large in size, from 2.0 to 2.7 m [6.5 to 9 ft]) in length, with some males reaching 3 m (9.8. ft). There are at least three types of LF, pulsed sounds, described as "grung," "snort," and "buzz" that are made by the male underwater (Reeves, et al. 1992).

3.3 Socioeconomics

3.3.1 Commercial and Recreational Fisheries

This section provides an overview of global marine fisheries production, employment and trade. Information provided by the Fisheries Department of the Food and Agriculture Organization (FAO) of the United Nations (UN) references the most recent year available or the year for which the most complete information was available. Additional information was gathered from the Department for Economic and Social Information and Policy Analysis of the United Nations, NMFS, the World Bank, and the International Whaling Commission (IWC).

3.3.1.1 Marine Fisheries Production

Marine fishing for commercial, recreational, industrial, or subsistence purposes occurs in almost all global waters with the most productive regions in coastal waters overlying the continental shelves. This is due to their higher primary productivity and the fact that the shallow ocean floor allows for the use of nets and traps. In contrast, the deep floor of the open ocean not only prevents effective commercial fishing, but also does not foster large fish populations. Commercial fishermen work offshore waters for species such as sharks, swordfish, tuna, and whales, while recreational fishers seek ocean pelagic species such as billfish, dolphinfish, tunas, and wahoo.

Information on global marine fisheries production by geographic location is compiled annually by the FAO. Nominal catches, as expressed in metric tons (mt), represent the live-weight-equivalent of fish or other marine species obtained by capture or aquaculture as recorded at the time of landing. Catches are recorded at the location of the landing, providing the FAO with information on the species caught by the landing's country, continent, and FAO fishing zone.

FAO's nominal catch data cover fish, crustaceans, mollusks, and miscellaneous aquatic animals caught for commercial, recreational, industrial, and subsistence purposes, as well as marine mammals and plants. In their global fisheries production totals, however, FAO does not include marine mammals and plants. Information on marine mammal catches is presented later in this subchapter.

Global Data

The general composition of 1995 global marine fisheries catches is presented in Table 3.3-1. As indicated, marine fishes and mollusks represent the majority of the total 92 million mt of nominal catches (79 and 12 percent, respectively). Of marine fishes, the group representing the greatest catch volume includes herrings, sardines, and anchovies with 22 million mt caught in 1995 (30 percent of marine fishes). Other groups with significant catch volumes, each representing about 15 percent of marine fishes, include: jacks, mullets and sauries at 11.2 million mt; miscellaneous marine fish at 11.2 million mt; and cod, hake and haddock at 10.6 million mt (FAO, 1997).

Table 3.3-1

Catches in Marine Fishing Areas by Type, 1995

ISSCAAP Division[1]	Catches (metric tons)	Percent of World Catch
Freshwater Fishes	36,100	0.04
Diadromous Fishes	2,117,900	2
Marine Fishes	72,937,700	79
Crustaceans	5,655,200	6
Mollusks	10,612,100	12
Whales, Seals, Other Aquatic Mammals[2]	NA	***
Miscellaneous Aquatic Animals	545,900	1
Miscellaneous Aquatic Products	NA	***
Aquatic Plants[2]	NA	***
Total	91,904,900	100

Notes:
1. ISSCAAP = International Standard Statistical Classification of Aquatic Animals and Plants.
2. Data on aquatic mammals and plants are excluded from all national, regional, and global totals.
NA = Not available or unobtainable.
Source: FAO, 1997.

Regional Trends

Nominal catches for each marine fishing zone in 1990 and 1995 are presented in Table 3.3-2. In these two years, the Northwest Pacific zone was by far the greatest single contributor to global marine fisheries production, recording over 25 million mt each year, or 30 percent of the global total. This zone, including the marine waters of China and the Russian Federation, has been the world’s most productive fishing zone since 1971 (Grainger, 1997).

The Southeast Pacific zone also was a major contributor to global marine fisheries catches in 1990 and 1995, providing 17 and 19 percent, respectively. The Southeast Pacific zone has historically been the most dynamic zone and is dominated by small pelagic species (Grainger, 1997). In 1995, the combined zones of the Pacific Ocean yielded the majority of all marine catches, with 59.2 million mt, or 65 percent of the world’s catches in marine waters.

Table 3.3-2

Nominal Catches in Marine Fishing Areas[1]

FAO Zone	**1990**		**1995**		**% Change 1990-95**
	Catches (metric tons)	**% of World**	**Catches (metric tons)**	**% of World**	
Arctic Sea	0	0	0	0	0
Atlantic, Northwest	3,288,600	4	2,065,500	2	-37
Atlantic, Northeast	9,198,300	11	11,794,400	13	+28
Atlantic, Western Central	1,708,800	2	1,895,000	2	+11
Atlantic, Eastern Central	4,101,200	5	3,194,300	3	-22
Mediterranean and Black Sea	1,528,000	2	1,921,700	2	+26
Atlantic, Southwest	2,028,600	2	2,402,100	3	+18
Atlantic, Southeast	1,415,300	2	1,294,600	1	-9
Atlantic, Antarctic	387,600	0	121,900	0	-69
Indian Ocean, Western	3,351,000	4	3,903,300	4	+16
Indian Ocean, Eastern	3,098,200	4	4,118,100	4	+33
Indian Ocean, Antarctic	34,400	0	9,700	0	-72
Pacific, Northwest	25,585,800	31	27,249,200	30	+7
Pacific, Northeast	3,405,600	4	3,066,900	3	-10
Pacific, Western Central	7,770,900	9	9,231,300	10	+19
Pacific, Eastern Central	1,520,100	2	1,547,000	2	+2
Pacific, Southwest	860,500	1	872,600	1	+1
Pacific, Southeast	13,971,700	17	17,217,400	19	+23
Pacific, Antarctic	700	0	0	0	-100
World Total[2]	83,255,400	100	91,904,900	100	+10

Note:

1. Includes fish, crustaceans, mollusks, and miscellaneous aquatic animals.
2. May not add due to rounding.

Source: FAO, 1997.

3.3.1.2 Marine Fisheries Employment

In 1990, more than 28 million persons worldwide were employed in the marine and freshwater fishing industry, twice as many as employed in 1970, due primarily to increases in fleet size and expansion of aquaculture (FAO, 1998). Of this total, the number of marine fishers is estimated at approximately 18.4 million based on the percentage of each country's total catch attributable to marine waters. The largest number of marine fishers (5.2 million in 1990) are found in China. India and Indonesia each contained an estimated 3 million fishers, or almost 17 percent of the global total in 1990. With Vietnam and the Philippines, these five countries combined included 70 percent of the world's marine fishers.

3.3.1.3 Fisheries Trade

In order to assess the contribution of fisheries activities to international economies, this section reviews the trade statistics associated with fish-related commodities. The United Nations Department for Economic and Social Information and Policy Analysis collects trade information for four commodities (excluding marine mammals):

- Fish (fresh, chilled, frozen);
- Fish (salted, dried, smoked);
- Shellfish (fresh, frozen); and
- Fish (prepared, preserved).

Combined, these commodities represent the total trade value directly related to both marine and inland fisheries production. Fish-related export values for major regions of the world as expressed in millions of U.S. dollars in 1995 are presented in Table 3.3-3. As can be seen, fish export value was highest in Asia, which at $16 billion in 1995 had 35 percent of the global fish-related export market. Europe and the Americas followed with 30 and 25 percent of global fish exports. Africa and Oceania had the lowest fish-related trade. However, the contribution of fish exports to total export volume for these two regions was higher than for other regions, indicating a relatively greater reliance on this commodity as a source of income.

For individual countries, fish-related and total trade statistics were reviewed for 1992, the year for which most complete data were available (United Nations, 1996). Of the 80 countries with separate fisheries export statistics, eight had volumes above $1 billion: Japan, U.S., Thailand, Norway, Denmark, Canada, China, and Iceland. Japan generated the highest export volume in fish-related commodities ($12 billion), representing only five percent of its total export volume. Iceland was the only country with exports over $1 billion where fish exports comprised more than ten percent of total exports. Countries with high dependence on fish commodity exports (from 20 to 95 percent of total trade) generally are islands or small coastal countries such as Greenland (94.7 percent), the Faroe Islands (86.6 percent), and Micronesia (86.2 percent).

Table 3.3-3

1995 Fish Exports by Region (in million $U.S.)[1]

Region	Total Fish Exports	% of World	Total Exports	Fish Exports (% of Total)
Africa	2,546	5.5	102,988	2.5
Americas	11,360	24.7	925,735	1.2
Asia	15,969	34.7	1,529,601	1.0
Europe	13,894	30.2	2,128,641	0.7
Oceania[2]	2,036	4.4	68,316	3.0
Subtotal	45,806	99.5	4,755,281	1.0
World Total	46,049	100.0	4,925,668	0.9

Notes:

1. Includes Standard International Trade Classifications 034; 035; 036; 037.
2. Estimated by UN Dept. for Economic and Social Information and Policy Analysis.

Source: United Nations, 1996.

3.3.1.4 Marine Mammals

As previously noted, information on nominal catches of marine mammals is not included in total fisheries catch data; however, FAO does compile data on marine mammal catches as reported by each country. Data for 1998 are shown in Table 3.3-4. Unlike the fisheries data, catch volume reflects the number of the individual species caught, not the total weight in metric tons.

Whale captures are guided by measures set forth by the IWC which, among other things, designates whale sanctuaries, sets limits on the numbers and sizes of whales that may be captured, and provides open and closed seasons and areas for whaling. The IWC was established under the International Convention for the Regulation of Whaling signed in 1946, and membership in the IWC is open to any country that adheres to the 1946 Convention.

In 1982 the IWC decided that there should be a pause in commercial whaling, but that aboriginal subsistence whaling and collections for scientific research should proceed as permitted. Aboriginal subsistence whaling of specific species is allowed in certain countries as follows:

- Denmark and Greenland - fin and minke whales;
- Russian Federation (Siberia) - gray whales;
- St. Vincent and The Grenadines - humpback whales; and
- U.S. (Alaska) - bowhead and occasionally gray whales.

Table 3.3-4

Nominal Catches of Marine Mammals, 1998

Species	Argentina[2]	Austrailia[2]	Brazil[2]	Canada	France[2]	Germany[2]	Greenland	Ireland[2]	Japan[2]	Korea Republic	Namibia	Netherlands[2]
Minke whale					1		173		562	45		
Fin whale							9					
Humpback whale							1		1			
Bryde's whale									1			
Baleen whales [1.]			1	1								
Sperm whale												
Harbor Porpoise						5		2				4
Long-finned pilot whale					1							1
Short-finned pilot whale									229			
Killer whale												
White whale												
Baird's beaked whale									54			
Toothed whale [1.]	15	47	136		48			29	13037	34		29
Walrus												
Bearded seal				59			394					
Grey seal												
Harbor seal							84					
Harp seal				249993			36752					
Hooded seal				10020			3536					
Northern fur seal												
Ringed seal				1234			44773					
So. African fur seal											29475	
Spotted seal												
Seals [1.]				62								
Aquatic mammals [1.]									1242			

Table 3.3-4

Nominal Catches of Marine Mammals, 1998

Species	New Zealand[2]	Norway[2]	Peru[2]	Russian Fed[2]	South Africa	Spain[2]	Swedan[2]	UK[2]	US[2]	Other	Total
Minke whale		625						3			1409
Fin whale											9
Humpback whale										2	4
Bryde's whale											1
Baleen whales[1.]				123					42		167
Sperm whale									1		1
Harbor Porpoise							14	33	2		60
Long-finned pilot whale	1										3
Short-finned pilot whale											229
Killer whale									1		1
White whale				27					266		393
Baird's beaked whale											54
Toothed whale[1.]	15		56		45	6		6	19	1877	15399
Walrus				950							950
Bearded seal				920							1373
Grey seal										4	4
Harbor seal								NA			84
Harp seal		2689		13370							302804
Hooded seal		6332									19888
Northern fur seal				7742					1553		9295
Ringed seal				2975							48982
So. African fur seal											29475
Spotted seal				181							181
Seals[1.]								NA		4	66
Aquatic mammals[1.]											1242

Notes: N/A = data unavailable/unobtainable; 1 = not elsewhare included; 2 = member of International Whaling Commission

Source: FAO, 1988

IWC scientific research permits have been issued as follows:

- Iceland - 292 fin and 70 sei whales;
- Norway - 289 minke whales; and
- Japan - 400± minke whales in the Antarctic and 100 minke whales around Japan.

Data in Table 3.3-4 reflect authorized minke whale catches for scientific research for Japan and Norway, and the catches authorized for aboriginal subsistence whaling in Greenland, the Russian Federation, and U.S.. Whale catches can vary significantly from year to year, thus the numbers for 1995 provide only a snapshot of annual whale catches. Iceland, for example, conducted a four-year research program between 1986-1989 resulting in taking 292 fin and 70 sei whales, yet no catches are recorded for 1995. Based on the information in Table 3.3-4, catches of marine mammals for commercial purposes appear to be primarily related to eared seals, hair seals, and walruses.

3.3.2 Other Recreational Activities

In addition to fishing, other recreational activities in marine waters include boating, surfing, water skiing, swimming, diving, and whale watching. Most of these activities would not be affected by SURTASS LFA sonar transmissions because they are conducted above the water's surface. Also, these activities largely occur in coastal waters, away from where SURTASS LFA sonar would operate. An exception may be whale watching where there may be a possibility that whale behavior would be affected, but only if sonar operations were being conducted nearby. Only those activities that could be affected, albeit remotely by SURTASS LFA sonar, will be further addressed in this subchapter.

3.3.2.1 Swimming and Snorkeling

Recreational swimming and snorkeling occur in marine waters worldwide. Most swimming sites are located immediately adjacent to the coastline and well within 5.6 km (3 nm) of the coast. Most swimming activity occurs at the air/water interface, (i.e., immediately adjacent to the ocean’s surface). For snorkeling activity, the swimming area extends from the surface to depths not greater than 2 m (6.5 ft). Deeper depths than this are unlikely for the average recreational swimmer. Other than for very short periods of time, people do not go below 2 m (6.5 ft).

3.3.2.2 Recreational Diving

Recreational diving sites are generally located between the shoreline and the 40 m (130 ft) depth contour, but can occur outside this boundary. Global diving statistics indicate a substantial growth in the activity over the decade 1986 to 1996 as measured by the number of divers that were certified during that time. The Professional Association of Diving Instructors (PADI), the world's largest dive training organization, issued approximately 277,400 diving certifications in 1986 and 728,300 in 1996, reflecting a ten percent average annual increase during those years (PADI, 1998). In fact, between 1967 and 1996, PADI issued a cumulative total of nearly 7 million diving certifications. The National Association of Underwater Instructors (NAUI) issues approximately 130,000 certifications annually (Davis and Tisdell, 1995).

It is estimated that over 1.2 million dive trips are taken to warm water destinations each year (Simmons, 1997), including the Caribbean, Gulf of Mexico, south Pacific Ocean, Mediterranean Sea, and Indian Ocean, as well as other locations (see box). Surveys of the demographics of diving students and instructors conducted by PADI in 1991 and 1996 revealed that most divers are males between 18 and 29 years old.

Diving Locations

- Aruba
- Australia
- Bahamas
- Barbados
- Belize
- Bermuda
- Bonaire
- British Virgin Islands
- Canada
- Cayman Islands
- Columbia
- Costa Rica
- Cuba
- Curacao
- Dominican Republic
- Ecuador
- Egypt
- England
- Fiji
- Fr. Polynesia
- Galapagos Is.
- Grenada
- Guam
- Haiti
- Honduras
- Italy
- Jamaica
- Malta
- Maldives
- Mexico
- Micronesia
- Micronesia
- Netherlands Antilles
- New Zealand
- Papua New Guinea
- Puerto Rico
- Philippines
- Scotland
- Seychelles
- Solomon Islands
- Spain
- Sri Lanka
- St. Kitts and Nevis
- St. Lucia
- Thailand
- Trinidad
- Turks & Caicos
- United States
- U.S. Virgin Islands
- Venezuela

Sources: PADI, 1998; Simmons, 1997; Taylor, 1982.

3.3.2.3 Whale Watching

Whale watching worldwide has been expanding rapidly as a commercial recreational industry in recent years. In 1994, an estimated 5.4 million people in 65 countries or territories participated in whale-watching excursions, a figure that has been growing at about ten percent per year (Whale and Dolphin Conservation Society, 1997). Recent statistics from Iceland also are illustrative of the growth of whale watching. In 1995, the total number of passengers on whale-watching trips in Iceland was 2,200; in 1996 that number had grown to about 9,700. By 1997 Iceland recorded 20,540 passengers, reflecting an increase of 110 percent over 1996 data, and an increase of over

800 percent when compared with 1995 data (Cetacean Society International [CSI], 1998).

Global revenues from whale watching are estimated at $500 million U.S. per year and have almost doubled since 1991 (International Fund for Animal Welfare, World Wildlife Fund, and Whale and Dolphin Conservation Society, 1997). Due to the seasonal migration of whales, the location of whale-watching activities varies by season, and the employment associated with the industry is temporary. A list of countries that currently offer recreational whale watching (see box) has been compiled by the Research Institute for High Energy Physics at the University of Helsinki (Lauhakangas, 1998). Members of the European Cetacean Society also provide whale-watching programs, and include: Azores, Belgium, Canary Islands, Denmark, Finland, France, Germany, Iceland, Ireland, Italy, Netherlands, Norway, Portugal, Russia, Spain, Sweden, Switzerland, Ukraine, and United Kingdom (Lauhakangas, 1998). The IWC and other whale preservation organizations support whale watching as a sustainable use of cetacean resources (IWC, 1998; CSI, 1998; Spalding, 1998). In 1996 the IWC adopted the following general principles for managing this emerging industry in order to help minimize adverse effects on whale populations:

- Manage the development of whale watching to minimize the risk of adverse impacts;
- Design, maintain and operate platforms to minimize the risk of adverse effects on cetaceans including disturbance from noise; and
- Allow the cetaceans to control the nature and duration of “interactions” (IWC, 1998).

Whale Watching Locations by Country

- Argentina
- Belize
- Brazil
- China
- Dominican Republic
- Hong Kong
- Kenya
- New Zealand
- South Africa
- USA
- Australia
- Costa Rica
- Canada
- Colombia
- Ecuador
- Israel
- Madagascar
- Peru
- Sri Lanka
- West Indies
- Bahamas
- Bermuda
- Chile
- Dominica
- Greenland
- Japan
- Mexico
- Philippines
- Tanzania
- European Cetacean Society

Source: Lauhakangas, 1998.

3.3.3 Research and Exploration Activities

This section summarizes the various research and exploration activities occurring or expected to occur in the ocean, with a focus on those activities that generate or make use of acoustic signals in conducting their operations. Included are activities undertaken by private companies for commercial purposes as well as those by government agencies and their contractors. The discussion is restricted to activities that are conducted undersea. Surface activities such as maritime transportation, surface research, and fishing are excluded from consideration.

3.3.3.1 Oceanographic Research

Oceanographic research, much of it sponsored by the world's governments, is conducted in all oceans of the world. This research is geared to refining and expanding our knowledge of marine biology (including the life habits of marine mammals), and marine geophysics (morphology and chemistry of the earth's crust). Researchers use ship-mounted equipment and unmanned and manned submersible vehicles. For example, several U.S. institutions, including the Woods Hole Oceanographic Institution (WHOI), the Scripps Institution of Oceanography, the Lamont-Doherty Geological Observatory, and several marine fisheries centers operated by NMFS, conduct research each year over the world's oceans. The several ships operated by WHOI alone conduct research that results in the ships being at sea 30 to 40 percent or more of the year. Many other governments operate or support similar oceanic research efforts.

Deployment of unmanned diving vessels from research ships constitutes a significant part of ocean research. Unmanned remotely operated vehicles (ROV) carry television cameras and other sampling equipment. ROVs are controlled using transponders, and a typical research effort involves placement of multiple transponder units on the ocean floor. Transponders send and receive HF FM signals to and from the research vehicle and the controlling ship on the surface. Signals establish location and control movement of the vessel and support its data-gathering activities.

The U.S., Canada, Australia, Japan, and several European government agencies conduct research with ROVs. The Canadian deep-sea vehicle ROPOS (Remotely Operated Platform for Ocean Science), for example, has conducted research at depths as great as 4,960 m (16,270 ft) in the Pacific and North Pacific near Oregon, Washington, and the Aleutians. There are, worldwide, about 16 manufacturers and 30 operator/marine service companies active with ROVs on a year-round basis in the oceans (Ontini, 1998).

Manned submersible vehicles are also used in ocean research. These vehicles communicate with the deploying ship using radios. Of the estimated 160 commercial and scientific submersibles built since 1960, approximately 40 are still operating.

Ocean acoustic tomography (OAT) is a research effort initiated by Scripps, the Massachusetts Institute of Technology (MIT), and others to determine the effectiveness of LF sound transmissions to map features of ocean circulation. LF sound slows down or speeds up as it travels across boundaries of different temperatures, pressures, or salinities. The Acoustic Thermometry of Ocean Climate (ATOC) project, an international research effort utilizing LF sound to observe temperature change in the oceans, has been completed in California and Hawaii. Under a new program, the Scripps Institution of Oceanography is proposing to reuse the sound source in Hawaii for its North Pacific Acoustic Laboratory (NPAL). NPAL's objectives would combine:

- A second phase of research on the feasibility and value of large-scale acoustic thermometry;
- Long-range underwater sound transmission studies; and
- Marine mammal monitoring and studies.

The University - National Oceanographic Laboratory System (UNOLS) is a consortium of 61 academic institutions involved in federally funded oceanographic research. Twenty of these institutions operate the 28 ships of the UNOLS Fleet. Ship schedules, geographic locations of proposed cruises, and other information are available at:

http://www.gso.uri.edu/unols/unols.html.

3.3.3.2 Oil and Gas Production

Major offshore oil and gas production regions include the continental shelf of the U.S. (Prudhoe Bay, Gulf of Mexico, and Southern California), the coasts of Venezuela and Mexico, the Persian Gulf, the North Sea, and the waters off Indonesia. Activity in U.S. coastal waters has extended out to depths of 900 m (2,952 ft). Although as technology developments continue, oil and gas production activities will extend to greater depths and associated greater distances from the coastline. At least one oil company is developing a drill ship that will be capable of drilling in depths up to 3,000 m (9,840 ft).

Currently, two types of offshore geophysical surveys are performed to obtain information on subsurface geologic formations in order to identify potential oil and gas reserves. Both methods employ high-energy seismic surveys (HESS). High-resolution seismic surveys collect data up to 300 m (9,845 ft) deep and are used for the initial site evaluation for drill rig emplacement and platform design. Deep seismic surveys obtain data up to several thousands of meters deep and are used to more accurately assess potential hydrocarbon reservoirs.

Seismic surveying operations are conducted from ships towing an array of instruments, including air guns, which release compressed air into the water, creating acoustic energy that penetrates the sea floor. The acoustic signals are reflected off the subsurface sedimentary layers and recorded near the ocean surface on hydrophones spaced along streamer cables that can be longer than 3 km (1.85 mi) (U.S. Dept of Interior, 1997). Alternatively, cable grids are laid on the ocean floor to act as receivers and are later retrieved.

When commercially viable reserves are identified, wells are drilled to confirm the presence of exploitable resources. Initial wells in a field are drilled from a ship. Once commercial levels of production are proven, permanent platforms and pipelines are installed. Alternatively, a new type of floating facility, representing an alternative to platform construction, may be used. Four or five development wells go into production, while the remaining wells are capped and abandoned. Capping is accomplished by ROVs or manned submarine vehicles.

Construction of five to seven percent of wells involves the use of subsea systems to install wellhead and related equipment on the ocean floor. The remaining systems use surface wellhead equipment. Both types use divers to connect production lines to pipeline systems. Installation of pipelines also requires survey of the seafloor to select a pipeline route. These surveys generally rely on the use of sonars that generate HF sound waves such as chirps and pinger signals.

Once wells and wellheads are established, they are operated around the clock for their project life, except for periods of maintenance and repair. Divers are occasionally needed to repair pipeline connections or subsea production systems. Divers also participate in removal of the platform and capping of wells when the field is abandoned.

3.3.3.3 Communication Cables

Communication cables have been placed on the seabeds of all the world's oceans. As the communication industry has grown, so has the cable-laying industry. Growth in demand spurred by financial institutions, the information technology industry, and the Internet continue to increase the amount of cable laid annually. In spite of technology advances to increase the number of communications carried by one cable, the pace of cable laying continues to increase. One survey suggests more than 650,000 km (350,000 nm) may be laid by 2003. Where possible, routes for laying cable are chosen to avoid hazardous areas, including surface and deep sea currents; seismic activity; military activity; off-shore oil, gas, and mineral exploration; and prime fishing areas (especially trawling which is trending toward deeper water).

Laying cable involves the use of towed sledges to assess the seabed prior to actually placing cable. The cable is buried at a depth of up to 3 m (9.8 ft). ROVs are used to monitor the burial process in shallow waters (less than 1,000 m [3,280 ft], to conduct actual burial in depths greater than 1,000 m (3,280 ft) and to inspect the job after burial.

3.3.4 Coastal Zone Management

Since 1972, 33 coastal states and territories have developed and implemented programs to ensure appropriate resource protection and compatibility of uses in their coastal zones. The programs are linked to existing state/territorial laws and authorities, such as tidal wetlands statutes, regional agreements, and the water quality certification under Section 401 of the Clean Water Act of 1977. The enforcement authority for the program is often a state coastal commission. Federal lands are excluded from the jurisdiction of the state coastal zone management programs, but activities on federal lands are subject to the Coastal Zone Management Act (CZMA) federal consistency requirements if the federal activity will affect any land or water or natural resource of the state's coastal zone, including reasonably foreseeable effects. Each state's coastal zone management program is required to contain the following elements:

- Identification of the boundaries of the coastal zone subject to the management program;
- Definition of permissible land uses and water users within the coastal zone;
- Inventory and designation of "areas of particular concern" within the coastal zone;
- Identification of the means by which the State proposes to exert control over the land and water uses;
- Guidelines on priorities of uses in particular areas;
- Description of the organizational structure proposed to implement the program;
- Definition of the term "beach" and a planning process addressing the protection of and access to public beaches and other public coastal areas of environmental, recreational, historical, aesthetic, ecological, or cultural value;
- Planning process addressing the location of energy facilities; and
- Planning process addressing shoreline erosion.

The landward boundaries of the coastal zone vary by state, reflecting both the natural and built environment. The seaward boundaries generally extend to the outer limits of the jurisdiction of the state, but not more than three geographic (nautical) miles into the Atlantic or Pacific oceans or three marine leagues (10.35 nm) into the Gulf of Mexico.

The specific coastal zone management policies identified under state programs vary depending upon the specific issues faced by their region. Many policies address the use, management, and/or development of land within the designated coastal region, often to reduce coastal hazards, promote water-dependent or appropriate land uses, and provide public access. Some policies seek to improve air or water quality in the coastal areas. Others address the protection of sensitive marine resources and habitats, support for coastal recreational activities, and the promotion of marine and estuarine research and education. While coastal zone management programs provide detailed recommendations on a variety of projects that may occur in coastal waters, they do not regulate the movement of commercial, recreational, or military shipping or boating. In addition, none of the programs contain specific provisions regarding sonar activities or related acoustic impacts.

However, if any of these activities affect state coastal resources, then these federal activities are subject to Section 307(c)(1) of the Federal Coastal Zone Management Act Reauthorization Amendments of 1979, which requires all federal agencies conducting or supporting activities within or outside the coastal zone that affect any land, water use, or natural resources of the coastal zone to be consistent, to the maximum extent practicable, with the enforceable policies of the affected state's coastal zone management program. A determination of consistency must be submitted by the responsible federal agency to the affected state's coastal program or commission for review. The determination generally includes a detailed description of the proposed activity, its expected effects upon the land or water uses or natural resources of the state's coastal zone, and an evaluation of the proposed activity in light of the applicable enforceable policies in the state's program.

Most of the state programs also identify geographic "areas of particular concern." Areas of particular concern are typically areas of high natural productivity or essential habitat for living resources, including fish and wildlife, and areas where development and facilities are dependent upon the utilization of, or access to, coastal waters. Table 3.3-5 provides information on the areas of particular concern and the relevant coastal zone management policies for those coastal states near which the SURTASS LFA sonar is likely to be operated.

Table 3.3-5

Relevant Policies of State Coastal Zone Management Programs

State/Territory	**Policies/Goals Relevant to SURTASS LFA Sonar Operation** [1]
	Pacific Ocean
Alaska	• Manage the following habitats so as to maintain or enhance the biological, physical, and chemical characteristics of the habitat which contribute to its capacity to support living resources: offshore areas, estuaries, wetlands and tideflats, rocky islands and seacliffs, barrier islands and lagoons, exposed high energy coasts, rivers streams, and lakes, and important upland habitat. In addition, offshore areas must be managed as a fisheries conservation zone so as to maintain or enhance the state's sport, commercial, and subsistence fishery. • Before a potentially conflicting use or activity may be authorized within designated subsistence areas, a study of the possible adverse impacts of the proposed potentially conflicting use or activity upon subsistence usage must be conducted and appropriate safeguards to assure subsistence usage must be provided.
Washington	• Shoreline Management Act policies call for fostering all reasonable and appropriate uses of the shorelines; protecting the public's right to use and enjoy the shoreline; and protecting the shoreline environment. Preference is given to uses that comply with the following policy, among others: the preferred uses protect the resources and ecology of the shoreline. • Ocean Resources Management Act policies guide activities in the Pacific Ocean and provide that uses that will not adversely impact renewable resources have preference over those that will. Activities that will adversely affect renewable resources, marine life, fishing, aquaculture, recreation, navigation, air, or water quality or other existing ocean or coastal uses, may only be allowed if certain criteria are met. Among others, criteria include that the activity will likely cause no long term, significant adverse impacts on coastal or marine resources and uses.
Oregon	• Allow only those activities and uses of ocean resources which are consistent with the goal of ocean resources conservation to maintain or, where necessary, restore the integrity, diversity, stability, complexity, and the productivity of marine biological communities and their habitats . Accommodate needs for economic development while avoiding wasteful uses and maintaining future availability. • Restrict uses or access, if necessary, protect endangered, threatened, and sensitive species or their habitats. • Conserve, protect and, where needed, enhance or restore marine habitats that are important to commercial and recreational fish species. Support research on marine ecosystems, fish populations, and fish habitat needs in order to promote sound fishery management decisions. • Provide state protection to marine birds and mammals, especially endangered, threatened and sensitive species, and to habitats which are critical to maintaining viable marine birds and mammal populations. With the exception of fisheries activities which do not adversely affect sensitive marine bird or mammal populations and safe passage and anchorage where necessary to protect human life, prohibit all other activities within ¼ mile of the thirty-three sensitive areas (identified in the Oregon Territorial Sea Plan).
California	• 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 the healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes. • Maintain optimum populations of marine organisms. • Protecting and upgrading facilities that serve the commercial and recreational boating industries, as well as recognizing and protecting the economic, commercial, and recreational importance of fishing activities.

Table 3.3-5

Relevant Policies of State Coastal Zone Management Programs (Continued)

State/Territory	Policies/Goals Relevant to SURTASS LFA Sonar Operation [1]
Hawaii	• Provide adequate, accessible, and diverse recreational opportunities in the coastal zone management area by: protecting coastal resources uniquely suited for recreational activities that cannot be provided in other areas. • Preserve valuable coastal ecosystems, including reefs, or significant biological or economic importance. • Exercise an overall conservation ethic, and practice stewardship in the protection, use, and development of marine and coastal resources. • Assure that the use and development of marine and coastal resources are ecologically and environmentally sound and economically beneficial. • Promote research, study, and understanding of ocean processes, marine life, and other ocean resources in order to acquire and inventory information necessary to understand how ocean development activities relate to and impact upon ocean and coastal resources.
Guam	• All living resources within the territorial waters of Guam, particularly corals and fish, shall be protected from over harvesting, and in the case of marine mammals, from any taking whatsoever. • The Government of Guam shall encourage development of varied types of recreational facilities located and maintained so as to be compatible with the surrounding environment and land uses, adequately serve community centers and urban areas, and protect beaches and such passive recreational areas as wildlife and marine conservation areas, scenic overlooks, parks, and historical sites.
Northern Mariana Islands	• Manage ecologically significant resource areas for their contribution to marine productivity and value as wildlife habitats, and preserve the functions and integrity of reefs, marine meadows, salt ponds, mangroves, and other significant natural areas. • Manage the development of the local subsistence, sport and commercial fisheries, consistent with other policies. • Protect all resources within the coastal waters, particularly sand, corals, fish and habitat from taking beyond sustainable levels and in the case of marine mammals and any species on the commonwealth and federal endangered species list, from any taking whatsoever. • Encourage the development of recreation facilities which are compatible with the surrounding environment and land-uses.
American Samoa	• American Samoa's coastal zone management program addresses coastal concerns of fishery habitat loss, coastal hazards, marine debris, and solid waste (NOAA, 1980).
Atlantic Ocean	
Maine	• Maine will have a healthy and productive marine ecosystem where management of the marine resources is based on an increased understanding of the Gulf of Maine. • Coastal communities will have a sustainable fisheries economic base which embraces personal responsibility for the Gulf of Maine. • Maine's Aquaculture industry will thrive in the global market for aquaculture products as a result of Maine's healthy and productive aquatic ecosystem.
New Hampshire	• Protecting coastal resources (i.e., coastal and estuarine waters; tidal and freshwater wetlands; beaches; sand dunes; rocky shores; fish, wildlife rare and endangered plant and animal species; submerged lands; and geologic formations). • Supporting public recreational opportunities and public access. • Promoting marine and estuarine research and education.
Massachusetts	• Protect coastal resource areas including salt marshes, shellfish beds, dunes, beaches, barrier beaches, salt ponds, eelgrass beds, and fresh water wetlands for their important role as natural habitats. • Ensure that developments proposed near existing public recreation sites minimize their adverse effects. • Support the development of environmentally sustainable aquaculture, both for commercial and enhancement purposes.

Table 3.3-5

Relevant Policies of State Coastal Zone Management Programs (Continued)

State/Territory	Policies/Goals Relevant to SURTASS LFA Sonar Operation [1]
Rhode Island	• Maintain a balance among the diverse activities that must coexist in Type 4 waters, which include the open waters of the Bay and the Sounds. While accommodating changing uses and activities, preserve and restore ecological systems. • Protect important fishing grounds and fishery habitats from alterations and activities that threaten the vitality of Rhode Island fisheries.
Connecticut	• To insure that the development, preservation or use of the land and water resources of the coastal area proceeds in a manner consistent with the capability of the land and water resources to support development, preservation or use without significantly disrupting either the natural environment or sound economic growth. • The commissioner shall: a) promote and coordinate management of water, land and air resources to assure their protection, enhancement and proper allocation and utilization; b) provide for the protection and management of plants, trees, fish, shellfish, wildlife and other animal life of all types, including the preservation of endangered species. • To manage estuarine embayments so as to insure that coastal uses proceed in a manner that assures sustained biological productivity, the maintenance of healthy marine populations and the maintenance of essential patterns of circulation, drainage and basin configuration. • To manage the state's fisheries in order to promote the economic benefits of commercial and recreational fishing, enhance recreational fishing opportunities, optimize the yield of all species, prevent the depletion or extinction of indigenous species, maintain and enhance the productivity of natural estuarine resources and preserve healthy fisheries resource for future generations.
New York	• Protecting fish and wildlife resources and habitats. • Supporting the commercial fishing industry and aquaculture. • Increasing publicly-accessible coastal recreational opportunities. • Protecting natural, cultural, scenic, and agricultural resources, including tidal and freshwater wetlands.
New Jersey	• Coastal actions are conditionally acceptable to the extent that minimal feasible interference is caused to the natural functioning of marine fish and fisheries, including the reproductive and migratory patterns of estuarine and marine estuarine dependent species of finfish and shellfish.
Delaware	• Preserve the quantity and quality of fish and wildlife to maximum extent possible. • Provide and maintain adequate and safe boating and fishing facilities for recreational use. • Protect endangered species to the maximum extent possible. • Assure a sustainable yield of state finfish and shellfish by enforcing harvest quotas, equipment and seasonal limitations, and licenses, as well as through measures of habitat enhancement and protection. • Federal actions which may interfere with or otherwise adversely affect fish and wildlife in DE shall be implemented only after careful consultation with Department of Natural Resources and Environmental Control and exploration of alternatives less damaging to such fish and wildlife.
Maryland	• In Critical Areas, conserving fish, wildlife, and plant habitats. • Preserving and protecting coastal resources (i.e., estuaries, wetlands, critical habitat areas, and fish and wildlife species).
Virginia	• Minimize damage to the productivity and diversity of the marine environment from the disruption of finfish and shellfish population balances or the alteration of subaqueous lands and aquatic vegetation. • Maintain wildlife habitat areas and preserve endangered fish and wildlife species. • Improve and maintain productive fisheries. • Provide and increase public recreational access to both coastal waters and shorefront lands. • To conserve and enhance finfish and shellfish resources, and to preserve and promote both commercial and recreational fisheries, and, thereby, to maximize food production and recreational opportunities.
North Carolina	• The preservation of natural resources (i.e., water use, scenic vistas, and fish and wildlife) and cultural resources. • Promotion of the coastal area's economic development, recreation and tourist facilities, and parklands.

Table 3.3-5

Relevant Policies of State Coastal Zone Management Programs (Continued)

State/Territory	**Policies/Goals Relevant to SURTASS LFA Sonar Operation [1]**
South Carolina	• Activities that would have a negative impact on wildlife and fisheries resources (the stocks or the habitats) will not be approved unless overriding socioeconomic considerations are involved. • Stocks and populations of wildlife and fisheries habitat, as well critical wildlife and fisheries habitat, should be protected and enhanced to the maximum extent possible.
Georgia	• Aid in promoting the conservation and development of state natural resources. • Promote profitable uses of lands and waters. • Promote coordination of existing scientific investigations with related work of other agencies to create sound conservation and development policies. • Identify and inventory any species considered rare, unusual, or in danger of extinction, and thus receive protected status.
Florida	• Chapter 370, F.S., Saltwater Fisheries, requires the conservation of the state's marine fishery resources and protection of threatened and endangered marine species, among other requirements. • Chapter 380, F.S., Land and Water Management, establishes land and water management policies which guide and coordinate local development decisions.
Alabama	• Encourage the maintenance of the quality and quantity of the living resource base. • Discourage activity that would result in adverse impacts to habitat for shellfish, finfish, and all economically valuable species or critical habitat for those species designated as endangered or threatened. • Encourage the maintenance of natural habitat to support living organisms in the coastal area. • Protect and enhance the water quality of the coastal area in order to protect its aquatic resources.
Mississippi	• Promote fisheries management, including finfishing, shrimping, mariculture, shellfishing, and oyster farming. • Protect, propagate, and conserve seafood and aquatic life.
Louisiana	• Minimize detrimental impacts on natural areas and wildlife habitats and fisheries by discouraging changes of natural systems.
Texas	• Encourage the designation of artificial reef development zones.
Puerto Rico	• Puerto Rico's coastal zone management program addresses sedimentation, erosion, coastal hazards, and illegal use of the island's maritime zone (NOAA, 1978).
Virgin Islands	• To encourage fishing and carefully monitor mariculture and, to the maximum extent feasible, to protect local fishing activities from encroachment by non-related development. • To conserve significant natural areas for their contributions to marine productivity and value as habitats for endangered species and other wildlife. • To protect complexes of marine resource systems of unique productivity (reefs, marine meadows, salt ponds, mangroves and other natural systems), and assure that activities in or adjacent to such complexes are designed and carried out so as to minimize adverse effects on marine productivity, habitat value, storm buffering capabilities, and water quality. • To consider use impacts on marine life and adjacent and related coastal environments. • To preserve and protect the environments of offshore islands and cays. • To protect and, where feasible or appropriate, enhance and increase public coastal recreational uses, areas and facilities.

Notes:
1. Relevant enforceable policies as provided by the individual states, or program goals summarized where necessary.

Sources: Coastal Zone Management Programs of individual states; see Literature Cited section.

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4 IMPACTS OF THE PROPOSED ACTION AND ALTERNATIVES

This chapter presents an analysis of the potential impacts or "effects" upon various components of the environment that could result from the implementation of the proposed action and of alternatives to the proposed action. Much of the basis for the analysis done in this chapter has been introduced in Subchapter 1.4 (Analytical Context).

Under the No Action Alternative, the SURTASS LFA sonar system would not be deployed. The effects of the No Action Alternative are those effects, going forward, that can be expected if the proposed project is not implemented. These would include the potential for increased underwater noise from additional ships and sonars, or additional time at sea (fewer ships/sonars) and more sonar pinging, to compensate for the loss of long-range detection capability afforded by SURTASS LFA sonar. In addition, there would be an increase in fuel consumption and expenditure of energy resources associated with additional ships or increased time at sea, most likely accompanied by an increase of petroleum by-product pollution, and solid and liquid wastes. Thus, there would be environmental impacts resulting from implementation of this alternative. The No Action Alternative would also fail to meet the U.S. need for improved capability in detecting quieter and harder-to-find foreign submarines at long range. Thus, U.S. forces would not have adequate time to react to, and defend against, potential submarine threats while maintaining a safe distance from a submarine's effective weapons range.

For SURTASS LFA Alternatives 1 and 2, potential impacts should be reviewed in the context of the basic operational characteristics of the system:

- A maximum of four systems would be deployed around the world, two of which would be stationed in the Pacific-Indian ocean area, and two in the Atlantic-Mediterranean area. The possibility of more than one vessel simultaneously conducting active sonar operations in the same area would be low.

- The R/V *Cory Chouest* is presently the only vessel equipped with a SURTASS LFA sonar system. This vessel is leased by the Military Sealift Command, operated by a civilian crew, and is under the control of the Commander-in-Chief of the Pacific Fleet (CINCPACFLT). As such, the R/V *Cory Chouest* is U.S. Coast Guard-certified for operations. In addition, it operates in accordance with all applicable federal and U.S. Navy rules and regulations related to environmental compliance. All future vessels to be equipped with SURTASS LFA sonar systems would also be U.S. Coast Guard-certified and compliant with all applicable federal and U.S. Navy environmental rules and regulations. SURTASS LFA vessel movements are not unusual or extraordinary and are part of routine operations of seagoing vessels. Therefore, there should be no unregulated environmental impacts from the operation of the SURTASS LFA sonar vessels.

The Navy and the USEPA are in the process of developing uniform national discharge standards for armed forces vessels. Once these standards are promulgated, the SURTASS LFA sonar vessels will be operated in compliance with them. Additionally, the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) prohibits certain discharge of oils, garbage, and other substances from vessels. The Convention is implemented by the Act to Prevent Pollution from Ships (APPS) (33 U.S.C. 1901 to 1915), which establishes requirements for the operation of U.S. Naval vessels. The vessels supporting the SURTASS LFA sonar systems would be operated in compliance with these requirements. Operation of the SURTASS LFA sonar system itself would not result in the discharge of pollutants regulated under APPS.

- At-sea missions would be temporary in nature (see Subchapter 2.2 [SURTASS LFA Sonar Deployment]). Of an estimated maximum 270 underway days per year, the SURTASS LFA sonar would be operated in the active mode about 108 days. During these 108 days, active transmissions would occur for a maximum of 432 hours per year per vessel.
- The duty cycle of the SURTASS LFA sonar would be limited (it would generally be on 10-20 percent of the time [physical maximum limit is 20 percent] and off the remaining 80-90 percent).

The types of potential effects on marine animals from SURTASS LFA sonar operations can be broken down into several categories:

- **Non-auditory injury**: This includes the potential for resonance of the swim bladder (fish) or lungs/organs (marine mammals), tissue damage, and mortality. For the purposes of the SURTASS LFA sonar analyses presented in this OEIS/EIS, all marine animals exposed to $\geq$ 180 dB are evaluated as if they are injured.
- **Permanent threshold shift (PTS)**: A severe situation occurs when sound intensity is very high or of such long duration that the result is a permanent threshold shift (PTS) or permanent hearing loss on the part of the listener. The intensity and duration of a sound that will cause PTS varies across species and even among individual animals. PTS is a consequence of the death of the sensory hair cells of the auditory maculae of the ear and a resultant loss of hearing ability in the general vicinity of the frequencies of stimulation (Salvi et al., 1986; Myrberg, 1990). In mammals the damaged sensory hair cells are never replaced. Damaged sensory hair cells were replaced in one species of fish that has been studied, but no investigations were performed to ascertain whether hearing was restored (Lombarte et al., 1993).

- **Temporary threshold shift (TTS)**: Sounds of sufficient loudness can cause a TTS in hearing under which an animal's hearing is impaired for a period of time. After termination of the intense sound, normal hearing ability returns (anywhere from minutes to days, depending on many factors including the intensity and duration of exposure to the intense sound). Hair cells may fatigue, but are not damaged during TTS; therefore, TTS is not considered to be an injury.

- **Behavioral change**: Various vertebrate species are affected by the presence of intense sounds in their environment (Salvi et al., 1986; Richardson et al., 1995b). For example, these effects may cause an animal to temporarily change its pattern of movement so that it goes around the loud source rather than continue on a course that would take it closer to the sound.

- **Masking**: The presence of intense sounds could interfere with an animal's ability to hear other sounds. The effect on an animal is that the sound could temporarily impair hearing by "auditory masking;" i.e., interfering with the animal's ability to detect biologically relevant sounds.

The remainder of Chapter 4 addresses the potential impacts of implementing Alternative 1 (employment with geographic restrictions and monitoring mitigation) and Alternative 2 (unrestricted employment). Subchapter 4.1 addresses the potential operational impacts of these alternatives on fish and sea turtles, Subchapter 4.2 details the potential impacts of these alternatives on marine mammals, and Subchapter 4.3 addresses potential impacts of these alternatives on the socioeconomic environment. Finally, Subchapter 4.4 addresses potential cumulative impacts of these alternatives.

4.1 Potential Impacts on Fish and Sea Turtles

There are very few studies of the potential effects of underwater sound on fish or sea turtles, and most of these examined the effects of sounds of much longer duration than the SURTASS LFA sonar signals. Subchapters 4.1.1 (Fish and Sharks) and 4.1.2 (Sea Turtles) analyze the potential effects of Alternatives 1 and 2 in relation to the following SURTASS LFA sonar operational parameters:

- 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.

4.1.1 Fish and Sharks

The following analysis pertains to Alternatives 1 and 2.

4.1.1.1 Fish Stocks

Non-auditory Injury

The primary potential for non-auditory impact to fishes would be resonance of fish swim bladders. Studies of fish with swim bladders show that the resonant frequency of the swim bladder is considerably above the frequency of best hearing and probably does not determine the shape of the audiogram (Rogers and Cox, 1988; Ye, 1996). The swim bladder of the codfish resonates at frequencies above the hearing range of the fish (Sand and Hawkins, 1973). Therefore, it is not expected that resonance of the swim bladder would play a significant role in response to LF sound (ARPA, 1995). Only the larger pelagic fish species (such as tuna) have swim bladders large enough to possibly be resonated by LF sound, and their prime habitat is in near-surface waters, where substantial sound transmission losses occur (Subchapter 4.3.2.1). Most fish that have swim bladders would be subject to resonance at higher frequencies only. The potential for occurrence of this effect is further reduced by the fact that SURTASS LFA sonar transmissions of single frequency tonals longer than 10 seconds are not expected.

Permanent Loss of Hearing

Hastings et al. (1996) studied the effects of intense sound stimulation on the ear and lateral line of a non-specialist freshwater fish (*Astronotus ocellatus,* the oscar). They exposed fish to a continuous sound at 300 Hz and a RL of 180 dB for one hour. They found there was some damage to the sensory hair cells of two of the otolith organs, the lagena and utricle at 300 Hz for a continuous signal for one hour. There was no apparent damage with other frequencies, sounds with shorter duty cycles, or shorter stimulation time, or when the tissue was studied immediately after the cessation of stimulation. The interpretation of these results was that exposure to a high intensity sound has the potential to damage the ear of fish. However, the sound had to be continuous and had to last at least one hour; and the damage was only evident sometime after exposure.

Additional studies suggest that intense sound may result in damage to the sensory hair cells in the ears of other fish. For two hours, Cox et al. (1986a, b; 1987) exposed goldfish (*Carassius auratus*), a freshwater hearing specialist, to pure tones at 250 and 500 Hz at 204 and 197 dB, respectively. They found some indications of sensory hair cell damage. Enger (1981) determined that some ciliary bundles (the sensory part of the hair cell) on sensory cells of the inner ear of the cod (*Gadus morhua*) were destroyed when exposed to sounds at several frequencies from 50 to 400 Hz at 180 dB for 1-5 hours.

Some fish are known to regenerate their sensory hair cells after damage from ototoxic drugs, but there are no data on regeneration after noise damage. Lombarte et al. (1993) studied the oscar (*Astronotus*), which is not a hearing specialist, using the damage induced by a drug (gentamicin sulphate) and showed that hair cells would regenerate within about 10 to 15 days of the termination of the drug regime. Unlike mammals, fish continue to produce sensory hair cells throughout life (Lombarte and Popper, 1994). Since hair cells recover from drug damage, it may be speculated that there might be recovery from at least some levels of noise injury. It is not possible to say, however, if replacement would occur after very high magnitudes of damage, or if the recovery would be fast enough to prevent mortality if the fish could not adequately hear prey or predators (recovery took up to 15 days in the study of the oscar).

In reviewing the results of their study and that of the few previous studies, Hastings et al. (1996) suggested that sounds 90 to 140 dB above a fish's hearing threshold may potentially injure the inner ear of a fish. This suggestion was supported in the findings of Enger (1981) in which injury occurred only when the stimulus was 100 to 110 dB above threshold at 200 to 250 Hz for the cod. Hastings et al. (1996) derived the values of 90 to 140 dB above threshold by examining the sound levels that caused minimal injury in the oscar, and then hypothesizing that extensive injury would require more energy. They suggest that RLs of 220 dB to 240 dB would potentially cause extensive damage to sensory hair cells in non-specialist fishes. Calculations for a hearing specialist like the squirrelfish using the Hastings et al. (1996) values (i.e., 90 to 140 dB above threshold) (see Figure 3.2-2) indicate RLs of 140-190 dB continuously for at least one hour would be necessary to induce hearing damage.

One cautionary note, as pointed out by Hastings et al. (1996), concerns the extrapolation from data for the oscar, goldfish and cod to other species. All three studies were done with fish confined in very small areas, and with long signal durations, in contrast to the relatively short exposure that would occur during operation of the SURTASS LFA sonar. Moreover, the ears of these species are not necessarily representative of all of the fish species that could be exposed to sound from SURTASS LFA sonar operations. Other species may be more or less sensitive to high intensity signals than the species tested to date. All of these studies involve pure tones with controlled rise and decay times.

The SURTASS LFA sonar ship will be moving at 3 kts (1.5 m/sec or 5 ft/sec). At this speed, it would take approximately 22 minutes to traverse the nominal diameter of the 180-dB sound field (2,000 m [6,600 ft]). So, it is unlikely that a stationary fish would be exposed to more than three sonar pings, even in the scenario where the fish is perfectly located to receive the maximum number of pings. Therefore, the assessment of potential risk should be centered on what RL could possibly cause hearing damage within three one-minute 180-dB exposure times (60-second nominal ping duration). Based on the limited geographic extent of SURTASS LFA sonar operations, the risk of PTS to fish must be considered minimal.

Temporary Loss of Hearing

In addition to the possibility of causing permanent injury to hearing, sound may cause temporary threshold shift (TTS), a temporary and reversible loss of hearing that may last for minutes to hours. TTS is quite common in humans and often occurs after listening to loud music, such as at a rock concert. While not well studied in non-mammalian vertebrates, one study has shown that a 149-dB RL (8-hour continuous duration) can cause TTS of more than 10 dB in goldfish (Popper and Clarke, 1976). While this TTS did not continue for more than 24 hours (and probably lasted a good deal less), TTS could impact a fish that depends on its hearing for finding food or escaping predators. In effect, a fish whose hearing capability has been partially (though temporarily) impaired may not hear a predator in the vicinity, or detect sounds being emitted by a potential food source. The five SURTASS LFA sonar operational parameters listed at the start of Subchapter 4.1 summarize the reasons that there would be minimal impact on any substantial fraction of a fish stock through TTS.

Behavioral Change

This issue concerns the behavior of fish near a high intensity sound source, beyond effects on the ear itself. The only relevant study is one by Klimley and Beavers (1998), who evaluated whether LF sounds had an effect on fish near a sound source. They played back a 75 Hz phase-modulated signal (37.5-Hz bandwidth) to three species of rockfish (non-specialists) in a 15 x 2 m (50 x 7 ft) pen in Bodega Bay, California. The fish exhibited little movement during the playback of the LF signals. They remained close to the sound source, despite received sound pressure levels of 145 to 153 dB. There was little difference in the fish's behavior during the sound playback period and the “silent” control period. The fish occupied the zone closest to the sound projector the entire duration of the test and control periods. Consequently, no significant response was observed in rockfish at received levels up to 153 dB. Extrapolation beyond this range would require more experiments and a probabilistic risk assessment model. Moreover, this study was performed with a single species of fish in an artificial environment (cage); thus, it is unknown whether the behavioral responses to LF sounds by this species, and under these conditions, can be extrapolated to other species and/or to fishes in a normal (open ocean) environment.

However, the Klimley and Beavers (1998) results suggest that rockfish could be unaffected by noise at this frequency and level. Other studies, however, strongly suggested that the LF noise produced by fishing vessels and their associated gear results in fish avoiding the vessels (Maniwa, 1971; Suzuki et al., 1979; Konigaya, 1980), and similar results have been found for incoherent, impulsive air gun sound (Engras et al., 1995; McCauley et al., 2000).

Masking

A sound reaching a fish at an amplitude lower than that which might cause PTS or TTS may have a significant impact on fish by preventing the fish from detecting intraspecific communication (Myrberg, 1981), detecting prey, and escaping capture. The decrement in ability to detect signals because of noise is called masking. Masking can take place whenever the received level of signal exceeds ambient noise levels or the hearing threshold of the animal.

The studies on auditory masking in fish have been limited in the number of species studied. The studies performed have shown that fish species that have been studied generally respond to masking signals in much the same way as terrestrial animals; most masking occurs when the masking sound is close in frequency to the sound being tested (Fay, 1974, 1988b; Fay and Megela Simmons, 1999). If the masking signal is of significantly different frequency from the sound that is important to the fish, then much less (or no) masking will occur.

One of the problems with existing masking data is that the bulk of the studies have been done with goldfish, a freshwater hearing specialist. While the few studies with non-specialists also show reasonably similar effects, the data on such species are much less extensive. As a result, less is known about masking in non-specialist and marine species. Tavolga (1967) was the first to study the effects of noise on pure-tone detection in two non-specialists. He reported that the masking effect was generally a linear function of masking level, independent of frequency. His measurements were of tonal thresholds at the edges of a masking band centered at 500 Hz for the blue-striped grunt. Results suggested that there are critical bands for fish, as in mammals, and these have now been confirmed in other species (Fay and Megela Simmons, 1999). In addition, Buerkle (1968) studied five frequency bandwidths for cod in the 20 to 340 Hz region. In fish, as in mammals, masking is most effective in the frequency region of the signal. Chapman and Hawkins (1973) found that ambient noise at higher sea states in the ocean have masking effects in cod, haddock and pollock.

Therefore, existing evidence supports the hypothesis that masking effects would potentially be significant for fish that have best hearing at the same frequencies as the SURTASS LFA sonar. However, given the 10 to 20 percent duty cycle and 100-second signal duration (maximum), masking would be temporary. Additionally, the 30-Hz (approximate maximum) bandwidth of SURTASS LFA sonar is only a small fraction of the animal's hearing range. Most fish have hearing bandwidths >30 Hz. In summary, masking effects are not expected to be severe, because the SURTASS LFA sonar bandwidth is very limited, signals do not remain at a single frequency for more than ten seconds, and the system is off 80 percent of the time.

Conclusions

If SURTASS LFA sonar operations occur in proximity to fish stocks, members of some fish species could potentially be affected by LF sounds. As stated above, it is reasonable to consider hearing loss or injury to fishes from SURTASS LFA sonar transmissions to be limited to the region ≥ 180 dB. However, a negligible portion of any fish stock would be present within the 180-dB sound field at any given time.

To quantify the possible effect of SURTASS LFA sonar on fish catches, an analysis of nominal SURTASS LFA sonar operations in a region off the Pacific Coast of the U.S. was conducted. The region selected was the NMFS Fisheries Resource Region—Pacific Coast, defined here to encompass the area from the Canadian to Mexican border, from the shoreline out to 926 km (500 nm). This analysis is carried out in Subchapter 4.3.1 (Commercial and Recreational Fisheries).

4.1.1.2 Shark Stocks

Non-auditory Injury

The criterion applied to sharks is the same as that for the risk of non-auditory injury to bony fish (i.e., the shark would have to be located within the 180-dB sound field during the time that the sonar was operating to be at risk of injury). The primary potential for non-auditory impacts to fish would be resonance of the fish swim bladder. Sharks do not have a swim bladder; thus, the utilization of this non-auditory criteria for sharks is conservative. A very small fraction of any shark stock would be exposed to these levels, even in the absence of mitigation.

Permanent Loss of Hearing

Fay (1988a) summarized the results of the very few hearing studies of the horn, lemon, and bull sharks. These data show that the lemon shark has the best hearing in the 40 to 4,300 Hz frequency band. The bull shark has the best hearing from 600 to 3,400 Hz with thresholds of 100 dB. Thresholds for the horn shark are above 120 dB. Hearing capability in sharks is on a par with or poorer than that of hearing non-specialist bony fishes, and there is no evidence that any shark is a hearing specialist. Because there are no studies on hearing injury in sharks, relevant data from studies of non-specialist bony fish have been used.

Because sharks are considered hearing non-specialists, the Hastings et al. (1996) data may potentially apply, indicating that RLs of 220 to 240 would be required to cause extensive damage to hearing capability, including PTS. Since these data were based on continuous sound exposure for at least one hour, it is conservative to consider hearing loss to be limited to the volume within the 180-dB sound field. The five SURTASS LFA sonar operational parameters listed at the start of this subchapter summarize reasons that there is minimal potential for impacting any substantial shark stock through PTS.

At the same time, while it is likely that the 180-dB value is highly conservative, extrapolating from bony fishes to sharks is difficult, especially since the ears of fishes and sharks have some significant differences in terms of associated structures that might be involved in hearing, and in the structure of certain regions of the ear. In particular, the ear structure involved in shark hearing may be the macula neglecta, a sensory receptor that, while very large in sharks, is tiny or not present in other vertebrates (Corwin, 1981; Popper and Fay, 1997). Because the macula neglecta has a somewhat different mechanism of sound-induced stimulation than do the otolithic organs of fish ears (i.e., the ear organs of fishes that were damaged in the Hastings et al. [1996] study), extrapolation on the effects of intense sounds may be provisional.

Temporary Loss of Hearing

There are no published scientific data on TTS in sharks caused by LF sound with acoustic characteristics similar to SURTASS LFA sonar. However, because sharks are considered hearing non-specialists and assuming they have similar hearing sensitivities as bony fish discussed previously, the potential for TTS to cause substantial deleterious effects on shark stocks due to SURTASS LFA sonar transmissions is probably very small. Due to the lack of more definitive data on shark 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, the aforementioned is based on the assumption that the stocks are evenly distributed. Further, the five SURTASS LFA sonar operational parameters listed at the start of Subchapter 4.1 summarize the reasons that there would be minimal impact on any substantial fraction of a shark stock through TTS.

Behavioral Change (Attraction/Repulsion)

It is well known that some sharks are attracted to pulsing LF sounds. It has been proposed that such sounds mimic the thrashing of struggling fish that are potential prey for the sharks (Nelson and Gruber, 1963; Nelson and Johnson, 1972, 1976). The structure of SURTASS LFA sonar signals is unlike sounds made by struggling marine animals.

Several shark species (the oceanic silky shark [*Carcharhinus falciformis*] and coastal lemon shark [*Negaprion brevirostris*]) have been observed withdrawing from LF sounds played from an underwater speaker (Myrberg et al., 1978; Klimley and Myrberg, 1979). Lemon sharks exhibited withdrawal responses to low to mid frequency sounds (500 to 4,000 Hz) raised 18 dB at an onset rate of 96 dB/sec to a peak amplitude of 123 dB (RL) from a continuous level, just masking broadband ambient noise (Klimley and Myrberg, 1979). Sharks withdrew from a normally attractive pulsed sound composed of frequencies of 150 to 300 Hz at RLs $\geq$111 dB.

Myrberg et al. (1978) reported that a silky shark withdrew 10 m (33 ft) from a speaker broadcasting a 150 to 600 Hz sound with a sudden onset and a peak sound pressure level of 154 dB. These sharks avoided a pulsed LF attractive sound when its SL was abruptly increased by >20 dB. Other factors enhancing withdrawal were sudden changes in the spectral or temporal qualities of the transmitted sound. These results do not rule out that such sounds may have been harmful to them after habituation; the tests were not designed to examine that point (Myrberg, pers. comm., 1999). Klimley (unpublished data) also noted the increase in tolerance of lemon sharks during successive sound playback tests. The pelagic whitetip (*Carcharhinus longimanus*) also showed a withdrawal response during limited tests (Myrberg et al., 1978).

It is not clear whether the SURTASS LFA sonar transmissions would repel or attract sharks (or under what acoustic conditions the same species might be attracted or repelled). However, since the likelihood of a significant portion of any shark stock being in the vicinity of the SURTASS LFA sonar source at any one time is low, this attraction or repulsion behavioral response is not considered an issue of concern.

Behavioral Change (Migration)

There is a considerable body of scientific evidence that oceanic sharks make directional migrations. The most rigorous study demonstrating this phenomenon involved placing a miniature heading sensor on scalloped hammerhead sharks (*Sphyrna lewini*) and tracking them (Klimley, 1993). The movements of these sharks between their daytime aggregations at a seamount and their nighttime feeding grounds at other surrounding seamounts were highly directional. Their paths generally coincided with magnetic ridges and valleys leading from a seamount, which may be characterized by a strong dipole field that could serve as a landmark. In addition, movements of the sharks often were along the edge of a magnetic lineation, oriented roughly in a north-south direction.

These results have led to the theory that sharks often migrate along magnetic “roads” that run north-south (coincident with magnetic lineations) and aggregate at “cities” that are seamounts and islands (with dipole fields) (Klimley, 1995).

In assessing the potential for SURTASS LFA sonar signals to affect shark migrations, it is noted that the SURTASS LFA sonar source frequency is between 100 and 500 Hz, a region of the acoustic spectrum where these species are best able to hear sound. Furthermore, the signal usually has no ramp-up, an acoustic property that has been shown to provoke withdrawal in an inshore species (*Negapion brevirostris*) (Klimley and Myrberg, 1979) and two pelagic species (*Carcharhinus falciformis and C. longimanus*) (Myrberg et al., 1978). These studies suggest that sharks can detect sounds with intensities below 180 dB. The issue is whether one or more SURTASS LFA sonar transmissions could possibly cause displacement of a shark from its migratory path, such that this activity might be disrupted to such an extent that the shark would not be able to reestablish its direction along the path.

The sharks are believed to be migrating along the edges of the magnetic lineations, where the gradients are greatest, moving back and forth across the gradient (estimated travel +/- 0.5 km [0.27 nm] either side) at an approximate speed of 1 m/sec (Klimley, pers. comm., 2000). Given that the maximum SURTASS LFA sonar signal length is 100 sec, a shark that was annoyed and moved away from the sound would travel approximately 100 m (328 ft) during that time. In the worst case, the ship would be positioned so that the shark's movement would be away from the gradient, and the shark would be at its maximum distance from the gradient at the time of the transmission. Assuming 100 m (328 ft) maximum displacement in this case, it would be likely that the shark would be able to eventually reestablish its direction along the path. Thus, the conclusion here is that it would be unlikely that significant impacts to shark migration would occur due to SURTASS LFA sonar operations in the open ocean.

Masking

Sharks use hearing to detect prey (Banner, 1972; Myrberg et al., 1972; Nelson and Johnson, 1972; Myrberg et al., 1976; Nelson and Johnson, 1976), and this detection ability may potentially be affected by masking. By way of example, Nelson and Johnson (1970) measured a lemon shark's detection threshold to a 300 Hz, 130 dB SL in two different sea states (sea states 1 and 2) and two different levels of vessel traffic (light and heavy). The shark's auditory threshold was decreased by 2 dB for sea state 2 versus sea state 1, a level of difference that is probably not significant since it is certainly within the variation of the hearing ability of the animal. The difference caused by light versus heavy vessel traffic was 18 dB (measured in sea state 1). This represented differences in masking ranges (due to sea state alone) of 45 m (148 ft) for sea state 2 versus 1; and 110 m (360 ft) for heavy versus light boat/ship traffic. Thus, it can be concluded that the masking range for sharks can be elevated by sea state and vessel traffic.

As in bony fishes, masking effects would be most significant for shark stocks with critical bandwidths at the same frequencies as the SURTASS LFA sonar. However, at a 10 to 20 percent duty cycle and a maximum 100-second transmission window, any masking would probably be temporary since the intermittent nature of the signal reduces the potential impact. Long-term effects of masking sounds on hearing and potential injury to shark hearing by intense sounds have not been studied. In summary, masking effects are not expected to be significant 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.

Conclusions

Some sharks in the SURTASS LFA sonar operations area would be affected by LF sounds. However, a negligible portion of any shark stock would be exposed to levels at or above 180 dB on an annual basis due to the small size of the LFA mitigation zone (180-dB sound field) relative to the open ocean areas inhabited by shark stocks.

Despite the ability of sharks to detect LF sound and the potential for affecting sharks that are migrating or aggregating at seamounts/islands, the potential for the SURTASS LFA sonar to affect shark stocks would not be significant. This conclusion is supported by the results from the mathematical calculation performed with fish in the NMFS Fisheries Resource Region Pacific

Coast (Subchapter 4.3.1) and the SURTASS LFA sonar operational parameters listed at the start of Subchapter 4.1 that ameliorate the potential impacts to fish and sharks.

4.1.1.3 Comparing Alternative 1 and Alternative 2

Alternative 1 (employment with geographic restrictions and monitoring mitigation) and Alternative 2 (unrestricted employment) would result in similar types of effects on fish and shark stocks. However, Alternative 1 includes geographic restrictions that limit the ocean areas in which the Navy would employ SURTASS LFA sonar such that the sound field does not exceed specified levels within 22 km (12 nm) of any coast, in offshore biological areas (OBIAs) during biologically important seasons (Figure 1-1), and in the vicinity of known recreational and commercial dive sites. Coastal waters, OBIAs, and recreational dive sites commonly contain significant concentrations, abundances and diversity of fish stocks. In contrast to Alternative 1, Alternative 2 does not impose any operational restrictions in coastal waters, OBIAs, or dive sites. For this reason, the potential level of impact on fish and shark stocks would be less under Alternative 1 than Alternative 2.

4.1.2 Sea Turtles

4.1.2.1 Alternative 1

Non-auditory Injury

The criterion applied here is that a sea turtle would have to be inside the LFA mitigation zone (180-dB sound field) during the time that the sonar was operating to be at risk of injury. 180 dB is 40 dB above the best estimates of hearing threshold for sea turtles in the 100-500 Hz frequency band. Thus, application of the 180-dB value as the level for potential injury to sea turtles should be considered reasonable, given what is known about the hearing of sea turtles. The five SURTASS LFA sonar operational parameters listed at the start of Subchapter 4.1 further support this conclusion.

Permanent Loss of Hearing

Although it is known that sea turtles can hear LF sound, there is limited information on their behavioral and physiological responses to LF sound underwater (Eckert, pers. comm.). In the few cases in which LF hearing has been tested in sea turtle species, individuals exhibited low ability to hear LF sound. Lenhardt (1994), in an unpublished presentation, suggested that maximum sound detection in sea turtles occurred between 100 and 800 Hz. Bartol et al. (1999) measured the hearing of 35 juvenile loggerhead sea turtles using auditory evoked potentials. Broadband click responses indicated the range of effective hearing to be from at least 250 to 750 Hz, with the most sensitive threshold recorded at the lowest frequency tested, 250 Hz.

Ridgway et al. (1969) found 300 and 400 Hz as the region of maximum sound detection for green turtles, with a rapid decline in capability for lower and higher signals. This study did not measure hearing capabilities in terms of behavioral responses, as has been done for fish and sharks, but directly measured responses from the ear.

Given the lack of scientific data on PTS in sea turtles caused by LF sound with acoustic characteristics similar to SURTASS LFA sonar, the criterion applied here is that a sea turtle would have to be inside the LFA mitigation zone (180-dB sound field) during the time that the sonar was operating to possibly incur PTS. The five SURTASS LFA sonar operational characteristics listed at the start of Subchapter 4.1 summarize the reasons why the potential for PTS impacts would be limited to a negligible fraction of any sea turtle stock. Any potential for impacts would be further reduced by visual and active acoustic mitigation procedures (see Chapter 5).

Temporary Loss of Hearing

As with PTS, there are no published scientific data on TTS in sea turtles caused by LF sound with acoustic characteristics similar to SURTASS LFA sonar. Nevertheless, the five SURTASS LFA sonar operational parameters listed at the start of Subchapter 4.1 summarize the reasons that there is minimal potential for impacting any substantial sea turtle stock through TTS.

Behavioral Change

Tagging studies have shown that sea turtles can travel many kilometers per day in the open ocean (Keinath, 1993). They make extensive migrations and movements, either for foraging opportunities or to breed. These movements may extend to thousands of kilometers (Mortimer and Carr, 1987; Bowen et al., 1995; Eckert, 1998, 1999).

This issue relates to the behavior of sea turtle stocks near a high intensity sound source, beyond effects on the animals' ears themselves. A change in behavior that causes displacement of animals from the site of their normal activities would be considered a deleterious effect. Displacement can occur in two dimensions: vertical and horizontal. For example, a turtle could move to the surface, where LF sound would be weaker, possibly exposing it to a higher degree of predation. As for horizontal displacement, this is probably of greatest importance for non-pelagic sea turtle species (green, olive ridley, hawksbill, Kemp's ridley), for which displacement from preferred benthic habitats could be construed as more serious.

If a sea turtle happened to be within proximity of a SURTASS LFA sonar operations area, it may hear the LF transmissions. Given that the majority of sea turtles encountered would probably be transiting in the open ocean from one site to another, the possibility of significant displacement would be unlikely. This is particularly due to: 1) the low number of SURTASS LFA sonars that would be deployed in the open ocean, 2) the geographic restrictions imposed on system employment, 3) the narrow bandwidth of the SURTASS LFA sonar active signal (approximately

30 Hz bandwidth), 4) the fact that the ship is always moving (coupled with low system duty cycle [maximum 20%], which means sea turtles would have less opportunity to be located in a sound field that could possibly cause a behavioral change), and 5) short at-sea mission times (maximum 20 days). Due to the lack of more definitive data on 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.

Masking

Masking effects are potentially significant for sea turtle species that have critical hearing bandwidths at the same frequencies as the SURTASS LFA sonar. However, masking would probably be temporary. The geographical restrictions (Subchapter 2.3.2.1) imposed on all SURTASS LFA sonar operations would limit the potential for masking of sea turtles in the vicinity of their nesting sites. In summary, masking effects are not expected to be severe because of the proposed 10 to 20 percent duty cycle, the maximum 100-second signal duration, the fact that the ship is always moving, the limited 30 Hz sonar bandwidth, and the signals not remaining at a single frequency for more than ten seconds.

Conclusions

Sea turtles could be affected (e.g., PTS) if they are inside the LFA mitigation zone (180-dB sound field) during a SURTASS LFA sonar transmission. Under Alternative 1, SURTASS LFA sonar operations would be below 180 dB (RL) within 22 km (12 nm) of any coastlines and offshore biologically important areas. Consequently, effects to a sea turtle stock could occur only if a significant portion of the stock encountered the SURTASS LFA sonar vessel in the open ocean. Given that the majority of sea turtle species inhabit the earth’s oceanic temperate zones, where sound propagation is predominantly characterized by downward refraction (higher transmission loss, shorter range), rather than ducting (lower transmission loss, longer range) which is usually found in cold-water regimes, it is exceedingly unlikely that a significant portion of any sea turtle stock could be found inside the LFA mitigation zone during a SURTASS LFA sonar transmission.

To quantify the potential impact on sea turtles, an analysis similar to that performed for fish in Subchapter 4.3.1. (Commercial and Recreational Fisheries) was done for Pacific Ocean leatherback sea turtles. The volume of Pacific Ocean habitat for leatherback sea turtles was calculated as 1.6 x 10^{16} m^3 by multiplying the total ocean area (Allen, 1995) by a leatherback turtle diving depth of 91 m (300 ft). An annual deployment (nominal six missions) of SURTASS LFA sonar would ensonify approximately 2.2 x 10^{12} m^3 to a depth of 91 m (300 ft). This is 0.00014 of the ocean volume. The leatherback was chosen for this analysis because it is the most pelagic of all of the sea turtles and has the largest range (i.e., tropics to subpolar).

The total worldwide population of leatherback sea turtles has been estimated at 43,000 (U.S. DoC, 1999). The Pacific population estimate of 18,000 animals was derived from extrapolation of female turtle abundance estimates (Eckert, pers. comm.). Even though the leatherback distribution in the Pacific is patchy and the data on their whereabouts are sparse, SURTASS LFA sonar operations would cover enough ocean area that it is assumed that the number of animals potentially impacted would average out. The default assumption for pelagic animals is to assume even distribution for population estimates; thus, an even distribution of leatherbacks throughout the ocean volume is used here. Given this, the possible number of times a leatherback sea turtle may be in the vicinity of a SURTASS LFA sonar vessel would be less than three per year per vessel (18,000 animals x 0.00014 ocean volume = 2.48).

In the unlikely event that SURTASS LFA sonar operations coincide with a sea turtle “hot spot,” the narrow bandwidth of the SURTASS LFA sonar active signal (approximately 30 Hz bandwidth), the fact that the ship is always moving (coupled with low system duty cycle [maximum 20%], which means sea turtles would have less opportunity to be located in the LFA mitigation zone during a transmission), and the monitoring mitigation incorporated into Alternative 1 (visual and active acoustic [HF] monitoring) would minimize the probability of impacts on animals in the vicinity .

4.1.2.2 Alternative 2

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.

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4.2 Potential Impacts on Marine Mammals

The analysis of potential impacts on marine mammals for this OEIS/EIS was developed based on a literature review, the results of the Navy's Low Frequency Sound Scientific Research Program (LFS SRP) and underwater acoustical modeling. The analytical process is summarized in Subchapter 1.4 (Analytical Context) and is outlined below.

- The Navy proposes to operate the SURTASS LFA sonar worldwide, with the exception of the areas shown in Figure 1-1 (principally the Arctic and Antarctic regions and offshore biologically important areas [Subchapter 2.3.2]) excluding areas necessary to limit sound levels to below 180 dB within 22 km (12 nm) of land. Given the geographic extent of the proposed operating area, it is neither reasonable nor practical to model all the areas of the world's oceans in which the system might be operated. Consequently, the first step in the computer modeling of acoustic impacts was to establish a set of representative SURTASS LFA sonar operational scenarios for sites where SURTASS LFA sonar could be employed. These scenarios are described in Subchapter 4.2.1 (Acoustic Modeling Sites).

- To assess the potential environmental impact of the SURTASS LFA sonar source, an innovative model was used to predict the sound field that a given species could be exposed to over time. This was a three-part process involving:

    - An animal's location in space (latitude, longitude and depth) and time;

    - The sound field at these locations and times; and

    - The integration of these two data sets to estimate the levels of sound to which specific animals would likely be exposed and, hence, the potential impact of the sound source on any specific animal. The computer models used to develop these analyses are described in Subchapter 4.2.2 (Acoustic Modeling).

- Next, a relationship between marine mammal exposure and the risk of injury or significant change in a biologically important behavior was developed. Using the results of acoustic modeling, the effects of SURTASS LFA sonar operations were assessed in relation to received levels (RLs) and repeated exposure. The development of this risk analysis process (risk continuum) for SURTASS LFA sonar is described in Subchapter 4.2.3 (Definition of Biological Risk and Determination of Risk Function).

The potential for injurious effects would occur within short ranges from the SURTASS LFA sonar; i.e., the LFA Mitigation Zone (Subchapter 2.3.2.2). The Low Frequency Sound Scientific Research Program (LFS SRP) dealt with long-range behavioral effects. Given that a LF sound source is loud and can be detected at low to moderate levels over large areas of the ocean, the concern would be that large percentages of species' stocks could be exposed to low to moderate received sound levels. If a significant portion of animal stocks experience significant change in biologically important behaviors at these low to moderate exposure levels such, then such exposures could potentially have an impact on rates of reproduction or survival.

How did the Navy address the above concerns? 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 site locations, using inputs from several workshops involving a broad group of interested parties (academic scientists, federal regulators, and representatives of environmental and animal welfare groups).

The results of the LFS SRP were important in developing an assessment of risk. In August 1996, the Navy's announcement of the preparation of an OEIS/EIS for the SURTASS LFA sonar system evoked comments by various groups concerned about potential impacts on marine mammals. The best available evidence at that time indicated that many cetacean species might be "harassed" at RLs as low as 120 dB, and avoidance responses were expected for levels >140 dB (Richardson et al., 1995b). The Navy, in conjunction with university scientists, developed the LFS SRP to test the behavioral responsiveness of four species of cetaceans (blue, fin, gray and humpback whales) and one pinniped (northern elephant seal) in conditions that maximized the chances of detecting responses and evaluating their biological significance. The species and sites selected for this research emerged from an extended process of consultation with scientists and conservation organizations (including animal welfare and non-governmental environmental organizations). Key findings of the LFS SRP are summarized in Subchapter 4.2.4 (Low Frequency Sound Scientific Research Program). The description of each phase of the field results can be found in Technical Report (TR) 1. Subchapter 4.2.5 (Risk Continuum Analysis) summarizes how the LFS SRP results were used in the development of the risk continuum process.

Given the complexity of this analytical process, two sample model runs are included in Subchapter 4.2.6 (Sample Model Runs). The conclusions of this OEIS/EIS, however, are based on the results of all the modeling runs, which can be found in TR 2.

Taken together, the LFS SRP results, the acoustical modeling, and the risk assessment provide an estimate of potential environmental impacts to marine mammal stocks. These are described in Subchapters 4.2.7 and 4.2.8 for Alternatives 1 and 2, respectively.

4.2.1 Acoustic Modeling Sites

The acoustic modeling sites (Figure 4.2-1 and Table 4.2-1) cover the major ocean regions of the world: North and South Pacific oceans, Indian Ocean, North and South Atlantic oceans, and the Mediterranean Sea. Marine mammal data are extracted from the most recent NMFS stock assessment reports and pertinent multinational scientific literature containing marine mammal distribution, abundance and/or density datasets. The locations were carefully selected to represent reasonable sites for each of the three major underwater sound propagation regimes where SURTASS LFA sonar could be employed. Acoustic analysis included underwater sound transmission via the following propagation paths:

- Deep water convergence zone (CZ) propagation;
- Near surface duct propagation; and
- Shallow water bottom interaction propagation.

These sites were selected to model the highest potential for effects from the use of SURTASS LFA sonar incorporating the following factors:

- Closest plausible proximity to land (from a SURTASS LFA sonar operations standpoint) where biological densities are higher, and/or offshore biologically important areas (particularly for animals most likely to be affected);
- Acoustic propagation conditions that allow minimum propagation loss, or transmission loss (TL) (i.e., longest acoustic transmission ranges); and
- Time of year selected for maximum animal abundance.

These sites represent the upper bound of impacts that can be expected from operation of the SURTASS LFA sonar system. Thus, if SURTASS LFA sonar operations were conducted in an area that was not acoustically modeled in this OEIS/EIS, the potential effects would most likely be less than those obtained from the most similar site in the analyses presented here.

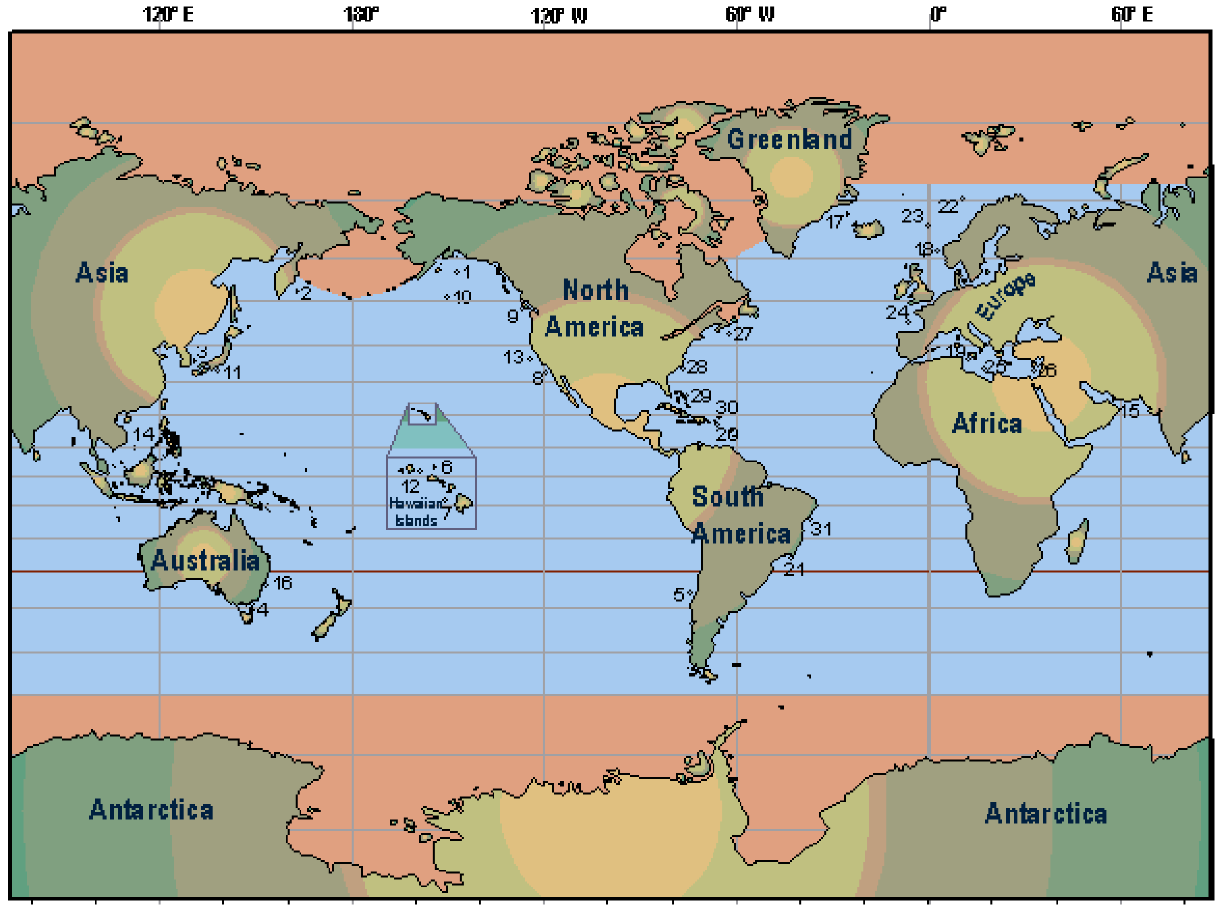

Figure 4.2-1. Acoustic Modeling Sites.

Table 4.2-1

Acoustic Modeling Sites

Site No.	Site Location	Acoustic Regime	Season	Marine Mammals Present	Training Type	Remarks
1	North Gulf of Alaska [57°N/147°W]	Surface duct	Summer (Jul)	blue, fin, humpback, gray, n. right, minke whales; pelagic dolphins; n. elephant seal; n. sea lion	ASWEX; bi/multi-static tests.	400 nm south of Prince William Sound; gray whale migration path (alternate).
2	East of Kamchatka, eastern Russia [52°N/163°E]	Deep water/duct	Summer (Jul)	blue, fin, humpback, minke, beaked whales; pelagic dolphins; n. fur seal; n. sea lion	Sub ops surveillance.	150 nm east of Petropavlovsk, Russia.
3	North Korea Strait [35°30'N/131°E]	Deep sound channel/ Bottom int.	Winter (Dec)	fin, humpback, gray, beaked whales; pelagic dolphins	Allied shall water ASWEX; bi/ multistatic tests with SSK.	90 nm east-northeast of Pusan, South Korea.
4	East Bass Strait, Australia [38°30'S/149°E]	Bottom int.	Winter (Jul)	fin, sei, Bryde's, s. right, beaked whales; pelagic dolphins; Australian fur & s. elephant seals	Allied shallow water ASWEX; bi/multistatic tests with SSK.	Approx. 70-80 nm offshore; between Australia and Tasmania.
5	West of Talcahuano, Chile [36°30'S/074°W]	Bottom int./CZ	Spring/ Fall (Oct/Apr)	blue, fin, humpback, s. right, sperm, beaked whales; pelagic dolphins; S. Am. fur seal	ASWEX in transition waters (deep-shallow) with SSK.	30 nm west of Chilean Navy submarine base; outside Gulf of Arauco.
6	North of Kauai, HI [25°N/159°30'W]	Deep water/CZ	Winter (Dec)	humpback, sperm, beaked, blackfish/killer whales; pelagic dolphins; Hawaiian monk seal	Northern Hawaiian RIMPAC; multinational ASWEX training ops.	>150 nm north of Kauai, HI.
7	South of Oahu, HI [19°30'N/158°30'W]	Deep water/CZ	Winter (Dec)	humpback, sperm, beaked blackfish/killer whales; pelagic dolphins; Hawaiian monk seal	Southern Hawaiian RIMPAC; multinational ASWEX training ops.	>100 nm south of Oahu, HI.

Table 4.2-1 (Continued)

Acoustic Modeling Sites

Site No.	Site Location	Acoustic Regime	Season	Marine Mammals Present	Training Type	Remarks
8	Southeast of San Nicolas Island, CA [32°40'N/119°W]	Deep water/CZ/ Bottom int.	fall (Oct)	blue, fin, sei, minke, beaked whales; pelagic dolphins; n. elephant, n. fur, Guadalupe fur seals; Calif. sea lion	JTFEX including ASWEX and possible ARG screen/ sanitization in SOAR	25 nm southwest of San Clemente Island, CA.
9	Offshore Juan de Fuca, WA [48°N/126°20'W]	Deep water/CZ/ Bottom int.	spring/ fall (Apr/Oct)	gray whale; pelagic dolphins; n. elephant, harbor seals; n. sea lion (fall)	Deep-shallow water area sanitization for sub base.	75 nm from JDF strait entrance, WA.
10	South Gulf of Alaska [51°N/150°W]	Half channel/ Bottom int.	summer (Jul)	blue, fin, humpback, gray, n. right, minke whales; pelagic dolphins; n. elephant seal; n. sea lion	Active sonar D&T, evaluation, performance calibration with sub.	1100-1200 nm south of Prince William Sound, AK.
11	South of Honshu, Japan [33°N/138°E]	Deep water/ bottom int.	Winter (Dec)	gray whale; pelagic dolphins	Allied shall water ASWEX; bi/ multistatic tests with SSK.	175 nm southwest of Yokosuka, Japan.
12	Northwest of Kauai, HI [22°35'N/160°25'W]	Bottom int./ CZ	Winter (Dec)	humpback, sperm, blackfish/killer whales; pelagic dolphins; Hawaiian monk seal	US Navy ASWEX; bi/multistatic sonar testing; CONOPS training with SSN.	45 nm northwest of PMRF--BARSTUR/BSURE/SWTR training support. Kauai, HI.
13	Offshore Central CA [36°30'N/124°W]	Deep water/ CZ/bottom int.	Spring/ Fall (Apr/Oct)	blue, fin, humpback, gray, beaked whales; pelagic dolphins; n. elephant, n. fur, harbor seals; n. sea, Calif. sea lions	ASWEX of opportunity using SSK prior to/after port call in Monterey, CA.	90 nm west of Pt. Lobos, CA.
14	West of Spratly Islands, South China Sea [10°N/112°E]	Deep water/CZ/ bottom int.	Winter (Dec)	Bryde's, blackfish/killer whales; pelagic dolphins	ASWEX training with SSK; stage from Singapore/ Kaohsiung.	100 nm northwest of Spratly Island.

Table 4.2-1 (Continued)

Acoustic Modeling Sites

Site No.	Site Location	Acoustic Regime	Season	Marine Mammals Present	Training Type	Remarks
15	Gulf of Oman [25°N/58°E]	Bottom int.	Summer (Jul)	humpback, Bryde's, sperm, beaked, blackfish/killer whales; pelagic dolphins	JTFS ops including underwater surveillance; SSK target of opportunity; possible inter/multinational ASWEX.	100 nm northwest of Muscat, Oman.
16	Offshore southeast coast of Australia [34°S/153°E]	Deep water/CZ/ bottom int.	Winter (Jul)	fin, sei, Bryde's, humpback, sperm, beaked whales; pelagic dolphins s. elephant seal	Allied deep water ASWEX; bi/multistatic tests with SSK.	100 nm east of Fleet Base East in Sydney, Australia.
17	Denmark Strait [67°45'N/025°W]	Duct/Bottom Int.	Fall/ Winter (Oct/Dec)	blue, fin, sei, minke, humpback, beaked whales; belugas; pelagic dolphins; hooded seals	Choke point ASWEX with sub. Bistatics with U.S. DD/DDG.	200 nm NNW of Reykjavik, Iceland.
18	West of Bergen, Norway [61°10'N/ 003°20'E]	Bottom int.	Summer (Jul)	blue, fin, minke, beaked, blackfish/killer whales; pelagic dolphins	ASWEX with NATO ally and Sweden using SSKs. Possible bistatics with U.S. DD/DDG/Swedish FSG.	75 nm NW of Bergen; Bergen is main Navy Operating Base.
19	Strait of Sicily [36°30'N/12°30'E]	Duct/ Bottom int.	Summer (Jul)	fin, minke, sperm, beaked, blackfish/killer whales; pelagic dolphins	SHAREM/Choke Point/Basin Localization with NATO allies: using SSKs. Bistatics with U.S. DD/DDG/German FFG.	100 nm WNW of Malta.
20	South of Puerto Rico [17°30'N/66°W]	CZ/Bottom Int.	Winter (Dec)	fin, Bryde's, minke, humpback, sperm, beaked, blackfish/killer whales; pelagic dolphins	FBE with multiple US assets, including US SSN, P-3C, SH-60R, etc. Multistatics ops.	45 nm SSW of Roosevelt Roads NS, Puerto Rico.
21	South of Rio de Janeiro, Brazil [24°S/043°W]	CZ/Bottom Int.	Winter (Jul)	blue, fin, minke, beaked whales; pelagic dolphins	UNITAS/ASWEX with SSKs. Bistatics with US DD/DDG/other DD/DDG.	60 nm south of Rio de Janeiro; location of Naval Base for submarines.
22	Northeast Norwegian Basin [70°00'N/010°00'E]	Deep water/CZ/Bottom Int.	Summer (Jul)	blue, fin, sei, minke, humpback, beaked, blackfish/killer whales; pelagic dolphins	Submarine ops surveillance; possible ASWEX with SSK. Possible bistatics with US DD/DDG/SSN.	230 nm west of Tromso, Norway; stage out of Norwegian Navy Northern Base (Sortland, Langoya Is.).

Table 4.2-1 (Continued)

Acoustic Modeling Sites

Site No.	Site Location	Acoustic Regime	Season	Marine Mammals Present	Training Type	Remarks
23	South Norwegian Basin between Iceland & Norway [65°00'N/000°]	Deep water/CZ	Summer (Jul)	blue, fin, minke, humpback, beaked, blackfish/killer whales; pelagic dolphins	NATO GINSEA ASWEX: using SSKs/SSN. Bistatics with US DD, DDG/FFG.	240 nm NW of Alesund, Norway; stage out of Norwegian Navy Southern Base (Haakonsvern, Bergen).
24	Bay of Biscay; west of France [45°30'N/007°W]	Duct; Deep water/CZ/	Fall (Oct)	fin, sei, minke, sperm, beaked, blackfish/killer whales; pelagic dolphins	SHAREM/NATO ASWEX: SSNs, SSKs. Bi/Multi-statics with DD, DDG/FFG.	200 nm SW of Brest, France. Stage out of Brest, which is French Naval Submarine Base (SSK).
25	Ionian Sea (South), Mediterranean [34°N/017°30'E]	Deep water/ CZ (weak)	Winter (Dec)	sperm, beaked, blackfish/killer whales; pelagic dolphins	Multinational ASW trials: using SSKs, FFGs.	250 nm SE of Malta. Stage out of Naples or Catania.
26	Levantine Sea, east Mediterranean [33°N/033°E]	CZ (weak)	Winter (Dec)	sperm, beaked whales; pelagic dolphins	Multinational USW Multistatic Experiment: SSKs, FSGs, FFGs.	100 nm west of Haifa, Israel. Stage out of Haifa, main Israel Navy base.
27	Sable Island Bank, east of Nova Scotia, Canada [42°30'N/062°30'W]	Duct/ Bottom Int.	Summer (Jul)	blue, fin, sei, minke, humpback, n. right, beaked, blackfish/ killer whales; pelagic dolphins	TTCP ASW Training/Experiment: SSNs, DD, DDG, SSK, FFG, Aurora MPA/FFG. Bi/Multi-static ops.	140 nm south of Halifax. Stage out of Halifax, main Canadian Navy base.
28	Onslow Bay, NC [33°45'N/076°15'W]	Bottom Int.	Spring (Apr)	fin, sei, minke, no. right whale, sperm, beaked, blackfish/ killer whales; pelagic dolphins	JTFEX including ASWEX and possible ARG screen/sanitization in SWTR of LWTC.	65 nm south of Morehead City, NC. Stage out of Norfolk, VA.

Table 4.2-1 (Continued)

Acoustic Modeling Sites

Site No.	Site Location	Acoustic Regime	Season	Marine Mammals Present	Training Type	Remarks
29	Northeast of Eleuthera Island, Bahamas [25°30'N/075°45'W]	CZ/ Bottom Int.	Winter (Dec)	fin, Bryde's, minke, humpback, sperm, beaked, blackfish/ killer whales; pelagic dolphins	SHAREM (pre/post sub AUTEC measurements): P-3C, DD, DDG/SSK. Bistatic ops.	100 nm NNE of Nassau. Stage out of Ft. Lauderdale/Nassau.
30	North of Puerto Rico [19°N/065°30'W]	CZ/ Bottom Int.	Winter (Dec)	fin, Bryde's, minke, humpback, sperm, beaked, blackfish/ killer whales; pelagic dolphins	FBE with multiple US assets, including SSN, P-3C, SH-60R, DD, DDG, etc. Multistatic ops.	50 nm north of Roosevelt Roads NS, Puerto Rico. Stage from Roosevelt Roads NS.
31	East of Salvador (Bahia), Brazil [13°S/037°45'W]	Deep water/ Bottom Int.	Winter (Jul)	blue, fin, Bryde's, minke, humpback, beaked whales; pelagic dolphins	ASWEX: SSK, FFG,SSN, DD, DDG, P-3C. Bi/multi-static ops.	45 nm east of Salvador (Bahia). Stage out of Salvador, Brazil's second largest Naval Base.

Notes:
ARG=Amphibious Ready Group
ASWEX=Antisubmarine Warfare Exercise
AUTEC=Atlantic Undersea T & E Center
BARSTUR=Barking Sands Tactical Underwater Range
BSURE=Barking Sands Underwater Range Expansion
CONOPS=Concept of Operation
CZ=Convergence Zone
DD=Destroyer
DDG=Guided Missile Destoyer
D&T=Development and Test
FBE=Fleet Battle Experiment
FFG=Guided Missile Frigate
FSG=Guided Missile Corvette
GINSEA=Greenland/Iceland/Norwegian Seas
JTFEX=Joint Task Force Exercise
JTFS=Joint Task Force Surveillance
LWTC=Littoral Warfare Training Complex
MPA=Maritime Patrol Aircraft
NATO=North Atlantic Treaty Organization
PMRF=Pacific Missile Range Facility
P-3C=Maritime Patrol Aircraft
RIMPAC=Rim of the Pacific
SHAREM=Ship, Helicopter ASW Readiness Effectiveness Measurement
SH-60R=ASW Helicopter
SOAR=Southern California ASW Range
SSK=Submarine (diesel-electric)
SSN=Submarine (nuclear)
SWTR=Shallow Water Training Range
TTCP=The Technical Cooperation Program

4.2.2 Acoustic Modeling

The acoustical modeling process for this OEIS/EIS was accomplished using the Navy's standard acoustic performance prediction TL model--Parabolic Equation (PE) version 3.4. The outputs from this model are the primary input to the Acoustic Integration Model (AIM). AIM simulations presented in this OEIS/EIS are specific to SURTASS LFA sonar.

4.2.2.1 Parabolic Equation Model

The PE model (see box) is one of the validated acoustic TL models in the Navy's Oceanographic and Atmospheric Master Library (OAML). The PE model has high spatial resolution, a factor that allowed more detailed study of diving animals that was considered important to the analysis. The PE model provides TL as a function of range and depth. It can use data from a wide variety of environmental acoustic databases to create realistic estimates for specific geographic locations.

Parabolic Equation (PE) Model (Version 3.4)

Environmental acoustic inputs to the PE model include the following:

- Sound speed as a function of range and depth in the water column;
- Sound speed, attenuation, and density as a function of range and depth in the sediment (or bottom loss as a function of range in the sediment);
- Bottom depth as a function of range;
- Surface loss as a function of range and wind speed;
- Loss due to surface ice as a function of range (when applicable);
- Volume attenuation as a function of range and depth in the water column, or flags instructing PE to compute the volume attenuation based on the acoustic frequency, or to ignore volume attenuation completely; and
- Frequency of the broadcast sound.

For this analysis, standard databases from the Navy's OAML were used for all of the above listed environmental and acoustical inputs. The bathymetry used was the Digital Bathymetric Data Base (DBDB) 1 or 5, which has a resolution of 1.9 km (1 nm) and 9.3 km (5 nm), respectively.

Geometric inputs include stationary-point (source) depth, moving-point (receiver) depth, PE half-beam width and beam shape, or user-supplied initial field, and maximum range of interest.

The output from the PE computation is TL versus range at the user-specified output depths and user-specified output ranges.

4.2.2.2 Acoustic Integration Model

AIM was used in this analysis to estimate exposures of marine mammals to LF sound (see box for AIM's structure, input requirements and outputs). The structure and logic for the AIM algorithms emerged during the February, 1997 SURTASS LFA Sonar Scientific Working Group Meeting #1 in Washington, DC. In general terms, AIM simulates:

- Characteristics of marine animals (e.g., species distribution, density, diving profiles, and general movement);
- SURTASS LFA sonar transmissions (e.g., sonar operating parameters); and
- The predicted sound field for each transmission.

Thus, AIM simulates acoustic exposure during a hypothetical SURTASS LFA sonar operation. Tables 4.2-2, 4.2-3, and 4.2-4, respectively, provide AIM input parameters for animal movement, diving behavior, and distribution, abundance, and density. The latter three are from the most recent NMFS stock assessment reports and other references listed at the end of Table 4.2-4. The inherent limitations to model input data availability, and the complexities involved in acquiring, collecting, collating and formatting these animal data, could allow the presence of an animal species at one or more sites to be overlooked. Using the best available NMFS and other worldwide information, a prudent approach has been applied, in that those animals that are deemed to have LF-sound sensitivity have been addressed. Moreover, the model runs are designed to portray high potential effects for each site (see Subchapter 4.2.1). For example, seasons were selected based on the potential for maximum LF-sensitive animal abundance.

Acoustic Integration Model (AIM)

AIM is composed of three separate elements:

The first element calculates the projected three-dimensional (3D) sound field from a hypothetical SURTASS LFA sonar source. The sound source can be moving or stationary. The resultant data field is a four-dimensional (4D) presentation (position, time) of sound pressure level (SPL).

The second element models the animals' distribution in space and diving behavior. This element assigns the animals to a start point and simulates their movement according to their expected behavior pattern. Programmable features in this element of the model include: (1) number of animals per unit area; (2) size of area in square nm; (3) individual animal start points, courses, propensity to change course, and speeds. The programmable features in the diving behavior are: (1) the depth of four zones within the water column (surface, transition, average diving, and maximum diving zones); (2) percent of time the animal spends in each zone (total among all four equals 100 percent).

The variability in animal behavior with respect to dive pattern, start location, and course/speed were simulated through the use of random variables. Each animal was assumed to swim at 3 kt (1.5 m/sec) and make a random turn every 15 minutes. For each sonar transmission, an animal is given a zone according to the user-provided probabilities, and is assigned a random depth within that dive profile zone.

The last element is the calculation of sound exposures. For each sonar transmission, or ping, the predicted location of each animal is used to select the appropriate RL from the modeled sound field described above. A histogram of RLs for each ping is computed for each animal, as well as summary statistics for each site. This process is repeated for each species in the region, to estimate possible effects of SURTASS LFA sonar operations.

Table 4.2-2

AIM Input Parameters for Animal Movement

Species	Sites	Swim Speed	Interval of Course Change	Angle of Course Change
All Animals	All Sites	3 kt (1.5 m/second)	15 minutes	0° - 360°

Table 4.2-3

AIM Input Parameters for Diving Behavior

Species	Dive Profile Zones (ft/m)							
	Surface	%	Transition	%	Average Dives	%	Max Dives	%
blue, fin, humpback, Bryde's whales	0-50/ 0-15.2	12	50-270/ 15.2-82.3	40	270-522/ 82.3-159.1	43	522-612/ 159.1-186.5	5
sperm, beaked whales; beluga; hooded seal	0-50/ 0-15.2	17	50-1200/ 15.2-365.8	13	1200-1800/ 365.8-548.6	50	1800-3500/ 548.6-1066.8	20
sei whale	0-50/ 0-15.2	20	50-150/ 15.2-45.7	20	150-250/ 45.7-76.2	40	250-450/ 76.2-137.2	20
minke whale	0-50/ 0-15.2	45	50-120/ 15.2-36.6	5	120-200/ 36.6-61.0	30	200-300/ 61.0-91.4	20
n./s. right whales	0-50/ 0-15.2	80	50-150/ 15.2-45.7	5	Not Applicable	0	150-250/ 45.7-76.2	15
gray whale	0-50/ 0-15.2	34	50-100/ 15.2-30.5	33	Not Applicable	0	100-150/ 30.5-45.7	33
blackfish/killer whales	0-50/ 0-15.2	20	50-800/ 15.2-243.8	20	800-1200/ 243.8-365.8	40	1200-1800/ 365.8-548.6	20
pelagic dolphins	0-50/ 0-15.2	30	50-150/ 15.2-45.7	30	150-300/ 45.7-91.4	30	300-750/ 91.4-228.6	10
n./s. elephant seals	0-50/ 0-15.2	13	50-732/ 15.2-223.1	20	732-1668/ 223.1-508.4	50	1668-4587/ 508.4-1398.1	17
n. sea lion	0-50/ 0-15.2	30	50-300/ 15.2-91.4	20	300-600/ 91.4-182.9	40	600-900/ 182.9-274.3	10
n. fur, harbor seals; Calif. sea lion	0-50/ 0-15.2	10	50-180/ 15.2-54.9	15	180-336/ 54.9-102.4	60	336-555/ 102.4-169.2	15
Guadalupe, Australian, S. American fur seals	0-50/ 0-15.2	44	50-100/ 15.2-30.5	30	100-150/ 30.5-45.7	20	150-250/ 45.7-76.2	6
Hawaiian monk seal	0-50/ 0-15.2	12	50-120/ 15.2-36.6	50	120-363/ 36.6-110.6	20	363-525/ 110.6-160.0	10

Table 4.2-4

AIM Inputs for Distribution, Abundance, and Density

Species	Site	Stock Estimate	Site Estimate	Distribution, Abundance, and Density Information
blue whale	1	1463	226	Feeding along shelf break; uniform distribution at depths >200m.
	2	1463	378	
	5	5000	46	South Pacific density=0.0036 animals/nm ^{2}. Uniform distribution at depths >200m.
	8	1463	556/366	Uniform distribution at depths >200m. (Site estimates are for Alternative 1/Alternative 2 cases)
	13	1463	365	
	10	1463	50	Uniform distribution at depths >200m.
	17	250	52	Summer distribution area in western North Atlantic is from Gulf of St. Lawrence to the pack ice. Density=.00023 animals/nm ^{2}. Highest density along shelf break, low density on shelf and off shelf.
	27	250	20	
	18	250	47	Spread from Iceland, British Isles, s. Norway north to Spitsbergen and Murmansk coast of Russia. Density=.00038. Highest density along shelf break, lowest density on shelf and in open ocean.
	22	250	32	
	23	250	6	
	21	2500	205	South Atlantic density=0.002 animals/nm ^{2}. Uniform distribution at depths >200m.
	31	2500	68	
fin whale	1	7500	102	Feeding off shelf, uniform distribution at depths >200m. (Site estimates are for Alternative 1/Alternative 2 cases)
	2	7500	202	
	3	7500	201	
	8	7500	278/183	
	13	7500	182	
	4	50,000	200	Density=0.0035 animals/nm ^{2}. Uniform distribution at depths >200m.
	5	50,000	199	
	16	50,000	99	
	10	7500	50	Uniform distribution at depths >200m.
	17	1704	61	Summer distribution area in western North Atlantic is from Gulf of St. Lawrence to the pack ice (Denmark Strait); density=0.0016 animals/nm ^{2}. Highest density along shelf break; low density on shelf and off shelf.
	27	1704	78	
	18	45596	223	North Atlantic population=47,300 animals; density=0.0052 animals/nm ^{2}. Highest density along shelf break; lowest density on shelf and in open ocean.
	19	1500	575	
	22	45596	128	
	23	45596	75	
	24	45596	216	
	20	1704	12	Winter distribution area in western North Atlantic is from Florida and the Greater Antilles to the pack ice. Estimate 2/3 of population in high density area (1136), 1/3 in low density area (568). Highest density along shelf break; low density on shelf and off shelf.
	28	1704	20	
	29	1704	42	
	30	1704	25	
	21	25,000	1296	South Atlantic density=0.0146 animals/nm ^{2}. Uniform distribution at depths >200m.
	31	25,000	455	
sei whale	4	18500	46	South Pacific abundance=18,500. This area is 0.0025 of South Pacific, therefore 46 animals in area. Uniform distribution at depths >200m.
	16	18500	68	
	8	7000	1064/697	Uniform distribution at depths >200m. (Site estimates are for Alternative 1/Alternative 2 cases).
	17	3000	104	Estimate 3000 in western North Atlantic, Gulf of St. Lawrence to the pack ice (Denmark Strait); density=0.0028 animals/nm ^{2}. High density along shelf break. Low density on shelf and off shelf.
	28	3000	58	

Table 4.2-4 (Cont'd)

AIM Inputs for Distribution, Abundance, and Density

Species	Site	Stock Estimate	Site Estimate	Distribution, Abundance, and Density Information
sei whale (continued)	22	3000	153	Summer from n. Norway to Bear Island and Novaya Zemlya. Density=0.0057 animals/nm^2. Highest density along shelf break; lowest density on shelf and in open ocean.
	24	3000	108	Winter off Spain, Portugal, northwest Africa. Density=0.0026 animals/nm^2. High density along shelf break; low density on shelf and in open ocean.
	27	3000	390	Density=0.004 animals/nm^2. Highest density along shelf break; low density on shelf and off shelf.
Bryde's whale	4	15000	35	South Pacific density=.00052 animals/nm^2. Uniform distribution at depths >200m.
	16	15000	17	
	14	20000	120	Western North Pacific density=0.002 animal/nm^2. Uniform distribution at depths >200m.
	15	7500	20	Indian Ocean density=.00054 animals/nm^2. Distributed evenly at depths >200m.
	20	10000	136	Distributed in western North Atlantic from southeast U.S. and south West Indies to Cabo Frio, Brazil (23°S, 43°W). Western North Atlantic density=0.005 animals/nm^2. High density along shelf break; low density on shelf and in open ocean.
	29	10000	448	
	30	10000	350	
	31	7500	203	South Atlantic density=.00066 animals/nm^2. Highest density along shelf break; low density on shelf and in open ocean.
minke whale	1	7500	1826	Uniform distribution.
	2	25000	1896	
	8	7500	1152/754	Migrating south, off shelf, uniform distribution.
	10	7500	100	Northern Pacific density=0.001 animals/nm^2. Uniform distribution.
	17	2145	585	North Atlantic population excluding Canadian east coast=149,000. Density=0.0156 animals/nm^2. Highest density along shelf break; low density on shelf and off shelf.
	18	149000	658	
	19	4500	575	
	22	149000	384	
	23	149000	225	
	24	149000	651	
	20	2145	360	In winter, most abundant in temperate waters, across entire North Atlantic; density=0.014 animals/nm^2. High density along shelf break; low density on shelf and in open ocean.
	28	2145	580	
	29	2145	1218	
	30	2145	506	
	21	190250	9925	South Atlantic density=0.1113 animals/nm^2. High density along shelf break; low density on shelf and in open ocean.
	31	190250	3541	
	27	2145	226	Density=0.004 animals/nm^2. High density along shelf break.
humpback whale	1	3698	1612	Feeding on the shelf, uniform distribution at depths <200m.
	2	1000	101	Feeding on the shelf with uniform distribution at depths <200m.
	3	1000	271	Breeding in strait. Uniform distribution at depths <200m.
	5	1290	117	Density=.0004 animals/nm^2. Uniform distribution at depths <200m.
	15	860	25	
	6	3698	48	Breeding inshore. Estimate offshore density at 0.008 animals/nm^2. Uniform distribution at depths <200m.
	7	3698	48	
	12	3698	593	
	10	3698	10	Do not expect any animals out in open ocean, but some may wander through area. Uniform distribution at depths <200m.
	13	3698	283	Uniform distribution in depths <200m.
	16	1290	96	Density=0.003 animals/nm^2. Uniform distribution at depths <200m.

Table 4.2-4 (Cont'd)

AIM Inputs for Distribution, Abundance, and Density

Species	Site	Stock Estimate	Site Estimate	Distribution, Abundance, and Density Information
humpback whale (continued)	17 27	10600 10600	403 413	Two major summer feeding grounds: northeast U.S./Canadian coast and Greenland/Iceland coast. Density=0.0106 animals/nm^2. Highest density along shelf break; low density on shelf and off shelf.
	20 29 30	10600 10600 10600	248 812 640	Winter breeding grounds are west coast of Haiti to Venezuelan coast. Density=0.009 animals/nm^2. High density along shelf break and on shelf. Low density in open ocean.
	22 23	5000 5000	304 182	Summer area around British Isles to Svalbard; density=0.0126 animals/nm^2. High density on shelf; low density in open ocean.
	31	3000	72	Density=.00098 animals/nm^2. High density along shelf break.
gray whale	1	21597	2862	Feeding on shelf. Uniform distribution at depths <100m.
	3	100	25	Breeding/calving in uniform distribution at depths <100m.
	9 13	21597 21597	1500 2250	Almost all will migrate past in March/April/May and November/December/January (12 weeks); therefore 250 animals would pass by each day. Uniform distribution at depths <200m.
	10	21597	10	Uniform distribution at depths <200m.
	11	100	50	Breeding/calving in coastal lagoons. Uniform distribution at depths <100m.
n. right whale	1	100	33	Feeding on shelf, uniform distribution at depths <200m.
	10	100	10	Uniform distribution at depths <200m.
	27	290	148	Uniform distribution at depths <200m.
	28	290	38	Estimate 100 animals will migrate through area over 8 weeks; therefore 35 animals in area for 20 day operation. Located at depths <200m.
s. right whale	4	1035	5	Density=.00007 animals/nm^2. Uniform distribution at depths >200m.
	5	1035	63	Density=.00037 animals/nm^2. Uniform distribution at depths >200m.
sperm whale	5 16	375000 375000	1222 3102	Density=0.026 animals/nm^2. Uniform distribution at depths >200m.
	6 7 12	187500 187500 187500	1000 1000 3362	Density=0.017 animals/nm^2. Uniform distribution at depths >200m.
	15	375000	1288	Distributed at depths >200m.
	19 24 25 26	5000 93750 5000 5000	750 705 296 296	Density=0.0205 animals/nm^2. Highest density along shelf break and in open ocean, lowest density on shelf.
	20 28 29 30	2698 2698 2698 2698	81 59 168 120	Western North Atlantic stock. Density = 0.003 animals/nm^2. Highest density at depths >1000m.
beaked whales	2	32850	840	Includes Baird's, Stejneger's, and Cuvier's in this area. Density=0.003 anml/nm^2 x 3 species. Uniform distribution at depths >1000m.
	3	32850	48	Includes Cuvier's in this area. Density=0.003 animals/nm^2. Uniform distribution at depths >1000m.
	4	71100	874	Includes Arnoux's, s. bottlenose whale, Andrew's, ginkgo-toothed, gray's, strap-toothed, Cuvier's. Density=0.003 animals/nm^2 x 7 species. Uniform distribution at depths >1000m.
	5	71100	286	Includes s. bottlenose whale, Cuvier's. Density=0.003 animals/nm^2 x 2 species. Uniform distribution at depths >1000m.

Table 4.2-4 (Cont'd)

AIM Inputs for Distribution, Abundance, and Density

Species	Site	Stock Estimate	Site Estimate	Distribution, Abundance, and Density Information
beaked whales (continued)	6	32780	173	Includes Cuvier's in this area. Density=0.003 animals/nm^2. Uniform distribution at depths >1000m.
	7	32780	173	Includes Cuvier's in this area. Density=0.003 animals/nm^2. Uniform distribution at depths >1000m.
	8	11967	1071/791	Includes Baird's, Cuvier's, Hubbs', and ginko-toothed in this area. Density = 0.003 animals/nm^2 x 4 species. Highest density at depths >1000m.
	13	11967	406	Includes Baird's, Cuvier's, Hubbs', and Stejneger's in this area. Density = 0.003 animals/nm^2 x 4 species. Highest density at depths >1000m.
	15	57680	68	Includes Cuvier's in this area. Density=0.003 animals/nm^2. Uniform distribution at depths >1000m.
	16	71100	396	Includes Arnoux's, s. bottlenose, Andrew's, gray's, strap-toothed, Cuvier's. Density=0.003 animals/nm^2 X 6 species. Uniform distribution at depths >1000m.
	17	55747	1751	Includes northern bottlenose whale in this area. North Atlantic density=0.0405 animals/nm^2. Highest density at depths >1000m.
	22	37043	2635	
	23	37043	584	
	18	37043	1395	Includes n. bottlenose (density=0.0405 animals/nm^2), Sowerby's, and Cuvier's (combined density=0.001 animals/nm^2) in this area. Highest density at depths >1000m.
	24	37043	1396	
	19	320	40	Includes Cuvier's at this site. Estimate 895 in eastern North Atlantic therefore density=0.001 animals/nm^2. Highest density at depths >1000m.
	20	55747	24	Includes Blainville's, Gervais', Cuvier's in this area. Density=0.001 animals/nm^2. Highest density at depths >1000m.
	29	55747	56	
	30	55747	40	
	21	34180	260	Includes Cuvier's in this area. Density=0.003 animals/nm^2. Highest density at depths >1000m.
	25	320	15	
	26	320	15	
	31	34180	91	
	27	55747	2275	Includes n. bottlenose (density=0.0405 animals/nm^2), Sowerby's, Blainville's, and True's (combined density=0.001 animals/nm^2) at this site. Highest density at depths >1000m.
	28	55747	20	Includes Blainville's, Gervais', True's, and Cuvier's at this site. Density=0.001 animals/nm^2. High density at depths >1000m.
beluga	17	14000	845	Move offshore in fall and winter, inshore to estuaries and bays in summer as ice recedes.
blackfish and killer whales	6	60000	173	Eastern Tropical Pacific total population ~60,000. Density=0.0043 animals/nm^2. Highest density at depths >1000m.
	7	60000	173	
	12	60000	97	
	14	47085	173	
	15	82673	112	
	18	780000	4563	Includes long-finned pilot whale. Density=0.135 animals/nm^2. Highest density at depths >1000m.
	22	780000	8777	
	23	780000	1944	
	24	780000	4671	
	19	4000	4960	Includes long-finned pilot and killer whales in this area. Density=0.135 animals/nm^2. Highest density at depths >1000m.
	25	4000	1944	

Table 4.2-4 (Cont'd)

AIM Inputs for Distribution, Abundance, and Density

Species	Site	Stock Estimate	Site Estimate	Distribution, Abundance, and Density Information
blackfish and killer whales (continued)	20 29 30	49685 49685 49685	264 714 540	Includes short-finned pilot, pygmy killer, killer, false killer, and melon-headed whales in this area. Density=0.0125 animals/nm^2. High density along shelf break and in open ocean.
	27	49685	703	Includes long-finned pilot at this site. Density=0.0125 animals/nm^2. Highest density along shelf break and in open ocean.
	28	49685	273	Includes short-finned pilot at this site. Density=0.0125 animals/nm^2. Highest density along shelf break and in open ocean.
pelagic dolphins	1 2 10	486000 486000 486000	21285 6660 2884	Includes Pacific white-sided dolphins and Dall's porpoise in this area. Density=0.05 animals/nm^2. Uniform distribution at depths >200m.
	3 11	3.0M 3.0M	34280 51432	Includes common, striped, long-snouted spinner, pantropical spotted, rough-toothed, bottlenose, Risso's, Pacific white-sided in this area. Density=0.01 animals/nm^2. Uniform distrib. at depths >200m.
	4 5	5.4M 5.4M	16008 18095	Includes common, s. right whale dolphin, bottlenose, Risso's. Density=0.38 animals/nm^2. Uniform distrib. at depths >200m.
	6 7 12 15	10.7M 10.7M 10.7M 10.7M	24624 24624 24624 19768	Includes common, striped, long-snouted spinner, pantropical spotted, bottlenose, Risso's. Density=0.76 animals/nm^2. Uniform distribution at depths >200m.
	8	460000	22620/12576	Includes common, striped, n. right whale dolphin, rough-toothed, bottlenose, Risso's, Pacific white-sided dolphins and Dall's porpoise in this area. Density=0.36 animals/nm^2. Uniform distribution at depths >200m.
	9	120500	5848	Includes n. right whale dolphin, Risso's, Pacific white-sided dolphins and Dall's porpoise in this area. Density=0.096 animals/nm^2. Uniform distribution at depths >200m.
	13	438000	8129	Includes common, n. right whale dolphin, bottlenose, Risso's, Pacific white-sided dolphins and Dall's porpoise. Density=0.35 animals/nm^2. Uniform distribution at depths >200m.
	14	12.0M	23093	Includes common, striped, long-snouted spinner, pantropical spotted, rough-toothed, bottlenose, Risso's, Fraser's in this area. Density=0.40/nm^2. Uniform distribution at depths >200m.
	16	5.9M	12540	Includes common, s. right whale, striped, rough-toothed, bottlenose, Risso's. Density=0.42 animals/nm^2. Uniform distribution at depths >200m.
	17	50000	949	Includes bottlenose, Atlantic white-sided, white-beaked dolphins at this site. Density=0.002 animals/nm^2. Uniform distribution at depths >200m.
	18	60808	864	Includes bottlenose, Risso's, Atlantic white-sided, white-beaked dolphins at this site. Density=0.0256 animals/nm^2. Highest density at shelf break and in open ocean, lowest density on shelf.
	19 25 26	58000 58000 58000	550 216 216	Includes common, striped, rough-toothed, bottlenose, Risso's dolphins at this site. Density=0.015 animals/nm^2. Highest density at shelf break and in open ocean, lowest density on shelf.
	20 21 28 29 30 31	77500 77500 77500 77500 77500 77500	456 1740 513 1162 870 629	Includes common, striped, short-snouted spinner, long-snouted spinner, pantropical spotted, Atlantic spotted, rough-toothed, bottlenose, Risso's. Density=0.0204 animals/nm^2. Highest density at shelf break and in open ocean, lowest density on shelf.

Table 4.2-4 (Cont'd)

AIM Inputs for Distribution, Abundance, and Density

Species	Site	Stock Estimate	Site Estimate	Distribution, Abundance, and Density Information
pelagic dolphins (continued)	22	30500	828	Includes bottlenose and white-beaked at this site. Density=0.0126 animals/nm^2. High density at shelf break and in open ocean.
	23	49700	326	Includes bottlenose, Atlantic white-sided, and white-beaked dolphins at this site. Density=0.0226 animals/nm^2. Highest density at shelf break and in open ocean, lowest density on shelf.
	24	75300	736	Includes common, striped, bottlenose, white-beaked, and Risso's at this site. Density=0.0212 animals/nm^2. Highest density at shelf break and in open ocean, lowest density on shelf.
	27	94800	1916	Includes common, striped, bottlenose, Atlantic white-sided, white-beaked, and Risso's at this site. Density=0.034 animals/nm^2. Highest density at shelf break and in open ocean, lowest density on shelf.
n. elephant seal	1	51625	5160	Males on beaches molting; females at sea foraging. Uniform distribution at depths >200m.
	8	51625	19676/ 12903	Non-breeding season, at sea foraging, most migrate north. Uniform distribution at depths >200m.
	9	51625	2916	Males on beaches molting; females at sea foraging. Uniform distribution at depths >200m.
	10	51625	5160	Males on beaches molting; females at sea foraging. Uniform distribution at depths >200m.
	13	51625	25819	Non-breeding season, at sea foraging, most migrate north. Uniform distribution at depths >200m.
s. elephant seal	4 16	200000 200000	460 231	South Pacific density=0.007 animals/nm^2. Offshore feeding; distribute evenly at depths >200m.
n. sea lion	1	30403	9903	Onshore at rookeries during May and June, then move into water to feed nearshore or over continental shelf (depths <200m).
	2	38893	2912	Onshore at rookeries during May and June, then move into water to feed nearshore or over continental shelf (depths <200m).
	9	30403	2808	No sea lion rookeries exist in WA, but OR/CA animals may migrate north during non-breeding season (Sept-Apr). Uniform distribution at depths <200m).
	10	30403	10	Onshore at rookeries during May and June, then move into water to feed nearshore or over continental shelf (depths <200m).
	13	30403	7592	Most southern rookery at Ano Nuevo (37°20'N), but animals may migrate into modeling site. Uniform distribution at depths <200m.
Calif. sea lion	8	18800	47000/ 37455	Females foraging near rookeries in Channel Islands.
	13	18800	17204	Males from Channel Island rookeries migrating through the area.
harbor seal	9	33384	18483	WA coast animals plus small amount of WA inland stock animals. Inhabit nearshore coastal and estuarine waters. Do not make extensive pelagic migrations.
	13	30293	18028	CA stock. Abundant in protected bays, inlets. Inhabit nearshore coastal and estuarine waters. Do not make extensive pelagic migrations.
hooded seal	17	250000	20571	Jan Mayen (West Ice) stock. Feeding in fall, early winter; prefer deep, offshore waters.
n. fur seal	2	162156	108104	Population at Commander Islands rookeries.
	8	848539	6170/ 6720	Population at San Miguel Island rookery .
	13	848539	2739	Found along shelf break.

Table 4.2-4 (Cont'd)

AIM Inputs for Distribution, Abundance, and Density

Species	Site	Stock Estimate	Site Estimate	Distribution, Abundance, and Density Information
Guadalupe fur seal	8	3028	317/303	Primarily around San Nicolas Island rookery. Site estimates are for Alternative 1/Alternative 2 cases
Australian fur seal	4	50000	18125	Density=8.33 animals/nm^2 of coastal shelf. Found within 5 km of coast.
S. Amer. fur seal	5	175000	8727	Density=0.33 animals/nm^2 along coastal South America. Primarily coastal, with slight concentration around shelf edge.
Hawaiian monk seal	6 7	1366 1366	0 0	No animals will be located >60 nm from the shore.
	12	1366	340	Feed in areas where water depths are 10-40m.

Notes:

1. Conversion factors:
   100m = 328.1 ft
   200m = 656.2 ft
   1000m = 3281 ft
   1 nm^2 = 3.43 km^2
2. When the distribution of a species is described as "uniform…at depths > 200m," this should be interpreted to mean that the species is distributed evenly over the area in the ocean where water depths are greater than 200m (656.2 ft).

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Stewart and DeLong, 1994
TENERA, 1994

Except for species with low densities, the number of animals in each AIM simulation was related to the expected animal densities for each species. For species with low densities, the AIM simulations were run with more animals than would be expected. This was to ensure that the result of the simulation was not unduly influenced by the chance placement of a few animals. At the conclusion of each model run, the data were normalized.

The results of the AIM analysis are displayed in two plots:

- Cumulative distribution function (CDF) of RL for each species of animals for each site modeled; and
- A RL histogram for each animal in all species modeled. This histogram shows the number of transmissions that each animal receives in 1-dB steps, up to the maximum RL for that animal.

The results of the AIM simulation process were used as the inputs to the risk continuum to estimate the risk of significant change in a biologically important behavior and of injury to marine mammals.

4.2.3 Definition of Biological Risk and Determination of Risk Function

In order to determine the potential impacts that exposure to LF sound from SURTASS LFA sonar operations could have on marine mammals, biological risk standards were defined with associated parameters of exposure. Based on the MMPA (Subchapter 1.3.3.1), the potential for biological risk was defined as the probability for injury or behavioral harassment of marine mammals. In this analysis, behavioral harassment is assumed to be a significant change in a biologically important behavior, which is consistent with the National Research Council's characterization (NRC, 2000). The potential for biological risk is a function of an animal's exposure to a sound that would potentially cause hearing, behavioral, psychological or physiological effects. The measurement parameters for determining exposure were RL in decibels, length of the signal (ping), and number of pings received.

This analysis of risk is an alternative to the use of all-or-nothing thresholds. The subsequent discussion of the risk function emphasizes the advantages of a smoothly varying model of biological risk in relation to sound exposure. However, for the purpose of the SURTASS LFA sonar analyses presented in this OEIS/EIS, all marine animals exposed to RLs $\geq$ 180 dB are evaluated as if they are injured.

When SURTASS LFA sonar transmits, there is a boundary that encloses a volume of RLs at or above 180 dB, and a volume outside this boundary that experiences RLs below 180 dB. In this analysis, the 180-dB figure is emphasized because the level of risk for marine mammals depends on their location in relation to the LFA mitigation zone.

Before the biological risk standards could be applied to realistic SURTASS LFA sonar operational scenarios, two factors had to be considered, which resulted in the development of the risk continuum approach. In assessing the potential risk of significant change in a biologically important behavior, two questions must be resolved:

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

These questions have been addressed by the use of a function that translates the history of repeated exposures (as calculated in the Acoustic Integration Model) into an equivalent RL for a single exposure with a comparable risk. This approach is similar to those adopted by previous studies of risk to human hearing (Richardson et al., 1995b; Crocker, 1997).

4.2.3.1 Effects of Repeated Exposure

The human model provides the most extensive data and is presently the best objective foundation for an assessment of repeated exposure. Long term hearing loss in humans is accelerated by chronic daily 8-hour workplace exposure (over time scales on the order of tens of years) to sounds at levels of 85 dB(A) (A-weighted; i.e., in air) or greater (Guide for Conservation of Hearing in Noise, American Academy of Ophthalmology and Otolaryngology, 1969; Ward, 1997). The sound power reference unit dB(A) is the accepted convention for frequency-weighted measure of hearing in humans. In young healthy humans, 0 dB(A) is the nominal threshold of best hearing, and measured free-field thresholds for the frequencies of best binaural hearing (400 - 8,000 Hz) vary between –10 to + 10 dB re 20 µPa (Beranek, 1954; Harris, 1998), depending on measurement objective and technique used.

It is intuitive to assume that the effects of exposure to multiple LF sounds would be greater than the effects of exposure to a single sound. A formula is needed to address the potential for accumulation of effects over a 20-day period (estimated maximum SURTASS LFA sonar mission period), allowing for varying RLs and a duty cycle of 20 percent or less. There are no published data on marine mammals regarding responses to repeated exposure to LF sound. Two lines of evidence from human studies were used to devise a plausible formula.

Richardson et al. (1995b), citing Kryter et al. (1966), discusses workplace damage risk criteria relative to exposure to continuous narrowband (one-third octave) noise. To relate to workplace data, note that during an 8-hour exposure during normal SURTASS LFA sonar operations, the pings would add up to a total of 48 to 96 minutes of LF sound transmission. The workplace damage risk criteria change from 88 dB to 82 dB to 80 dB, as the duration of exposure changes from 8 to 2 hours to 30 minutes. These changes indicate that the effects of increased exposure are not constant across this range of durations. When continuous exposure increases from 30 minutes to 2 hours per day, the effect scales with 10 $\log_{10}(T)$. When continuous exposure increases from

2 to 8 hours per day, the effect scales with 3.3 $\log_{10}(T)$. These values do not account for the probable reduction of effect due to the long intervals between SURTASS LFA sonar pings.

The second line of evidence comes from repeated exposure to impulsive sounds. Richardson et al. (1995b), citing Kryter (1985) and Ward (1968), discussed the relationship between repeated exposures of the human ear to impulsive sound and a TTS in the subject's hearing. The risk threshold is lowered by 5 dB per ten-fold increase in the number of pulses per exposure if the number of pulses per exposure is less than 100. These findings are consistent with qualitative statements by Crocker (1997). Following this logic, if a ping of level L is repeated N times, the single ping equivalent (SPE) level is defined as $L + 5 \log_{10}(N)$ in dB. For example, using this formula, 100 pings at 170 dB are equivalent to one ping at 180 dB.

Due to the lack of information on behavioral responses, the 5 $\log_{10}(N)$ formula has been chosen for assessing the risk to a marine mammal for significant change in a biologically important behavior due to repeated exposures to LF sound such as SURTASS LFA sonar transmissions.

The following provides some mathematical details of how the 5 $\log_{10}(N)$ factor was implemented for repeated exposure to varying levels:

- For each animal in the AIM simulation, the RL of each ping was calculated as the animal moved in relation to the sound source;
- These RLs were converted into raw acoustic intensities (proportional to the intensity of the signal, or the variance of the waveform);
- To correctly summarize the intensities, their values were squared and summed together; and
- This sum was converted back to an equivalent dB value by taking the base 10 logarithm of the sum, and multiplying it by 5.

In this process, an SPE RL is larger than the maximum RL of any single ping in a sequence (see box). Also, the SPE for a sequence consisting of a single loud ping and a long series of much softer pings is almost the same as the level of the single loud ping. A ping duration (length) of 60 seconds was assumed in the modeling and risk assessment calculations using SPE. The adoption of 60 seconds and 20 percent as the standard ping duration and duty cycle, respectively, for calculations in this OEIS/EIS, provides a reasonable estimate of the potential for effects from real-world operations without sacrificing the conservative nature of the analysis process.

Sample Single Ping Equivalent (SPE) and Risk Examples

A generic example to illustrate the calculations used for translating the number of pings into an SPE is shown in Figure 4.2-2a (Sample Single Ping Equivalent [SPE] Calculation). This illustration assumes a marine mammal is exposed to a total of ten SURTASS LFA sonar transmissions, or pings, at received levels (RL) between 150-159 dB. The pings are delineated by individual bins of one dB each. The example illustration shows that the animal was exposed to two pings at 150 dB RL, none at 151 dB RL, three pings at 152 dB RL, etc. To arrive at a total SPE for the entire exposure, the intensity level for each ping is first calculated (i.e., 1×10^{15} µPa for each of the two 150 dB RL exposures, 1.58×10^{15} µPa for each of three 152 dB RL exposures, etc). These intensity values are then squared and added together. Taking $5 \log_{10}$ of this sum of the squared intensities (1.24×10^{32}) results in a total SPE of 160.47 dB.

An example of the effect of increased RL can be seen in Figure 4.2-2b (Single Ping Equivalent Risk Function), which displays the probability function for a single ping. At an RL of 150 dB, the risk of significant change in a biologically important behavior is 2.5 percent. The RL corresponding to 50 percent risk on this curve is 165 dB. At 180 dB, the risk of significant change in a biologically important behavior is 95 percent. For the above SPE example, the risk function would predict a 24.48 percent probability of significant change in a biologically important behavior.

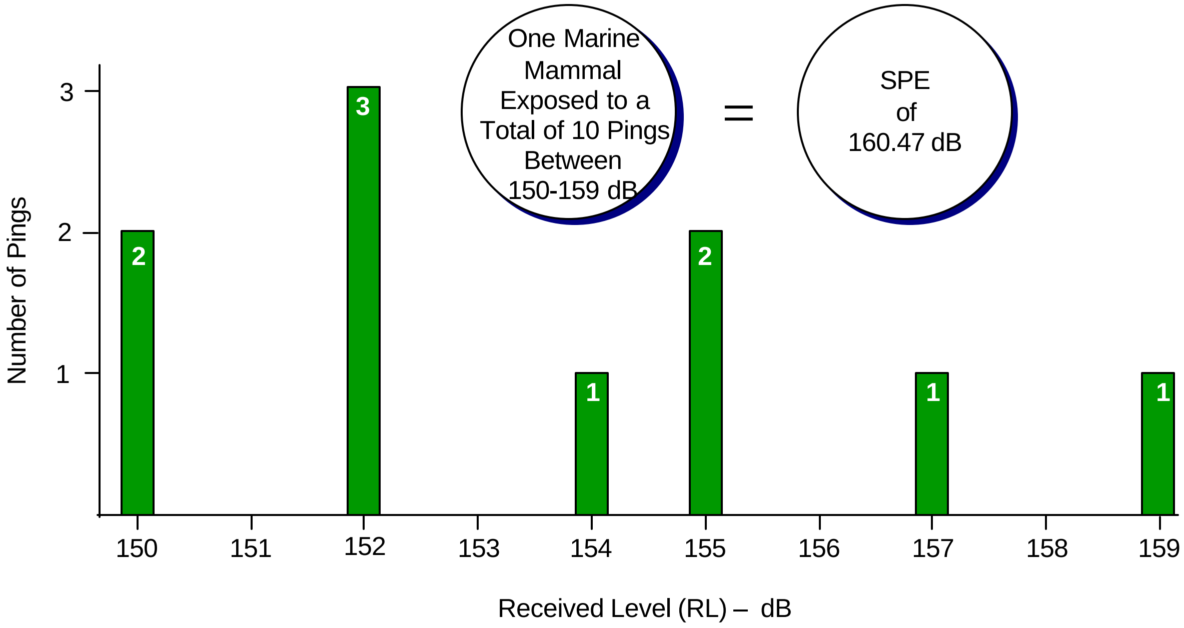

Figure 4.2-2a. Sample Single Ping Equivalent (SPE) Calculation.

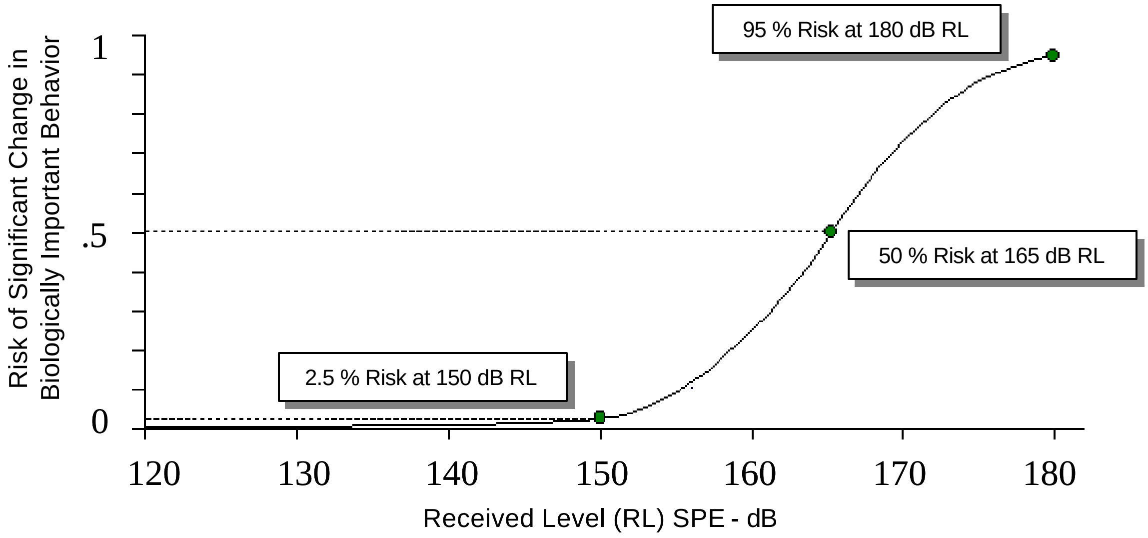

Figure 4.2-2b. Single Ping Equivalent Risk Function.

4.2.3.2 Determination of Risk Function

Up to now, the definition of biological risk to marine mammals has generally been based on a received sound level threshold for individual species. For example, 120 dB has been used as a threshold for behavioral modification (NRC, 1994). However, this approach sets a discrete threshold below which any RL value is considered risk-free, and any value above it has been considered certain to cause responses by marine mammals. Nonetheless, it is unreasonable to assume that in a large animal stock a one-decibel increase (say, from 119 dB to 120 dB) would cause a change from no behavioral response to all animals in the stock responding.

The widely adopted approach used here to assess biological risk is a smooth, continuous function that maps RL to risk. Scientifically, this acknowledges that individuals may vary in responsiveness. Mathematically, this eliminates the possibility for dramatic changes in estimated impact as a result of small changes in parameter values. As a result, the potential for misleading results is greatly reduced. These were the reasons for developing the risk continuum.

In order to represent a probability of risk, the function should have a value near zero at very low exposures, and a value near one for very high exposures. One class of functions that satisfies this criterion is cumulative probability distributions, or cumulative distribution functions (CDFs). In selecting a particular functional expression for risk, several criteria were identified:

- The function must use parameters to focus discussion on regions of uncertainty;
- The function should contain a limited number of parameters;
- The function should be capable of accurately fitting experimental data; and
- The function should be reasonably convenient for algebraic manipulations.

The function used here is adapted from the solution in Feller (1968):

$$R = \frac{1-\left(\dfrac{L-B}{K}\right)^{-A}}{1-\left(\dfrac{L-B}{K}\right)^{-2A}}$$

Where:
R = risk (0-1.0);
L = RL in dB;
B = basement RL in dB, below which risk is negligible (119 dB);
K = the RL increment above basement in dB at which there is 50 percent risk (46 dB); and
A = risk transition sharpness parameter (10) (explained in Subchapter 4.2.5.2).

In order to use this function, the values of the three parameters (B, K, and A) need to be established. As will be explained in Subchapter 4.2.5, the values used in this OEIS/EIS analysis are based on the results of the 1997-98 LFS SRP. Prior to the LFS SRP, a 50 percent probability of avoidance at 100 m (328 ft) might have been associated with a RL of 120 dB (Malme et al., 1983, 1984). It was also hypothesized, prior to the LFS SRP, that marine mammals exposed to RLs near 140 dB would depart the area (e.g., Richardson et al., 1995b). It is critical, therefore, to examine the logic that motivated the selection of experiments for the LFS SRP, how those results relate to earlier data, and how the LFS SRP results relate to the development of the risk continuum.

4.2.4 Low Frequency Sound Scientific Research Program (LFS SRP)

In 1997, there was a widespread consensus that cetacean response to LF sound signals needed to be better defined using controlled experiments. In response, the Navy worked with scientists to develop the LFS SRP. The LFS SRP was designed to supplement the data from previous studies. Also, the Navy made the SURTASS LFA sonar vessel (R/V *Cory Chouest*) available to the LFS

SRP, which enabled greater control over RL due to the dynamic range of the ship's transmission system and the quality of its environmental acoustic modeling capabilities. Logistical constraints limited the experimental use of the SURTASS LFA sonar to the North Pacific.

4.2.4.1 Previous Studies

Prior to the LFS SRP, the best information regarding whale responses to continuous, LF, anthropogenic noise was summarized by Richardson et al. (1995b):

> "Some marine mammals tolerate, at least for a few hours, continuous sound at received levels above 120 dB re 1 μPa. However, others exhibit avoidance when the noise level reaches ~120 dB .... It is doubtful that many marine mammals would remain for long in areas where received levels of continuous underwater noise are 140+ dB at frequencies to which the animals are most sensitive."

There have been several studies that have demonstrated responses of marine mammals to exposure levels ranging from detection threshold to 120 dB:

- One study examined responses of gray whales migrating along the California coast to various sound sources located in their migration corridor (Malme et al., 1983, 1984). Gray whales showed statistically significant responses to four different underwater playbacks of continuous sound at RLs of approximately 120 dB. The sources of the playbacks were typical of a drillship, semisubmersible, drilling platform, and production platform. This study was replicated in Phase II of the LFS SRP using SURTASS LFA sonar stimuli. However, the Phase II research demonstrated that it may be invalid to apply the inshore (2 km [1.1 nm] from shore) response model (when 50 percent of the whales avoided SURTASS LFA sonar stimuli at RL of 141 ±3 dB) to sources that are offshore (4 km [2.2 nm] from shore) of migrating whales, and that whales did not avoid offshore sources at RLs of 140 dB.

- Two other studies concern Arctic animals. Belugas (white whales) and narwhals showed behavioral responses to noise from an icebreaker at 50 km (27 nm). At this range, the RL of the noise is near the detection threshold. Richardson et al. (1995b) point out that the strong reactions to icebreaker noise are unique in the marine mammal disturbance literature. These reactions appeared similar to the responses of each species to their most significant predator, the killer whale (Finley et al., 1990). It is not known why these animals were so sensitive to icebreaker noise and responded as if it were a predator. But, if these animals are responding to ice breakers as if to predators, it was understandable why these animals would show strong responses at detection threshold. This response has not been noted for other sound stimuli, only playback of killer whale calls. The sensitive responses of the Arctic species may relate to the fact that these animals are hunted using motorized boats. Other factors specific to the Arctic that may contribute to this sensitivity are sounds of ice-breaking that may mimic a potentially dangerous movement of ice, scarcity of ships in the high Arctic, and low background noise and good underwater sound propagation in Arctic waters.

- Controlled playback experiments and observations around actual industrial sources show bowhead whales avoid drill ship noise at estimated RLs of 110 to 115 dB and seismic sources at estimated RLs of 110 to 132 dB (Richardson et al., 1995a; Richardson, 1997, 1998).

4.2.4.2 Selection of Species and Study Sites

The selection of species and study sites for the LFS SRP 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 this group's decisions was that baleen whales became the focus of all three projects, since they were thought most likely among all marine species to have sensitive hearing in the SURTASS LFA sonar frequency band (Figure 1-4 [Marine Mammal Audiograms]), because of their protected status and because of prior evidence of avoidance responses to LF sounds. Study sites were selected that offered the best opportunities for detailed observations combined with previous research that documented undisturbed patterns of behavior and distribution, or avoidance reactions to anthropogenic sound at low RLs.

This focus on the most sensitive species and the best sites for detecting a response was intended to produce a model of response that could be applied to other species for which data were lacking. This was a critical element of the logic of the LFS SRP. Extrapolation was unavoidable. By selecting marine mammal species that probably have the most sensitive LF hearing, the LFS SRP results produced a model of response that is likely to overestimate the responses of other species.

For the purposes of this OEIS/EIS, the LFS SRP was the best option available to obtain critical scientific data under time and funding constraints. The Navy would continue to monitor marine mammals detected during SURTASS LFA sonar operations to further substantiate the LFS SRP results and to ensure that the assumptions used in the scientific analyses presented herein remain valid.

The species and settings chosen for the three phases of the LF sound playback experiments were:

- Blue and fin whales feeding in the Southern California Bight (Phase I) (September-October 1997);

- Gray whales migrating past the central California coast (Phase II) (January 1998); and

- Humpback whales off Hawaii (February-March 1998) (Phase III).

These studies included three important behavioral contexts for baleen whales: feeding, migrating, and breeding. The first phase also involved some studies of northern elephant seals tagged with acoustic data loggers. Elephant seals are considered among the most sensitive pinnipeds to LF sound and are deep divers (Le Boeuf, 1994). The third phase was designed to include playbacks with sperm whales, but no animals were encountered during the offshore portions of the cruise schedule. Sperm whales are listed by the U.S. as endangered under the ESA, and they were suspected to be the toothed whale most sensitive to LF sound (Ketten, 1997). There have also been reports of sperm whales being sensitive to anthropogenic transient noise (Watkins and Schevill, 1975; Watkins et al., 1985; Bowles et al., 1994; Mate et al., 1994b).

4.2.4.3 Research Program

The 1997-98 LFS SRP was designed to ensure that no marine mammal was exposed to RLs exceeding 160 dB. The LFS SRP produced new information about responses to the SURTASS LFA sonar sounds at RLs from 120 to 155 dB. The LFS SRP team explicitly focused on situations that promoted high RLs (maximum 160 dB), but were seldom able to achieve RLs in the high region of this exposure range due to the natural movements of the whales and maneuvering constraints of the LF source vessel.

During the first phase of LFS SRP research, the source ship operated routinely with the full source array (18 source projectors) at source levels similar to those that would be used in normal Navy operations. The ship also approached whales while operating two of the projectors at full power levels. Over the 19-day period, there were no immediately obvious responses from either blue or fin whales as noted during observations made from any of the research vessels during playback of LFA sounds (see TR 1).

In the second phase of LFS SRP research, migrating gray whales showed responses similar to those observed in earlier research (Malme et al., 1983, 1984) when the source was moored in the migration corridor (2 km [1.1 nm] from shore). The study extended those results with confirmation that a louder SL elicited a larger scale avoidance response. However, when the source was placed offshore (4 km [2.2 nm] from shore) of the migration corridor, the avoidance response was not evident. This implies that the inshore avoidance model -- in which 50 percent of the whales avoid exposure to levels of 141 ±3 dB -- may not be valid for whales in proximity to an offshore source (Buck and Tyack, 2000).

The third phase of LFS SRP research examined potential effects of SURTASS LFA sonar transmissions on singing humpback whales. These whales showed some apparent avoidance responses and cessation of song during specific LFA sound transmissions at RLs ranging from

120 to 150 dB. However, an equal number of singing whales exposed to the same levels showed no cessation of song during the same LFA sound transmissions. Of the whales that did stop singing, there was little response to subsequent LFA sound transmissions; most joined with other whales or resumed singing within less then an hour of the possible response. Those that did not stop singing, sang longer songs during the period of LFA transmissions, and returned to baseline after transmissions stopped (Miller et al., 2000; TR 1). Further analysis is required to establish how often male humpbacks stop singing in the absence of the SURTASS LFA sonar transmissions, and to evaluate the significance of the song cessation observed during playbacks.

This kind of brief interruption, followed by resumption of normal interactions, is similar to that seen when whales interrupt one another or when small vessels approach whales (Miller et al., 2000). If whales are in a breeding habitat where vessel interactions are frequent, then the aggregate impact of all disruptive stimuli could become significant. However, because the SURTASS LFA sonar system would be operated well offshore of these humpback breeding areas, it is likely that the cumulative impact of numerous inshore vessels would be significantly greater on these animals than that caused by an occasional offshore series of SURTASS LFA sonar transmissions.

In summary, the scientific objective of the LFS SRP was to conduct independent field research in the form of controlled experimental tests of how baleen whales responded to SURTASS LFA sonar signals. Taken together, the three phases of the LFS SRP do not support the hypothesis that most baleen whales exposed to RLs near 140 dB would exhibit disturbance of behavior and avoid the area. These experiments, which exposed baleen whales to RLs ranging from 120 to about 155 dB, detected only minor, short-term behavioral responses. Short-term behavioral responses do not necessarily constitute significant changes in biologically important behaviors. The fact that none of the LFS SRP observations revealed a significant change in a biologically important behavior helped determine an upper bound for risk. The IFS SRP results cannot, however, be used to prove that there is zero risk at these levels. Accordingly, the risk continuum presented below assumes that risk is small, but not zero, at the RLs achieved during the LFS SRP. The risk continuum modeled a smooth increase in risk that culminates in a 95 percent level of risk of significant change in a biologically important behavior at 180 dB. In this region, the risk continuum is unsupported by observations. However, the AIM simulation results indicate that a small fraction of any marine mammal stock would be exposed to sound levels exceeding 155 dB (see Appendix D and Figures 1-5a through 1-5c).

4.2.5 Risk Continuum Analysis

The values of B, A, and K need to be specified in order to utilize the risk function in Subchapter 4.2.3. The risk continuum function approximates the dose-response function in a manner analogous to pharmacological risk assessment (see Appendix D). In this case, the risk function is combined with the distribution of sound exposure levels to estimate aggregate impact on a stock.

4.2.5.1 Basement Value for Risk - The B Parameter

The B parameter defines the basement value for risk, below which the risk is so low that calculations are impractical. This 119-dB level is taken as the estimate of RL (SPE) below which the risk of significant change in a biologically important behavior approaches zero for the SURTASS LFA sonar risk assessment. This level is the value at which avoidance reactions have been noted in bowhead, beluga and gray whales (which are mitigated by geographic restrictions on SURTASS LFA sonar operations [see Subchapter 2.3.2.1]). The Navy recognizes that for actual risk of changes in behavior to be zero, the signal-to-noise ratio at the animal must also be zero. However, the present convention of ending the risk calculation at 119 dB has a negligible impact on subsequent calculations, because the risk function does not attain appreciable values until RLs (SPEs) exceed 130 dB (Figure 4.2-2b).

4.2.5.2 Risk Transition - The A Parameter

The A parameter controls how rapidly risk transitions from low to high values with increasing RL (SPE). As A increases, the slope of the risk function increases. For very large values of A, the risk function can approximate a threshold response. The value used here (A=10) (Figure 4.2-2b) produces a curve that has a more gradual transition than the curves developed by the analyses of migratory gray whale studies (Malme et al., 1984). The choice of a more gradual slope than the empirical data was consistent with all other decisions to make conservative assumptions when extrapolating from other data sets (see Subchapter 1.4.3 [Analytical Approach] and Appendix D [Sensitivity Analysis of the Risk Function Curve]).

4.2.5.3 The K Parameter

Given the lack of consistent and sustained response in all three LFS SRP phases, the RL (SPE) at which 50 percent risk may occur is above 150 dB. Thus, the LFS SRP data cannot be used to specify the value of K directly. Instead, this analysis set the value of K (in conjunction with A) such that the risk for an SPE exposure of 150 dB was 2.5 percent and the risk at 180 dB was 95 percent. Thus, K equals 46 dB, which is the RL (SPE) increment above basement at which there is 50 percent risk, leading to an estimated 50 percent risk at an SPE of 165 dB (i.e., 119 dB + 46 dB). The 2.5 percent risk estimate at 150 dB reflects the fact that tens of experimental trials at RLs (SPEs) up to 155 dB failed to reveal any response that could be construed as affecting survival or reproduction. The 95 percent risk value at 180 dB reflects the assumption that most individuals may be at risk, but that a small fraction (five percent) of the population would not be at risk.

4.2.6 Sample Model Run

The following two examples are intended to illustrate the PE model and AIM simulation and the subsequent analysis of the resulting data using the risk continuum. The steps of the risk analysis, including the inputs and outputs of each process, are illustrated in Figure 4.2-3 (SURTASS LFA Sonar Risk Analysis Flowchart). Each of these elements will be described in the following examples. The selection of sites and the thought processes behind it were previously discussed in Subchapter 4.2.1.

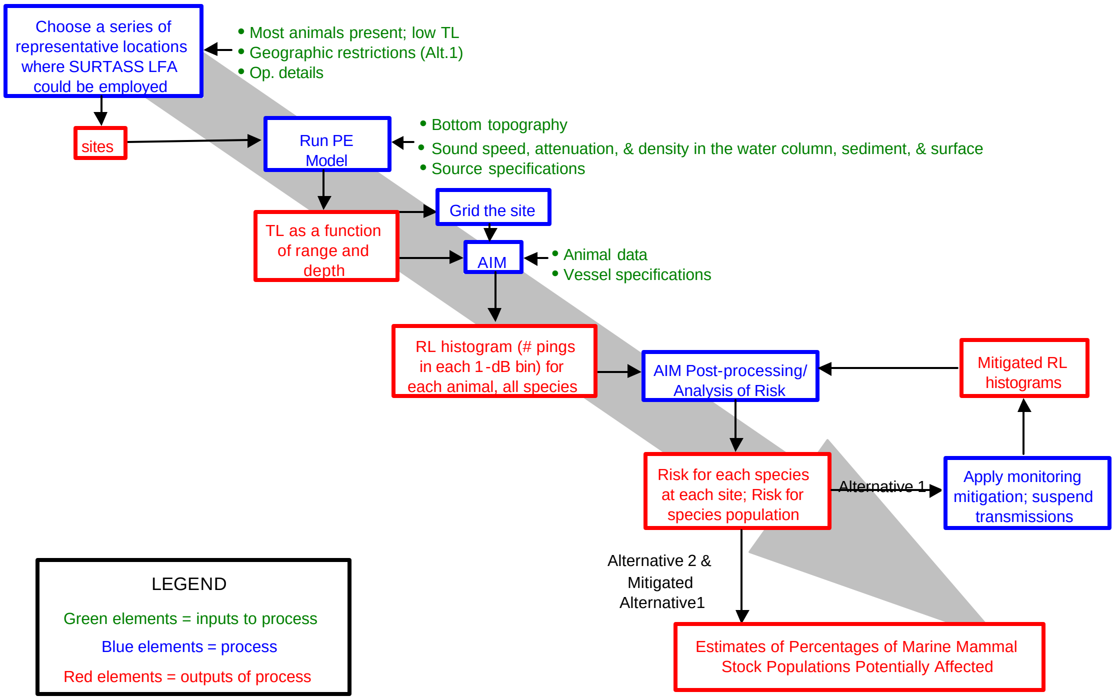

Figure 4.2-3. SURTASS LFA Sonar Risk Analysis Flowchart.

4.2.6.1 PE Model Input Parameters and Data

Table 4.2-5 provides many of the acoustic and positional parameters required for the acoustic modeling in these two examples. The Navy standard PE acoustic model, with the accompanying data bases, was used to model the environment and examine four azimuths. Two sample PE field plots showing the 000° true bearing are provided as Figure 4.2-4 (PE Field Plot for the Gulf of Alaska, 000°T Azimuth) and Figure 4.2-5 (PE Field Plot for Onslow Bay 000°T Azimuth). These figures show the TL predicted for each site as a function of range from the source and depth in the ocean. In each figure, the source is in the upper far left of the plot (i.e., where the small arrow points to the depth axis at 120 m [400 ft]) where the TL values are lowest. For the Gulf of Alaska case note the presence of the duct as indicated by the low level of TL (approximately 80 to 85 dB

Table 4.2-5

PE Input Parameters

Parameter	Gulf of Alaska	Onslow Bay
Location	57°N 147°W	33°5’ N 76°15’ W
Season	Summer	Spring
Source Depth	400 ft (120 m)	400 ft (120 m)
Source Beam Pattern	Omni-directional source	Omni-directional source
Frequency	300 Hz (nominal)	300 Hz (nominal)
Repetition Rate	Every 15 minutes	Every 15 minutes
Azimuthal Radials Modeled	000, 090, 180, 270°True (T)	000, 090, 180, 270°T

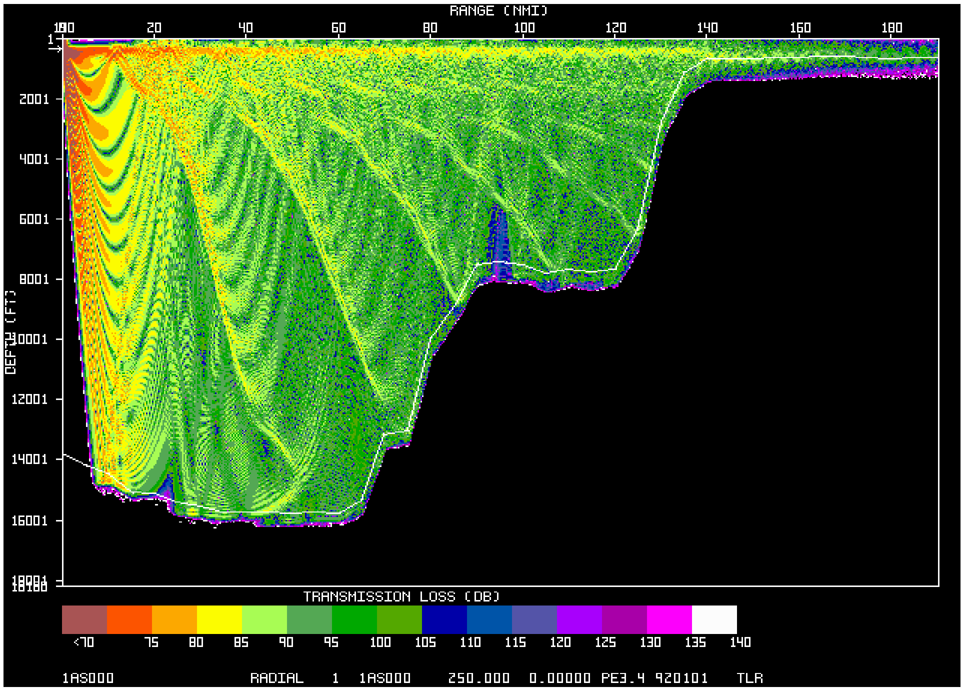

Figure 4.2-4. PE Field Plot for the Gulf of Alaska, 000°T Azimuth.

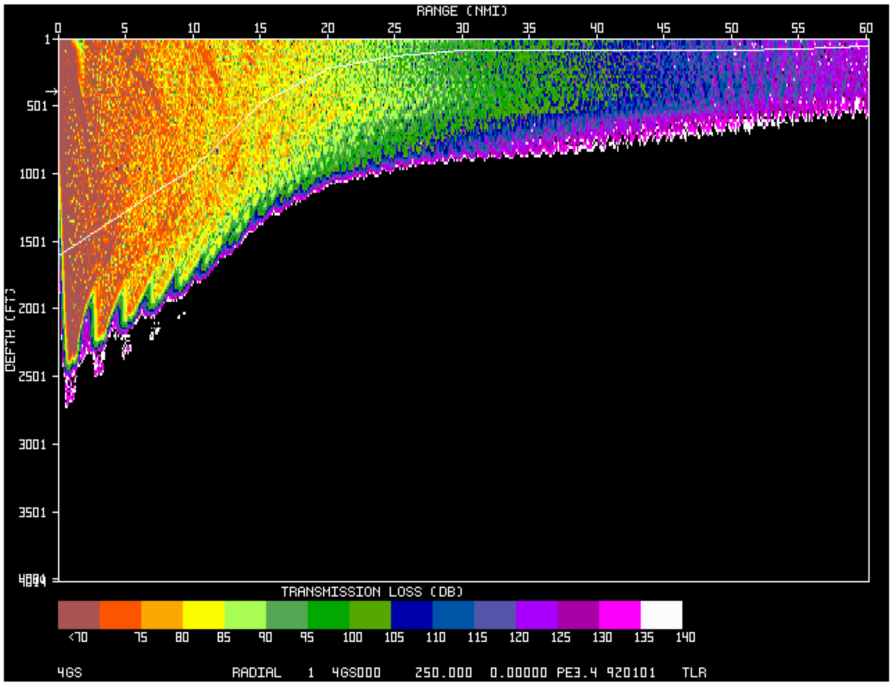

Figure 4.2-5. PE Field Plot for Onslow Bay, 000°T Azimuth.

and colored yellow) at the 120 to 150-m (400 to 500-ft) depth out to over 185 km (100 nm) from the source. In the Onslow Bay case, the propagation mode is strongly bottom interactive (bottom bounce) due to the water depth and sound speed profile, with the energy in the water column decreasing rapidly as it propagates up-slope and toward shore.

The locations of these examples can be seen in Figure 4.2-6 (AIM Site 1, Northern Gulf of Alaska) and Figure 4.2-7 (AIM Site 28, Onslow Bay) as the dots. Also shown on these figures is the sectioning, or grid spacing, used to create the initial distribution of the marine animals. In the first case (Gulf of Alaska), the source is well offshore (approximately 330 km [180 nm]) and in relatively deep water, while for the Onslow Bay case the source is in water less than 305 m (1,000 ft) deep, and closer (111 km [60 nm]) to shore.

4.2.6.2 AIM Input Parameters and Data

The initial distribution of marine animals is provided to AIM by a Monte Carlo method (see box). In this method, each of the sections (i.e., the rectangles shown in Figures 4.2-6 and 4.2-7) is assigned an animal weight or density for each of the modeled species, and the Monte Carlo method distributes the start positions of the animals in the sections. The distributions of the initial positions for two of these species, blue and humpback whales, are provided in Figure 4.2-8 (Initial Blue Whale Positions, Gulf of Alaska) and Figure 4.2-9 (Initial Humpback Whale Positions, Gulf of Alaska), respectively for the Gulf of Alaska case.

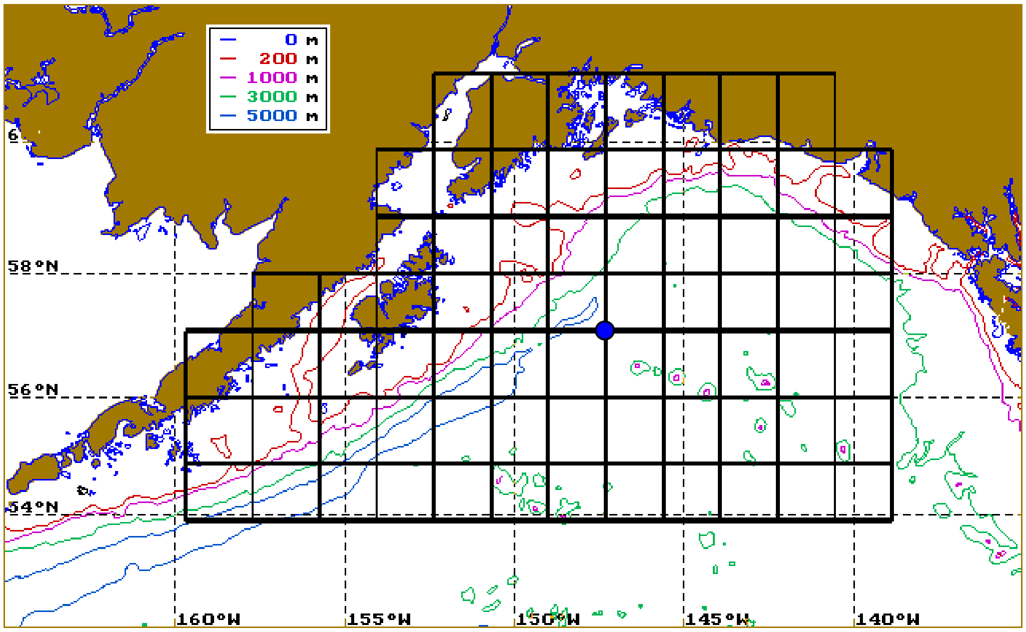

Figure 4.2-6. AIM Site 1, Northern Gulf of Alaska.

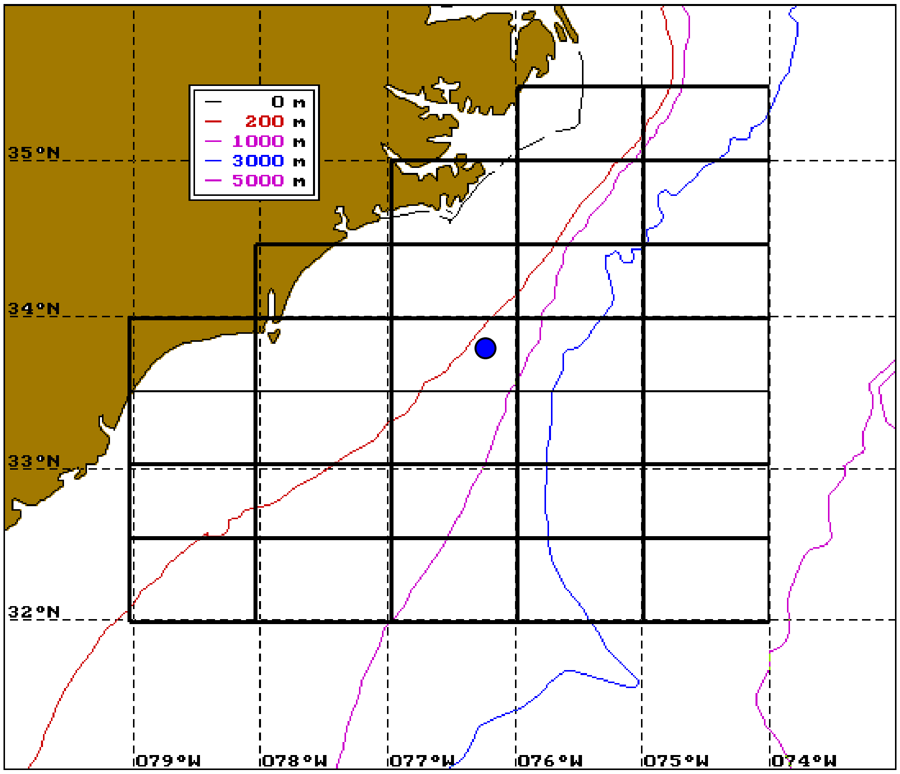

Figure 4.2-7. AIM Site 28, Onslow Bay

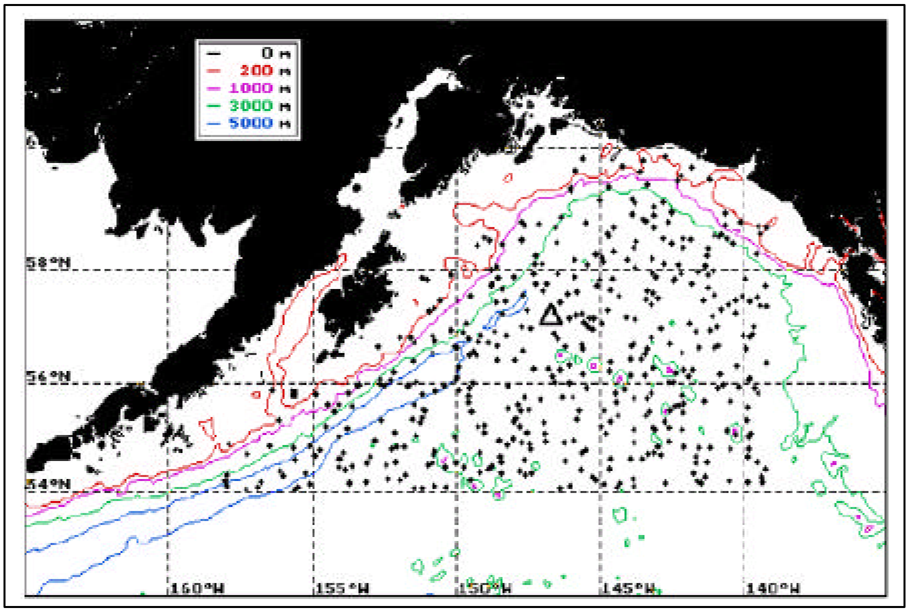

Figure 4.2-8. Initial Blue Whale Positions, Gulf of Alaska.

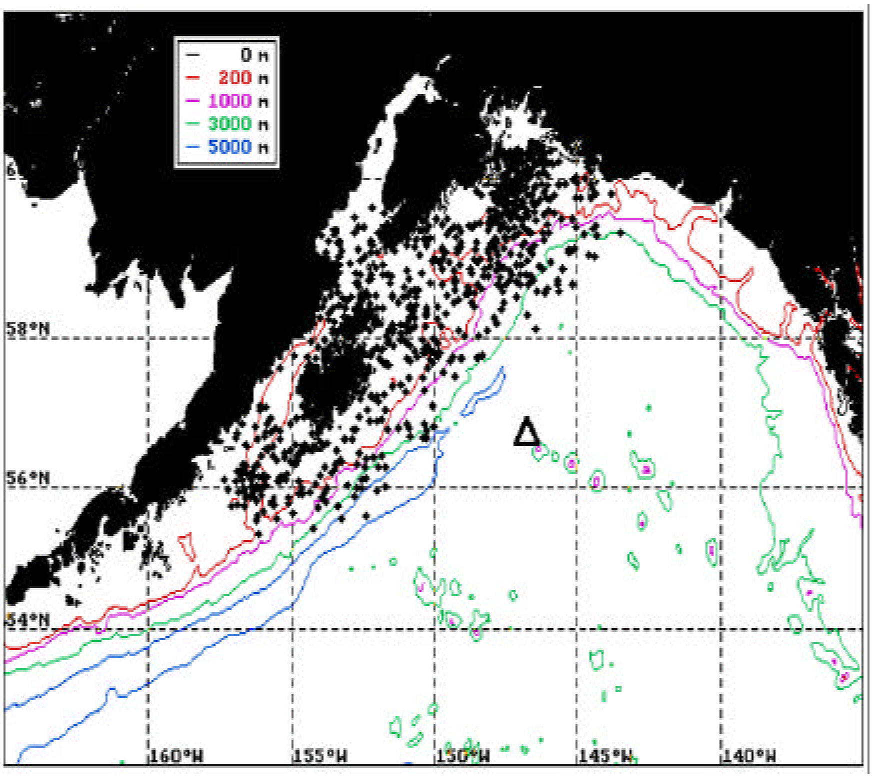

Figure 4.2-9. Initial Humpback Whale Positions, Gulf of Alaska.

Figure 4.2-10 (Initial Northern Right Whale Positions, Onslow Bay) and Figure 4.2-11 (Initial Beaked Whale Positions, Onslow Bay) show the initial positions of northern right whales and beaked whales in the Onslow Bay site. Note that in the Gulf of Alaska, the humpbacks are concentrated primarily near shore, while the blue whales remain offshore (i.e., greater than 110 km [60 nm] offshore). In the Onslow Bay site, the northern right whales are also concentrated near shore, while the beaked whales remain farther offshore, distributed in deeper water. Each of these figures also shows the ship track (triangle) for a typical 24-hour period.

Monte Carlo Method

The Monte Carlo Method is a technique for obtaining an approximate solution to certain mathematical and physical problems, characteristically involving the replacement of a probability distribution by sample values and usually done on a computer (Neufeldt, 1997).

It should be noted that the best available scientific data for each species were used to model their individual dive profiles (animal dive data were used when available; otherwise surrogate animal data were used) and distributions in the modeled areas. This precluded homogeneously-distributed animal densities in the three dimensions of latitude, longitude, and depth, as can be seen in the initial animal positions shown in Figures 4.2-8, 4.2-9, 4.2-10, and 4.2-11. Furthermore, the percentage of the stock that is included in the modeled area compared to the entire stock region is unique to each species. For example, 43.6 percent of the eastern North Pacific humpback stock is expected in the Gulf of Alaska case, whereas only 4.4 percent of the eastern North Pacific pelagic dolphin stock is expected in the Gulf of Alaska site. Obviously these factors (dive profile, local distribution pattern, and regional stock distribution pattern) will influence the percentage of the stock potentially affected, and the resulting take estimates.

Table 4.2-6 identifies most of the other critical parameters used with AIM. The animal decision interval, which in this analysis coincided with the transmission cycle, allowed animals to maneuver in three dimensions. The animal cone direction specified in the table was the variation in direction that the animal was allowed to take at any one of these decision points. In these cases, the animals could maneuver in azimuth in an unrestricted manner. Table 4.2-7 identifies the four diving zones for the blue, humpback, northern right and beaked whales used in this example and the percentage of time the animals are assumed to spend at each depth.

In these regions, for these two modes of propagation (ducted and bottom interactive), it was determined that at least 100 and 200 animals (for the 20-day period with a 15-minute transmission repetition rate) were required to achieve statistical significance for the Gulf of Alaska and Onslow Bay cases, respectively. In these cases, 460 blue and humpback whales were modeled for the Gulf of Alaska, while 520 northern right whales and 380 beaked whales were modeled for Onslow Bay, based on density estimates.

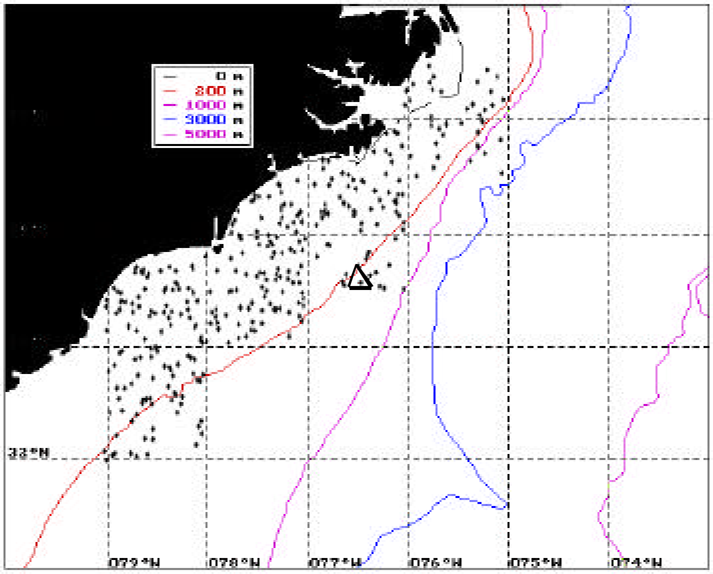

Figure 4.2-10. Initial Northern Right Whale Positions, Onslow Bay.

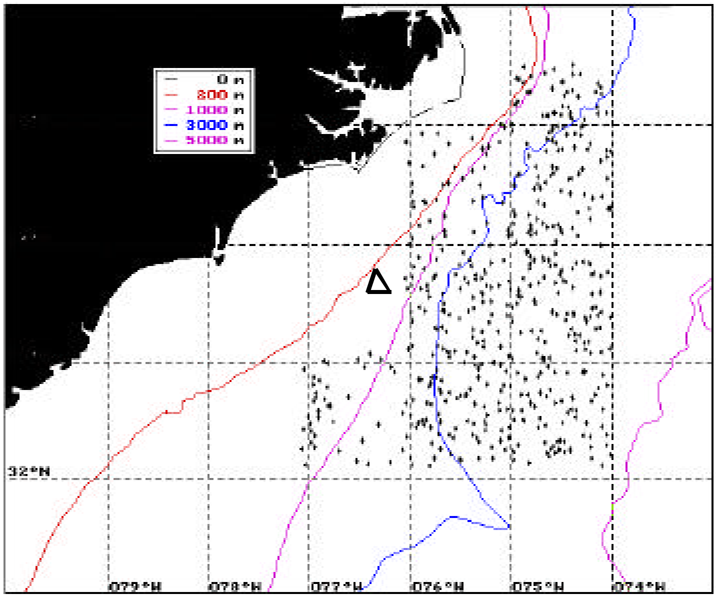

Figure 4.2-11. Initial Beaked Whale Positions, Onslow Bay.

Table 4.2-6

AIM Input Parameters

Parameter	Value
Source Vessel Speed	3 knots (1.5 m/s)
Source Vessel Courses	150, 270, 030°T
Source Leg Duration	8 hours (3 legs per day)
Mission Duration	20 days (repeat triangle 20 times)
Animal Speed	3 knots (1.5 m/s)
Animal Decision Interval	15 minutes
Animal Directional Cone	360°

Table 4.2-7

Diving Regimes

Zones	Blue and Humpback		Northern Right		Beaked	
	Depth Range (ft/m)	Percent of Time in Regime	Depth Range (ft/m)	Percent of Time in Regime	Depth Range (ft/m)	Percent of Time in Regime
Surface	0-50/ 0-15.2	12	0-50/ 0-15.2	80	0-50/ 0-15.2	17
Transition	50-270/ 15.2-82	40	50-150/ 15.2-45.7	5	50-1200/ 15.2-365.8	13
Average Diving	270-522/ 82-159	43			1200-1800/ 365.8-548.6	50
Maximum Diving	522-612/ 159-186.5	5	150-250/ 45.7-76.2	15	1800-3500/ 548.6-1066.8	20

As stated earlier, the number of animals modeled does not represent the actual estimated abundance in the area. Once the model is run and a statistically significant result is obtained, this result is scaled (i.e., multiplied or divided by a scaling factor) until it is appropriate for the actual estimated animal abundance in the modeled site area. For example, if 460 whales were modeled and the abundance estimate was actually 920 whales, the results would be scaled up (multiplied) by a factor of 2 (920 ÷ 460 = 2).

4.2.6.3 Processing AIM Results Using the Risk Continuum

The AIM results were then processed using the risk continuum to derive the percentages given in Tables 4.2-8 and 4.2-9. These percentages estimate the portion of the stock potentially affected due to SPE levels ≥180 dB, and potentially affected due to all SPE levels, for Alternative 1 (geographic mitigation only, and geographic + monitoring mitigation). These values were corrected to account for the percentage of animals affected in relation to the area's stock. The mathematics of processing the AIM results using the risk continuum consists of the following steps:

- AIM output data, histograms of number of transmissions in each RL bin, were translated into an SPE RL for each individual in a modeled stock;
- SPE RLs were translated into risk probabilities using the single-ping risk function;
- The risk probabilities for all individuals were summed to obtain an aggregate risk value expressed as the percentage of the modeled stock potentially affected.; and
- The risk probability for the modeled stock was multiplied by the ratio of the actual stock to the modeled stock to obtain a normalized risk value for the regional stock.

For example, suppose SPE risks for a modeled stock of five animals from an actual stock of 100 animals are calculated as 2.5, 1.1, 5.3, 3.4 and 1.7 percent. The risk to the modeled stock is the average of the five individual risks (2.8 percent). The risk to the actual stock would then be 0.14 percent (2.8 x 5/100). This value is used as the percentage of stock potentially affected.

Table 4.2-8

Potentially Affected Stock (geographic mitigation only)

Site	Species	Potential for Effects ≥180 dB RL (percent)	Potential for Effects—All RLs (percent)
Gulf of Alaska	Blue whales	0	6.87
	Humpback whales	0	12.39
Onslow Bay	Northern right whales	0.31	1.19
	Beaked Whales	0	0.01

Table 4.2-9

Potentially Affected Stock (geographic + monitoring mitigation)

Site	Species	Potential for Effects ≥180 dB RL (percent)	Potential for Effects—All RLs (percent)
Gulf of Alaska	Blue whales	0	6.87
	Humpback whales	0	12.39
Onslow Bay	Northern right whales	0	0.88
	Beaked Whales	0	0.01

For Alternative 1, an additional step is included in the risk analysis. The effect of the geographic restrictions and monitoring mitigation, described in Chapter 4.2.7.1, is applied to the AIM output, and risk is recalculated.

4.2.7 Alternative 1

Table 4.2-10 gives estimates of percentages of marine mammal stocks potentially affected by Alternative 1. Stock estimates were derived through literature searches and the results are provided in Table 4.2-4. Note that the species listed under the marine mammal column are those considered to be potentially most vulnerable to LF sound. The column labeled Alternative 1 (with geographic mitigation) provides estimated percentages of marine mammal stocks that could potentially be affected due to SPE levels <180 dB and ≥180 dB (the latter shown within parentheses). The column labeled Alternative 1 (with geographic + monitoring mitigation) also provides estimated percentages of marine mammal stocks that could potentially be affected by factoring in the effects of monitoring mitigation. In addition, the reduction in potential effects due to the use of proposed monitoring mitigation (see Subchapter 4.2.7.1) is estimated.

In the case of small odontocetes, particularly for pelagic dolphins, this analysis deliberately overestimates the number of affected animals. These numbers would have been substantially lower if the results of the Ridgway et al. (1997) (Schlundt et al. [2000]) study on behavioral modification threshold and temporary threshold shift (TTS) with bottlenose dolphins were incorporated as the criterion for significant change in a biologically important behavior. Schlundt et al. (2000) found that no subjects (bottlenose dolphins) exhibited masked temporary threshold shifts at levels up to 193 dB at 400 Hz, a value well above the 180-dB criterion utilized by this analysis for the onset of potential injury. As is the case throughout this OEIS/EIS, the Navy has chosen to apply a prudent approach and utilize scientifically conservative thresholds. The reader is referred to Subchapter 1.4.2 (Adequacy of Scientific Information on Marine Animals) for additional discussion on this topic.

Table 4.2-10
AIM Modeling for Sites 1 - 31 Showing Percentages of Marine Mammal Stocks Potentially Affected[1]
(With Geographic and Monitoring Mitigation)

Site	Site Location		Marine Mammal	Alternative 1 (with geographic mitigation)[2]	Monitoring Mitigation Conversion Factors		Alternative 1 (with geographic+monitoring mitigation)[2]	
				Potential for Effects <180 dB[4] (≥180 dB)[3]	No. of pings ≥180 dB (normalized)[5]	No. of pings suspended (system turned off)	Potential for Effects <180 dB[4] (≥180 dB)[3]	Reduction of Potential for Effects[6]
1	Pacific/Indian Ocean Area	North Gulf of Alaska	blue whale	6.87	0	0	6.87	0
			fin whale	0.60	0		0.60	0
			humpback whale	12.39	0		12.39	0
			gray whale	1.37	0		1.37	0
			n. right whale	3.02	0		3.02	0
			minke whale	3.61	0		3.61	0
			pelagic dolphins	0.06	0		0.06	0
			n. sea lion	7.98	0		7.98	0
2		East of Kamchatka, Russia	blue whale	6.55 (0.13)[3]	9	74	6.27	0.41
			fin whale	0.68 (0.01)[3]	9		0.65	0.04
			humpback whale	0.94	0		0.80	0.14
			minke whale	1.20 (0.07)[3]	33		1.16	0.11
			beaked whales	1.58 (0.04)[3]	12		1.59	0.03
			pelagic dolphins	0.02	49		0.02	0
			n. fur seal	5.98	0		5.21	0.77
			n. sea lion	0.28	0		0.19	0.09
3		North Korea Strait	fin whale	0.41 (0.18)[3]	34	81	0.42(0.03)[3]	0.14
			humpback whale	2.31 (1.15)[3]	50		2.49(0.21)[3]	0.76
			gray whale	0.67	0		0.35	0.32
			beaked whales	0.06	7		0.06	0
			pelagic dolphins	0.09 (0.04)[3]	31		0.09(0.01)[3]	0.03
4		East Bass Strait, Australia	fin whale	0.09 (0.01)[3]	9	73	0.09	0.01
			sei whale	0.05 (0.01)[3]	28		0.06	0
			Bryde's whale	0.05	9		0.05	0
			s. right whale	0.06 (0.01)[3]	18		0.06	0.01
			beaked whales	0.27 (0.02)[3]	9		0.26	0.03
			pelagic dolphins	0.03	18		0.03	0
			Australian fur seal	1.32	0		1.12	0.20
			s. elephant seal	0.06 (0.01)[3]	19		0.05	0.02

Table 4.2-10
AIM Modeling for Sites 1 - 31 Showing Percentages of Marine Mammal Stocks Potentially Affected[1]
(With Geographic and Monitoring Mitigation)

Site	Site Location		Marine Mammals	Alternative 1 (with geographic mitigation)[2]	Monitoring Mitigation Conversion Factors		Alternative 1 (with geographic+monitoring mitigation)[2]	
				Potential for Effects <180 dB[4] (≥180 dB)[3]	No. of pings ≥180 dB (normalized)[5]	No. of pings suspended (system turned off)	Potential for Effects <180 dB[4] (≥180 dB)[3]	Reduction of Potential for Effects[6]
5	Pacific/Indian Ocean Area	West of Talcahuano, Chile	blue whale	0.34 (0.02)[3]	9	92	0.32	0.04
			fin whale	0.15 (0.01)[3]	9		0.14	0.02
			humpback whale	3.37 (0.20)[3]	9		3.15	0.42
			s. right whale	1.52 (0.30)[3]	16		1.32	0.50
			sperm whale	0.16 (0.02)[3]	19		0.16	0.02
			beaked whales	0.20 (0.02)[3]	18		0.19	0.03
			pelagic dolphins	0.06	15		0.05	0.01
			S. Am. fur seal	0.77 (0.12)[3]	45		0.73	0.16
6		North of Kauai, HI	humpback whale	0.49 (0.11)[3]	40	98	0.50	0.10
			sperm whale	0.16 (0.04)[3]	28		0.16	0.04
			beaked whales	0.15 (0.04)[3]	28		0.15	0.04
			blackfish/killer whales	0.09 (0.03)[3]	46		0.10	0.02
			pelagic dolphins	0.09 (0.01)[3]	6		0.08	0.02
			monk seal	0	0		0	0
7		South of Oahu, HI	humpback whale	0.62 (0.13)[3]	31	60	0.67	0.08
			sperm whale	0.18 (0.02)[3]	15		0.17	0.03
			beaked whales	0.18 (0.02)[3]	15		0.17	0.03
			blackfish/killer whales	0.11 (0.02)[3]	14		0.10	0.03
			pelagic dolphins	0.10 (0.02)[3]	16		0.11	0.01
			monk seal	0	0		0	0
8		Southeast of San Nicolas Island, CA	blue whale	9.15 (0.81)[3]	59	306	8.08	1.60
			fin whale	0.89 (0.08)[3]	59		0.79	0.15
			sei whale	1.38 (0.15)[3]	47		1.12	0.36
			minke whale	2.98 (0.43)[3]	58		2.48	0.78
			beaked whales	4.52 (0.37)[3]	104		4.53	0.36
			pelagic dolphins	0.04	77		0.03	0.01
			n. elephant seal	8.55 (0.81)[3]	58		7.90	1.18
			n. fur seal	0.15	2		0.12	0.03
			Guadalupe fur seal	1.95	0		0.45	1.50
9		Offshore WA	gray whale	2.57 (0.10)[3]	19	118	2.48	0.19
			pelagic dolphins	0.03	40		0.02	0.01
			n. elephant seal	1.71 (0.08)[3]	25		1.65	0.14
			n. sea lion	4.46 (0.48)[3]	95		4.52	0.40

Table 4.2-10
AIM Modeling for Sites 1 - 31 Showing Percentages of Marine Mammal Stocks Potentially Affected[1] (With Geographic and Monitoring Mitigation)

Site	Site Location		Marine Mammals	Alternative 1 (with geographic mitigation)[2]	Monitoring Mitigation Conversion Factors		Alternative 1 (with geographic+monitoring mitigation)[2]	
				Potential for Effects <180 dB[4] (≥180 dB)[3]	No. of pings ≥180 dB (normalized)[5]	No. of pings suspended (system turned off)	Potential for Effects <180 dB[4] (≥180 dB)[3]	Reduction of Potential for Effects[6]
10	Pacific/Indian Ocean Area	South Gulf of Alaska	blue whale	2.05 (0.30)[3]	49	195	2.13	0.22
			fin whale	0.40 (0.06)[3]	49		0.42	0.04
			humpback whale	0.16 (0.02)[3]	49		0.17	0.01
			gray whale	0.03	31		0.02	0.01
			n. right whale	4.66 (0.50)[3]	12		4.13	1.03
			minke whale	0.75 (0.05)[3]	16		0.72	0.08
			pelagic dolphins	0.02	40		0.02	0
			n. sea lion	0.02	49		0.02	0
11		South of Japan	gray whale	5.02	0	12	4.95	0.07
			pelagic dolphins	0.38 (0.04)[3]	18		0.40	0.02
12		Northwest of Kauai, HI	humpback whale	2.49 (0.09)[3]	33	155	1.90	0.68
			sperm whale	0.15 (0.04)[3]	62		0.11	0.08
			blackfish/killer whales	0 .02	66		0.01	0.01
			pelagic dolphins	0.04 (0.01)[3]	69		0.04	0.01
			monk seal	3.63 (0.10)[3]	5		2.39	1.34
13		Offshore central CA	blue whale	7.52 (0.50)[3]	46	259	6.23	1.79
			fin whale	0.73 (0.05)[3]	46		0.61	0.17
			humpback whale	2.31 (0.15)[3]	46		1.91	0.55
			gray whale	1.39	0		0.93	0.46
			beaked whales	1.25 (0.08)[3]	64		1.12	0.21
			pelagic dolphins	0.03	81		0.03	0
			n. elephant seal	12.82 (0.38)[3]	15		10.76	2.44
			n. sea lion	7.90	0		5.39	2.51
			n. fur seal	0.11 (0.01)[3]	95		0.09	0.03
14		West of Spratly Islands	Bryde's whale	0.33 (0.03)[3]	21	67	0.33	0.03
			blackfish/killer whales	0.15 (0.03)[3]	58		0.16	0.02
			pelagic dolphins	0.38 (0.03)[3]	22		0.38	0.03
15		Gulf of Oman	humpback whale	0.17 (0.11)[3]	51	318	0.20	0.08
			Bryde's whale	0.02 (0.01)[3]	97		0.02	0.01
			sperm whale	0.03 (0.01)[3]	65		0.03	0.01
			beaked whales	0.01	112		0.01	0
			blackfish/killer whales	0.01 (0.01)[3]	71		0.01	0.01
			pelagic dolphins	0.01 (0.01)[3]	86		0.01	0.01

Table 4.2-10

AIM Modeling for Sites 1 - 31 Showing Percentages of Marine Mammal Stocks Potentially Affected[1] (With Geographic and Monitoring Mitigation)

Site	Site Location		Marine Mammals	Alternative 1 (with geographic mitigation)^{2}	Monitoring Mitigation Conversion Factors		Alternative 1 (with geographic+monitoring mitigation)^{2}	
				Potential for Effects <180 dB^{4} (≥180 dB)^{3}	No. of pings ≥180 dB (normalized)^{5}	No. of pings suspended (system turned off)	Potential for Effects <180 dB^{4} (≥180 dB)^{3}	Reduction of Potential for Effects^{6}
16	Pacific/Indian Ocean Area	Offshore Southeast Australia	fin whale	0.08 (0.01)^{3}	52	295	0.06	0.03
			sei whale	0.14 (0.01)^{3}	52		0.10	0.05
			Bryde's whale	0.05	52		0.03	0.02
			humpback	1.79 (0.50)^{3}	69		1.29	1.00
			sperm whale	0.22 (0.02)^{3}	52		0.16	0.08
			beaked whales	0.15 (0.01)^{3}	52		0.11	0.05
			pelagic dolphins	0.05	65		0.03	0.02
			s. elephant seal	0.04	53		0.02	0.02
17	Atlantic Ocean/Med. Sea Area	Denmark Strait	blue whale	14.07 (0.32)^{3}	45	164	13.77	0.62
			fin whale	0.09	45		0.09	0
			sei whale	2.21 (0.04)^{3}	30		2.11	0.14
			minke whale	0.21 (0.01)^{3}	30		0.20	0.02
			humpback whale	5.45 (0.12)^{3}	45		5.33	0.24
			beaked whales	1.81 (0.05)^{3}	24		1.43	0.43
			pelagic dolphins	0.46 (0.01)^{3}	30		0.42	0.05
18		West of Bergen, Norway	blue whale	10.15 (0.48)^{3}	81	216	9.83	0.80
			fin whale	0.26 (0.01)^{3}	81		0.26	0.01
			minke whale	0.22 (0.02)^{3}	122		0.22	0.02
			beaked whales	0.99 (0.05)^{3}	15		0.35	0.69
			blackfish/killer whales	0.20	9		0.14	0.06
			pelagic dolphins	0.33 (0.01)^{3}	20		0.20	0.04
19		Strait of Sicily, Mediterranean	fin whale	7.76 (0.41)^{3}	77	146	7.69	0.48
			minke whale	7.10 (0.23)^{3}	29		6.75	0.58
			sperm whale	6.10 (0.30)^{3}	19		5.13	1.27
			blackfish/killer whales	5.48 (0.30)^{3}	38		4.96	0.82
			beaked whales	5.09 (0.25)^{3}	19		4.27	1.07
			pelagic dolphins	6.29 (0.25)^{3}	39		5.92	0.62
20		South of Puerto Rico	fin whale	0.29 (0.04)^{3}	111	275	0.28	0.05
			Bryde's whale	0.51 (0.07)^{3}	67		0.50	0.08
			minke whale	6.09 (1.00)^{3}	111		5.96	1.13
			humpback whale	0.88 (0.13)^{3}	48		0.86	0.15
			beaked whales	0.01	11		0.01	0
			blackfish/killer whales	0.13 (0.01)^{3}	34		0.12	0.02
			pelagic dolphins	0.13 (0.01)^{3}	34		0.12	0.02

Table 4.2-10
AIM Modeling for Sites 1 - 31 Showing Percentages of Marine Mammal Stocks Potentially Affected[1] (With Geographic and Monitoring Mitigation)

Site	Site Location		Marine Mammals	Alternative 1 (with geographic mitigation)[2]	Monitoring Mitigation Conversion Factors		Alternative 1 (with geographic+monitoring mitigation)[2]	
				Potential for Effects <180 dB[4] (≥180 dB)[3]	No. of pings ≥180 dB (normalized)[5]	No. of pings suspended (system turned off)	Potential for Effects <180 dB[4] (≥180 dB)[3]	Reduction of Potential for Effects[6]
21	Atlantic Ocean/Med. Sea Area	South of Rio de Janeiro, Brazil	blue whale	0.21 (0.09)[3]	22	40	0.27	0.03
			fin whale	0.01 (0.01)[3]	22		0.02	0
			minke whale	0.01	3		0.01	0
			beaked whales	0.07	2		0.07	0
			pelagic dolphins	0.01	11		0.01	0
22		Northeast Norwegian Basin	blue whale	6.74 (0.16)[3]	12	112	6.56	0.34
			fin whale	0.15	12		0.14	0.01
			sei whale	2.64 (0.04)[3]	4		2.50	0.18
			minke whale	0.12	8		0.11	0.01
			humpback whale	3.20 (0.08)[3]	12		3.12	0.16
			beaked whales	3.01 (0.10)[3]	40		2.93	0.18
			blackfish/killer whales	0.50 (0.02)[3]	40		0.49	0.03
			pelagic dolphins	0.35 (0.01)[3]	41		0.33	0.03
23		South Norwegian Basin (between Iceland & Norway)	blue whale	1.58 (0.12)[3]	24	116	1.58	0.12
			fin whale	0.11 (0.01)[3]	24		0.11	0.01
			minke whale	0.09 (0.01)[3]	31		0.09	0.01
			humpback whale	2.39 (0.18)[3]	25		2.40	0.17
			beaked whales	0.83 (0.14)[3]	31		0.95	0.08
			blackfish/killer whales	0.16 (0.01)[3]	25		0.15	0.02
			pelagic dolphins	0.17 (0.02)[3]	15		0.17	0.02
24		Bay of Biscay, west of France	fin whale	0.25	5	82	0.24	0.01
			sei whale	1.56 (0.01)[3]	8		1.42	0.15
			minke whale	0.14	10		0.13	0.01
			sperm whale	0.41 (0.01)[3]	20		0.41	0.01
			beaked whales	2.06 (0.05)[3]	20		2.03	0.08
			blackfish/killer whales	0.36 (0.01)[3]	20		0.36	0.01
			pelagic dolphins	0.32 (0.01)[3]	41		0.30	0.03
25		Ionian Sea (South), Med. Sea	sperm whales	4.25 (0.19)[3]	18	53	4.38	0.06
			beaked whales	3.37 (0.15)[3]	19		3.47	0.05
			blackfish/killer whales	3.40 (0.30)[3]	28		3.66	0.04
			pelagic dolphins	3.13 (0.25)[3]	15		3.31	0.07
26		Levantine Sea, E. Med. Sea	sperm whale	3.61 (0.41)[3]	31	71	3.89	0.13
			beaked whales	2.86 (0.32)[3]	31		3.08	0.10
			pelagic dolphins	2.85 (0.42)[3]	46		3.14	0.13

Table 4.2-10

AIM Modeling for Sites 1 - 31 Showing Percentages of Marine Mammal Stocks Potentially Affected[1] (With Geographic and Monitoring Mitigation)

Site	Site Location		Marine Mammals	Alternative 1 (with geographic mitigation)[2]	Monitoring Mitigation Conversion Factors		Alternative 1 (with geographic+monitoring mitigation)[2]	
				Potential for Effects <180 dB[4] (≥180 dB)[3]	No. of pings ≥180 dB (normalized)[5]	No. of pings suspended (system turned off)	Potential for Effects <180 dB[4] (≥180 dB)[3]	Reduction of Potential for Effects[6]
27	Atlantic Ocean/Med. Sea Area	Sable Island Bank, east of Nova Scotia	blue whale	2.53 (0.13)[3]	81	262	2.29	0.37
			fin whale	1.45 (0.08)[3]	81		1.31	0.22
			sei whale	3.76 (0.22)[3]	64		3.25	0.73
			minke whale	2.58 (0.16)[3]	64		2.13	0.61
			humpback whale	0.90 (0.01)[3]	3		0.74	0.17
			n. right whale	3.69	0		1.66	2.03
			beaked whales	1.02 (0.05)[3]	17		0.88	0.19
			blackfish/killer whales	0.41 (0.03)[3]	37		0.36	0.08
			pelagic dolphins	0.42 (0.03)[3]	50		0.34	0.11
28		Onslow Bay, east of NC	fin whale	0.12 (0.03)[3]	65	281	0.11	0.04
			sei whale	0.17 (0.08)[3]	151		0.18	0.07
			minke whale	2.52 (0.87)[3]	75		2.42	0.97
			n. right whale	0.88 (0.31)[3]	73		0.86	0.33
			beaked whales	0.01	7		0.01	0
			blackfish/killer whales	0.08 (0.01)[3]	30		0.06	0.03
			pelagic dolphins	0.03 (0.01)[3]	25		0.02	0.02
29		Northeast of Eleuthera Island, Bahamas	fin whale	0.45 (0.01)[3]	8	63	0.40	0.06
			Bryde's whale	0.81 (0.02)[3]	8		0.72	0.11
			minke whale	8.27 (0.27)[3]	8		7.63	0.91
			humpback whale	1.46 (0.03)[3]	8		1.30	0.19
			beaked whales	0.02	10		0.02	0
			blackfish/killer whales	0.29 (0.02)[3]	27		0.28	0.03
			pelagic dolphins	0.24 (0.01)[3]	27		0.23	0.02
30		North of Puerto Rico	fin whale	0.31 (0.01)[3]	19	180	0.26	0.06
			Bryde's whale	0.67 (0.06)[3]	50		0.57	0.16
			minke whale	3.78 (0.36)[3]	25		3.33	0.81
			humpback whale	1.22 (0.11)[3]	50		1.05	0.28
			beaked whales	0.01	23		0.01	0
			blackfish/killer whales	0.24 (0.01)[3]	86		0.20	0.04
			pelagic dolphins	0.19 (0.01)[3]	19		0.16	0.04

Table 4.2-10

AIM Modeling for Sites 1 - 31 Showing Percentages of Marine Mammal Stocks Potentially Affected[1] (With Geographic and Monitoring Mitigation)

Site	Site Location		Marine Mammals	Alternative 1 (with geographic mitigation)[2]	Monitoring Mitigation Conversion Factors		Alternative 1 (with geographic+monitoring mitigation)[2]	
				Potential for Effects <180 dB[4] (≥180 dB)[3]	No. of pings ≥180 dB (normalized)[5]	No. of pings suspended (system turned)	Potential for Effects <180 dB[4] (≥180 dB)[3]	Reduction of Potential for Effects[6]
31	Atlantic Ocean/Med. Sea Area	East of Salvador (Bahia), Brazil	blue whale	0.62 (0.08)[3]	29	115	0.58	0.12
			fin whale	0.42 (0.05)[3]	29		0.39	0.08
			Bryde's whale	0.62 (0.08)[3]	29		0.58	0.12
			minke whale	0.27 (0.04)[3]	3		0.27	0.04
			humpback whale	1.91 (0.23)[3]	29		1.80	0.34
			beaked whales	0.04 (0.01)[3]	35		0.04	0.01
			pelagic dolphins	0.02	21		0.02	0

Notes:

1. Sequence of calculation: estimate of percentage of population affected within site area acoustically modeled (see Subchapter 4.2), then apply that percentage to stocks defined by NOAA/NMFS.
2. See Chapter 5.
3. ( ) = Annual estimate of percentages of marine mammal stocks affected by injury.
4. Calculated with risk continuum (see Subchapter 4.2).
5. Based on single ping CDF.
6. Difference between estimate of percentage of marine mammal stocks potentially affected < 180 dB and ≥ 180 dB Alternative 1 (with geographic mitigation) and Alternative 1 (with geographic + monitoring mitigation).

4.2.7.1 Effectiveness of Monitoring Mitigation

The following discussion describes the methodology used to calculate an overall effectiveness estimate for the proposed SURTASS LFA sonar monitoring to prevent injury. This calculation uses a conservative approach similar to the one employed by the Navy in the *Final EIS for Shock Testing the Seawolf Submarine* (DoN, 1998).

It should be noted that the *Seawolf* shock testing differed in several ways from the proposed action in the SURTASS LFA sonar OEIS/EIS. Primarily, the shock testing was accomplished only during daylight hours with reasonably calm sea states. Conversely, SURTASS LFA sonar could potentially operate anytime during the day or night and in relatively high sea states. These factors were taken into consideration in modifying the calculation to more accurately reflect SURTASS LFA sonar operations.

The monitoring mitigation for *Seawolf* shock testing consisted of aerial, surface (visual), and passive acoustic monitoring. However, aerial monitoring is not feasible for SURTASS LFA sonar operations and is not considered further. Thus, SURTASS LFA sonar monitoring mitigation incorporated into Alternative 1 consists of surface (visual), passive acoustic, and active acoustic monitoring methods. It is important to note that the effectiveness of any single SURTASS LFA sonar monitoring method is relatively independent of the other two.

Visual monitoring is limited to daylight hours, and its effectiveness declines during high sea states. In cetacean line transect surveys, the range of visual sighting effectiveness (distance from the ship's track, called effective strip width) varies with the animal size, number of animals in the group, reliability of conspicuous behaviors (blows), pattern of surfacing behavior, and positions of the observers (e.g., height above the water). For most large baleen whales, effective strip width can be about 3 km (1.6 nm) up through Beaufort 6 (Buckland et al., 1993). For harbor porpoises, which are much smaller and less demonstrative on the surface, effective strip width is about 250 m (273 yd) (Palka, 1996). The percentage of animals that pass unseen is difficult to determine, but for minke whales, Schweder et al. (1992) estimated that about half of the animals passed unseen by the visual survey crew. Palka (1996) and Barlow (1988) estimated that about 25 percent of the harbor porpoises were missed by their visual survey teams.

Passive acoustic detection is considered to have a higher probability of detection of some cetaceans than visual. There are indications that effective strip width and detection rates are greater than that for visual (Thomas et al., 1986; Clark and Fristrup, 1997), but the percentage of animals that pass by unheard is unknown. Frequency coverage for this mitigation method using the SURTASS passive array is between 0 and 500 Hz. Vocalizing animals that would be expected to be detected include the gray, humpback, fin, blue, and minke whales, and some of the beaked whale and dolphin species.

Because visual and passive monitoring have limitations, as discussed above, the Navy developed a different technology involving the use of a high frequency, fish-finder type sonar, as discussed in Subchapter 2.3.2.2. The HF/M3 sonar will allow 24-hour, all-weather **active acoustic monitoring** of marine mammals and sea turtles.

Applying a methodology similar to that used for *Seawolf*, the SURTASS LFA sonar mitigation (monitoring) effectiveness (ME) would be represented as follows:

$$ME_{combined} = \text{function}\ (ME_{passive} + ME_{visual} + ME_{active})$$

The *Seawolf* Shock Testing EIS (DoN, 1998) proposed using a broadband passive detection system. With this system, the *Seawolf* EIS assumed the following estimates for **passive acoustic** detection (1.0 = 100 percent):

Sperm whales and *Stenella* dolphins:	$ME_{passive} = 0.75$
Other odontocetes except Cuvier's beaked whales:	$ME_{passive} = 0.50$
Baleen whales and Cuvier's beaked whale:	$ME_{passive} = 0.25$

Because the SURTASS passive array has limited bandwidth, the lowest (conservative) value of 0.25 was used for $ME_{passive}$.

Next, the contribution of **visual monitoring** was added to the passive acoustic monitoring effectiveness based on the following:

$$ME_{passive+visual} = ME_{passive} + [ME_{visual} \times (1 - ME_{passive})]$$

From the *Seawolf* Shock Testing EIS, the mitigation effectiveness for surface visual monitoring ranged from 0.855 for baleen whales and many odontocetes, to 0.24 for the sperm whales, to 0.18 for Cuvier's beaked whales. For this OEIS/EIS, ME_{visual} was estimated from the lowest value (0.18) and then divided in half to account for the possible operation of SURTASS LFA sonar during nighttime, inclement weather, and high sea states. Therefore, ME_{visual} was set at 0.09, which compares to 0.125-0.25 used as rough estimates for ship-based visual surveys of deep-diving whales. The overall combined passive plus visual monitoring mitigation effectiveness was calculated to be $ME_{passive+visual} = 0.32$.

To be conservative, the **active acoustic** monitoring effectiveness of the HF/M3 sonar was limited to 0.5 for these calculations (See Subchapter 2.3.2.2). Its contribution was then added to the combined passive acoustic and visual monitoring effectiveness to arrive at an overall monitoring effectiveness:

$$ME_{combined} = ME_{active} + [ME_{passive+visual} \times (1 - ME_{active})]$$

This calculation results in an overall combined mitigation effectiveness of $ME_{combined} = 0.66$. In all cases, in keeping with a prudent approach, conservative values and assumptions were used.

The Navy continues to work to improve this value, particularly in conditions where visual monitoring is ineffective, through the development of the HF/M3 sonar.

The first of two columns in Table 4.2-10 under Monitoring Mitigation Conversion Factors identifies the number of transmissions that would need to be suspended, or terminated, to prevent any animal of that species from being exposed to a RL of 180 dB or higher. Since the probability that a single-ping RL would be 180 dB or higher is small (typically much less than one percent for any one species), the potential of an animal being exposed to more than one transmission at or above 180 dB is coincidentally very small. The ship is moving in two dimensions, the animal is moving in three dimensions, the system is off at least 80 percent of the time, the maximum ping length is only 100 seconds, so even a small change in the animal's depth could readily move it out of the sonar beam pattern. Therefore, for any site, the number of transmissions terminated for all the species can be summed. Furthermore, if the source is shut down for one species, all species benefit from the reduced number of transmissions that contribute to their SPE.

With the contribution from suspended transmissions applied, new SPEs were calculated for each animal. These new SPEs were then used in the risk continuum to determine the potential for effects to the entire stock. These estimates of the percentage of the stock that could potentially be affected are provided under the columns for Alternative 1 (with geographic + monitoring mitigation). This represents the cases when SURTASS LFA sonar transmissions would be delayed or suspended because an animal has been detected within the 180-dB sound field or is projected to pass through it. It also reflects the $ME_{combined}$ of 0.66. False alarm rates for the three monitoring techniques would be low and are considered in the values used.

The second of the two columns under Monitoring Mitigation Conversion Factors shows the total number of transmissions that would be delayed or suspended at any site based on the $ME_{combined}$ of 0.66. For example, the total number of pings at or above 180 dB at Site 2 is 112. Since $ME_{combined}$ is 0.66, a total of 74 pings (112 x 0.66) would be suspended at Site 2.

4.2.7.2 Nominal Annual Operating Schedule

The analysis conducted thus far calculates the risk by modeled site only. The next step is to relate that analysis to annual operations of the SURTASS LFA sonar vessel(s). To estimate the percentage of marine mammal stocks potentially affected on a yearly basis, it is necessary to look at the nominal annual operating schedule. As discussed in Chapter 2, no more than six SURTASS LFA sonar operations per year would be scheduled for each of the SURTASS LFA sonar vessels (maximum of four systems/vessels covered by this OEIS/EIS). With two vessels in the Pacific-Indian Ocean area and two vessels in the Atlantic-Mediterranean area, there could be up to 12 operations in each area.

Sites 1 through 16 represent modeled locations in the Pacific and Indian Oceans. Sites 17 through 31 represent modeled locations in the Atlantic Ocean and Mediterranean Sea. Given that there are 16 sites analyzed for 20 days of active sonar operations each for the Pacific-Indian

Ocean area, the percentages of marine mammal stocks potentially affected by Alternative 1 for any 12 of these 16 can be summed. By using the maximum number of missions in one year, this results in conservative estimates of percentages of marine mammal stocks potentially affected from two SURTASS LFA sonar systems (with geographic + monitoring mitigation) conducting a total of 12 active missions in 12 randomly selected sites over the course of a year in the Pacific-Indian Ocean hemisphere (Table 4.2-11). The same observations can be made for randomly selecting 12 of the 15 sites in the Atlantic Ocean-Mediterranean Sea (Table 4.2-12).

Most importantly, many of the real-world SURTASS LFA sonar operations would occur in less environmentally or biologically sensitive locales -- more than likely in the open ocean rather than in proximity to coastal areas, and not all during the most biologically sensitive season (as was modeled). Thus, these estimates of affected marine mammal stocks adhere to a prudent approach and are conservatively high.

Note that in Tables 4.2-11 and 4.2-12 the potential effects of the 12 active missions are divided across the stocks of each large geographic area (i.e., the Pacific Ocean-Indian Ocean hemisphere and the Atlantic Ocean-Mediterranean Sea). Since marine mammal stocks are reproductively isolated, decreases in one stock cannot be replaced by animals from another stock. Therefore, to accurately assess the potential effect of SURTASS LFA sonar transmission, each stock was examined independently.

4.2.7.3 Potential Effects of the HF/M3 Source

The source level required for the HF/M3 sonar to effectively detect marine mammals (and possibly sea turtles) out to the 180-dB LFA mitigation zone under the most adverse oceanographic conditions (low echo return and high ambient noise) is on the order of 220 dB. (See Table 10-4 for comparisons with commercial fish finder sonars.) The Navy has designed the HF/M3 sonar to be as benign as possible within the marine environment in order to minimize potential effects to marine mammals and sea turtles. These features include the following:

- The HF/M3 sonar source frequency is >30 kHz, which pushes its frequency band well away from the best hearing bandwidth of mysticetes, pinnipeds and sea turtles (but within the odontocete best hearing band);

- Duty cycle is variable, but below 10 percent;

- The maximum HF/M3 sonar pulse duration is 40 milliseconds (msec). Ridgway et al. (1997)/Schlundt et al. (2000) reported that measured TTS in bottlenose dolphins for a 20 kHz, 1-second pulse occurred at RLs of 193-196 dB. For a 30 kHz, 40-msec pulse, the estimated range from the HF/M3 sonar of 193 dB RL would be 22 m (72 ft); and

- Transmission Loss (TL) is very high due to the high frequency.

Table 4.2-11

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

Stock Areas	Eastern North Pacific	Western North Pacific	South Pacific	Indian Ocean
Sites	6, 9, 10, 13	2, 3, 11, 14	4, 5, 16	15
Species	Potential for Effects < 180 dB[2] (≥ 180 dB)[1]	Potential for Effects < 180 dB[2] (≥ 180 dB)[1]	Potential for Effects < 180 dB[2] (≥ 180 dB)[1]	Potential for Effects < 180 dB[2] (≥ 180 dB)[1]
blue whale	8.36	6.27	0.32	N/M[3]
fin whale	1.03	1.07(0.03)[1]	0.29	N/M[3]
sei whale	N/M[3]	N/M[3]	0.16	N/M[3]
Bryde's whale	N/M[3]	0.33	0.08	0.02
minke whale	0.72	1.16	N/M[3]	N/M[3]
humpback whale	2.58	3.29(0.21)[1]	4.44	0.20
gray whale	3.43	5.30	N/M[3]	N/M[3]
n. right whale	4.13	N/M[3]	N/M[3]	N/M[3]
s. right whale	N/M[3]	N/M[3]	1.38	N/M[3]
sperm whale	0.16	N/M[3]	0.32	0.03
beaked whale	1.27	1.65	0.56	0.01
blackfish/killer whales	0.10	0.16	N/M[3]	0.01
pelagic dolphins	0.15	0.89(0.01)[1]	0.11	0.01
n. elephant seal	12.41	N/M[3]	N/M[3]	N/M[3]
s. elephant seal	N/M[3]	N/M[3]	0.07	N/M[3]
n. sea lion	9.93	0.19	N/M[3]	N/M[3]
n. fur seal	0.09	5.21	N/M[3]	N/M[3]
Australian fur seal	N/M[3]	N/M[3]	1.12	N/M[3]
S. American fur seal	N/M[3]	N/M[3]	0.73	N/M[3]

Notes:

1. ( ) = Annual estimate of percentages of marine mammal stocks affected by injury.
2. Calculated with risk continuum (see Subchapter 4.2).
3. N/M = Not Modeled. This species was not modeled at the sites due to nonexistent or insignificant populations.

Table 4.2-12

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

Stock Areas	Eastern North Atlantic	Western North Atlantic	South Atlantic	Mediterranean Sea
Sites	18, 22, 24	17, 27, 28, 30	21, 31	19, 25, 26
Species	Potential for Effects < 180 dB^2 (≥ 180 dB)^1	Potential for Effects < 180 dB^2 (≥ 180 dB)^1	Potential for Effects < 180 dB^2 (≥ 180 dB)^1	Potential for Effects < 180 dB^2 (≥ 180 dB)^1
blue whale	16.39	16.06	0.85	N/M^3
fin whale	0.64	1.77	0.41	7.69
sei whale	3.92	5.54	N/M^3	N/M^3
Bryde's whale	N/M^3	0.57	0.58	N/M^3
minke whale	0.46	8.08	0.28	6.75
humpback whale	3.12	7.12	1.80	N/M^3
n. right whale	N/M^3	2.52	N/M^3	N/M^3
sperm whale	0.41	N/M^3	N/M^3	13.40
beaked whale	5.31	2.33	0.11	10.82
blackfish/killer whales	0.99	0.62	N/M^3	8.62
pelagic dolphins	0.83	0.94	0.03	12.37

Notes:

1. ( ) = Annual estimate of percentages of marine mammal stocks affected by injury.
2. Calculated with risk continuum (see Subchapter 4.2).
3. N/M = Not Modeled. This species was not modeled at the sites due to nonexistent or insignificant populations.

In addition, as supplementary safety measures, the following operational procedures would be applied to operation of the HF/M3 sonar:

- The HF/M3 sonar source level would be ramped up over a five-minute period to allow time for any marine animal close to the sonar to move away; and
- The HF/M3 sonar source level would be reduced as a detected marine mammal or sea turtle approaches the sonar. Thus, as the animal is tracked in closer, the SL would be adjusted to ensure the RL at the animal is below 180 dB.

The application of these operational procedures reduces potential impacts of the HF/M3 sonar to marine mammal and sea turtle stocks to negligible levels.

4.2.7.4 Analysis of Employment of Two Sources at One Site

Thus far in the document, the analyses have been for one source operating at the modeled sites. This situation would hold true for the vast majority of operations due to the limited number (up to four) of SURTASS LFA sonar systems planned to be built and the limited operational conditions that could warrant the use of two sources in proximity to each other. However, the remote possibility exists that operational requirements or training exercises could require two sources simultaneously in one geographic area. The effect of the presence of two sources transmitting in one area can be conservatively approximated by doubling the single source potential effects provided for that site in Table 4.2-10. The following example demonstrates that this approach would adhere to a prudent approach and be a conservative estimate of the effect of two sources operating together.

The Gulf of Oman, Site 15, was selected as the representative case. The original positions for both the single source and the two simultaneously operated sources can be seen in Figure 4.2-12 (Pacific/Indian Ocean Site 15 - 2 Sources). These three positions are reasonable operational alternatives for the deployment of the SURTASS LFA sonar source. The PE model and AIM simulation results for Alternative 1 previously presented for the single source case in Table 4.2-10, are shown again in Table 4.2-13, as the “Gulf of Oman, Single Source” rows. The results of simple doubling are presented in the rows identified as “Gulf of Oman, doubling of single source results.”

To analyze the effect of two sources operating simultaneously in the area, the PE and AIM simulations were subsequently run with two sources at the positions shown in Figure 4.2-12. The resultant percentages of affected stocks are shown in the rows labeled “Gulf of Oman, Two Separate, Single Sources Combined.” As can be seen, these values are lower than the values shown for simple doubling of the single source results -- on average 75 percent or less of the more conservative doubled estimates. Therefore, in lieu of performing additional model analyses, doubling of the sites modeled in this document conservatively bounds the effect of employing two sources at one site.

This conclusion includes the assessment of whether the two sonars could transmit such that their sound fields would converge, thus generating a sound field of greater intensity. The potential for this occurring is negligible— even in the unlikely event that both sonars transmitted exactly in phase (time, depth, vertical steering angle, waveform, wavetrain, pulse length, pulse repetition rate, duty cycle) and in such proximity that the transmitted sound fields were trapped within the same transmission path. The resultant sound field still could only be as intense as the addition of both.

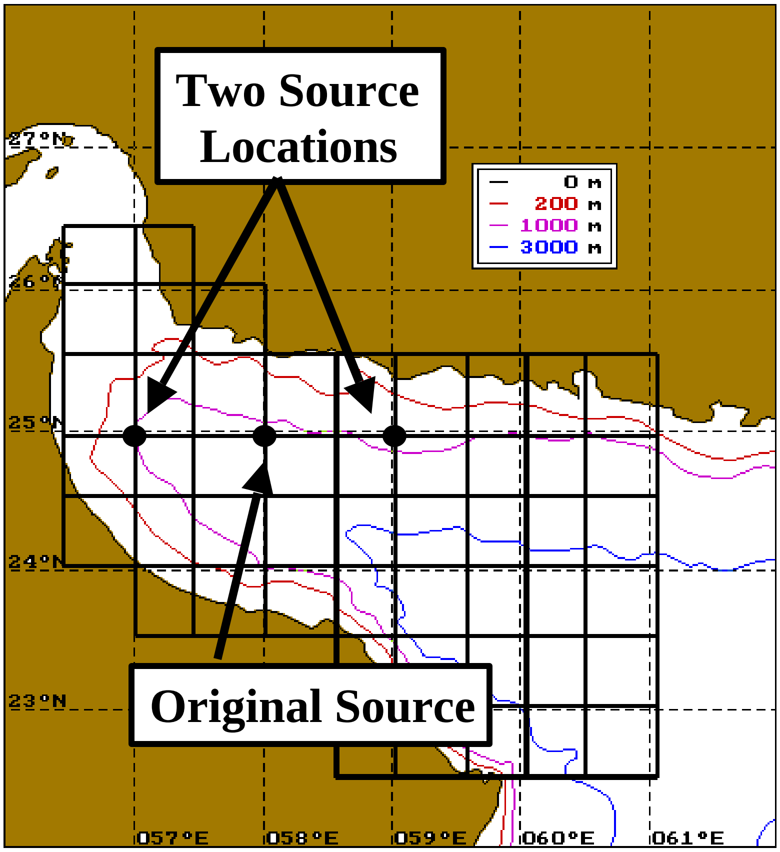

Figure 4.2-12. Pacific / Indian Ocean Site 15 - Two Sources.

Table 4.2-13

Estimates of Percentages of Marine Mammal Stock Potentially Affected by Two Sources Operating in One Site Area (Alternative 1)

Gulf of Oman (Site 15)	Marine Mammal	Alternative 1 (with geographic mitigation) Potential for Effects <180 dB (≥180 dB)[1]
Single Source	humpback whale	0.17 (0.11)
	Bryde’s whale	0.02 (0.01)
	sperm whale	0.03 (0.01)
	beaked whales	0.01
	"blackfish" & killer whales	0.01 (0.01)
	pelagic dolphins	0.01 (0.01)
Doubling of Single Source Results	humpback whale	0.54 (0.22)
	Bryde’s whale	0.04 (0.02)
	sperm whale	0.06 (0.02)
	beaked whales	0.02
	"blackfish" & killer whales	0.02 (0.02)
	pelagic dolphins	0.02 (0.02)
Two Separate, Single Sources Combined	humpback whale	0.49 (0.18)
	Bryde’s whale	0.03 (0.01)
	sperm whale	0.04 (0.01)
	beaked whales	0.02
	"blackfish" & killer whales	0.02
	pelagic dolphins	0.02 (0.01)

Notes:
1. ( ) = Annual estimate of percentages of marine mammal stocks affected by injury.

4.2.7.5 Biological Context

The LFS SRP field research provided important results on and insights into the types of responses of whales to SURTASS LFA sonar signals and how those responses scaled relative to RL and context. Prior to the LFS SRP, marine mammal scientists expected immediately obvious responses from whales at exposure levels > 140 dB and statistically significant responses at levels around 120 dB. This expectation was based on responses detected in previous research to continuous industrial sounds (Malme et al. 1983, 1984; Richardson et al. 1995b).

The LFS SRP results showed that some whales responded to SURTASS LFA sonar signals: some whales either changed their levels of vocal activity, moved away from or approached the SURTASS LFA source vessel, or did both. In Phase II, there was a statistically significant avoidance response when the source was inshore (but not offshore) (Buck and Tyack, 2000). The level of response was in proportion to the level of sound received at the whale. In Phase III, some whales reduced vocal activity or avoided the SURTASS LFA sonar vessel. Those that continued singing, increased song length, but the tendency for these responses did not increase with increasing RL (Tyack and Clark 1998; Miller et al., 2000). However, in all cases, responding whales resumed normal activities within a few tens of minutes after initial exposure to the LFA signal.

Thus, overall, the LFS SRP results confirmed that some portion of the whales exposed to the SURTASS LFA sonar responded behaviorally, but the responses were short-lived.

It is important to raise the question of what level of behavioral response could result in a stock-level impact and, therefore, threaten a species' survival. Calculations carried out in this subchapter (4.2) provide the basis for the conclusion that the potential impact on any stock of marine mammals from injury due to SURTASS LFA sonar operations is negligible. The primary potential effect from SURTASS LFA sonar is significant change in a biologically important behavior. For this to translate into a stock-level impact, a significant portion of a population would have to be exposed to and respond to SURTASS LFA sonar so as to effectively reduce the chances of individual survival or breeding. The most likely scenario that marine biologists could hypothesize under which this might happen was if SURTASS LFA sonar was operated in a concentrated breeding area throughout an entire breeding season, or operated in a feeding area for months at a time. The Navy's plans for SURTASS LFA sonar operation significantly reduce the chances of such scenarios, because: 1) the SURTASS LFA sonar will not be operated within 22 km (12 nm) of the coastline, or in places and during times of the year when marine mammals are engaged in critical activities, and 2) because of short (maximum 20-day) mission lengths.

Another possible concern would be that a large percentage of a stock could be exposed to moderate to low received sound levels over the long term. If animals are affected at these moderate to low exposure levels such that they experience significant changes in biologically important behaviors after long-term exposure, then such exposures could have an impact on rates of reproduction or survival. Analysis results discussed below address this concern.

The AIM estimations (incorporating LFS SRP results) help quantify the exposure statistics at the stock level. In order to understand the significance of the normalized percentages of a stock estimated at risk (Tables 4.2-10, 4.2-11, and 4.2-12), it is necessary to consider how this risk might affect an animal's life history (including the potential for long-term impacts). For example, and purely as a hypothetical case, in an open ocean breeding area, some fraction of the animals might have a reduced probability of breeding during the 20 days of transmissions (maximum time for a typical at-sea mission in an operational area). Using a very conservative assumption that half of the animals lost one quarter of their breeding season, this would represent a loss of from 1 to 5 percent of an animal's lifetime reproduction potential (1 percent of total lifetime breeding periods for larger, long-lived animals; 5 percent for smaller, short-lived animals).

For example, one-half of 1,000 animals in an open ocean breeding area = 500 animals; assume 20 breeding seasons in a lifetime, so loss of one quarter of one season = 1 ÷ (20 x 4) = 0.0125, or approximately 1 percent of an animal's lifetime potential. Thus, in this example, 500 of the animals in this breeding area would lose 1 percent of their lifetime breeding potential. The larger fraction of 5 percent would be associated with some of the smaller marine mammals; however, the potential severity of this effect is mitigated at the stock level by their larger stock sizes and shorter generation times.

Thus, the percentage of the stock affected biologically would be a very small fraction of the overall stock. These types of assessments that include a potential for long-term impact at the individual level have been the basis for the estimate of very small, if not negligible, potential for impacts at the stock level, and emphasize the conservativeness of the AIM risk estimates.

The impact on foraging animals might be comparable to that in breeding areas. Here, it is assumed that the impact would involve reduced foraging efficiency for at most 20 days out of a foraging season of perhaps 90 days. Even with a 25 percent reduction in foraging efficiency for all of the 20 days, this would represent only a 5 percent reduction in food intake for that season. For example, 25 percent of 20 days = 5 days; 5 days out of 90 days = 5.5% (5 ÷ 90 = 0.055). In both cases, 20 days of exposure is certainly an overestimate of the duration, because most of the SPE exposure for individuals with high risk values takes place during a small fraction of the SURTASS LFA sonar exercise, when the individuals happen to pass close to the ship.

The preceding discussion assumes that animals at risk do not move away from the SURTASS LFA sonar source to lessen its effects. Richardson et al. (1995b) stated that it would be unlikely that any marine mammal would remain for long in areas where there was continuous underwater noise exceeding 140 dB. However, no reduction in sighting rates (see TR 1 Tables B-1, 2 and 3 [LFS SRP Phase I], and Tables D-1, 2 and 3 [Phase III]) or acoustic detection was found within the vicinity of the SURTASS LFA sonar source vessel during LFS SRP projects (lasting for a few weeks). Thus, avoidance of the >140 dB zone of exposure occurred much less than expected.

4.2.7.6 Potential for Indirect Effects

Pelagic fish are food for many marine mammals. If fish were within the 180-dB sound field of the SURTASS LFA sonar source, they could potentially be affected. However, it is unlikely that prey availability (for mysticetes, odontocetes, and pinnipeds) would be altered for more than a few hours. Based on previous analyses of potential effects on fish, the possibility for injury to fish on a stock level is negligible. The potential for significant indirect effects is therefore estimated to be very low. Subchapter 4.1.1 (Fish and Sharks) also addresses the issue of the potential for SURTASS LFA sonar to impact fish stocks.

4.2.7.7 Potential for Masking

Richardson et al. (1995b) argue that the maximum radius of influence of an industrial noise (including broadband LF sound transmission) on a marine mammal is the distance from the source to the point at which the noise can barely be heard. This range is determined by either the hearing sensitivity of the animal or the background noise level present. Dahlheim et al. (1984) determined that gray whales in the San Ignacio Lagoon, Baja, California shifted the frequencies of their vocalizations away from the predominant ambient noise producers in the lagoon to overcome masking effects. As an issue for marine mammals, broadband LF shipping noise is likely to be more detrimental than narrowband, low duty cycle SURTASS LFA sonar sound. Industrial masking (which could include LF sound like SURTASS LFA sonar) is most likely to affect some species' ability to detect communication calls and natural sounds (i.e., surf noise, prey noise, etc.) (Richardson et al., 1995b). In summary, masking effects are not expected to be severe, because the SURTASS LFA sonar bandwidth is very limited (approximately 30 Hz), maximum pulse length is 100 seconds, signals do not remain at a single frequency for more than 10 seconds, and the system is off at least 80 percent of the time.

Mysticetes

Masking effects could be significant for many mysticete species because they vocalize at LFs and are thought to have hearing that is sensitive at the SURTASS LFA sonar frequencies. This is especially true for those animals that do not use other frequency bands. However, at a maximum 20 percent duty cycle, it is anticipated that masking would be temporary. That is, at least 80 percent of the time a whale would be able to perceive incoming signals through a LF transmission, and the possibility of effective masking would only occur for environmental sounds shorter than the SURTASS LFA sonar signal transmission period [maximum 100 seconds], that happened to fall within that window.

Odontocetes

The echolocation calls of toothed whales are subject to masking by high frequency noises. Human data indicate LF sound can mask high frequency sounds (i.e., upward masking). Studies on captive odontocetes by Au et al. (1974, 1985, 1993) indicate that some species may use various processes to reduce masking effects (e.g., adjustments in echolocation call intensity and/or frequency as a function of background noise conditions). Inasmuch as echolocation calls are of much higher frequencies than SURTASS LFA sonar, the extent of upward masking (i.e., LFs masking HFs) would be limited. There is also evidence that the directional hearing abilities of odondocetes are useful in reducing masking at the high frequencies used for echolocation, but not at the low-moderate frequencies used for communication (Zaitseva et al., 1980).

As part of an environmental assessment of icebreaker noise in the Canadian Arctic, the masking of beluga vocalizations was studied (Erbe and Farmer, 1998). Beluga signals' dominant frequency spectra range from whistles (2 to 5.9 kHz), to pulsed tones (1 to 8 kHz), to noisy vocalizations (4.2-8.3 kHz) (Schevill and Lawrence, 1949; Sjare and Smith, 1986a, b). Erbe and Farmer (1998) state that temporally continuous calls such as whistles are more robust to masking than are pulsed calls. Furthermore, masking depends on the amount of energy the marine mammal's call and the potentially masking noise share in so-called critical bands, which are characteristic of the animal's auditory frequency filter. Masked hearing thresholds (measured or predicted) are of little use unless they can be related to noise types and levels in the field.

An ocean sound propagation model was applied to a conversion of critical signal-to-noise ratios to distances between a noise source, a calling beluga and a listening beluga (Erbe and Farmer, 1998). Results were that propeller cavitation noise masked furthest with a maximum radius of 22 km (12 nm); bubbler system noise masked out to 15 km (8 nm); and naturally occurring ice cracking masked to 8 m (26 ft). Erbe's and Farmer's (1998) study produced the first data on the masking of animal vocalizations by real underwater noise. Erbe and Farmer (1998) showed that the zone of masking around a noise source will, in general, be smaller than the zone of audibility.

Although LF hearing has not been studied in many odontocete species, those species that have been tested (beluga, killer whale, false killer whale, Risso's dolphin, and bottlenose dolphin) exhibit poor audiometric and behavioral sensitivity to LF sound. For sounds dominated by LF components, the maximum radius of audibility for most odontocete species may often be noise-limited when sensitivity is good, and sensitivity-limited when sensitivity is poor. At a maximum 20 percent duty cycle, it is anticipated that any masking of odontocetes would be temporary (i.e., at least 80 percent of the time an animal would be able to perceive incoming signals through LF sounds). The possibility of effective masking would only occur for environmental sounds that happen during the ping transmission (maximum 100 seconds) and are at or, at least close to, the frequencies in the 30-Hertz-wide bandwidth signal, during the 10 seconds the SURTASS LFA sonar was transmitting in that bandwidth.

Pinnipeds

The same general principles concerning masking for mysticetes and odontocetes apply to pinnipeds. For many pinnipeds (e.g., fur seal, harbor seal), the radius of audibility of higher frequency, anthropogenic sounds (e.g., 5 to 30 kHz), would normally be limited by the background noise level, since these species are more sensitive to MF and HF sounds than to LF sounds. For sounds dominated by LF components, the maximum radius of audibility for these species may often be determined by their hearing sensitivity, rather than the background noise level.

Masking effects could be expected to be important for some pinniped species, particularly elephant seals because they have good hearing at the frequency of SURTASS LFA sonar. However, at a maximum 20 percent duty cycle, it is anticipated that masking would be temporary (i.e., at least 80 percent of the time a pinniped would be able to perceive incoming signals through LF sounds, and the possibility of effective masking would only occur for environmental sounds shorter than the SURTASS LFA sonar signal transmission period [maximum 100 seconds], that happened to fall within that window).

4.2.7.8 Summary

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 under the MMPA from NMFS for the taking of marine mammals incidental to the employment of SURTASS LFA sonar during training, testing and routine military operations, and is consulting with NMFS under Section 7 of the ESA. 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.

4.2.8 Alternative 2

Under Alternative 2, there would be no geographic restrictions or monitoring mitigation. Two case studies (one in the Pacific-Indian Ocean area and one in the Atlantic Ocean-Mediterranean Sea area) are presented here to portray the additional potential for effects without geographic restrictions or monitoring mitigation.

Table 4.2-14 provides the modeled values for Alternative 2 for Site 8 (southeast of San Nicolas Island, California) and for Site 23 (South Norwegian Basin). The values for Alternative 1 from Table 4.2-10 are also provided to facilitate comparative analysis both alternatives. Specifically, the potential for effects due to SPE levels ≥180 dB (shown in parentheses) is reduced from as much as 1.39 percent for Alternative 2 to zero percent for Alternative 1, while the potential for effects due to SPE levels <180 dB is reduced by as much as 4.45 percent (from 5.75 percent for Alternative 2 to 1.58 percent for Alternative 1). Note that the second column under Alternative 2 in the table shows the increase of potential for effects due to SPE levels from the Alternative 1 case.

With the exception of beaked whales (for SPE levels <180 dB), Alternative 2 shows an increase in potential effects for all species. The cause for the slight decrease in effects under Alternative 2 for beaked whales is two-fold: 1) by moving the source further offshore it is closer to the highest concentrations of beaked whales, and 2) a peculiarity of Site 8 and the source positions chosen is that for Alternative 2 a shallow water area (Tanner Bank) between the source and the highest concentrations of beaked whales minimizes the projected sound field offshore at great depths. Therefore, other offshore species, like pelagic dolphins and pilot whales, who are shallow divers, are not protected like the deeper diving beaked whales.

Clearly, Alternative 1 is superior to Alternative 2 as a reduced risk selection.

Table 4.2-14

Estimates of Percentages of Marine Mammal Stocks Potentially Affected (With and Without Mitigation)

Site	Site Location		Marine Mammal	Alternative 1 (with geographic+monitoring mitigation)[1]	Alternative 2 (no mitigation)	
				Potential for Effects <180 dB[3] (≥180 dB)[2]	Potential for Effects <180 dB[3] (≥180 dB)[2]	Increase of Potential for Effects[4]
8	Pacific Ocean Area	Southeast of San Nicolas Island, CA	blue whale	8.08	8.51 (1.39)[2]	1.81
			fin whale	0.79	0.83 (0.14)[2]	0.18
			sei whale	1.12	3.32 (0.33)[2]	2.52
			minke whale	2.48	3.21 (0.30)[2]	1.03
			beaked whales	3.34	2.96 (0.23)[2]	-0.15
			pelagic dolphins	0.03	0.05	0.02
			n. elephant seal	7.90	8.37 (0.95)[2]	1.42
			n. fur seal	0.12	0.17	0.05
			Guadalupe fur seal	1.45	4.74 (0.26)[2]	3.55
23	Atlantic Ocean Area	South Norwegian Basin (between Iceland and Norway)	blue whale	1.58	5.75 (0.28)[2]	4.45
			fin whale	0.11	0.13 (0.01)[2]	0.03
			minke whale	0.09	0.10 (0.01)[2]	0.02
			humpback whale	2.40	2.73 (0.13)[2]	0.46
			beaked whales	0.95	2.02 (0.10)[2]	1.17
			blackfish/killer whales	0.15	0.35	0.20
			pelagic dolphins	0.17	0.23 (0.01)[2]	0.07

Notes:
1. See Chapter 5.
2. ( ) = Annual estimate of percentages of marine mammal stocks affected by injury.
3. Calculated with risk continuum (see Subchapter 4.2).
4. Difference between estimates of percentage of marine mammal stocks potentially affected <180 dB and ≥180 dB for Alternative 1 and for Alternative 2.

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4.3 Socioeconomics

This subchapter addresses the potential impacts to commercial and recreational fisheries, other recreational activities in marine waters, research and exploration activities, and coastal zone management that could result from implementation of the alternatives under consideration.

4.3.1 Commercial and Recreational Fisheries

4.3.1.1 Alternative 1

Under Alternative 1, the SURTASS LFA sonar would be employed, but its geographic operation would be restricted. Sound levels generated by the operation of the sonar would not be allowed to be ≥ 180 dB within 22 km (12 nm) of the coast or in offshore biologically important areas during biologically important seasons (see Chapter 2). Offshore biologically important areas are where the highest fisheries productivity is found. In addition, sound fields generated by the SURTASS LFA sonar under this alternative would not be allowed to exceed 145 dB in the vicinity of known recreational and commercial dive sites. The former are generally defined as from the shoreline out to the 40-m (130-ft) depth contour, but it is recognized that there are other sites that may be outside of this boundary. The latter would be obtained from the worldwide Divers Alert Network (DAN) and other available sources.

Alternative 1 would have no significant impacts on commercial and recreational fish captures in marine waters, fisheries trade, or related employment due to the temporary nature of SURTASS LFA sonar employment. This includes its limited duty cycle (on no more than 20 percent of the time) and the relatively short signal duration (maximum of 100 seconds) -- and the fact that pelagic fish are generally widely dispersed and a negligible portion of any fish stock would be expected in the LFA mitigation zone (180 dB [RL] radius) during sonar transmissions. Moreover, due to the lack of more definitive data on fish stock distributions in the open ocean where SURTASS LFA sonar would be operating, it is infeasible to estimate the percentage of a stock (or fish clumps/schools) that could be located in a SURTASS LFA sonar operations area at a potentially vulnerable depth, during a sound transmission. Therefore, for the calculation provided below, it is assumed that the stocks are evenly distributed.

To quantify the possible effect of SURTASS LFA sonar on fish catches, an analysis of nominal SURTASS LFA sonar operations in a region off the Pacific Coast of the U.S. was conducted. The region selected was the NMFS Fisheries Resource Region—Pacific Coast, defined here to encompass the area from the Canadian to Mexican border, from the shoreline out to 926 km (500 nm).

To do this, the maximum volume of ocean water that could possibly be ensonified (within the LFA mitigation zone) during one year's operations of the SURTASS LFA sonar was first calculated. Using the SURTASS LFA sonar deployment data provided in Table 2-1, the following values resulted:

Vessel speed:	5.6 kph (3 kt)
Operating hours per day	20 hr/day
Distance traveled per day	112,000 m
Width of track (2 x radius of 180-dB sound field):	2,000 m
Vertical extent of affected area:	80 m
Days of transmission per mission (max.):	18
Missions per year in the region (max.):	3
Total volume affected annually (max.):	9.7×10^{11} m^3

The volume of water in this region potentially containing pelagic fish was calculated as follows:

Distance from Canadian to Mexican border (1020 nm):	1,880,040 m
Distance off the coast (500 nm):	926,000 m
Minimum vertical extent of region expected to contain pelagic fish:	80 m
Total volume for region:	1.4×10^{14} m^3

From the above calculations, the ratio of the total volume of the region ensonified at or above 180 dB during a year would be 0.0069 (or 0.69 percent). The total recent annual yield (RAY) for the Pacific Coast Region is estimated at 51,166 tons (1/3 of recent average commercial + recreational catch for combined Pacific Coast/Alaska regions [U.S. DoC, 1999]). RAY is the reported fishery landings averaged for the most recent three-year period of workable data (U.S. DoC, 1999).

If it is assumed that the RAY represents the number of pelagic fish catch in this region that could potentially be affected by SURTASS LFA sonar, then the maximum fish tonnage that SURTASS LFA operations could potentially affect would be a little over 350 tons. However, it is more likely that the vessel would only be in the Pacific Coastal Region about 20 percent of the time, reducing the number to 70 tons. Thus, even assuming that all fish exposed to the SURTASS LFA sonar 180-dB sound field would be affected, the percent of fish catch potentially affected would be negligible compared to the tonnage of fish harvested commercially and recreationally in the region (51,166 tons).

4.3.1.2 Alternative 2

Under Alternative 2, unconstrained employment of the SURTASS LFA sonar would occur in global marine waters without geographic restrictions or monitoring. The only limitations would be related to the temporary nature of the sonar operation and its limited duty cycle. Nevertheless, given the large stocks and wide geographic distribution of fish stocks expected to be present in the areas affected by SURTASS LFA sonar operation, impacts on fishery stocks would not be significant. The calculations above for Alternative 1 are also applicable to Alternative 2. Consequently, Alternative 2 would have no significant impacts on commercial or recreational fishing in marine waters or fisheries-related employment or trade.

4.3.2 Other Recreational Activities

4.3.2.1 Alternative 1

Swimming and Snorkeling

Participants in activities that may involve submersion below the ocean's surface, such as swimming, surfing, and snorkeling, would not be significantly impacted by exposure to LF sounds transmitted from the SURTASS LFA sonar. In making this determination, several factors were considered:

- **Beach Location** - Exposure to LF sound energy would be eliminated or greatly reduced at beaches that are separated from the open ocean by a land mass (such as beaches that exist inside barrier islands), or beaches along the broad, shallow portion of the continental shelf; and

- **Water Depths Used by Swimmers** - As noted in Subchapter 3.3.2, other than for very short periods of time, swimming and snorkeling occur in areas that extend from the surface to depths not greater than 2 m (6.5 ft). Applying acoustic theory and detailed measurements to these depths, there would be substantial sound transmission losses occurring in the top layer of water (about 1.8 m [6 ft]) where swimmers would most likely be found. Sound fields in this layer of water would be about 20 dB less than the sound fields in adjacent deeper water.

In addition to these factors, under Alternative 1, employment of the SURTASS LFA sonar would be restricted to SPLs not to exceed 145 dB in known recreational and commercial diving sites.

As described below, research conducted by the Navy (see TR 3) indicates that LF sound levels below 145 dB do not have an adverse effect on humans (recreational or commercial divers) in water. Therefore, there would be no significant impacts to persons engaged in swimming, surfing, and snorkeling under Alternative 1.

Diving

A February 1993 anonymous French Navy diver report attributed annoying LF sound off Corsica and Marseilles in the western Mediterranean Sea to U.S. Navy experimental research operations. In a separate event, a U.S. Navy diver, assigned to Explosive Ordnance Disposal Mobile Unit Eight, was a diver-subject in an *in situ* test conducted off the southeastern coast of Sicily at a depth of 19.8 m (65 ft). He was exposed to a single LFA transmission on 21 February 1993. While the planned RL was 140 dB, post-test analysis indicated the RL may have been as high as 150 dB or higher. He reported that he felt sound throughout his body and "numbness and tingling" in his extremities which persisted for approximately two hours after the event. During a physical examination three days after the test, he was without complaint. The physician's assessment was that he was healthy. Pursuant to these incidents, the Navy initiated scientific studies on the potential effects of LF sound on human divers. These are discussed below.

Two controlled studies with humans have been conducted on LF sound exposures. The first study by the Navy was conducted by the Applied Research Laboratory, University of Texas, from 1993 to 1995. Eighty-seven subjects participated in 437 tests under the control of the Naval Submarine Medical Research Laboratory (NSMRL). During one of these tests, a U.S. Navy diver reported experiencing intermittent symptoms of memory loss and seizures over a two-year period after a 15-minute continuous exposure to LF sound at 160 dB RL on 17 May 1994. Since 1996, subsequent neurological examinations have shown no evidence of a seizure disorder; all problems related to the LF sound exposure have been resolved. It should be noted that the maximum permissible SURTASS LFA sonar-generated SPL at known recreational and commercial dive sites would be 145 dB, which is 15 dB lower than the 160-dB SPL to which this diver was exposed. Furthermore, the maximum ping length for SURTASS LFA sonar is 100 seconds. Therefore, the potential for a recurrence of this event is negligible. At the conclusion of this NSMRL study, official guidance for alerted Navy divers was set at a maximum SPL of 160 dB for less than 2 minutes at one exposure and for less than 15 minutes a day. An "alerted diver" is a diver that is aware that he is going to hear a signal.

The second study was conducted by ONR and NSMRL between June 1997 and November 1998 in conjunction with a consortium of university and military laboratories (provided as TR 3 to this OEIS/EIS). Its purpose was to develop guidance for safe exposure limits for recreational and commercial divers exposed to LF sound such as that created during the operation of the SURTASS LFA sonar system. Computer modeling and animal and human studies were performed.

The study concluded that the maximum intensity used during testing (received level of 157 dB) did not produce physiological evidence of damage in human subjects. Furthermore, there was only a two percent very severe aversion reaction by divers at a level of 148 dB. NSMRL, therefore, determined that scaling back the intensity by 3 dB (3 dB reduction equals a 50 percent reduction in signal strength) would provide a suitable margin of safety for divers. Thus, a prudent approach was applied in the selection of this 145-dB criterion.

In June 1999 NSMRL set interim guidance for operation of low frequency underwater sound sources in the presence of recreational divers at 145 dB. This guidance was endorsed by both the Navy's Bureau of Medicine and Surgery and the Naval Sea System Command (see Appendix A). Because operation of the SURTASS LFA sonar systems would be restricted to 145 dB in known areas of recreational and commercial diving, under Alternative 1 the potential for effects on diving or related human activities in water would be negligible. This is further supported by the concept of SURTASS LFA sonar operations, which limits operational efficiency in shallow water areas where most diving occurs. Also, these types of operations would not normally be carried out in the vicinity of deep-water commercial platforms that may use divers, or vessels used for blue-water recreational diving. See Subchapter 5 (Mitigation Measures) for further discussion on this topic.

The distance of the 145-dB sound field from the SURTASS LFA sonar vessel is unique to each operational site and/or scenario due to the high variability in underwater sound propagation characteristics. The technique of sound field determination through the estimation of sound pressure levels (SPL) (see Subchapter 5.1.3) is the most reliable method of ensuring that the criterion of 145 dB maximum RL at known recreational and commercial dive sites is maintained.

Whale Watching

Under Alternative 1, the SURTASS LFA sonar sound field is restricted to less than 180 dB (RL) within 22 km (12 nm) of coastlines and in offshore biologically important areas during biologically important seasons, and will not exceed 145 dB for known recreational and commercial dive sites. One of the reasons these geographic restrictions are imposed on SURTASS LFA sonar operations is because these can be areas of concentrations of marine mammals -- prime whale watching locations; another is that most human swimming, snorkeling and diving activity occurs in these areas. Consequently, there would no significant impacts on whale watching activities as a result of the employment of SURTASS LFA sonar under Alternative 1, primarily because SURTASS LFA sonar operations avoid prime whale watching areas. Moreover, the 145-dB restriction for commercial and recreational dive sites would help protect whales and, accordingly, the whale watching industry.

4.3.2.2 Alternative 2

Swimming, Snorkeling, and Diving

Since Alternative 2 does not incorporate the geographic restrictions that are included in Alternative 1, swimmers, surfers, snorkelers, or divers could be affected by exposure to the LF sound generated by the SURTASS LFA sonar.

Whale Watching

Under Alternative 2, the unconstrained employment of SURTASS LFA sonar could result in injury or prolonged disturbance of biologically important behavior of marine mammals. Therefore, whale watching activities could potentially be impacted by implementation of Alternative 2.

4.3.3 Research and Exploration Activities

4.3.3.1 Alternative 1

Alternative 1 would not result in adverse impacts to existing governmental, commercial, or academic research and exploration activities. Under Alternative 1 the RL would not exceed 145 dB within known commercial and recreational dive sites. This would include blue water dive sites related to oceanic research, identified through DAN and interaction with major state diver organizations. Many of these efforts are conducted from vessels under the University National Oceanographic Laboratory System (UNOLS), which cooperates with the Navy on a continuous basis. In addition, data compiled from the proposed LTM Program could be used to supplement ongoing and future oceanographic and marine environmental research endeavors.

4.3.3.2 Alternative 2

With the exception of research and exploration activities that would require human diving, Alternative 2 would not result in significant impacts on existing governmental, commercial, or academic research and exploration activities.

4.3.4 Coastal Zone Management

Under Section 307(c)(1) of the Federal Coastal Zone Management Act, the Navy is required to conduct SURTASS LFA sonar operations that may affect land or water uses or natural resources of the coastal zone in a manner that is consistent, to the maximum extent practicable, with the enforceable policies of the coastal zone management program of each affected state. As noted in Subchapter 3.3.4, the seaward boundaries of state coastal zones extend to the outer limits of the jurisdiction of the state, which is delineated by the territorial sea (5.56 km [3 nm]) for the 48 contiguous states, Alaska, Hawaii and U.S.-affiliated islands (territorial waters extend to 16.67 km [9 nm] off Texas, the Florida Gulf Coast and Puerto Rico) (U.S. DoC, 1999).

The state coastal zone management policies and goals that may relate to SURTASS LFA sonar employment are presented in Table 3.3-5. Excluded from this table are policies related to land development in the coastal zone, which is the primary focus of coastal zone management programs. The state policies that address seaward concerns and are relevant to operation of the SURTASS LFA sonar generally fall into four categories: coastal industry, marine resources research and planning, natural resources protection and preservation, and recreation (see box).

Coastal Zone Management Policy Overview

Coastal Industry

- Support the commercial fishing industry
- Encourage the development and practice of aquaculture
- Promote the development of coastal resources, commercial industries, fisheries and energy sources
- Promote the use of commercial and recreational harbors
- Promote the coastal area’s economic development and tourist facilities
- Support subsistence usage, fish and seafood processing, and timber, mining, and mineral processing

Marine Resources Research and Planning

- Manage and protect marine resources and habitats
- Practice comprehensive planning for marine resources
- Promote marine and estuarine research and education

Natural Resources Protection and Preservation

- Safeguard environmentally sensitive habitats and coastal ecosystems
- Protect, restore, and manage natural coastal habitats and resources, including fisheries and other marine communities, ocean resources, rare and endangered species
- Conserve fish, wildlife, and plant habitats in critical areas

Recreation

- Provide and expand publicly accessible coastal recreational opportunities and areas
- Promote environmentally compatible coastal recreation and publicly accessible facilities and parklands
- Enhance those areas used for recreational boating activities

4.3.4.1 Alternative 1

The Navy has determined that Alternative 1 would be consistent, to the maximum extent practicable, with the relevant enforceable policies of the coastal zone management programs of potentially affected states and territories (operations would be conducted in the coastal waters of only those states where concurrence of consistency certification has been received), as follows:

- **Coastal Industry** - There would be no impacts to land-based coastal industries in state regulated coastal zones since the SURTASS LFA sonar would be employed solely in marine waters. Also, the seaward aspects of coastal industries, including fisheries and aquaculture, would not be affected under Alternative 1 because no significant impacts are expected to the commercial or recreational fisheries stocks or related captures, trade, or employment. Under Alternative 1, SURTASS LFA sonar-transmitted sound field levels would not be ≥ 180 dB within 22 km (12 nm) of the coastline or in offshore biologically important areas during biologically important seasons that are outside of 22 km (12 nm). In addition, sound fields generated by the SURTASS LFA sonar under this alternative would not exceed 145 dB at known recreational and commercial dive sites. Given these restrictions in inshore areas of the coastal zone where fisheries productivity is the highest, implementation of Alternative 1 would have no significant impacts on fisheries or related industries. Also, operation of the SURTASS LFA sonar would have no effect on the use of commercial or recreational harbors since no new ship operations would occur there nor would commercial or recreational harbors be associated with the sonar operation. Therefore, implementation of Alternative 1 would be consistent to the maximum extent practicable with state coastal zone management policies addressing the promotion and support of coastal industries.

- **Marine Resources Research and Planning -** Under Alternative 1, there would be no significant impacts on marine resources in the coastal zone due to the operational and geographic restrictions to be imposed as described above. Therefore, implementation of Alternative 1 would be consistent to the maximum extent practicable with state coastal zone management policies addressing marine resources research and planning.

- **Natural Resources Protection and Preservation** - Implementation of Alternative 1 would be consistent to the maximum extent practicable with state policies on the protection and preservation of natural resources. The geographic restrictions on SURTASS LFA sonar sound fields within coastal areas and in offshore biologically important areas would serve to safeguard environmentally sensitive habitats and ecosystems within the coastal zone. Moreover, there would be no significant adverse effects on natural coastal habitats and resources, including fisheries stocks and other marine communities, ocean resources, or threatened/endangered species' stocks.

- **Recreation** - Implementation of Alternative 1 would be consistent to the maximum extent practicable with state coastal zone management policies addressing coastal recreational opportunities. There would be no impacts on land-based coastal recreational opportunities since the SURTASS LFA sonar would be operated solely in marine waters and would not affect land use or access. In addition, there would be no seaward impacts on recreational opportunities, including whale watching, as a result of the geographic and operational restrictions incorporated into Alternative 1. Because operation of the SURTASS LFA sonar systems would be restricted to 145 dB in known areas of recreational and commercial diving, under Alternative 1, the potential for effects on diving would be negligible.

4.3.4.2 Alternative 2

The Navy has determined that the lack of geographic or operational restrictions on employment of the SURTASS LFA sonar under Alternative 2 may not be consistent with the relevant enforceable policies of affected states' coastal zone programs. Unrestricted operation of the SURTASS LFA sonar system could result in impacts not consistent with coastal management policies involving marine resources research, planning and recreation.

4.3.5 Environmental Justice

Restrictions imposed on the operation of the SURTASS LFA sonar system would result in sound fields below 180 dB within 22 km (12 nm) of the coastline and in offshore biologically important areas during biologically important seasons that are outside of 22 km (12 nm). In addition, sound fields generated by the SURTASS LFA sonar would not exceed 145 dB at known recreational and commercial dive sites. Furthermore, as discussed earlier in this chapter, the imposition of proposed operational restrictions would preclude significant impacts on commercial and recreational fisheries, other recreational activities in marine waters, research and exploration activities, and coastal zone management. As a result, there would be no significant impact to human populations inhabiting the coastal zone. Therefore, as evaluated in accordance with EO 12898, Environmental Justice, employment of the SURTASS LFA sonar system as proposed under either Alternative 1 or 2 would not have any adverse environmental or health impacts on minority or low-income populations.

In addition, EO 13045, Protection of Children from Environmental Health Risks and Safety Risks, requires each federal agency to identify and assess environmental health and safety risks to children. “Environmental health and safety risks” are defined as “risks to health or to safety that are attributable to products or substances that the child is likely to come in contact with or ingest.” For the reasons provided in the discussion of environmental justice above, the proposed action would not have any adverse effects on children.

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4.4 Potential Cumulative Impacts

Cumulative impacts, which can result from individually minor, but collectively significant, actions taking place over time and space, have been defined by the Council on Environmental Quality (CEQ) in 40 CFR 1508.7 as:

> Impacts on the environment which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions.

The potential cumulative impact issue associated with SURTASS LFA sonar operations is the addition of underwater sound to oceanic ambient noise levels, which in turn could have impacts on marine animals. Natural Resources Defense Council (NRDC) (1994) states that increased oceanic ambient noise level could potentially affect marine mammals and sea turtles. Richardson et al. (1995a) state that baleen whales often interrupt their normal behavior and swim rapidly away in response to strong or rapidly changing vessel noise.

This potential impact should be viewed in the following contexts:

- Recent changes to ambient sound levels in the world's oceans;
- Operational parameters of the SURTASS LFA sonar system, including proposed mitigation; and
- The contribution of SURTASS LFA sonar to oceanic noise levels relative to other human-generated sources of oceanic noise.

4.4.1 Recent Changes in Oceanic Noise Levels

Ambient noise is environmental background noise. It is generally unwanted sound—sound that clutters and masks other sounds of interest (Richardson et al., 1995b). Thus, any potential for cumulative impact should be put into the context of recent changes to ambient sound levels in the world's oceans:

- Ross (1976) estimated that shipping had caused a rise in ambient noise levels of 10 dB between 1950 and 1975, and he predicted another 5-dB increase by the 21st Century.
- Urick (1986) states that "there is a global increase of sound levels in the sea resulting from shipping, recreation, aircraft, and naval operations, as well as research."

- Aggregate traffic noise arises from the combined effects of all shipping at long ranges, originating between 10 km (5.4 nm) to distances up to 4,000 km (2,160 nm) in deep water. Shipping noise generally dominates ambient noise at frequencies between 20 and 300 Hz (Richardson et al., 1995b).

- Holmes (1997) states that shipping traffic has increased enough over the past 30 years to raise background noise levels in the deep ocean roughly 5 dB within the 50-500 Hz frequency band in the busier waters of the Northern Hemisphere.

- Based on recent evidence, researchers have concluded that ambient noise levels in the oceans have increased dramatically in the last decade, with the vast majority being directly attributed to commercial shipping (NMFS, 1998; NRDC, 1999).

- With the advent of the global economy the size of the merchant fleet has doubled, tonnage has quadrupled, and the cumulative effects from so much traffic dominates the lower frequency regime in many regions of the world (NRDC, 1999).

- In the early 1930s, the world merchant fleet was made up of some 30,000 ships, but by the early 1980s it had reached 75,000 ships (Cuyvers, 1984; NRDC, 1999).

- Curtis et al. (1999) determined that in the North Pacific Ocean the LF components of ambient noise consist of whale, shipping, and wind-generated sounds.

Sources other than shipping that contribute to ambient noise in the oceans include natural sounds (e.g., earthquakes, storms, snapping shrimp, marine mammals, fish, etc.) and other human generated sources (e.g., hydrocarbon exploration and production, drilling, and aircraft sonic booms).

4.4.2 SURTASS LFA Operational Parameters

Any cumulative impacts on fish (including sharks), sea turtle or marine mammal stocks from implementation of the proposed action are a long-term issue, and are estimated to be extremely small. This can be attributed to the following:

- The system would be operated for a relatively brief period of time on an annual basis (estimated maximum of 432 hours per vessel per year).

- The system would operate at a low duty cycle (on no more than 20 percent of the time), and for relatively short periods of time in any given area.

- The system would not be stationary.

- A maximum of only four systems would be operational (with usually only 1-2 at sea at any one time, and almost always in separate oceans). An analysis of the potential effects of two SURTASS LFA sonar sources operating simultaneously in the same area is presented in Subchapter 4.2.7.4. This is a scenario of remote possibility, which can be conservatively bounded by doubling the single source estimates of potential impact on marine mammal stocks.

Moreover, all observations made during the LFS SRP suggest that impacts terminate when transmissions stop. Thus, the maximum scale on which any impacts would be expected to occur would be a 20-day mission.

4.4.3 SURTASS LFA Sonar Compared with other Human-Generated Sources of Oceanic Noise

When transmitting, SURTASS LFA sonar will add to regional noise levels. To estimate the degree of this effect, the operation of SURTASS LFA sonar systems (maximum of four worldwide) can be contrasted with oceanic shipping, the dominant contributor to LF ambient noise in the oceans. Sound would be introduced into the ocean from SURTASS LFA sonar signals only when the sonar was actually transmitting. The nominal annual and 30-day deployment schedule for SURTASS LFA sonar (Table 2-1) would involve a maximum of 432 hours of active transmissions per system per year. This equates to 18 days per system, or 72 days for all four (maximum) SURTASS LFA sonar systems combined.

Oceangoing merchant vessels, on the other hand, transmit sound into the ocean constantly whenever they are underway. The four SURTASS LFA sonars would be transmitting sound into the ocean for a total maximum of 72 days per year vs. 21.9 million days per year for the 60,000 vessels of the world’s merchant fleet (assuming 80 percent of the merchant ships at sea at any one time). Therefore, within the existing environment, the potential for accumulation of noise in the ocean by the intermittent operation of SURTASS LFA sonars is considered negligible.

A comparison can also be made between SURTASS LFA sonar operations and seismic surveys using airguns. For example, if SURTASS LFA sonar generates a maximum of 432 hours of active transmissions per system per year, and the nominal ping duration is 60 sec, the system produces about 26,000 pings per year at an individual source projector level of approximately 215 dB. Contrast that to seismic survey airguns with a source level of up to and exceeding 250 dB (Richardson et al., 1995b), with a “shot” every 15 seconds, or 240 shots per hour, 24 hours per day. At that rate, a seismic survey produces as many shots in 108 hours as a SURTASS LFA sonar system produces pings in a full year.

Although there is more acoustic energy in a single 60-second SURTASS LFA sonar ping than in a single airgun shot of a few milliseconds, seismic survey airguns are more prevalent and they operate seven days a week. For example, a seismic survey vessel normally works for at least two weeks straight, producing almost 81,000 shots. In the Gulf of Mexico alone, there are typically three such survey vessels operating on any given day and over 100 seismic surveys are conducted there annually (MMS, 1997).

Therefore, even accounting for the unlikely scenario that each of four SURTASS LFA sonar systems transmitted 432 hours in a year, they would introduce far fewer signals and far less total acoustic energy into the ocean than seismic survey airguns in the Gulf of Mexico alone. Moreover, the world fleet of vessels conducting seismic surveys totaled 106 in July 1997.

4.4.4 Conclusions

In summary, the potential for cumulative impacts from SURTASS LFA sonar operations is extremely small and has been addressed by limitations proposed for employment of the system (i.e., geographical restrictions and monitoring mitigation). The geographic restriction imposed by the 145-dB exposure criterion for known commercial and recreational dive sites supports the conclusion that SURTASS LFA sonar contributions to oceanic ambient noise would be small and incremental. That is, the 145-dB restriction would further limit (in addition to the 180-dB geographic restriction) the accumulation of anthropogenic sound in coastal areas.

Even if considered in combination with other underwater sounds, such as commercial shipping, other operational, research, and exploration activities (e.g., acoustic thermometry, hydrocarbon exploration and production), recreational water activities, and naturally-occurring sounds (e.g., storms, lightning strikes, subsea earthquakes, underwater volcanoes, whale vocalizations, etc.), the SURTASS LFA sonar system does not add appreciably to the underwater sounds that fish, sea turtle and marine mammal stocks are exposed.

In addition, it should be noted that the short-term LFS SRP behavioral studies were guided by a desire to understand long-term effects and took into account pre-existing impacts and stock estimates (i.e., the state of health of the stock). Finally, SURTASS LFA sonar operations would not generally occur in areas of other high levels of human activities (e.g., high shipping density).

In the case of fish and sharks, there are cumulative impacts on their stocks from other human activities (e.g., over-fishing). However, this OEIS/EIS addresses this issue from the context of underwater sound, and it was determined that SURTASS LFA sonar sound would not significantly affect these stocks (Subchapter 4.1). This finding is supported by the four statements highlighted above (Subchapter 4.4.2).

Unlike Alternative 2, Alternative 1 proposes to restrict SURTASS LFA sonar sound field levels in coastal waters, offshore biologically important areas during biologically important seasons, and in known commercial and recreational dive sites. Because of these geographic restrictions, Alternative 1 would contribute less to cumulative oceanic ambient noise than Alternative 2.

The issue of potential cumulative impacts will continue to be addressed by the Navy through analysis of pertinent results from future underwater LF sound research efforts and the LTM Program (Subchapter 2.4).

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5 MITIGATION MEASURES

Mitigation, as defined by the Council on Environmental Quality (CEQ), includes measures to minimize impacts by limiting the degree or magnitude of a proposed action and its implementation. As determined in Chapter 4, the employment of SURTASS LFA sonar under Alternative 1 would meet the Navy's purpose and need and reduce potential impacts through the mitigation measures discussed in this chapter.

The objective of these mitigation measures is to prevent of injury to marine mammals and sea turtles, and to avoid risk of injury to human divers. This objective would be met by:

- Ensuring that coastal waters within 22 km (12 nm) of shore are not exposed to SURTASS LFA sonar signal levels $\geq$ 180 dB;
- Ensuring that no offshore biologically important areas are exposed to SURTASS LFA sonar signal levels $\geq$ 180 dB during critical seasons;
- Minimizing exposure of marine mammals and sea turtles to SURTASS LFA sonar signal levels below 180 dB by monitoring for their presence and suspending transmissions when one of these organisms enters this zone; and
- Assuring that no known recreational or commercial dive sites are subjected to LF sound pressure levels greater than 145 dB.

Strict adherence to these measures should ensure that there would be no significant impact on marine mammal stocks, sea turtle stocks, and recreational or commercial divers.

LFA Mitigation Zone

The LFA mitigation zone covers a volume ensonified to a level $\geq$ 180 dB by the SURTASS LFA sonar transmit array. Under normal operating conditions, this zone will vary between the nominal ranges of 0.75 to 1.0 km (0.40 to 0.54 nm) from the source array ranging over a depth of approximately 87 to 157 m (285 to 515 ft). (The center of the array is at a nominal depth of 122 m [400 ft]). Under rare conditions (e.g., strong acoustic duct) this range could be somewhat greater than 1 km (0.54 nm). Knowledge of local environmental conditions (such as sound speed profiles [depth vs. temperature] and sea state) that affect sound propagation is critical to the successful operation of SURTASS LFA sonar and is monitored on a near-real-time basis. Therefore, the SURTASS LFA sonar operators would have foreknowledge of such anomalous acoustic conditions and would mitigate to the LFA mitigation zone even when this was beyond 1 km (0.54 nm).

5.1 Geographic Restrictions

The following geographic restrictions apply to the employment of SURTASS LFA sonar:

- SURTASS LFA sonar-generated sound field would be below 180 dB 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;
- 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; and
- SURTASS LFA sonar operators would estimate sound pressure levels (SPL) 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 cited above.

5.1.1 Offshore Biologically Important Areas

There are certain areas of the world's oceans that are biologically important to marine mammals and sea turtles as defined in Subchapter 2.3.2.1. Because the majority of these areas exist within the coastal zone, SURTASS LFA sonar operations would be conducted such that the sound field is below 180 dB within 22 km (12 nm) of any coastline and in any offshore biologically important areas that are outside this 22 km (12 nm) zone during the biologically important season for that particular area. The 22-km (12-nm) restriction includes many marine-related critical habitats and sanctuaries (e.g., Hawaiian Islands Humpback Whale National Marine Sanctuary). The SURTASS LFA sonar sound field would be estimated in accordance with Subchapter 5.1.3. The actions to be taken if the above criteria were exceeded are also discussed in Subchapter 5.1.3.

5.1.2 Recreational and Commercial Dive Sites

SURTASS LFA sonar operations would be constrained in the vicinity of known recreational and commercial dive sites to ensure that the sound field at such sites does not exceed 145 dB. Recreational dive sites are generally defined as coastal areas from the shoreline out to the 40-m (130-ft) depth contour, which are frequented by recreational divers; but it is recognized that there are other sites that may be outside this boundary. The SURTASS LFA sonar sound field would be estimated in accordance with Subchapter 5.1.3. The action to be taken if the above criteria were exceeded is also discussed in Subchapter 5.1.3.

5.1.3 Sound Field Modeling

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 sound field criteria cited in Subchapters 5.1.1 and 5.1.2 above.

Sound field limits would be estimated using near-real-time environmental data and underwater acoustic performance prediction models. These models are an integral part of the SURTASS LFA sonar processing system. The acoustic models would determine the sound field by predicting the SPLs, or received levels, at various distances from the SURTASS LFA sonar source location. Acoustic model updates would be made at least every 12 hours, or more frequently when meteorological or oceanographic conditions change.

If the sound field criteria listed in Subchapters 5.1.1 and 5.1.2 were exceeded, the sonar operator would notify the Officer in Charge (OIC), who would order the delay or suspension of transmissions. If it were predicted that the SPLs would exceed the criteria within the next 12 hours, the OIC would also be notified in order to take the necessary action to ensure that the sound field criteria would not be exceeded.

5.2 Monitoring to Prevent Injury to Marine Mammals and Sea Turtles

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 passive (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 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 LFA mitigation zone.

5.2.1 Visual Monitoring

Visual monitoring would include daytime observations for marine mammals and sea turtles from the vessel. Daytime is defined as 30 minutes before sunrise until 30 minutes after sunset. Visual monitoring would begin 30 minutes before sunrise or 30 minutes before the SURTASS LFA sonar is deployed. Monitoring would continue until 30 minutes after sunset or until the SURTASS LFA sonar is recovered. Observations would be made by personnel trained in detecting and identifying marine mammals and sea turtles. Marine mammal biologists qualified in conducting at-sea marine mammal visual monitoring from surface vessels would train and qualify designated ship personnel to conduct at-sea visual monitoring. The objective of these observations would be to maintain a track of any marine mammals and/or sea turtles observed and to ensure that none approach the source close enough to enter the LFA mitigation zone.

These personnel would maintain a topside watch and marine mammal/sea turtle observation log during all operations that employ SURTASS LFA sonar in the active mode. The numbers and identification of marine mammals/sea turtles sighted, as well as any unusual behavior, would be entered into the log. A designated ship's officer would monitor the conduct of the visual watches and periodically review the log entries. There are two potential visual monitoring scenarios.

First, if a potentially affected marine mammal or sea turtle were sighted outside of the LFA mitigation zone, the observer would notify the OIC. The OIC would then notify the HF/M3 sonar operator to determine the range and projected track of the animal. If it was determined that the animal would pass within the LFA mitigation zone, the OIC would order the delay or suspension of SURTASS LFA sonar transmissions when the animal entered the LFA mitigation zone. If the animal were visually observed within 2 km (1.1 nm) and 45 degrees either side of the bow, the OIC would order the delay or suspension of SURTASS LFA sonar transmissions. The observer would continue visual monitoring/recording until the animal was no longer seen.

Second, if the potentially affected animal were sighted within the LFA mitigation zone, the observer would notify the OIC who would order the immediate delay or suspension of SURTASS LFA sonar transmissions.

All sightings would be recorded in the log and provided as part of the LTM Program to monitor for potential long-term environmental effects.

5.2.2 Passive Acoustic Monitoring

Passive acoustic monitoring would be conducted when SURTASS is deployed, using the SURTASS towed horizontal line array to listen for vocalizing marine mammals as an indicator of their presence. If the sound were estimated to be from a marine mammal that may be potentially affected by SURTASS LFA sonar, the technician would notify the OIC who would alert the HF/M3 sonar operator and visual observers. If prior to or during transmissions, the OIC would then order the delay or suspension of the SURTASS LFA sonar transmissions when the animal entered the LFA mitigation zone.

All contacts would be recorded in the log and provided as part of the LTM Program to monitor for potential long-term environmental effects.

5.2.3 Active Acoustic Monitoring

HF active acoustic monitoring would use the HF/M3 sonar to detect, locate, and track marine mammals (and possibly sea turtles) that could pass close enough to the SURTASS LFA sonar array to enter the LFA mitigation zone. HF acoustic monitoring would begin 30 minutes before the first SURTASS LFA sonar transmission of a given mission was scheduled to commence and continue until transmissions were terminated. Prior to full-power operations, the HF/M3 sonar power level would be ramped-up over a period of 5 minutes from 180 dB in 10-dB increments until full power (if required) was attained to ensure that there were no inadvertent exposures of local animals to RLs $\geq$ 180 dB from the HF/M3 sonar. There are two potential scenarios for mitigation via active acoustic monitoring.

First, if a contact were detected outside of the LFA mitigation zone, the HF/M3 sonar operator would determine the range and projected track of the animal. If it was determined that the animal would pass within the LFA mitigation zone, the sonar operator would notify the OIC. The OIC would then order the delay or suspension of transmissions when the animal was predicted to enter the LFA mitigation zone.

Second, if a contact were detected by the HF/M3 sonar within the LFA mitigation zone, the observer would notify the OIC who would order the immediate delay or suspension of transmissions.

All contacts would be recorded in the log and provided as part of the LTM Program.

5.2.4 Resumption of SURTASS LFA Sonar Transmissions

SURTASS LFA sonar transmissions could commence/resume 15 minutes after there was no further detection by the HF/M3 sonar and there was no further visual observation of the animal within the LFA mitigation zone.

5.3 Summary of Mitigation

Table 5-1 is a summary of the proposed mitigation, the criteria for each, and the actions required.

Table 5-1

Summary of Mitigation

Mitigation	Criteria	Actions
Geographic Restrictions		
22 km (12 nm) from coastline and offshore biologically important areas during biologically important seasons outside of 22 km (12 nm)	Sound field below 180 dB, based on SPL modeling.	Delay/suspend SURTASS LFA sonar operations.
Recreational and commercial dive sites[1]	Sound field not to exceed 145 dB, based on SPL modeling.	Delay/suspend SURTASS LFA sonar operations.
Monitoring to Prevent Injury to Marine Mammals and Sea Turtles		
Visual Monitoring	Potentially affected species near the vessel but outside of the LFA mitigation zone.	Notify OIC.
	Potentially affected species sighted within 2 km (1.1 nm) and 45 degrees either side of the bow or inside of the LFA mitigation zone.	Delay/suspend SURTASS LFA sonar operations.
Passive Acoustic Monitoring	Potentially affected species detected.	Notify OIC.
Active Acoustic Monitoring	Contact detected and determined to have a track that would pass within the LFA mitigation zone.	Notify OIC.
	Potentially affected species detected inside of the LFA mitigation zone.	Delay/suspend SURTASS LFA sonar operations.

Notes:

1. Recreational dive sites are generally defined as coastal areas from the shoreline out to the 40-m (130-ft) depth contour.

6 RELATIONSHIP OF THE PROPOSED ACTION TO FEDERAL, STATE, AND LOCAL PLANS, POLICIES, AND CONTROLS

Operation of the SURTASS LFA sonar system would comply with all applicable federal, state, regional, and local laws and regulations. The following environmental statutes impose requirements that have been considered in the proposed action:

- Executive Order 12114;
- NEPA;
- Clean Water Act;
- Act to Prevent Pollution from Ships;
- Coastal Zone Management Act;
- Endangered Species Act;
- Marine Mammal Protection Act;
- Marine Protection, Research, and Sanctuaries Act;
- Migratory Bird Treaty Act;
- Executive Orders 12898 and 13045, Environmental Justice; and
- Magnuson-Stevens Act.

In addition, during preparation of this OEIS/EIS, relevant state, regional, and local authorities were asked to identify any existing policies and programs that may apply to the project.

6.1 Executive Order 12114

Executive Order (EO) 12114, “Environmental Effects Abroad of Major Federal Actions,” requires the analysis of the environmental impacts of a federal agency’s action(s) that could significantly affect the global commons, the environment of a foreign nation, or protected global resources. This OEIS/EIS has been prepared in accordance with 32 CFR Part 187 and with the Navy’s guidance in OPNAVINST 5090.1B, Appendix E.

6.2 National Environmental Policy Act (NEPA)

This EIS has been prepared in accordance with the Council on Environmental Quality regulations implementing NEPA (40 CFR Part 1500-1508) and Navy NEPA procedures (OPNAVINST 5090.1B). The preparation of this EIS and the provision for its public review are being conducted in compliance with NEPA.

6.3 Clean Water Act

The purpose of the Clean Water Act (CWA) is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. One means by which this is accomplished is through the regulation, in the form of permits, of discharges of pollutants to navigable and ocean waters. Operation of the SURTASS LFA sonar system will not result in the discharge of any pollutant to such waters. Operation of the vessels supporting SURTASS LFA will result only in discharges incidental to normal operations of a vessel. No permit is required for these discharges. The Navy and the USEPA are in the process of developing uniform national discharge standards for DoD vessels under the federal CWA. These standards will apply to vessels operated out to 22 km (12 nm) from the U.S.

6.4 Act to Prevent Pollution from Ships

The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) prohibits certain discharges of oil, garbage, and other substances from vessels. The Convention is implemented by the Act to Prevent Pollution from Ships (APPS) (33 U.S.C. 1901 to 1915), which establishes requirements for the operation of U.S. Navy vessels. The vessels supporting the SURTASS LFA sonar system will operate in compliance with these requirements. The sonar system itself will not result in the discharge of any pollutants regulated under APPS.

6.5 Coastal Zone Management Act

The Coastal Zone Management Act (CZMA) provides for coastal states to develop coastal zone management programs to achieve wise use of the land and water resources of the coastal zone. Under CZMA, federal agency activities, inside or outside the coastal zone, that affect any land, water use, or natural resource of the coastal zone must be carried out in a manner that is consistent to the maximum extent practicable with the enforceable policies of approved State management programs of those states listed in Table 3.3-5. The Navy has determined that under the preferred alternative, employment of the SURTASS LFA sonar would be consistent to the maximum extent practicable with the following relevant coastal zone management policies:

- **Coastal Industry** - There would be no impacts to land-based coastal industries in the state regulated coastal zones since the SURTASS LFA sonar would be employed solely in marine waters and its operation would be restricted to beyond 22 km (12 nm) for the protection of certain marine animals and recreational diving sites.

- **Marine Resources Research and Planning -** Proposed restrictions on operation of the proposed action (see Chapter 2) would result in no adverse effects on marine resources in the coastal zone. In addition, the Navy would be actively promoting marine research through its proposed LTM Program related to the effects of LF sonar on a variety of marine species in varying ocean environments during different seasons. This effort would supplement ongoing and future oceanographic and marine environmental research endeavors.

- **Natural Resources Protection and Preservation** - Operational restrictions to be imposed within coastal areas and in offshore biologically important areas during biologically important seasons (see Chapter 2) would serve to safeguard environmentally sensitive habitats and ecosystems within the coastal zone.
- **Recreation** - There would be no impacts on land-based coastal recreation opportunities since the SURTASS LFA sonar would be operated solely in marine waters and would not affect land use or access.

The Draft OEIS/EIS was submitted to 23 states and 5 territories with coastlines that potentially could be affected by the proposed action.

6.6 Endangered Species Act

The Endangered Species Act (ESA) provides for the listing of endangered and threatened species of plants and animals as well as the designation of critical habitat for listed species. The ESA prohibits the taking of any listed species without (for federal agencies) an “Incidental Take Statement.” The definition of “taking” includes injury and harassment. The ESA also requires federal agencies to exercise their authorities, in consultation with designated agencies (in effect, the U.S. Fish and Wildlife Service (USFWS) and NMFS, as appropriate), to conserve endangered species. It further requires federal agencies to consult with these agencies on any action that may jeopardize the continued existence of any threatened or endangered species, which has been interpreted by regulation to require consultation for any action that “may affect” such species. For actions that may adversely affect species, the regulatory agencies may recommend mitigation. Such mitigation is required if an agency action would otherwise jeopardize the species existence, and it may be required if agency action will result in a take and, therefore, require an incidental take authorization.

The Navy has determined that operation of the SURTASS LFA sonar system will not adversely affect any endangered or threatened species or the critical habitat of any protected species under the jurisdiction of the USFWS. The Draft OEIS/EIS served as the basis for the development of the Biological Assessment, required under the ESA, for endangered or threatened marine species and their critical habitats. Upon completion of the Draft OEIS/EIS and its formal filing with USEPA, the Navy initiated formal consultation with NMFS on 4 October 1999 (See Appendix A [Correspondence]). Based on information in the Biological Assessment, NMFS is required to provide the Navy with a Biological Opinion on whether the proposed action would be likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. That Biological Opinion may include an incidental take statement if the proposed action will result in any takes of listed species.

6.7 Marine Mammal Protection Act

The Marine Mammal Protection Act (MMPA), subject to limited exceptions, prohibits any person or vessel subject to the jurisdiction of the United States from "taking" marine mammals in the United States or on the high seas without authorization. "Taking" includes harm or harassment. Section 101(a)(5) of the MMPA directs the Secretary of Commerce to allow, upon request, the incidental (but not intentional) taking of marine mammals by U.S. citizens who engage in a specified activity (exclusive of commercial fishing) within a specified geographical region if certain findings are made and regulations are issued. Permission may be granted by the Secretary for the incidental take of marine mammals if the taking will: 1) have a negligible impact on the species or stock(s); and 2) not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses. Regulations must be issued setting forth the permissible methods of taking and the requirements for monitoring and reporting such taking.

The Navy will operate the SURTASS LFA sonar system in compliance with the MMPA. On 12 August 1999, the Navy submitted an application for a letter of authorization under section 101(a)(5)(A) of the MMPA to take marine mammals incidentally through operation of the SURTASS LFA sonar system (See Appendix A [Correspondence]).

6.8 Marine Protection, Research, and Sanctuaries Act

The Marine Protection, Research, and Sanctuaries Act (MPRSA) of 1972 prohibits persons or vessels subject to U.S. jurisdiction from transporting from the U.S. any material for the purpose of dumping it into ocean waters without a permit. The term "dumping," however, does not include the intentional placement of any device in ocean waters or on the land beneath such waters when such placement occurs pursuant to an authorized federal or state program. The operation of the proposed SURTASS LFA sonar system would not involve any ocean dumping. During the reauthorization in 1992, Title III was renamed the National Marine Sanctuaries Act. Title I and II of the MPRSA remain in force to protect the ocean through the prevention of ocean dumping of toxic materials.

The Act authorizes the Secretary of Commerce to designate and manage areas of the marine environment with nationally significant aesthetic, ecological, historical, or recreational values as National Marine Sanctuaries. The primary objective of this law is to protect marine resources, such as coral reefs, sunken historical vessels or unique habitats, while facilitating all "compatible" public and private uses of those resources. Sanctuaries, frequently compared to underwater parks, are managed according to Management Plans, prepared by the National Oceanic and Atmospheric Administration (NOAA) on a site-by-site basis.

NOAA administers the National Marine Sanctuary Program through the Sanctuaries and Reserves Division of the Office of Ocean and Coastal Resource Management.

On November 29, 2000, the Navy corresponded with the National Marine Sanctuaries Program concerning the National Marine Sanctuaries Act for the operation of SURTASS LFA Sonar. In its letter the Navy determined that operation of the SURTASS LFA sonar in accordance with Alternative 1 (Restricted Operation - preferred alternative) of the Draft OEIS/EIS would not destroy, cause the loss of, or injure any sanctuary resource. Therefore no consultation with the Office of Ocean and Coastal Resource Management is required. A copy of this letter is provided in Appendix A.

6.9 Migratory Bird Treaty Act

The Migratory Bird Treaty Act (MBTA) implements a number of treaties between the United States and other countries that require controls on the taking, killing, and possession of migratory birds. Operation of the SURTASS LFA sonar system will not result in the taking or killing of any migratory birds.

6.10 Executive Orders 12898 and 13045, Environmental Justice

Executive Order 12898, “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,” directs each federal agency to incorporate environmental justice into its mission and activities. The Navy has evaluated operation of the SURTASS LFA sonar system in accordance with the requirements of the Executive Order and has determined that operation of the system would not have any adverse environmental or health impacts on minority or low-income populations.

Executive Order 13045, “Protection of Children from Environmental Health Risks and Safety Risks,” requires each federal agency to identify and assess environmental health and safety risks to children. “Environmental health and safety risks” are defined as “risks to health or to safety that are attributable to products or substances that the child is likely to come in contact with or ingest.” The Navy has evaluated the operation of the SURTASS LFA sonar system and has determined that the proposed action would not have any adverse effect on children.

6.11 Magnuson-Stevens Fisheries Conservation and Management Act

The Magnuson-Stevens Fisheries Conservation and Management Act addresses the sustainability of fish stocks through risk-averse management practices and habitat protection, including the designation of essential fish habitats. The proposed operation of the SURTASS LFA sonar system would not involve the alteration of essential fish habitats or reduce the productive capacity of any fish stock.

On 28 February 2000, the Navy submitted a determination of no adverse effects on essential fish habitats for the operation of the SURTASS LFA sonar to the Office of Habitat Conservation, NMFS (See Appendix A [Correspondence]).

6.12 State and Local Plans and Policies

The Navy pursues close and harmonious planning relations with local and regional agencies and planning commissions of adjacent cities, counties, and states for cooperation and resolution of mutual land use and environment-related problems. In addition, coordination may be made with state and regional planning clearing houses as established by EO 12372 of 1982. Since the SURTASS LFA sonar system would be deployed beyond 22 km (12 nm) from the coast, it would have no effect on local plans and policies other than coastal zone management and planning. The Navy has addressed coastal zone management issues for states where the potential exists for offshore employment of the SURTASS LFA sonar and has obtained copies of state management plans for the purpose of ensuring consistency between the plans and the proposed action (see Subchapter 6.5).

7 UNAVOIDABLE ADVERSE EFFECTS

Unavoidable adverse impacts of the proposed action include effects on any stock of marine mammals from injury (considered to be a negligible potential based on the scientific analysis presented herein), and effects on the stock of any marine mammal fom a significant change to a biologically important behavior (considered to be a minimal potential based on the scientific analysis presented herein).

Some fish stocks could be affected by the LF sounds. However, a negligible portion of any fish stock would be exposed on an annual basis. Some sharks in the SURTASS LFA sonar operations area would be affected by the LF sounds. However, a negligible portion of any shark stock would be within the LFA mitigation zone at any given time. No impact on non-pelagic commercial or recreational fisheries is expected because of the geographic restrictions that would be imposed on SURTASS LFA sonar operations (Chapter 5).

Sea turtles could be affected if they are inside the LFA mitigation zone. The sound field for potential non-auditory injury or permanent hearing loss is assumed to be within the LFA mitigation zone. Under the proposed action (Alternative 1), SURTASS LFA sonar RLs would be below 180-dB within 22 km (12 nm) of any coastlines and offshore biologically important areas. Consequently, effects to a sea turtle stock could occur only if a significant portion of a sea turtle stock encountered the SURTASS LFA sonar during active transmissions in the open ocean. The expected number of interactions between SURTASS LFA sonar and the pelagic leatherback sea turtle has been estimated to be less than three per year (see Subchapter 4.1.2).

In summary, almost all potential impacts to marine mammals and sea turtles would be avoidable due to the geographic restrictions and monitoring implemented to prevent injury to marine mammals and sea turtles that would be conducted coincident with all SURTASS LFA sonar operations.

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8 RELATIONSHIP BETWEEN SHORT TERM USES OF MAN'S ENVIRONMENT AND THE ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The proposed employment of the SURTASS LFA sonar would meet the Navy's need for improved capability in detecting quieter and hard-to-find foreign submarines at long range. This capability would provide Naval forces with adequate time to react to, and defend against, potential submarine threats while remaining a safe distance beyond an enemy submarine's effective weapon range. Both short- and long-term commitments of labor and capital, along with use of non-renewable materials for machine power and maintenance, would result from the proposed action. Adherence to the proposed operating restrictions coupled with the proposed mitigation measures (see Chapter 5) would minimize the effects of the proposed action on the marine environment and improve knowledge of the marine environment in the areas where the SURTASS LFA sonar system would be operated. Consequently, the majority of the effects of operating the SURTASS LFA sonar would be temporary in nature and would have no significant adverse long-term impacts on the maintenance and enhancement of long-term biological productivity.

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9 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Section 102(c)(v) of NEPA requires that an EIS identify "any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented." While implementing the limited SURTASS LFA sonar system would provide important benefits by providing the Navy enhanced detection of submarines, nonrenewable resources would be consumed during the design, construction and operation of the proposed system. Since the reuse of these resources may not be possible, they could be considered irreversibly and irretrievably committed should the proposed action be implemented. The nonrenewable resources would include expendable materials, such as steel, fuel and energy that would be used during the construction and operation of the proposed system. The Navy is not aware of any cultural resources that would be irreversibly and irretrievably committed or lost should the proposed action be implemented.

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10 PUBLIC REVIEW PROCESS AND RESPONSE TO COMMENTS

Public involvement in the review of draft Environmental Impact Statements (DEISs) is stipulated in 40 CFR Part 1503 of the Council on Environmental Quality's (CEQ) regulations implementing the National Environmental Policy Review Act (NEPA) and in OPNAVINST 5090.1B. These regulations and guidance provide for active solicitation of public comment via the scoping process, public comment periods, and public hearings. This chapter has been prepared to document the public involvement process in preparation of the Draft OEIS/EIS. This chapter also presents the response to questions and comments raised by individual commentors during the public comment period on the Draft OEIS/EIS.

10.1 Public Review Process

10.1.1 Notice of Intent

The Notice of Intent (NOI) for this project was published in the *Federal Register* on July 18, 1996 (FR Vol. 61 No. 139). It broadly described the proposed action, the alternatives to be considered, and the analyses to be conducted for this OEIS/EIS. The NOI also announced that three public scoping meetings would be held during August 1996. The public scoping period was originally scheduled to end on September 4, 1996, but was extended to receive written comments up to and including September 14, 1996.

10.1.2 The Scoping Process

In addition to the NOI, scoping letters were sent to federal, state, and local officials and agencies, as well as members of the general public, notifying them of the beginning of the EIS process. Public scoping meetings for this project were held as follows:

- Norfolk, Virginia - August 3, 1996;
- San Diego, California - August 6, 1996; and
- Honolulu, Hawaii - August 8, 1996.

Comments were received from various agencies, groups, and individuals. General areas of concern expressed by commentors included (but not listed in order of importance):

- **SURTASS LFA Sonar Characteristics -** A variety of commentors asked that the Navy make public all relevant performance characteristics of the SURTASS LFA sonar system, including frequency, source level, bandwidth, and beamforming capabilities. The OEIS/EIS evaluation of potential effects of the system's LF sound on marine animals is based on all the relevant parameters, but certain of these remain classified for national security purposes.

- **Process and OEIS/EIS Content -** Some commentors remarked that the worldwide scope of the SURTASS LFA sonar intended Fleet employment was adequate cause for the environmental impact statement to be conducted under both NEPA and EO 12114 procedures. The Navy has directed that development and processing of the OEIS/EIS be conducted under both NEPA and EO 12114 procedures.

- **Program Need and Deployment -** A number of commentors stated that the Navy's assertion of the need to deploy the system was insufficient. The public commented that the Navy must ascertain that the technology is not one that has potential for easily developed countermeasures. The OEIS/EIS reviews both the technical and military need for SURTASS LFA in detail. Current and envisioned countermeasure systems and operations that a threat submarine may employ against tactical passive and active sonars (mid-frequency) would be partially or wholly ineffective against low frequency active sonar. The OEIS/EIS also analyzes a number of alternatives, including geographic restrictions to limit operations in areas of high animal densities and monitoring mitigation to detect animals close to the transmit array.

- **Potential Impacts -** Commentors stated that all species potentially affected by the system should be covered. The analysis should assess potential impacts on all animals, not just those definitively known to be sensitive to LF sound or those in the zone of influence of the immediate sound source. Other commentors noted that the OEIS/EIS must consider the potential for impact on diver hearing sensitivity, resonance of air containing cavities, mechanoreceptor cell functions and human acoustic annoyance. The OEIS/EIS has taken a universal approach, which considers the potential effects on all marine animals and both recreational and commercial divers.

10.1.3 Information Repositories

Documents produced for the SURTASS LFA Draft OEIS/EIS were made available for review at seventeen 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).

10.2 Public Involvement Outside of NEPA Process

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.

In addition, the Navy has 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, 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. 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.

10.3 Public Hearings and Comment Opportunities for the Draft OEIS/EIS

10.3.1 Filing and Distribution of the 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 (FR Vol. 64 No. 146).

10.3.2 Public Review Period and Public Hearings

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 29th in Norfolk, VA;
- October 12th in San Diego, CA; and
- October 14th 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.

10.4 Comments on the Draft OEIS/EIS

10.4.1 Receipt of Comments

Comments on the Draft OEIS/EIS were received in the following forms: letters, written statements delivered at the public hearings, oral statements made at the public hearings, written statements received via facsimile and e-mail correspondence, and oral statements received via toll-free telephone voice mail. In some cases, oral statements were summaries or verbatim readings of written statements submitted at the public hearings or of letters that were sent to the Navy. Written and oral comments were received from over 1,000 commentors, including federal, state, regional, and local agencies, groups and associations, and private individuals. Comments postmarked by October 28, 1999, or received via facsimile, voice mail, or e-mail by 5:00 pm on October 28, 1999, were reviewed and are considered in this chapter.

10.4.2 Identification of Comments

The Navy received 1,070 comments and 11 petitions during the public comment period, which ended on October 28, 1999. In addition, no statements were presented at the September 29, 1999, public hearing in Norfolk, VA; 10 statements were presented at the October 12, 1999, public hearing in San Diego, CA; and 4 statements were presented at the October 14, 1999, public hearing in Honolulu, HI.

Each comment or statement received, whether written, contained in the transcripts of the public hearings, or transcribed from voice mail, was assigned one of the following letter codes:

G	Federal agencies and officials;
C	Congresspersons;
NN	NOAA/NMFS;
S	State or local agencies and officials;
O	Organizations and associations;
F	Form letters;
I	Individuals; and
P	Petitions

These labels were assigned for the convenience of readers and to assist the organization of this document; priority or special treatment was neither intended nor given in the responses to comments. Within each of the categories, each comment or statement was then assigned a number, in the order it was received and processed (e.g., F-001, S-001). Form letters were assigned both an individual/organization number and a form letter number.

All comments received were categorized into 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.

Written hearing transcripts are provided in Appendix F.

Comment submissions have been included in Appendix E to this Final OEIS/EIS. The alphanumeric code associated with each written submission is marked at the top of each page of the letter. Comment letters or statements are reprinted in numerical order. Only one representative entry for each form letter has been reproduced in Appendix E.

Tables 10-1 through 10-3 present lists of the commentors.

Table 10-1. Congresspersons and Federal/State/Local Agencies

Organization	Commentor Number	Location
County of Kauai	S-004	S-004
Marine Mammal Commission	G-001	G-001
NOAA/NMFS	NN-001	NN-001
State of California - California Coastal Commission	S-003	S-003
State of Delaware - Dept. of Nat. Resources & Env. Control	S-007	S-007
State of Georgia - Coastal Resources Division	S-006	S-006
State of Hawaii - DLNR	S-002	S-002
State of New Jersey - Dept. of Env. Protection	S-005	S-005
State of Texas	S-001	S-001
US Congress (Rep. P. Mink)	C-001	C-001
US Department of Interior	G-003	G-003
US Environmental Protection Agency	G-002	G-002

Table 10-2. Organizations and Associations

Organization	Commentor Number	Location
American Cetacean Society	O-027	O-027
Animal Embrace	O-036	F-002
Animal Protection Institute	O-009	O-009
Animal Welfare Institute	O-049	O-049
Australians for Animals	O-044	O-044
Bahamas Marine Mammal Survey	O-025	O-025
Cascadia Research Collective	O-054	O-054
Center for Whale Research	O-026	O-026
Cetacean Society International	O-039	O-039
Citizens for the Protection of Animals	O-013	F-001
Comprehensive Communications	O-024	O-024
Council of All Beings Animals, Insects, all of Nature	O-052	O-052
Dr. Jonathan Gordon	O-043	O-043
Dr. Marsha Green	O-055	O-055
Dr. Weilgart	O-020	O-020
Dr. Whitehead	O-021	O-021
Earth Island Institute	O-050	O-050
Earthjustice Legal Defense Fund	O-051	O-051
Ecology Protectors Society	O-019	O-019
Elsa Nature Conservancy	O-029	O-029
Environment & Community Organized, Inc.	O-031	F-001
Friday Harbor Laboratories	O-042	O-042
Global Agenda	O-041	F-001
Hawley and Wright Inc	O-040	O-040
In Defense of Animals	O-017	O-017
International Woman's Fishing Association	O-002	O-002
Just Cause Marketing	O-003	F-001
Lanny Sinkin	O-046	O-046
Lanny Sinkin	O-004	O-004
Lanny Sinkin	O-057	O-057

Organization	Commentor Number	Location
League for Coastal Protection	O-037	O-037
Marine Mammal Connection	O-032	F-001
Marine Society of the Pacific NW	O-014	F-002
Marion County Humane Society	O-001	O-001
National Council of SPCAs	O-012	O-012
Natural Resources Defense Council	O-028	O-028
Natural Resources Defense Council	O-033	O-033
Observe Respect & Compassion for Animals	O-022	O-022
ORCALAB	O-058	O-058
Orenda Wildlife Land Trust	O-011	F-001
Pacific Whale Foundation	O-053	O-053
Paradise Newland	O-045	O-045
Plan to Protect Kona	O-034	O-034
Planetary Partners	O-005	F-001
Psychologists for the Ethical Treatment of Animals	O-030	O-030
Quick Silver Advertising	O-010	F-001
Sea Shepherd Conservation Society	O-023	O-023
Sierra Club	O-015	O-038
Sierra Club	O-038	O-038
Sierra Club of Kaua'I	O-056	F-001
Sitka Conservation Society	O-048	F-001
SPCA of Pennsylvania	O-035	F-002
Student Animal Legal Defense Fund, Northwestern School of Law, Lewis & Clark College	O-018	O-018
Swiss Coalition for the Protection of Whales	O-008	F-001
The Humane Society of the U.S.	O-047	O-047
Verband Tierschutz-Organisationen	O-007	F-001
Whale and Dolphin Conservation Society	O-016	O-016
Working Group for the Protection of Marine Mammals	O-006	F-001

Table 10-3. Individual Commentors

Last Name	First Name	Title	Comentor Number	Location
Aadland	Judy		I-461	I-461
a'Becket	Suzanne		I-314	F-003
Adams	Elizabeth M.		I-303	F-001
Adams	Liz		I-784	F-001
Agnew	Donna		I-403	F-001
Aindeer	C.L.		I-547	F-001
Alarcon	Natalie		I-233	F-001
Alcindor	Habiba		I-087	F-001
Amber	Sharmai & Keith		I-065	F-001
Andelson	Jonathan G.		I-294	I-294
Anderson	Sherri		I-668	F-001
Andrews	John		I-008	I-008
ANON			I-953	F-002
ANON			I-142	I-142
Arcarese	Jo Ann		I-210	F-002
Archer	Cameo		I-324	I-324
Argo	Mary		I-787	F-001
Argyriru	Anne X.		I-820	F-001
Armstrong	John & Gladys		I-801	F-001
Armstrong	Ryan & Jerel		I-771	F-001
Arnold	JS		I-583	F-002
Arotzarena	Marianne		I-741	F-002
Ash	Michelle		I-649	F-001
Atchley	Jae R.		I-564	F-001
Aughtman	Denise		I-401	F-001
Aungst	Melinda E.		I-099	F-002
Averett	Susan		I-552	F-001
Axell	Janet		I-698	F-001
Bach	Susan M.		I-260	I-260
Baggett	Kathleen		I-493	F-001
Baillargeon	John		I-183	F-001
Baker	Raquel L.		I-789	F-001

Last Name	First Name	Title	Comentor Number	Location
Baldwin	Patty		I-567	F-001
Balsley	Rachel		I-570	F-004
Baning	Sally		I-830	F-001
Banks	Julie		I-222	I-222
Barber	Christina		I-141	I-141
Bareilles	Paul		I-939	F-001
Barham	Ann		I-157	F-001
Barker	Anne N.		I-348	F-001
Barlow	Mark		I-943	F-001
Barnhart	Stephanie A.		I-438	F-001
Barr-Marks	Terri		I-287	I-287
Bartola	Celia		I-496	I-496
Baseel	Eston		I-371	F-001
Basham	Robert	PhD	I-476	F-001
Baumann	Linda		I-110	I-110
Bautista	Erica		I-633	F-005
Beach	Maximillian		I-793	F-001
Beach	Mary Kay		I-794	F-001
Beal	Chandra		I-096	F-002
Beatty	Mary Pat		I-665	F-001
Beavers	Sallie C.		I-918	I-918
Beeler	J. Frederic		I-590	F-001
Beiter	Caryn		I-201	F-001
Beiter	Catherine		I-199	F-001
Beiter	Paul		I-202	F-001
Belanger	Susan		I-241	F-001
Belle	Laura		I-274	F-001
Belloso-Curiel	Jorge		I-214	I-214
Bennett	Jennifer Block		I-114	F-001
Bennett	William S.	BSEE	I-043	F-001
Berger	Richard		I-295	F-001
Berlandt	Spring		I-825	F-004
Berman	Emily		I-885	F-004
Berner	Joan		I-015	F-001

Last Name	First Name	Title	Comentor Number	Location
Bernstein	Karen, Steven, Diane		I-010	F-001
Bernstein	Alison		I-040	F-001
Bertrand	Kathleen		I-074	F-001
Bird	Joan R.	Dr.	I-781	I-781
Black	Peggy		I-121	F-001
Blackwelder	Alma		I-358	F-002
Blackwell	Chanel		I-646	F-001
Blaesing	Darla		I-896	F-001
Blank	Mark		I-648	F-001
Blechman	Shelley		I-489	F-001
Bloem	Joanna		I-762	F-001
Bloomer	Joe		I-225	F-001
Blough	Shirley		I-100	F-002
Bloxam	Sherry		I-832	F-001
Blum	Charles	Dr.	I-116	F-001
Bond	Deborah		I-928	F-001
Bonk	Marliese		I-176	F-002
Bonn	Stephen & Beatrice		I-588	F-001
Bowdle	Tracy		I-227	F-001
Bowers	Kristin		I-384	F-001
Boyd	Leah		I-359	F-001
Brackney	Megan		I-806	I-806
Brahman	SwanSong		I-250	F-001
Brakel	Judy		I-357	F-001
Brannen	Dianne		I-677	F-001
Bregman	Janice		I-112	F-002
Breslin	Kathie		I-689	F-001
Brezna	Robin L.		I-381	F-001
Briggs	Samuel L.	Sr.	I-865	F-001
Brook	Lena		I-078	F-001
Brook	Alison		I-895	F-001
Brooks	Kevin S.		I-463	F-001
Brooks	Tamar		I-119	F-001
Brown	Barbara F.	PhD	I-317	F-001

Last Name	First Name	Title	Comentor Number	Location
Brown	Shannon		I-440	F-001
Brunetti	David		I-312	F-002
Buckler	James R. Jr.		I-026	F-001
Burke	Jason		I-978	F-001
Burmeister	Mary C.		I-221	F-001
Burnett	Jennifer S.		I-022	F-001
Busa	Julie		I-368	F-001
Bushnell	Kay		I-156	I-156
Butler	Carolyn S.		I-550	F-001
Butler	Elizabeth		I-964	F-001
Callis	Sharron L.		I-308	F-001
Calvez	Leigh		I-499	I-499
Campbell	Laura		I-023	F-001
Campbell	Marty		I-587	I-587
Campo	Cindy		I-055	F-001
Campo	Joanna		I-037	F-001
Campo	Angela		I-056	F-001
Campo	Anthony		I-052	F-001
Carlson	Kenneth		I-783	F-001
Carlson	Sallie		I-335	F-002
Carollo	Chris		I-863	I-863
Carpenter	Barbara		I-398	I-398
Carr	Eileen		I-871	F-004
Carr	Steve		I-629	F-001
Carreiro	Trisha		I-850	F-001
Cartosi	Florence A.		I-064	F-001
Carty	John		I-031	F-001
Carvalho	Jo Ann		I-704	F-001
Cassteel	Sindona		I-319	F-001
Casteel	Margaret		I-254	F-001
Catori	Roman		I-627	F-005
Caudillo	M.		I-833	F-001
Cawley	Sandy		I-639	F-001
Cender	Jonathan		I-966	F-001

Last Name	First Name	Title	Comentor Number	Location
Chamberlain	Donald P.	Dir.	I-441	F-001
Chapelle	Gauthier		I-431	I-431
Charron	Lisa		I-336	F-001
Chase	Heather		I-231	F-001
Chason	Anne L.		I-515	F-001
Chatfield	Mady		I-922	F-001
Chatfield	Richard K.		I-932	F-001
Chaya	Helen		I-819	F-004
Cherry	Sylvia A.		I-449	F-001
Chew	Carolyn		I-961	F-001
Christopher	Diane		I-900	F-001
Chynoweth	Ann		I-193	F-002
Cichocki	Willow		I-738	F-001
Clare	Melissa		I-913	I-913
Clark	Pamela		I-846	F-001
Clark	John C.	CAPT	I-901	F-001
Cleland	Trena M.		I-795	I-795
Clendening	Cathy		I-382	I-382
Cobb	Eric		I-1017	F-001
Cocks	K.L.		I-761	F-001
Cohen	M.		I-363	I-363
Coldiron	Amanda		I-623	F-005
Coleman	Casey		I-717	F-001
Collier	Carol B.		I-238	F-001
Collins	Nicole		I-968	F-001
Collins	Judith		I-508	F-001
Collins	Diana & Rory		I-219	F-001
Collins	Adria L.		I-505	F-001
Comas	Patrick		I-617	F-005
Conger	Isis		I-1019	F-001
Conley	Linda		I-262	I-262
Cooley	Lauren		I-870	F-005
Cooley	Lauren		I-624	F-003
Cordero	Charles A.	Jr.	I-500	F-001

Last Name	First Name	Title	Comentor Number	Location
Corwin	Tom		I-527	F-001
Costa	Gina		I-610	F-005
Courson	Jeffrey		I-894	F-001
Coye	Margaret		I-005	I-005
Coyote	Tara		I-857	F-001
Craft	Catherine		I-858	F-005
Crean	Dennis M.		I-396	I-396
Crom	Nancy		I-837	F-001
Cronbaugh	Phyllis		I-642	F-001
Cronk	Sophia		I-464	F-001
Crow	Barbara		I-946	F-001
Crum	Johnathan		I-594	F-003
Culen	Patricia		I-697	I-697
Cunningham	Kat		I-137	F-001
Curnell	Lori R.		I-187	F-001
Curry	Raymond		I-369	F-002
Czarnecki	Michael		I-507	F-001
Dance	Jennifer		I-676	F-001
Danielson	Patricia J.		I-759	F-001
Dantis	Denise		I-716	F-001
DaVico	Judith & Kenneth		I-906	F-001
David	MD		I-723	F-001
Davis	Shannon		I-140	I-140
Davis	Jonathan		I-651	F-001
Davis	Nicole R.		I-135	F-001
Davis	Cameron		I-751	I-751
Dawes	Kai		I-593	F-001
Day	Judith		I-386	F-001
Deatrich	Dylan		I-637	F-003
Dechter	Bryan		I-235	F-001
Dellavo	Bill		I-184	F-001
Demakas	Athena		I-986	F-001
Denison	James		I-765	F-002
Dennison	Gail E.		I-985	F-001

Last Name	First Name	Title	Comentor Number	Location
Dente	Marj		I-580	F-001
DePalma	Bozena		I-320	F-001
Desler	Nancy		I-088	F-001
Detwiler	Ken		I-502	F-001
Devine	Walter		I-182	F-001
Devine	Anne C.		I-185	I-185
DeWig	Karen		I-670	F-001
di Sciara	G.N.		I-478	I-478
Diburmin	David		I-776	I-776
Dietal	Judith L.		I-474	F-001
Dietch	Judith		I-938	I-938
Digardi	Sandra		I-916	F-001
DiMezzo	Tracy		I-625	F-001
Dix	Michael		I-613	F-001
Doeninghaus	Kim		I-566	F-004
Dorey	Kathleen		I-081	F-001
Dorsey	Alice		I-283	F-002
Doughty	Roy D.		I-397	F-001
Douglas	Susan		I-299	I-299
Douglas	Robin		I-198	I-198
Dowling (Ret)	Robert J.	LTCOL	I-211	F-001
Drake	Helen		I-852	F-001
Drebert	Greg		I-890	F-001
duBois	Julie		I-746	F-001
Duffy	Megan		I-631	F-005
Dumm	Don		I-767	I-767
Dunnellan	Ed		I-929	F-001
Duong	Anh		I-755	F-001
Dustin	Asa		I-976	F-001
Dux	Penelope		I-960	I-960
Dyak	Miriam		I-296	F-001
Each	Edward		I-721	F-001
Earth	Robin		I-881	F-004

Last Name	First Name	Title	Comentor Number	Location
Eaton	Margaret		I-172	I-172
Edgar	Laura		I-436	F-002
Edwards	Michael		I-996	F-001
Eichler	Monika		I-640	F-001
Einkauf	Ellen		I-316	I-316
Elders	Stephanie		I-699	F-001
Elizabeth	Laureen		I-538	I-538
Elliott	Naneki		I-748	F-001
Ellis	Lisa		I-919	F-001
Ernst	Bill		I-452	F-001
Espinosa	Susan M.		I-706	I-706
Evans	Dierdre		I-782	F-001
Evans	Janice A.		I-582	I-582
Evans	F.		I-004	I-004
Evans	Dave		I-315	F-001
Evans	Bryan		I-915	I-915
Everett	Diana		I-423	F-001
Evers	Lisa R.		I-562	F-001
Evers	Craig		I-802	F-001
Everts	Nancy K.		I-473	F-001
Faeste	Tanya		I-977	F-001
Fahrbach	Gisella		I-077	F-001
Fano	Emily		I-293	F-001
Fantuz	Jennifer R.		I-758	I-758
Farley	Alan		I-970	F-001
Farrell	Belinda		I-084	F-001
Fauntleroy	Dearing		I-289	F-001
Fauth	Megan		I-600	F-005
Fazin	Jennifer R.		I-054	F-001
Fazin	Jay		I-053	F-001
Fedorak	Steve		I-601	F-003
Feldman	Richard & Lana		I-693	I-693
Ferguson	Dawn		I-683	I-683
Fernandez	Rona S.		I-790	F-001

Last Name	First Name	Title	Comentor Number	Location
Ferraro	Caroline		I-638	F-005
Feuerstein	Trisha Lamb		I-204	F-001
Fielding	Heidi		I-309	F-001
Finnegan	Judie		I-029	F-001
Firth	Carol		I-826	F-002
Fishbach	Michael		I-584	F-001
Fisher	Madeleine D.		I-520	F-001
Fitzjarrald	Joan		I-494	I-494
Flag	Diana		I-822	F-004
Flanagan	J.E.		I-707	F-001
Fleischauer	Karl		I-450	F-001
Formasi	Sallie		I-569	F-004
Fortuny	Erika C.		I-322	F-002
Francis	Khalile		I-656	F-005
Francis	Susan		I-155	F-002
Franey	John		I-975	F-001
Freedkin	Steve		I-269	I-269
Freeman	Rosie		I-692	F-002
Frey	Susan		I-927	F-001
Friedman	Amalia		I-1015	F-001
Friedrichsen	A.		I-733	F-001
Gales	Eileen		I-778	F-001
Galli	William		I-663	F-002
Galloway	Fiona L.		I-518	F-001
Gally	Karen		I-1009	F-001
Gambino	Jill		I-353	F-002
Gans	Edward A.		I-038	F-001
Garcia	Luis		I-614	F-003
Garson	Paul		I-085	I-085
Gates	Michael		I-664	F-001
Gaynor	Kathleen		I-650	F-005
Gebru	Seble		I-634	F-005
Geffen	Elaine K.		I-059	F-001
Genevich	Genny		I-223	F-001

Last Name	First Name	Title	Comentor Number	Location
Genteel	Linda		I-523	F-002
Gerbracht	Heidi		I-094	F-002
Gerritson	Stephen L.		I-548	I-548
Gerwick-Brodeur	Madeline		I-719	I-719
Gianantoni	Maryann		I-050	F-001
Gibson	Constance B.		I-519	F-001
Gilbert	Joel		I-458	I-458
Gillespie	Nicholas		I-967	F-001
Gimon	Zoe		I-245	I-245
Giorni	Chris		I-861	I-861
Glassman	Mark		I-606	F-001
Glinsky	Natasha		I-878	F-001
Golden	Monique		I-983	F-001
Goldman	Sue		I-006	I-006
Gomez	German		I-605	F-001
Gompertz	Rolf & Carol		I-391	F-001
Gonzalez	Sandra E.		I-383	F-001
Goodlove	Glenn	LCSW	I-220	I-220
Goodman	Sierra		I-115	F-001
Goodman	Tama		I-824	F-004
Goodman	Robert		I-497	F-001
Goodman	Roberta		I-902	I-902
Gordon	David M.		I-841	F-001
Gordon	Elinore B.		I-337	I-337
Gorla	Salvatore & Lisa		I-796	F-001
Goulart	Monica		I-102	F-001
Graehl	Christopher		I-1011	F-001
Graham	Mary Huber		I-799	F-001
Graham	Nicole		I-834	F-001
Graham	Tonya		I-888	F-001
Greenwood	Candace		I-891	F-001
Gregg	Doralene		I-998	F-001
Griffin	Clarice		I-654	F-005
Griffin	Nell		I-126	F-001

Last Name	**First Name**	**Title**	**Comentor Number**	**Location**
Groode	Justin S.		I-435	F-001
Grossman	Doree		I-568	F-004
Gudbrandsen	Sharon		I-791	F-001
Guerin	Karen		I-713	F-001
Gundersen	Dan		I-265	I-265
Gustavsson	Yvonne		I-465	I-465
Haarstick	Karen	MS	I-712	F-001
Hachey	Leanne		I-728	F-001
Hafner	Brenda J.		I-427	F-001
Hagen	Carole E.		I-973	F-001
Hale	Annette		I-577	F-001
Hall	Susan		I-373	F-002
Hall	Jaime		I-628	F-005
Hallal	Norman J.		I-903	F-001
Halley	Aricea S.		I-982	F-001
Haltom	Gale M.	Freight Auditor	I-448	I-448
Hamel	Donna		I-379	I-379
Handy	Jane		I-148	F-001
Handy	Jane		I-131	F-001
Handy	Myra		I-083	F-001
Hanley	Bridget		I-218	I-218
Hansen	Barbara J.		I-341	F-001
Haralson	Cindi		I-884	F-004
Harding	Kristen		I-868	F-005
Harrington	Patty	Rev.	I-352	I-352
Harris	Marjorie A.		I-732	I-732
Harrison	Charlene		I-754	F-001
Hawkins	Karen		I-526	F-001
Hayes	Gerri		I-727	F-001
Hazelton	Naomi		I-1006	F-001
Hearey	Kate		I-643	F-001
Heber	Brooke		I-080b	F-001
Hebert	Genevieve A.		I-089	F-001

Last Name	First Name	Title	Comentor Number	Location
Heeley	Diane		I-847	F-001
Heemstra	Karin		I-818	F-004
Heilsburg	Carol		I-685	F-001
Heller	Joan S.		I-041	I-041
Helmer	Sue		I-034	F-001
Henderson	Rhonda S.		I-378	F-001
Herold	Eston		I-989	F-001
Herzig	Sarah		I-575	F-001
Hess	Donald S.		I-851	F-001
Hicks	Debbie		I-701	F-001
Hicks	Doug		I-239	I-239
Hicks	Doug		I-192	I-192
Hill	Deborah		I-745	F-001
Hills	Mary L.		I-1016	F-001
Hines	Lori		I-400	I-400
Hinman	Dorothy		I-803	F-001
Hitzeman	Lee Ann		I-586	F-001
Hoehn	Lee		I-344	F-001
Holt	Catherine F.		I-175	I-175
Honish	Joan		I-511	F-001
Hooker	S K.		I-682	I-682
Hoop	Heidi		I-914	F-001
Hopler	Jean		I-044	F-001
Hopler	Robert S.		I-057	F-001
Hopler	Jay R.		I-036	F-001
Hotchkiss	Karen		I-252	F-002
Howard	Charlotte		I-962	F-001
Howard	Kristin		I-813	F-001
Howell	Mark		I-839	F-001
Hoy	Nancy Jo		I-170	I-170
Hughes	Julie C.		I-486	F-001
Hughes	Charlona		I-092	F-001
Hughes	Blake		I-138	I-138
Hunter	Christyna M.		I-124	F-002

Last Name	First Name	Title	Comentor Number	Location
Hurley	Nancy		I-158	F-001
Huse	G.		I-814	F-004
Hyson	Michael		I-1020	I-1020
Iglehat-Austen	Hallie		I-455	I-455
Jacobs	John		I-524	F-001
Jacobson	Laurie		I-773	F-001
James	Clarity		I-253	F-001
Jansen	Carolyn		I-559	F-001
Jarvarty	J.		I-980	F-001
Jaynes	Lynne S.		I-334	F-001
Jaynes	Michael M.		I-333	F-001
John	Lyn		I-242	I-242
Johnson	Susan		I-954	I-954
Johnson	Jennifer		I-399	F-002
Johnson	Joanne		I-556	F-002
Johnson	Christian		I-354	F-001
Johnson	Catherine		I-160	F-001
Johnson	Neil		I-506	F-001
Johnson	Shari		I-521	F-001
Jolly	Paul		I-042	I-042
Jones	Guy G.		I-009	I-009
Jones	Jeremy A.		I-726	I-726
Jones	Caroline		I-630	F-005
Jones	Carrie		I-644	F-001
Jones	Robert H.		I-080a	F-001
Jones	Gwendolyn		I-456	I-456
Kallail	Kara		I-536	F-001
Kanter	Alton G.		I-994	F-001
Kany	Patrick		I-595	F-005
Kaplan	Steve		I-209	F-001
Kaplinsky	Nick		I-873	I-873
Kari	Carol A.		I-118	F-001
Kas	Ethel & Robert		I-045	F-003
Katzeff	Anne S.		I-377	F-001

Last Name	First Name	Title	Comentor Number	Location
Kearny	Gresson		I-674	I-674
Keehn	Suzanne		I-763	F-001
Kehoe	Christopher M.		I-971	F-001
Keleyhers	Shelagh		I-731	I-731
Kelleher	Donna	DVM	I-082	F-001
Kelner	Marian		I-161	F-002
Kelsey	Colleen & Steve		I-735	F-001
Kemper	Virginia		I-848	F-001
Kennedy	Mari		I-897	F-001
Kerstine	Hans		I-672	F-001
Keyser	Fred J.		I-266	F-001
Killough	Maurine		I-924	F-001
Kimball	Renee Daphne		I-277	F-001
Kimbrell	John		I-103	F-002
King	Timothy		I-503	F-001
King	Kathleen A.		I-097	F-003
Kiokemeistar	Karen		I-340	F-001
Kirby	Suzanne J.	Dr.	I-062	F-001
Kirkland	Victoria L.		I-477	I-477
Kizanis	Brenda		I-457	F-001
Klinkhart	Amd		I-001	I-001
Knick	Benjamin		I-720	F-001
Koch	William G.	Sr.	I-215	F-001
Koch	Wendy		I-740	I-740
Koenig	Susan		I-872	F-004
Kolder	Linda Jo		I-067	F-001
Kornegger	Peggy		I-338	F-001
Kowal	Deborah		I-443	F-002
Kozaski	Rachel		I-302	F-001
Kramer	Valerie		I-145	F-002
Kramer	Jan		I-495	I-495
Krause	John		I-446	F-001
Kreidler	Nicolay		I-710	F-001
Kreutner	Melissa		I-228	F-001

Last Name	First Name	Title	Comentor Number	Location
Krizek	Angela Rosa		I-513	F-001
Kubislak	Kathe		I-483	F-001
Kuehlwein	Robert E.		I-402	I-402
Kull	Kristina		I-785	I-785
LaBriere	Karin		I-125	F-001
Laderman	John		I-573	F-001
Lager	Lisa Marie		I-856	F-001
Lamb	Lisa		I-956	I-956
Lamb	Ray		I-480	I-480
Lamb	Christine		I-705	F-001
Lambert	Barbara	DDS	I-149	I-149
Lapluewicz	Janice K.		I-563	F-001
LaPorta	Julia		I-1004	F-001
Larson-Jeyte	Lorna		I-911	F-001
Lavander	Leslie		I-216	F-001
LeBlanc	Laurie A.		I-282	F-001
Lee	Karen		I-261	I-261
Lee	Mike		I-950	F-001
Lehman	Karen		I-742	F-001
Lehmann	Karen		I-936	F-001
Lehmann	Christopher D.		I-743	F-001
Lemery	Kate		I-186	I-186
Lersch	Gert & Marlies		I-667	F-001
Lesher	Deborah A.		I-509	F-001
Leslie	Matt		I-002	I-002
Levenson	Wendy	Atty.	I-749	F-002
Levin	Genevieve		I-416	F-001
Levin	Helene D.		I-482	F-001
Levy	Jody		I-485	F-001
Lewis	Rebekah		I-657	F-001
Lichtenstein	Steven		I-258	F-002
Lichter	Sheldon		I-898	F-001
Lichter	Russell		I-560	F-001
Liddle	Catherine J.		I-997	F-001

Last Name	First Name	Title	Comentor Number	Location
Lightner	Tiffanie		I-883	F-004
Lill	Wayne P.	Jr.	I-429	F-001
Linder	Sally		I-808	F-001
Lindsay	Melissa R.		I-912	F-001
Linhardt	Heather		I-969	F-001
Lloyd	Jason		I-612	F-005
Lombard	Jesse		I-988	F-001
Longmore	Sandra		I-376	F-001
Lorden	Lisa J.		I-305	F-001
Lorenzen	Michael G.		I-931	F-001
Lotterhos	Ann M.		I-263	I-263
Love	Cherie		I-828	F-001
Lovette-Black	James C.	Rev.	I-113	F-002
Loyd	Rita		I-162	F-001
Loyd	Jody S.		I-528	F-001
Lucas	Alicia		I-596	F-001
Lucas-Allison	Augusta		I-163	F-004
Lumpkin	Edward		I-370	F-002
Lynch	James		I-195	F-002
Lynne	Nancy		I-1002	F-001
Macfadden	Jennifer		I-722	F-001
MacLaren	Mary		I-387	F-001
MacNeil	Susan		I-060	F-001
MacPhee	Bonnie		I-662	I-662
Mae	Jessie		I-467	F-001
Mae	David		I-752	F-001
Magana	Michelle		I-736	F-001
Magill	Cheryl A.		I-766	I-766
Magnusson	Kristina		I-821a	F-004
Magnusson	Kristina		I-821b	F-001
Mahoney	Kathleen		I-224	I-224
Mainzinger	Krysti		I-188	F-001
Maio	Elsie		I-554	F-001
Mair	Gayle		I-836	F-001

Last Name	First Name	Title	Comentor Number	Location
Malchisky	Michele		I-063	F-002
Malkin	Cathy		I-688	F-001
Malone	Leigh A.		I-123	F-001
Mankin	Lynnda		I-068	F-001
Manning	Bay		I-724	I-724
Marburger	Lisa		I-355	F-001
Marks	Tiffany		I-510	F-001
Marshall	Pat		I-306	F-002
Marshall	Mary		I-469	F-001
Martin	Jan		I-134	I-134
Martin	C.A.		I-362	F-001
Martin	Jan		I-133	F-002
Martineau	Nicole		I-281	F-001
Martinello	Joy		I-247	I-247
Mastrapa	Elizabeth		I-173	F-001
Matkins	Teryl S.		I-120	F-001
Matlile	Jay		I-1003	F-001
Matthews	Natalie		I-136	F-001
Mauger	Maura		I-992	F-001
Maxwell	Nelson		I-268	F-001
May	Donald		I-331	F-002
Mayrovitz	Suzanne		I-321	F-001
Mazzone	Marie		I-671	F-001
McCaffrey	Dona I.		I-304	F-002
McCain, III	C.S.		I-835	I-835
McCarthy	Nancy W.		I-212	F-001
McChesney	Paula		I-935	F-001
McGill	Ryan		I-1014	F-001
McHale	Carol S.		I-565	F-004
McHenry	Betz		I-874	F-004
McKinney	Parks		I-286	F-001
McKinnon	Rayna		I-609	F-001
McLauglin	Christine A		I-256	F-001
McLean	Sarah		I-691	F-001

Last Name	First Name	Title	Comentor Number	Location
McNamee	Bonnie A		I-251	F-001
McNeil	M		I-275	F-001
McRaine	Malone B.		I-905	F-001
McVay	Sterling		I-542	F-001
Meissner	Stephanie		I-132	F-002
Mercer	Marijane		I-838	F-001
Metropole	Christienne		I-178	F-001
Metz	Geri		I-700	I-700
Meyer	Keni Mae		I-949	F-001
Miller	Richard		I-459	F-001
Miller	Chastity		I-127	F-002
Miller	Susan L.		I-090	F-001
Miller	Gaye S.		I-987	F-001
Miller	Benjamin		I-990	F-001
Milton	Eileen		I-517	I-517
Miskowich	Meredith		I-696	F-001
Misukewicz	Christine		I-106	F-002
Mitchell	Eric		I-659	F-005
Mitchell	Matthew		I-432	F-001
Mitnik	Susan		I-993	F-001
Mittelstedt	Jolene		I-154	F-002
Mize	Anne B.		I-546	F-001
Monagan	Michael		I-273	F-001
Moncrief	Fern		I-229	F-001
Monrone	Jody		I-257	F-001
Montague	Susan		I-576	F-002
Moore	Laura		I-194	F-002
Moore	Susan		I-165	I-165
Moore	Jim		I-174	I-174
Morabito	Kyle F.		I-447	F-001
Moran	Jennifer		I-869	F-005
Morgan	Linda		I-284	F-002
Morningstar	Larry		I-965	F-001
Morrill	Victoria		I-531	F-001

Last Name	First Name	Title	Comentor Number	Location
Morris	Lindsey		I-093	F-001
Morris	Kirstin		I-579	F-001
Morton	Jess		I-003	I-003
Motz	Nancy		I-095	F-001
Mouwen	Patrick		I-760	I-760
Moy	Christopher		I-599	F-003
Mullane	Sharon		I-027	F-001
Munroe	Susan		I-923	F-001
Murray	Kevin J.		I-410	F-001
Murray	Jay		I-424	I-424
Musco	Anne		I-777	I-777
Myers	Marilyn & Michael		I-585	F-001
Na Hung	Prusa		I-571	F-004
Nagel	Robert F.		I-829	F-001
Nation	Alicia		I-390	F-001
Nations	Jim		I-827	F-001
Neale	Christopher		I-207	F-001
Neale	Heddi L.		I-205	F-001
Neale	Irene		I-206	F-001
Nelson	Patricia		I-098	F-002
Newling	Donna J.		I-933	F-001
Newman	Galen		I-708	F-001
Newman	David		I-555	F-001
Newsom	Clerca		I-374	I-374
Noble	June		I-047	I-047
Norman	Melissa		I-991	F-001
Norman	Neal		I-995	F-001
Norris	Marya		I-981	F-001
Norton	Richard		I-421	F-001
Novak	Catherine		I-772	F-001
Nuell	Joy		I-343	I-343
Nultemeier	Eric L.		I-189	F-001
Nungara	Ruanne		I-366	F-001
Oberste-Lehn	Deane	Dr.	I-769	I-769

Last Name	First Name	Title	Comentor Number	Location
O'Brien	Willo S.		I-475	F-001
Oleigoarthigh	Maitin		I-658	F-001
Oliver	Della		I-107	F-002
Olsen	Jennifer A.		I-1012	F-001
Olson	Andrea		I-815	F-004
O'Malley	Thomas		I-831	I-831
O'Malley	Marya		I-957	I-957
O'Neal	Joyce		I-013	F-001
O'Neill	Adrienne		I-598	F-001
Ono	Mark		I-702	F-001
Orvieto	Darlene		I-409	F-001
Page	Chris		I-159	F-002
Pampera	John		I-709	F-002
Pangaia	J'aime ona		I-551	F-001
Papadoplos	Anastasia		I-661	F-001
Pardee	Cyndi		I-737	F-001
Parizeau	N.		I-012	F-001
Parkin	John		I-862	F-004
Parkman	E. Breck		I-844	F-001
Parnell	Kristie		I-365	F-001
Parrish	Kathy		I-208	F-002
Parrish-Nichols	Evan & Jocelyn		I-553	F-001
Patch	Lisa		I-288	F-001
Patil	Meghan		I-318	F-001
Pavlick	Amanda		I-619	F-005
Payne	Lareina		I-1018	F-001
Payne	Susan		I-768	F-001
Peach	Ahbra		I-944	F-001
Pearse	Alison A.		I-855	F-001
Peck	Natalie		I-561	F-001
Peck	Barbara		I-1005	F-001
Peinemann	Myles		I-249	F-001
Pelletier	Wendy		I-007	I-007
Perez	Juan & Jill		I-864	I-864

Last Name	First Name	Title	Comentor Number	Location
Perlman	Frances		I-213	F-002
Perrer	I-298		F-003	
Perry	Linda		I-255	F-002
Peugh	Barbara		I-139	I-139
Philcrantz	Carol		I-197	F-001
Phillips	Shiona		I-530	F-001
Phinney	Richard C.		I-471	F-001
Piccoli	Jessica		I-632	F-001
Picolla	Marcy K.		I-468	F-001
Pierce	Rebecca		I-259	F-001
Pierce	Heidi		I-597	F-005
Podolske	James		I-788	F-001
Pollick	Aaron		I-635	F-003
Pollow	Ruth		I-753	F-001
Pomeroy	Scott		I-963	F-001
Pomies	Jackie		I-108	F-002
Pope	Wellington T.		I-512	I-512
Poplin	Stan		I-075	F-001
Porke	Rachel		I-792	F-001
Porter	Rachel		I-534	F-001
Portida	Alberto		I-899	F-001
Potter	John	Dr.	I-425	I-425
Pounds	Dale & Rick		I-453	F-001
Praria	Kimberly		I-647	F-001
Pravata	Todd		I-111	F-002
Pretne	M.		I-434	F-001
Putman	Victoria		I-558	I-558
Quart	Diane		I-011	F-001
Query	Mark A.		I-972	F-001
Quinn	Daniel		I-076	F-001
Rabel	Therese E.		I-039	F-001
Radziszewski	Joseph P.		I-422	F-001
Ragan	Margaret		I-487	F-001
Ragsac	Candida		I-1013	F-001

Last Name	First Name	Title	Comentor Number	Location
Ramirez	Luisa		I-297	F-001
Ramsey	Val M.		I-237	F-001
Rand	Robert W.		I-290	I-290
Ranna	Margaret U.	P. Geol.	I-472	I-472
Rapino	Tony		I-626	F-003
Ratza	Coreen		I-168	F-001
Ray	Mindy		I-404	F-001
Reich	Susanna		I-069	F-001
Reid	Heather		I-016	F-001
Reigle	Dom		I-611	F-003
Remer	Roy		I-525	F-003
Rendell	Luke		I-501	I-501
Retson	Barbara K.		I-840	F-001
Revell	Karen		I-892	I-892
Reyes	Miriam E.		I-014	F-001
Reyes	Olga		I-046	F-001
Reynolds	Patrick		I-484	F-001
Rhodes	Robin		I-798	F-001
Richard	John J.	CFA	I-750	F-001
Richards	Devin		I-853	F-001
Richards	Chevonne		I-350	F-001
Richardson	Chaska		I-129	F-001
Richardson	Riser		I-797	F-001
Richardson	Michael		I-310	F-001
Richardson	Heather		I-636	F-001
Richardson	Leif		I-810	F-001
Riehm	Louisa		I-217	I-217
Ries	Jennifer		I-420	F-001
Riser	Carol		I-311	F-001
Ritchie	Erin M.		I-603	F-001
Rivkin	Irina		I-572	F-004
Robbins	Holli Joy		I-999	F-001
Roberti	Alexandria		I-882	F-004
Robinson	Jennifer		I-616	F-001

Last Name	First Name	Title	Comentor Number	Location
Robinson	Serina		I-621	F-005
Rogers	Dean		I-035	F-001
Rohr	Patricia		I-715	F-001
Rooney	Mary		I-236	F-001
Rose	Linda M.		I-481	F-001
Rosemarin	Kenneth H.		I-529	F-001
Rosenthal	Linda		I-498	F-001
Ross	Lee		I-679	I-679
Roth	James		I-451	F-001
Rozett	Ella & Bob		I-433	F-001
Rush	Kimberly		I-959	F-001
Sahler-Beleele	Emily		I-300	F-001
Salido	Paris M.		I-361	F-001
Samuelson	Catherine		I-389	F-001
Santer	Johanna		I-725	I-725
Santos	William P.		I-925	F-001
Saputo	Vicki		I-066	F-001
Sardi	Diane		I-714	F-001
Saunders	Leslie E.		I-079	F-001
Savoner	Lynn		I-357	F-001
Schaefer	Katherine		I-615	F-003
Schafer	Vincent		I-641	F-001
Schechter	Jill		I-544	I-544
Scheetz	Eli		I-958	F-001
Schiff	Jean M.		I-246	F-001
Schlappich	Larry		I-152	F-001
Schlappich	Georgine		I-153	F-001
Schlappich	Christine		I-380	F-001
Schmidt	Michael I.		I-940	F-001
Schoch	Patty J.		I-061	F-001
Schoichet	Ellis		I-744	F-001
Schramm	Greg		I-860	I-860
Schultz	Linda		I-842	F-001
Schultz	Joseph		I-780	I-780

Last Name	First Name	Title	Comentor Number	Location
Schwartz	Denise		I-407	F-001
Schwartz	Stuart		I-490	F-001
Schwartz	Jacqueline		I-491	F-001
Schwarz-Nagley	Sharon		I-444	I-444
Scianna	Mary		I-652	F-003
Scott	Melinda		I-1007	F-001
Scotten	Donna		I-072	F-001
Scotten	Harmony		I-070	F-001
Scotti	Marni		I-191	F-002
Segal	Katherin King		I-203	F-001
Sekera	Michael		I-730	I-730
Sekkowitz	Rhona I.		I-017	F-001
Selfridge	Barbara		I-875	I-875
Selle	Todd		I-537	F-001
Sellitto	Antoinette		I-346	I-346
Selquist	Donna J.		I-479	I-479
Seymour	Paul		I-232	I-232
Seymour	Audrey		I-367	F-001
Seyor	Deva		I-1000	F-001
Shadrach	Jonathan		I-1008	F-001
Shahhosseini	Karen		I-462	F-001
Shain	Mark		I-532	F-001
Shandler	Jalien		I-301	I-301
Shanks	Brenda L.		I-466	F-001
Shanley	G.Y.		I-539	F-001
Shapiro	Daniel		I-030	I-030
Shelburne	Linda		I-437	F-001
Sheppard	Jennifer		I-1010	F-001
Shewalter	Wendy A.		I-729	F-001
Shimek	David		I-979	F-001
Shinn	Margaret		I-492	F-001
Shubb	Linda		I-843	F-001
Shumway	Loretta W.		I-091	F-001
Siegel	Lisa		I-535	F-001

Last Name	First Name	Title	Comentor Number	Location
Siegenthaler	Dolores		I-086	I-086
Silver	Mark		I-280	F-001
Simon	Michelle		I-876	I-876
Singh Khalsa	M.A.	Dr.	I-540	I-540
Siphtroth	Michael		I-955	I-955
Skinder	Jennifer L.		I-809	F-001
Skulnik	David		I-117	F-001
Sligh	Kabrene		I-655	F-005
Smith	Amy		I-025	F-001
Smith	Kelle Ahein		I-541	F-001
Smith	Ben M.	III	I-150	F-002
Smith	Nancy		I-445	I-445
Smith	Nils		I-128	F-001
Smith	James		I-071	F-001
Smultea	Mari A.		I-770	I-770
Soule	David		I-804	F-001
Spellmeyer	Susanna		I-032	F-001
Spivey	Janet J.		I-718	F-002
St. Aubin	Janet		I-151	F-002
Stabile	Diane		I-169	F-001
Stacy	Eryk		I-105	F-002
Stahr-Brown	J.		I-739	F-001
Starbuck	Kristen		I-144	F-001
Stark	June B.		I-904	F-001
Stark	Rebecca		I-734	F-001
Stark	Anna		I-686	F-001
Stark	Anna		I-805	F-005
Starr	Kayla M.		I-887	F-001
Stateler	Ann		I-893	I-893
Steele	Kat		I-711	F-001
Steele	Nathan		I-602	F-001
Stein	Karin		I-442	I-442
Stevens	Hanna E.		I-545	F-001
Stevenson	Keri		I-200	F-001

Last Name	First Name	Title	Comentor Number	Location
Stewart	Kay		I-240	I-240
Stickley	Joan F.		I-166	I-166
Stickley	Joan F.		I-167	F-001
Stocker	Michael		I-349	I-349
Stofflet	Suzanne		I-028	F-001
Stok	P.		I-073	F-001
Stotland	Judi		I-230	F-001
Stowe	Danielle		I-823	F-004
Strauss	Stan		I-684	F-001
Streeter	Sherry		I-278	I-278
Strenger	Lori		I-143	F-002
Strong	A.J.		I-428	F-001
Stulte	Marsha		I-415	F-001
Sumner	B.J.		I-607	F-003
Sundberg	Bryon		I-104	F-002
Sutton	Justine		I-574	F-004
Sutton	Beverley		I-226	F-001
Swain	D		I-816	F-004
Swanson	Scott		I-177	F-001
Swanson	John		I-779	I-779
Swartz	Stacy		I-234	F-002
Swaynginn	Sarah		I-645	F-005
Swetlik	Daniel		I-926	F-001
Swiecicki	A.G.		I-522	I-522
Swiecuki	Jenny		I-879	F-004
Swindell	Tom		I-947	F-001
Szundy	Noel B.		I-866	F-001
Tancini	Bernadette		I-504	F-001
Taniguchi	Misty		I-1001	F-001
Taormina	Steven		I-460	F-001
Tarango	Norma		I-703	F-001
Tashian	Barry		I-812	F-001
Taylor	Aubrey		I-147	F-001
Tegtmeier	Diane		I-291	I-291

Last Name	First Name	Title	Comentor Number	Location
Teitge	Miles		I-048	F-003
Temple	Timothy A.		I-470	I-470
Tepley	Lee	Dr.	I-454	I-454
Terra	Xo		I-811	F-001
Terraluna	Manuela		I-345	F-001
Tertes	Andrew		I-917	I-917
Thai	Karuna		I-695	F-001
Thesier	Kelli		I-618	F-001
Thiemt	Martha		I-058	F-001
Thomson	Sheila		I-122	F-001
Tittiger	Michael		I-578	F-001
Titus	Dorothy J.		I-375	F-001
Tonsignant	Matthew		I-859	I-859
Torrence	Laura		I-325	F-001
Torres-Speeg	Mildred		I-413	F-001
Trees	Jonne		I-418	F-001
Trego	Laura		I-267	I-267
Trimble	Robert L.		I-756	F-001
Trombadore	James		I-033	F-001
Tullgren	Eliza		I-660	F-001
Turner	Alicia		I-272	F-001
Turner	Chitra		I-276	F-001
Turowski	Patrice & Joseph		I-109	F-001
Tuttle	Chris		I-332	F-001
Ugles	Sam		I-248	I-248
Unanian	Betty		I-984	F-001
VaJames	Carole		I-196	F-002
Valladares	Tracey		I-018	F-001
Van Arsdale	William G.		I-271	F-001
Van Dyne	Jan		I-372	F-002
Van Oake	Jim		I-952	I-952
Vandervord	Nicole		I-024	F-001
Verrill	Andrea		I-581	F-001
Verte	Grace		I-889	F-001

Last Name	First Name	Title	Comentor Number	Location
Vgbaya	Boi-Lucia		I-620	F-005
Victor	Arisa		I-395	I-395
Vignard	Paul		I-942	F-001
Vigo	Maru		I-243	F-002
Vineyard	Robert P.		I-021	I-021
Volpe	Michael		I-393	F-001
Volpe	James D.		I-392	F-001
Volpe	Sherry D.		I-411	F-001
Vossen	Marisa		I-945	F-001
Wadleigh	Annette M.		I-807	I-807
Wagner	Emily		I-653	F-005
Wakefield	Jamie Rae		I-049	F-001
Walden	Robin		I-533	F-001
Walker	Markia		I-608	F-003
Walker	Alison		I-681	I-681
Walsh	Terri		I-880	F-004
Walsh	Wendy		I-360	F-001
Walther	Regina		I-307	F-001
Waters	Darlene J.		I-439	F-001
Watson	Karen D.		I-130	F-001
Watson	Margaret & Joe		I-146	F-001
Watson	Rosemary		I-394	F-001
Weary	Dana M.		I-757	I-757
Weaver	Abigail		I-051	F-001
Webb	Patricia D.		I-327	F-001
Webb	Mary H.		I-786	F-001
Weber	Sonya N.		I-364	F-001
Weber	Merryl		I-180	F-001
Weber	Stephen A.		I-179	F-001
Weeks	Susan		I-323	F-001
Weingartz	Ruth		I-849	F-001
Weir	Kathleen		I-948	F-001
Weiseth	Paul R.	DVM	I-974	F-001
Weishelt	Christine		I-171	F-001

Last Name	First Name	Title	Comentor Number	Location
Welfelt	Sandy		I-019	F-001
Wells	Melissa		I-264	I-264
Wells	Amy		I-774	F-001
Wendt	Roger		I-673	F-001
Wentzel	Adam		I-800	F-003
Werner	Kate		I-622	F-001
Westermeier	Barbara A.		I-020	F-001
Wheatley	Douglas		I-591	F-001
Wheaton	Judith		I-430	F-002
White	Todd		I-604	F-005
Whiting	Pamela		I-385	F-001
Wiederanders	Ellen		I-313	F-003
Wiklund	Nancy		I-817	F-004
Wilbur	Kim		I-775	I-775
Wiles	Juliette		I-687	I-687
Willaby	Melissa		I-845	F-001
Willcox	Maia K.		I-678	I-678
Williams	Susan		I-347	F-002
Williams	Michael		I-867	F-001
Williams	Robert A.		I-930	F-001
Williamson	M. Todd	Dr	I-690	F-002
Wilson	Patricia		I-330	F-001
Wilson	Gordon E.		I-934	F-001
Winston	Diane		I-589	F-004
Wirtz	Maria		I-190	F-002
Wolf	Melissa		I-694	I-694
Wolfanger	Tammy		I-328	F-002
Wood	Genevieve		I-908	I-908
Wood	Rhianna		I-909	I-909
Wood	Peter		I-910	I-910
Wood	Lisa		I-907	I-907
Wooley	Ann M.		I-951	F-001
Woywood	Clemens		I-675	F-001
Wray	Amy M.		I-164	F-001

Last Name	First Name	Title	Comentor Number	Location
Wright	Jodie		I-557	F-001
Wright	Rhonda	Dr.	I-342	F-002
Wu	Carol & Keelyn		I-414	F-001
Wursten	Mary E.		I-417	F-001
Wursten	Elisabeth		I-285	F-001
Y.	Dave		I-877	I-877
York	Lee		I-101	F-002
York	Linda Sparrow		I-292	F-001
Yosho	C.		I-937	F-001
Young	Allen		I-406	I-406
Young	Jerielle		I-339	F-001
Young	Cathleen		I-412	I-412
Young-Nycz	Denise		I-244	F-002
Zaich	Dana		I-941	F-001
Zawatsky	Tara		I-592	F-003
Zenobi	Nadine		I-351	F-003
Ziomek	Karen		I-405	F-002
Zoidis	Ann M.		I-764	I-764

10.4.3 Detailed Response to Comments

This subchapter presents the detailed response to comments made by all commentors on the Draft OEIS/EIS.

CHAPTER 1 PURPOSE AND NEED

ISSUE 1-1: THE SUBMARINE THREAT

Comment 1-1.1: The Cold War has ended; what is the justification for the need for the SURTASS LFA sonar? (G-001, I-008, I-030, I-240, I-247, I-248, I-269, I-290, I-687, I-764, I-864, I-913, I-915, O-020, O-027, O-038, O-039, O-040, O-051, O-055, O-057, O-058)

Response: Subchapter 1.1 (Background) has been revised to more clearly describe the need for SURTASS LFA sonar. This revised description of “need” includes official references that outline the critical national security need for SURTASS LFA sonar deployment (see Subchapter 1.1.1 [The Submarine Threat]), and the addition of Subchapter 1.1.2 entitled “U.S. Navy’s Antisubmarine Warfare Mission.”

In summary, there is an immediate and fundamental national security need for SURTASS LFA sonar (i.e., quieter, more sophisticated foreign submarines present a threat to the national security of the United States, its territories, and allies and must be detected and tracked). To meet this threat, the Navy investigated both non-acoustic and acoustic technologies to enhance antisubmarine warfare (ASW) capabilities.

Comment 1-1.2: How does long-range detection help kill a submarine or prevent it from launching a missile? (G-001, O-047, O-058)

Response: In test exercises, SURTASS LFA sonar proved to be the only system physically capable of providing reliable and dependable long-range detection. Long-range detection provides the cueing (indications and warning) necessary for other shorter-range ASW systems in the vicinity to identify and find the target, and neutralize it with the appropriate weapon prior to the target launching its missile(s).

Comment 1-1.3: Why won’t alternative technologies work as well or better? (O-047, S-007)

Response: Subchapter 1.2 (U.S. Navy Research and Development Initiative) addresses the issue of alternative technologies vs. SURTASS LFA sonar. The use of conventional (existing)

Fleet assets (ASW surface and submarine combatants and aircraft) for long-range detection is not feasible from tactical and economic perspectives. The use of a substantially larger number of units may attain a level of long-range coverage and early detection; however, the need identified in this OEIS/EIS is for long-range detection. Subchapters 1.2.1 (Non-Acoustic Underwater Detection Technologies) and 1.2.2 (New Active Sonar Technology) have been expanded to explain why non-acoustic alternate underwater detection technologies, and new mid- and high-frequency active sonar technologies cannot provide the needed long-range detection and longer reaction times necessary to respond to the threat.

Comment 1-1.4: Does the "need" statement for SURTASS LFA sonar include the ability to detect submarines in coastal environments? (O-057)

Response: The "need" statement for SURTASS LFA sonar as stated in the Final OEIS/EIS does not specifically include or exclude the ability to detect submarines in coastal environments. However, SURTASS LFA sonar operations are restricted to transmitted sound field levels that will not be $\geq$ 180 dB within 22 km (12 nm) of any coast, including islands, and will not exceed 145 dB at known recreational or commercial dive sites.

Comment 1-1.5: What is the long-term potential of the proposed action to effectively meet the need? Is the SURTASS LFA sonar signal susceptible to being scattered or deflected by a "stealth-submarine"? (I-512, I-917, O-028)

Response: The long-term potential for the proposed action to meet the need for reliable and dependable long-range detection of stealthy submarines should remain high for the foreseeable future. This OEIS/EIS addresses the use of up to four SURTASS LFA sonar systems. Any future program beyond the scope of this OEIS/EIS could trigger the requirement for additional environmental compliance documentation.

Basic physics (relating to wavelength) states that a practical anechoic coating cannot be developed to absorb or scatter LF sound. Thus SURTASS LFA sonar has an inherent advantage over other sonars because of the difficulty in developing an effective method for deflecting or scattering of LF sound.

Comment 1-1.6: How will the SURTASS LFA sonar vessel be protected from detection when actively pinging? How can the SURTASS LFA sonar vessel remain undetected when transmitting? (I-477, I-764, I-769, O-027, O-037, O-047, O-049)

Response: SURTASS LFA sonar vessels cannot remain undetected, and will be protected. Naval operations of this nature are classified.

Comment 1-1.7: Who are the National Command Authorities? (G-001, O-027)

Response: Revisions to Chapter 1 (Purpose and Need) identify the National Command Authorities (NCA) as the President and the Secretary of Defense (or their duly designated alternates or successors), as assisted by the Chairman of the Joint Chiefs of Staff.

Comment 1-1.8: Define "heightened threat condition." (NN001, I-424, I-501, I-764, O-026, O-027, O-038)

Response: Heightened threat conditions refer to a variety of situations where there is a greater risk that U.S. forces could come under attack or become involved in conflict. Because military forces must be prepared at all times to protect themselves and to respond to changing circumstances, these situations may also include military operations other than war where the use or threat of force is not planned (JCS, 1997).

Comment 1-1.9: Why doesn't the DRAFT OEIS/EIS evaluate impacts of SURTASS LFA sonar operations during "heightened threat conditions?" (I-682, O-028, O-043, O-053)

Response: The evaluation of potential impacts of SURTASS LFA sonar operations during heightened threat conditions is beyond the scope of this document.

Comment 1-1.10: Clarify the definition of LF at <1000 Hz and SURTASS LFA sonar operating between 100 and 500 Hz. (G-001, I-681)

Response: Clarifications have been made to Chapter 1 of the Final OEIS/EIS. SURTASS LFA sonar operates in the low frequency band (below 1000 Hz) within the frequency range of 100 and 500 Hz.

ISSUE 1-2: U.S. NAVY RESEARCH AND DEVELOPMENT (R&D) INITIATIVES

Comment 1-2.1: Provide details on the Advanced Deployable System (ADS). (I-769, O-027)

Response: ADS is an undersea warfare system designed to lie on the ocean bottom and make passive (receive only) detections. Further details on the ADS are beyond the scope of this OEIS/EIS. Questions or comments on this system should be addressed to the organization under which it is being developed, Commander, Space and Naval Warfare Systems Command, 53560 Hull Street, San Diego, CA 92152-5001.

Comment 1-2.2: Provide details on the “thin, low-frequency sound projectors for use in shallow water” as described at the Acoustical Society of America conference. (O-027)

Response: Details on “thin, low-frequency sound projectors for use in shallow water” are likewise beyond the scope of this OEIS/EIS. Questions or comments on this concept should be addressed to the organization under which this technology is being managed, Commanding Officer, Naval Research Laboratory, 4555 Overlook Ave., SW, Washington, DC, 20375.

Comment 1-2.3: Expand discussion of other passive acoustic sonars with more acute devices to filter out ambient noise and isolate submarine noises. (O-047)

Response: There are passive acoustic sonars with the ability to filter out much of the ambient noise and isolate submarine noises, under the correct environmental conditions. However, when these systems work, they are adequate for short ranges only; they do not provide the long-range detection capability that only SURTASS LFA sonar can deliver. Subchapter 1.2 (U.S. Navy Research and Development Initiative) explains how the Navy has developed SURTASS LFA sonar through a systematic research and testing program. This started with addressing fundamental scientific and technology issues (e.g., reverberation, target strength, acoustic propagation and forward scattering) and other basic sensor issues such as signal processing and system design tradeoffs. Thereupon, the next phase of the initiative built upon the basic science, exploring new scientific and technical issues. During each of the phases, the Navy studied issues related to operation of these systems effectively and efficiently in the undersea warfare environment.

Comment 1-2.4: Are SURTASS LFA sonar R&D initiatives really for a much larger future program? (O-038)

Response: No.

ISSUE 1-3: ENVIRONMENTAL IMPACT ANALYSIS PROCESS

Comment 1-3.1: Who is the “decision-maker?” (O-027)

Response: The “decision-maker” refers to the Secretary of the Navy, or designee, who is responsible for the approval of the Record of Decision (ROD) (OPNAVINST 5090.1B).

Comment 1-3.2: Was the decision to implement Alternative 1 made before the Draft OEIS/EIS was prepared? (I-764, O-046, O-051)

Response: No decision to implement Alternative 1 was made before the Draft OEIS/EIS was prepared.

Comment 1-3.3: Discuss the possibility of approval of the proposed action even if it is not the environmentally preferred. (O-027)

Response: As stated in Subchapter 1.3.2 of the Final OEIS/EIS, the ROD will identify all alternatives that were considered, specifying the alternative or alternatives that were considered to be environmentally preferable. In the ROD the agency may discuss preference for the alternative that would fulfill its statutory mission and responsibilities, giving utmost consideration to economic, environmental, technical and other factors. The concept of the agency’s preferred alternative is different from the environmentally preferable alternative although in some cases the same alternative may be preferable by both criteria.

The ROD also will describe the public involvement and agency's decision-making process and will present the agency’s commitments to any mitigation measures. The NEPA procedures must insure the availability of pertinent environmental information to the decision-maker and the public. The decision-maker may approve the agency’s preferred alternative even if it is not the environmentally preferable alternative.

Comment 1-3.4: The Draft OEIS/EIS is not concise, clear, and to the point; is too technical and does not adequately describe and evaluate the potential for impacts of the proposed action and alternatives. (I-682, I-764, O-019, O-040, O-051, O-053, O-055)

Response: A major effort was undertaken to simplify the Draft OEIS/EIS to the greatest extent possible. For example, Appendix B (Fundamentals of Underwater Sound) was included, and explanatory “text boxes” were included where deemed appropriate to fully explain or expand upon technical issues or definitions. Nevertheless, the central topic of this OEIS/EIS is basically an intricate scientific process made up of a number of complex issues. The Navy believes the description and evaluation of potential environmental impacts of the proposed action and alternatives presented in the Draft OEIS/EIS were adequate to inform both the public and Navy decision-makers and meets the CEQ requirements of 40 CFR 1502.8.

Comment 1-3.5: Why was $350M spent on SURTASS LFA sonar before the OEIS/EIS was completed? (I-501, I-764, I-770, O-027, O-051, O-057)

Response: Money spent to date related to the SURTASS LFA sonar program falls into several different categories. SURTASS LFA sonar itself was the result of a lengthy research and development program that represented a substantial expenditure of funds. In addition, the Navy contracted for construction of a ship that was capable of carrying the equipment for the passive (listening only) component (SURTASS) as well as the active component (LFA). Also, the LFS SRP was expensive, but it contributed significantly and directly to the EIS process. In any event, the monies expended on the SURTASS LFA sonar program do not bind the Navy to deploy the SURTASS LFA sonar as proposed.

Comment 1-3.6: The Navy is attempting to bypass the existing regulatory environment by creating new public policy and new and unjustified standards of sound exposure based on a paucity of scientific data. A variety of sea tests alone cannot validate the results in the Draft OEIS/EIS. Discuss how the lack of information affected the ability to evaluate possible adverse impacts on marine life. (G-002, I-003, I-005, I-030, I-501, I-678, I-758, I-764, O-028, O-037, O-039, O-040, O-042, O-050, O-051, O-055)

Response: Throughout the entire EIS process, the Navy has addressed every aspect of pertinent regulatory requirements. In Subchapters 1.4.1 and 1.4.2 of the Final OEIS/EIS, the Navy acknowledges that there remain scientific data gaps that must be accounted for in the estimate of potential direct and indirect effects on marine life from the employment of SURTASS LFA sonar.

A prudent approach has been used in estimating the potential effects on the marine environment from employment of SURTASS LFA sonar by: 1) determining impacts on overall stocks; 2) determining conservative impact reference points; 3) quantifying uncertainties; 4) developing a risk continuum to estimate the impact to each stock; and 5) developing mitigation measures to minimize potential effects to marine animal stocks.

The method of dealing with incomplete information for this OEIS/EIS is systematic and has withstood careful evaluation from leading marine acousticians and biologists. Additionally, the National Research Council (NRC) has stated (concerning the definition of Level B harassment under the MMPA), "the ultimate long-term goal should be a risk function involving intensity and duration of exposure (see Miller, 1974) for each species, but our current lack of knowledge impedes this goal." (NRC, 2000). Through the Low Frequency Sound Scientific Research Program (LFS SRP) and this OEIS/EIS analysis, the Navy has provided a risk function for whales between 119 and 180 dB sound pressure levels. The Office of Naval Research (ONR) and the Naval Submarine Medical Research Laboratory (NSMRL) also conducted research on the potential effects of LF sound levels on humans in water.

Comment 1-3.7: Impact analysis is inappropriately based on MMPA's "negligible" standard. In this context, NMFS, as a cooperating agency on this OEIS/EIS, is willing to extrapolate for estimates of potential SURTASS LFA sonar impact, but is not willing to do so for dolphin takes from tuna harvesting. (O-047, O-051)

Response: This is a question of NMFS policy, which is outside of the scope of this OEIS/EIS.

Comment 1-3.8: Did the Navy agree with the Marine Mammal Commission's (MMC) comment on the "notice of intent to prepare an EIS for SURTASS LFA sonar, and the MMC's 1997 annual report to Congress (LFA section)?" (I-343, I-425, I-540, I-740, I-864, I-915, O-039, O-051, O-055)

Response: In the Marine Mammal Commission (MMC) comments (MMC letter dated 4 September 1996) to the Navy's Notice of Intent (NOI) to prepare an EIS for the employment of the SURTASS LFA sonar (FR Vol. 61 No. 139) and in the MMC Annual Report to Congress 1997 (MMC, 1998), the Commission pointed out that marine mammals and/or listed species "possibly could" be affected. Based on MMC's comments and others stating that there may be insufficient information available for the assessment of the potential environmental impacts, the Navy convened a scientific working group of government and non-government scientists to provide advice on needed research. The Navy, based on inputs from the scientific group, developed and implemented the three-phase Low Frequency Sound Scientific Research Program (LFS SRP) (see Subchapter 4.2.4). The goals, as set by the scientific group, were to determine short-term behavioral impacts to those marine mammals presumed to have the greatest sensitivity to LF sound, the baleen whales.

In the MMC Annual Report to Congress 1998 (MMC, 1999), the Commission stated that information presented to the Commission and its Committee of Science Advisors during the annual meeting in Portland, Maine (10 to 12 November 1998) by the Navy concerning the LFS SRP indicated that:

- The experiment detected few effects on marine mammals;
- These effects appeared to be biologically insignificant; and
- The study results, combined with available information on the distribution and critical habitats of marine mammals in the potential operation areas, should enable the Navy to develop an operational strategy that poses minimal risk to marine mammals.

The Commission commended the Navy for the LFS SRP and other efforts to ensure that the Navy's activities do not adversely affect marine mammals or their habitats (MMC, 1999).

The Commission also concurred with the NOI that many of the possible effects on marine mammals might be avoided or minimized by combinations of measures, such as identifying and avoiding particularly sensitive species and areas. This has been accomplished through the geographic restrictions and monitoring mitigation presented in Chapter 5 (Mitigation Measures).

In its comment letter to the Navy's NOI (MMC letter dated 4 September 1996) and in its annual report to Congress in 1997 (MMC, 1998), the Commission provided an itemized list of six possible effects of SURTASS LFA sonar transmissions on marine mammals. The data gathered during the LTM Program will be used to assess long-term effects including those identified in the fifth MMC item, related to stress.

The MMC comments on the Draft OEIS/EIS can be found in Appendix E of Volume II of the Final OEIS/EIS.

Comment 1-3.9: Why were data and issues pertaining to prior legal challenges to the SURTASS LFA sonar program and evidence supporting those challenges not considered in the Draft OEIS/EIS? (I-766, O-004, O-034, O-051, O-057)

Response: All relevant issues and any information from those proceedings have been considered. Declarations concerning Phase III of the LFS SRP can be found in Appendix C.

Comment 1-3.10: There was insufficient time between the Draft OEIS/EIS publication and public hearings. (I-240, I-454, I-683, I-719, I-766, I-769)

Response: The Notice of Availability for the Draft OEIS/EIS was published in the Federal Register on July 30, 1999 (FR Vol. 64 No. 146). The Draft is usually circulated for review and comment over a 45-day period. This Draft was made available for public comment for twice that time, for 90 days, with comments accepted through October 28, 1999. The public hearings were held on September 29, 1999 in Norfolk, VA; on October 12, 1999 in San Diego, CA; and on October 14, 1999 in Honolulu, HI (FR Vol. 64 No. 177).

The Navy believes that there was sufficient time for public review of the available Draft OEIS/EIS between the time it was published and the public hearings. Moreover, the additional time allocated before the close of the public comment period allowed the public more opportunity to make their remarks.

In addition to the official public hearings, there were five open houses held between 19 August and 5 October 1999 in Los Angeles, CA; Miami, FL; Honolulu, HI; Boston, MA; and Seattle, WA to provide information to the public.

Comment 1-3.11: The technical reports were not included with the mailing of the Draft OEIS/EIS. (I-454, I-582, I-766, O-039, O-051)

Response: The three technical reports were available and provided to everyone requesting them. As technical report attachments, they were incorporated by reference and, hence, not mailed out with the Draft OEIS/EIS. This procedure met the requirements set forth in 40 CFR 1500.4 (Reducing paperwork) and 40 CFR 1500.21 (Incorporation by reference).

CHAPTER 2 DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

ISSUE 2-1: SURTASS LFA SONAR TECHNOLOGY

Comment 2-1.1: What is the maximum source level of the SURTASS LFA sonar? (I-770, O-027, O-040, O-051, O-055, O-057)

Response: The source level (SL) of an individual source projector of the SURTASS LFA sonar array is approximately 215 dB. The sound field of the array can never be higher than the SL of an individual source projector.

Comment 2-1.2a: Why does a linear vertical line array such as the SURTASS LFA sonar not result in a source level of 240 dB? Did the impact analysis include the potential effects of only a single element or the entire array? (I-454, I-683, I-764, I-766, O-027, O-039, O-055, O-057)

Response: For SURTASS LFA sonar systems employing more than one source projector (i.e., an array of projectors), the SL described at 1 meter from the source array is a theoretical calculation, as the sound field beam formed by the array is focused at a significant range (up to 100 m [109 yd]) from the array, where propagation loss has already caused a decrease in received level (RL) of over 40 dB. In proximity of the SURTASS LFA sonar array, SL approximates that of an individual projector (215 dB).

Because of beam forming, the power output of many sonars is described in terms of "effective power" or "effective source level." For the sound radiated from a single source projector, omnidirectional point source, the term "effective source level" refers to the actual sound level at 1 meter from the source. However, a linear array such as the SURTASS LFA vertical line array (VLA) has a wide aperture and is not a point source. Thus, for SURTASS LFA sonar, the "effective source level" refers to the sound level at 1 m from a *hypothetical point source*, which approximates the VLA when listening to it from a distant point in the far field. See Appendix B for additional discussion.

In the case of SURTASS LFA sonar, the RLs inside of 1 km (1,094 yd) are not determined by the theoretical "effective source level." In proximity of the VLA, the sound field is not higher than that of an individual source projector, and at distances several hundreds of meters from the VLA, where beam focusing occurs, the RL will have already fallen by more than 40 dB. The impact analysis was based on the entire array, not on a single source projector.

Comment 2-1.2b: Research suggests that the first indicator of physical damage to whales from LF sounds is temporary hearing loss, which can occur from exposure to 185-200 dB. At higher levels, tissue damage in the lungs, heart, and nervous system can occur. The Navy's actual planned transmission level could rise to as high as 215 dB. (C-001)

Response: The issue is received level (RL), not source level (SL). For purposes of the SURTASS LFA sonar analyses presented in this OEIS/EIS, all marine animals exposed to RLs ≥180 dB are evaluated as if they are injured. The Navy has designed monitoring mitigation to ensure that marine animals do not get within the 180-dB sound field of the SURTASS LFA sonar. See Chapter 5 for more information.

The analysis did not attempt to quantify the damage risk threshold (DRT) for higher levels of injury.

Comment 2-1.3: Is the 180-dB contour always 1 km (0.54 nm) from the LFA source? Are there any conditions (e.g., convergence zone propagation) where the 180-dB contour may be further from the LFA source? (G-001, I-454, NN001, O-027, S-003)

Response: The calculated range from the SURTASS LFA source array for the 180-dB sound field contour is expected to almost never be more than 1 km (0.54 nm). Under some conditions, the 180-dB contour could be somewhat greater than 1 km. However, mitigation is applied to the sound field (180 dB), not a specific range.

Comment 2-1.4: Explain the model used to define the 180-dB sound field contour; why is the sound field the same at top and bottom of the sound field? Provide better graphics (Figure S-3 of the Draft OEIS/EIS) for the 180-dB projected sound field. (G-001, I-454, O-039)

Response: The model, or calculation, used to define the 180-dB sound field contour is the standard spherical spreading algorithm (20 log R, where R = range in meters) (Urick, 1983). This equates to the sound intensity decreasing in proportion to the square of the range.

The 180-dB sound field is not necessarily the same at the top and bottom because the vertical aperture of the beam formed from the center of the LFA VLA (approximately 122 m [400 ft] deep) is narrow; thus, within the short range of the 180-dB sound field, the narrow vertical beam has negligible opportunity to interact with the ocean surface or seafloor.

Figures S-4 and 2-4 (HF/M3 Sonar Detection and LFA Mitigation Zones) has been revised in the Final OEIS/EIS to better portray the 180-dB sound field.

Comment 2-1.5: What are the ranges from the source for other sound field contours? What is the volume that would be ensonified at 140, 160, and 180 dB? Are 145-dB convergence zones taken into account for diver mitigation? (G-001, I-454, NN001, O-020, O-039, O-040, S-003)

Response: The ranges and the volumes vary under different oceanographic conditions; however, the Navy will apply geographic restrictions to the sound field level of 180 dB and 145 dB (divers), regardless of the ranges from the source. In the OEIS/EIS 31 acoustic modeling sites were analyzed. These sites covered the major ocean regions of the world: North and South Pacific oceans, Indian Ocean, North and South Atlantic oceans, and the Mediterranean Sea. The locations were carefully selected to represent reasonable sites for each of the three major underwater sound propagation regimes where SURTASS LFA sonar could be employed. Acoustic analysis included underwater sound transmission via the following propagation paths:

- Deep water convergence zone (CZ) propagation;
- Near surface duct propagation; and
- Shallow water bottom interaction propagation.

Detailed results of these analyses are presented in Subchapter 4.2 of the OEIS/EIS and in Technical Report 2 (Acoustic Modeling Results). Figures B-1 through B-31 of TR 2 provide the parabolic equation (PE) transmission loss (TL) plots for each of the 31 sites. These plots provide TL as a function of depth and range from the source.

Comment 2-1.6: Is the LFA signal strength at a given distance most attenuated at the surface? (O-039)

Response: From the water's surface to depths not greater than 2 m (6.5 ft), acoustic theory and detailed measurements (Jensen, 1981) indicate that there would be substantial sound transmission losses occurring in this top layer of water. Sound fields from SURTASS LFA sonar transmissions in this layer of water would be about 20 dB less than the sound fields in adjacent deeper water.

Comment 2-1.7: The Draft OEIS/EIS states that low frequency for underwater acoustics is below 1000 Hz, but that the SURTASS LFA sonar frequency range is between 100 and 500 Hz; please clarify. (I-424, I-681, O-020)

Response: In general, low frequency underwater sound is often defined to be below 1000 Hz (NRC, 2000). Typical LF sounds are the noise made by large ships and the vocalizations of large whales. SURTASS LFA sonar transmits LF sound into the ocean between 100 and 500 Hz.

Comment 2-1.8: How will the Navy assure that the frequency will not go below 100 Hz? (I-424, S-003)

Response: The SURTASS LFA sonar system's design does not allow for transmissions below 100 Hz.

Comment 2-1.9: Comparative data on the LFA signal and representative cetacean vocalizations should be given in the OEIS/EIS. (G-001)

Response: Figure 2-2 (Comparison of Humpback Whale and SURTASS LFA Sonar Signatures) compares an LFA signal with that of a humpback whale. Additionally, Subchapters 3.2.4 (Cetaceans [Mysticetes]) and 3.2.5 (Cetaceans [Odontocetes]) provide more details on cetacean vocal ranges.

Comment 2-1.10: Explain the difference between SURTASS (passive) and LFA (active) and that installations on T-AGOS type vessels can be either passive or both. (I-424)

Response: Subchapters 2.1.1 (Active System Component) and 2.1.2 (Passive System Component) of the Final OEIS/EIS have been revised to better explain the differences between SURTASS (passive) and LFA (active), and how installations on T-AGOS type vessels can be either passive or both. For example, the active component of the SURTASS LFA sonar system, LFA, is an augmentation to the passive detection system (SURTASS), to be used when passive system performance is inadequate.

Comment 2-1.11: Verify that the maximum number of vessels will be four as per the Draft OEIS/EIS. (I-424, I-764)

Response: This OEIS/EIS addresses the employment of up to four SURTASS LFA sonar systems worldwide. The employment of any additional systems (i.e., greater than four) could require further environmental planning documentation.

Comment 2-1.12: What is the name of the T-AGOS vessel on the cover of the Draft OEIS/EIS? (I-424)

Response: The vessel on the cover of the Draft OEIS/EIS is USNS *Victorious*: Ocean Surveillance Ship (T-AGOS 19). T-AGOS 19-Class and the *Impeccable*-Class (T-AGOS 23) ocean surveillance ships are potential platforms for the additional three SURTASS LFA sonar systems.

Comment 2-1.13: Discuss LFA countermeasures (e.g., can LFA be defeated by active jamming?). (I-290, I-769, O-020)

Response: Countermeasures have been evaluated during the validation of the Navy operational requirement for SURTASS LFA sonar. However, naval operations of this nature are classified.

Comment 2-1.14: Revise Figures S-2 and 2-1 to better illustrate the depth and scale. (G-001)

Response: These figures have been revised in the Final OEIS/EIS.

Comment 2-1.15: The DEIS does not explain why the proposed number of ships, speakers, broadcasts, and length of duty cycle are needed. (O-051)

Response: The Navy's evaluation of the different ways in which SURTASS LFA sonar technology could be configured and deployed (while still fulfilling the Navy's long-range submarine detection objectives) led to the following conclusions: 1) no less than four ships would be needed for SURTASS LFA sonar to meet operational requirements; 2) Navy ships would need to be able to operate SURTASS LFA sonar technology extensively throughout U.S. and international waters; and 3) SURTASS LFA sonar technology would need to be capable of operating at source levels of up to 215 decibels. The types of broadcasts, number of source projectors (speakers), and duty cycle were determined through extensive design and testing to optimize the system's ability to meet its operational requirements.

ISSUE 2-2: SURTASS LFA SONAR DEPLOYMENT

Comment 2-2.1: How can enemy activities be detected if SURTASS LFA sonar is not operating 24 hours per day, 365 days per year? How effective is SURTASS LFA sonar going to be because of the restricted areas? (I-006, O-027)

Response: This type of tactical information is beyond the scope of this OEIS/EIS. Active sonars of this type are not used 24 hours per day, 365 days per year. SURTASS LFA sonar deployment is discussed in Subchapter 2.2. The restricted areas will not affect SURTASS LFA sonar routine training and testing, as well as the use of the system during military operations.

Comment 2-2.2: What efforts are being undertaken to determine minimum deployment transmission time needed to ensure military readiness? (O-042)

Response: The training time needed to ensure military readiness will be determined by the Fleet commanders on a case-by-case basis. Because of the uncertainties in the world's political climate today, a detailed account of future operating locations and conditions is necessarily somewhat speculative. However, the operational tempo would not be expected to be greater than the nominal annual deployment schedule presented in Subchapter 2.2 (SURTASS LFA Sonar Deployment).

Comment 2-2.3: Will the testing of new SURTASS LFA sonar systems (i.e., systems #2, #3, and #4) and training of new crews be concentrated in specific areas, such as the Southern California Bight? (NN001)

Response: SURTASS LFA sonar operations, including testing of new systems as they come on line and training of new crews, would not be concentrated in specific areas, but would take place within the operational area defined in Chapter 1 (Purpose and Need) (see Figure 1-1 [SURTASS LFA Sonar Potential Areas of Operations]). All proposed SURTASS LFA sonar operations (including testing) would be in accordance with the mitigation measures under Alternative 1.

Comment 2-2.4: Will SURTASS LFA sonar operations be conducted during low visibility (night, fog, and rain)? (O-020, S-003)

Response: Because the Navy trains under the same or as close to the actual conditions under which they expect to fight, there will be times when SURTASS LFA sonar operations will have to be conducted during periods of low visibility. This is why the mitigation measure of visual monitoring is supplemented by passive acoustic monitoring and active acoustic monitoring (High Frequency Marine Mammal Monitoring [HF/M3] sonar). Chapter 5 (Mitigation Measures) provides more details on the mitigation measures.

Comment 2-2.5: Redefine the meaning of maximum 20 percent duty cycle; give examples and describe actual use in terms of timing of sequence of acoustic pings. Is the maximum duty cycle of 20 percent even for "worst case" missions; if not, what would it be? (I-681, I-764, NN001, O-016, O-017, O-039)

Response: Average duty cycle (ratio of sound "on" time to total time) is less than 20 percent, even for "worst case" missions. The typical duty cycle is between 10 and 20 percent (20 percent is the maximum physical limit of the LFA system at maximum power). The system will not be operated at duty cycles higher than 20 percent.

Pulse length (i.e., ping duration) can be from 6 to 100 seconds long. Nominal length is 60 seconds. Longer durations are reserved for very long-range detections. These longer pulse lengths are mitigated by the fact that the longer ranges require lower duty cycles to allow for reception of return echoes. In other words, the longer the pulse length, the more time the system is "off" (not transmitting). The time between pings varies between 6 and 15 minutes.

Active sonar operations could be conducted up to 20 hours during an exercise day, although the system would actually be transmitting for only a maximum of 4 hours per day—resulting in 72 hours per mission and 432 hours per year of active transmission time based on a 20 percent maximum duty cycle.

Comment 2-2.6: Would all four systems ever be deployed at one time? (I-424, O-016)

Response: The possibility of all four being at sea, conducting active transmission operations simultaneously, would be extremely remote.

Comment 2-2.7: If submarines operate in polar regions, why will LFA not operate there? (O-027)

Response: The Navy made a decision not to operate in polar regions.

ISSUE 2-3: ALTERNATIVES

Comment 2-3.1: The Navy must disclose the reasons why any alternatives were eliminated from consideration, particularly the No Action alternative. The Navy did not evaluate a reasonable range of alternatives; only Alternative 1 was considered. The alternative analysis presented is brief, inadequate and insufficient. (F-002, I-758, I-764, O-016, O-017, O-022, O-046, O-051,O-055, O-057)

Response: The No Action alternative has not been eliminated. The Draft OEIS/EIS provided the rationale as to why the No Action alternative was not preferred. Basically, the lack of long-range submarine detection capability would make it possible for potentially hostile submarines to clandestinely place themselves into position to threaten U.S. Fleet units and land-based targets. In addition, without this long-range surveillance capability, the reaction times to submarines would be greatly reduced and the effectiveness of close-in, tactical systems to neutralize threats would be seriously, if not fatally, compromised. The National Environmental Policy Act (NEPA) requires federal agencies to prepare an EIS that provides the public with reasonable alternatives (including the No Action alternative) that would avoid or minimize adverse impacts or enhance the quality of the environment. The Council on Environmental Quality (CEQ) defines "reasonable alternatives" to include those that are practical or feasible from the technical and economic standpoint, and that at least partially satisfy the mission needs (Reinke and Swartz, 1999). However, the lead agency is not required to engage in speculation or contemplation about future plans that could influence the EIS's analysis of potential direct and indirect effects. The Navy believes that the alternatives selected and analyzed in the OEIS/EIS are sufficient and satisfactory in accordance with the guidelines described above, such that both the public and the

Navy decision-makers are being provided with adequate information from which to draw their respective conclusions. The ultimate decision as to whether to go forward with the proposed action, and the restrictions and/or mitigation to be applied thereto, rests with the decision-maker and will be reflected in the ROD.

Comment 2-3.2: The Draft OEIS/EIS does not adequately describe the proposed action (preferred alternative). (I-682, O-004, O-051, O-057)

Response: Supplemental information has been provided in Subchapter 2.3.2 (Alternative 1 [The Preferred Alternative]) of the Final OEIS/EIS.

Comment 2-3.3a: The Draft OEIS/EIS provides an incomplete analysis of alternatives: other alternatives have been ignored, such as lower operating/deployment levels, alternative passive systems, continued research programs, alternative mitigation measures, use of existing systems, and deploying only as needed for national defense. (NN001, O-017, O-028, O-040, O-047, O-051, O-053, O-058)

Response: Planned operating/deployment levels of SURTASS LFA sonar systems are based on best scientific and engineering analysis and judgment in response to Naval operational requirements involving the need for improved capability to detect quieter and harder-to-find foreign submarines at long range (see Chapter 1 [Purpose and Need]).

The comment on “alternative passive systems” is responded to under Issue 1-2 (U.S. Navy Research and Development (R&D) Initiatives). The Navy has chosen not to make “continued research programs” a separate alternative, but to continue research under the proposed Long Term Monitoring (LTM) Program (Subchapter 2.4). There are other Navy research programs not directly associated with the SURTASS LFA sonar program, such as ONR's Marine Mammal Biology Program and the U.S. Navy Marine Mammal Program of the Space and Naval Warfare Systems Command (SPAWAR) Center, San Diego.

The use of existing (ASW) systems as an alternative to SURTASS LFA sonar is responded to under Issue 1-1 (The Submarine Threat) and Subchapter 1.2 (U.S. Navy Research and Development Initiative).

The use of the system only for national defense with no training as an alternative is not feasible. In order for highly technical and complex systems to function efficiently, continuous training of the operators is required. In addition, these systems must be operated on a regular basis to assure that they are available when needed.

Comment 2-3.3b: Why isn't the alternative measure of lower source levels considered as an alternative? (O-037, O-051)

Response: The SURTASS LFA sonar vessel would most likely change its location in order to ensure the geographic restrictions are met rather than lower SL, which may not provide sufficient detection range in directions away from the coast and OBIAs. For many of the operational regions, the full 215-dB SL would be required to meet the SURTASS LFA sonar mission. Therefore, lowering source level was not considered an alternative.

Comment 2-3.4: Recommend adopting the No Action alternative while research continues on the potential impacts of low frequency sound on LF-sensitive species and on the already noisy ocean. (I-139, I-140, I-424, I-770, O-038, O-039, O-047)

Response: Our understanding of the mechanics of hearing in, and the effects of various types of underwater noise on, marine animals and human divers are incomplete and still evolving. There are gaps in the scientific data that must be accounted for in the estimate of potential direct and indirect effects on marine life from the employment of SURTASS LFA sonar. However, the state of the scientific research to date is adequate for the use of LF sound transmissions for the critical national security need addressed in Chapter 1. While all the questions on the potential for LF sound to affect marine life are not yet answered, and may not be answered in the foreseeable future, the Navy has combined rigorous scientific methodology with a prudent approach throughout this OEIS/EIS to protect the marine environment.

Research will continue on the potential impacts of low frequency sound on LF-sensitive species, both within the framework of the LTM Program, and in other basic, applied, and advanced technology research projects that the Navy is either funding directly, or is involved with. Generalized LF sound research related to ocean noise is beyond the scope of the SURTASS LFA sonar program, but some LF ocean ambient noise data collection would be carried out automatically in various ocean basins where SURTASS LFA sonar would be operated. This would involve standard Navy recorders using the passive SURTASS horizontal line array (see Subchapter 2.4.2.2 [LF Ocean Ambient Noise Level Data Collection]).

Comment 2-3.5: Recommend that deployment of SURTASS LFA sonar be deferred until long-term effects have been determined. (I-682, O-027, O-051, O-053)

Response: The Navy believes they have adequately studied the pertinent issues with regard to the potential for LF sound effects on marine animals to go forward with employment of SURTASS LFA sonar, with the concomitant geographic restrictions and monitoring mitigation. Deferring deployment of SURTASS LFA sonar until long-term effects could be determined would be detrimental to national security. Also, such delay would forestall the benefit that would come from implementation of the LTM Program (see Subchapter 2.4 [Long Term Monitoring Program]).

Comment 2-3.6: The presentation of Alternative 1 as the preferred alternative is confusing and contradictory because two different alternatives are presented as one. There is obviously a major difference in an Alternative 1 that would limit use of SURTASS LFA to only passive missions in geographically-restricted areas and an Alternative 1 that would permit broadcasts up to 180 dB and/or 145 dB in geographically-restricted areas. (O-004, O-057)

Response: There is only one Alternative 1. Passive SURTASS listening operations, not involving LFA signal transmissions, would have no geographical restrictions, are not analyzed in this OEIS/EIS, and were only addressed in Subchapter 2.2 (SURTASS LFA Sonar Deployment) to explain fully to the public that the SURTASS LFA sonar vessel could be used for Navy tasking other than LFA operations. Under Alternative 1, SURTASS LFA sonar active operations would be subject to the following geographic restrictions: 1) SURTASS LFA sonar transmitted sound field levels would not be ≥ 180 dB within 22 km (12 nm) of any coastline, nor in offshore biologically important areas, during biologically important seasons; and 2) SURTASS LFA sonar transmitted sound field levels would not exceed 145 dB at known recreational or commercial dive sites.

Comment 2-3.7: The Navy has failed to develop appropriate alternatives in light of unresolved conflicts (i.e., areas of controversy and issues of concern have not been resolved by the Navy's Scientific Research Program, and are not mentioned in the Draft OEIS/EIS). (I-425, O-028, O-050, O-051)

Response: The Navy-sponsored Low Frequency Sound Scientific Research Program (LFS SRP) involved unique and consequential scientific field research to fill data gaps under the independent direction of some of the world's top marine mammal biologists. All issues of concern with respect to the potential for impacts on LF-sensitive marine mammals from employment of SURTASS LFA sonar have not been resolved by the LFS SRP, nor can they be in the foreseeable future (see Subchapter 1.4.2). However, the Navy believes that data collection during the LFS SRP, coupled with existing data, was sufficient to support the development of an OEIS/EIS.

Comment 2-3.8: Subchapter 2.3.3 (Alternative 2) should also state that Alternative 2 is not preferred because of potential impacts to sea turtle and human divers as well as marine mammals. It should also be noted that as well as not being consistent with the "CNO's commitment to protect the environment and good stewardship," Alternative 2 would also not be consistent with the MMPA and ESA if there were unauthorized takes. (G-001, NN001)

Response: The Navy agrees. Alternative 2 would not be consistent with the CNO's commitment to the protection of the environment and good stewardship of the sea. It also would be inconsistent with the MMPA and ESA if the action would result in the taking of marine mammals and/or species listed as threatened or endangered and taking authority had not been obtained. Subchapter 2.3.3 has been modified accordingly.

Comment 2-3.9: Provide more technical information on the High Frequency Marine Mammal Monitoring (HF/M3) sonar, including: 1) is it omni-directional; 2) can it detect equally well above and below the array; and 3) will LFA transmissions interfere with it? (O-039)

Response: The Final OEIS/EIS provides revised and updated information in Subchapter 2.3.2.2 (Monitoring to Prevent Injury). Some of the pertinent information includes the following:

- The HF/M3 sonar is omni-directional (360 degrees) in the horizontal, with a 10-degree vertical beamwidth that can be steered 10 degrees above or below the horizontal.

- The HF/M3 sonar provides detection capability above and below the vertical line source array, except for *directly* above or below. However, since the whole system is moving through the water, an animal would have to exactly match the ship's course and speed while converging on the source array from above or below to avoid being detected. This confluence of events is highly unlikely.

- The HF/M3 sonar is affected during the LFA transissions, but it is fully effective within five seconds after they end.

Comment 2-3.10: Can LFA be steered? How will steering affect the sound level at a distance? (I-454)

Response: SURTASS LFA sonar's transmitted beam is omnidirectional in the horizontal plane, with a narrow vertical beamwidth that can be steered above and below the horizontal. See Figure 2-4 (HF/M3 Sonar Detection and LFA Mitigation Zones). The calculation for the impact assessment considered the beam patterns and steering.

ISSUE 2-4: LONG TERM MONITORING PROGRAM

Comment 2-4.1a: Long term monitoring is neither optional nor precautionary—it is essential to measure the actual effects of SURTASS LFA sonar on marine animals. LTM Program annual assessment must include not just non-serious injuries and non-injurious harassment, but also any serious injury or harassment. Meaningful levels of injury and harassment should be measured prior to SURTASS LFA sonar operations in order to establish a baseline. (I-245, I-264, I-267, I-425, I-548, I-582, I-764, I-917, O-020, O-027, O-047, O-051, S-004)

Response: The Navy acknowledges that long-term monitoring is important. The LTM Program would serve to continue monitoring of potential effects of the SURTASS LFA sonar.

The LTM Program annual report will provide NMFS with information on the recent year's SURTASS LFA sonar operations with regard to marine mammals, including the Navy's assessment of whether any taking occurred within the LFA mitigation zone (180-dB sound field).

The Navy would not seek to procure, nor would it be likely that NMFS would approve of, a scientific research permit that would allow for testing of marine mammals to the point of injury in order to establish such a baseline. It is not practical to systematically assay (or sacrifice) free-ranging animals in the open ocean to evaluate levels of injury.

Comment 2-4.1b: Who will oversee the LTM Program? Who will review the monitoring protocols and results? (G-001, O-051)

Response: The Navy will collaborate with NMFS to determine the most efficient and effective oversight mechanism for the LTM Program. NMFS will review the monitoring protocols and results. Additional information is provided in Subchapter 2.4 (Long Term Monitoring Program). Oversight details will be provided in the ROD.

Comment 2-4.2: What monitoring will be done to confirm the validity of assumptions upon which OEIS/EIS conclusions are made, particularly stemming from the lack of information and/or uncertainties (data gaps)? Why can't data gaps be filled before SURTASS LFA sonar is deployed? (G-001, O-025, O-028, O-055, S-007)

Response: The LTM Program reporting requirements will help validate the AIM estimates for animals within the 180-dB sound field. However, the conservative assumptions about the risk continuum cannot be verified by the LTM program. The Navy acknowledges that there remain scientific data gaps that must be accounted for in the estimate of potential direct and indirect effects on marine life from the employment of SURTASS LFA sonar. Subchapter 1.4 of the Final OEIS/EIS discusses this issue.

Subchapter 1.4 also addresses why some data gaps cannot be filled before the deployment of SURTASS LFA sonar. However, application of the rule of reason indicates that the Navy has undertaken a reasonable search for relevant, current information associated with identified potential effects. Further, the Navy believes that the Final OEIS/EIS contains a reasonably thorough discussion of the significant aspects of the probable environmental consequences.

Comment 2-4.3: More detailed analysis is needed on severely endangered species, such as right whales and monk seals. (G-001, I-908, O-057)

Response: The severely endangered right whales and monk seals have been thoroughly analyzed. Northern and southern right whales are addressed in Subchapter 3.2.4.3 (Coastal Mysticete Species). The offshore biologically important area (OBIA 1) consisting of the 200-m isobath of the North American East Coast provides specific protection for northern right whales. Further, in Subchapter 4.2 (Potential Impacts on Marine Mammals), northern right whales are analyzed at model sites 1 (North Gulf of Alaska), 10 (South Gulf of Alaska), 27 (Sable Island Bank, Nova Scotia), and 28 (Onslow Bay, NC). Southern right whales are analyzed at sites 4 (East Bass Strait, Australia) and 5 (West of Talcahuano, Chile).

Mediterranean and Hawaiian monk seals are addressed in Subchapter 3.2.6.2 (Phocids). Further, in Subchapter 4.2, Hawaiian monk seals are analyzed at model sites 6 (north of Kauai, HI), 7 (south of Oahu, HI), and 12 (northwest of Kauai, HI). Monk seals are also protected by the geographic restictions limiting received levels to 180 dB within 22 km (12 nm) of any coastline including islands.

Comment 2-4.4: The LTM Program should verify that the effects of the HF/M3 sonar are negligible. (G-001, O-043)

Response: One of the three monitoring elements of the LTM Program includes verification and validation of the HF/M3 sonar's performance and determination that the effects of the HF/M3 sonar on marine mammals and sea turtles are negligible.

Comment 2-4.5: Passive high frequency monitoring needs to be above 65-75 kHz to be effective. (O-020)

Response: Because passive acoustic montoring only detects animals that are generating sound, the Navy uses LF passive monitoring as an indicator of the presence of marine mammals. HF passive monitoring is not part of the proposed monitoring mitigation. To provide more reliable detection of animals, the Navy developed the HF/M3 sonar for active acoustic monitoring.

The Navy plans to explore the feasibility of augmenting the HF/M3 sonar with appropriate passive HF detection capability for collection of vocalization data from odontocetes (e.g., sperm whales and dolphins) to broaden the passive data collection effort. Because few marine mammals vocalize exclusively above 65 kHz, the Navy does not intend to explore passive HF detection capability above 40 kHz.

Comment 2-4.6: Monitoring of operations of two sources at one site should be undertaken to verify the OEIS/EIS conclusion that the presence of two sources transmitting in one area can be conservatively approximated by doubling the single source potential effects. (G-001)

Response: The laws of physics dictate that in the rare circumstances when two sonars signals are additive, the maximum sound energy in the water would not exceed double that of a single signal. This was confirmed by the analysis of two sources at one sight in Subchapter 4.2.7.4. If two sources were deployed in one area, appropriate monitoring would take place in order to verify the OEIS/EIS conclusion that the presence of two sources transmitting in one site can be conservatively approximated by doubling the single source potential effects.

Comment 2-4.7: Marine mammal vocalizations should be monitored before, during and after SURTASS LFA sonar transmissions to validate the assumption that marine mammals beyond the 180-dB acoustic threshold (criterion) will not be affected in significant ways by LFA and the HF/M3 sonar transmission, and that the HF/M3 sonar can detect animals within it. (G-001, S-003)

Response: The LTM Program reporting requirements will help validate the AIM estimates for animals within the 180-dB sound field. However, the conservative assumptions about the risk continuum cannot be verified by the LTM program. Subchapter 2.3.2.2 (Monitoring to Prevent Injury) states that passive acoustic monitoring for vocalizing marine mammals would be conducted whenever SURTASS LFA sonar is transmitting. Monitoring would begin 30 minutes before transmissions were scheduled to commence, and continue until 30 minutes after transmissions were suspended or terminated.

Analysis and testing of the HF/M3 sonar operating capabilities indicates that this system substantially increases the chances of detecting marine mammals (and possibly sea turtles) within the LFA mitigation zone (i.e., inside the 180-dB sound field). The probability of detection of various marine mammals is presented in Figure 2-5. The probability of detection for large cetaceans is over 0.95 at greater than 1 km (0.54 nm). For small cetaceans at 1 km (0.54 nm), the value ranges from 0.73 to 0.95.

Comment 2-4.8: Monitoring of sound pressure levels should be undertaken to determine the efficacy of Navy underwater acoustic prediction models. (NN001)

Response: For tactical purposes, the Navy has developed state-of-the-art models. The Navy frequently conducts TL surveys in conjunction with its ASW operations to validate these models. As a result of this broad experience, constantly improving techniques, and routine ASW training operations, U.S. Navy sonar technicians are well qualified at determining how LF sound propagates underwater. This, in turn, helps the Navy determine the capability and efficiency of their acoustic models used for SURTASS LFA sonar operations. These models have been subjected to a long and complex validation and verification process, and no additional monitoring of the sound field is required. Subchapter 2.3.2.1 (Geographic Restrictions) discusses this topic.

Comment 2-4.9: Request elaboration on how the LTM Program will conduct annual assessment of the potential cumulative impacts from SURTASS LFA sonar operations, including tabulation of non-serious injury and non-injurious harassment. How will the Navy collect this data? (G-001, O-051, S-003)

Response: The terms non-serious injury and non-injurous harassment are no longer used in the OEIS/EIS. Subchapter 4.4 (Potential Cumulative Impacts) addresses the issue of the potential for cumulative impacts from SURTASS LFA sonar operations. In the Navy's annual report to NMFS, there would be an assessment of any long-term and/or cumulative impacts attributable to SURTASS LFA sonar operations, including: 1) assessment of any long-term effects from SURTASS LFA sonar operations; and 2) any discernible or estimated cumulative impacts from SURTASS LFA sonar operations. In addition, the Navy's annual report to NMFS would include an assessment of whether any taking of marine mammal(s) occurred within the LFA mitigation zone (180-dB sound field) during SURTASS LFA sonar operations, and reports of any verifiable diver incidents. The nominal inputs to this assessment would be expected to be date, time, vessel, LOA area, number(s) and type(s) of marine mammals affected, assessment basis (observed injury, behavioral response, model calculation), LFA mitigation zone radius, bearing from vessel, and whether operations were delayed, suspended or terminated. Only counts of animals detected within the 180-dB mitigation zone will be reported. Contacts outside of the LFA mitigation zone would only be used for estimates of animal density.

Comment 2-4.10: Will the LTM Program monitor increases in ambient noise? Will the LTM Program monitor marine mammal reactions to non-SURTASS LFA sonar sources? Is this needed to determine cumulative effects? (S-003)

Response: As discussed in Subchapter 2.4.2.2 (LF Ocean Ambient Noise Level Data Collection), unclassified LF ocean ambient noise data collection would be carried out incidentally in the ocean basins in which SURTASS LFA sonar operations occur using standard Navy recorders and the passive (SURTASS) array, whenever feasible.

Monitoring marine mammal reactions to non-SURTASS LFA sonar sources is beyond the scope of the LTM Program. Cumulative impacts are discussed in the Response to Comment 2-4.9.

Comment 2-4.11: Will the LTM Program determine if SURTASS LFA sonar operations cause a decrease in biological fitness and/or affect long-term behavior and cumulative effects? (G-001, I-683, O-027, S-007)

Response: See Response to Comment 2-4.9 above for how the Navy would assess whether any taking of marine mammals occurred from SURTASS LFA sonar operations, and how any long-term and/or cumulative impacts attributable to SURTASS LFA sonar operations would be assessed.

Comment 2-4.12: Will the LTM Program end in five years and, if so, what will the Navy do to monitor for effects on marine mammal stocks to determine impacts in the five- to ten-year timeframe? (G-001, O-040, S-003, S-004)

Response: The LTM Program has been budgeted by the Navy at a level of $1M per year for five years, starting with the issuance of the first LOA. One-half of this funding will go to marine environmental research organizations outside of the Navy, to provide scientific and technical support in addressing the pertinent principal objectives of the LTM Program.

Comment 2-4.13: The Navy's LTM Program should coordinate with other associated and appropriate NMFS programs. (G-001)

Response: The Navy has and will continue to coordinate with other associated and appropriate NMFS programs, such as the Marine Mammal Acoustic Program/Acoustic Criteria Workshop and the Navy/NMFS Environmental Coordination Group.

Comment 2-4.14: The Navy should define a timetable for the LTM Program and provide a secure budget. (O-028)

Response: If the Record of Decision (ROD) by the Navy authorizes SURTASS LFA sonar employment, the Navy will provide a detailed LTM Program plan as outlined in Subchapter 2.4 (Long Term Monitoring Program). The LTM Program has been budgeted by the Navy at a level of $1M per year for five years, starting with the issuance of the first LOA.

Comment 2-4.15: Will the Navy's annual report to NMFS be subject to peer review? Will it be available to the public and the California Coastal Commission? (O-051, S-003)

Response: The annual report will not be subject to peer review. However, once the Navy's annual report is submitted to NMFS, it becomes a matter of public record.

CHAPTER 3 AFFECTED ENVIRONMENT

ISSUE 3-1: AFFECTED ENVIRONMENT: ACOUSTIC ENVIRONMENT

Comment 3-1.1: Define "deep sound channel" in the document prior to Figures 3.1-4 and 3.1-5. (NN001)

Response: Definition has been added to Subchapter 3.1.3 (Ocean Acoustic Regimes) of the Final OEIS/EIS.

Comment 3-1.2: Discuss how underwater sound is used for human communications. (G-001)

Response: Underwater communication between surface vessels and/or submarines is accomplished through the use of underwater telephones. These devices are the underwater analog of a radio transmitter-receiver (Urick, 1983). They generally utilize frequencies between 1.5 and 50 kHz (Watts, 1995).

Comment 3-1.3: Table 3.1-2: Add Navy shock trial information (20 kg TNT). (G-001)

Response: Information regarding peak pressure level for a charge of 4,536 kg (10,000 lb) TNT has been added to Table 3.1-2 (Summary and Comparison of Source Levels for Selected Sources of Anthropogenic LF Underwater Noise). The Navy's proposal for the Shock Trials of the *Seawolf* Submarine was to use a submerged charge of 4,536 kg (10,000 lb) TNT (DON, 1998), not 20 kg (44.1 lb).

Comment 3-1.4: What is the relevance of internal ocean waves to the impact assessment? (G-001)

Response: Internal ocean waves are not relevant to the impact assessment and have been deleted from Subchapter 3.1.2.4 (Winds and Waves) of the Final OEIS/EIS.

Comment 3-1.5: Quote from Urick (1983) that ambient noise is the "sound of the sea itself" is inappropriate. (O-027)

Response: Because the quote is not relevant to the discussion, it has been removed from the Final OEIS/EIS.

ISSUE 3-2: AFFECTED ENVIRONMENT: MARINE ORGANISMS - SPECIES SCREENING

Comment 3-2.1: Where data are missing or insufficient on one species, comparable data from a related species were used. Which species specifically? (O-027)

- **Response:** The statement concerning the use of comparable data from related species is found on page 3.2-3 of the Draft OEIS/EIS and specifically refers to acoustic sensitivity. Subchapter 1.4.1 (Adequacy of Scientific Information) of the Final OEIS/EIS discusses incomplete information. This use of comparable acoustic sensitivity data included such conservative assumptions as: 1) Data concerning LF hearing for the green, loggerhead, and Kemp's ridley sea turtles were extrapolated to the olive ridley, hawksbill, and leatherback sea turtles for which there are few data; 2) Baleen whales were used as indicator species for other marine animals in these studies because they are the animals that are the most likely to have the greatest sensitivity to LF sound, have protected status under law, and have shown avoidance responses to LF sounds; and 3) Although only a small percentage of fish species have been studied for hearing and sound production capabilities, all species that occur in pelagic waters were evaluated for potential LF sound impacts.

Comment 3-2.2: Screening criteria did not consider physiological, behavioral, and psychological effects/neurologic systems or non-hearing effects. (G-001, I-005, I-501, O-021, O-027, O-039, O-050, S-007)

Response: The above effects were considered in the screening criteria. As stated in Subchapter 3.2.1 (Species Screening) of the OEIS/EIS, the following criteria were used: 1) Does the proposed SURTASS LFA sonar geographical sphere of acoustic influence overlap the distribution of the species? If so, 2) Is the species capable of being physically affected by LF sound? Are acoustic impedance mismatches large enough to enable LF sound to have a physical effect or can the species sense/detect LF sound? These are sufficient to protect species from behavioral, psychological/neurological, and non-hearing effects. If the species met the screening criteria, it was then evaluated for potential effects in Chapter 4 (Impacts of the Proposed Action and Alternatives). Therefore, this is a conservative procedure.

Comment 3-2.3: The classification and elimination of invertebrates are confusing. They are located on the ocean floor in areas where LFA will operate. Also, cephalopods (squid and octopus) are mollusks. Justify exclusion of all decapods and cephalopods because of high hearing thresholds. Why were horseshoe crabs eliminated? (NN001, I-240, I-269, I-770, I-907, O-020, O-027, O-040, O-047, O-050, S-007)

Response: The classification and elimination of invertebrates (including horseshoe crabs) during the screening process have been clarified in Subchapter 3.2.1 (Species Screening) of the Final OEIS/EIS. Cephalopods and decapods were eliminated from further consideration because of their poor LF hearing, with hearing thresholds estimated to be 146 dB and 150 dB, respectively.

Comment 3-2.4: Correct Figure 3.2-1 to match text. (NN001)

Response: Revisions have been made to Figure 3.2-1(Species Selection Rationale) in the Final OEIS/EIS.

Comment 3-2.5: What about LF sound causing resonance in air cavities? Why were fish eggs and larvae eliminated from evaluation for LF sound effects? (G-001, I-269, I-287, I-907, O-020)

Response: Resonance can occur in gas cavities, such as fish swim bladders and gas bubbles. What resonance means is that energy is effectively transmitted from the medium (water) into the gas cavity or the surrounding tissue. The dominant organisms, which cause the scattering of sound signals due to air cavity resonance between 2 and 10 kHz, are the various types of fish that possess swim bladders (Urick, 1983). Scattering due to resonance above 20 kHz are likely to be caused by zooplankton and phytoplankton (Urick, 1983).

The resonant frequency of fish swimbladders decreases with fish length, with a small change due to water depth. For example, northern anchovies, which are 110-130 mm (4.3-5.1 inches) in length, have a measured resonance frequency of 1.3 kHz (Holliday, 1972), while a 350 mm (13.8 in) cod has a resonant frequency of 400 to 560 Hz at depths of 10-30 m (32.8-98.4 ft), respectively (McCarthney and Stubbs, 1971).

Fish are not expected to be significantly affected by resonance because the SURTASS LFA sonar signal is lower in frequency than the resonance for even the larger fish and as fish size decreases the resonant frequency increases.

Banner and Hyatt (1973) found that when members of two species of shallow-water marine fishes, *Cyprinodon variegatus* and *Fundulus similis*, were held in aquaria with sound pressure levels 40-50 dB above that experienced in their normal environment (40-1000 Hz band: likely bracketing the range of hearing), severe problems arose. The viability of the eggs of *C. variegatus* was significantly reduced over that recorded from the controls, and the growth rates for the fry of both species were significantly less than those shown for comparable fry held at a sound pressure level about 20 dB quieter. (Myrberg, 1990) However, this experiment exposed the subjects to continuous noise for period of eight hours per day for twelve days and longer. This is significantly longer than the maximum exposure fish eggs and larvae could receive from the moving SURTASS LFA source with a maximum signal length of 100 seconds and a 20 percent duty cycle.

Research on the effects of seismic airgun energy releases on fish eggs and larvae concluded that noticeable impacts would only result from large numbers of multiple exposures to full seismic arrays (TRACOR, 1987).

The SURTASS LFA sonar vessel travels at 5.6 kph (3 kt) during operations, with 6 to 15 minutes between pings. This means that fish eggs and larvae that are stationary would receive a maximum of 1.4 to 3.6 pings before the vessel moved out of range. Based on their limited exposure to SURTASS LFA sonar signals, fish eggs and larvae were eliminated from further consideration.

Comment 3-2.6: Why were flora eliminated? (I-269, O-027, O-040)

Response: Flora were eliminated because they did not meet the screening criteria of being physically affected by LF sound (see Subchapter 3.2.1). Also, plants are not known to have sensory systems that could potentially be susceptible to acoustic energy.

Comment 3-2.7: Seabirds - What is the basis for claiming "no impact" to seabirds that are wholly dependent upon fish stocks for survival? What is the basis for the claim that there would be no impacts on seabirds because they can easily disperse? (I-269, I-517, O-025, O-027, O-051, S-007)

Response: Subchapter 4.1.1 (Fish and Sharks) of the Draft OEIS/EIS concluded that the potential for the SURTASS LFA sonar to affect fish stocks would not be significant. Therefore, sea bird stocks that are wholly dependent upon fish stocks for survival would also not be significantly affected. The basis of the statement concerning the dispersion of sea birds is found in Croll et al. (1999), page iv.

Comment 3-2.8: Based on the Navy's current strategy to move into the littoral zone, why were shallow water species (including fish and non-mammalians) eliminated? What are the potential effects in the littoral zone? (I-269, I-907, O-027, O-047)

Response: Coastal species were eliminated, not shallow water species. All species were included for areas where SURTASS LFA sonar could potentially operate. Several "littoral areas" were modeled as discussed in Subchapter 4.2.1 (Acoustic Modeling Sites). The littoral operating environment does not necessarily include or exclude any waters because of depth; it can include both deep and shallow water.

Comment 3-2.9: What level of LF sound will penetrate into Arctic and Antarctic (polar circle) waters? (O-027)

Response: As shown in Figure 1-1 (SURTASS LFA Sonar Potential Areas of Operation), the sonar would be deployed in such a manner as to prevent exposing all excluded areas from sound pressure levels greater than 180 dB. In the Arctic (above 66° 30'N), a portion of the Norwegian, Greenland, and Barents seas below 72°N is in the potential operating area of SURTASS LFA sonar. The farthest south that the system will potentially operate will be 60°S. Therefore, SURTASS LFA sonar will not be operated within 704 km (380 nm) of the Antarctic Circle (66° 30'S).

Three acoustic modeling sites were selected near or above the Arctic Circle (Site 17–Denmark Strait, Site–22 Northeast Norwegian Basin, and Site 23–South Norwegian Basin Between Iceland and Norway). The results of the PE modeling are presented in the SURTASS LFA Sonar Technical Report (TR) 2, Acoustic Modeling. Plots of transmission loss (TL) versus range and depth are presented in Appendix B of TR 2.

Comment 3-2.10: Beluga whales and harp, hooded, and ringed seals occur outside of Arctic waters and should be included in the subsequent analyses. Why were bowhead whales not included in any impact scenarios? (G-001, O-027)

Response: Harp, hooded, and ringed seals do occur outside of Arctic waters; however, harp and ringed seals are pagophilic (ice-loving), and their predominant habitat is shore-fast sea ice (Reeves et al., 1992; Wynne and Schwartz, 1999). SURTASS LFA sonar will not operate where ice floes are common.

Hooded seals have recently been seen in more temperate waters, as far south as the coast of Massachusetts. Hooded seals have been included in the analyses for acoustic modeling site numbers 17, 18, 22, and 23 (See Subchapter 4.2 [Potential Impacts on Marine Mammals]). The estimates for the percentage of stocks potentially affected (Table 4.2-10) for beaked whales at these sites are considered reasonable surrogate values for the hooded seal stock.

The only areas in which belugas (white whales) may be found where there is a potential for them to be exposed to SURTASS LFA sonar signals is the Greenland Sea (Leatherwood and Reeves, 1983). The estimates for the percentage of stocks potentially affected (Table 4.2-10) for beaked whales at Site 17 are considered reasonable surrogate values for the beluga stock in the area. Moreover, beluga audiograms indicate poor LF hearing (Ridgway et al., 1997).

Bowhead whales were eliminated from the impact assessment because they are only found in Arctic waters and usually close to ice floes (Subchapter 3.2.1.2 [Vertebrates]), where the SURTASS LFA sonar would not be operated.

Comment 3-2.11: Why were ESA candidate species not analyzed? Was NMFS consulted before elimination? (G-001)

Response: On May 18, 1998, pursuant to Section 7 of the Endangered Species Act, the Navy requested from NMFS and the USFWS a compilation of listed, proposed, and candidate species and designated and proposed critical habitats for the North and South Pacific Oceans; Northwest, Northeast, and South Atlantic Oceans; Indian Ocean; and Mediterranean Sea. On January 27, 1999, NMFS responded, providing the requested information. However, no candidate species were provided at that time. Copies of these letters were provided in Appendix A (Correspondence), in the Draft OEIS/EIS.

At the time of NMFS's response, there were no candidate species. Since then, two have been added. In June 1999, NMFS published the "Endangered and Threatened Species Revision of Candidate Species List Under the Endangered Species Act" in the Federal Register (FR Vol. 64 No. 120) which added the Cook Inlet stock of belugas (white whales) and the Gulf of Maine stock of harbor porpoises.

The Cook Inlet beluga stock is located in coastal waters and, therefore, is not within the geographic region that SURTASS LFA sonar would operate. This stock of belugas, therefore, was excluded from further analysis. More information is provided in Subchapter 3.2.5.1 (Odontocete Deep Divers).

The Gulf of Maine stock of harbor porpoise is coastal ranging on the east coast of the U.S. from North Carolina to Maine and Nova Scotia (Wynne and Schwartz, 1999). These stocks are located in the Offshore Biologically Important Area defined by the 200-m (656-ft) isobath off the east coast of the U.S. (see Table 2-3). Therefore, they were excluded from further analysis.

Comment 3-2.12: Why wasn't "Marine Vertebrates and Low Frequency Sound, Technical Report for LFA EIS," prepared by Croll et al. (1999) referenced in the Draft OEIS/EIS the same as the other three technical reports (i.e., in a manner suggesting that it was available for review)? (I-501, I-517, I-766, O-020, O-039)

Response: Notwithstanding the title of the report, the University of California-Santa Cruz (UCSC) was not commissioned to prepare a technical report that was to be included in the OEIS/EIS. They provided factual material on a global scale for marine animals that could potentially be affected by the proposed action. Croll et al. (1999) was used to develop Chapter 3 (Affected Environment) and is extensively referenced.

Croll et al. (1999) has been made available by the UCSC Marine Vertebrates Ecology Group on their website at http://macarthur.ucsc.edu:4000/eir_site/EIS_SITE.home.

ISSUE 3-3: AFFECTED ENVIRONMENT: MARINE ORGANISMS - FISH

Comment 3-3.1: Correct the list of endangered fish for coho salmon. (NN001)

Response: Revisions have been made to Subchapter 3.2.2.4 (Threatened and Endangered Fish Stocks) of the Final OEIS/EIS.

ISSUE 3-4: AFFECTED ENVIRONMENT: MARINE ORGANISMS - SEA TURTLES

Comment 3-4.1: Correct the ESA status of sea turtles. (NN001)

Response: Revisions have been made to Subchapter 3.2.3 (Sea Turtles) of the Final OEIS/EIS.

ISSUE 3-5: AFFECTED ENVIRONMENT: MARINE ORGANISMS - MYSTICETES

Comment 3-5.1a: What is the scientific basis for coastal and pelagic classification of mysticetes? (O-027)

Response: The references cited in Subchapter 3.2.4 (Cetaceans [Mysticetes]) demonstrate that different mysticetes have coastal or pelagic tendencies. These general categories were utilized to distinguish the specific species' trends to be either coastal or pelagic.

Comment 3-5.1b: It is misleading to describe vocal signals as "redundant." (O-051)

Response: In Subchapter 3.2.4.1 (Mysticete Acoustic Capabilities) in the Final OEIS/EIS, the word "redundant" has been changed to "repetitive."

Comment 3-5.2: Table 3.2-3 (Information Summary for Mysticetes) acknowledges that we know almost nothing about the hearing of mysticetes. (I-425, I-501, O-051)

Response: There are no direct measurements available on the hearing sensitivity of any baleen whale. Indirect evidence from several sources strongly suggests that members of this suborder are much more sensitive to LF sound than are the odontocetes (NRC, 1994). There are no specific data on sensitivity, frequency or intensity discrimination, or localization ability. However, gray whales can detect killer whale sounds at RLs about equal to the ambient broadband noise level. During experiments playing back natural sounds to mysticete whales, three species (southern right, humpback, and gray whales) oriented to and approached sound sources indicating that they are capable of localizing LF sounds.

Furthermore, based on a comparative study of the inner ear auditory morphology in mysticetes, Ketten (1997) hypothesized that some large mysticetes have acute infrasonic hearing. Based on this information, the OEIS/EIS assumed that the most sensitive mysticetes are representative of all mysticetes. To assure that incomplete information on one species did not bias the analysis, all species of mysticetes found within the potential geographic operating area of SURTASS LFA sonar were assumed to be potentially affected by LF sound and analyzed for potential effects.

Comment 3-5.3: Correct the ESA status of the western Pacific gray whale. (G-001, NN001)

Response: Revisions have been made to Subchapter 3.2.4.3 (Coastal Mysticete Species) in the Final OEIS/EIS.

Comment 3-5.4: What were the DEIS's source(s) for cetacean stock assessments? The commentor states that the values are far overestimated (e.g., blue whales at 19,000 animals and humpback whales at 90,000). (O-027)

Response: The sources of the various stock assessments are provided in Table 4.2-4 (AIM Inputs for Distribution, Abundance, and Density). However, the stock numbers of 19,000 and 90,000 for blue and humpback whales, respectively, given by the commentor were not in the Draft OEIS/EIS.

ISSUE 3-6: AFFECTED ENVIRONMENT: MARINE ORGANISMS – ODONTOCETES

Comment 3-6.1: Does the Draft OEIS/EIS deny that large odontocetes (especially sperm whales) are vulnerable to LF sound? Did the Draft OEIS/EIS consider that orcas (killer whales) produce sounds as low as 0.1 kHz? (O-039)

Response: Evidence from several sources suggests that odontocetes are much less sensitive to LF sound than are the mysticetes (NRC, 1994). Based on a study of the morphology of the auditory apparatus of mysticetes, Ketten (1997) hypothesized that large mysticetes have acute infrasonic hearing. Based on this, and to assure that incomplete information on odontocetes did not bias the analysis, all species of large odontocetes found within the potential geographic operating area of SURTASS LFA sonar were assumed to be potentially affected by LF sound and thus analyzed for potential effects.

Table 3.2-4 (Information Summary for Odontocetes) of the Draft OEIS/EIS states that killer whales "produce sounds from 0.1 kHz to 85 kHz and hear sounds from <0.5 kHz to 105 kHz." This table also states that sperm whales "produce sounds from 0.1 kHz to 30 kHz."

Comment 3-6.2: The Draft OEIS/EIS refers to pilot whales as "blackfish." These species are not fish and pilot whale is the preferred common name. (G-001)

Response: "Blackfish" include the pygmy killer whale, melon-headed whale, false killer whale, short-finned pilot whale, long-finned pilot whale and killer whale (from *Whales, Dolphins and Porpoises*, Carwardine, 1995). In addition, many of these species have common names such as the "many-toothed blackfish" and "Hawaiian blackfish" for the melon-headed whale, and the "slender blackfish" for the Pygmy killer whale (Ridgway and Harrison, 1994).

ISSUE 3-7: AFFECTED ENVIRONMENT: MARINE ORGANISMS - PINNIPEDS

Comment 3-7.1: Make Table 3.2-5 consistent with other tables in the chapter. (G-001)

Response: Table 3.2-5 (Information Summary for Otariids) has been made consistent in the Final OEIS/EIS.

Comment 3-7.2: Table 3.2-6 should provide estimates of the sizes of the three gray seal populations and the Hawaiian and Mediterrean monk seal populations. (G-001)

Response: Table 3.2-6 has been updated with the above information.

Comment 3-7.3: Note separate eastern and western stocks of northern (Steller) sea lions. (G-001)

Response: Revisions have been made to Subchapter 3.2.6.1 (Otariids) of the Final OEIS/EIS concerning the listed status under the ESA for the eastern and western stocks.

Comment 3-7.4: There are three distinct harbor seal stocks in the North Pacific. Harbor seal diving data for the Atlantic is different from the Pacific. (G-001)

Response: There are several harbor seal stocks recognized by NMFS in the North Pacific: California coastal waters, Oregon and Washington coastal waters, and Washington inland waters. There are also three stocks in Alaskan waters: southeast Alaska coastal waters, Gulf of Alaska, and the Bering Sea. Only one stock is recognized in the Atlantic: the western North Atlantic stock. This species is mostly found in coastal waters, using sandy or rocky sites as haulouts and pupping sites (Wynne and Schwartz, 1999). Pupping often occurs on traditionally used protected sites in upper reaches of bays. Harbor seals are also found in the coastal areas of the eastern North Atlantic in the Baltic Sea, British Isles, and Norway.

Reeves et al. (1992) state that harbor seals off the California coast dove to maximum depths of 54-446 m (177-1,463 ft), while average dive depths were 17-87 m (56-285 ft). Harbor seal diving data for the North Atlantic show that at Sable Island, Nova Scotia, males primarily made deep dives (maximum depth of 208 m [682 ft]) offshore early in the breeding season (Coltman et al., 1997). However, when the different diving depths for the Pacific and Atlantic stocks are compared, the variance is not sufficient to change the results of the analysis.

No impacts on these stocks are expected because none are located near areas where SURTASS LFA sonar is expected to operate. Moreover, due to their relatively large size (1.7-1.9 m [5.6-6.3 ft]), it is highly probable they would be detected by the HF/M3 sonar within the LFA mitigation zone.

Comment 3-7.5: Lack of overt behavioral reactions from elephant seals in the Acoustic Thermometry of Ocean Climate (ATOC) Marine Mammal Research Projects (MMRPs) should not be over-interpreted. (G-001, O-047)

Response: Subchapter 3.2.6.2 (Phocids) of the Final OEIS/EIS has been revised to: "indicate that these sounds did not cause any short-term changes in dive behavior associated with (ATOC) transmissions."

Comment 3-7.6: Add reference(s) for monk seal hearing. (G-001)

Response: Revisions with reference citation have been added in Subchapter 3.2.6.2 (Phocids) in the Final OEIS/EIS.

Comment 3-7.7: Dismissing all significant discussion of impacts on otariids because they are generally coastal is not warranted. (O-047)

Response: Otariids were not dismissed in either the Draft or Final OEIS/EIS. Fourteen (14) species of otariids are discussed in Subchapter 3.2.6.1 (Otariids) of the OEIS/EIS and considered for potential impacts. Otariids are analyzed in Subchapter 4.2 (Potential Impacts on Marine Mammals) of the OEIS/EIS with results shown in Tables 4.2-10, 4.2-11 and 4.2-14.

Comment 3-7.8: The DEIS states that the endangered Hawaiian monk seal is not found at depths greater than 60 nm (sic), but fails to connect this information with the proposed action. Table 4.2-4 indicates that the seals feed in areas 10-40 m deep, but Table 3.2-6 indicates that they dive to 490 m. (O-051)

Response: The Draft OEIS/EIS states that for the modeling of the Hawaiian monk seal no animal will be found at distances greater than 111 km (60 nm) from the coast. Table 4.2-4 has been corrected to remove the reference to feeding in areas 10-40 m (33-131 ft) in depth, as this refers to the Mediterranean monk seal. The Hawaiian monk seal may forage in deep water, diving to depths of at least 490 m (1,608 ft). The discussion in Subchapter 3.2.6.2 (Phocids) concerning monk seals has been divided into separate discussions for the Hawaiian and Mediterranean monk seals.

ISSUE 3-8: AFFECTED ENVIRONMENT: MARINE ORGANISMS - MARINE MAMMALS (GENERAL)

Comment 3-8.1: Baseline information on distribution, basic biology, and essential behavior is not available (for marine mammals). Therefore, it is impossible to evaluate the proposed action's effects on these animals. The Draft OEIS/EIS contains insufficient information pertaining to potential impacts connected to loud anthropogenic noise on marine mammals, and marine mammal prey species distribution. (F-002, G-002, I-517, O-047)

Response: Because of the large diversity of marine animals and the expanse of their environment, it would be impossible to obtain all of the information for every species. The Navy has made a good faith effort to obtain the best environmental information available for all LF-sensitive species.

The Navy recognized that there was incomplete scientific information on the potential effects of LF sound on LF-sensitive marine mammals. In order to address the most critical of these data gaps (LF sound impacts on the most LF-sensitive marine mammals–baleen whales), the Navy performed extensive field research in the LFS SRP as discussed in Subchapter 4.2.4 (Low Frequency Sound Scientific Research Program). Incomplete or unavailable information is further discussed in Subchapter 1.4.1 (Adequacy of Scientific Information).

Comment 3-8.2: Discuss whale avoidance of the ATOC sound source during the California ATOC MMRP. Discuss the controversy concerning ATOC. (I-517, I-764, O-020, O-047, O-054)

Response: The California and Hawaii ATOC MMRPs were designed to determine the potential effects of acoustic transmissions on marine mammals and other marine life. All of the effects detected by the MMRPs were subtle and found only after statistical analyses for humpbacks off Hawaii. The researchers concluded that these subtle effects would not adversely impact the survival of an individual whale or the status of the North Pacific humpback whale stock (Frankel and Clark, 1999; 2000).

The ATOC project differs from the SURTASS LFA sonar program. Acoustic characteristics of the two LF sources are dissimilar, and they are deployed in different ways (ATOC is stationary on the sea floor at a depth of over 800 m [2625 ft]; SURTASS LFA sonar is at a depth of approximately 122 m [400 ft] and moves at 5.6 kph [3 kts]). The frequency for ATOC m-sequence sound was 75 Hz and that of SURTASS LFA sonar is between 100 and 500 Hz. The results of the MMRPs are, however, similar to the conclusions of the LFS SRP, which found that received levels of 120 to 150 dB elicited only minor, short-term behavioral responses from exposed animals, but not significant changes in biologically important behaviors.The discussion of any controversy concerning ATOC is beyond the scope of this OEIS/EIS.

Comment 3-8.3: For information on potentially affected resources that is not available, the Navy must make it clear that such information is lacking. If the overall cost to obtain it is exorbitant, or the means to obtain it are unknown, the Navy must include a "statement of relevance of the incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts" and "a summary of existing credible scientific evidence which is relevant to evaluating the reasonably foreseeable significant adverse impact to the human environment." Indicate when necessary information is incomplete or unavailable, acknowledge scientific disagreement and data gaps, and evaluate indeterminate adverse impacts based on approaches or methods generally accepted by the academic community. (I-425, I-682, O-016, O-018, O-051, O-053)

Response: This issue is addressed in the Final OEIS/EIS in Subchapter 1.4.1 (Adequacy of Scientific Information).

Comment 3-8.4: Recommendations and conclusions from the HESS Workshops (Sept 96 & Feb 99), the Workshops on Anthropogenic Noise in the Marine Environment - ONR (Feb 98), the Seismic and Marine Mammal Workshop - London (Jun 98), and Croll et al. (1999) are concerned with "unknown hearing thresholds and scientific ignorance." Does the Draft OEIS/EIS give lip service to environmental concerns based on these conflicting views? The Draft OEIS/EIS does not apply the Precautionary Principle, but rather plays down risks and seeks an absolute excessive limit based on operational need rather than environmental concerns. (I-425, I-477, I-501, O-018, O-020, O-038, O-039, O-047, O-049, O-051)

Response: For 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. Environmental concerns expressed by various workshops, such as the above, were an integral part of this determination. See Subchapter 1.4.2.1 (Estimating the Potential for Injury to Marine Mammals) of the OEIS/EIS.

Application of the Precautionary Principle is not required by law. Nevertheless, the Navy has adopted a prudent approach using conservative assumptions for identifying and analyzing potential impacts to the environment.

ISSUE 3-9: AFFECTED ENVIRONMENT: SOCIOECONOMIC

Comment 3-9.1: There is more up-to-date information available for Table 3.3-4 (Nominal Catches of Marine Mammals, 1995). (G-001)

Response: Table 3.3-4 (Nominal Catches of Marine Mammals, 1998) has been updated to 1998 data (latest available) based on compiled data on marine mammal catches as reported by each country to the Food and Argriculture Organization (FAO) of the United Nations (FAO, 1998).

Comment 3-9.2: The reference to ATOC should be updated, as this activity is no longer occurring in California and is moving from testing to operational mode in Hawaii. (NN001)

Response: The ATOC project has been completed in both California and Hawaii. Under a new proposal, the ATOC sound source and cable in Hawaii would be reused for the North Pacific Acoustic Laboratory (NPAL) project. Subchapter 3.3.3.1 (Oceanographic Research) of the Final OEIS/EIS has been updated with additional information on NPAL.

Comment 3-9.3: The following new and revised language (underlined) should be incorporated into Subchapter 3.3.4 (Coastal Zone Management):

Since 1972, 33 coastal states and territories have developed and implemented programs to ensure appropriate resource protection and compatibility of uses in their coastal zones. The programs.....Federal lands are excluded from the jurisdiction of the state coastal zone management programs, but activities on Federal lands are subject to the CZMA federal consistency requirement if the federal activity will affect any land or water or natural resource of the state's coastal zone, including reasonably foreseeable effects. Each state's coastal zone......

........related acoustic impacts. However, again, if any of these Federal activities affect state coastal resources, then the activity is subject to CZMA § 308(c)(1) and the activity must be consistent to the maximum extent practicable with the state's CZMA enforceable policies. (NN001)

Response: The above revisions have been made to Subchapter 3.3.4 (Coastal Zone Management) of the Final OEIS/EIS.

CHAPTER 4 IMPACTS OF THE PROPOSED ACTION AND ALTERNATIVES

ISSUE 4-1: POTENTIAL IMPACTS ON FISH

Comment 4-1.1: Why isn't moving out of the sound field, if bothered, an impact in and of itself? What is the basis that vulnerable fish will move "out of harm's way" to reduce impacts? (I-240, NN001, O-020, O-039)

Response: The term "moving out of harm's way" is no longer in the OEIS/EIS. An annoyed animal moving out of the sound field could be construed as being affected; however, not all effects are significant for NEPA purposes, nor do all effects result in incidental taking for MMPA or ESA purposes. See revised Final OEIS/EIS Subchapter 4.1 (Potential Impacts on Fish and Sea Turtles).

Comment 4-1.2: The conclusion that SURTASS LFA sonar will have negligible to no impact on fish is unfounded and speculative due to lack of data. What is the basis for the Alternative 1 statement that there would be no significant impact on fish because they are widely dispersed and few individuals would be inside the LFA mitigation zone (180-dB sound field)? Fish may remain in an area of high intensity sound possibly as a normal fright response. Impacts are too narrowly defined. What about behavioral changes? (I-267, I-269, I-287, I-349, I-477, I-918, I-1020, O-020, O-027, O-038, O-039, O-047, O-050, O-051, O-058, S-005, S-007)

Response: Subchapter 4.1.1.1 (Fish Stocks) addresses the issue of fish moving out of the sound field to reduce impacts. However, some fish may remain in an area of high intensity sound even as their sensory receptors are being injured.

Subchapter 4.3.1 (Commercial and Recreational Fisheries) includes a calculation of the possible effect of SURTASS LFA sonar operations on fish catches in a region off the Pacific Coast of the U.S. Some fish stocks could be affected by the LF sounds. However, a negligible portion of any fish stock would be exposed on an annual basis. No impact on commercial or recreational fisheries is expected because of the geographic restrictions that would be imposed on SURTASS LFA sonar operations (Chapter 5 [Mitigation Measures]).

Comment 4-1.3: Fish are not evenly distributed; they tend to clump and school. Provide supporting data for statement that SURTASS LFA sonar would not reduce the productive capacity of any fish stock. (O-039, O-047, O-051, O-055, S-007)

Response: Many fish species tend to clump or school. Clumping/schooling may be important for a single event, but because of the temporal and spatial scale of SURTASS LFA sonar employment on an annual basis, the importance of clumping/schooling fish is relatively low for such broad-scale operations. Moreover, due to the lack of more definitive data on fish stock distributions in the open ocean where SURTASS LFA sonar would be operating, it is infeasible to estimate the percentage of a stock (or fish clumps/schools) that could be located in a SURTASS LFA sonar operations area at a potentially vulnerable depth, during a sound transmission. Therefore, for the calculation provided in Subchapter 4.3.1, it is assumed that the stocks are evenly distributed.

The term "productive capacity" was not used in the Draft OEIS/EIS. The results from analysis in Subchapter 4.1.1 (Fish and Sharks) conclude that a negligible portion of any fish/shark stock would be exposed on an annual basis.

Comment 4-1.4: There is a lack of meaningful analysis of SURTASS LFA sonar effects on salmon and other listed fish in the Draft OEIS/EIS. (I-764, I-770, O-027, O-028, O-047, O-051)

Response: Analysis was carried out in response to the comment (see Subchapter 4.1.1 [Fish and Sharks]). In addition, Subchapter 3.2.2.4 (Threatened and Endangered Fish Stocks) provides a listing of threatened or endangered fish that potentially could be affected by the SURTASS LFA sonar sound source. For example, salmon are protected in their spawning areas, which are coastal and inland waterways. However, because of the nearshore geographic restrictions imposed on SURTASS LFA sonar (see Subchapter 5.1[Geographic Restrictions]), any potential for impacts on salmon are likely to be minimal (Croll et al., 1999).

Comment 4-1.5: Croll et al. (1999) (pages 15 and 57) give justification for not deploying SURTASS LFA sonar. (I-766)

Response: The relevant comments from Croll et al. (1999) concern potential impacts to eels (Anguilliformes), tuna and mackerel (Scombridae). There is one species of eel that can detect LF sound (Jerko et al., 1989) and a conger eel that produces sound. Scombrids produce sounds and are capable of detecting LF sound. There is no reason to believe these species are more susceptible to injury from LF sounds than hearing specialist fish species, and there is no reason to believe that SURTASS LFA sonar operations could affect a significant fraction of the habitat of any of these species. The following quotations from Croll et al. (1999) are their summaries for these species: 1) "Most eel species live in coastal nearshore waters or in quite deep water (Moyle and Cech, 1996; Helfman et al., 1997); consequently, impacts to this order should be minimal." 2) "Because both SURTASS LFA sonar operations and scombrids are highly mobile, stock-level impacts on scombrids are likely to be minimal." 3) "Because the proposed protocol of SURTASS LFA sonar operations calls for a moving vessel to produce relatively short blasts of sound with several minutes between blasts, the effects of this operation are likely to be minimal for most species of fish. As long as SURTASS LFA sonar operations are conducted away from near-shore habitats and distant from known aggregations of pelagic fishes, the direct physical effects on fish stocks of operations should be minimal."

Comment 4-1.6: Justify extrapolation that risk of physical harm or injury to fish would be no greater than for marine mammals. (I-240, O-021, O-047, S-005)

Response: Marine mammals have the lowest hearing thresholds (i.e., require less sound to hear) among all marine animals measured so far. Therefore, risk criteria developed for marine mammals are likely to be conservative for all other marine animal species.

Comment 4-1.7: The 180-dB criterion for potential injury is not conservative and not based on best available information. Croll et al. (1999) on page 32 suggested keeping intensities below 150 dB where fish concentrations are located. (I-240, I-517, I-918, O-020, O-021, O-047)

Response: Subchapter 4.1.1.1 (Fish Stocks) summarizes the studies documenting permanent hearing loss to fishes, and all of these cases involved exposure to sound levels above 180 dB, and often for much longer durations than the SURTASS LFA sonar transmits. The Croll et al. (1999) recommendation referred to scopaednids, and was based on the lack of observed rockfish responses at RLs of 153 dB (Klimley and Beavers, 1998).

Comment 4-1.8: What is the basis for extrapolating data on a half-dozen fish species to 25,000 species to support the conclusion that there will be no significant impact? (O-027)

Response: It is impractical to study every marine animal species, so where data are lacking, data are extrapolated from the closely related species. The criteria applied to all fishes is consistent with that applied to marine mammals, and existing scientific evidence supports the conclusion that marine mammals have the best hearing among all marine animals.

Comment 4-1.9: When fish hair (sensory) cells regenerate, are their functions the same as before they were damaged? (O-027)

Response: This has never been investigated. Lombarte et al. (1993) only studied the structural elements of the ear, and their function. Some data from studies of bird species suggest that some hearing function is restored as sensory hair cells regenerate.

Comment 4-1.10: Are there non-hearing impacts from SURTASS LFA sonar transmissions; e.g., can swimbladders, fish eyes, fish eggs and larvae be affected? (I-517, O-020, O-027, O-039, O-051, O-055)

Response: Non-hearing injury is generally believed to occur at higher RLs or longer exposure durations than hearing injury. Resonance of air cavities is discussed in Response to Comment 3-2.5.

Research on the effects of seismic airgun energy releases on fish eggs and larvae concluded that noticeable impacts would only result from large numbers of multiple exposures to full seismic arrays (TRACOR, 1987). Banner and Hyatt (1973) noted that under controlled testing conditions, the viability of the eggs of one species of estuarine fish (Cyprinodon variegates) was reduced in aquaria when a LF (40-1,000 Hz) noise source at 105-120 dB SL, which was approximately 40-50 dB above ambient noise, was maintained over a number of consecutive days. There is no reason to believe that viviparous (internally fertilizing and live-bearing) fishes would be affected by SURTASS LFA sonar source transmissions, and the chance of premature release of larvae (already fertilized) occurring as a result of the transmissions is negligible (ARPA, 1995). Moreover, SURTASS LFA sonar signals are of relatively short duration, and the duty cycle of these transmissions is low.

Comment 4-1.11: There is no method for detecting sharks/fish. (O-027, O-028, O-039)

Response: No provision for detecting and/or mitigating the potential for fish/shark effects was proposed, or called for by the biological analysis in this OEIS/EIS because the percentage of fish/shark stocks potentially exposed to the 180-dB sound field would be negligible. Moreover, due to the lack of more definitive data on fish/shark stock distributions in the open ocean where SURTASS LFA sonar would be operating, 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, for the calculation provided in Subchapter 4.3.1, it is assumed that the stocks are evenly distributed.

Comment 4-1.12: What is the potential effect on fish that are within the LFA mitigation zone at start-up? (O-039)

Response: The level of potential effects on fish in the LFA mitigation zone are independent of time of start-up or termination of transmissions. All analyses indicate effects within the LFA mitigation zone occur only during the actual transmission.

Comment 4-1.13: Will the SURTASS LFA sonar signal confuse fish and hamper their determining an evasion route? (O-039)

Response: The estimates of potential risk to fish species are intended to include these kinds of potential effects.

Comment 4-1.14: The Draft OEIS/EIS did not cite existing information on sound work for weakfish, croaker and black drum. (S-005)

Response: These species are not of special concern, because their primary habitat is shallow-water shelf areas, where SURTASS LFA sonar would not be operating.

Comment 4-1.15: Why are effects on forage fish not addressed? (O-027)

Response: The potential for effects on forage fish are addressed in Subchapter 4.2.7.6 (Potential for Indirect Effects).

Comment 4-1.16: What is the basis for the statement that if a food source (fish) is displaced from an area that others will move into the area to repopulate? (O-027)

Response: This statement has been removed in response to the comment.

Comment 4-1.17: There is no discussion of attraction and avoidance of sharks to LF sound. (O-051, S-005)

Response: The discussion in Subchapter 4.1.1.2 (Shark Stocks) has been amplified in response to this comment.

Comment 4-1.18: Sharks perform highly directional migrations that might also be disrupted. (O-051)

Response: The discussion in Subchapter 4.1.1.2 (Shark Stocks) has been amplified in response to this comment.

Comment 4-1.19: What is the basis of the statement that sharks have to be co-located with the vessel to be subject to serious injury? (I-764, O-027)

Response: For clarity, the term “co-located” is no longer used, and the discussion of shark responses to LF sounds (Subchapter 4.1.1.2) has been amplified in response to comments.

Comment 4-1.20: What is the basis for the conclusion of insignificant impact to sharks because of their wide dispersal in the ocean? (O-027, O-047)

Response: SURTASS LFA sonar operations would expose small, discrete regions of the ocean to high sound levels. This operational constraint bounds the potential impact on widely distributed stocks, whose ranges are orders of magnitude larger. Moreover, due to the lack of more definitive data on shark stock distributions in the open ocean where SURTASS LFA sonar would be operating, 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, the results of the analyses presented in Subchapter 4.1.1.2 (Shark Stocks) are based on the assumption that the stocks are evenly distributed.

Comment 4-1.21: Why was there no mention of great white, mako and tiger sharks in the Draft OEIS/EIS? (O-027)

Response: The discussion on sharks was general and applied to all shark species. There is no basis for special treatment of great white, mako, or tiger sharks.

Comment 4-1.22: The cumulative effects on sharks need to include all human impacts. (O-047)

Response: The OEIS/EIS shows that SURTASS LFA sonar operations would have a negligible contribution to ambient noise levels in the ocean. In the broader context of all human impacts, the significance of SURTASS LFA sonar operations is even more insignificant.

ISSUE 4-2: POTENTIAL IMPACTS ON SEA TURTLES

Comment 4-2.1: Why isn't moving out of the sound field, if bothered, an impact in and of itself? What is the basis that sea turtles will move "out of harm's way" to reduce impacts? (I-269, NN001, O-020, O-039)

Response: The discussion of animal displacement due to SURTASS LFA sonar sounds (Subchapter 4.1.2) has been revised and updated in response to comments.

Comment 4-2.2: The conclusion that SURTASS LFA sonar will have negligible to no impact on sea turtles is unfounded and speculative due to lack of data. What is the scientific basis that no sea turtles will be impacted by SURTASS LFA sonar? (I-267, I-918, NN001, O-027, O-047, O-050, O-051, O-057, S-007)

Response: The discussion of impacts on sea turtles (Subchapter 4.1.2 [Sea Turtles]) has been revised and updated in response to comments. The focus of the revised discussion is the potential impact on sea turtle stocks, not individuals. The analysis indicates negligible potential for effects on stocks.

Comment 4-2.3: Many sea turtles may escape detection by visual and active acoustic methods. (I-240, NN001, O-027)

Response: No mitigation effort can totally eliminate the possibility of impact on an individual sea turtle. The proposed mitigation procedures include a new instrument (HF/M3 sonar) that was specifically developed to improve detection of marine mammals. This device would also offer the potential for detecting sea turtles, thereby reducing the potential impact of SURTASS LFA sonar operations on sea turtles.

Comment 4-2.4: Sea turtles are not only coastal, but have relatively high densities offshore at distances greater than 22 km (12 nm); consequently there is a relatively high probability of encounter with sea turtles, contrary to what the Draft OEIS/EIS says. (I-770, I-918, O-027)

Response: Only the olive ridley and leatherback turtles spend much of their time in the open ocean as adults, with the latter having the highest potential for interacting with SURTASS LFA sonar because of its truly pan-oceanic habitat. It is also recognized that juvenile sea turtles inhabit pelagic areas during the first years of their lives. However, a small fraction of the pelagic habitats would be exposed to RLs in excess of 180 dB on an annual basis, so the potential worst-case impacts to sea turtle stocks are extremely low. Due to the lack of more definitive data on sea turtle stock distributions in the open ocean, where SURTASS LFA sonar operations would occur, 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, for the analyses presented in Subchapter 4.1.2, it is assumed that the stocks are evenly distributed.

Comment 4-2.5: The 180-dB criterion is not precautionary; a criterion lower than 180 dB should be used in areas of high sea turtle concentrations. (I-240, I-918, O-047)

Response: Based on limited data, it is concluded that sea turtles do not have particularly good LF hearing (see Subchapter 4.1.2 [Sea Turtles]). 180 dB is 40 dB above the best estimates of hearing threshold for sea turtles in the 100-500 Hz frequency band; thus, application of the 180-dB value as the RL for potential injury to sea turtles should be considered conservative.

Comment 4-2.6: What is the basis for the statement that sea turtles have to be co-located with the vessel to be subject to serious injury? (I-764, O-047)

Response: For clarity, the term "co-located" has been removed from the OEIS/EIS, and the analysis in Subchapter 4.1.2 (Sea Turtles) has been revised and updated in response to the comments.

Comment 4-2.7: There is no impact analysis on sea turtle essential behaviors (e.g., ocean migrations and nesting). (O-051)

Response: Subchapter 4.1.2.1 (Alternative 1) of the Final OEIS/EIS has been expanded to better address the potential for impacts on sea turtle migration patterns. Although the data are sparse, no adverse impacts are expected. The geographic restrictions imposed on SURTASS LFA sonar operations (i.e., no operations within 22 km [12 nm] of the coast) would preclude impacts on sea turtle nesting on beaches (Eckert, pers. comm., 1999).

ISSUE 4-3: POTENTIAL IMPACT ON MARINE MAMMALS—ACOUSTIC MODELING

Comment 4-3.1: Are the references used for marine mammal stock assessments the most up-to-date? (G-001, I-501, NN001, O-027)

Response: The references used for marine mammal stock assessments were the most recently available among published findings, according to the National Marine Fisheries Service at the time the Draft OEIS/EIS was published.

Comment 4-3.2: Why no beaked whales at Sites 8 and 13? (O-027)

Response: The AIM simulations and tables of results have been revised to include beaked whales at these sites.

Comment 4-3.3: Sites do not accurately represent pinnipeds in certain regions: Site 1: add harbor and northern elephant seals; Site 8: add California sea lions; Site 9: add harbor and northern elephant seals; Site 10: add northern elephant seals; Site 13: add California sea lions and harbor seals; Site 17: add gray, hooded, harp, and ringed seals. (G-001)

Response: The rationale for the inclusion or exclusion of certain pinniped species is as follows:

- Harbor seals were not included at Site 1 because Reeves et al. (1992) state that in the eastern Pacific, harbor seals are abundant in protected inlets, bays, and fiords but are generally less abundant along simple, exposed coasts and around small islands in the

Commander, Aleutian, and Pribilof Island chains. Thus, they have only a remote chance of being exposed to SURTASS LFA sonar sound fields and the risk to these animals is negligible. Only male northern elephant seals migrate as far north into the Gulf of Alaska as Site 1, but they haul out (i.e., on land) to molt during June-August (Le Boeuf and Laws, 1994), and thus would not be exposed to SURTASS LFA sonar sound fields during the time period modeled in the OEIS/EIS. Extrapolation of results from Site 13 model analysis for northern elephant seals to Site 1 provides a very conservative estimate of the percentage of stock of elephant seals potentially affected in the north Gulf of Alaska (since only a small part of the offshore central California stock of northern elephant seals migrate to the north Gulf of Alaska).

- According to Croll et al. (1999) male California sea lions migrate north near shore in the vicinity of Site 8, while females disperse near shore. They feed at depths of 26 to 74 m (85 to 243 ft), with maximum dive depth to 376 m (1,234 ft) (Reeves et al., 1992). They have been added to Site 8 in Tables 4.2-1 and 4.2-4. Potential effects on this species are similar to the results modeled for northern fur seals at the same site.

- At Site 9, harbor seal pupping occurs at rookeries in May, with the animals being waterborne for the better part of the rest of the year. In this region, they are known to feed in epibenthic habitats near shore, with average dive depths 17 to 87 m (56 to 285 ft) and maximum dive depth 446 m (1,463 ft). Potential effects on this species are similar to the results modeled for northern fur seals at the same site. If male northern elephant seals are present at this site during the spring or fall, they would be migrating through the area, although most would be feeding in the Gulf of Alaska at this time. Females may be in the area feeding, but would be located from the coastline to 150 deg W.

- Harbor seals and northern elephant seals have been added to Site 9 in Tables 4.2-1 and 4.2-4. Results from northern elephant seal modeling have been added to Table 4.2-10 and Table 4.2-12.

- Only male northern elephant seals migrate as far north into the Gulf of Alaska as Site 10, but they haul out to molt (i.e., on land) during June-August (Le Boeuf and Laws, 1994). Thus they would not be exposed to SURTASS LFA sonar sound fields during the time period modeled in the OEIS/EIS. Females may be feeding about 528 km (285 nm) southeast of this site (Le Boeuf, 1994). The extrapolation of results from Site 13 model analysis for northern elephant seals to Site 10 is in keeping with the prudent approach applied throughout this OEIS/EIS. The percentage of stock of elephant seals potentially affected in the south Gulf of Alaska (Site 10) would never approach that derived for Site 13 (since only a small part of the offshore central California stock of northern elephant seals migrate to the south Gulf of Alaska).

- According to Croll et al. (1999) male California sea lions migrate north near shore in the vicinity of Site 13, while females disperse near shore. Potential effects on this species are similar to the results modeled for northern fur seals at the same site. At Site 13, harbor seal pupping occurs at rookeries in May, with the animals being waterborne for the better part of the rest of the year. California sea lions and harbor seals have been added to Site 13 in Tables 4.2-1 and 4.2-4.

- With respect to Site 17, the predominant habitat for harp and ringed seals is shore-fast sea ice (Reeves et al., 1992; Wynne and Schwartz, 1999), which is not an operating area for SURTASS LFA sonar. Hooded seals are only found in the North Atlantic, primarily north of the Gulf of St. Lawrence and prefer thick, drifting ice floes or deep offshore waters (Wynne and Schwartz, 1999). SURTASS LFA sonar will not be operating in areas where ice floes are common. Even though hooded seals have been recently seen off the coast of Massachusetts, there is no evidence that the hooded seal is particularly sensitive to LF sound. Moreover, due to their relatively large size (2.0-2.7 m [6.5-9.0 ft]), detection by the HF/M3 sonar within the LFA mitigation zone would be a high probability. Extrapolation of results from Site 17 model analysis for beaked whales to hooded seals provides a very conservative estimate of the percentage of stock of hooded seals that could potentially be affected there.

- Any gray seals found in the vicinity of Site 17 would be part of the eastern Atlantic stock. Their breeding season is from September through mid-October with rookeries located along the coast of Norway and the Faroe Islands (Reeves et al., 1992); thus, they would not be present at the site during the time periods modeled.

Comment 4-3.4: Sperm whales are missing from Sites 20, 28, 29, and 30. (O-020) (O-025)

Response: Sperm whales have been added to sites 20, 28, 29 and 30, and Tables 4.2-1 and 4.2-4 have been updated appropriately. Potential effects on this species can be estimated from the modeling results for beaked whales at these sites.

Comment 4-3.5: Why aren't orcas (killer whales) included in modeling sites? (O-027)

Response: Orcas, or killer whales, were included in the modeling analysis within the group "blackfish and killer whales" (see Table 4.2-4 [AIM Inputs for Distribution, Abundance, and Density]). Subchapter 4.2 (Potential Impacts on Marine Mammals) has been revised accordingly in the Final OEIS/EIS.

Comment 4-3.6: Why wasn't the Low Frequency Sound Scientific Research Program (LFS SRP) Phase III site off the west coast of the Big Island of Hawaii used as one of the model sites? (O-057)

Response: Phase III was located within the 22 km (12 nm) coastal geographic restriction zone; therefore, it would not be a SURTASS LFA sonar operations site. This site was chosen for scientific research because the high densities of humpback whales there would allow more frequent experiments, and because a long history of prior studies provided valuable background information.

Comment 4-3.7: There are insufficient data available (occurrence, abundance, distribution) for marine mammals in the Bahamas (Site 29) to assess their status; data used to run the model are primarily statistical extrapolations with little or no scientific basis. Beaked whale distribution (not randomly distributed, but tend to clump and follow terrain) and diving data are incorrect for those whales in the Bahamas. (I-682, O-025, O-026, O-053)

Response: The analysis in the OEIS/EIS is based on an extensive review of scientific publications, but some published material and the majority of unpublished findings may have been missed (potentially including dive data). However, tendencies to aggregate in relation to bottom terrain, or school, would not markedly affect the annual estimates of potential effects from SURTASS LFA sonar operations. Due to the wide range of SURTASS LFA sonar operations, some areas will have more animals than expected, and some fewer animals than expected. However, because of the conservative procedures and assumptions used in the modeling (Subchapter 1.4.3), the possibility of any differences causing a substantial increase in the percentages of marine mammal stocks potentially affected (Table 4.2-10) is remote.

Comment 4-3.8: Animal densities are many orders of magnitude higher near coastlines and continental slopes; therefore, modeling underestimates animal densities. (O-020, O-021, O-043)

Response: The Navy agrees that marine animal densities are generally higher near coastlines and continental slopes. The best available data from NMFS and other literature sources were used in all model cases, which reflected higher densities in those regions. Moreover, higher animal densities were explicitly modeled with the acoustic integration model (e.g., see Figures 4.2-8 through 4.2-11).

Comment 4-3.9: Abundance estimates for Dall's porpoise seem unreasonably high, and there are several discrete stocks in the North Pacific. (G-001)

Response: The abundance estimates for Dall's porpoise are from Croll et al. (1999). The Navy agrees with the commentors that in the western North Pacific, differences have been noted among animals from three areas: Pacific coast of Japan, Sea of Japan, and the Sea of Okhotsk. However, by utilizing high abundance numbers, the analysis results are conservative.

Comment 4-3.10: How can the model accurately simulate the number of animals per unit area, their courses, their propensity to change course, their speed, their depth of dives, and time they spend at four depth zones in the water column, when actually we don't even know how many whales are in a given area, much less any details about their diving behavior? (I-290, I-501, I-682, O-020, O-025, O-042, O-047, O-053)

Response: Data regarding time spent in specific depth zones were taken from published reports for each species, or from reports for closely related species. These animal dive depth parameters were the most important in affecting the overall estimates of potential impact. Nominal values were used for animal movement patterns. Changes in these parameters may alter the total number of animals exposed, and the extent of potential cumulative impact to some individuals, but these changes would not materially change the overall estimate of potential impact, especially relative to animal dive depth parameters.

Comment 4.3-11: The percentage of stock potentially affected that was reported in the Draft OEIS/EIS underestimates the number of individuals that may be affected and may overstate the probability that they will be affected; what are the implications for small or depleted stocks when the potential for the entire stock is taken into account? (G-001, O-042)

Response: The AIM simulation is likely to underestimate the number of animals exposed, and overestimates their exposure, because the model does not allow animals to leave the area, nor does it allow new animals to enter the area. These artificial conditions make the modeling more practical to implement. The effects of these two conditions tend to compensate for each other, in terms of the overall assessment of potential impact. Regarding small or depleted stocks, there is no evidence of a plausible scenario where SURTASS LFA sonar operations could jeopardize an entire stock of marine mammals, given the geographic restrictions and monitoring mitigation that would be imposed upon the proposed action. Moreover, the AIM analysis sites were selected to model the highest potential for effects from the use of SURTASS LFA sonar. This and the other eight conservative procedures and assumptions applied in research and modeling associated with the development of this OEIS/EIS are discussed in Subchapter 1.4.3.

Comment 4-3.12: Were single-ping-equivalent (SPE) calculations used in the 31 sites modeled? (O-039)

Response: Yes, SPE calculations were used in the 31 sites modeled.

Comment 4-3.13: Acoustic Integration Model (AIM) input data are very poorly known; these input parameters should be assessed by experts with local knowledge. (I-769, O-043)

Response: AIM input parameters were reviewed and cross-checked with marine biology experts (see List of Preparers and Reviewers), many of which had local knowledge. AIM input parameters are provided in Tables 4.2-2 through 4.2-4.

Comment 4-3.14: The sensitivity of AIM-predicted outcomes to the variability and errors of input data should be addressed. (I-454, O-043)

Response: Specific sensitivity studies were not conducted during the AIM analyses. The best available transmission loss algorithms, environmental-acoustic databases, animal population values, and animal characteristics were used for AIM input.

AIM has been implemented to generate statistically significant scenarios. In order to achieve statistical significance, each of the propagation regimes was evaluated; and the variability of the model predictions was examined as a function of animal densities present. For a given propagation regime, various densities of animals were modeled and compared to a reference grid of one animal every 100 yd (91.4 m). Statistical significance was achieved when the resultant cumulative distribution function (CDF) of the received level (RL) for the animal densities was continuously within three decibels of the reference CDF for each scenario. Grid spacing of 100 yd (91.4 m) intervals was used because it is the minimum resolution for the parabolic equation (PE) transmission loss model. Agreement between acoustic predictions and actual at-sea RLs on the order of 2-3 dB is considered to be very good modeling for the highly variable (spatially and temporally) ocean propagation environment.

Comment 4-3.15: The Draft OEIS/EIS reports estimated takes to two decimal places with no confidence levels. (I-501)

Response: Estimated takes were carried out to two decimal places in order to show the potential for effects to all marine mammals modeled while applying a consistent scientific presentation format. Because of the Navy's adoption of a prudent approach for this OEIS/EIS, the values given are conservative and represent upper bounds. Confidence levels (i.e., a range of possible values; for example, 0.12 +/- 0.04 would mean the range of values would be from 0.08 to 0.16) may have been appropriate if the estimated takes were average or median values.

Comment 4-3.16: How can the Parabolic Equation (PE) model be applied to a towed array (moving source) and continuously varying environmental conditions? (I-290, I-454, I-769, O-027)

Response: The PE model can be used with both stationary and moving sources, and is range-dependent. The AIM simulations accounted for varying environmental conditions.

Comment 4-3.17: The graphics in TR 2 do not apply to the SURTASS LFA sonar system, which is not omni-directional. (I-454)

Response: The SURTASS LFA system's transmitted beam is omni-directional (360 degrees) in the horizontal with a narrow beamwidth in the vertical.

Comment 4-3.18: Analysis must assess the program comprehensively "in space and time (and) under various scenarios of system operation." (O-028)

Response: The modeling sites (scenarios) presented in the Final OEIS/EIS do assess the program (SURTASS LFA sonar) comprehensively in space and time under various scenarios of system operation.

Comment 4-3.19: Why isn't the potential for long-term effects built into the OEIS/EIS models? (O-018, O-027)

Response: The potential for long-term effects is built into the AIM simulation technique to the extent possible, in that it accounts for full (maximum) 20-day SURTASS LFA sonar operational missions (Table 4.2-10). The addition of different modeling sites on an annual basis also supports assessment of the potential for long-term effects (Table 4.2-11, 4.2-12, 4.2-13, and 4.2-14).

Comment 4.3-20: Why is there a larger percentage of impact to severely listed right whales than recovered gray whales? (O-027)

Response: For the northern right whale, it is possible to select a modeling site that affects a larger fraction of the stock than is possible with the gray whale. The percentage of potential effects values is largely constrained by the degree of spatial concentration of the stock, rather than the number of individuals in the stock.

Comment 4-3.21: How can a percentage of impact be assessed if a species was not modeled? (O-027)

Response: When a species was not explicitly modeled, percentage of potential effects were estimated by matching their distribution and diving tendencies to a species that was modeled at that particular site, and making an adjustment for differing animal densities, when necessary.

Comment 4-3.22: Justify how you can have significant “take” rates with no overall impacts to stocks. (O-027)

Response: Subchapter 4.2.7.8 (Summary) states that, under Alternative 1, the potential for effects on any stock of marine mammals from injury is negligible, and the effects on the stock of any marine mammal from significant change in a biologically important behavior is minimal. Therefore, based on the results of this analysis, there will be no significant "takes" of marine mammal stocks and, accordingly, no overall impacts to stocks. Even with some individual animal takes, there is no impact on the species’ stock if the number of takes is a negligible percentage of the population (Subchapter 4.2.7.5 [Biological Context]).

Comment 4-3.23: Did risk analysis (acoustic modeling) consider the convergence zone acoustic propagation path? (G-001)

Response: Acoustic modeling did account for convergence zones.

Comment 4-3.24: What evidence is there that behavioral responses are mediated by the average received level (RL) rather than the maximum RL? (O-042)

Response: The OEIS/EIS uses single-ping-equivalent (SPE), which gives exposure values both larger than average or maximum received levels (RL).

Comment 4-3.25: What would be the impact on the estimated number of takes (by harassment) if it were based on 50 percent of the individuals exposed to 120 dB at any time, as opposed to the model used in the Draft OEIS/EIS? (I-425, O-042)

Response: The results from all three phases of the LFS SRP are fundamentally inconsistent with the assumption that 50 percent of the individuals exposed to RLs of approximately 120 dB (actual value used in the analysis was 119 dB) suffer significant change in a biologically important behavior. There was no justification for modeling this unrealistic scenario.

Comment 4-3.26: Table 4.2-4 shows a uniform distribution of greater than 200 m (656 ft) for the blue, fin, and sei whales, but maximum depths per Table 4.2-3 are 159.1 - 186.5 m (522 – 612 ft). This should be rectified. (NN001)

Response: Table 4.2-3 describes the maximum depth to which blue, fin and sei whales dive. On the other hand, Table 4.2-4 describes the distributional preferences in the ocean that these species exhibit. That is, blue, fin and sei whales are typically found at uniform distributions in waters whose depths are greater than 200 m (656 ft). So, as an example, a blue whale may be found in an area whose water depth is 1,500 m (4,920 ft), but the maximum depth in the water column that the animal is known to dive to is 186.5 m (612 ft); thus, the animal does not transit through the entire water column.

Comment 4-3.27: Different models should be used for impact based on cumulative noise exposure (the physical injury and hearing loss models) and for impacts based on noise-induced behavioral changes. (O-042)

Response: Effectively two models are used in the analysis: 1) 100 percent chance of "injury" above 180 dB and 2) the risk continuum for the significant change in a biologically important behavior.

Comment 4-3.28: Why were fin whales not modeled in the Mediterranean Sea? (I-501)

Response: Fin whales were modeled at Site 19, Strait of Sicily (See Table 4.2-10). Table S-2 in the Executive Summary erroneously reversed the values for the fin and blue whales in the Mediterranean Sea. This has been corrected in the Final OEIS/EIS. Fin whales have not been observed in the eastern portion of the central basin or the eastern basin of the Mediterranean Sea, from sighting data compiled over 21 years (Beaubrun et al., 1995); therefore, they were not modeled at Sites 25 or 26. Fin whales are typically seen in the Ligurian Sea and the western basin and were modeled at Site 19, Strait of Sicily.

Comment 4-3.29: Why were sperm whales not modeled in the western North Pacific? (I-501)

Response: Sperm whales occur throughout all oceans of the world; however, their distribution tends to be in clusters. Therefore, sperm whales were modeled in areas of historically high concentration, such as the Hawaiian Islands (Sites 6, 7, 12), and eastern Australia and New Zealand (Site 16). The potential effects on sperm whales can be estimated in the western North Pacific (Site 2) from the modeling results for beaked whales there.

Comment 4-3.30: What happens when the SURTASS LFA sonar transmissions enter the SOFAR channel? (I-681)

Response: Depending on environmental conditions, sound can travel long distances in the deep sound channel or Sound Frequency and Ranging (SOFAR) channel. The modeling in the OEIS/EIS accounts for all environmental conditions, including ducting and the SOFAR channel (when it exists), as will modeling performed in support of deployment of the sonar. Subchapter

B.5.2 and Figure B-7 of Appendix B explain and illustrate the characteristics of the deep sound channel.

ISSUE 4-4: POTENTIAL IMPACTS ON MARINE MAMMALS—BIOLOGICAL RISK AND RISK FUNCTION

Comment 4-4.1: If available information and data are insufficient to determine risk, both uncertainties and possibility of consequences of uncertainties should be noted. No effort is made to identify data gaps, to describe areas of scientific disagreement or controversy, or to qualify conclusions regarding biological significance in light of either. (G-001, I-425, I-682, I-907, O-016, O-026, O-028, O-051, O-053, O-057)

Response: Final OEIS/EIS Subchapter 1.4 deals with the issue of data gaps (i.e., incomplete or unavailable information). In addition, revisions have been made in the Final OEIS/EIS Chapter 4 (Impacts of the Proposed Action and Alternatives) to better reflect areas of scientific disagreement or controversy, and to qualify conclusions regarding biological significance in light of either.

Comment 4-4.2: Why are data regarding marine mammal avoidance from other sonars ignored? (I-501, I-770)

Response: The Navy considered all the relevant data regarding LF sonars. Note that SURTASS LFA sonar is different than traditional active sonar systems because it has longer pulse lengths, whereas the majority of other sonars are mid- to high-frequency short-pulse sonars. Other known sonar studies have focused on mid- to high-frequency sonars with acoustic characteristics different from SURTASS LFA sonar, so that they are not particularly relevant to analyses pertaining to LF sonar such as the SURTASS LFA sonar. For example, the following references pertain to mid- to high-frequency acoustic sources: Watkins and Schevill, 1975 (*Sperm whales* [Physeter macrocephalus] *react to pingers*); Maybaum, 1990 (*Effects of a 3.3 kHz sonar system on humpback whales,* Megaptera novaeangliae, *in Hawaiian waters*). For additional information on the subject, Richardson et al. (1995b) address reaction to different types of active sonars by mysticetes, odontocetes, and pinnipeds.

Comment 4-4.3: Risk function is incomplete because frequency and depth were not considered. (O-057)

Response: Frequency and depth are accounted for in the acoustic modeling and risk analysis process.

Comment 4-4.4: The Final OEIS/EIS should include a determination as to whether repeated ping acoustic signals are more harmful to baleen whales than single pings. There is no behavioral basis for the SPE approach. (G-003, O-020, O-027)

Response: The single-ping-equivalent (SPE) calculations do assume that multiple ping exposures are more harmful. Subchapters 4.2.3.1 (Effects of Repeated Exposure) and 4.2.5 (Risk Continuum Analysis) provide explanations and an illustration (Figure 4.2-2a, Sample Single Ping Equivalent [SPE] Calculation).

Comment 4-4.5: For SPE calculations and risk functions, what consideration is given to ping duration? (I-240, NN001, O-020, O-027)

Response: A ping duration of 60 seconds is used in modeling and risk assessment calculations using SPE; this information has been included in the Final OEIS/EIS. Although pulse length (ping duration) can be 6-100 seconds, nominal pulse length is 60 seconds. For more information, see Subchapter 4.2.3.1 (Effects of Repeated Exposure).

Comment 4-4.6: The Navy's SPE concept is based on assumptions that have not and cannot be verified. The Draft OEIS/EIS failed to state that Richardson et al. (1995b) emphasized that extrapolating from human in-air data to postulate the effects of repeated exposure should be done with extreme caution, and that values from this extrapolation presented in Richardson et al. (1995b) are extremely speculative, given the unknown relevance of human in-air data to marine mammals underwater. Further, these statements were made about impulsive noise (e.g., airguns) not continuous noise as from SURTASS LFA sonar. (I-240, I-425, I-454, NN001, O-027, O-028, O-039, O-047)

Response: The SPE concept is related to widely accepted methods for comparing sounds of different durations. It is universally acknowledged that increased exposure duration increases the severity of potential impact. The SPE calculation is conservative in assuming that the increase in potential effects observed by extending the duration of a continuous sound stimulus applies to a sequence of SURTASS LFA sonar pulses (pings), even though the transmissions are separated by many minutes when the system is off. This applies to SURTASS LFA sonar-type signals, not continuous sound.

Comment 4-4.7: Elaborate on the statement in the Draft OEIS/EIS that an increase in 10 dB represents a 10-fold increase in physical units (dB), but only a doubling in the level as perceived by humans. (G-001, NN001)

Response: It is assumed that the commentor's term “level” means loudness, as is the case throughout the OEIS/EIS. This does not necessarily imply that all humans and all species and age/sex groups of marine mammals would perceive the increase as an exact doubling of loudness or intensity. This statement must be considered to be a generalization to aid in the explanation that neither humans nor marine mammals would perceive anything near a 10-fold increase in loudness but, rather, much closer to a two-fold (doubling) increase (Kryter, 1985). Available information is insufficient to make specific determinations as to how various species of marine mammals would perceive a 10-dB increase in sound level.

Comment 4-4.8: Will repeated exposure lead to gradual hearing loss? (I-681, O-016)

Response: The SPE calculation assumes that repeated exposure at sufficiently high intensity levels increases the risk of permanent hearing loss (PTS). For the purpose of this analysis, hearing loss is assumed to occur at SPE levels above 180 dB.

Comment 4-4.9: Who was on the scientific team that established risk of harm from a single ping to be 180 dB, and what is the rationale and justification behind their finding? (I-005, I-240, I-770, O-034, O-039, O-042)

Response: The 180-dB criterion emerged from technical meetings that preceded or were concurrent with the LFS SRP, involving many scientists, the majority of whom who had no connection with the LFS SRP. For the purposes of this document 180-dB received level is considered the point above which some potential serious problems in the hearing capacity of marine mammals could start to occur. Several scientific and technical workshops and meetings at which the 180-dB criterion were developed are:

- HESS Team Workshop. Pepperdine University School of Law, June 12-13, 1997 (Knastner, 1998);
- Office of Naval Research Workshop on the Effects of Man-Made Noise on the Marine Environment. Washington, DC, February 9-12, 1998 (Gisiner, 1998); and
- National Marine Fisheries Service (Office of Protected Resources) Workshop on Acoustic Criteria. Silver Spring, MD, September 9-12, 1998.

Comment 4-4.10: On what basis are all non-hearing effects of LF sound on marine mammals dismissed? (I-501, I-907, O-027, O-051)

Response: The Navy did not dismiss non-hearing effects in the Draft OEIS/EIS. Subchapter 4.2.7.6 (Potential for Indirect Effects) discusses the potential for non-hearing effects, including the potential that pelagic fish would be affected and thus be unavailable as prey food for marine mammals. Hearing impacts are, however, analyzed at greater length because they are believed to occur at lower sound levels, and shorter durations, than non-hearing impacts. Therefore, using hearing impacts as the primary basis for impact analysis is a more conservative methodology, consistent with the Navy's overall prudent approach, than using non-hearing impacts.

Comment 4-4.11: The scientific community is presently unable to assess physiological and behavioral impacts. (F-001, O-020, O-025)

Response: The scientific community is increasingly able to assess physiological and behavioral impacts on marine mammals from LF sound. The difficulty facing the scientists is estimating the consequences of such impacts. This Final OEIS/EIS is based on a technically rigorous process to address these issues, which has been endorsed by NMFS and members of the marine biological scientific community as the most logical methodology to follow at this time. With regard to incomplete or unavailable information (e.g., physiological and behavioral impact metrics for LF sound on marine mammals, particularly large baleen whales), see Subchapter 1.4.

Comment 4-4.12: Where is the analysis of long-term and indirect effects such as habitat abandonment, feeding, breeding, migrating, etc.? (C-001, I-005, I-683, I-770, O-018, O-027, O-050, O-051, S-007)

Response: Habitat abandonment has not been analyzed in long-term and indirect effects, but the three-phase LFS SRP was designed to address this, and none was observed. Subchapter 4.2.7.5 (Biological Context) addresses the potential for long-term effects such as loss of part of a breeding season, loss of part of a foraging season, and reduction of individual animals' reproductive success. The potential for indirect effects is addressed in Subchapter 4.2.7.6. Evaluating the potential for long-term effects from SURTASS LFA sonar operations is a goal of the Long Term Monitoring Program (Subchapter 2.4). With regard to incomplete or unavailable information (e.g., quantification of long-term and indirect effects from LF sound on marine mammals), see Subchapter 1.4.

Comment 4-4.13: What is the effect of SURTASS LFA sonar sounds on reproductive organs? What are the effects on a pregnant marine mammal? (I-005) (I-681)

Response: There is no reason to anticipate that reproductive organs would be more sensitive to SURTASS LFA sonar signals than hearing organs. Because a marine mammal's fetus is composed of the same tissue type as its mother, it is not considered to be at any greater risk than the mother.

Comment 4-4.14: Are effects from SURTASS LFA sonar more serious for the young of a species? (I-681, I-683)

Response: The primary factors increasing risk to a marine species would be a more pelagic and deeper distribution of animals in the water column. No clear examples were identified during the analysis in which juveniles rather than adults met these criteria.

Comment 4-4.15: What is the effect of resonance in air spaces? (I-681, I-1020, O-026, O-042)

Response: Respiratory cavities of various sizes can be induced to resonate in response to strong underwater sounds with appropriate wavelengths (Duykers and Percy, 1978; ARPA, 1995). Resonance in air cavities increases the probability of tissue damage. SURTASS LFA sonar signals typically remain at one frequency for only 10 seconds or less of the total signal length of up to 100 seconds. Therefore the potential resonance effect would not occur for the full duration of a SURTASS LFA sonar pulse (ping).

Comment 4-4.16: Could the SURTASS LFA sonar signal be mistaken by marine mammals to be from conspecifics? (G-001)

Response: The SURTASS LFA sonar signal is not expected to be mistaken for conspecific signals because marine mammals have evolved the ability to discriminate sounds from related species, which are far more similar. Fin whale calls are much shorter than SURTASS LFA sonar signals. Many blue whale sounds are of roughly comparable duration but of lower frequency. Humpbacks generate sounds in the same frequency band as SURTASS LFA sonar, which in some ways might appear to be similar. However, taking into account the whale sound characteristics of frequency, duration, frequency-modulation rate, and repetition rates (duty cycle), their sounds are unique and, therefore, different from the SURTASS LFA sonar signals.

Comment 4-4.17: What about effects of masking on communications and confusion in navigation? Masking of higher frequencies should be considered. (I-770, I-909)

Response: The potential for masking is addressed in Subchapter 4.2.7.7. Although suspected, there is no clear evidence of a significant role of underwater sound in marine mammal navigation. The field research performed in Phase II of the LFS SRP with migrating gray whales off the coast of central California included the assessment of such effects, but none were observed. Moreover, the low duty cycle of SURTASS LFA sonar reduces the risk of masking within any frequency regime.

Comment 4-4.18: There is a significant body of research data showing that whales clearly begin to avoid sounds at 115-120 dB. (I-287, I-425, I-501, I-517, I-540, I-764, I-770, O-020, O-043, O-051, O-055)

Response: Although some whales have been shown to avoid sounds at 120 dB RL, this result does not relate to all whales. The 120-dB value for gray whales is relevant only when the sound source is directly in the animals' migratory path (where SURTASS LFA sonar would not operate). The LFS SRP results showed that gray whales do not respond to 155 dB RL outside their migratory path. Gray whales inhabit a unique environment, and all research conducted to date indicates that their behavior does not generalize to other species.

The 120-dB value for belugas (white whales) and bowhead whales is not relevant because these species primarily inhabit polar regions where SURTASS LFA sonar would be operated. Some species that do inhabit areas where SURTASS LFA sonar is planned to operate (blue, fin, humpback) were shown during the LFS SRP Phases I and III to not respond at 120 dB RL, and exhibited only infrequent, minor, short-term behavioral responses at 155 dB RL. The ATOC Marine Mammal Research Program (MMRP) concluded that there was an absence of responsiveness to 120 dB RL in humpback and sperm whales. The agreement between scientific research data from both the ATOC MMRP and the LFS SRP shows that the more recent findings supercede the earlier studies and rightfully are used as the basis for decision-making regarding SURTASS LFA sonar.

Comment 4-4.19: Why isn't the Mediterranean Sea Cuvier's beaked whale strandings incident reported on in the OEIS/EIS? (I-008, I-030, I-240, I-269, I-290, I-425, I-454, I-477, I-499, I-501, I-517, I-582, I-678, I-682, I-730, I-732, I-764, I-766, I-769, I-770, I-915, I-917, I-1020, O-020, O-021, O-026, O-028, O-037, O-038, O-039, O-040, O-043, O-047, O-049, O-050, O-051, O-053, O-054, O-055, S-003, S-007)

Response: The Mediterranean Sea Cuvier's beaked whale strandings incident is now addressed in Subchapter 3.2.5.1 of the Final OEIS/EIS.

Comment 4-4.20: Why isn't the incident of the three dead humpbacks in California waters due to ATOC testing and the two dead whales reported seen near the ATOC sound source off Kauai in 1997 included in the OEIS/EIS? Why isn't there mention of the strandings in the Canary Islands in 1985, 1988 and 1989 during naval fleet operations? (I-008, I-582, I-769, I-915, I-917, O-039, O-051)

Response: There is no evidence to conclude that any of the mentioned humpback mortalities were a result of the 75 Hz Acoustic Thermometry of Ocean Climate (ATOC) signal. There was only one whale carcass found off Hawaii, which was so badly decomposed that it could not be identified. NMFS determined that there were no associations between ATOC transmissions and the whale mortalities in either California or Hawaii.

ATOC and SURTASS LFA sonar have different acoustic signal parameters (different frequencies, source levels, pulse lengths, duty cycle, and waveforms) and their deployment techniques are very different (ATOC source is stationary on the ocean floor at approximately 900 m [2,950 ft], SURTASS LFA is deployed from a moving ship at approximately 122 m [400 ft] depth in the water column).

As for the Canary Island strandings, there were no known LF active sonars employed in naval fleet operations during the 1985-89 time period. The Canary Island strandings are addressed in Subchapter 3.2.5.1.

Comment 4-4.21: There should be a correlation analysis of SURTASS LFA sonar operations vs. known stranding events over the past 10-12 years. (I-008, I-021, I-192, I-425, I-582, I-587, I-682, I-683, O-037, O-038, O-039, O-047, O-050, O-053)

Response: Analyses of potential correlations between known marine mammal stranding events and SURTASS LFA sonar operations by Dr. Peter Tyack have revealed no evidence of any relationship between the two.

Comment 4-4.22: Discuss the recent series of strandings of beaked and pilot whales in the Caribbean, which may have occurred subsequent to naval maneuvers. Note: This is not the Bahamian stranding event of 2000. (O-047) Also in 1998, a beaked whale and a sperm whale stranded on Kauai while the Navy was engaged in maneuvers in Hawaii. (O-051)

Response: See Response to Comment 4.4-21.

Comment 4-4.23: Previous Studies: The Draft EIS fails to devote adequate time to discussing, or fails to mention, the small amount of data available regarding marine mammals reactions to loud anthropogenic noise. (O-047)

Response: Previous studies regarding whale responses to anthropogenic noise were discussed in Subchapter 4.2.4.1 (Previous Studies) of the Draft OEIS/EIS. Additional information is provided in the Response to Comment 4-4.2 and Subchapter 1.4.

Comment 4-4.24: SURTASS LFA sonar transmissions could interfere with marine mammals' sleep, and repeated stress can take a toll on the animals' immune system, leaving them more vulnerable to parasites and other infections. Extreme stress or panic may cause whales to become disoriented and stranded, or disorientation may result from damage to their hearing or other aspects of their navigational sonar systems. (I-956, O-051,)

Response: See Responses to Comments 4-4.10, 4-4.11, and 4-4.12.

Comment 4-4.25: Ocean Mammal Institute scientists, studying the effects of vessel traffic on humpback whales in Hawaiian waters, showed that whales change their behavior around engine sounds starting at about 120 dB. (I-517)

Response: The only information available on the above study is a brief summary (undated) posted on the Ocean Mammal Institute (OMI) website. The researchers reported that humpback whales changed their behavior when approached by boats with 200 hp engines, which produced a RL of 120 dB at 100 m at 2,000 Hz. The frequency of the engine noise used to elicit responses from the whales was substantially higher than that of the SURTASS LFA sonar's signal. Therefore, any results are not directly comparable to the scientific analyses herein.

At close ranges sound intensity and spectral content change rapidly, providing clues to the whales that something is approaching rapidly–thus eliciting an avoidance response, which is not necessarily based on sound level. The OMI study did not control for this alternative hypothesis.

In addition, it is common knowledge that humpback whales in Hawaiian waters show marked avoidance of sailboats under sail alone, making no underwater sound. The OMI study is further invalidated because it did not separate the underwater sound of motors from the near presence of the vessel producing it.

ISSUE 4-5: POTENTIAL IMPACTS ON MARINE MAMMALS—LFS SCIENTIFIC RESEARCH PROGRAM

Comment 4-5.1: Goals of the LFS SRP were not met. Because only four species were studied, further studies are needed on other marine animals at SURTASS LFA sonar operating levels, rather than extrapolating these results to predict responses at higher levels (i.e., extrapolation of 155 dB to 180 dB criterion). TR 1 states that "responses did not scale consistently to received levels and it will be difficult to extrapolate from these results to predict responses at higher levels." (F-001, F-003, I-042, I-240, I-269, I-343, I-425, I-477, I-478, I-499, I-501, I-517, I-540, I-682, I-740, I-769, I-770, I-861, I-863, I-907, I-956, O-002, O-016, O-017, O-018, O-020, O-022, O-023, O-026, O-028, O-030, O-034, O-037, O-038, O-039, O-040, O-043, O-047, O-049, O-050, O-051, O-053, O-054, O-055, O-057, O-058, S-003, S-004, S-007)

Response: The goals of the LFS SRP were met. This field study was designed to identify the areas associated with high LF sound levels on biologically important behaviors and to analyze potential impacts on marine mammals. This integrated at-sea research effort was conducted by distinguished marine biologists and bio-acousticians on an independent basis.

In 1997 and 1998, SURTASS LFA stakeholders meetings in Boston, MA and Washington, DC brought together marine biologists and bioacousticians from government laboratories and academia, representatives from non-governmental environmental groups, and Navy and environmental organization attorneys, who all agreed that baleen whales should be the indicator species for the LFS SRP. The scientific goal was to ascertain whether and at what RLs marine mammals would respond to SURTASS LFA sonar sounds. Subchapter 4.2.4 (Low Frequency Sound Scientific Research Program [LFS SRP]) and the TR 1 report (LFS SRP Technical Report) substantiate how the majority of the LFS SRP goals were met.

It is impossible to conduct studies of all marine animal species. Accordingly, four mysticete species (blue, fin, gray, humpback whales) were selected because: 1) they are considered most likely among all marine animals to have the best hearing in the SURTASS LFA sonar frequency band, 2) most have protected status under the law, and 3) there is prior evidence of some avoidance responses to LF sounds. Their responses to LF sound signals during the LFS SRP were to serve as indicators for the responses of other potentially LF-sensitive species, which were presumed to be less vulnerable to SURTASS LFA sonar signals.

The analysis presented herein does not extrapolate from 150 dB to 180 dB. The selection of the 180-dB criterion was not related to results from the LFS SRP. The Navy accepts that risk is high at 180 dB RL, and assumes that risk of a significant change in a biologically important behavior is low below 150 dB RL because of the relatively modest responses observed during the LFS SRP. The risk continuum is a biologically reasonable formula for reconciling the LFS SRP data with the conventional assumption of high risk at 180 dB RL. The fact that responses did not consistently scale with RL confirms the risk continuum assumption that not all individuals will react identically when exposed to the same level of SURTASS LFA sonar signals.

Comment 4-5.2: The Navy picked four baleen whales to study because it was convenient for the short time period that was available; no study was done on sea turtles because it would have been too difficult. Why were sperm and beaked whales eliminated from the study? (I-240, I-477, I-501, I-682, I-769, I-956, O-016, O-020, O-021, O-026, O-027, O-038, O-039, O-040, O-047, O-049, O-053, O-057)

Response: The selection of species and study sites emerged from an extensive review in several workshops by a broad range of interest groups, including academic scientists, federal regulators, and representatives from environmental and animal welfare organizations. The outcome of extensive dialogue among this diverse group was that baleen whales should be the focus of all three phases because they were thought most likely to have the best LF hearing, for the most part they are listed species, and there are prior data indicating avoidance responses by baleen whales to LF sound.

Phase III was designed to allow playback experiments with sperm whales, but no animals were encountered during the offshore portions of the cruise schedule. Sperm whales are listed as endangered and are suspected to be the toothed whale most LF-sensitive, as they are the largest odontocete. Beaked whales were not considered for a number of reasons: 1) they are thought to be more sensitive to mid- and high-frequency sound, rather than LF sound, like SURTASS LFA sonar; and 2) they are not listed as threatened or endangered. Sea turtles were not studied because, although they hear at LF, their ears are quite insensitive.

Comment 4-5.3: Explain the misquote of Watkins et al. (1985) in Subchapter 4.2.4.1 of the Draft OEIS/EIS. The paper really stated, "....sperm whales exposed to strong pulses from submarine sonars in the eastern Caribbean became silent, interrupted their activity, and moved away (Watkins et al. 1985a, 1993)." (O-027)

Response: The statement in Subchapter 4.2.4.1 (Selection of Species and Study Sites) of the Draft OEIS/EIS referred to in the comment is as follows: "There have also been anecdotal reports of sperm whales being sensitive to manmade transient noise (Watkins et al. 1985; Watkins and Schevill, 1975)." The Navy does not agree that there was any misquote. The quote cited in the above comment is found on page 302 of Richardson et al. (1995b), which was not the source of the above sentence.

Comment 4-5.4: How were measured and predicted RLs compared; and was this used to determine the 180 dB/1 km threshold (criterion) of concern? (O-043, S-003)

Response: Measured and predicted (modeled) RLs were compared by collecting RL data from hydrophones off the observation boat (not the source boat) whenever feasible. These data validated that the range from the SURTASS LFA sonar source array for the 180-dB sound field contour was 1 km (0.54 nm) during the LFS SRP (see Response to Comment 2-1.3). See Subchapter 2.3.2.2 (Monitoring to Prevent Injury) for further discussion on the LFA mitigation zone (180-dB sound field).

Comment 4-5.5: TR 2 results are obsolete because they are based on sound propagation from an omni-directional source whereas the Draft OEIS/EIS is actually concerned with propagation from a highly directional array. (I-454, I-766, I-861)

Response: All modeling carried out for TR 2 and the OEIS/EIS uses the correct SURTASS LFA operational parameters: omnidirectional in the horizontal with a narrow vertical beamwidth. See Subchapter 2.1.1 (Active System Component).

Comment 4-5.6: The LFS SRP was too short to determine biological significance of responses. (O-009, O-016, O-020, O-027, O-028, O-039, O-047, O-051)

Response: The LFS SRP was one of the largest scientific field studies on the potential impact of underwater sound on marine mammals ever undertaken, and consisted of four baleen whale indicator species and three phases, each in a different geographical location. Many scientific metrics were part of the LFS SRP, including aerial surveys, Sound Surveillance System (SOSUS) data collection, observation vessel sightings, and shore-based visual observations, which yielded large experimental datasets, collected in the wild. All of these provided information relating to more than just the potential for short-term biological behavioral effects. The scientific investigators observed some short-term behavior responses and some longer-term responses during the longer Phase I and III research, which approached the time period of a full SURTASS LFA sonar mission. The Navy and the independent scientists involved in the LFS SRP believe that the data from the LFS SRP, when combined with other data, provide an adequate basis for the analysis contained in the OEIS/EIS.

Comment 4-5.7: Define "biological significance." (I-499, I-501, I-770, I-956, O-027, O-028, O-039)

Response: The National Research Council (NRC, 2000) states that “regulatory efforts directed at minimizing and mitigating the effects of anthropogenic sounds on marine mammals and other marine organisms should have the goal of minimizing the risk of injury and meaningful disturbance of biologically significant activities, where biological significance is defined as having potential demographic effects on reproduction or longevity." This corresponds with the Navy’s interpretation in this OEIS/EIS, including the potential risk of injury, and significant change in a biologically important behavior (i.e., those activities essential to the continued existence of a species, such as feeding, migrating, breeding and calving).

Comment 4-5.8: Biologically significant effects on population parameters, such as birth rate, growth rate, and death rate are largely unknown—short-term studies like the LFS SRP cannot address them. (I-517, I-764, I-769, I-907, O-016, O-020, O-027, O-039, O-047, O-051, S-002)

Response: Short-term studies like the LFS SRP can address the potential for impacts on behaviors that relate to demographic parameters such as birth rate, growth rate and death rate. For example, the LFS SRP addressed feeding rates, which relate to birth and growth rates. With regard to incomplete and unavailable information, see Subchapter 1.4.4 (NEPA Disclosure).

Comment 4-5.9: Did the LFS SRP demonstrate an absence of harm? Explain why a statistical power analysis was not carried out to back up LFS SRP conclusions. (I-770, O-027, O-039)

Response: The LFS SRP was intended to collect field data to better understand the potential responses of cetaceans to LF sound. If by "absence of harm" the commentor is asking whether the LFS SRP explicitly demonstrated no harm at the RLs to which the animals were exposed, the answer is no. Nor could it be expected to do so. With non-human subjects, researchers are limited to inferences based on observable responses, and reasonable extrapolations based on those inferences.

A power analysis was not appropriate because the results from the LFS SRP were not meant to be used in attempting to prove no effect.

Comment 4-5.10: The LFS SRP was inconclusive. For example:

- Phase I: 1) blue and fin whales exhibited vocal responses to sound source; and 2) sighting rates for blue whales decreased throughout the study period.

- Phase II: 1) there was statistically significant deviation of gray whales from the close-in source; 2) what was the assumed number and percentage of passing whales not tracked? 3) were there more track deviations just after start-up? 4) what is the reason for fewer deviations for the off-shore source? and 5) gray whales migrating close to shore may not show significant reactions to an offshore source, but offshore pelagic cetaceans may show similar reactions to SURTASS LFA sonar as those observed for the migrating gray whales to the near-shore source.

- Phase III: 1) humpback whales temporarily ceased vocalizing and left the immediate area of the sound source (what follow-up observations were conducted on those singers that left?); 2) there was a lack of initial baseline data of whale locations and adequate monitoring during tests (e.g., no aerial surveys); 3) Mobley's 1998 survey report and other important studies were ignored (Myrberg, 1990; Richardson et al., 1995); and 4) why was 1-25 March selected as the timeframe for Phase III—humpbacks were redistributing for pre-migration?

(G-001, F-001, I-003, I-030, I-042, I-247, I-248, I-287, I-290, I-425, I-499, I-501, I-517, I-558, I-582, I-681, I-683, I-687, I-694, I-725, I-740, I-757, I-767, I-770, I-892, I-907, I-908, I-909, I-917, O-004, O-016, O-020, O-021, O-022, O-023, O-024, O-026, O-027, O-028, O-029, O-034, O-038, O-039, O-043, O-047, O-051, O-054, O-055, O-057, O-058, S-002, S-003, S-007)

Response: The LFS SRP was intended to collect field research data regarding the responses of selected species of cetaceans to LF sound and, in that respect, the independent scientist principal investigators and the Navy strongly believe it was successful. The Navy did not expect that these data would provide the definitive, final answer on this issue. Nevertheless, these data, combined with existing data, provide a reasonable basis for informed decision-making regarding the proposed action. Subchapter 4.2.4 (Low Frequency Sound Scientific Research Program) explains how these field studies addressed three important behavioral contexts for baleen whales: blue and fin whales feeding in the Southern California Bight, gray whales migrating past the central California coast, and humpback whales breeding off Hawaii.

Phase I: Initial analysis of some of the acoustic data indicated a decrease in vocal activity by blue and fin whales during SURTASS LFA sonar transmissions. However, a subsequent, more detailed analysis using data from all three passive receivers (on R/V *Cory Chouest*, seafloor-mounted "pop-up" hydrophones, and SOSUS [Sound Surveillance System] microphone arrays on the sea bottom) indicated that there were no significant differences in vocal activity between the periods when SURTASS LFA sonar was not transmitting and when it was transmitting. Sighting rates for blue whales were variable during the study period, as would be expected. Based on the initial analysis of the data, there is no evidence that any decrease in sighting rate of blue whales during the study period can be attributed to SURTASS LFA sonar transmissions.

Phase II: Gray whales tended to avoid coming close to the SURTASS LFA sonar sound source when it was centered in their migratory pathway, and the amount of avoidance when the source was near shore (1.9 km [1 nm] from the coast) was proportional to its RL. This experiment was intentionally designed to elicit an avoidance response and to determine if the response was proportional to the RL.

The migrating gray whales showed the same response when random noise was transmitted, indicating that the SURTASS LFA sonar sound does not evoke a stronger avoidance response than random noise. There was little to no avoidance response to the source when it was placed 3.8 km (2 nm) offshore, even though the RLs at the whales were the same as when the source was only 1.9 km offshore.

Fifty percent of the whales avoided the inshore source at a RL of 140 dB at their closest point of approach.This is 20 dB higher than the response levels when gray whales were exposed to continuous industrial noises in a 1983-84 study (Malme et al. 1983, 1984). The conclusions of Phase II are not sensitive to the percentage of whales not tracked.

Offshore pelagic cetaceans may show similar reactions to SURTASS LFA sonar as those reactions observed from the migrating gray whales to a near-shore source location. However, there are no known open ocean marine mammal migration corridors that are as concentrated and well-defined as that for the gray whale.

Phase III: Some singing humpback whales showed some apparent avoidance responses and cessation of singing at RLs ranging from 120-155 dB. However, an equal number of singing whales exposed to the same levels showed no avoidance or cessation of song. Ongoing analysis of these Phase III data will help establish how often male humpbacks stopped singing in the absence of the SURTASS LFA sonar transmissions, and evaluate any significance of the song cessation observed during playback experiments. However, in the independent scientists' and the

Navy's view this is not required before a reasoned decision on SURTASS LFA sonar employment occurs.

Follow-up observations on those specific animals that exhibited apparent avoidance reactions were attempted for as long as possible. Once an animal stopped singing and left the immediate area of the independent observation team, it was not possible to find that animal again.

There was adequate monitoring during the test, which included shore station visual observations, photo-identification from the observation vessel (OV), acoustic monitoring and recording from the OV, acoustic monitoring and recording from the playback vessel (PBV), and sound transmission loss and RL modeling.

There were adequate baseline data regarding whale locations. Also, prior to the commencement of SURTASS LFA sonar transmissions, whale locations were mapped to the fullest extent practicable. Three inter-island aerial surveys were conducted during the research period by Dr. Joseph Mobley of the University of Hawaii as part of a separate research project. These 1998 surveys used the same standardized protocol as the 1993 and 1995 surveys, thus providing a basis for comparison among 1993, 1995 and 1998 humpback sighting distributions and densities for the Big Island area. These three years with surveys are the most important of any such studies of humpback whale demographics in the Hawaiian Islands. Their results are comparable. In fact, based on six years of aerial survey work, Mobley et al. (1999) have concluded that the humpback whale stock in Hawaiian waters is growing at a rate of 7 percent per year. Other important studies, such as Richardson et al. (1995b) and Myrberg (1990) have been reviewed and pertinent data and findings incorporated into the OEIS/EIS and referenced accordingly (for example, see Subchapter 1.4 and Chapter 4).

Typically, humpback whales are seen in Hawaii's waters from November through mid-April, and are most numerous near shore from December through February. Their departure appears to commence in early March, few are seen in April, and males leave before females and their recent offspring. For a variety of reasons beyond the control of the research team, Phase III studies could not commence until early March, 1998, relatively late in the whale season. Thus, the decrease in whale numbers in March is entirely in keeping with the typical departure schedule for humpbacks.

Comment 4-5.11: Not knowing of an effect or not observing an effect is not the same as no effect or impact. (I-764, O-020)

Response: The Navy agrees. See Response to Comment 4-5.9.

Comment 4-5.12: The LFS SRP did not consider possible long-term significance of short-term behavioral responses. (G-001, I-499, I-501, I-764, O-017, O-027, O-028, O-040, O-047)

Response: The LFS SRP was designed specifically to study short-term behavioral responses that could have possible long-term significance through significant change in a biologically important behavior: baleen whale feeding, migration, and breeding. See Response to Comment 4-5.6.

Comment 4-5.13: The LFS SRP did not measure small-scale physical behavior when underwater, such as orientation, via sub-surface follow-through observations. (O-027)

Response: Close underwater follows of individual mysticete whales are extremely difficult to accomplish for extended periods of time. Under the field conditions for any of the three LFS SRP phases, it would not have been possible to collect enough observations for statistical analysis. Details of underwater movements could be obtained using specialized tags that are still under development; however, this is expensive, time-consuming, and increases the likelihood that the observational methods themselves provoke disturbance. The LFS SRP was not designed to test for any possible detectable change in behavior but, rather, to focus on the potential for disruption of whale activity. Phase III did continuously monitor humpback singing throughout their dives, as this is clearly an important activity. However, in Phase II, it is not clear how important very short changes in animal orientation are to gray whales in their migration corridor.

Comment 4-5.14: The LFS SRP did not measure physiological reactions (TTS, PTS, stress, other soft tissue damage). (I-425, O-016, O-017, O-038, O-047, O-055, S-002)

Response: The LFS SRP field research studies were designed to complement Office of Naval Research and Chief of Naval Operations-sponsored laboratory studies on temporary threshold shift (TTS), physiological stress, and soft tissue damage. This was planned to be accomplished by having the LFS SRP focus on the potential for baleen whale behavioral reactions to LF sound in the wild. See Response to Comment 4-5.13 above. Methods to investigate physiological reactions (e.g., TTS, PTS, stress) to underwater LF sound have only recently been accomplished on captive small toothed whales and seals, and are not yet available for free-ranging large whales.

Comment 4-5.15: The LFS SRP did not measure less easily observed behavioral responses (e.g., difference in reproduction success, foraging efficiency, reaction time to vessels, acoustic ability to "see" obstacles). (I-501, O-047)

Response: The LFS SRP intentionally measured behaviors that have been traditionally observed in wild whales and for which there was reasonable consensus on linkage to biological significance (e.g., diving -- feeding, direction of movement -- migrating, and song function -- reproducing). Furthermore, the LFS SRP chose behaviors for species from which there were existing baseline data. The LFS SRP did not attempt to measure such things as reproductive success or foraging efficiency because it takes an animal lifetime to study this. Foraging success can be measured in many animals, but marine biologists do not have viable techniques to measure the cost/benefit of foraging in cetaceans.

Measure of reaction time to vessels was not attempted because these animals are underwater and cannot be observed for large portions of the time, and to obtain such data would require tagging the animals (see Responses to Comments 4-5.13 and 4-5.14, above). Therefore, measures of these behaviors were not part of the scientific research protocols adopted by the independent marine mammal biologists and bio-acousticians carrying out the experiments.

Comment 4-5.16: The LFS SRP did not measure SURTASS LFA sonar impacts on habitat, ecosystems, populations, or other species. (I-764, I-907, O-020, O-051)

Response: The independent marine mammal biologists and bio-acousticians who were Principal Investigators for the LFS SRP selected the most plausible and likely impacts to address, in particular, significant change in a biologically important behavior. They observed none. Sighting rate data were collected during all three phases of the LFS SRP for all marine mammal and sea turtle species present at the sites as a potential measure of changes in habitat use (see also Responses to Comments 4-5.13 to 4-5.15, above). Other less plausible and unlikely effects were not addressed.

Comment 4-5.17: The LFS SRP did not measure distribution, abundance and productivity of prey species. (O-016, O-020)

Response: During Phase I of the LFS SRP, which focused on blue and fin whales feeding, extensive prey field mapping and analysis were performed. The study species were not feeding at the other two LFS SRP sites. Also see the response to Comments 4-5.13 to 4-5.16 above.

Comment 4-5.18: The Draft OEIS/EIS was published before the LFS SRP final results were completed and peer reviewed. Will the LFS SRP research results be peer reviewed and published? (I-501, I-682, I-764, I-770, NN001, O-027, O-039, O-043, O-046, O-053, O-057, S-002)

Response: The conduct of scientific peer review is usually and understandably an extensive and lengthy process. The independent scientists who collected the LFS SRP data presented their preliminary results to the SURTASS LFA Scientific Working Group. Based on recommendations from the members of that group, which included NMFS and leading marine mammal biologists and bio-acousticians, the Navy went forward with the Draft OEIS/EIS.

Results from the LFS SRP are being peer-reviewed and have been/will be published. See Response to Comment 4-5.19.

Comment 4-5.19: TR 1 indicates additional analyses will be conducted; when and where will the results be available? (I-770, O-004, O-016, O-038, O-039, O-043, O-057, S-003)

Response: The LFS SRP principal investigators will submit results of the additional analyses for publication in various scientific journals; e.g., *Journal of the Acoustical Society of America; Marine Mammalogy*. The article "Whale songs lengthen in response to sonar" concerning observations of male humpback whale during Phase III of the LFS SRP was recently published in *Nature* (Miller et al., 2000).

Comment 4-5.20: The Navy should run extensive, long-term tests of SURTASS LFA sonar in every habitat it expects to operate. (O-009, O-027, O-047, O-058, S-003)

Response: It is not feasible for the Navy to run extensive, long-term tests of SURTASS LFA sonar in every habitat it expects to operate. Modeling was accomplished at 31 sites representative of a wide variety of environments (habitats) in which the system would be expected to operate (see Subchapter 4.2.1 [Acoustic Modeling Sites]). These sites were designed using a prudent approach to model the highest potential effects from the use of SURTASS LFA sonar. The results are believed to represent the upper bound of exposures and potential impacts that could be expected from fleet training and operations. Under the Navy's proposed LTM Program (Subchapter 2.4), they would monitor and report on any impacts to marine mammals during SURTASS LFA sonar operations in every operations area actually used.

Comment 4-5.21: The LFS SRP did not measure responses to full-scale (building up to and including 180 dB receive levels) operation of the SURTASS LFA sonar. The Navy should perform additional tests at full-scale operational power levels of the SURTASS LFA sonar to establish the 180-dB threshold (criterion). (F-001, F-003, I-185, I-269, I-287, I-290, I-499, I-517, I-582, I-674, I-694, I-726, I-740, I-764, I-770, O-009, O-017, O-022, O-023, O-030, O-042, O-043, O-047, O-050, O-054, O-055, O-058, S-003)

Response: In some of the LFS SRP Phase I experiments (studying the responses of feeding blue and fin whales), the SURTASS LFA source was transmitting at operational power levels. Even under these circumstances very few animals were exposed at received levels as high as 155 dB. The research was specifically designed so as to NOT expose animals to higher received levels. These research results confirmed what is predicted from the Acoustic Integration Model that a very small percentage of animals will be close enough to the SURTASS LFA sonar to experience levels above 155 dB. The Navy would not seek a scientific research permit to perform field tests at higher RLs to animals in the wild. Moreover, injury cannot be studied in the wild. Any such experiments should be undertaken under controlled laboratory conditions, with animals in a more controlled setting. Moreover, the Navy believes it has adequate data to assess what the potential for impacts would be for RLs $\geq$ 180 dB RL for the LF sounds from SURTASS LFA sonar, without the need to try to actually expose animals to that RL.

Comment 4-5.22: What is the ratio difference of intensity in SURTASS LFA sonar transmission source levels (SL) between the LFS SRP testing and what will be used for operational deployment? (I-454, I-517, I-917)

Response: The maximum source level for the SURTASS LFA sonar is 215 dB. For Phase I, there was no difference (operational SL - see Response to Comment 4-5.21 above); for Phase II, operational SL less 15 dB was used; and for Phase III, operational SL less 10 dB was used.

Comment 4-5.23: The sample size to achieve statistical significance in the AIM (model) was 100-200 animals in two different locations while those for Phases I and III of the SRP were on the order of 5-30 animals. (I-004, I-770, I-956, O-039, O-047, S-002)

Response: Required sample size depends on strength of effect. The sample size for focal individual studies was as large as possible, subject to the constraints of this technique. Many more individuals were sampled using visual scanning from the source vessel and shore stations, and using passive acoustic sensing methods. Analyses of these extensive data sets will go on for the foreseeable future.

As stated in Subchapter 4.2.2.2 (Acoustic Integration Model), the number of animals in an AIM simulation is related to the expected animal densities for the specific species being modeled. For low densities (e.g., LFS SRP sample sizes), AIM is run with more animals than would be expected to ensure that the results are not unduly influenced by the chance placement of a few animals (outliers). The minimum number of animals is predicated upon cumulative distribution function (CDF) requirements in order to obtain consistent results. The AIM simulation results were adjusted for each species at a site as a ratio of the expected densities.

Comment 4-5.24: Could lack of reaction by the baleen whales exposed to SURTASS LFA sonar signals be due to accommodation to the signal over time by the subject animals (i.e., habituation)? (I-478, I-512, NN001, O-039, O-043, O-047, O-051, S-007)

Response: Habituation, or accommodation to repeated presentation of a sound, has been documented (Malme et al., 1985; Dolphin, 1987; Richardson et al., 1995b). The responses documented during the LFS SRP could have included effects due to habituation. Habituation will reduce the likelihood that SURTASS LFA sonar operations will cause behavioral disruption. The only possible concern would be that habituation might cause animals to be more likely to swim within the LFA mitigation zone. However, monitoring mitigation procedures (Chapter 5) have been developed to detect animals before they are close enough to be injured.

Comment 4-5.25: Why wasn't there a discussion of: (1) the melon-headed whale calf that was rescued off Hawaii shortly after Phase III, (2) the lone humpback whale calf observed breaching during Phase III, and (3) the dead baby humpback found on Oahu whose ear was supposedly necropsied? (F-001, I-021, I-030, I-042, I-287, I-290, I-499, I-517, I-558, I-582, I-683, I-694, I-740, I-861, I-915, I-917, I-1020, O-004, O-022, O-023, O-038, O-039, O-051, O-055, O-057)

Response: (1) The 44-kg (96-lb) melon-headed whale calf was rescued off of the Big Island of Hawaii about two weeks after the LFS SRP Phase III test was completed, and therefore could not have been made to strand by these tests.

(2) There was an assessment of the calf breachings during the field research for Phase III. As reported in TR 1, "....preliminary examination of our mother-calf follows show no indication that playbacks were associated with separation of mother and calf nor with increased rates of breaching." The breaching lone humpback whale calf also was assessed by Eugene T. Nitta, who was at that time the Protected Species Program Manager for the Pacific Islands Area Office, Southwest Region of NMFS. In a declaration to the United States District Court for the District of Hawaii, concerning his preliminary assessment of the situation with the "calf" on March 9, 1998, he stated that "Humpback whale calves often exhibit surface and aerial behavior, and it is not unusual to observe a calf breaching 20 to 30 times in succession. Pectoral fin slapping and tail slaps are also common. This type of behavior may continue for hours depending upon the age and size of the whale. Yearling whales also often exhibit this behavior and may be difficult to distinguish from large calves of the year from a distance." He also stated that there was no way to determine if the "calf" was abandoned, orphaned, otherwise separated from its mother, reunited with its mother, or if the whale was a small yearling, as no further sightings of the lone small whale were received. Additional information concerning this breaching activity is also available in the Declaration of Dr. Kurt Fristrup, the Assistant Director of the Bioacoustics Research Program at the Cornell Laboratory of Ornithology and Chief Scientist aboard the R/V *Cory Chouest* during Phase III. The complete texts of these declarations are provided in Appendix C (LFS SRP Phase III U.S. District Court Declarations and Other Information).

(3) This episode is not included in the OEIS/EIS because all evidence indicates that the calf died prior to the first Phase III transmissions. Therefore, SURTASS LFA sonar transmissions during Phase III of the LFS SRP had no relation to this animal's demise.

Comment 4-5.26: Why were no follow-up studies done for those humans who reported suffering ill effects from having been in the water during Hawaiian LFS SRP Phase III

SURTASS LFA sonar transmissions? (I-290, I-424, I-517, I-683, I-687, I-766, I-769, I-861, I-892, I-915, I-1020, O-004, O-027, O-038, O-051, O-055, O-057, S-003)

Response: No follow-up studies were done because there was no credible evidence to support allegations that humans suffered any ill effects from SURTASS LFA sonar transmissions. See Appendix C for copies of the declarations from the plaintiffs and from scientists for the defense (Navy). The pertinent court records are a matter of public record.

Comment 4-5.27: Where are the data from studies and tests prior to the LFS SRP? (I-517, I-682, I-770, NN-001, O-026, O-027, O-053)

Response: The OEIS/EIS reviews the results of prior studies. Many of those studies were published in journals that subjected them to scrutiny of the peer-review process. Further review of the primary data was unwarranted. Development of the marine mammal monitoring mitigation presented herein included review of pertinent prior test data.

Comment 4-5.28: Does TR 1 include all data from the LFS SRP that were used in the Draft OEIS/EIS? (I-454, I-681, O-039)

Response: TR 1 contains an overview of all data from the LFS SRP that was used in the Draft OEIS/EIS. The entire data sets are in various forms (e.g., over 4,000 hours of acoustic recordings, extensive focal follow field notes, computer files of animal positions from theodolite readings) and reside in different laboratories of the research scientists.

Comment 4-5.29: The unexplained gap in control data displayed in TR 1 Figure B-27 (Comparison of acoustic detections of patterned sequences of fin whale sounds on a day without and with SURTASS LFA sonar playback) makes the charted comparisons between 'SURTASS LFA sonar' and 'control' confusing, if not invalid. The same is true for TR 1 Figure B-28. (O-039)

Response: The Navy regrets any confusion caused by the lack of explanation regarding the one-hour gap in control data displayed in TR 1 Figures B-27 and B-28; this was due to the R/V *Cory Chouest's* towed horizontal line array being in a turn and not in a data collection mode.

Comment 4-5.30: If TR 1 Figure B-29 displays RL as a function of depth, why don't all related charts do the same? (O-039)

Response: Figure B-29 does not display RL as a function of depth. It displays a plot showing the tracks of the R/V C*ory Chouest*, R/V *Dariabar*, and the focal fin whale during a direct-path approach mode playback experiment on 21 September 1997.

Comment 4-5.31: TR 1 Figure B-34 displays data from 20 and 21 September 1997, as does B-27 and B-28; however, the SURTASS LFA sonar "on" times do not equate. A labeling error has occurred with TR 1 Figures B-35 and B-36; the data are reversed. (O-039)

Response: Figure B-29 uses Greenwich Mean Time (Zulu time), while Figures B-28 and B-34 use local time (Pacific Daylight Time). This and Figures B-35 and B-36 have been corrected in TR 1.

Comment 4-5.32: TR 3 states that the most and the least diver adverse reactions were to frequencies of 100 Hz and 250 Hz, respectively; why was the center frequency of 250 Hz picked for the LFS SRP? (I-424)

Response: The center frequency of 250 Hz was picked for the LFS SRP because it falls within the frequency regime of the SURTASS LFA sonar (100-500 Hz). The diver study and the LFS SRP were independent studies.

Comment 4-5.33: Why wasn't Dr. Hal Whitehead's reanalysis of the aerial data collected as part of the SRP, which found significant effects of the source sounds related to cetacean group size, included/addressed in the Draft OEIS/EIS? (I-770)

Response: No reanalysis of LFS SRP aerial data has been published by Dr. Whitehead.

Comment 4-5.34: More analysis is needed on the potential for LF sound effects on deep-diving marine mammal species. (O-047)

Response: The Navy followed a systematic process for selecting the marine mammal indicator species used during the LFS SRP, using inputs from government research laboratories, expert marine mammal biologists and bioacousticians, and public environmental groups. It was believed that the most prudent and conservative approach would be to use the most LF-sensitive marine mammals (baleen whales), which in turn are believed to be the most sensitive to LF sound of all marine life. Most existing evidence supports the conclusion that deep-diving species such as sperm and beaked whales do not have as high a sensitivity to LF sound. Based on risk analysis provided in the Final OEIS/EIS, they are considered to be at no greater risk than baleen whales.

Comment 4-5.35: What frequencies were used? What were the ping durations? NN001

Response: Details of the LFS SRP, such as frequency and ping duration, are discussed in TR 1, Low Frequency Sound Scientific Research Program (Responses for Four Species of Whales to Sounds of SURTASS LFA Sonar Transmissions).

Comment 4-5.36: The results of the tagging program from Phase I should have been discussed in the Draft OEIS/EIS. (NN001)

Response: Details of the LFS SRP tagging program in Phase I are discussed in TR 1, Low Frequency Sound Scientific Research Program (Responses for Four Species of Whales to Sounds of SURTASS LFA Sonar Transmissions).

Comment 4-5.37: From the information extracted from the "pop-ups," were the RLs similar to those that were expected by the model? (NN001)

Response: The four "pop-ups" deployed during Phase I of the LFS SRP were at depths of 1,200 to 1,400 m (3,940 to 4,590 ft) and recorded continuously (passively) for 10 days. These units were used to collect data for assessing any changes in vocal behavior of individual whales over time scales of minutes to hours. They were not used to evaluate RLs. However, a comparison of the RLs measured on the R/V *Dariabar's* hydrophones to levels estimated from the transmission loss model verified that the model estimates were accurate predictors of the actual sound field. The two pop-ups deployed during Phase II of the LFS SRP were at depths of 25-30 m (82-98 ft) in the center of the gray whale migratory path. Data collected have not been used to evaluate RLs, but transmission loss (TL) analysis verifies that the TL model used to forecast propagation conditions (PE version 3.4; see Subchapter 4.2.2.1) matched closely with the empirical measurements done at sea. See TR 1 for more details.

Comment 4-5.38: " Hastings et al. (1996)...found that there was some damage to the sensory hair cells of two otolith organs (in fish)...The only apparent damage found four days after stimulation." These findings are disturbing if there is a delayed response in damage. Were the exposed whales of Phases I, II, and III studied four days after exposure? Were fish? (O-020)

Response: The damage to the hearing organs of fish in the Hastings et al (1996) study was only detected after the onset of degeneration. The time offset of four days was a reflection of the delay in sacrificing the fish for analysis, not an indication of delayed sensory damage. Moreover, this issue is irrelevant to the LFS SRP because exposure levels were too low for damage to occur.

Comment 4-5.39: Alternative Hypothesis: Animals might remain in biologically productive areas or continue biologically important activity despite harmful noise, and potential increase in impacts. (I-425, O 028, O-039, O-047)

Response: It is possible that animals might tolerate high levels of potentially aversive exposure when engaged in critical behaviors. However, as indicated through the LFS SRP results and the predictions from the AIM simulations and as stated in the mitigation procedures, the chances of an animal being exposed to levels high enough to cause hearing damage are considered to be negligible. In the case of behavioral responses at intermediate levels, the hypothesis that responses remain low despite the occurrence of the sound exposure supports the conclusion that behavioral impacts would be minimal.

The following addresses the hypothetical situation in which behavioral tolerance to exposure somehow leads to unobserved changes in physiology, which might cause, for example, a decrease in metabolic uptake of nutrients or a change in reproductive status. As described in TR 1, and within this OEIS/EIS, the independent scientific research team that conducted the LFS SRP did detect some behavioral responses that were statistically significant but none was prolonged, and all animals returned to normal behavioral activities within tens of minutes. The levels of these responses were of the same orders of magnitude as minor responses to natural events (e.g., other singers, approach of another animal) or other human activities (e.g., small vessel approaches). The concern expressed in this proposed alternate hypothesis is addressed in the OEIS/EIS Risk Assessment section. Here, results from the Acoustic Integration Model runs predict that the total exposure to the SURTASS LFA sonar for any individual animal is quite limited.

Comment 4-5.40: There is a need for large-scale distribution assessment before, during, and after tests of this kind to at least attempt to deal with more subtle impacts such as masking of marine mammal sounds or impacts that accumulate with repeated exposure at levels that do not directly injure. (O-038)

Response: In Phase I of the LFS SRP, the research study design specifically included the objective of comparing blue and fin whale distributions and activities before, during, and after experimental use of the SURTASS LFA sonar. Comparisons included aerial surveys, vessel surveys, and passive acoustic data. Croll et al. (in press) reported the results of this Phase I research effort. They conclude that overall, whale distributions and diving behavior were more strongly linked to prey (food) abundance than SURTASS LFA sonar transmissions. In general, large-scale distribution assessment methods (e.g., aerial surveys) do not provide the statistical power to detect subtle potential impacts, such as masking. Such effects are more appropriately studied using more sensitive research methods.

Comment 4-5.41: Will the EIS permit all Phase III focal follows to be depicted as the few samples are, and as all Phase I focal follows are? (O-039)

Response: Focal follows in Phase I and Phase III of the LFS SRP are discussed in TR 1, including depiction of samples for each.

Comment 4-5.42: Assessment of the physical damage to the whales' hearing apparatus was not conducted. (O-040)

Response: The conduct of necropsies on whales during studies is not allowed without permit and was not considered as a research option for the LFS SRP.

Comment 4-5.43: The Navy neither interprets nor extrapolates to other species the results of the LFS SRP with the "utmost caution." (O-047)

Response: The selection of a representative species to be used 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 this group’s decisions was such that baleen whales (mysticetes) were the group most sensitive to LF sounds and, therefore, most at risk from the SURTASS LFA sonar. This is because they are considered most likely among all marine life to have the best hearing in the SURTASS LFA sonar frequency band, because they are known to show avoidance responses to human-made LF sounds, and because of their protected status. Four species from this group became the focus of the three-phases LFS SRP. Because mysticetes are considered the most sensitive to LF sound, they are used as indicators for other marine animals in the OEIS/EIS analysis of underwater acoustic impacts.

The composite audiogram shown in Figure 1-4 (Marine Mammal Audiograms) supports the supposition that baleen whales (mysticetes) have the best LF hearing of all marine mammals. Studies on pelagic fish and sea turtles indicate that their LF hearing is not in the sensitivity range of baleen whales; and all existing evidence supports the conclusion that deep-diving species, such as sperm and beaked whales, do not have LF hearing as good as that of mysticetes.

By selecting marine mammal species that probably have the most sensitive LF hearing, the LFS SRP results produced a model of response that is likely to overestimate the responses of other species.

Comment 4-5.44: The scientists reach conclusions based on data that appear to contradict the conclusions. For example, TR 1 states, "There were not significant differences between the distribution of animals around the PBV (playback vessel) during control and playback conditions." Yet Figure D-26 appears to show far fewer whales in the vicinity of the PBV during playback and a distribution pattern of a lower percentage of whales close to the PBV. (O-057)

Response: There was no statistically significant difference in the overall distribution of the number of animals during Phase III of the LFS SRP.

Comment 4-5.45: The LFS SRP and the Draft OEIS/EIS did not consider the possibility that the scientists were unable to locate sperm whales for testing because broadcast prior to testing had driven them away. (O-057)

Response: This possibility is highly unlikely, particularly given the fact that almost all Phase III LFS SRP SURTASS LFA sonar transmissions occurred in shallow water, not normally frequented by sperm whales (which are not very common in near-shore Hawaiian waters), and that its signal frequency is below 500 Hz, which is not in the sperm whale's primary hearing register. In addition, during the LFS SRP, acoustic monitoring commenced before transmissions. Moreover, it would be impossible to scientifically prove or disprove such a hypothesis.

Comment 4-5.46: What is the Navy's justification for continuing testing in Phase III when numerous sources, both civilian and scientific, observed multiple marine mammals displaying acute behavioral responses, such as repeated/prolonged activity (vocalizing, breaching, blowing, time on surface, etc.)? (I-917)

Response: The "acute behavioral responses" reported by the Ocean Mammal Institute observers during Phase III of the LFS SRP were assessed by Eugene T. Nitta, who was at that time the Protected Species Program Manager for the Pacific Islands Area Office, Southwest Region of NMFS. In a declaration to the United States District Court for the District of Hawaii, he stated, "Based on the information I have received to date, I do not believe that a causal relationship has been demonstrated between the scientific research performed under Permit No. 875-1401 (the LFS SRP Scientific Research Permit) and the behaviors observed, and that there is insufficient evidence to suspend transmissions pursuant to Research Condition B.6 of Permit No. 875-1401." His declaration can be found in Appendix C, along with those of Chris Reid, Barbara Schmid, Kevin Merrill, Dr. Marsha Green, Dr. Kurt Fristrup, and Dr. Joseph Mobley.

ISSUE 4-6: POTENTIAL IMPACTS ON MARINE MAMMALS - RISK CONTINUUM ANALYSIS

Comment 4-6.1: The LFS SRP does not support the 180-dB criterion; how was the 180-dB threshold extrapolated from LFS SRP data? How can it fit all species? The Draft OEIS/EIS states that several studies demonstrate that the 180-dB criterion is conservative; please delineate citations and quotes. (F-002, G-001, I-240, I-267, I-269, I-337, I-425, I-454, I-477, I-512, I-517, I-682, I-764, I-770, I-917, NN001, O-016, O-021, O-027, O-037, O-038, O-039, O-040, O-043, O-047, O-049, O-051, O-053, O-055, O-057, S-003)

Response: Several scientific and technical workshops and meetings at which the 180-dB criterion were developed are: (1) the High Energy Seismic Survey (HESS) Team Workshop (June 12-13, 1997) (Knastner, 1998), (2) the Office of Naval Research Workshop on the Effects of Anthropogenic Noise on the Marine Environment (February 10-12, 1998) (Gisiner, 1998), and (3) the National Marine Fisheries Service (Office of Protected Resources) Workshop on Acoustic Criteria (September 9-12, 1998). The 180-dB criterion for SURTASS LFA sonar operations was not extrapolated from LFS SRP data. Subchapter 1.4 provides supporting evidence for the 180-dB criterion, and why it is deemed to be a conservative value.

Comment 4-6.2: There are no LFS SRP data concerning the possible responses of representative cetaceans to LF sound above 155 dB. (G-001, I-240, I-770, O-027, O-039, O-051, O-057)

Response: The Navy acknowledges that there are no LFS SRP data concerning the possible responses of representative cetaceans to LF sound above 155 dB. However, the risk continuum model specifically addresses the potential for risk between 155 and 180 dB RL, and uses a very conservative methodology. In Subchapter 1.4.2.2 (Estimating the Potential for Behavioral Effect), data are presented in three figures that illustrate that the preponderance of all modeled RLs for mysticetes, odontocetes, and pinnipeds fall below the 155-dB level, which is in the range of exposures studied during the LFS SRP. Additional information is provided in Appendix D (Sensitivity Analysis of the Risk Function Curve). These results demonstrate that a very small portion of the modeled animals experienced pings with RLs exceeding 155 dB.

Comment 4-6.3: There could be substantial behavioral responses between 155 and 180 dB RL. (G-001, I-425, I-558, O-021, O-047)

Response: The risk continuum explicitly represents the potential for significant change in a biologically important behavior within the 150 to 180 dB RL range.

Comment 4-6.4: Each LFA "ping" is a continuous noise source and experts agree that a continuous sound should be 'worse' for a baleen whale than a short-pulsed sound. Based on limited data on dolphin's auditory system integration time, the specific values are that impacts from single, continuous noises, such as LFA, are at [hearing threshold] levels 5-10 dB less than for impulsive sounds. There are no data for [the impact of continuous sound on] whales, and no reason to assume anything less conservative. (I-425, O-039, O-043)

Response: 100-second long "pings" are considered to be an intermediate duration source, not a continuous source, such as that from an icebreaker, a drillship or a marine dredger. Ridgway et al.'s (1997) (recently published in the Journal of the Acoustical Society of America as Schlundt et al. [2000]) results document temporary threshold shift in bottlenose dolphins exposed to a one-second signal at a RL of 192 dB. For the purposes of the analyses presented in this OEIS/EIS, the 180-dB criterion represents a SURTASS LFA sonar single-ping RL (up to a maximum of a 100 second-long ping) that can be considered to be a scientifically reasonable estimate for the potential onset of injury.

Comment 4-6.5: Why is the criterion at or below 180 dB considered to have no biologically significant effects on breeding, feeding, detection of prey, etc.? Is the 180-dB criterion based on "best thresholds?" Are thresholds known for most marine mammals? (F-002, G-001, I-425, I-478, I-501, I-517, I-558, O-034, O-039)

Response: The OEIS/EIS results assume that risk of significant change in a biologically important behavior exceeds 95 percent at SPE levels of 180 dB and above (which includes the potential for biologically significant effects on breeding, feeding, and detection of prey). Best hearing thresholds have been measured for some small odontocetes and pinnipeds. The OEIS/EIS analysis assumes that mysticetes have comparable hearing thresholds at the frequencies used by SURTASS LFA sonar. The text related to this topic has been revised and relocated to Subchapter 1.4.

Comment 4-6.6: The Draft OEIS/EIS states that for serious injury, the animal would have to be well within the 180-dB sound field at onset of transmission; disagree that the probability of this occurring is near zero. (O-020, O-047)

Response: For 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. Signal spreading loss calculations demonstrate that animals would have to be well within the 180-dB boundary to experience significantly higher RLs that could induce serious injury. AIM qualified the probability of such an event and indicated that the possibility of an animal being that close to the source is very small, especially with the proposed mitigation.

Comment 4-6.7: Provide empirical justification for statement that "a single-ping RL of 180 dB can be considered a conservative estimate for non-serious injury, such as TTS, in odontocetes, based upon damage risk assessment criteria designed to protect human beings." (I-337, I-454, O-020, O-039, O-047)

Response: For 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. Subchapter 1.4

provides justification for this determination. The terms "non-serious injury" and "serious injury" have been eliminated from the Final OEIS/EIS.

Comment 4-6.8: If the criterion was lowered below 180 dB, what would be the potential impact to large aggregations of cetaceans? (O-039)

Response: Lowering the criterion for SURTASS LFA sonar below 180 dB would increase the area affected and the number of animals potentially affected. However, inspection of the histograms (from very conservative data) provided in Subchapter 1.4 (Analytical Context) show the preponderance of animal exposures are for RLs below 155 dB. Thus the relative overall impact of lowering the criterion to 175 dB, for example, would be quite small.

Comment 4-6.9: Provide justification that a 95 percent take at 180 dB is conservative. (G-001, I-454, I-477, I-478, I-501, NN001, O-016, O-027, O-047, O-057)

Response: See Subchapter 1.4.2.1 (Estimating the Potential for Injury to Marine Mammals) for discussion on the conservativeness of the selection of this 180-dB criterion for SURTASS LFA sonar.

Comment 4-6.10: What percentage of animals will experience non-serious injury at 180 dB? (I-454, I-770, O-037, O-042, O-047)

Response: Based on public comments and discussions with NMFS, the Final OEIS/EIS does not use the terms "serious injury" or "non-serious injury." There are no data that permit accurate prediction of this percentage, so the OEIS/EIS adopted the conservative assumption that all marine mammals exposed to RLs at or above 180 dB would be evaluated as if they were injured.

Comment 4-6.11: What percentage of animals will experience serious injury, mortality or predator avoidance? (I-337, I-425, I-477, I-770, I-909, O-020, O-022, O-039, O-042, O-047, O-057)

Response: Although it is impossible to predict exactly what SPE values, or single-ping RLs, would correspond to serious injury or mortality, the AIM results indicate that very few individuals would ever be exposed to RLs in excess of 180 dB (Tables 4.2-10, -11, -12). The risk continuum analysis accounts for behavioral problems, such as impaired avoidance of predators.

Comment 4-6.12: What percentage of animals will experience serious injury above 180 dB? (I-425, I-770, O-047)

Response: See Tables 4.2-10, 4.2-11, and 4.2-12 and Response to Comment 4-6.10.

Comment 4-6.13: The 180-dB criterion relies on Ridgway's TTS measurements; their TTS thresholds of 194-201 dB [3 kHz] are not valid for a 100-second signal. The HESS panel considered 180 dB RL serious; what is the threshold for serious injury in the OEIS/EIS? (I-425, I-907, I-909, O-020, O-028, O-033, O-039, O-043, O-047)

Response: Auditory injury does not include TTS, in which no tissue is perminently damaged and in which loss of function is fully recoverable. Ridgway et al. (1997) and Schlundt et al. (2000) data can be used to extrapolate responses to the SURTASS LFA sonar signals, using established methods of adjusting for differences in signal duration (see Subchapter 1.4.2.1). A panel of nine experts in the fields of marine biology and acoustics sponsored by Southern California's High Energy Seismic Survey (HESS) Team convened at Pepperdine University in June, 1997 to develop marine mammal exposure criteria (Knastner, 1998). The consensus of the combined experts was that they were " 'apprehensive' about levels above 180 dB re 1 µPa (rms) with respect to overt behavioral, physiological, and hearing effects on marine mammals in general. Therefore, the 180-dB radius, as initially defined by transmission loss model and verified on-site, is recommended as the safety zone distance to be used for all seismic surveys within the southern California study area." There is no threshold for "serious injury" in the Final OEIS/EIS.

Comment 4.6-14: Does the Navy agree with the HESS panel that animals more sensitive to LF sound may need more protection? (O-039)

Response: The Navy and the independent LFS SRP researchers explicitly focused their attention on the animal species believed to have the best LF hearing. The risk continuum used the results of these studies to estimate the potential for impact for other species that have less capable LF hearing.

Comment 4.6-15: What is the basis for the Navy's assumption that serious injury could occur at greater than 195 dB RL? (I-425, S-003)

Response: The Final OEIS/EIS does not distinguish between serious injury and non-serious injury. For 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.

Comment 4-6.16: How does the Navy's OEIS/EIS risk continuum relate to the ONR Workshop on the Effects of Anthropogenic Noise in the Marine Environment? (O-039)

Response: The ONR Workshop on the Effects of Anthropogenic Noise in the Marine Environment (10-12 February 1998) broadly addressed similar environmental issues as the LFS SRP. The risk continuum was developed to provide a means of interpreting the LFS SRP data, coupled with existing data.

Comment 4-6.17: Discuss the potential for the risk continuum to be invalid or incorrect because of uncertainties and errors with assumptions for AIM inputs. (I-454, I-478, O-020, O-039, O-047)

Response: It is important to recognize that the risk continuum and the AIM simulation are relatively independent, and they address different issues. AIM estimates the exposure of free-ranging animals to SURTASS LFA sonar pings. The risk continuum translates a history of sound exposure to biological risk. Accordingly, assumptions made to develop one model have only indirect effects on the other.

Comment 4-6.18: A gradual slope for the risk function as portrayed in the Draft OEIS/EIS is not conservative. (O-043, O-047)

Response: Subchapter 1.4.3 discusses the conservativeness of the gradual slope of the risk function. To reinforce this, Appendix D (Sensitivity Analysis of the Risk Function Curve) has been added to the Final OEIS/EIS.

Comment 4-6.19: Justify selection of 150 dB as SPL for 2.5 percent of exposed animals. (I-425, I-501, O-039, O-047, O-057)

Response: Subchapter 4.2.3.2 (Determination of Risk Function) presents a model for the increase in biological risk as a function of cumulative exposure to SURTASS LFA sonar signals. This is a continuous function, whose shape is bounded by observations from the three LFS SRP phases on the low exposure end, and prior scientific consensus that assumed risk is very high at 180 dB (Subchapter 1.4) on the high exposure end. The risk function values below 180 dB were not fitted to specific values (Figure 4.2-2b). The 2.5 percent value at 150 dB was provided as an illustrative example only. The risk levels between 119 dB and 155 dB can be used to predict the number of significant changes in biologically important behaviors that should have been observed during the LFS SRP. No such responses were observed during many tens of trials. Alternative risk functions that predict higher risk are inconsistent with the LFS SRP observations.

Comment 4-6.20: What are the references for the Navy's determination that cetaceans cannot be injured or impacted by external sounds greater than or equal to those they produce (i.e., acoustic reflex). (I-240, I-454, I-501, O-020, O-027, O-039, O-042, O-043, O-047)

Response: As stated in the Draft OEIS/EIS, terrestrial mammals have a mechanism (acoustic reflex) that protects their ears from high intensity sound exposure from either an external source or from the animal's own vocalization (Suga and Simmons, 1975). The protective benefit of this acoustic reflex is not factored into the evaluation of the potential of risk presented in the OEIS/EIS.

Comment 4.6-21: Why is 145 dB used for humans and 180 dB for marine mammals? (G-001, I-424, I-517, O-017, O-020, O-027, O-042, O-047, O-055)

Response: These values represent different criteria: psychological aversion from direct measurements with human divers (TR 3), and the exposure level at or above which all marine mammals are evaluated as if they are injured (Subchapter 1.4 [Analytical Context]). The level of potential effects for humans is lower than that for marine mammals primarily because of the inherent physiological and psychological differences. A human diver is in an unnatural, hazardous and unpredictable environment. Breathing compressed air introduces special risks for humans underwater. The potential for a startle response that could have serious consequences is much greater for humans underwater than a marine mammal. Marine mammals are in their natural habitat, their ears are pressure-adapted to their environment, and they are accustomed to hearing LF sounds underwater.

Comment 4.6-22: If the 120-dB harassment threshold were used rather than the 180-dB injury threshold, the affected area would be vast. (O-021)

Response: Prior studies of gray whales were used as a basis for the 120-dB "harassment" criterion, where 120 dB was the average received level for a continuous industrial noise source at which approximately 50 percent of the animals deviated from their normal migratory paths, and where harassment constituted deviations of a few hundred meters in a migration track that covers several thousand miles. It is difficult to argue that such behavioral responses actually constitute a threat to survival or reproduction. This was the primary issue that the LFS SRP addressed. Results from that field research suggested that the 120-dB threshold is not correct for LF sounds interacting with baleen whales, such as those animals that were indicator species for the LFS SRP (blue, fin, gray and humpback whales). The AIM simulation and risk continuum analyses provided herein seek to make conservative estimates of the potential for risk in terms of survivorship and reproduction.

Comment 4.6-23: The LFS SRP results are insufficient to establish zero risk at 120 dB; this is not precautionary and goes against previous research. B is the basement RL in dB below which there is no risk; this is unknowable. (I-478, O-016, O-020, O-042, O-043, O-047, O-057)

Response: Scientific data cannot establish zero risk. Given the shape of the risk function, 120 dB can be viewed as the number that risk is so low, it is pointless to calculate risk below it. Changing this basement value for risk by as much as ± 10 dB (110-130 dB) would not affect the number of potential impacts and would not alter the cumulative risk values.

Comment 4-6.24: Justify PTS at 100 m (330 ft) and tissue damage even closer. On what scientific basis does the Navy make their assertion regarding TTS to PTS? (O-027, O-047)

Response: Subchapter 4.2.7.5 (Biological Context) has been revised to remove the statement regarding PTS and tissue damage, and categories of potential effects on marine animals from SURTASS LFA sonar operations have been provided at the start of Chapter 4 (Impacts of the Proposed Action and Alternatives). Non-auditory injury includes the potential for resonance of the swim bladder (fish) or lungs/organs (marine mammals), tissue damage, and mortality. Undetected marine animals within the 180-dB sound field during SURTASS LFA sonar transmissions are considered at risk of injury.

Permanent threshold shift (PTS) is a severe situation that occurs when sound intensity is very high or of such long duration that the result is a PTS or permanent hearing loss on the part of the listener. The intensity and duration of a sound that will cause PTS varies across species and even among individual animals. PTS is a consequence of the death of the sensory hair cells of the auditory maculae of the ear and a resultant loss of hearing ability near the frequencies of stimulation (Salvi et al., 1986; Myrberg, 1990). In mammals the damaged sensory hair cells are never replaced. Damaged sensory hair cells were replaced in one species of fish that has been studied, but no investigations were performed to ascertain whether hearing was restored (Lombarte et al., 1993).

Comment 4-6.25: Relate non-serious injury and non-injurious harassment to Levels A and B harassment definitions under the MMPA. Clarify use of serious injury, non-serious injury, physical injury, serious harassment, non-serious harassment, non-serious harm, harassment, and non-injurious harassment. (G-001, I-454, O-037, O-039, O-047, O-051)

Response: Based on public comments and discussions with NMFS, the terms non-serious injury and non-injurious harassment are not used in the Final OEIS/EIS. The scientific analyses underpinning the Final OEIS/EIS are not tied to the legal definitions of Levels A and B harassment under the MMPA.

Comment 4-6.26: Regarding the Draft OEIS/EIS statement that the frequency of maximum sensitivity for odontocetes is well above the SURTASS LFA sonar operating band, too few have been tested to support this statement, especially the deep-diving sperm and beaked whales. (I-478, I-501, O-020, O-021, O-039, O-043)

Response: Recent evaluation of inner ear mechanics for sperm whales (Ketten, 1994a) indicates that their ears are not well adapted for LF hearing. However, there is anecdotal behavioral response evidence indicating that they can hear some LF sounds. Studies on the basic auditory mechanisms of beaked whale hearing have only just recently begun, but all indications are that the inner ears of these species are also not well adapted for low frequency. Of all odontocetes, sperm and beaked whales are the most likely to have some LF-sound sensitivity, and they are modeled at a number of the 31 sites selected for analysis. Scientists that study marine mammal audition believe that the underwater acoustic testing of small odontocetes, coupled with some necropsies on their hearing mechanisms, are adequate proof that their frequency of maximum sensitivity is above 500 Hz, the upper level of the SURTASS LFA sonar operating band. For reasons set forth in Subchapter 3.2.5 (Cetaceans [Odontocetes]), odontocete species studied to date (less sperm and beaked whales) have demonstrated that their hearing is most sensitive and acute in the high frequencies of 10-100 kHz. The risk analysis derived from baleen whale data is applied to all marine animals. There is no evidence that any odontocete is more specialized for LF hearing than baleen whales, meaning this is a very conservative stance, particularly for dolphins, which are known not to be very sensitive at LFs.

Comment 4-6.27: How can the Draft OEIS/EIS conclude that 80 dB above threshold is valid for odontocetes and that 180-220 dB would be the chronic exposure limit? (I-425, O-027, O-039)

Response: Subchapter 1.4.2.1 (Estimating the Potential for Injury to Marine Mammals) explains the rationale underlying the estimate of 180 dB as the level at which accelerated hearing loss could occur with chronic exposure (about 8 hours per day over about 10 years) in the 100-500 Hz frequency band of the SURTASS LFA sonar. The 180-dB level was determined to be acceptable as the one-time exposure limit based on selection of 60 dB re 1 µPa as the lower limit of the estimated marine mammal hearing threshold in the 100-500 Hz frequency band. Because of the lack of direct measurements of hearing loss in marine mammals due to LF sound exposure, these estimates were, by necessity, based on human hearing studies.

Comment 4-6.28: Because of uncertainties in baleen whale threshold levels, shouldn't the "best hearing threshold" be below 80 dB, say 40 dB? (I-425, O-027, O-033, O-039)

Response: According to Ketten (1998) modeling, 80 dB is a realistic value for lowest hearing threshold for mysticetes. Ambient noise at LF is higher than at HF, so it is unlikely that mysticetes would have hearing thresholds lower than odontocetes, who hear in the HF frequency band.

Comment 4-6.29: Does the Navy agree with Richardson et al. (1995b), which supports the hypothesis that PTS may occur with a single sound of 195-225 dB for a 40-dB threshold for marine mammals? Justify the use of Richardson et al. (1995b) and Au et al. (1997) [as citations] in Subchapter 4.2.5 of the Draft OEIS/EIS. (I-425, I-478, O-034, O-039, O-047, O-057)

Response: The Navy agrees with Richardson et al. (1995b). The Navy believes there is no justification required for the use of Richardson et al. (1995b) and Au et al. (1997) in the OEIS/EIS; both citations are correct in the context of their use. Richardson et al. and Au at al. address the frequency band closest to SURTASS LFA sonar (i.e., 500 Hz and 75 Hz, respectively).

Comment 4-6.30: If human experiences are to be applied to potential marine mammal experiences, will the Navy EIS consider the 10-12 February 1998 ONR Workshop Report on the *Effects of Anthropogenic Noise in the Marine Environment* that noted that divers reported rotational movement of the visual field coinciding with the onset and termination of the stimulus and some divers exposed had shown symptoms suggestive of central nervous system and/or other vestibular disorders when exposed to continuous noise? (O-039)

Response: The comment on the ONR Workshop Report (Gisiner, 1998) refers to a Montague and Strickland (1961) report that noted that divers reported rotational movement of the visual field starting at about 165 dB re 20 microPascal (191 dB re 1 µPa at 1 m) for a 1,500 Hz pure tone for one second. This and other literature was available to medical researchers who derived the Bureau of Medicine and Surgery’s 145-dB RL criterion (Appendix A). The difference in reference pressures between 165 dB re 20 microPascal and 191 dB re 1 microPascal should be noted. For purposes of the SURTASS LFA sonar analyses presented in this OEIS/EIS, all marine mammals exposed to RLs ≥180 dB are evaluated as if they are injured. This is 11 dB below 191 dB for rotational movement.

Comment 4-6.31: Discuss Kastak et al. (1999) results for TTS in pinnipeds. (I-425, I-917, O-020, O-028, O-047)

Response: Research is continuously producing additional results; the Kastak et al. (1999) paper was published after the Draft OEIS/EIS was written. Their results are included and discussed in Subchapter 1.4.

Comment 4-6.32: The Draft OEIS/EIS fails to identify the full term of SURTASS LFA sonar exposure. (I-917, O-016)

Response: The Navy assumes by "full term" the commentor means for a full year of operations. Subchapter 2.2 (SURTASS LFA Sonar Deployment) addresses the use of SURTASS LFA sonar on a per annum basis as opposed to an individual 20-day mission basis.

Comment 4-6.33: Can the Navy deny implications for severe behavioral responses to SURTASS LFA sonar at start up that could confound an animal such that it may not be able to escape from the 180-dB sound field? (I-425, O-039)

Response: The risk continuum used in this OEIS/EIS assumes a high (95 percent) risk of the potential for significant change in a biologically important behavior at 180 dB RL, which is a very conservative estimate. The AIM analysis does not incorporate animal avoidance to exposure; they remain in the area and all exposures at or above 180 dB are considered takes. See Subchapter 1.4.3 (Analytical Approach) for details on the conservative assumptions used in research and modeling efforts.

Comment 4-6.34: What would be the confounding effects of the naval task force surrounding the SURTASS LFA sonar vessel? (O-039)

Response: It is unclear whether SURTASS LFA sonar signals would pose greater problems in this context; there are no data bearing on this point. However, the fraction of the ocean's volume that might be affected by this kind of operation would be extremely small.

Comment 4-6.35: What studies is the Navy using to prove the safety of 215 dB and higher broadcasts in the water? (I-917, S-007)

Response: The Navy assumes that the commentor is referring to a source level (SL) of 215 dB and higher. Biological impacts relate to received level (RL), not SL. The AIM simulation is a detailed effort to determine the RLs that free-ranging animals would experience.

Comment 4-6.36: What SPLs has the Navy discovered that could cause seizures, memory loss in humans and other trauma to humans and other marine mammals? (F-005, I-917)

Response: TR 3 (Summary Report on the Bioeffects of Low Frequency Waterborne Sound) addresses the issue of what SPLs the Navy-sponsored research has discovered to cause effects on human divers in the water. This report also describes the case of a Navy diver who experienced intermittent symptoms of memory loss and seizures for two years after a 15-minute continuous exposure to LF sound at 160 dB SPL. These symptoms have since been resolved with no further complications. It should be noted that the maximum permissible SURTASS LFA sonar-generated SPL at known recreational and commercial dive sites is 145 dB, which is 15 dB lower than the 160-dB SPL to which this diver was exposed. Furthermore, the maximum ping length for SURTASS LFA sonar is 100 seconds.

Subchapter 4.2 (Potential Impacts on Marine Mammals) addresses the SPLs that the Navy believes to cause effects on marine mammals.

Comment 4-6.37: Humpback whales not permanently leaving an area does not necessarily imply no significant impact. (I-425, O-047)

Response: Subchapter 4.2.4 (Low Frequency Sound Scientific Research Program) cited Richardson et al. (1995b) who (prior to the LFS SRP) stated, “It is doubtful that many marine mammals would remain for long in areas where RLs of continuous underwater noise are 140+ dB at frequencies to which the animals are most sensitive.” This expectation was not borne out by any of the LFS SRP phases. Phase III of the LFS SRP demonstrated that humpbacks exposed to non-continuous sound RLs ranging from 119 to about 155 dB showed only short-term behavioral responses, but no significant change in the biologically important behavior of singing.

Comment 4-6.38: Based on what is known from testing, appropriate conclusions about potential injury to animals from SURTASS LFA sonar should be inconclusive, not biologically insignificant. The Navy’s findings of biological insignificance rest on the LFS SRP and Ridgway et al.’s (1997) dolphin study; these data are limited and extrapolation is unjustified. (I-425, O-028, O-033, O-038)

Response: The LFS SRP and Ridgway et al.’s (1997) dolphin study (recently published in the Journal of the Acoustic Society of America as Schlundt et al. [2000]) provide a limited data set. However, the Navy’s findings do not rest solely on these two sources of information. Subchapter 4.2 (Potential Impacts on Marine Mammals) references and cites numerous other literature, studies and analyses, which are integrated with the risk continuum analysis of this OEIS/EIS to come to the reasonable conclusions stated above.

Comment 4-6.39: Subchapter 4.2 has almost a complete disregard of all cautionary segments of Croll et al. (1999). (I-501, O-016, O-020, O-021)

Response: Dr. Croll was part of the SURTASS LFA sonar OEIS/EIS team, and the Navy has incorporated relevant factual material (including some cautionary segments) from his report into the Final OEIS/EIS.

For example, the following quote is from the executive summary of Croll et al. (1999) concerning masking sounds for cetaceans: "Consequently, the most serious potential impacts of LFA are likely its potential contribution to a long-term decrease in the foraging efficiency or communication efficiency of marine animals. Because some marine animals (e.g. large social odontocete cetaceans such as *Pyseter*, *Hyperoodon*, and *Berardius*) have extremely low potential population growth rates, are poorly known, and difficult to study, small decreases in their reproductive rate could have serious impacts on population size yet be undetected by any known monitoring system."

Because of concern for masking by the SURTASS LFA sonar OEIS/EIS team, the potential impact of masking was assessed in Subchapter 4.2.7.7 (Potential for Masking). In summary, masking effects are not expected to be severe because the SURTASS LFA sonar bandwidth is very limited (approximately 30 Hz), the signals do not remain at the same frequency for more than 10 seconds, and the duty cycle is limited (system off at least 80 percent of the time).

Croll et al. (1999) also stated, "It is possible (perhaps likely) that brief interruptions of normal behavior or short-term physiological responses to LFS have few serious welfare implications and no serious effects on survival and reproductive success in cetacean populations. However, long-term impacts (e.g., displacement, masking of biologically important signals), while more difficult to identify and quantify, may be biologically significant through reductions in foraging efficiency, survival, or reproductive success. In many cases the basic information needed to understand the long-term consequences of human-produced sound is missing. As a result, completely different conclusions may be drawn from the same sparse data set................"

Subchapter 4.2.7.5 (Biological Context) addresses the question of what level of behavioral response could result in a stock level-impact and, therefore, threaten a species' survival. Because there was no evidence of large-scale behavioral effects during the LFS SRP, the scientists have interpreted the results as indicating that the scale of the potential impacts is limited.

Comment 4-6.40: Clearly define the exact types of effects (i.e., TTS). Also describe how physical effects to the animals may relate to behavioral effects, as there were some behavioral effects during the SRP at 155 dB. (NN001)

Response: The types of potential effects on marine animals from SURTASS LFA sonar operations are given in the introduction to Chapter 4. The relationship of behavioral responses as they relate to physical effects is addressed in Subchapter 4.2.7.5 (Biological Context).

Comment 4-6.41: It is essential that what is meant by "population" is clearly and unambiguously stated. (O-043)

Response: In the Draft OEIS/EIS the terms "stock," "population," and "stock population" were used interchangeably. This has been clarified in the Final OEIS/EIS. The term "stock" refers to a group of related animals of the same species or smaller taxa that are usually located within a specific geographic area that interbreed when mature (16 U.S.C. 1362). "Population" refers to the interbreeding set of animals, either in specific stocks or within a specific geographic area. The term "stock population" is no longer used.

Comment 4-6.42: The SURTASS LFA sonar signal has a second harmonic that is only 30 dB down from the main signal. This means an exposure of 150 dB at 1 km at frequencies of up to 1,000 Hz. In addition, the frequency modulation of the signal would produce significant energy at frequencies well above 1,000 Hz. These could be a problem for odontocetes and other creatures sensitive to higher frequencies. (I-730, I-732)

Response: Harmonics were considered, but their effects are considered minimal because of the energy loss associated with them. As stated by the commentor, the level of the second harmonic is at least 30 dB down and only 150 dB at 1 km (0.54 nm). This RL for the intermittent transmission of the SURTASS LFA sonar signal should pose no threat of injury to marine animals. In addition, source level harmonics above 1 kHz would be at considerably lower levels (e.g., 50 dB lower than the fundamental) and would have more energy loss than the second harmonic due to absorption. There is no physical acoustic reason to support the statement that "the frequency modulation of the signal would produce significant energy at frequencies well above 1,000 Hz." Acoustic monitoring of RLs from the LFS SRP verify the predictions that harmonic energy from the SURTASS LFA source is substantially below RLs of the fundamental.

Comment 4-6.43: The document makes the assumption throughout that since LFA sound will be intermittent, this cycle is better for the marine species. This assumption by the Navy is invalid and unsubstantiated because the sound is like repetitive stress, or will have a cumulative effect. (I-764)

Response: The LFS SRP measured behavioral responses of baleen whales using signal characteristics and duty cycles similar to those that will be used in SURTASS LFA sonar operations. The assumptions made concerning the intermittent nature of the SURTASS LFA sonar signal do not include only the duty cycle. The LFS SRP also takes into account that the vessel is moving and that operations will rarely be conducted in the same area for extended periods. Therefore, animals will not be subjected to repeated signals over the periods of time necessary to cause stress.

Comment 4-6.44: The positive aspects of a moving source are somewhat negated in the case of the SURTASS LFA sonar, as the source vessel travels at only 3 knots. (O-047)

Response: During a typical SURTASS LFA sonar operation, each nominal period of transmission would be for nine hours, twice a day. Assuming the vessel uses a triangular track geometry, it would cover 16.7 km (9 nm) on each of the triangle’s legs. The only way that a marine animal could be continuously exposed to high RLs would be if it followed the vessel.

Because this is not likely to happen, the moving source can be considered a positive mitigating aspect of SURTASS LFA sonar operations.

ISSUE 4-7: POTENTIAL IMPACTS ON MARINE MAMMALS - ALTERNATIVE 1

Comment 4-7.1: Although the unstated assumptions for the Subchapter on Indirect Effects seem reasonable, it is important to recognize that they may not be valid and to point out the possible consequences if they are not valid. (G-001)

Response: The Navy agrees that assumptions such as those in Subchapter 4.2.7.6 (Potential for Indirect Effects) cannot be considered to always be valid. If fish were within the LFA mitigation zone during transmission, they could potentially be affected. However, it is difficult to envision a SURTASS LFA sonar operational scenario where a fish stock is affected to such an extent that prey availability for marine mammals would be altered for longer than a few hours at most. See Subchapter 4.1.1 (Fish) for further discussion on the potential for SURTASS LFA sonar to impact fish stocks.

Comment 4-7.2: Clarification is needed for the discussion on the potential for masking. What is the basis for the claim that masking in odontocetes would be only minor and temporary? (G-001, O-027, O-047)

Response: There are very few odontocetes that vocalize or have low hearing thresholds in the SURTASS LFA sonar frequency band. Given that the SURTASS LFA sonar signals are transient, with a limited bandwidth, unlike broadband industrial noise or natural noises (surf noise, etc.), with a maximum duty cycle of 20 percent, the conclusion in the Final OEIS/EIS that any masking in mysticetes, odontocetes, or pinnipeds is considered to be minor and temporary, is considered valid.

Comment 4-7.3: Clarify “noise limited” and “sensitivity limited” as related to masking in marine mammals. (G-001)

Response: For underwater sounds dominated by LF components, the maximum range of acoustic detection between the listening animal and the sound source may often be noise limited. That is, levels of ambient noise (in the frequency range of the distant sound) at the animal would limit its ability to detect a distant sound. In general, for a given source level, the further away the sound source is, the more likely it is that local ambient noise levels will be greater than the received level of the distant sound, which would thus go undetected by the listening animal. Chances of detection are higher when hearing sensitivity is better (i.e., auditory threshold is lower) for the source frequency, and in this case local ambient noise levels will limit the detection. In contrast, when hearing sensitivity is poor (i.e., auditory threshold is higher) for the source frequency, the chances of detection are limited by the animal's hearing sensitivity and ambient noise is not as much of a limiting factor in detection. See Subchapter 4.2.7.7 (Potential for Masking) for additional discussion on this topic.

Comment 4-7.4: What studies has the Navy undertaken to ensure that those species whose vocal and/or hearing ranges are outside the frequency range of SURTASS LFA sonar are not impacted? (O-027)

Response: With regard to species whose vocal and/or hearing ranges are outside the frequency range of SURTASS LFA sonar, Richardson et al.'s (1995b) finding is germane: "For practical purposes, the only relevant noise is that within the masking bandwidth, perhaps one-third octave wide, centered at the frequency of the signal." Note: a one-third octave band is a frequency band whose upper limit in Hertz is 1.26 times the lower limit; bandwidth is proportional to center frequency. Additionally, the proposed geographic restrictions and monitoring mitigation measures, which are designed to protect all potentially affected species, are independent of the individual's vocal and/or hearing range. The Navy makes conservative assumptions throughout the OEIS/EIS (e.g., the most LF-sensitive marine mammals were studied and the results for those most sensitive species were extrapolated to non LF-sensitive animals).

Comment 4-7.5: Are the impacts analysis in the Draft OEIS/EIS based on full power capability of SURTASS LFA sonar? (O-051)

Response: Yes. The impacts analyses in the Draft OEIS/EIS were based on full power capability of the SURTASS LFA sonar.

Comment 4-7.6: How were the percentages of potentially affected populations calculated to 1/100th of a percent? (O-051)

Response: Subchapter 4.2 (Potential Impacts to Marine Mammals) lists the analytical process to derive the percentages of potentially affected stocks. Subchapter 4.2.2 (Acoustic Modeling) describes the acoustic modeling process employed in this OEIS/EIS. Subchapter 4.2.6 (Sample Model Run) provides two examples of how the Parabolic Equation (PE) and Acoustic Integration Model (AIM) are used with the risk continuum to produce the percentages of potentially affected stocks. A standard format of two decimal places was adopted for the table, which allows the display of some small, but non-zero percentages.

Comment 4-7.7: With regard to the analysis of employment of two sources at one site, are there situations where the two sources could converge; if so, then doubling would be invalid? (G-001, O-020)

Response: Coherent addition of two or more sources would be extremely difficult to accomplish in practice, and would be limited to a very small area. The chance of this happening by accident is vanishingly small. See Subchapter 4.2.7.4 (Analysis of Employment of Two Sources at One Site).

Comment 4-7.8: Why was the Gulf of Oman chosen for an example, given that it has low animal densities? (O-027)

Response: The Gulf of Oman site was chosen for its high potential for operational significance.

Comment 4-7.9: In the analysis of employment of two sources at one site, how can the 75 percent criterion (values for two, separate, single sources combined were on average 75 percent lower than the values from doubling single source results) from one site be extrapolated to all sites? (G-001, O-020)

Response: The Draft OEIS/EIS did not extrapolate the 75 percent criterion to all sites. As stated in Subchapter 4.2.7.4 (Analysis of Employment of Two Sources at One Site) and Table 4.2-13, the actual model results for two sources were lower than simply doubling of the single source results—on average 75 percent or less of the more conservative doubled estimates. Therefore, in lieu of performing additional model analyses, doubling of the sites modeled results in the OEIS/EIS conservatively bounds the potential effect of employing two sources at one site.

Comment 4-7.10: What is the scientific basis that even the smallest percentage of negative reproductive potential will not have an impact? (O-027, O-042)

Response: The reproductive success of animal stocks varies under natural conditions. If an anthropogenic effect is small and variable in relation to the range of natural variation, and if it does not increase the risk that the stock will decline, then the potential for effects on the stock would be considered negligible.

Comment 4-7.11: On what scientific basis does the Navy assert that a 5-10 percent reduction in food intake will not negatively impact species in general, and lactating females and juvenile animals in particular? (O-027, O-038, O-042)

Response: This hypothetical example illustrated the potential magnitudes of the effects on a stock, assuming that SURTASS LFA sonar signals would seriously disrupt feeding behavior. Such disruptions in feeding behavior were not observed during the LFS SRP. It is very unlikely that any marine animal stock would exist if it could not withstand a 5-10 percent variability in foraging success, because these stocks evolved in the context of natural fluctuations in food availability. See Subchapter 4.2.7.5 (Biological Context) for further discussion on this topic.

Comment 4-7.12: On what scientific basis does the Navy claim that there will be no immediate deaths of marine mammals from SURTASS LFA sonar? (I-501, O-027, O-039)

Response: From a scientific and engineering standpoint, there is no plausible mechanism for immediate mortality upon exposure to SURTASS LFA sonar signals (100-500 Hz at 215 dB). All prior research results support this conclusion. See Subchapter 1.4.2.1 (Estimating the Potential for Injury to Marine Mammals) for further discussion on this topic.

Comment 4-7.13: Where is the research indicating that RLs from 240 to 180 dB will not cause immediate death or severe injury leading to death? (O-027)

Response: For purposes of the SURTASS LFA sonar analyses presented in this OEIS/EIS, all marine mammals exposed to RLs ≥180 dB are evaluated as if they are injured. See the Response to Comment 4-7.12 above.

Comment 4-7.14: At what decibel level will a marine mammal suffer disorientation, PTS or other injury serious enough to interfere with foraging, nursing, migrating, prey evasion or breeding capability, all of which will lead to death, not only of individuals, but of entire stocks? (O-016, O-027)

Response: All marine mammals exposed to RLs at or above 180 dB are evaluated as if they were injured. The risk continuum models the potential impact of significant change in a biologically important behavior.

Comment 4-7.15: More thorough consideration of the possible impacts of SURTASS LFA sonar operations on phocid mating, pup-rearing, and other biologically important behavior seems necessary. (G-001)

Response: Most phocid mating and pup-rearing takes place on or near land or ice; thus, the potential for effects from SURTASS LFA sonar operations would be minimal.

The Navy applies the findings from LF-sensitive baleen whale field research to phocids, which are thought to be less sensitive to LF sound; thus adhering to a prudent approach. See Subchapter 4.2 (Potential Impacts on Marine Mammals) for analysis results on phocids (northern/southern elephant seal and Hawaiian monk seal).

Comment 4-7.16: How can the Navy dismiss any long-term effects of the proposed action by offering to mitigate and monitor the project? (O-019, O-051)

Response: The Navy does not dismiss any potential long-term impacts. The short-term LFS SRP studies were guided by a desire to understand long-term effects. The Navy's proposal to continue research within the framework of the Long Term Monitoring Program (Subchapter 2.4) represents a substantive effort to help resolve the outstanding questions regarding biological impact, including the potential for long-term effects.

Comment 4.7-17: The Draft OEIS/EIS considers that marine mammal reproduction potential can only be affected during the breeding season, when effects on foraging would also have an impact on reproductive success (because the food ingested goes into making energy for calf development and feeding, and migration to and from breeding sites). (G-001, I-501)

Response: The risk continuum aggregates all forms of biological impact, in terms of potential for reductions in survival or reproduction. This includes the potential for effects of reduced foraging on reproductive success. See Subchapter 4.2.7.5 (Biological Context) for further discussion on this topic.

Comment 4.7-18: The Navy underestimates the potential for harm to threatened and endangered wildlife. (O-012, O-038)

Response: The Navy believes the Final OEIS/EIS has identified all potential direct and indirect effects on listed species that are known, and has made a good faith effort to explain the potential for effects that are not known but are reasonably foreseeable.

Comment 4-7.19: The Draft OEIS/EIS is generally inconsistent with ONR's Report on its 1998 Workshop on the Effects of Anthropogenic Noise in the Marine Environment. (O-027)

Response: In most areas, the Draft OEIS/EIS is consistent with the results of the ONR report on its 1998 workshop (Gisiner, 1998). However, some differences can be traced to the incorporation of new material in the Draft OEIS/EIS, which was not available when the workshop was held. Furthermore, the goals of the workshop and Draft OEIS/EIS differ. The former was "a framework upon which project proponents, resource managers, biologists and acousticians, legal experts, economic experts, advocacy groups and the public can structure their discussions during the formulation of policies and plans of action with regard to anthropogenic underwater noise." The goals of this Final OEIS/EIS are different and are stated in Chapter 1 (Purpose and Need).

Comment 4-7.20: On what scientific basis does the Navy claim that, given the large size of the ensonified area, significant portions, if not all individuals, of any given stock of animals will not be impacted? (O-027)

Response: Table 4.2-10 gives the estimates of the percentages of marine mammal stocks potentially affected by Alternative 1. This table demonstrates that for the 31 sites modeled, there were no "significant portions" of any marine mammal stocks affected. The scientific basis for the modeling analysis is detailed in Subchapter 4.2 (Potential Impacts on Marine Mammals) of the OEIS/EIS. Subchapters 4.1.1 and 4.1.2 address the potential for impacts on fish (including sharks) and sea turtles, respectively.

Comment 4-7.21: The Navy's claim that the SURTASS LFA sonar sounds would have no impacts (i.e., non-significant) is not well-based. (I-764)

Response: The Navy did not claim that there would be no impacts. In summary, under Alternative 1, the potential for effects on any stock of marine mammals from injury is negligible, and the potential for effects on the stocks of any marine mammal from significant change in a biological important behavior is minimal. The actual predicted percentages of marine mammal stocks potentially affected are given in Table 4.2-10 for the 31 modeled sites. Moreover, the potential for any fish/shark stocks to be affected by SURTASS LFA sonar would not be significant. It was also determined that it would be unlikely that any sea turtle stocks would experience significant impacts.

ISSUE 4-8: POTENTIAL IMPACTS ON MARINE MAMMALS - ALTERNATIVE 2

Comment 4-8.1: There are only minor differences between Alternatives 1 and 2; this underlines that both mitigated and unmitigated risk that SURTASS LFA sonar poses are underestimated. (O-047)

Response: While the potential tempo of operations under Alternatives 1 and 2 are the same, there are significant differences between the two alternatives. Alternative 1 has the following constraints: 1) geographic restrictions (Subchapter 2.3.2.1); 2) monitoring to prevent injury (Subchapter 2.3.2.2); and 3) reporting (Subchapter 2.3.2.3). Alternative 2 would involve unconstrained operations of SURTASS LFA sonar in the active mode (Subchapter 2.3.3). In Subchapter 4.2.8 (Alternative 2) two case studies were analyzed (one in the Pacific-Indian Ocean area and one in the Altantic-Mediterranean Sea area). The results were compared to Alternative 1 and are given in Table 4.2-14 (Estimates of Percentages of Marine Mammal Stocks Potentially Affected [With and Without Mitigation]). These results demonstrate that Alternative 1 is superior to Alternative 2 because Alternative 1 reduces the risk of potential injury while still permitting the SURTASS LFA sonar mission to be accomplished. In any event, the Navy disagrees that the risk for either Alternative 1 or Alternative 2 is underestimated.

Comment 4-8.2: Why are only North Pacific site estimates referenced as "for Alternative 1/Alternative 2 cases?" What does this mean? (O-027)

Response: There were two cases analyzed for the Alternative 1 vs. Alternative 2 case study. These included: (1) North Pacific Ocean site 8 (southeast of San Nicolas Island, CA), and (2) North Atlantic Ocean site 23 (south Norwegian Basin). Results of these analyses are given in Subchapter 4.2.8 (Alternative 2). Table 4.2-14 (Estimates of Percentages of Marine Mammal Stocks Potentially Affected [With and Without Mitigation]) shows that Alternative 1 is superior to Alternative 2 because Alternative 1 reduces the risk of potential injury while still permitting the SURTASS LFA sonar mission to be accomplished. Based on these results, it is expected that Alternative 1, because of the proposed mitigation, will be superior to Alternative 2 (no mitigation) for all modeled sites.

ISSUE 4-9: POTENTIAL SOCIOECONOMIC IMPACTS

Comment 4-9.1: The discussion of the short- and long- term potential impacts on social and economic factors for the entire world is too broad and general, completely meaningless. They are evaluated in only seven pages. (O-051)

Response: There were 18 pages of discussion in Subchapter 3.3 of the Draft OEIS/EIS, which discussed the following worldwide socioeconomic issues:

- Commercial and recreational fishing;
- Other recreational activities;
- Research and exploration activities; and
- Coastal zone management for states and territories, which included 23 coastal states and five territories.

The analysis in Subchapter 4.3 (Socioeconomics), which was seven pages in length, analyzed the potential effects on both Alternatives 1 and 2 for:

- Commercial and recreational fisheries;
- Swimming and snorkeling, diving;
- Whale watching;
- Research and exploration; and
- Coastal zone management for coastal industry, marine resources research and planning, natural resource protection and preservation, and recreation.

Subchapter 4.3 was seven pages in length because it summarized analyses presented elsewhere in the Draft OEIS/EIS and/or supporting technical reports. For example, the potential impacts to fish were found in Subchapter 4.1.1 (Fish and Sharks), which concluded that the potential impact of injury to fish and shark stocks would not be significant. Also the potential impacts to divers/swimmers were addressed in TR 3 (Summary Report on the Bioeffects of Low Frequency Waterborne Sound [on divers]).

The potential socioeconomic impacts for the proposed action were also evaluated in accordance with EO 12898 (Environmental Justice) and EO 13045 (Protection of Children from Environmental Health Risks and Safety Risks).

Comment 4-9.2: What about the effects of SURTASS LFA sonar on public and private mid-ocean research? Why does the Draft OEIS/EIS dismiss the possibility of impacts to all non-diving academic research? (O-027, O-047)

Response: Subchapters 3.3.3 and 4.3.3 address research and exploration activities. Under Alternative 1, the RL would not exceed 145 dB within known blue-water dive sites related to mid-ocean research, identified through DAN and interaction with major state diver organizations. Many of these efforts are conducted from vessels under the University National Oceanographic Laboratory System (UNOLS), which cooperates with the Navy on a continuous basis. The only feasible impact that SURTASS LFA sonar operations could possibly have on non-diving academic research would be sound contamination of an acoustic research experiment. Either the Office of Naval Research (ONR) or the National Science Foundation (NSF) would be aware of any open-ocean research of this nature. ONR and NSF are located in Arlington, Virginia, and they cooperate on this type of research on a continuous basis. Thus, information on this would be readily available.

Comment 4-9.3: Where is the discussion of the whale-watching tour boat lawsuit against the Navy in Hawaii? (I-030, I-917, O-051, O-057)

Response: The fact that these lawsuits were filed is not, by itself, relevant to the proposed action. See the Response to Comment 1-3.9.

Comment 4-9.4: Discuss the research by the Navy on "bubble growth." Is the information publicly available? Respond to Crum and Mao, 1996, JASA 99:5. (I-917, O-027)

Response: The only work sponsored by the Navy looking at the bubble growth issue was published by Crum and Mao (1996) in the Journal of the Acoustical Society of America. This work hypothesized that received levels would have to exceed 190-dB SPL in order for there to be the possibility of significant bubble growth. Furthermore, the tissue would have to be supersaturated with gas. No further work was funded in the area of the potential for effects of ensonification on bubble growth, because it was evident from early research that generated the military guidance that the sound intensity for the recreational guidance would not exceed 160 dB SPL, well below the 190-dB SPL lower bound for bubble growth from Crum and Mao (1996).

Comment 4-9.5: The diver study cannot be extrapolated to the general diving community because test subjects were in better medical health and fitness and were disciplined military personnel. (I-424, O-047, O-057, S-003)

Response: The investigations into recreational diver response were measurements of aversion. The divers involved were recreational divers that happened to be in the military, but had only civilian certification for diving. Furthermore, there was a wide variation in diving experience, with some divers having as few as four dives prior to the testing. Waivers of physical and training standards were requested and obtained to allow the use of non-military trained divers. The only physical standards that were adhered to were that divers had to be free of any absolute contraindications for diving as described in the Recreational SCUBA Training Council's guidelines for physicians.

Comment 4-9.6: Why did the Navy not wait until all TR 3 references (particularly seven preliminary reports/studies) were available to the public? (O-004, O-057)

Response: The pertinent data from the above studies are given in TR 3. The preliminary reports were withheld at the request of the authors, who are in the process of submitting journal articles. The peer review process for journals takes up to three years for the article to reach print and be published. The 145-dB guidance was promulgated after investigators concluded that it was reliable, and that there was no reason to wait until formal publication of any articles based on the research.

The performers and their institutions are Dr. D. Dalecki - University of Rochester, Dr. P. H. Rogers - Georgia Institute of Technology, Dr. R. Jackson - Boston University, Dr. T. K. McIntoch - University of Pennsylvania, Dr. R. D. Kopke - Naval Medical Center San Diego, Dr. E. D. Thalmann - Duke University, Mr. D. L. Orr - Divers Alert Network, Dr. M. Pestorious - University of Texas/Applied Research Laboratory, and Dr. J. R. Sims - Naval Submarine Medical Research Laboratory.

Comment 4-9.7: TR 3 states that 100 Hz LF sound is well tolerated at a SPL of 136 dB for up to 28 sec. How can this be raised to 145 dB at 100 sec? TR 3 did not test divers at 145 dB for 100 sec. (I-424, I-681, O-057)

Response: There have been divers tested with 100-second signals at 160 dB SPL at frequencies down to 160 Hz without deleterious effects (Steevens, 1995). In the Steevens (1995) study the diver was exposed to nine 100-second signals with a 100-second break in between.

This is a duty cycle of 50 percent, which is more than twice the duty cycle proposed in the guidance for the study (maximum duty cycle of 20 percent). In effect, with a duty cycle of 20 percent, this means that, in a worst-case scenario of a 100-second signal, the sound is off for 400 seconds or almost 7 minutes between each signal. In addition, no effects were observed that could be attributed to duration in the aversion measures in the study (TR 3). Based on this and the lack of physiological impact for divers who have been tested for a 100-second signal (Steevens, 1995), it was felt appropriate to use 100 seconds as the maximum signal duration. A longer signal duration could not have been supported because these have not been tested.

Comment 4-9.8: Has TR 3 been reviewed and approved by BUMED? (S-003)

Response: Yes. The letter reference is: Assistant Chief, Operational Medicine and Fleet Support (MED-02), Bureau of Medicine and Surgery (BUMED), Department of the Navy ltr 6120 Ser 21/0196 of 18 October 1999. A copy of this document is provided in Appendix A (Correspondence).

Comment 4-9.9: TR 3 uses mean values. This is not a conservative approach. (I-681)

Response: While mean values were used to characterize many of the responses to underwater sound, the guidance was derived from cumulative response data. See Figure 1 in TR 3. In this case, a very prudent and conservative approach was developed for the guidance.

Comment 4-9.10: Clarify human lung resonance frequency. What is the resonance frequency at the surface to 6 feet for the human lymph system? (I-424, O-057)

Response: TR 3 results discuss the measurement of human lung resonance frequency to be 40 Hz within 1 meter of the surface. The resonance frequency increases to 70 Hz at a 18.3 m (60 ft) depth and to 80 Hz at a 36.6 m (120 ft) depth. The most significant resonance effects take place in air-filled spaces. The human lymph nodes do not have any air-filled spaces. They are mostly tissue with a small amount of fluid. The occurrence of resonance is also dependent on the relationship between the wavelength of the sound (the distance traveled by the sound in one cycle) and the size of the object. The relationship is proportional. Small objects resonate at short wavelengths (high frequencies) and large objects resonate at long wavelengths (low frequencies).

The lungs resonate at about 40 Hz at the surface and have a residual volume of over 1 liter (0.04 ft^3). This is at least 1000 times the volume of a lymph node. Thus, the expected resonant frequency for a lymph node at the surface would be on the order of 40,000 Hz, based on volume alone. While there are other factors affecting resonance, they could not move the lymph node resonant frequency down to the 100-500 Hz region.

Comment 4-9.11: What is the scientific basis for the 145-dB criterion? (I-424, O-027)

Response: TR 3 presents the scientific basis for the 145-dB criterion. See also Subchapter 4.3.2 (Other Recreational Activities).

Comment 4-9.12: Why didn't the Navy adopt the mitigation procedure used for LFA-13 (i.e., for 130 to 139 dB RL do initial spot checks, and for >139 dB RL continuously monitor)? What about BUMED guidance of 130 dB for non-Navy divers? (O-027, O-057)

Response: This recommendation was made before the human diver research program was conducted and was based on data that the vibration threshold in the 100 to 500 Hz frequency region was estimated at 130-dB SPL. The 130-dB SPL guidance promulgated by BUMED was based on a recommendation by the Navy Environmental Health Center (NEHC) and the Naval Submarine Medical Research Laboratory (NSMRL). It noted that the level was used because of the paucity of data to support any higher level, not because they had definitive evidence that higher levels were hazardous. The data from the human diver program (TR 3) generated new guidance recommending a maximum level of 145-dB SPL between 100 and 500 Hz based on actual human diving research.

Comment 4-9.13: Discuss Final California ATOC EIS statement that at 100 Hz, 160 dB diver facemask and sinuses resonate. (I-424)

Response: 100 Hz is at the lowest end of the SURTASS LFA sonar transmit spectrum and not commonly used for operations. 160 dB is 15 dB higher than the 145-dB RL criterion that would be applied to known dive sites under the proposed Alternative 1.

Comment 4-9.14: Will human diver behavior be altered when sound is first perceived at 84 to 100 dB? (I-424)

Response: These sounds will likely not be detected in the open ocean at the detection thresholds indicated in TR 3 because the ocean is not as quiet as the test pool where these thresholds were measured. Furthermore, biological and mechanical noise, such as from marine mammals and ships, may well mask the sounds for a diver. This means that the detection of the sound by the diver will require higher signal intensity. Based on the results discussed in TR 3, no significant alteration of behavior is expected below 145 dB RL.

Comment 4-9.15: In "Exposure Guidelines for Navy Divers," section titled "Possible Effects of Exposure to Low Frequency Acoustics" states 10 possible impacts. Provide a complete explanation of how every one of these "possible effects" may impact future dive careers. (I-424, I-683, O-057)

Response: The 10 possible impacts identified in the comment were:

- Auditory – When testing at levels of 160-dB SPL at 250 Hz for 100 seconds there was no observable Temporary Threshold Shift (TTS); thus, there would be no permanent threshold shift (PTS) at these intensities as well. There are also data showing no TTS at 125 Hz at 145 dB SPL for a 4-minute (over twice as long) ensonification.
- Vibro-tactile – This response was investigated and an article was published in the Journal of the Acoustical Society of America (JASA) showing that levels well above 180-dB SPL would be required to have any impact on the vibro-tactile system.
- Contractile forces of muscles – This was examined in the context of tissue damage to the cardiovascular system, and it was estimated that the sound intensity would have to be greater than 180-dB SPL for damage to occur.
- Irregular heartbeat – There has been no observation in any dive study of irregular heartbeat. The only finding has been the slowing of heart rate, which is attributed to an orienting response. The diver hears the sound and starts paying attention. The decrease in heart rate is no different that what would be expected if the diver were to orient on a particularly beautiful fish.
- Lung-gas interface – This was studied and the results are provided in TR 3.
- Rectified diffusion – This was considered by Crum and Mao (1996), and it was concluded that the sound level would have to be greater than 190-dB SPL to be an issue.
- Central nervous system/vestibular – Both of these areas were investigated, and the data are presented in TR 3.
- Cavitation – The intensity for cavitation is above 190-dB SPL at these frequencies and thus not an issue for the guidance.
- Hyperthermia – There is no evidence to support hyperthermia; and based on tissue stress analysis, the intensity required to start activating tissue would have to be above 180-dB SPL.
- Tissue shearing due to radiation pressure – This was studied, and the data are presented in TR 3, Table 3.

In summary, any exposures below 160-dB SPL would not be expected to cause physiological damage to a diver. Thus, sound intensities below this level should have no long-term impact on a diving career, and the 145-dB RL mitigation provides additional assurance that no diver would be harmed.

Comment 4-9.17: Dissemination of LF sound symptomatic information and a complaint hot-line number to major dive boat operators and hospital emergency rooms should be provided. (I-683)

Response: The Navy will present a plan for setting up a reporting network via the Divers Alert Network (DAN). In addition, the LTM Program (Subchapter 2.4.2.5 [Incident Monitoring]) includes recreational and commercial diver incident monitoring (i.e., the Navy would coordinate with the principal clearinghouses for information on diver-related incidents).

Comment 4-9.18: There are no data on the impact of SURTASS LFA sonar on snorkelers. (I-907, O-057)

Response: Snorkeling and diving typically occur in the same areas. When the snorkeling is done on the surface, it becomes swimming and this is covered in Subchapter 4.3.2.1 (Alternative 1). Based on the application of underwater acoustic theory and detailed measurements to depths not greater than 2 m (6.5 ft), there would be substantial sound transmission losses occurring in the top layer of water where most swimmers and snorkelers are found. Sound fields in this layer of water would be about 20 dB lower than the sound fields in adjacent deeper water. This is due to the pressure-release effect near the water's surface.

If the snorkeling occurs at greater depths, the diving guidance would apply and the 145-dB SPL limit would be used. Dive sites will not be subjected to SPLs greater than 145 dB. This should protect the snorkelers as well as the divers.

Comment 4-9.19: The Navy has ignored evidence: swimmer/diver complaints and potential injury follow-up studies related to Phase III of the LFS SRP. (I-424, I-517, I-683, I-766, I-769, I-892, I-915, I-1020, O-004, O-027, O-038, O-040, O-051, O-055, O-057, S-003)

Response: See Responses to Comments 1-3.9, 4-5.26 and 4-9.3.

Comment 4-9.20: Discuss the complaint of a SCUBA diver concerning the SURTASS LFA sonar transmissions beginning on August 25, 1994. (I-424, O-027, O-051, O-055)

Response: Based on the evidence produced by the diver, his complaint involved sound in the 30-43 Hz frequency range. He stated that he heard and recorded LF sounds (on an underwater video recorder) on nine separate dates (from August 1994 through November 1995) in the vicinity of Point Lobos State Park (south of Carmel, CA). He further stated that analysis of the tapes showed smooth, coherent energy at 38 Hz. The diver could have heard sounds from the SURTASS LFA sonar because it was operating in the area in August 1994. However, his recorded evidence is inconsistent with any sounds that the SURTASS LFA sonar could produce. The lowest source transmission frequency of SURTASS LFA sonar during this period was 160 Hz. In addition, Navy scientists who evaluated his recording determined that the recorded 38-Hz strumming was due to the electromechanical coupling of his hydrophone.

Comment 4-9.21: Direct measurements (of SPL) are needed at each dive site. Modeling is required for each dive site to determine sound propagation characteristics. (O-027)

Response: It is not necessary nor feasible for the Navy to conduct direct SPL measurements at each known dive site. The Navy will monitor the environmental conditions (i.e., sound speed profile, water temperature versus depth, etc.) on a continuing basis during all SURTASS LFA sonar operations as per the SPL monitoring requirements of the OEIS/EIS. These data will be used to estimate SPLs prior to and during operations in order to provide the information necessary to modify operations, including the delay or suspension of transmissions, so as not to exceed the 145-dB sound field criterion.

Sound field limits would be estimated using near real-time environmental data and underwater acoustic performance prediction models. These models are an integral part of the SURTASS LFA sonar processing system. The acoustic models would determine the sound field by predicting the SPLs, or received levels, at various distances from the SURTASS LFA sonar source location. Acoustic model updates would be made at least every 12 hours, or more frequently, if meteorological or oceanographic conditions change.

Comment 4-9.22: What about "blue water" diver safety? How far would the SURTASS LFA sonar source have to be from these mid-ocean dive sites for 145 dB? (O-027)

Response: In accordance with the mitigation in the OEIS/EIS, the SURTASS LFA sonar sound field would be less than 145 dB within any known commercial or recreational dive sites, including "blue water" sites. The Navy would contact commercial dive organizations to determine the locations of “blue water” diving sites. For recreational “blue water” dive sites the Navy would notify DAN and other diving organizations concerning SURTASS LFA sonar operations on a case-by-case basis. In addition, when the Navy files a Notice to Mariners for major naval exercises, it would include the notification of any SURTASS LFA sonar participation. Moreover, virtually all research-based blue-water diving involves ships of the University National Oceanographic Laboratory System (UNOLS) fleet, which are relatively easy to monitor.

The distance from the transmit array to the 145-dB sound field depends on oceanographic conditions. Sound field limits would be estimated using near real-time environmental data and underwater acoustic performance prediction models prior to and during all SURTASS LFA sonar operations. SURTASS LFA sonar transmissions would be delayed or suspended on confirmation of a diver in the water within the 145-dB sound field.

Comment 4-9.23: How can the Navy say the effects of LF sound is gender-neutral if they haven't tested the effect on a pregnant female? The commentor also stated that he is not advocating that this be done. (I-424)

Response: The Navy concurs that this should not be done. The protocols for such testing (e.g., calibration controls) fall under the framework of unavailable information (i.e., information that has not been obtained because the means of obtaining meaningful, viable data, are unknown at this time) (see Subchapter 1.4.4 [NEPA Disclosure]).

Comment 4-9.24: Why wasn't testing done on humans in open water? (I-681)

Response: Given the rigorous safety standards for testing with humans (e.g., Committee for the Protection of Human Subjects), it was not feasible to conduct this testing in open water.

Comment 4-9.25: During the LFS SRP testing off Hawaii, the Navy claimed that all major dive operations and boat captains had been notified and given a contact name and number to report any negative human effects. Captains on Kona and others stated that they had not been contacted. (I-683)

Response: On 29 January 1998, notices were sent to 15 dive shops on Hawaii with a request that they post the notice in their places of business. The point of contact and three telephone numbers were listed in the Notice. A copy of the Notice is provided in Appendix C. In addition, notices were sent to the Professional Association of Dive Instructors (PADI), National Association of Underwater Instructors (NAUI), and the Divers Alert Network (DAN).

Comment 4-9.26: Discuss the Navy diver who was briefly exposed to 160 dB and immediately experienced symptoms of dizziness and drowsiness serious enough to require hospitalization, followed later by memory loss and seizures. Two years following the incident he was still using anti-depressants and anti-seizure medication. (I-892, O-057)

Response: See Response to Comment 4-6.36.

ISSUE 4-10: POTENTIAL CUMULATIVE IMPACTS

Comment 4-10.1: The discussion of cumulative impacts is disappointingly small. What about other anthropogenic noise as related to the potential for cumulative effects? (G-001, I-501, I-517, I-764, NN001, O-020, O-026, O-037, O-043, O-047, O-050, O-051, S-003)

Response: The SURTASS LFA sonar contribution to the total ocean noise levels is negligible. Additional information has been added to Subchapter 4.4 (Potential Cumulative Impacts).

Comment 4-10.2: Have increasing ambient noise levels caused whales to tolerate LF noise, even to damaging levels? (O-039, O-051)

Response: It is assumed that marine animals have evolved to adapt to current oceanic ambient noise levels. Within the existing marine environment, the potential for accumulation of noise in the ocean from the intermittent operation of SURTASS LFA sonars is considered negligible (Subchapter 4.4). Thus, given that such a negligible increase in ambient noise would not approach TTS levels, there would be no inference that whales would tolerate annoying LF noise to a level where they could possibly incur hearing damage.

Comment 4-10.3: What about other LF sources (ATOC, seismic, NATO systems, etc.)? (G-001, O-051, S-003)

Response: Subchapter 3.1.1 (Ambient Noise) discusses other LF sources of ocean noise.

Comment 4-10.4: Are other nations developing or procuring SURTASS LFA sonar technology? (O-038, O-043, O-054, S-003)

Response: No other nations are developing or procuring the U.S. SURTASS LFA sonar or any other system that operates below 450 Hz. However, the Navy is aware of testing of LF active sonar systems above 500 Hz by the Supreme Allied Command Atlantic Undersea Research Centre (SACLANTCEN) and some NATO nations.

Comment 4-10.5: Would SURTASS LFA sonar countermeasures put additional LF signals into water? (S-003)

Response: There is no existing countermeasure that produces LF signals.

Comment 4-10.6: What is the relationship of SURTASS LFA sonar to SOFAR/RAFOS? (I-424)

Response: RAFOS is SOund Fixing And Ranging (SOFAR) spelled backwards. This ocean research data collection system is operated by the Naval Postgraduate School and is not related in any way with SURTASS LFA sonar.

Comment 4-10.7: What is the life span of a SURTASS LFA sonar system? (NN001)

Response: Approximately 20 years.

Comment 4-10.8: What is the rationale (scientific basis) for the conclusion of no significant cumulative effects? What are the assumptions for which the conclusions are based? (G-001, O-027, S-003)

Response: Subchapter 4.4 (Potential Cumulative Impacts) addresses these issues.

Comment 4-10.9: Define "significant cumulative effects." (O-027)

Response: This term is not used in Subchapter 4.4 (Potential Cumulative Impacts) of the Final OEIS/EIS.

Comment 4-10.10: Under potential cumulative impacts, why are fish and sea turtles lumped together for injury at 180 dB? (NN001, O-027)

Response: Based on analysis of the LFS SRP data taken on the most LF-sensitive marine mammals (baleen whales), the risk analyses in Subchapter 4.2.5 (Risk Continuum Analysis) concludes that for purposes of the SURTASS LFA sonar analyses presented in this OEIS/EIS, all marine mammals (including baleen whales) exposed to RLs $\geq$180 dB are evaluated as if they are injured. Given that this group is the most LF-sensitive, in keeping with a prudent approach, the Navy has adopted this criterion also for fish and sea turtles, which are not as LF-sensitive.

Comment 4-10.11: In the determination of cumulative effects, was there an assessment of other incidental "takes" such as bi-catch, climate change, El Niño, etc.? (G-001)

Response: While there is a global issue of cumulative impacts on all marine life, underwater sound is the principal issue with the proposed action.

Comment 4-10.12: The source vessel moving should not be used as a mitigation factor. What is the basis for fewer animals being impacted by a moving source? (O-020, O-027, O-047)

Response: A stationary source, if permanently installed, increases the chances for repeated exposures, and has higher potential for causing cumulative impacts than a moving source such as the SURTASS LFA sonar vessel. More animals could be exposed to sound generated from a moving source, but overall fewer animals are at risk because of the lower cumulative exposures per animal.

Comment 4-10.13: Will the Navy share ship-quieting technology with the commercial shipping industry? (I-003, I-501, O-027, O-038)

Response: Ship-quieting technologies are commercially available.

Comment 4-10.14: Are there any potential effects of LFA noise where background levels may already be challenging resident or visiting animals? The issue of sound in the oceans is an ecosystem level problem, and there may be areas where cumulative and chronic sound may be causing impacts at a scale we are not measuring. (NN001)

Response: Within the existing marine environment, any potential for accumulation of noise in the ocean from the intermittent operation of SURTASS LFA sonars would be negligible. See Subchapter 4.4 (Potential Cumulative Impacts) for additional discussion on this topic.

Comment 4-10.15: The discussion of the possible effects of the SURTASS LFA sonar transmissions relative to PBR levels should be placed in the section concerning possible cumulative effects. (G-001)

Response: Because there is no scientific or engineering basis for immediate mortality upon exposure to SURTASS LFA sonar signals (100-500 Hz at 215 dB), and all prior research results support this conclusion, the discussion of potential biological removal (PBR) is not in the Final OEIS/EIS.

Comment 4-10.16: How much heat would be generated in surrounding seawater at the proposed level of 235 dB? How would this change in temperature affect the ocean environment? (I-910)

Response: The amount of heat generated in the seawater from operation of SURTASS LFA sonar would be minimal, and this would be dissipated quickly because the water mass encompassing the source projectors is continually being replaced as they move through the water. Moreover, it is transmitting no more than 20 percent of the time.

CHAPTER 5: MITIGATION MEASURES

ISSUE 5-1: MITIGATION MEASURES: GEOGRAPHIC RESTRICTIONS

Comment 5-1.1: For the two offshore biologically important areas in the Draft OEIS/EIS, was any modeling done? Why were they not chosen as modeling sites? (O-039)

Response: The acoustic modeling sites were selected to represent reasonable scenarios for each of the three ocean acoustic regimes where SURTASS LFA sonar would be employed. No offshore biologically important areas were chosen because operations in these areas are limited as discussed in Subchapter 2.3.2.1 (Geographic Restrictions) of the Final OEIS/EIS. Site 28, Onslow Bay, was the closest site to an offshore biologically important area (the 200-m [660-ft] isobath off the East Coast). The selection factors for modeling sites are given in Subchapter 4.2.1 (Acoustic Modeling Sites) of the Final OEIS/EIS.

Comment 5-1.2: What criteria will be used to determine offshore biologically important areas? Independent researchers should be used to identify additional biologically important areas. Define biologically important activities? Do they include mating, communications and navigation? Consult with NMFS to determine additional monitoring or research needed to identify and ensure that marine mammals are not affected in other biologically important areas. New biologically important areas should be able to be designated by NMFS/Navy after the Final OEIS/EIS. Insufficient information is available to define many such offshore biologically important areas and biologically important seasons; areas exist of which we are unaware. Why were time restrictions (seasonal exclusions) imposed on the offshore biologically important areas (OBIAs)? (G-001, I-764, I-501, I-682, NN001, O-016, O-026, O-028, O-039, O-042, O-047, O-051, O-053, O-054, S-003)

Response: Offshore biologically important areas (OBIAs) are defined in Subchapter 2.3.2.1 (Geographic Restrictions) of the Final OEIS/EIS as those areas of the world's oceans outside of 22 km (12 nm) of a coastline where marine animals of concern (those listed under the Endangered Species Act and/or marine mammals) congregate in high densities to carry out biologically important (significant) activities. Chapter 5 (Mitigation Measures) and Table 5-1 (Summary of Mitigation) of the OEIS/EIS state that geographic restrictions include offshore biologically important areas during biologically important seasons. Geographic restrictions apply to OBIAs 1 and 2 year-round and to OBIA 3 from October to March. Biologically important activities are those essential to the continued existence of a species, such as migration, breeding/calving, or feeding.

The list of OBIAs in Subchapter 2.3.2.1 (Geographic Restrictions) may be expanded by the Navy in coordination with NMFS. Additional OBIAs may also be proposed and reviewed during the Long Term Monitoring Program (Subchapter 2.4). A process will be instituted through NMFS where an organization/individual can nominate extremely sensitive areas, which are outside of 22 km (12 nm) of the coast, as candidate OBIAs. The nominating organization/ individual will be responsible for providing sufficient information to NMFS on the candidate OBIA to allow for a decision by NMFS and the Navy.

Time restrictions (seasonal exclusions) are included in the definition of OBIAs because, if there are specific seasons that affected marine animal(s) are not present in high densities within the OBIA, standard geographic restrictions and monitoring mitigation would apply for that area. For example, this would occur for OBIA #3 (Antarctic Convergence Zone) from April through September (see Subchapter 2.3.2.1 and Table 2-3).

Comment 5-1.3: How will the Navy evaluate transmissions of SURTASS LFA sonar signals to assure that received levels in OBIAs and dive sites do not exceed 180 dB and 145 dB, respectively? (I-681, I-770, O-027, O-051)

Response: As discussed in the Subchapter 2.3.2.1 (Geographic Restrictions) and Subchapter 5.1.3 (Sound Field Determination) of the Draft OEIS/EIS, SPLs will be calculated utilizing onboard acoustic models and near real-time environmental data before and during all active transmissions. Acoustic models will be updated every 12 hours, or more frequently, when meteorological or oceanographic conditions change.

Comment 5-1.4: Why the 22-km (12-nm) restriction? What is the scientific basis for this limit? Why not the 2000-m (6,600-ft) isobath? Or, 370-km (200-nm) limit? Or, 80 km (43 nm) off the U.S. West coast? Should there be a 93-km (50-nm) exclusion zone with some buffer? The 200-m (660-ft) isobath would protect 27 additional species. Provide a more detailed description of 22-km (12-nm) restriction; i.e., area around islands and island systems? (I-681, I-764, O-016, O-020, O-027, O-028, O-042, O-054)

Response: As discussed in Chapter 1 (Purpose and Need) of the Final OEIS/EIS, the Navy needs SURTASS LFA sonar to improve its capability to detect quieter and harder-to-find foreign submarines at long range. Restricting operations to outside of 80 to 370 km (43 to 200 nm) of the coast would severely limit the effectiveness of the sonar to detect submarines at long enough ranges to allow proper responses. The 22-km (12-nm) restriction applies to islands and island systems.

Many of the concentrations of marine animals occur within 22 km (12 nm) of a coastline. Because of animal concentration and migration routes, this limit was extended to the 200-m (660-ft) isobath for the East Coast of the United States (from 28°N to 50°N west of 40°W) to protect more species. This area has been designated as an OBIA as shown in Table 2-3 (Offshore Biologically Important Areas). The results of the modeling demonstrated that the number of potential takes for the 31 sites modeled with mitigation would not be significant. Many of these sites were within 370 km (200 nm) of land and/or the 2000-m (6,600-ft) isobath.

Comment 5-1.5: The standard should be less than 150 dB within 22 km (12 nm) of shore or offshore biologically important areas. (S-002)

Response: The proposed criterion was intended to ensure that no marine animals could be injured within 22 km (12 nm) of shore. The motivation for AIM and risk continuum analyses was to avoid specifying artificial thresholds for allowable risk at lower values. Selection of 150 dB (or any other value) would be arbitrary and unsupportable at present. In practice, the geographic restriction to avoid exposing divers to levels in excess of 145 dB would provide comparable protection for all near-shore marine animals.

Comment 5-1.6: The 200-m (660-ft) isobath does not provide protection for the northern bottlenose, northern right, sei, and humpback whales because they do not only inhabit this area. (I-501, I-682, O-020, O-021, O-053)

Response: The goal of the 200-m (660-ft) isobath restriction is to limit the RLs of LF sound in certain areas of high marine mammal and listed species concentrations. This restriction would enhance protection to concentrations of the above species and significantly reduce the number of these and other animals potentially affected.

Comment 5-1.7: Many National Marine Sanctuaries (NMSs) are outside of the 22-km (12-nm) limit. 180-dB SPL should be kept out of all NMSs. The Navy should outline its plans to consult, as necessary, with the Office of Ocean and Coastal Resources Management for SURTASS LFA sonar operations in or near NMSs. Notification should be made to specific NMSs. (I-424, NN001, O-051)

Response: The guidelines for prohibited activities within NMSs vary by sanctuary. These can be found in 15 CFR 922.60 to 922.187 (Subparts F through Q). Generally these include (taken from Subpart P—Florida Keys NMS for example purposes):

- Mineral and hydrocarbon exploration, development and production;
- Removal of, injury to, or possession of coral or live rock;
- Alteration of, or construction on, the seabed;
- Discharge or deposit of materials or other matter;
- Operation of vessels (in a manner potentially injurious to the sanctuary);
- Conduct of diving/snorkeling without a flag;
- Release of exotic species;

- Damage or removal of markers;
- Movement of, removal of, injury to, or possession of Sanctuary historical resources;
- Take or possession of protected wildlife except as authorized by the MMPA (16 U.S.C 1361 et seq.), the ESA (16 U.S.C. 1531 et seq.), and the MBTA (16 U.S.C. 703 et seq.);
- Possession or use of explosives or electrical charges;
- Harvest or possession of marine life; and
- Interference with law enforcement.

Of these, the only activity that potentially could apply to the proposed action would be the taking of protected wildlife. On 29 November 2000, the Navy submitted at letter to the National Marine Sanctuaries Program of NOAA concerning "Consultation under the National Marine Sanctuaries Act for the Operation of the SURTASS LFA Sonar." In this letter the Navy determined that the proposed operation of SURTASS LFA sonar in accordance with Alternative 1 will not destroy, cause the lose of, or injury any sanctuary resources, and therefore no consultation with the Office of Ocean and Coastal Resources is required. A copy of this letter is provided in Appendix A.

However, as discussed in Subchapter 6.6 (Endangered Species Act), the Navy has initiated formal consultation under the ESA with NMFS. In addition, as discussed in Subchapter 6.7 (Marine Mammal Protection Act), the Navy has submitted a request to NMFS for a letter of authorization for the incidental taking of marine mammals under the MMPA. Operation of the SURTASS LFA sonar will not result in the taking of any migratory birds, therefore the Migratory Bird Treaty Act does not apply.

Comment 5-1.8: NMSs are common recreational dive sites, such as the Channel Islands NMS, Flower Garden Bank NMS, and Florida Keys NMS. Could LF sound at the Monitor NMS potentially affect both divers and the vessel (wreck)? (I-681, NN001)

Response: The Navy recognizes that NMSs are known dive sites. The geographic restrictions for SURTASS LFA sonar operations for recreational and commercial dive sites apply. These restrictions are that SURTASS LFA sonar transmitted sound fields would not exceed 145 dB at known recreational and commercial dive sites.

The Monitor NMS is located southeast of Cape Hatteras, NC, in 69 m (225 ft) of water. This is inside the offshore biologically important area delineated by the 200-m (660-ft) isobath of the North American East Coast (See Subchapter 2.3.2.1 [Geographic Restrictions]).

Comment 5-1.9: How will the Navy determine blue-water dive sites? How will the Navy notify the public concerning exercises? (I-681, I-683, O-027)

Response: "Blue water" diver safety is discussed in the Response to Comment 4-9.22. The Navy will contact commercial dive organizations to determine the locations of "blue water" diving sites prior to operations. For recreational dive sites the Navy will notify DAN, and other diving organizations, concerning operations on a case-by-case basis. In addition, when the Navy files a Notice to Mariners for major naval exercises, it would include notification of any SURTASS LFA sonar participation.

Comment 5-1.10: Will the Navy coordinate with dive organizations? (I-681, O-027, S-005)

Response: For recreational dive sites the Navy will notify DAN, and other diving organizations, concerning operations on a case-by-case basis. In addition, when the Navy files a Notice to Mariners for major naval exercises it would include notification of SURTASS LFA sonar participation.

Comment 5-1.11: Why were only two OBIAs designated? Recommended additions to offshore biologically important areas:

- Extend southern boundary of U.S. East Coast biologically important area (200-m isobath) from 30ºN to 28ºN.
- Costa Rica dome (9ºN, 89ºW).
- For sea turtles in eastern Pacific: (1) Central American coast out to 700 km, and (2) Equatorial Convergence around 2-5ºN out to 125ºW.
- Indian Ocean whale sanctuary
- Southern Ocean whale sanctuary
- Eastern Tropical Pacific
- Hawaiian Islands and Penguin Bank
- Channel Islands and Santa Barbara Channel
- Gulf of Alaska
- Marshall Islands
- Great Barrier Reef
- Gulf of Carpentaria (Australia)
- Yaeyama Archipelago (Japan)
- Korea Strait
- Bohai Bay (China)
- Fernando de Noronha Archipelago (Brazil)
- Atol das Rocas (Brazil)
- Milieuzone Noordzee (Netherlands)
- Ligurian Sea Cetacean Sanctuary
- Gulf of Gabes (Tunisa)
- Gulf of Sirte (Libya)
- Aegean Sea (Greece, Turkey)
- Gulf of Maine

- Bay of Fundy
- Cape Cod Bay
- Cape Mendocino
- Frederick Sound
- Great South Channel
- Gulf of Mexico
- Gulf of California
- Monterey Bay
- Prince William Sound
- Puget Sound
- St. Simon Island to Melbourne Beach
- San Diego Bay
- San Francisco Bay
- Farallon Islands

(I-764, I-769, I-917, I-918, O-016, O-020, O-028, O-051, O-054, S-002, S-003, S-006)

Response: For the Draft OEIS/EIS only two OBIAs outside of the 22 km (12 nm) geographic restriction were considered to meet the criteria (where marine mammals or other listed species congregate in high densities to carry out biologically important activities [i.e., those behaviors essential to the continued existence of these species—migration, breeding and calving, and feeding]). Based on the evaluation of comments received on the Draft OEIS/EIS, the following modifications and addition have been made to the OBIAs in Subchapter 2.3.2.1 (Geographic Restrictions) of the Final OEIS/EIS: (1) the extension of the southern boundary of the U.S. East Coast OBIA from 30°N to 28°N, (2) the expansion of the Antarctic Convergence, and (3) the addition of the Costa Rica dome. Additional information demonstrating that the other areas warrant establishment was not documented in the comments. Large ocean areas (e.g., Indian Ocean) cannot be considered an OBIA.

The criteria for nomination of additional OBIAs are discussed in Response to Comment 5-1.2.

Comment 5-1.12: Additional areas to consider as biologically important:

- Humpback whale migration routes;
- Tribal subsistence areas;
- Offshore areas used by pelagic animals, such as seamounts; and
- Whale watching areas.

(G-001, NN001)

Response: Humpback whale migration routes close to coastlines are covered by geographic restrictions. Pelagic migration routes are covered adequately by the monitoring mitigation discussed in Subchapter 2.3.2.2 (Monitoring to Prevent Injury) and Subchapter 5.2 (Monitoring to Prevent Injury to Marine Mammals and Sea Turtles) of the Final OEIS/EIS.

Tribal subsistence areas are adequately covered by geographic restrictions in Subchapter 2.3.2.1 (Geographic Restrictions) and Subchapter 5.1.3 (Sound Field Determination) of the OEIS/EIS and monitoring mitigation (above).

The Costa Rica dome has been added to the list of OBIAs in Table 2-3 (Offshore Biologically Important Areas).

Whale watching occurs mostly within the areas covered by the geographic restrictions (above); and, therefore, would not be affected.

Comment 5-1.13: The Draft OEIS/EIS portrays the vast majority of the world oceans as non-sensitive; nevertheless within those areas are regions of greater or lesser biological productivity, sensitivity, and at least seasonally high concentrations of marine mammals. This type of information should be provided and areas of lesser sensitivity considered higher priority for LFA use. (S-003)

Response: The OEIS/EIS recognizes that there are areas of greater or lesser biological productivity, etc. and has set up specific geographic restrictions for these reasons. The operation of SURTASS LFA sonar would be geographically restricted within 22 km (12 nm) of any coastline and in offshore biologically important areas as discussed in Subchapter 2.3.2.1 (Geographic Restrictions). The procedure for the nomination of additional offshore biologically important areas is provided in the Response to Comment 5-1.2.

These mitigation measures will reduce the potential impacts to marine mammals from SURTASS LFA sonar transmissions based on the ability of the Navy to avoid affecting animals by operating in areas of lower animal densities (geographic restrictions) and detecting animals that are close enough to the transmit array to potentially be affected (monitoring to prevent injury). Therefore, areas of lesser sensitivity have been considered as priority for the proposed employment of the SURTASS LFA sonar.

Comment 5-1.14: Will the Navy deny that the 180-dB criterion decision was made with the caveat that the LFA system was to comply with NEPA with minimal operational constraints? Will the Navy deny that the 180-dB RL criterion came from seeking the highest possible value of RL and a mission-oriented recognition that 1 km was the borderline for potential mitigation? The mitigation zone around the LFA ship had to be small enough to permit some potential for detecting and responding to some of the vulnerable marine life. To rely on mitigation for predicted ranges over 1 km would be extremely difficult (i.e., the 180-dB criterion is based on convenience). (O-039, O-043)

Response: For the purposes of this document 180-dB received level is considered the point above which some potential serious problems in the hearing capacity of marine mammals could start to occur. The 180-dB criterion was developed, at least in part, at three scientific and technical workshops and meetings between June 1997 and September 1998. The 180-dB RL criterion for SURTASS LFA sonar operations was based on this criterion, and the mitigation protocols were developed accordingly.

For additional information, see Responses to Comments 4-4.9, 5-1.5, and 5-2.1 and Subchapter 1.4.2.1 (Estimating the Threshold of Potential Injury to Marine Animals).

ISSUE 5-2: MITIGATION MEASURES: MONITORING TO PREVENT INJURY TO MARINE MAMMALS AND SEA TURTLES

Comment 5-2.1: Considering the vast lack of knowledge on marine mammal behavior, what scientific basis does the Navy use to assert that impacts can be mitigated? Physical harm (injury) is the only basis for the mitigation threshold (criterion) of 180 dB. Mitigation strategy ignores behavioral impacts and impacts outside of the 180 dB mitigation zone. (O-027, O-038, O-039, O-047, O-051)

Response: Mitigation to reduce the potential impacts to marine mammals from SURTASS LFA sonar transmissions is based on the ability of the Navy to avoid affecting animals by operating in areas of lower animal densities (geographic restrictions) and detecting animals that are close enough to the transmit array to potentially be affected (monitoring to prevent injury). This mitigation strategy also will inherently reduce potential incidental takes, including behavioral impacts, for marine mammals and listed species. These potential takes have been calculated in Subchapter 4.2 (Potential Impacts on Marine Mammals) of the Final OEIS/EIS and have been determined to be minimal.

The specific nature of what received level (RL) of sound requires mitigation has been an evolving topic of evaluation within the regulatory community. Coincident with the timeframe of the LFS SRP test sequence there have been several national-scale workshops with the express purpose of addressing acoustic mitigation requirements. For the purposes of this document 180-dB received level is considered the point above which some potential serious problems in the hearing capacity of marine mammals could start to occur. Several scientific and technical workshops and meetings at which the 180-dB criterion were developed are:

- "Mitigation Guidelines for High-Energy Seismic Surveys off Southern California," HESS Workshop Report of 12 June 1998, A. Knastner Ed., Mediation Institute, Pepperdine University, CA (Knastner, 1998);

- NMFS Acoustic Criteria Workshop, 9-11 September 1998, Dr. Roger Gentry and Dr. Jeanette Thomas Co-Chairs; and

- ONR Workshop on the Effects of Anthropogenic Noise in the Marine Environment, Dr. R. Gisiner Chair, 10-12 February 1998 (Gisiner, 1998).

Factoring this new guideline into a practical mitigation criterion suggests that any sound-producing system power down when animals are detected within or clearly begin to approach this boundary. The limits used to determine the size of the LFA mitigation zone (180-dB sound field) are based on this methodology.

More details on the rationale behind the 180-dB criterion are presented in Subchapter 1.4 (Analytical Context) of the Final OEIS/EIS.

Comment 5-2.2: Will the Navy tolerate frequent shutdowns due to marine animals within a 1-km (0.54-nm) radius? (O-027)

Response: Yes. The Navy is committed to the mitigation measures contained in this Final OEIS/EIS.

Comment 5-2.3: Use of additional surface craft and aircraft for monitoring should be considered. (NN001, O-043)

Response: Monitoring mitigation is designed to ensure that marine mammals and sea turtles are not within the LFA mitigation zone during SURTASS LFA sonar transmissions. Because this zone is usually less than 1 km (0.54 nm), the use of aircraft and additional surface vessels would not measurably increase the efficiency of the mitigation monitoring, and would not be cost-effective.

Comment 5-2.4: Justify 70-99 percent (80 percent) detection effectiveness of mitigation. Justify 70 percent detection effectiveness (for the active acoustic monitoring mitigation–HF/M3 sonar). If the Navy is confident in monitoring mitigation, then why are geographic restrictions recommended? (I-425, I-501, I-770, I-956, O-016, O-027, O-028, O-039, O-043, O-047, O-051, O-054, NN001, S-003)

Response: The mitigation effectiveness calculations have been revised in the Final OEIS/EIS.

The HF/M3 sonar is designed to ensure that marine mammals and sea turtles are not within the LFA mitigation zone during SURTASS LFA sonar transmissions. It provides 24-hour detection for marine animals, even during poor visibility conditions. The system was developed from commercial off-the-shelf components for detecting and locating animals ranging in size from large whales to sea turtles, with initial detection from 2 to 3 km (1.1 to 1.6 nm) (Ellison and Stein, 1999).

The conservative nature and accuracy of the estimate of 50 percent effectiveness for active acoustic monitoring mitigation and overall mitigation effectiveness of 66 percent is discussed in Subchapter 4.2.7.1 (Effectiveness of Monitoring Mitigation). In addition, the conservativeness of the 50 percent value is supported by the results of recent testing and analysis that have determined that the probability of detection for small cetaceans at 1 km (0.54 nm) is from 73 to 95 percent and for larger cetaceans is over 95 percent at and beyond 1 km (0.54 nm). Detection rates for sea turtles should be similar to those of small cetaceans.

The geographic restrictions provide broad protection for areas where marine animals of concern congregate in high densities and where they engage in biologically important activities over particular periods of time. The monitoring mitigation provides additional protection, beyond the geographic restrictions, for the specific areas within close range of SURTASS LFA sonar operations.

Comment 5-2.5: What is the effectiveness of visual monitoring? Marine mammals cannot be seen at 5.6 km (3 nm), maybe at 500 m (546 yd). What about bad weather? (I-425, I-501, I-682, NN001, O-020, O-028, O-039, O-043, O-051, O-053, O-054, S-003)

Response: Visual monitoring is only effective during daylight hours and in moderate sea states and good weather. Subchapter 4.2.7.1 (Effectiveness of Monitoring Mitigation) of the Final OEIS/EIS provides a revised calculation for the effectiveness of mitigation monitoring, and includes visual monitoring.

The statement concerning the ability to visually detect marine mammals under normal visibility at 5.6 km (3 nm) was incorrectly quoted and has been removed from Subchapter 5.2.1 (Visual Monitoring) of the Final OEIS/EIS.

Comment 5-2.6: What new (monitoring) technologies are being explored (IR, etc.)? (O-042)

Response: Because visual and passive monitoring have obvious limitations, a different technology was explored and developed for a 24-hour, all-weather method for monitoring marine mammals and sea turtles. This involved the use of a high frequency, fish-finder type sonar, as discussed in Subchapter 2.3.2.2 (Monitoring to Prevent Injury) of the Final OEIS/EIS. Because active monitoring uses existing technology, other, less proven technologies, such as infrared (IR), were not explored because of their higher technical risk and potential for lower effectiveness. See Response to Comment 5.2-11.

Comment 5-2.7: Provide justification that effective strip width will be greater because the SURTASS LFA sonar vessel moves slower than survey vessels? (I-501, O-020, O-039, O-043)

Response: In cetacean line-transect surveys, the range of visual sighting effectiveness (distance from the ship's track, called effective strip width) varies with the animal size, reliability of conspicuous behaviors (blows), and pattern of surfacing behavior. The SURTASS LFA sonar vessel's speed during operations is 5.6 km/hr (3 kts), which is about one-third the speed of most cetacean survey vessels. The effective strip width should be greater, and the percentage of animals seen should be greater than that of the typical surveys because these are a function of the amount of observation time available per unit area, which is greater at slower speeds. More information is provided in Subchapter 4.2.7.1 (Effectiveness of Monitoring Mitigation) in the Final OEIS/EIS.

Comment 5-2.8: What is the effectiveness of passive acoustic monitoring? Cite literature as to amount and frequency of vocalization. (I-425, I-501, I-682, NN001, O-028, O-053, O-054, S-003)

Response: Passive acoustic monitoring is effective only when marine mammals are generating sound. Subchapter 4.2.7.1 (Effectiveness of Monitoring Mitigation) of the Final OEIS/EIS provides a revised calculation for the effectiveness of mitigation monitoring, and includes passive acoustic monitoring.

Comment 5-2.9: Will Navy technicians passively detect all whale calls? What is the frequency range of passive monitoring? Can passive acoustics determine range? (I-501, NN001, O-027, S-003)

Response: The passive acoustic monitoring system should be able to detect cetacean sounds that are between 10 - 500 Hz. This includes calls and songs from mysticetes and a small percentage of sounds from odontocetes. Passive acoustic measurements can determine the range to animals that are within a few kilometers to the side of the vessel. However, for more distant animals or animals directly in front or astern of the vessel, only the bearing to the animal can be determined. The HF/M3 sonar system is expected to detect and provide ranges of vocalizing mysticetes up to approximately 2 km (1.1 nm) from the SURTASS LFA sonar source.

Comment 5-2.10: What was the passive acoustic detection efficiency using Canary and Popeye systems in the LFS SRP? What was the number of animals detected? (NN001)

Response: Clark and Fristrup (1997) showed that passive acoustic detections of blue and fin whales were 4-6 times more likely than visual detections. Information concerning the utilization of the Advanced Canary and Advanced Popeye systems during the LFS SRP is provided in Technical Report 1.

Comment 5-2.11: What operational testing has been done on the HF/M3 sonar? (I-425, O-039, O-043)

Response: The operational testing accomplished on the HF/M3 sonar is listed in Table 2-4 (HF/M3 Sonar Testing).

Comment 5-2.12: For the engineering estimates of effectiveness of 90 to 95 percent for the HF/M3 sonar, what targets were used? (I-501, O-020, O-039)

Response: In order to validate the overall performance of the HF/M3 sonar with its design parameters, it was necessary to utilize reference (or artificial) targets of known geometry and target strength. Four targets were used for the Seneca Lake testing. They were each composed of three orthogonal discs (i.e., they are all at right angles to each other) with diameters of 15.2, 25.4, 45.7, and 81.2 cm (6, 10, 18, and 32 inches), respectively. The target for the Baja testing was a 81.2-cm (32-inch) diameter artificial target with a target strength (TS) of -2.1 dB. During the Baja test, several whales were also successfully tracked (Ellison and Stein, 2000).

In roughly 170 hours of at-sea testing with artificial targets, six whales have coincidentally been spotted on the surface after strong detections were made in the same general vicinity on the HF/M3 system. Approximately 75 other objects have been detected during testing which were believed to be marine mammals. A dedicated experiment designed to verify the system's ability to detect bottlenose dolphins was conducted off the coast of San Diego in August 2000.

Comment 5-2.13: What additional HF/M3 sonar testing will be done before the Final OEIS/EIS? Testing should be accomplished by an independent team. (O-039, O-043)

Response: All planned HF/M3 sonar evaluations, verifications and validations have been completed before the publication of the Final OEIS/EIS. See the Response to Comment 5-2.11. Results (including sonar effectiveness) will be independently reviewed by NMFS as a condition of the Letter of Authorization (LOA) for the incidental taking of marine mammals under the MMPA, with a report to NMFS not later than 120 days prior to the expiration of the first LOA.

Comment 5-2.14: Address the difficulties associated with active monitoring of marine mammals, including tendency for adipose tissue to absorb sound waves. (O-028)

Response: The tendency for adipose tissue of marine mammals to absorb sound waves and the ability to detect smaller species of cetaceans and turtles were considered in the primary HF/M3 sonar design capabilities. HF/M3 system requirements are provided in Ellison and Stein (2000).

Comment 5-2.15: What are the detection rates of smaller species of cetaceans, sea turtles, and listed fish? (I-918, O-028, O-038)

Response: The probability of detection of various marine mammals is presented in Figure 2-5. The probability of detection for small cetaceans at 1 km (0.54 nm) is from 0.73 to 0.95. Detection rates for sea turtles should be similar to those of small cetaceans. There are no listed fish that inhabit the SURTASS LFA sonar operating areas. Moreover, the HF/M3 sonar was not designed to detect fish.

Comment 5-2.16: What is the area of coverage of the HF/M3 sonar both vertically and horizontally? (O-028, O-039, S-003)

Response: The HF/M3 sonar is installed on the SURTASS LFA sonar transmit vertical line array (VLA) just above the first projector at a nominal depth of 86 m (282 ft). The area covered by the HF/M3 sonar is nominally 2 km (1.1 nm) omni-directional (horizontal) from the source array with a vertical beam width of 10 degrees.

Comment 5-2.17: Are there any blind spots? Won't the LFA loudspeakers themselves interfere with the HF/M3 signal and detection? (NN001, O-028, O-039, S-003)

Response: The only blind spots for the HF/M3 sonar would be a small volume directly above and below the VLA. Because the SURTASS LFA sonar vessel is moving, these blind spots are not stationary.

The HF/M3 sonar is affected during LFA transmissions, but is fully effective within five seconds after they end.

Comment 5-2.18: Overlay HF/M3 coverage with SURTASS LFA sonar's 180-dB sound field. (NN001, O-028)

Response: See Figure 2-4 (HF/M3 Sonar Detection and LFA Mitigation Zones) in the Final OEIS/EIS.

Comment 5-2.19: The HF/M3 sonar source level is to be adjusted to ensure that RLs are below levels that could cause injury to marine mammals; what are those levels? Provide evaluation of the possible effects of HF/M3 sonar on odontocetes. (I-512, I-764, I-917, O-042, O-047)

Response: The HF/M3 sonar SL will be adjusted to ensure that RLs at marine mammals will not be $\geq$ 180 dB. The HF/M3 sonar will have a lesser effect on marine animals than most types of similar commercially available sonars because of the ability of the operator to reduce SL when approached by a marine animal. The evaluation of the potential effects of the HF/M3 sonar is discussed in Subchapter 4.2.7.3 in the Final OEIS/EIS.

Comment 5-2.20: The HF/M3 sonar's SL is 220 dB at 1 m. The Draft OEIS/EIS also states that it is 193 dB at 7 m. How was this calculated? (S-003)

Response: The RL at 22.4 m is 193 dB based on spherical spreading (20 log R). Subchapter 4.2.7.3 of the Final OEIS/EIS has been corrected.

Comment 5-2.21: Has the Navy prepared a Draft OEIS/EIS for the HF/M3 sonar? (I-501, I-682, I-917, O-053, O-057)

Response: The HF/M3 sonar is basically a fish-finder type sonar with similar frequency ranges and power output, as shown in Table 10-4 (Acoustic Parameters for Commercial Fish Finder Sonars and the HF/M3 Sonar). These sonar types are commercially available and used worldwide, and are unregulated. The use of the HF/M3 sonar is an integral part of Alternative 1 as described in Subchapter 2.3.2 (Alternative 1 [The Preferred Alternative]). The potential impacts of the HF/M3 sonar are discussed in Subchapter 4.2.7.3 in the OEIS/EIS. Therefore, the environmental documentation requirements for the HF/M3 sonar have been met by this OEIS/EIS.

Table 10-4

Acoustic Parameters for Commercial Fish Finder Sonars and the HF/M3 Sonar

Acoustic Parameter	Commercial Fish Finder Sonars					HF/M3 Sonar
	Simrad ES 60	SI-TEX 210	Furuno Model FCV-582	Garmin GPSMAP 235	Raytheon Model L750	
Source Level (peak main lobe) (dB re 1 µPa at 1 m)	~237	~223	220	220	220	220
Frequency (kHz)	18-200	50-200	50	50	50	30-40
Power (electrical) (rms-Watts)	1,000-4,000	1,000	500	500	500	360
Range (ft/m)	4,200/ 1,300	3,000/914	2,500/762	1,200/366	1,900/579	6,562/2,000

Comment 5-2.22: 30 kHz is not out of the range of the best hearing of most odontocetes. Provide an assessment of the possible effects of the HF/M3 sonar on odontocetes. (G-001, O-027, O-042)

Response: Subchapter 4.2.7.3 (Potential Effects of the HF/M3 Source) of the Final OEIS/EIS has been revised to correct the hearing range of most odontocetes. In Subchapter 4.2.7.3 it was determined that the impact of the HF/M3 sonar to marine mammals would be negligible.

Comment 5-2.23: Will the Navy use the HF/M3 sonar to drive dolphins away from the SURTASS LFA sonar vessel? (O-039)

Response: No.

Comment 5-2.24: Watkins and Schevill (1975) research indicates that in the presence of active sonar, vocalizations may decrease; thus, the HF/M3 sonar may reduce the effectiveness of passive acoustic monitoring. (O-043)

Response: The cited paper discussed a 12.5-kHz pinger that was dissimilar to the HF/M3 sonar. Still, the operational protocols for passive acoustic monitoring and the HF/M3 sonar may be modified if experience indicates that the reduction in passive acoustic detection performance is significant.

Comment 5-2.25: If mitigation is applied to RLs lower than 180 dB, would the OEIS/EIS consider beam forming and focused signal refraction over distance? (O-039)

Response: Monitoring mitigation does not apply to RLs below 180 dB. However, the models utilized to calculate sonar performance do consider both beam forming and refraction over distance in the calculations.

Comment 5-2.26: Cite evidence that HF/M3 sonar "ramp-up" will have the desired effect. Are animals attracted to sonar during ramp-up? (G-001, I-770, I-917, O-027, O-043, O-047)

Response: "Ramp-up" of acoustic sources (such as seismic projectors, etc.) has not been proven to be effective in causing marine animals to move away from a sound source. There are no studies to show that animals are attracted during sonar "ramp-up." Until it is proven ineffective, it is recommended as mitigation. Therefore, the HF/M3 sonar will be "ramped-up" 30 minutes prior to commencement of SURTASS LFA sonar transmissions to determine that the LFA mitigation zone is clear of marine animals. Assessment of the efficacy of mitigation measures is one of the elements of the LTM Program.

Comment 5-2.27: Add ramp-up of the SURTASS LFA sonar to the mitigation. Will ramp-up of the SURTASS LFA sonar diminish its operational effectiveness? (O-039, O-043, O-047)

Response: The ramp-up of SURTASS LFA sonar would diminish operational effectiveness because it could alert potential targets. Regardless, it is not required because the HF/M3 sonar will be "ramped-up" prior to LF transmissions to determine that the LFA mitigation zone is clear of marine animals.

Comment 5-2.28: When will sea turtles be monitored? What is the ability to detect turtles? What is the monitoring effectiveness? How will the Navy assure that sea turtles will not be taken? Can sea turtles be visually detected within 1 km (0.54 nm) of the vessel? (I-918, NN001, O-038, O-043)

Response: Sea turtles will be monitored both visually and with active acoustics. Because sea turtles do not make sounds that can be detected passively and are smaller than most marine mammals, the overall monitoring effectiveness will be less than that for most marine mammals.

The Navy cannot assure that individual sea turtles will not be incidentally taken, but has proposed mitigation measures to reduce the potential impacts. Monitoring mitigation is designed to reduce to negligible levels the chances that a sea turtle would be exposed to high levels of SURTASS LFA sonar transmissions. The use of 180-dB criteria in this analysis for potential injury to sea turtles is conservative as discussed in Subchapter 4.1.2 (Sea Turtles) of the Final OEIS/EIS. The Navy has conducted an ESA Section 7 consultation with NMFS.

ISSUE 5-3: MITIGATION MEASURES: GENERAL

Comment 5-3.1: How does the Navy plan to mitigate impacts in vast ocean basins? (O-016, O-040, O-051)

Response: Monitoring mitigation is designed to reduce the potential for injury to marine species within the LFA mitigation zone, where injury may be an issue. This monitoring will be required for all operations including those in "vast ocean basins."

Comment 5-3.2: How can impacts to fish be mitigated? Why no mitigation protocols for schooling fish? (I-918, O-027, O-039)

Response: Impacts to fish stocks are mitigated via the geographic restrictions. There is no specific monitoring mitigation for pelagic fish species and no protocols for schooling fish because the Final OEIS/EIS concludes that the potential impact to fish stocks is not significant (see Subchapter 4.1.1 [Fish and Sharks]). Therefore, no protocols are required.

Comment 5-3.3: How accurately can 145 and 180 dB RLs be measured (calculated)? Within 3 dB? Can the models be used to predict convergence zones? (I-517, I-681, NN001)

Response: In previous tests, acoustic model fidelity has been shown to be on average ± 5 dB (see TR 1). The models do predict convergence zones based on oceanic environmental condition.

Comment 5-3.4: Will there be SPL monitoring to determine the efficacy of Navy models to predict sound fields? (NN001, O-051)

Response: See the Response to Comments 4-5.4, 4-5.37, and 5-3.3 for additional information.

Comment 5-3.5: How will the Navy monitor and model the sound field around SURTASS LFA sonar? (O-051)

Response: The Navy will model the SPL (or sound field) around the SURTASS LFA sonar transmit array as discussed in Subchapter 2.3.2.1 (Geographic Restrictions) and Subchapter 5.1.3 (Sound Field Modeling) of the OEIS/EIS.

Comment 5-3.6: Mitigation range should be predicated on maximum SPE values, where 180-dB equivalent distance is beyond 1 km (0.54 nm). Will there be independent monitoring of the sound field? (O-039, O-047, O-051)

Response: It is impossible to calculate SPE values without complete, three-dimensional tracks of the potentially exposed animals. Thus, SPE measures cannot be used as part of a mitigation protocol.

Comment 5-3.7: Protocols should be outlined if any marine animal should become injured as a result of exposure. Coordination with worldwide marine mammal stranding networks should be detailed. (NN001)

Response: As stated in Subchapter 2.4.2.5 (Incident Monitoring), the Navy will coordinate with the principal worldwide marine mammal stranding networks, including federal, state, and international organizations as part of the Long Term Monitoring Program. Based on the results of the analysis showing that only a small percentage of marine mammal stocks may be exposed to SPE levels ≥180 dB, the probability of injury to marine mammals has been determined to be negligible. Therefore, injury protocols are not deemed necessary.

CHAPTER 6: RELATIONSHIP OF PROPOSED ACTION TO FEDERAL, STATE, AND LOCAL PLANS, POLICIES, AND CONTROLS

ISSUE 6-1: RELATIONSHIP OF PROPOSED ACTION TO FEDERAL, STATE, AND LOCAL PLANS, POLICIES, AND CONTROLS

Comment 6-1.1: Coastal Zone Management Act: Add a summary of results of "consistency determinations" on a state-by-state basis. Add a summary of impacts to the coastal areas, species, etc. for each coastal state. The Navy's assessment of SURTASS LFA sonar's potential conflicts with the objectives of federal, regional, state and local land-use planning and is dismissive. (O-027, O-028, S-003, S-005, S-007)

Response: As required by the Code of Federal Regulations (CFR) Part 923, Coastal Zone Management Program Regulations and CFR 930, Federal Consistency with Approved Coastal Management Programs, 23 states and 5 territories with coastal zones that could potentially be affected by the proposed action were submitted copies of the Draft OEIS/EIS for review in accordance with their coastal management plans. These consistency reviews included coastal-land use planning.

Comment 6-1.2: Endangered Species Act: How can the Biological Assessment (BA) be derived from the Draft OEIS/EIS prior to the Final OEIS/EIS? The Navy's BA (i.e., Draft OEIS/EIS) has discounted threatened and endangered species such as salmon, known to occupy the system's extended range. Because of data gaps the Biological Opinion (BO) should either be (1) delayed or (2) developed giving the benefit of the doubt to the species. Explain how the USFWS was offered the opportunity to be a cooperating agency and provide a listing of potentially affected listed species and critical habitats under their jurisdiction. Who is the decision-maker under ESA? Does the Navy maintain that it is not subject to the ESA in the EEZs of foreign nations? (O-018, O-027, O-028, O-057)

Response: The SURTASS LFA sonar Biological Assessment (BA) was submitted to NMFS on 12 August 1999 in accordance with NOAA/NMFS procedures, which allows the submittal of BAs based on draft EISs. Additionally, in the comments received from the U.S. Environmental Protection Agency, it was recommended that information from the NMFS BO be included in the Final OEIS/EIS. Because the comments on the Draft OEIS/EIS resulted in no significant new information and no substantive changes to the outcome of the analysis, the Draft OEIS/EIS is considered sufficient basis for the BO. However, when the Final OEIS/EIS is submitted to NMFS, they will be notified of any changes that could potentially affect the BO.

Listed species, such as salmon, are not discounted in the BA and Draft OEIS/EIS. They were not analyzed because the proposed action will not take place in coastal zones and rivers where they are listed (See 50 CFR 17.11, Endangered and Threatened Wildlife).

There is no reason to delay the BO because of data gaps. Data gaps are discussed in Subchapter 1.4.1 (Adequacy of Scientific Information on Marine Animals) in the Final OEIS/EIS. The Navy considers the analysis to be conservative.

On May 18, 1998, pursuant to Section 7 of the Endangered Species Act, the Navy requested from NMFS and the USFWS a compilation of listed, proposed, and candidate species and designated and proposed critical habitats for the North and South Pacific Oceans; Northwest, Northeast, and South Atlantic Oceans; Indian Ocean; and Mediterranean Sea. On January 27, 1999, NFMS responded, providing the requested information. Copies of these letters were provided in Appendix A (Correspondence) in the Draft OEIS/EIS. The Department of Interior was provided multiple copies of the Draft OEIS/EIS for review and an additional copy was sent directly to the USFWS. On November 22, 1999, the Department of Interior provided comments on the Draft OEIS/EIS. These comments did not address any listed species under their jurisdiction. No comments on the Draft OEIS/EIS were received from the USFWS.

The authority for consultation under Section 7 of the ESA has been delegated to the Director, Office of Protected Resources, NMFS.

The impact analysis in the OEIS/EIS considered all species listed under the ESA that were potentially found in the areas where SURTASS LFA sonar could operate (Figure 1-1 [SURTASS LFA Sonar Potential Areas of Operation]). These areas include the EEZs of foreign nations, where applicable.

Comment 6-1.3: Marine Mammal Protection Act: Monitoring and verification of negligible effects of the HF/M3 sonar on odontocetes is needed. Why was an application for incidental takes submitted prior to the Final OEIS/EIS? Why was the Letter of Authorization (LOA) request submitted before the Final OEIS/EIS? Who is the decision-maker for the MMPA? (O-018, O-027, O-028, O-046)

Response: Monitoring and verification of the potential effects on marine mammals of the HF/M3 sonar will occur as part of the Long Term Monitoring Program (See Subchapter 2.4 [Long Term Monitoring Program] of the Final OEIS/EIS). The LOA request was submitted in accordance with NFMS regulations. NMFS is the decision-maker for permitting under the MMPA. Because the comments on the Draft OEIS/EIS resulted in no substantive changes to the outcome of the analysis, the Draft OEIS/EIS is considered sufficient basis for the LOA request However, when the Final OEIS/EIS is submitted to NMFS, they will be notified of any changes that could potentially affect this request.

Comment 6-1.4: Magnuson-Stevens Fisheries Conservation and Management Act: The Navy must initiate consultation with NMFS, or explain in the Final OEIS/EIS the basis for their conclusion that the proposed action would not adversely affect Essential Fish Habitats (EFH). It is questionable that "(LFA) would not.....reduce the productivity of any fish stock." (NN001, O-020)

Response: The Navy has determined that the proposed action would have no adverse effects on EFHs (DON letter, Serial 01C/069 of 28 February 2000) (See Appendix A [Correspondence]). The potential impacts of the proposed action on fish stocks are discussed in the Response to Comment 4-1.2.

Comment 6-1.5: Does the proposed action violate United Nations Convention on the Law of the Sea (UNCLOS) and other international conventions, treaties, and agreements concerning pollution of the seas? Does this document meet the requirements under EO 12114 for an overseas environmental analysis (OEIS)? (I-764, O-028, O-044)

Response: When the U.S. Government becomes a signor to an international agreement, Congress must ratify it and enact legislation to implement its requirements. As an example, the International Convention for Prevention of Pollution from Ships (MARPOL 73/78) was implemented by the Act to Prevent Pollution from Ships (APPS) (33 U.S.C. 1901 to 1915). The SURTASS LFA sonar vessels will operate in accordance with all applicable federal and U.S. Navy environmental rules and regulations; thereby, they will be compliant with all U.S. and international conventions, treaties, and agreements concerning pollution of the seas of which the Congress has ratified.

At present, the U.S. is not a signor to the UNCLOS. Under UNCLOS, Part VII, Articles 95 and 96, warships and ships used only for government non-commercial service have immunity.

As stated in Subchapters 1.3.1 and 6.1 (Executive Order 12114) this OEIS/EIS has been prepared to meet the requirements of an Overseas Environmental Impact Statement (OEIS) in accordance with 32 CFR 187 and with the Navy's guidance in OPNAVINST 5090.1B, Appendix E.

Comment 6-1.6: Is the proposed action inconsistent with the National Marine Sanctuary (NMS) Guidelines? (I-740, I-764, O-028)

Response: No. The guidelines for prohibited activities within NMSs vary among sanctuaries. These can be found in 15 CFR 922.60 to 922.187 (Subparts F through Q). For more details, see Response to Comment 5-1.7 and Appendix A for a copy of the Navy's letter to the National Marine Sanctuaries Program of 29 November 2000.

Comment 6-1.7: Noise restrictions, such as those imposed by the National Park Service, should be adopted for NMSs. (I-764)

Response: The Navy has no authority over NMSs.

Comment 6-1.8: What legal right does the Navy have to bombard international coastlines with SURTASS LFA sonar transmissions? (O-049)

Response: Based on the geographic restrictions described in Chapter 5 (Mitigation Measures) of the OEIS/EIS, SURTASS LFA sonar transmissions will be restricted to received levels below 180 dB within 22 km (12 nm) of any coastline.

Comment 6-1.9: Why wasn't the Hawaiian Senate Resolution (SR No. 84) addressed in the Draft OEIS/EIS? (I-766)

Note: Resolution 84 of the Hawaiian Senate, Twentieth Legislature, 1999, State of Hawaii, was a resolution: "Urging the United States Congress to Ban Any Further Tests of the Low Frequency Active Sonar System in Hawaiian Waters."

Response: The Navy has stated, and reaffirmed in U.S. District Court, that the SURTASS LFA sonar would not be deployed until all legal requirements have been met (e.g., NEPA, MMPA, ESA, CZMA).

CHAPTER 7 UNAVOIDABLE ADVERSE EFFECTS

ISSUE 7-1: UNAVOIDABLE ADVERSE EFFECTS

Comment 7-1.1: Based on the Cuvier's beaked whale incident, conclusions of no significant unavoidable adverse effects related to the deployment of the SURTASS LFA sonar system are inaccurate. (I-682, O-053)

Response: There is an allegation that North Atlantic Treaty Organization (NATO) "LFA sonar experiments" were responsible for the stranding of several Cuvier's beaked whales on the coast of Greece in 1996. It is important to realize that the system NATO used was not SURTASS LFA sonar, but a different system with different operating characteristics. Therefore, equating the two systems is inappropriate. The Mediterranean Sea Cuvier's beaked whale strandings incident is addressed in more detail in Subchapter 3.2.5.1 of the Final OEIS/EIS.

Comment 7-1.2: Just because individual risk is low, this does not mean that accidental injury will not eventually occur. Also this risk increases with increased system use. (I-681, O-047)

Response: The risk of injury, although negligible, cannot be eliminated and scales with usage.

CHAPTER 8 RELATIONSHIP BETWEEN SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE ENHANCEMENT OF LONG-TERM PRODUCTIVITY

ISSUE 8-1: RELATIONSHIP BETWEEN SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Comment 8-1.1: Is it really appropriate to assume that only short-term effects means there will be no long-term effects? Can short-term effects over time cause long-term effects? (NN001)

Response: Short-term effects over time can cause long-term effects. However, because of the proposed mitigation and the facts that the SURTASS LFA sonar vessel is not stationary and that operations are usually in different ocean locations with short mission durations (20 days), short-term effects in the same area over time would be minimal. Therefore, there should be no significant long-term effects caused by short-term operations of the SURTASS LFA sonar over time.

Comment 8-1.2: Based on the LFS SRP, justify the statement that "all effects of operating the SURTASS LFA sonar would be temporary in nature......" (O-047)

Response: The above statement from Chapter 8 was not based on the results of the LFS SRP.

Comment 8-1.3: Croll, et al (1999) statements (listed below) conflict with the conclusions of Chapter 8 and are absent from the Draft OEIS/EIS:

- Page IX: "...the most serious potential impacts of LFA are likely its potential contribution to a long-term decrease in the foraging efficiency or communications of marine animals....small decreases in reproduction rate could have serious impacts on population (stock) size yet be undetected by any known monitoring system."
- Page XI: "... long-term impacts (e.g. displacement, masking of biological important signals) while more difficult to identify and quantify, may be biologically significant through reductions in foraging efficiency, survival or reproductive success. In many cases, the basic information needed to understand the long-term consequences of human-produced sound is missing."
- Page XII: "Because various species of fish use sound to maintain the cohesiveness of schools, detect predators, communicate with mates or competitors, and potentially to navigate, the addition of low frequency sound would, potentially, have dire consequences for fish."

- Page XIII: "It is possible that low frequency noise masks the approach of predators and shifts the importance of various demographic processes in the dynamics of fish population (stock)."
- Page XIII: "...no work has been performed that test the effects of low frequency noise on the ecological process."

(I-501, O-020)

Response: The Marine Mammal and Seabird Ecology Group, Institute of Marine Sciences, University of California-Santa Cruz, was tasked by the Navy to provide factual data on marine species that could potentially be affected by LF sound. Their report is titled "Marine Vertebrates and Low Frequency Sound Technical Report for LFA EIS" (Croll et al., 1999). Factual data from their report were factored into the OEIS/EIS.

The page IX comment concerns the possible effects to cetaceans of increased anthropogenic noise in the oceans as compared between pre-shipping conditions and present shipping conditions and the potential for this increase to mask communications. As presented in Subchapter 4.4 (Potential Cumulative Impacts) of the OEIS/EIS, most of this increase in anthropogenic noise is due to shipping (NRDC, 1999). The subchapter also concludes that any potential for the accumulation of ambient noise by the intermittent operation of the SURTASS LFA sonar would be negligible.

The quotation from page XI concerns long-term effects. The Navy believes it has adequately studied the pertinent issues with regard to the potential for LF sound effects on marine animals to go forward with employment of SURTASS LFA sonar, with the concomitant geographic restrictions and monitoring mitigation.

The quotations from pages XII and XIII concern masking in fish. Croll et al. (1999) state on page XII, "Extraneous low frequency sound has rarely been demonstrated to impact fish populations (stocks); however, very few rigorous studies have been conducted that have the power to test the impacts of loud, low frequency sound on fish." The first quote from this page concerns masking, which is not loud, LF sound. Subchapter 4.1.1.1 (Fish Stocks) of the OEIS/EIS concludes that masking effects are not expected to be significant because the SURTASS LFA sonar bandwidth (approximately 30 Hz) is very limited, signals do not remain at a single frequency for more than 10 seconds, and the system is off (not transmitting) at least 80 percent of the time.

See Subchapter 1.4 (Analytical Context) for discussion on the adequacy of scientific information. The SURTASS LFA sonar signal has been determined not to significantly affect the ambient noise levels as discussed above (Subchapter 4.4). In addition, Croll et al. (1999) state, "As long as SURTASS LFA operations are conducted away from nearshore habitats and distant from known aggregations of pelagic fishes, the direct physical effects on fish stocks of operations should be minimal."

CHAPTER 9 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

ISSUE 9-1: IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Comment 9-1.1: Justify the expenditure of $350M before NEPA requirements were met? The second SURTASS LFA sonar system is to be operational in FY-2000, meaning that funds were committed prior to the FEIS/ROD? (I-831, O-047, O-057)

Response: See the Response to Comment 1-3.5.

Comment 9-1.2: What is the program cost to date? What are the ongoing costs in terms of material and personnel? (O-027)

Response: The program cost to date is approximately $350M. Operations and maintenance costs for the R/V *Cory Chouest* are $7.5M for FY 2000.

CHAPTER 14 PREPARERS AND REVIEWERS

ISSUE 14-1: PREPARERS AND REVIEWERS

Comment 14-1.1: Why is the inclusion of Mr. Hollingshead and Dr. Gentry as preparers of the Draft OEIS/EIS not inappropriate given their roles in the office responsible for regulatory oversight? (O-057)

Response: CEQ regulations (40 CFR § 1501.6) stipulate that any federal agency having either jurisdiction by law, or expertise on subject matter that should be addressed in the draft EIS, may be a cooperating agency whenever requested. For the Draft OEIS/EIS, NMFS, as a federal agency, met both of these criteria. For this action, NMFS' role under NEPA is explained in their letter to the Navy on April 1, 1998 (see Appendix A) and was limited to review and comment on the OEIS/EIS during its preparation. In addition, because the publishing of a Rule and issuance of a Letter of Authorization under the MMPA constitute a federal action, NMFS also has a NEPA responsibility. NMFS anticipates that their responsibility will be satisfied by adopting the Navy's Final OEIS/EIS, in whole or in part, as its own NEPA document when making the final decision on the issuance of the small take authorization, in accordance with 40 CFR § 1506.3.

APPENDIX B FUNDAMENTALS OF UNDERWATER SOUND

ISSUE B-1

Comment B-1.1: Several comments made direct comparisons of decibels in air (dB[A]) to those in water (dB). (F-005, I-245, I-683, O-017, O-040, O-052)

Response: Sound levels in air (dB[A]) are not the same as sound levels in water (dB) because: (1) the reference pressure values by accepted convention differ by 26 dB, and (2) there is a difference in acoustic impedance (product of density and sound velocity) between air and water. This is presented in more detail in Appendix B of the Final OEIS/EIS.

Comment B-1.2: Adding 35.5 dB to the sound levels to correct for the impedance differences between air and water is controversial and not straightforward. (O-020)

Response: The uncertain nature of comparing sound levels in water versus air concerns whether animals detect sounds as pressure or as energy. If sound is detected as pressure, than using the correction for impedance difference is correct. However, if an animal detects sound as only energy, than this correction is not required. Section B.3 (Measuring the Intensity of Sound) in Appendix B presents more details on the correction for the difference in impedance between air and water.

Appendix B also stated that, given the potential for confusion of sound levels in air and water, the OEIS/EIS generally avoids cross-media comparisons. Because the analyses presented in this OEIS/EIS only concern the measurement of sound pressure levels in water and all sound levels were in dB re 1 µPa at 1 m (the standard for water), the uncertain nature of conversion from water to air standards is not relevant to these analyses.

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GLOSSARY

Acoustics: The scientific study of sound, especially of its generation, transmission, and reception.

Ambient noise: The typical or persistent environmental background noise present in the ocean.

Anadromous: Pertaining to fishes that travel from their primary ocean habitats to fresh water to spawn; examples include salmon, shad, and lampreys.

Anthropogenic noise: Noise related to or produced by human activities.

Antisubmarine warfare (ASW): Naval operations conducted against submarines, their supporting forces and operating bases.

Baleen: The filtering plates that hang from the upper jaw of baleen whales.

Baleen whales: The filter-feeding whales, also known as mysticetes.

Biologically important activities/behaviors: Those activities or behaviors essential to the continued existence of a species, such as migration, breeding/calving, or feeding.

Biologically important areas (offshore): Offshore biologically important areas are defined as those areas of the world's oceans outside of 22 km (12 nm) of a coastline where marine animals of concern (those animals listed under the Endangered Species Act and/or marine mammals) congregate in high densities to carry out biologically important activities. Biologically important areas include:

- Migration corridors;
- Breeding and calving grounds; and
- Feeding grounds.

Cephalopod: Any of various mollusks of class Cephalopoda, such as an octopus or squid, having a beaked head, an internal shell in some species, and prehensile tentacles.

Cetacean: Of or belonging to the order Cetacea, which includes aquatic mammals with anterior flippers, no posterior limbs, and a dorsal fin; such as whales, dolphins and porpoise.

Convergence zone (CZ): The region in the deep ocean where sound rays, refracted from the depths, arrive at the surface in successive intervals of 55 to 64 kilometers (30 to 35 nautical miles). The repeated occurrence of these zones to several hundred miles from the sound source depends on the refraction of sound at depth and the reflection of these rays at the surface.

Critical habitat: The area where the species of concern resides that contains physical or biological characteristics essential to the survival of the species, or the area surrounding such habitats, which are essential to the survival of the species. However, it does not include all habitats that could be used by the species.

Cumulative distribution function: A graphic representation of cumulative percentage of observations or data at each division point on the horizontal scale.

Decapod: A crustacean of the order Decapoda, such as a crab, lobster, or shrimp, characteristically having five pair of locomotion appendages, each joined to a segment of the thorax.

Decibel (dB): A unit used to express the relative difference in power, usually between acoustic or electrical signals, equal to ten times the common logarithm of the ratio of the two levels.

Duct: A layer in the ocean where refraction and probably reflection result in the trapping of sound waves.

Duty cycle: The ratio of the time the sound is being transmitted over the total time period, measured in percent.

Endangered species: Defined in 16 U.S.C. 1532 as any species that is in danger of extinction throughout all or a significant portion of its range (other than a species of Class Insecta designated as a pest). Federally endangered species are listed in 50 CFR 17.11 and 17.12.

Frequency: Description of the rate of disturbance, or vibration, measured in cycles per second. Cycles per second are usually referred to as the unit of measure of Hertz (Hz). In acoustics, frequency is characterized in general terms as low, mid, or high. The U.S. Navy categorizes these as follows:

- **Low frequency (LF)** sound is below 1,000 Hz;
- **Mid frequency (MF)** sound is between 1 and 10 kHz; and
- **High frequency (HF)** sound is above 10 kHz.

Habitat: Place where an animal or plant normally lives, often characterized by a dominant plant form or physical characteristic.

Harassment: Under the Marine Mammal Protection Act, any act of pursuit, torment, or annoyance that has the potential to:

- Injure a marine mammal or marine mammal stock in the wild; or

- Disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

Hertz (Hz): The unit of measure of frequency in cycles per second. 1,000 Hz is usually referred to as 1 kiloHertz (kHz).

Histogram: A graphic representation of a frequency distribution in which the widths on contiguous vertical bars are proportional to the class widths of the variable and the heights of the bars at are proportional to the class frequency.

Impedance (acoustic): The product of density and sound speed.

Invertebrate: Lacking a backbone or spinal column.

LFA mitigation zone: The LFA mitigation zone covers a volume ensonified to a level $\geq$ 180 dB by the SURTASS LFA sonar transmit array. Under normal operating conditions, this zone will vary between the nominal ranges of 0.75 to 1.0 km (0.40 to 0.54 nm) from the source array over a depth of approximately 87 to 157 m (285 to 515 ft). (The center of the array is at a nominal depth of 122 m [400 ft]). Under rare conditions (e.g., strong acoustic duct) this range could be somewhat greater than 1 km (0.54 nm).

Masking: The obscuring of sounds of interest by interfering sounds, generally at similar frequencies (Richardson et al., 1995b).

Mustelids: Fur-bearing mammals of the family Mustelidae including the badger, otter, mink and weasel.

Mysticete: Any of several whales having symmetrical skulls, paired blow holes, and plates of whale bone (baleen plates) instead of teeth of the suborder Mysticeti. Filter-feeding whales, also referred to as baleen whales.

Odontocete: Any of the toothed whales (without baleen plates) having a single blow hole and asymmetric skull of the suborder Odontoceti, such as orcas, dolphins, and porpoises.

Otariid: One of three families of Pinnipedia having small but well formed ears (known as "eared" seals) including eared seals, sea lions, and fur seals.

Otolith: One of many minute calcareous particles found in the inner ear of certain vertebrates.

Pelagic: Living in the water column. Plants and animals that are free-floating and drift passively, or animals that are strong swimmers.

Period: The time required for a wave crest to traverse a distance equal to one wavelength.

Permanent threshold shift (PTS): The deterioration of hearing due to prolonged or repeated exposure sounds which accelerate the normal process of gradual hearing loss (Kryter, 1985), and the permanent hearing damage due to brief exposure to extremely high sound levels (Richardson et al., 1995b)

Phocid: One of three families of Pinnipedia having no external ears and short and course hair (known as "hair" seals).

Pinniped: Of or belonging to the Pinnipedia, an order of aquatic mammals that include seals, sea lions, walruses and similar animals having fin-like flippers for locomotion. They are carnivorous and "haul out" on shore to have their pups.

Received level (RL): The level of sound that arrives at the receiver, or listening device (hydrophone). It is measured in decibels referenced to 1 microPascal root-mean-square (rms). Put simply, the received level is the source level minus the transmission losses from the sound traveling through the water.

Record of Decision (ROD): In regard to an Environmental Impact Statement (EIS), the notice published in the *Federal Register* that contains the lead agency's decision, and identifies both the alternatives and the mitigation measures to be used.

Reflection: Process by which a traveling wave is deflected by a boundary between two media. Angle of reflection equals angle of incidence. (Richardson et al, 1995b)

Refraction: Bending of a sound wave passing through a boundary between two media; may also occur when physical properties of a single medium change along the propagation path (Richardson et al., 1995b).

Root mean squared: The square root of the arithmetic mean of the squares of a set of numbers.

Salinity: A measure of the quantity of dissolved salts in seawater. It is formally defined as the total amount of dissolved solids in seawater in parts per thousand (‰) by weight when all the carbonate has been converted to oxide, the bromide and iodide to chloride, and all organic matter is completely oxidized.

Scoping: Early consultation with federal and state agencies, and interested public to identify possible alternatives and the significant issues to be addressed in the EIS.

Single Ping Equivalent (SPE): The single ping equivalent (SPE) is the methodology used during the acoustic modeling of potential impacts to marine animals from exposure to LF sound. This method estimates the total exposure of each individually modeled animal, which was exposed to multiple pings over an extended period of time. This was accomplished by the summation of the intensities for all received pings into an equivalent exposure from one ping, which is always at a higher level than the highest individual ping received.

Sirenian: A herbivorous aquatic mammal of the order Sirenia, which include the manatee and dugong.

SONAR: An acronym for SOund NAvigation and Ranging. It includes any system that uses underwater sound, or acoustics, for observations and communications. There are two broad types of sonar:

- **Passive sonar** detects the sound created by an object (source) in the water. This is a one-way transmission of sound waves traveling through the water from the source to the receiver; and

- **Active sonar** detects objects by creating a sound pulse, or ping, that transmits through the water and reflects off the target, returning in the form of an echo. This is a two-way transmission (source to reflector to receiver) and is a form of echolocation.

Sound channel axis: The depth at which minimum sound velocity occurs in the ocean.

Sound pressure level (SPL): Twenty times the logarithm to the base 10 of the ratio of the pressure to the reference pressure, in decibels at a specific point. The reference pressure shall be explicitly stated. SPL is usually measured in decibels referenced to 1 microPascal (rms).

Sound speed: Sound speed is the velocity that sound waves travel through a medium. Sound speed through seawater is approximately 1,500 meters per second (4,920 feet per second). It varies with water temperature, salinity, and depth (pressure). Sound speed increases with increases in temperature and pressure (depth), and to a lesser extent with increase in salinity. This change in speed as sound travels through water causes the travel path to bend in the direction of lower velocity.

Sound speed profile (SSP): The sound speed profile (SSP) is a graphic representation of the sound speed versus depth of the ocean. These profiles vary with latitude, season, and time of day.

Source Level (SL): The sound transmitted into the water by a sound source, such as an active sonar ping. SL is usually measured in decibels referenced to 1 microPascal at 1 m (3.28 ft).

SURTASS LFA sonar: Long-range, all-weather low frequency (between 100 and 500 Hz) sonar system composed of both active and passive components. SURTASS (Surveillance Towed Array Sensor System) is the passive component. LFA (Low Frequency Active) is the active component.

Take: To harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt any of these activities.

Taxon: A taxonomic (system of arranging animals and plants into natural, related groups based on some factor common to each such as structure, embryology, biochemistry, etc.) category or unit, as species, genus, etc.

Temporary threshold shift (TTS): Temporary increases in threshold occurring after exposure to high noise levels, which can last from minutes to hours to days (Richardson et al., 1995b).

Transmission loss (TL): Energy losses as the pressure wave, or sound, travels through the water, the associated wavefront diminishes due to the spreading of the sound over an increasingly larger volume and the absorption of some of the energy by seawater.

Threatened species: Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. Threatened species are listed in 50 CFR 17.12.

Vertebrate: A member of the subphylum Vertebrata, a primary division of the phylum Chordata that includes fishes, amphibians, reptile, birds, and mammals, all which are characterized by a segmented bony or cartilaginous spinal column (i.e. backbone).

Wavelength: The distance between corresponding points of two successive waves.

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APPENDIX A

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DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, D.C. 20350-2000

5090 IN REPLY REFER TO
Ser N874E/8U657109
20 January 1998

Mr. Richard E. Sanderson
Director
Office of Federal Activities
U.S. Environmental Protection Agency
Washington D.C. 20460

Dear Mr. Sanderson,

As you are aware, the Navy is in the process of preparing an environmental impact statement (EIS) in connection with the proposed operational deployment of the Surface Towed Array Surveillance System (SURTASS) Low Frequency Active (LFA) sonar. Notification of the Navy's intent to prepare the EIS was provided in the Federal Register of July 18th, 1996 (61 Fed.Reg. 37452). The Environmental Protection Agency (EPA) provided scoping comments in a letter dated September 5th, 1996, a copy of which is enclosed.

Over the past two years the Navy has been conducting important research on the effects of low frequency sound on the marine environment. We anticipate that this and related research will be completed in mid-1998, and that the process of synthesizing the data into a draft EIS can begin.

In preparation for the important work ahead, the Navy invites EPA become a "cooperating agency," under 40 CFR 1501.6, for the preparation of the EIS. I request that you designate one or more persons to serve as point(s) of contact with the Navy regarding preparation of the LFA EIS. Ideally, such person(s) would be available to serve as your point of contact over the next year, by which time we hope to complete a record of decision in this matter. Similar invitations are being extended to the National Ocean Service, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service and the Marine Mammal Commission.

To improve Navy and cooperating agency understanding of the issues involved, the Navy will host a meeting of cooperating agency representatives at 1:00 PM on Wednesday, 18 February 1998. The meeting will be in Suite 4000, Presidential Tower, 2511 South Jefferson Davis Highway, Arlington, VA. We would like to provide a brief on progress to date, and discuss the plan for completing this process. Please have your designee(s) contact me or LCDR Ted Berger as soon as possible to confirm meeting attendance. LCDR Berger and I can be contacted at (703) 604-6344. Thank you.

Neil E. Rondorf
Captain, U.S. Navy

Enclosure

Copy to:
DASN(E&S) (E. L. Munsell)

DEPARTMENT OF DEFENSE UNITED STATES OF AMERICA

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, D.C. 20350-2000

5090 IN REPLY REFER TO
Ser N874E/8U657106
20 January 1998

The Honorable John G. Rogers
Director, U.S. Fish & Wildlife Service
Interior Building
1849 C Street, N.W.
Washington, D.C. 20240

Dear Mr. Rogers,

The Navy is in the process of preparing an environmental impact statement (EIS) in connection with the proposed operational deployment of the Surface Towed Array Surveillance System (SURTASS) Low Frequency Active (LFA) sonar. Notification of the Navy's intent to prepare the EIS was provided in the Federal Register of July 18th, 1996 (61 Fed.Reg. 37452).

Over the past two years the Navy has conducted research on the effects of low frequency sound on the marine environment. We anticipate that this and other ongoing research will be completed in mid-1998, and that the process of synthesizing the data into a draft EIS can begin.

In preparation for the important work ahead, the Navy would like to invite the U.S. Fish and Wildlife Service to become a "cooperating agency," under 40 CFR 1501.6, for the preparation of the EIS. I request that you designate one or more persons to serve as point(s) of contact with the Navy regarding preparation of the LFA EIS. Ideally, such person(s) would be available to serve as your point of contact over the next year, by which time we hope to complete a record of decision in this matter. Similar invitations are being extended to the National Ocean Service, the National Marine Fisheries Service, the Marine Mammal Commission and the Environmental Protection Agency.

The Navy recognizes that in addition to completing the EIS, Endangered Species Act consultation will probably be necessary in connection with the proposed operational deployment of the LFA sonar. We look forward to Fish and Wildlife Service assistance in determining the appropriate scope and timing of any necessary consultation.

To improve Navy and cooperating agency understanding of the issues involved, the Navy will host a meeting of cooperating agency representatives at 1:00 PM on Wednesday, 18 February 1998. The meeting will be in Suite 4000, Presidential Tower, 2511 South Jefferson Davis Highway, Arlington, VA. We would like to provide a brief on progress to date, and discuss the plan for completing this process. Please have your designee(s) contact me or LCDR Ted Berger as soon as possible to confirm meeting attendance. LCDR Berger and I can be contacted at (703) 604-6344. Thank you.

Neil E. Rondorf
Captain, U.S. Navy

Copy to:
DASN(E&S) (E. L. Munsell)

DEPARTMENT OF DEFENSE UNITED STATES OF AMERICA

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, D.C. 20350-2000

5090 IN REPLY REFER TO
Ser N874E/8U657107
20 January 1998

Dr. Nancy Foster
Assistant Administrator
for Ocean Services and Coastal Zone Management
United States Department of Commerce
Washington D.C. 20230

Dear Ms. Foster,

The Navy is in the process of preparing an environmental impact statement (EIS) in connection with the proposed operational deployment of the Surface Towed Array Surveillance System (SURTASS) Low Frequency Active (LFA) sonar. Notification of the Navy's intent to prepare the EIS was provided in the Federal Register of July 18th, 1996 (61 Fed.Reg. 37452). In a letter dated August 30th, 1996, a copy of which is enclosed for your convenience, Ms. Donna Wieting provided scoping comments on behalf of the National Ocean Service.

Over the past two years the National Ocean Service has informally provided invaluable advice and assistance to the Navy in this effort. With the support of the Service, other agencies and private environmental groups, the Navy is conducting important research on the effects of low frequency sound on the marine environment. We anticipate that this and other ongoing research will be completed in mid-1998, and that the process of synthesizing the data into a draft EIS can begin.

In preparation for the important work ahead, the Navy would like to formalize the existing working relationship between the Navy and the National Ocean Service with respect to the LFA EIS. The Navy therefore invites the National Ocean Service and/or an appropriate component thereof to become a "cooperating agency," under 40 CFR 1501.6, for the preparation of the EIS. I request that you designate one or more persons to serve as point(s) of contact with the Navy regarding preparation of the LFA EIS. Ideally, such person(s) would be available to serve as your point of contact over the next year, by which time we hope to complete a record of decision in this matter. Similar invitations are being extended to the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, the Marine Mammal Commission and the Environmental Protection Agency.

To improve Navy and cooperating agency understanding of the issues involved, the Navy will host a meeting of cooperating agency representatives at 1:00 PM on Wednesday, 18 February 1998. The meeting will be in Suite 4000, Presidential Tower, 2511 South Jefferson Davis Highway, Arlington, VA. We would like to provide

5090
Ser N874E/8U657107
20 January 1998

a brief on progress to date, and discuss the plan for completing this process. Please have your designee(s) contact me or LCDR Ted Berger as soon as possible to confirm meeting attendance. LCDR Berger and I can be contacted at (703) 604-6344. Thank you.

N E Rondorf
Neil E. Rondorf
Captain, U.S. Navy

Enclosure

Copy to:
DASN(E&S) (E. L. Munsell)

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, D.C. 20350-2000

5090 IN REPLY REFER TO
Ser N874E/8U657110
20 January 1998

Mr. Rolland A. Schmitten
Assistant Administrator for Fisheries
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910

Dear Mr. Schmitten,

As you are aware, the Navy is in the process of preparing an environmental impact statement (EIS) in connection with the proposed operational deployment of the Surface Towed Array Surveillance System (SURTASS) Low Frequency Active (LFA) sonar. Notification of the Navy's intent to prepare the EIS was provided in the Federal Register of July 18th, 1996 (61 Fed.Reg. 37452). In a letter dated August 30th, 1996, a copy of which is enclosed for your convenience, Ms. Donna Wieting provided scoping comments on behalf of the National Marine Fisheries Service (NMFS).

Over the past two years NMFS has informally provided invaluable advice and assistance to the Navy in this effort. With the support of the Service, other agencies and private environmental groups, the Navy is conducting important research on the effects of low frequency sound on the marine environment. We anticipate that this and other ongoing research will be completed in mid-1998, and that the process of synthesizing the data into a draft EIS can begin.

In preparation for the important work ahead, the Navy would like to formalize the existing working relationship between the Navy and NMFS with respect to the LFA EIS. The Navy therefore invites NMFS to become a "cooperating agency," under 40 CFR 1501.6, for the preparation of the EIS. I request that you designate one or more persons to serve as point(s) of contact with the Navy regarding preparation of the LFA EIS. Ideally, such person(s) would be available to serve as your point of contact over the next year, by which time we hope to complete a record of decision in this matter. Similar invitations are being extended to the National Ocean Service, the U.S. Fish and Wildlife Service, the Marine Mammal Commission and the Environmental Protection Agency.

The Navy recognizes that in addition to completing the EIS, Endangered Species Act consultation will probably be necessary in connection with the proposed operational deployment of the LFA sonar. We look forward to NMFS assistance in determining the appropriate scope and timing of any necessary consultation.

5090
Ser N874E/8U657110
20 January 1998

To improve Navy and cooperating agency understanding of the issues involved, the Navy will host a meeting of cooperating agency representatives at 1:00 PM on Wednesday, 18 February 1998. The meeting will be in Suite 4000, Presidential Tower, 2511 South Jefferson Davis Highway, Arlington, VA. We would like to provide a brief on progress to date, and discuss the plan for completing this process. Please have your designee(s) contact me or LCDR Ted Berger as soon as possible to confirm meeting attendance. LCDR Berger and I can be contacted at (703) 604-6344. Thank you.

Neil E. Rondorf
Captain, U.S. Navy

Enclosure

Copy to:
DASN(E&S) (E. L. Munsell)

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, D.C. 20350-2000

5090 IN REPLY REFER TO
Ser N874E/8U657108
20 January 1998

Mr. John Twiss
Executive Director
Marine Mammal Commission
4340 East-West Highway
Bethesda, Maryland 20814

Dear Mr. Twiss,

As you are aware, the Navy is in the process of preparing an environmental impact statement (EIS) in connection with the proposed operational deployment of the Surface Towed Array Surveillance System (SURTASS) Low Frequency Active (LFA) sonar. Notification of the Navy's intent to prepare the EIS was provided in the Federal Register of July 18th, 1996 (61 Fed.Reg. 37452). The Marine Mammal Commission (MMC) provided scoping comments in a letter dated September 4th, 1996, a copy of which is enclosed.

Over the past two years the MMC has informally provided invaluable advice and assistance to the Navy in this effort. With the Commission's assistance, and that of other agencies and private environmental groups, the Navy is conducting important research on the effects of low frequency sound on the marine environment. We anticipate that this and other ongoing research will be completed in mid-1998, and that the process of synthesizing the data into a draft EIS can begin.

In preparation for the important work ahead, the Navy would like to formalize the existing working relationship between the Navy and the MMC with respect to the LFA EIS. The Navy therefore invites the MMC to become a "cooperating agency," under 40 CFR 1501.6, for the preparation of the EIS. I request that you designate one or more persons to serve as point(s) of contact with the Navy regarding preparation of the LFA EIS. Ideally, such person(s) would be available to serve as your point of contact over the next year, by which time we hope to complete a record of decision in this matter. Similar invitations are being extended to the National Ocean Service, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, and the Environmental Protection Agency.

To improve Navy and cooperating agency understanding of the issues involved, the Navy will host a meeting of cooperating agency representatives at 1:00 PM on Wednesday, 18 February 1998. The meeting will be in Suite 4000, Presidential Tower, 2511 South Jefferson Davis Highway, Arlington, VA. We would like to provide a brief on progress to date, and discuss the plan for completing this process. Please have your designee(s) contact me or LCDR Ted Berger as soon as possible to confirm meeting attendance. LCDR Berger and I can be contacted at (703) 604-6344. Thank you.

Neil E. Rondorf
Captain, U.S. Navy

Enclosure
Copy to:
DASN(E&S) (E. L. Munsell)

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, Maryland 20910

APR 1 1998

Captain Neil Rondorf
Department of the Navy
Office of the Chief of Naval
Operations
2000 Navy Pentagon
Washington, D.C. 20350-2000

Dear Captain Rondorf:

Thank you for your letter requesting the National Marine Fisheries Service (NMFS) to be a cooperating agency (as that term is defined by the Council on Environmental Quality (40 CFR 1501.6)), in the preparation of a Draft Environmental Impact Statement (DEIS) for the operational deployment of the Surface Towed Array Surveillance System Low Frequency Active (SURTASS-LFA) Sonar.

We support the U.S. Navy's determination to do a DEIS on this activity and have participated in the scoping process under the National Environmental Policy Act (NEPA) and have permitted recent research on impacts from SURTASS-LFA on marine mammals. In cooperating with the U.S. Navy on this activity, NMFS has a dual role, both through (and limited to) review and comment on the DEIS during preparation and in the regulatory process involved with processing an incidental small take application under section 101(a)(5)(A) of the Marine Mammal Protection Act. NMFS will also be in formal consultation with the U.S. Navy for this activity under section 7 of the Endangered Species Act. Therefore, although NMFS agrees to be a fully cooperating agency in the preparation of the DEIS, because of its regulatory role, we believe that it would be inappropriate for NMFS to be a signatory agency on the document. As a result, we reserve the ability to review that document when it is released to the general public, and to provide the U.S. Navy with appropriate comments. Provided our comments are addressed in the Final EIS, NMFS is prepared to adopt the U.S. Navy FEIS when making its determination on the issuance of a small take authorization.

If you need additional information, please contact Mr. Kenneth Hollingshead, (301/713-2055), who will be the point of contact for the preparation of the SURTASS-LFA DEIS.

Sincerely,

Hilda Diaz-Soltero

Hilda Diaz-Soltero
Director
Office of Protected Resources

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE NAVY
SPACE AND NAVAL WARFARE SYSTEMS COMMAND
4301 PACIFIC HIGHWAY
SAN DIEGO, CA 92110-3127

5090
Ser PMW182-2/102
18 MAY 98

The Honorable John G. Rogers
Director, U.S. Fish and Wildlife Service
Interior Building
1849 C Street, NW
Washington, DC 20240

Dear Mr. Rogers,

The Navy is in the process of preparing an environmental impact statement (EIS) in connection with the proposed operational deployment of the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA). The Chief of Naval Operations (Code N874) recently invited the U.S. Fish and Wildlife Service (USFWS) to become a cooperating agency under 40 CFR 1501.6, for the preparation of this EIS (ref: CNO ltr Ser N874E/8U657106 of 20 Jan 98). The Navy's EIS is proposed to be a global document covering all ocean regimes in which SURTASS LFA is intended to be operated, including the North and South Pacific Oceans; Northwest, Northeast, and South Atlantic Oceans; Indian Ocean; and Mediterranean Sea.

Pursuant to Section 7 of the Endangered Species Act of 1973, as amended, we request your assistance in providing compilations of listed, proposed, and candidate threatened and endangered species under the cognizance of the USFWS, including known temporal and spatial movements; and compilations of designated or proposed critical habitats for the above-listed species under the cognizance of the USFWS. These compilations are required for each of the oceanic areas listed in the above paragraph in which USFWS has responsibility. In order to meet the EIS schedule the above information is requested by 1 August 1998.

Point of contact for this program is the undersigned at (703) 919-0593 or E-mail: jjsqared@aol.com.

Sincerely,

J. S. JOHNSON
By direction

Copy to:
ASN(I&E) (CDR B. Stamey)
CNO (N45, CAPT R. Evans; N874, CAPT N. Rondorf)
SPAWAR (PMW 182)
OGC/ASN(I&E) (CAPT J. Quinn)
MAI (C. Spikes)
TAMS (J. Coyle)

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE NAVY
SPACE AND NAVAL WARFARE SYSTEMS COMMAND
4301 PACIFIC HIGHWAY
SAN DIEGO, CA 92110-3127

5090
Ser PMW182-2/103
18 MAY 98

Ms. Hilda Diaz-Soltero
Director, Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20901

Dear Ms. Diaz-Soltero,

The Navy is in the process of preparing an environmental impact statement (EIS) in connection with the proposed operational deployment of the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA). The Chief of Naval Operations (Code N874) recently invited to become, and the NMFS has confirmed its role as, a cooperating agency under 40 CFR 1501.6 for the preparation of this EIS. The Navy's EIS is proposed to be a global document covering all ocean regimes in which SURTASS LFA is intended to be operated, including the North and South Pacific Oceans; Northwest, Northeast, and South Atlantic Oceans; Indian Ocean; and Mediterranean Sea.

Pursuant to Section 7 of the Endangered Species Act of 1973, as amended, we request your assistance in providing compilations of listed, proposed, and candidate threatened and endangered species under the cognizance of the NMFS, including known temporal and spatial movements; and compilations of designated or proposed critical habitats for the above-listed species under the cognizance of the NMFS. These compilations are required for each of the oceanic areas listed in the above paragraph. In order to meet the EIS schedule the above information is requested by 1 August 1998.

Point of contact for this program is the undersigned at (703) 919-0593 or E-mail: jjsqared@aol.com.

Sincerely,

J. S. JOHNSON
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CNO (N45, CAPT R. Evans; N874, CAPT N. Rondorf)
SPAWAR (PMW 182)
OGC/ASN(I&E) (CAPT J. Quinn)
NMFS/OPR (K Hollingshead; C. Johnson)
MAI (C. Spikes)
TAMS(J. Coyle)

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, D.C. 20350-2000

IN REPLY REFER TO

5090
N874E1/8U657210
28 September 1998

Ms. Gabrielle LaRoche
Coastal Zone Management Coordinator
Division of Government Coordination
P.O. Box 110030
Juneau, AK 99811-0030

Dear Ms. LaRoche:

SUBJECT: FEDERAL CONSISTENCY WITH STATE OF ALASKA COASTAL ZONE MANAGEMENT PROGRAM

The Navy is currently preparing a DRAFT Environmental Impact Statement (DEIS) for employment of Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) Sonar. The DEIS will include the Navy's Coastal Zone Management (CZM) consistency determination on the proposed project. To that end, we are reviewing the policies/plans contained in Alaska's State Coastal Management Program (6 AAC 50). The purpose of this letter is to request a point f contact be designated in order to initiate a dialog with your office, thus ensuring that the CZM review process is efficiently accomplished in full accordance with your office's procedures and appropriate CZM objectives/policies.

The Chief of Naval Operations (CNO) point of contact on this matter is Mr. Joseph Johnson who can be reached at phone: (703) 919-0593 or (703) 604-7390/fax: (703) 604-7848.

Sincerely,

John E. Curtis for
Neil E. Rondorf
Captain, U.S. Navy
Head Undersea Surveillance (N874)

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, Maryland 20910

JAN 27 1999

Mr. Joseph Johnson
Space and Naval Warfare Systems Command
Department of the Navy
4301 Pacific Highway
San Diego, CA 92110-3127

Dear Mr. Johnson:

On May 18, 1998, the Space and Naval Warfare Systems Command (SPAWAR), U.S. Navy, requested consultation with the National Marine Fisheries Service (NMFS), under section 7 of the Endangered Species Act (ESA), for the proposed operational deployment of the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS-LFA). SURTASS-LFA is intended for operations in North and South Pacific Oceans, Northwest, Northeast, and South Atlantic Oceans, Indian Ocean, and Mediterranean Sea. This activity will be subject to review under the National Environmental Policy Act (NEPA) and the Navy is preparing a draft environmental impact statement (DEIS).

You requested NMFS provide compilations of listed, proposed, and candidate threatened and endangered species that are the responsibility of NMFS under the ESA, including known temporal and spatial movements; and compilations of designated or proposed critical habitats for the above-listed species. These lists and compilations are required for each of the oceanic areas provided.

The take prohibitions of the ESA apply both to takes in U.S. territorial waters and to takes by people under U.S. jurisdiction while on the high seas. Since your activity will not take place within 12 miles of the coast of the United States, coastal species that are on the List of Endangered and Threatened Species have not been included. For the most part, species under consideration for your activity would include the large whale species, the seals and Steller sea lion, and the various sea turtle species. A summary description of each of these species is enclosed for your consideration. In addition, for your convenience in writing the Biological Assessment and the DEIS, I have enclosed several reports on the status of sea turtles and marine mammals.

We look forward to receipt of your Biological Assessment.

Sincerely,

Hilda Diaz-Soltero
Director
Office of Protected Resources

Enclosures

NATIONAL MARINE FISHERIES SERVICE

LIST OF THREATENED AND ENDANGERED MARINE SPECIES

FOUND IN OFFSHORE WATERS

Marine Mammals

Right whale (*Eubalaena glacialis*) (E).

Current estimates of the northern right whale populations indicate there are no more than 500 individuals, with 295 found in the North Atlantic Ocean and less than 200 in the North Pacific Ocean.

Blue whale (*Balaenoptera musculus*) (E).

Blue whales are found worldwide. Blue whales are severely depleted in all oceans of the world. The population status of blue whales in the Northern Hemisphere is unknown. Sightings have increased off central California and on the Pacific coast of Mexico and Central America, but these increases may be attributed to increased observer effort rather than trends in abundance.

Fin whale (*Balaenoptera physalus*) (E).

Fin whales are found worldwide, between 20° and 75°N and between 20° and 75°S. Northern and southern hemisphere stocks are thought to be reproductively distinct. The status of stocks of fin whales is unknown, but the species was severely depleted by commercial whaling activities. The present world population estimate is 120,000 individuals. While the species is depleted relative to historical levels, it is considered abundant compared to other large whale species. No trend analyses for this species are available.

Sei whale (*Balaenoptera borealis*) (E).

The status of sei whales is unknown throughout the world. The species was severely depleted by commercial whaling primarily in the 1950s-1970s. Although the sei whale does not appear to be in immediate danger of extinction, no relevant new information on any stock is available.

Sei whales are found worldwide in all oceans. They seasonally migrate from high latitude summer feeding grounds to lower latitude wintering areas. Populations north and south of the equator are assumed to be separate, as their migrations are 6 months out of phase. In the North Pacific, sei whales winter in waters from 20°N to 23°N, and summer from 35°N to 40-50°N. In the Antarctic, sei whales spend the summer between 40°S and 50°S.

The winter distribution is unknown. In the North Atlantic, the northern summer limit is thought to be 72°N. Little is known about winter distribution.

Humpback whale *(Megaptera novaeangliae)* (E).

Humpback whales are the fourth most numerically depleted large cetacean worldwide. Prior to commercial whaling the worldwide population is thought to have been in excess of 125,000. Approximately 7,000 humpbacks occur in U.S. waters.

Western North Pacific Gray whale (*Eschrichtius robustus*) (E)

The western North Pacific or "Korean" stock of gray whales apparently breeds off the coast of eastern Asia. This stock formerly occupied the northern Sea of Okhotsk in the summer, and migrated along the coast of eastern Asia to winter calving grounds which probably lie along the coast of southern China in Gwangxi and Gwangdong provinces, and around Hainan Island. The status of the western Pacific stock of gray whales is uncertain. Sightings of 24 animals in the Okhotsk Sea and nine off the tip of Kamchatka in 1983 and 34 in 1989 in the Okhotsk Sea suggest that the stock is small. There is no evidence that it has reoccupied its entire former range and initial stock size may have been only a few thousand. It is likely that the stock is below a critical population size sufficient for recovery and may be almost extinct.

Sperm whale *(Physeter macrocephalus)* (E)

The sperm whale is the most abundant of the large whale species. The present world abundance is estimated at 2,000,000 individuals, which is over eight times greater than the combined total population estimates of the other six endangered large whale species.

Sperm whales inhabit all oceans of the world. Their distribution is dependent on their food source and suitable conditions for breeding, and varies with the sex and age composition of the group. Sperm whales tend to inhabit areas with a water depth of 600 meters or more, and are uncommon in waters less than 300 meters deep.

Steller sea lion *(Eumetopias jubatus)* (T/E).

Found in the North Pacific Ocean of U.S., Canada, and Russia, the Steller (northern) sea lion was listed as threatened throughout its range on December 4, 1990. The centers of abundance and distribution are the Gulf of Alaska and Aleutian Islands, respectively. Rookeries (breeding colonies) are found from the central Kuril Islands to Ano Nuevo Island, California; most large rookeries are in the Gulf of Alaska and Aleutian Islands. More than 50 Steller sea lion rookeries and a greater number of haulout sites have been identified.

During the 1985 breeding season, 68,000 animals were counted on Alaska rookeries from Kenai Peninsula to Kiska Island, compared to 140,000 in 1956-60. A 1988 Status Report concluded that the population size in 1985 was probably below 50 percent of the historic population size in 1956-60 and below the lower bound of its Optimum Sustainable Population level under the MMPA. A comparable survey conducted in 1989 showed that the number observed on rookeries from Kenai to Kiska declined to 25,000 animals. This indicates a decline of about 82 percent from 1956-60 to 1989 in this area. NMFS has conducted yearly Steller sea lion population censuses in Alaska since 1989. From 1989-1992, counts of adult and juvenile Steller sea lions at Kenai-Kiska index sites declined by 11 percent. From 1990-1993, pup counts declined at 10.7 percent per year from southeastern Alaska to the eastern Aleutian Islands, and by 12.7 percent per year from Kenai Peninsula to the eastern Aleutian Islands. These data indicate that the Steller sea lion population decline has not abated.

Species abundance estimates during the late 1970s ranged from 248,000 to 300,000 adult and juvenile animals. However, counts at rookeries and haulout sites throughout most of Alaska and the USSR in 1989, plus estimates from surveys conducted in recent years at locations not counted in 1989, provide a range-wide Steller sea lion population estimate of about 116,000.

Guadalupe fur seal (*Arctocephalus townsendi*) (T).

Guadalupe fur seals breed along the eastern coast of Guadalupe Island, approximately 200 km west of Baja California. In addition, individuals have been sighted in the southern California Channel Islands, including two males who established territories on San Nicolas Island. In 1993, the population was estimated to be about 7,408 animals.The Guadalupe fur seal was listed as threatened throughout its range on December 16, 1985. Althougha systematic survey of population abundance has not been conducted for some time, there is anecdotal evidence that the population continues to increase. Mexican scientists have indicated that the numbers of animals on Guadalupe Island seem to be increasing. In addition, the species seems to be expanding its range. In addition to regular sightings of animals on San Miguel and San Nicolas Islands off the southern California coast, animals were observed hauled out on San Clemente Island during 1991.

Hawaiian monk seal (*Monachus schauinslandi*) (E)

The population is currently estimated to be approximately 1,238 seals (including pups) on the northern Hawaiian Islands and 40 on the main islands. Counts have been made at the atolls, islands and reefs where they haul out in the northwest Hawaiian Islands since the late 1950s. NMFS estimates that currently there are approximately 1,400 animals.

Mediterranean monk seal *(Monachus monachus)* (E).

Found in a few scattered locations in the Mediterranean Sea, this species is considered close to extinction.

Sea Turtles

Loggerhead turtle *(Caretta caretta)* (T) This species is found circumglobally in tropical and temperate seas and oceans, usually in coastal waters.

Green turtle *(Chelonia mydas)* E/T This species is found circumglobally in tropical and temperate seas and oceans. Green turtles in U.S. waters are listed as threatened except for the Florida breeding population, which is listed as endangered.

Leatherback sea turtle *(Dermochelys coriacea)* (E) Tropical, temperate and subtropical seas of the Atlantic, Pacific and Indian Oceans from approximately 71° N to 47° S. It also enters the Mediterranean Sea. This species migrates great distances annually.

Hawksbill turtle *(Eretmochelys imbricata)* (E) A species found in tropical nearshore seas.

Kemp's ridley *(Lepidochelys kempii)* (E) Tropical and temperate seas in Northwest Atlantic, including Gulf of Mexico. Occasional individuals may reach European waters.

Olive Ridley *(Lepidochelys olivacea)*. E. Circumglobal in tropical and temperate seas and oceans. More abundant than other sea turtle species.

CRITICAL HABITAT

Marine mammals

Critical habitat has been designated for the northern right whale along the east coast of the United States in Great South Channel, Cape Cod Bay and southeastern U.S. coast (enclosure)

Critical habitat has been designated for the Steller sea lion in the Gulf of Alaska and Bering Sea (enclosure)

Critical habitat has been designated for the Hawaiian monk seals on the Northwestern Hawaiian Islands (enclosure).

Reptiles

NMFS has designated critical habitat for the threatened green sea turtle to include coastal waters surrounding Culebra Island, Puerto Rico; Hawksbill sea turtle in the coastal waters surrounding Mona and Monito Islands, Puerto Rico, and for leatherback sea turtles off St. Croix, Virgin Islands (enclosures).

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, D.C. 20350-2000

IN REPLY REFER TO

9462
N874/9U659009
12 August 1999

From: Chief of Naval Operations (N874)
To: National Marine Fisheries Service, Regional Headquarters, Assistant Administrator for Fisheries, Silver Spring, MD 20910

Subj: LETTER OF AUTHORIZATION FOR THE INCIDENTAL TAKE OF MARINE MAMMALS ASSOCIATED WITH THE EMPLOYMENT OF SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR

Ref: (a) Draft Overseas Environmental Impact Statement and Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar, July 1999

Encl: (1) Request for Letter of Authorization for the Incidental Take of Marine Mammals Associated with the Employment of Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar

1. The Navy requests that the National Marine Fisheries Service (NMFS) review the enclosed Request for Letter of Authorization (LOA) for the incidental take of marine mammals associated with the employment of the SURTASS LFA Sonar System on a worldwide basis (less the Arctic and Antarctic Oceans). The Navy petitions NMFS for regulations and requests authorization for the incidental take of marine mammals associated with the employment of SURTASS LFA Sonar under Section 101A5A of the Marine Mammal Protection Act for a period of five years, beginning in FY 0000, for the ten geographic operating regions cited in the attachment.

2. SURTASS LFA is an active sonar that will allow the Navy to meet its need in the 21st Century to detect quieter and harder-to-find enemy submarines at long enough ranges to allow US Fleet units adequate time to react. No other technologies for underwater detection (including other active sonar systems) will provide this long-range detection on a reliable basis.

Subj: LETTER OF AUTHORIZATION FOR THE INCIDENTAL TAKE OF MARINE
MAMMALS ASSOCIATED WITH THE EMPLOYMENT OF SURVEILLANCE
TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE
(SURTASS LFA) SONAR

3. The Navy intends to operate up to four SURTASS LFA Sonar systems. At present only one is operational, installed onboard the Research Vessel *Cory Chouest*.

4. Based on the scientific analyses detailed in the Draft Overseas Environmental Impact Statement and Environmental Impact Statement (DOEIS/EIS) (Reference (a)), the Navy, with NMFS as a cooperating agency, concluded that the incidental taking of marine mammals due to SURTASS LFA Sonar employment would be small and have no more than a negligible impact on the affected marine mammal stocks or habitats. This conclusion is particularly supported by the proposed mitigation measures (geographic restrictions and monitoring) that would be implemented for SURTASS LFA operations and the proposed Long Term Monitoring Program.

5. The Navy understands that NMFS will make a final decision on the request after the Navy and NMFS have completed the Final OEIS/EIS and NMFS has considered the information in the Final OEIS/EIS as well as any comments on the request for incidental take authorization.

6. I appreciate your prompt review and look forward to receiving your comments on this project. Please direct all inquiries regarding this request to Mr. Joseph S. Johnson at (703) 601-1687.

S. C. MILLER, III
Head, Undersea Surveillance

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, D.C. 20350-2000

IN REPLY REFER TO

9462
Ser N874E1/9U658989
4 Oct 99

From: Chief of Naval Operations (N874)
To: Mr. Donald R. Knowles, Director, Office of Protected Resources National Marine Fisheries Service, 1315 East West Highway, Silver Spring, MD 20910

Subj: REQUEST FOR REVIEW OF THE BIOLOGICAL ASSESSMENT FOR THE EMPLOYMENT OF SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR

Ref: (a) Draft Overseas Environmental Impact Statement and Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar, July 1999

Encl: (1) Biological Assessment for the Employment of Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar

1. The Navy requests initiation of formal consultation under Section 7 of the Endangered Species Act for the employment of the SURTASS LFA Sonar System on a worldwide basis (less the Arctic and Antarctic Oceans and certain biologically important areas) as shown in Enclosure (1). The enclosed Biological Assessment describes the proposed project. The primary action addressed in reference (a) is the transmission of underwater low frequency sound and its potential effects on various marine species, with particular regard for marine mammals and threatened and endangered species.

2. SURTASS LFA is an active sonar that would allow the Navy to meet its need in the 21st Century to detect quieter and harder-to-find enemy submarines at long enough ranges to allow US Fleet unit's adequate time to react. No other technologies for underwater detection (including other active sonar systems) would provide this long-range detection on a reliable basis.

3. The Navy intends to operate up to four SURTASS LFA Sonar systems. At present only one is operational, installed onboard the Research Vessel *Cory Chouest*.

Subj: REQUEST FOR REVIEW OF THE BIOLOGICAL ASSESSMENT FOR THE EMPLOYMENT OF SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR

4. We look forward to receiving your Biological Opinion on this project. Please direct all inquiries regarding this request to Mr. Joseph S. Johnson at (703) 604-7882.

S. C. MILLER, III
Head, Undersea Surveillance

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE NAVY
NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY
NAVAL SUBMARINE BASE NEW LONDON
GROTON, CONNECTICUT 06349-5900

IN REPLY REFER TO:
3900
Ser 01C/069
February 28, 2000

From: Commanding Officer, Naval Submarine Medical Research Laboratory (01C)
To: Dr. Andrew J. Kemmerer, Director, Office of Habitat Conservation, National Marine Fisheries Service, 1315 East-West Highway, Silver Spring, MD 20910

Subj: DETERMINATION OF NO ADVERSE EFFECTS ON ESSENTIAL FISH HABITATS FROM THE OPERATION OF SURTASS LFA SONAR

Ref: (a) Draft Overseas Environmental Impact Statement and Environmental Impact Statement (Draft OEIS/EIS) for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar, July 1999

1. The Essential Fish Habitat (EFH) provisions of the Magnuson-Stevens Fishery Conservation and Management Act require that Federal agencies consult with the National Marine Fisheries Service (NMFS) for actions that may adversely affect EFH. As detailed in reference (a), the Navy intends to operate the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar in most oceans of the world with the exception of Arctic and Antarctic areas and other specified offshore areas that are biologically important to marine animals. However, with a maximum of four systems, these deployments could only cover a very small portion the oceans during any given year. Additionally, due to operational and physical constraints, each system would operate for a maximum of only 432 hours per year.

2. Essential fish habitat is defined as waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity. The introduction of low frequency sound into an EFH would have no adverse affects to its physical aspects. Additionally, due to geographic mitigation restrictions required by reference (a), the sound field would not exceed 180 dB re: 1 µ Pa (rms) within 22 kilometers (km) (12 nautical miles [nm]) of any coastline or islands and not inside of the 200-meter (m) (656-feet [ft]) isobath for most of the East Coast of the United States. The operation of SURTASS LFA Sonar, therefore, would have negligible impacts on coastal regions.

3. The only potential for adverse effects would be to prey species. As discussed in reference (a), the potential for fish to be injured would occur only within the 180-decibel (dB) sound field of the SURTASS LFA Sonar transmit array. This area can be approximated by a flat disc that is 1 km (0.54 nm) or less in radius, approximately 65 m (212.5 ft) in height, and centered horizontally on the mid-depth (about 78 m (257 feet)) of the LFA vertical line array. The analysis in reference (a) concluded that the potential for the SURTASS LFA Sonar to affect fish stocks would not be significant.

4. Because SURTASS LFA Sonar operations are temporal in nature and have a small zone of potential injury, effects to the overall stock populations of any prey species would be negligible. Since the SURTASS LFA sonar vessel must be underway during transmissions and with most operations not being conducted at the same site, the potential for cumulative effects to any EFH is negligible.

5. Based on the above, the Navy has determined that operation of the SURTASS LFA Sonar in accordance with reference (a) would have no adverse effects on EFHs. NMFS is requested to inform the Navy if they do not agree with this finding.

6. Please direct all inquiries regarding this determination to Mr. Joseph S. Johnson at (703) 604-7882.

Joseph S J

JOSEPH S. JOHNSON
Deputy, Special Programs
By direction of the Commanding Officer

Copy to w/ ref (a):
Northeast Region EFH Coordinator
Southeast Region EFH Coordinator
Southwest Region EFH Coordinator (California)
Southwest Region EFH Coordinator (Hawaii)
Northwest Region EFH Coordinator
Alaska Region EFH Coordinator

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, D.C. 20350-2000

IN REPLY REFER TO
9462
N874/OU658949
6 Apr 00

From: Chief of Naval Operations (N874)
To: National Marine Fisheries Service, Regional Headquarters, Assistant Administrator for Fisheries, Silver Spring, MD 20910

Subj: LETTER OF AUTHORIZATION FOR THE INCIDENTAL TAKE OF MARINE MAMMALS ASSOCIATED WITH THE EMPLOYMENT OF SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR

Ref: (a) CNO (N874) ltr 9462 Ser N874/9U659009 of 12 Aug 99
(b) SURTASS LFA High Frequency Marine Mammal Monitoring (HF/M3) Sonar System Description and Test & Evaluation

Encl: (1) SURTASS LFA Sonar Potential Operating Areas (chart)
(2) Navy annual notification to National Marine Fisheries Service (NMFS) of area requirements (example)
(3) Navy Annual Report to NMFS (example)

1. By reference (a), the Navy forwarded to the NMFS a "Request for Letter of Authorization (LOA) for the Incidental Take of Marine Mammals Associated with the Employment of Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar." This letter will serve as an update to the Navy's request and lists the substantive modifications that should be made to the initial request. The updates listed below have been discussed in detail and agreed upon in principle by Mr. Kenneth R. Hollingshead of NMFS's Office of Protected Resources.

a. LOA Areas: The Navy proposes an increase from 10 to 16 total areas worldwide (enclosure 1), which more closely match the established Food and Agriculture Organization (FAO) fisheries regions. This chart also shows the addition of Offshore Biologically Important Area (OBIA) #2 (Costa Rica Dome) and the expansion of OBIA #3.

(1) Each year the Navy will furnish NMFS with the list of areas planned for LFA operations for the upcoming year. Enclosure (2) provides an example of such a notification. The

Navy will continue to work in close cooperation with NMFS on any substantive changes to SURTASS LFA ship operating schedules that involve employment of LFA outside of the operating areas covered in the LOA for that year.

(2) The Navy understands that NMFS proposes to issue one LOA for each SURTASS LFA sonar system. The above annual notification to NMFS of areas planned for LFA operations for the following year would be separate from the annual report to NMFS, discussed below.

(a) The Navy will submit annual reports (unclassified) to NMFS 90 days prior to the expiration of the current LOAs. The purpose of the annual report will be to provide information on the recent year's SURTASS LFA sonar operations with regard to marine mammals, including the Navy's assessment of whether any taking occurred within the LFA mitigation zone (180-dB sound field). Enclosure (3) is an example of such a report.

(b) <u>LOA Annual Renewal</u>: The Navy endorses the following terminology in the Proposed Rule for each LOA: "Letters of Authorization, including geographical operating areas for one year of operations using SURTASS LFA sonar #______, with automatic annual renewal for up to five years, will be contingent upon receipt from the Navy of complete annual reports and notification of the areas needed for the following year's operations. The Navy may assume automatic renewal unless otherwise notified."

(c) <u>Navy Unscheduled Operations</u>: This refers only to operations in area(s) other than those under the active LOA for that year. These instances will be rare. The Navy will notify NMFS of any unscheduled activity and, for classified operations, the Navy will provide a "classified excursion notification" to the appropriate NMFS personnel who hold the requisite security clearances.

(d) <u>Mitigation</u>: Based on preliminary assessment of the comments received during the public review of the Draft OEIS/EIS, the Navy does not anticipate any substantive changes to the proposed mitigation measures in the Final OEIS/EIS. The following information amplifies and augments reference (a). Geographic restrictions include operation of the SURTASS LFA sonar such that the sound field does not exceed: 1) 180 dB within 22 km (12 nm) of any coastline, nor in the offshore biologically important areas outside the 22-km zone (see update in 1.a above) during the biologically important season for that particular area; 2) 145 dB in the vicinity of known recreational and commercial dive sites, which secondarily mitigates impacts on marine mammals and other marine life.

(1) Under Alternative 1, SURTASS LFA sonar operators would estimate sound pressure levels prior to and during LFA transmission sequences. Navy standard acoustic models calculate received levels (RL) for various ranges and depths. These models are an integral part of the SURTASS LFA sonar processing system and provide the operators the information necessary to make decisions to modify operations, including delay or suspension of transmissions, in order not to exceed RL criteria for geographically restricted areas.

(2) Monitoring to prevent injury includes: 1) Visual monitoring; no update to reference (a); 2) Passive acoustic monitoring; no update to reference (a); and 3) High frequency active acoustic monitoring. The high frequency marine mammal monitoring (HF/M3) sonar would operate continuously at sea while the SURTASS LFA sonar is transmitting. Ongoing analysis of the HF/M3 sonar operating capabilities indicates that this system substantially increases the chances of detecting marine mammals (and possibly sea turtles) within the LFA mitigation zone; i.e., inside the 180-dB sound field (reference [b]). During 1999 engineering trials, baleen whales were detected at ranges nominally twice (2 km [1.1 nm]) those required for SURTASS LFA sonar monitoring mitigation (maximum of 1 km [0.54 nm]). The HF/M3 sonar operational effectiveness is continuously being verified and validated, including extensive engineering trials at the US Navy acoustic range at Seneca Lake, NY (February, 2000), and onboard R/V *Cory Chouest* (March-April, 2000).

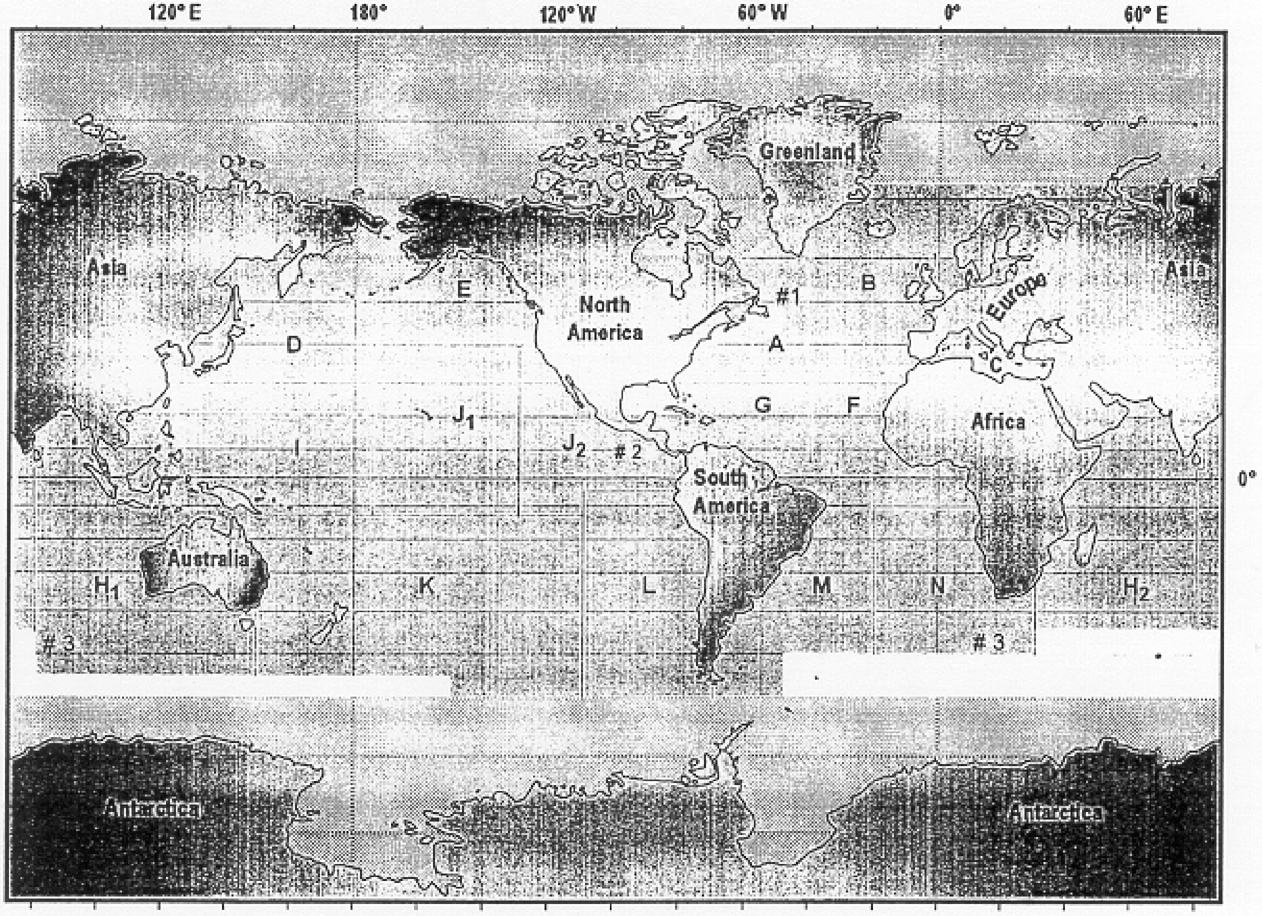
2. The Navy believes the mitigation measures it has proposed reduce the impacts on marine mammals and other marine life to the lowest extent practicable.

Subj: LETTER OF AUTHORIZATION FOR THE INCIDENTAL TAKE OF MARINE MAMMALS ASSOCIATED WITH THE EMPLOYMENT OF SURVEILLANCE TOWED ARRAY SENSOR SYSTEM LOW FREQUENCY ACTIVE (SURTASS LFA) SONAR

3. The point of contact for this project is Mr. Joseph S. Johnson (Code N874E1), who can be reached at 703-604-7882, E-mail: johnson.joseph@hq.navy.mil.

S. C. MILLER, III.
Head, Undersea Surveillance

SURTASS LFA Sonar Potential Operating Areas



Offshore Biologically Important Areas (outside of 12 nm or 22 km)

EXAMPLE ONLY
NOT FOR DISTRIBUTION OR CITATION

9462
N874/[SERIAL]
[DATE]

From: Chief of Naval Operations (N874)
To: National Marine Fisheries Service, Regional Headquarters
Assistant Administrator for Fisheries, Silver Spring,
MD 20910

Subj: NOTIFICATION OF AREAS PLANNED FOR CY 2001 SURTASS LFA SONAR OPERATIONS UNDER NMFS LETTER OF AUTHORIZATION FOR SURTASS LFA SONAR #_____

Ref: (a) NMFS LOA XXX dtd xxxxxxx

1. Pursuant to reference (a), the following is provided as notification of the areas planned for SURTASS LFA sonar #_____ operations during calendar year 2001:

a. Areas: A, B, G, F.

b. Planning schedule, tentative:

- Up to two LFA operations in Area A, one during winter and one during spring 2001.
- Up to four LFA operations in Area B, three during summer and one during fall, 2001.
- One LFA operation in Area G, during winter, 2001.
- One LFA operation in Area F, time TBD.

2. The point of contact for this project is Mr. Joseph S. Johnson (Code N874E1), who can be reached at 703-604-7882, E-mail: johnson.joseph@hq.navy.mil.

S. C. MILLER, III
Head, Undersea Surveillance

EXAMPLE ONLY
NOT FOR DISTRIBUTION OR CITATION

Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA)
Annual Report to the National Marine Fisheries Service
for the time period: 1 October 2000 through 30 September 2001

1.0 Unclassified logs of marine mammal and sea turtle sightings (bearing [deg T] and range [nm/yd] from the vessel) during SURTASS LFA sonar operations, including any delay, suspension, or termination of operations. The table below is an example of such a log.

Date	Julian Day	Time (Z)	Vessel	LOA Area	M/M or sea turtle type	No. of animals obs.	M/M pass. acous. det?	Bearing (deg T) from vessel	Range (nm/ yd) from vessel	Ops delay, sus- pend, or term?	Log keeper name	Narr/ Re- marks (1)

(1) No. times animal(s) observed, color(s), size of smallest/largest, general behavior and/or direction of movement, passive acoustic vocalization details (signal length[s], type [pulsed, continuous, etc.], loudness).

2.0 Unclassified logs of HF/M3 sonar alarms caused by detection of marine mammals or sea turtles projected to enter the LFA mitigation zone (180-dB sound field), or detected within the zone, including bearing (deg T) and range from vessel. The table below is an example of such a log.

Date	Julian Day	Time (Z)	Vessel	LOA Area	M/M or sea turtle?	No. of animals det.	LFA Mit. Zone radius	Bearing (deg T) from vessel	Range (nm/ yd) from vessel	Ops delay, sus- pend, or term?	Log keeper name	Narr/ Re- marks (1)

(1) Estimate of type(s) of animals detected, number of times animal(s) detected, estimate of size of smallest/largest, general behavior and/or direction of movement.

EXAMPLE ONLY
NOT FOR DISTRIBUTION OR CITATION

3.0 Assessment of whether any taking of marine mammal(s) occurred within the LFA mitigation zone (180-dB sound field) during SURTASS LFA sonar operations. The table below is an example of such an assessment.

Date	Julian Date	Time (Z)	Vessel	LOA Area	M/M(s) affected (no./ type)	Assess. basis (1)	LFA Mit. Zone radius	Bearing (deg T) from vessel	Ops delay, suspend, or term?	Narr/ Re-marks

(1) observed injury, behavioral response, or model calculation.

4.0 Assessment of any long-term and/or cumulative effects attributable to SURTASS LFA sonar operations, including: 1) assessment of any long-term ecological process(es) that may be exhibiting effects from SURTASS LFA sonar operations; and 2) any discernible or estimated cumulative impacts from SURTASS LFA sonar operations.

DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND
2531 JEFFERSON DAVIS HWY
ARLINGTON VA 22242-5160

IN REPLY REFER TO

6120
Ser 00C3B/3201
10 Nov 1999

SECOND ENDORSEMENT on CO,NSMRL ltr 9462 Ser 40/201 of 3 Jun 99

From: Commander, Naval Sea Systems Command (SEA 00C)
To: Chief of Naval Operations (N87)

Subj: INTERIM GUIDANCE FOR OPERATION OF LOW FREQUENCY UNDERWATER SOUND SOURCES IN THE PRESENCE OF RECREATIONAL DIVERS

Ref: (a) CO, NSMRL ltr 9462 Ser 40/201 of 3 Jun 99 with enclosures
(b) Asst Chief, BUMED ltr 6120 Ser 21/0196 of 18 Oct 99

1. Forwarded. Concur with interim guidance as outlined in enclosure (1) of reference (a) on recreational/commercial diver exposure to low frequency water-borne sound in the operating range of U.S.Navy low frequency sonar systems and related underwater sound sources.

2. As stated in reference (b), the real safety of military, recreational, and commercial divers during operation of low frequency underwater sound sources is dependent upon compliance with operational restrictions on their use within littoral areas, including adequate notification.

3. Continuing research is ongoing at Naval Submarine Medical Research Laboratory (NSMRL) to address the remainder of the low frequency region not covered by current guidance.

4. Orinators point of contact at NAVSEA OOC is CAPT Chris Murray at DSN 327-2766 or commercial (703) 607-2766 x220.

R. Asher
By direction

Copy to:
CO, NHRC
BUMED MED-26
CO, NSMRL

DEPARTMENT OF THE NAVY
BUREAU OF MEDICINE AND SURGERY
2300 E STREET NW
WASHINGTON DC 20372-5300

IN REPLY REFER TO

6120
Ser 21/0196
18 Oct 99

[illegible]

SUPSALV

FIRST ENDORSEMENT on CO, NSMRL ltr 9462 Ser 40/201 of 3 Jun 99

From: Assistant Chief, Operational Medicine and Fleet Support (MED-02)
To: Chief of Naval Operations (N87)
Via: Commander, Naval Sea Systems Command (NAVSEA-OOC)

Subj: INTERIM GUIDANCE FOR OPERATION OF LOW FREQUENCY UNDERWATER SOUND SOURCES IN THE PRESENCE OF RECREATIONAL DIVERS

Ref: (a) CO, NSMRL ltr 9462 Ser 40/201 of 3 Jun 99 with enclosures

1. Forwarded. As outlined in enclosure (1) of reference (a), concur with the interim guidance on recreational/commercial diver exposure to low frequency water-borne sound in the operating range of U.S. Navy low frequency sonar systems and related underwater sound sources. As stated in enclosure (2) of reference (a), "the guidance must be understood as a whole, that is, the components do not stand alone, but are derived based on all of the components in the guidance taken together."

2. Frequency and sound pressure are set and therefore known at the source. The way the sound pressure leaving the source attenuates in the water is subject to many variables (including frequency, water depth, bottom type, temperature and salinity layers, etc.). Consequently, the sound pressure arriving at a diver in the water column, within the range of the sound source, can only be predicted.

3. The real safety of military, recreational, and commercial divers during operation of low frequency underwater sound sources is dependent upon compliance with operational restrictions on their use within littoral areas, including adequate notification.

4. Naval Submarine Medical Research Laboratory (NSMRL) is implementing a monitoring and mitigation program for divers with SPAWAR support in association with deployment of the SURTASS Low Frequency Active (LFA) system. NSMRL is also leading a three year research effort funded by Office of Naval Research to address the remainder of the low frequency region not covered by current guidance, namely 500 – 2500 Hertz. This work will provide the basis for any additional guidance on the safe operation of low frequency underwater sound sources.

5. My point of contact at BUMED is CAPT John Murray at DSN 762-3449 or commercial (202) 762-3449.

Joan M. Engel
JOAN M. ENGEL
Assistant Chief for Operational
Medicine and Fleet Support

ENCLOSURE( )

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE NAVY
NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY
NAVAL SUBMARINE BASE NEW LONDON
GROTON, CONNECTICUT 06349-5900

IN REPLY REFER TO:
9462
Ser 40/201
03 June 1999

From: Commanding Officer
To: Chief of Naval Operations, ATTN: Director, Submarine Warfare Division (N87), 2000 Navy Pentagon, Room 4D542, Washington, DC 20350-2000
Via: (1) Chief, Bureau of Medicine and Surgery (BUMED-21)
(2) Commander, Naval Sea Systems Command (Code OOC)

Subj: INTERIM GUIDANCE FOR OPERATION OF LOW FREQUENCY UNDERWATER SOUND SOURCES IN THE PRESENCE OF RECREATIONAL DIVERS

Ref: (a) COMSPAWAR ltr 9462 Ser PMW182P/197
(b) NSMRL ltr Ser 01/1016 of 04 October 1995

Encl: (1) Subject Interim Guidance
(2) Draft NSMRL Technical Report, "Summary Report on the Bio-effects of Low Frequency Water Borne Sound"

1. In response to tasking outlined in reference (a), enclosure (1) provides interim guidance on recreational diver exposure to low frequency water borne sound in the operating range of US Navy low frequency sonar systems and related underwater sound sources.

2. The background section in enclosure (2) provides a context for the user. In addition, the following summary outlines the rationale for the guidance:

a. The guidance specifications primarily reflect those conditions which were found to be free of significant problems and are based on experimental evidence.

b. No standoff distance is provided due to the extreme difficulty of accurately predicting wave propagation in shallow water.

c. No arbitrary safety factor was used in any calculation.

d. No depth, gender, or equipment restrictions are provided, as hard data are lacking to suggest these are major concerns at the proposed guidance sound intensity limits. Evidence did suggest that lung resonance did increase as a function of diver depth and at deeper depths (greater than 200 feet) lung resonance could be possible within the guidance frequency band, but would not cross 150 Hz until between 600 and 700-foot depths. Equipment used by divers during testing included neoprene wet suits.

ENCLOSURE( )

e. Three representative waveforms from LFA (pure tones and two frequency sweeps) were selected by the researchers for testing. The nature of future waveform changes will dictate whether additional testing will be necessary.

3. The guidance can be generalized only to those populations comparable in fitness to with fitness comparable to the general population, excluding those with compromised cardiovascular, respiratory, and neurological systems which may be more susceptible to sound-induced injury.

4. The guidance is interim and limited to the parameters outlined in enclosure (1). Information was not available to address the following:

- frequencies lower than 100 Hz or higher than 500 Hz
- continuous sound exposures between 100 seconds and 5 minutes.

5. <u>Recommendations</u>:

a. Approve interim guidance.

b. Direct operational forces to notify the diving community, both recreational and commercial, of their intentions to operate the low-frequency underwater sound.

c. Educate the global diving community as to what the diver may experience in the presence of low frequency underwater sound.

d. Assign top priority and resources for research to the determination of damage risk thresholds by frequency and type of sound exposure (i.e., continuous (above 500 Hz), intermittent, impulsive).

6. Additional dissemination of study findings will be forthcoming from this laboratory. NSMRL technical points of contact are Dr. Edward Cudahy at 860-694-3391 and LT Eric Hanson at 860-694-2510.

M T Wooster
M. T. WOOSTER

Copy to:
CO, NHRC
BUMED MED-26

Guidance for Recreational/Commercial Diver Exposure
to
Low-Frequency Water-Borne Sound

1. **Purpose**:

This interim guidance addresses the potential risk to divers exposed to intense underwater sound generated by low-frequency sonar and other sound systems that deliver low frequency, non-impulsive sound.

2. **Scope**:

It applies to recreational and commercial divers who are diving in accordance with standard diving practice and who are diving without physical conditions considered disqualifying for diving.

3. **Guidance**:

For sonars and other underwater sound sources operating in the narrow frequency band of 100-500 Hz (excluding blast/impulse noise), the following guidance applies:

a) do not exceed overall sound pressure of 145 dB re 1 μPa, measured or estimated at the site of the diver with the diver absent,

b) total exposure time is limited to 3 hours per day (cumulative exposure to sound <u>on</u>),

c) pulse length is limited to 100 seconds (duration over which sound is <u>on</u> continuously),

d) duty cycle is limited to 20% (during exposure, sound <u>off</u> duration between sound <u>on</u> should be 4 times the duration of sound <u>on</u>),

e) for sound pressures below 145 dB re 1 μPa, total cumulative exposure may be doubled for every 4 dB decrease in sound pressure.

ENCLOSURE(1)

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEPARTMENT OF THE NAVY
NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY
NAVAL SUBMARINE BASE NEW LONDON
GROTON, CONNECTICUT 06349-5900

IN REPLY REFER TO:

3900
Ser 01C/276
29 Nov 00

From: Commanding Officer, Naval Submarine Medical Research Laboratory (01C)
To: Daniel Basta, Acting Chief, National Marine Sanctuary Program, NOAA SSMC4 (N/ORM6), 1305 East-West Highway, 11th Floor, Silver Spring, MD 20910

Subj: CONSULTATION UNDER THE NATIONAL MARINE SANCTUARIES ACT FOR THE OPERATION OF SURTASS LFA SONAR

Ref: (a) Draft Overseas Environmental Impact Statement and Environmental Impact Statement (Draft OEIS/EIS) for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar, July 1999

1. The National Marine Sanctuaries Act (16 U.S.C. 1431 et. seq., as amended) requires that Federal agencies consult with the Office of Ocean and Coastal Resource Management, National Ocean Service for actions that are likely to destroy, cause the loss of, or injure any sanctuary resource. As detailed in reference (a), the Navy proposes to operate the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar in oceanic areas with the exception of Arctic and Antarctic areas and other specified offshore areas that are biologically important to marine animals.

2. The Navy prepared a Draft OEIS/EIS in July 1999 to study the potential environmental effects of the employment of the SURTASS LFA sonar system 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 purpose of the proposed action is to meet U.S. need for improved capability to detect quieter and harder-to-find foreign submarines at long range. 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.

3. 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 (Restricted Operation), and Alternative 2 (Unrestricted Operation). Alternative 1 is the Navy's preferred alternative.

4. National Marine Sanctuaries (NMSs) are areas designated and managed by the Secretary of Commerce that are marine environments with nationally significant aesthetic, ecological, historical, or recreational values. There are 13 designated NMSs. Sanctuary regulations require that military activities be carried out in a manner that avoids to the maximum extent practicable adverse impacts on Sanctuary resources and qualities. The Navy has determined that Alternative 1 (Restricted Operation - the Navy's preferred alternative) of the Draft OEIS/EIS would meet this requirement.

5. Alternative 1 (Restricted Operation - the Navy's preferred alternative) best meets the U.S. Navy's purpose and need while minimizing potential environmental effects. This alternative includes geographic restrictions and monitoring to mitigate effects on the marine environment, while satisfying the stated purpose of the proposed action to meet U.S. need for improved capability to detect quieter and harder-to-find foreign submarines at long range.

6. The following geographic restrictions would limit the coastal areas in which the Navy would deploy the SURTASS LFA sonar under this alternative (as discussed in the Draft OEIS/EIS) such that the sound field does not exceed:

- 180 dB within 22 km (12 nm) of any coastline (including islands), nor in offshore biologically important areas that exist outside of the 22-km (12 nm) zone during biologically important seasons; and

- 145 dB in the vicinity of known recreational and commercial dive sites. Sites frequented by recreational divers are generally defined as from the shoreline out to the 40-meter (m) (130-feet [ft]) depth contour.

7. Implementation of the preferred alternative also provides for monitoring during operations of the SURTASS LFA sonar to prevent injury to marine mammals (and possibly sea turtles) by ensuring to the maximum extent possible that they are not within

the LFA mitigation zone (180-dB SURTASS LFA sonar sound field) during LF transmissions.

LFA Mitigation Zone

The LFA mitigation zone covers an area ensonified to a level ≥ 180 dB by the SURTASS LFA sonar transmit array. Under normal operating conditions, the range of this 180-dB sound field will vary between the nominal ranges of 0.75 to 1.0 km (0.40 to 0.54 nm) from the source array over a depth of approximately 122 ± 35 m (400 ± 115 ft). (The center of the array is at a nominal depth of 122 m [400 ft]). Under rare conditions (e.g., strong acoustic duct) this range could be somewhat greater than 1 km (0.54 nm). Knowledge of local environmental conditions (such as sound speed profiles [depth vs. temperature] and sea state) that affect sound propagation is critical to the successful operation of the SURTASS LFA sonar and is monitored on a near-real-time basis. Therefore, the SURTASS LFA sonar operators would have foreknowledge of such anomalous acoustic conditions and would mitigate to the 180-dB range even when this was beyond 1 km (0.54 nm).

8. The following three monitoring techniques would be utilized:

- Visual monitoring for marine mammals and sea turtles from the SURTASS LFA sonar vessel during daylight hours;
- Use of the passive (low frequency) SURTASS array to listen for sounds generated by marine mammals as an indicator of their presence; and
- Use of high frequency (HF) active sonar to detect/locate/track potentially affected marine mammals (and possibly sea turtles) near the SURTASS LFA sonar vessel and the sound field produced by the SURTASS LFA sonar source array.

9. The Navy has determined that operation of the SURTASS LFA sonar in accordance with Alternative 1 (Restricted Operation - preferred alternative) of reference (a) would not destroy, cause the loss of, or injure any sanctuary resource, and therefore no

consultation with the Office of Ocean and Coastal Resource Management is required. Please inform the Navy if you do not agree with this finding.

10. Please direct all inquiries to me at (703) 604-7882.

Joseph S. Johnson
Deputy, Special Programs
By direction of the
Commanding Officer

APPENDIX B

FUNDAMENTALS OF UNDERWATER SOUND

APPENDIX B

FUNDAMENTALS OF UNDERWATER SOUND

This appendix provides a tutorial on the fundamentals of underwater sound to assist the reader in understanding the technical aspects of the operation of the SURTASS LFA sonar and the determination of its potential impacts to the oceanic environment.

B.1 Description of Sound

Sound is a wave of pressure variations propagating through a medium, as shown in Figure B-1 (Sound Pressure Propagation). Pressure variations are created by compressing and relaxing the medium. In human speech, vibrations of the vocal chords create pressure variations. In a loud speaker, the motion of the diaphragm creates pressure variations. The motion of the speaker diaphragm is most noticeable in the "woofer" or bass element of a speaker.

One of the simplest forms of pressure variation is a pure tone, which can be described by a sine function. This is shown in Figure B-2 (Pure Tone Sound Wave). Each cycle of a pure tone consists of an interval of higher and lower pressure, and the frequency of a tone is measured by the number of cycles it completes in a second. These units are called Hertz, or cycles per second, and abbreviated as Hz. The usual metric prefixes apply (e.g., 1,000 Hz is equal to 1 kilohertz [kHz]). The wavelength of a pure tone is measured as the number of meters traveled by the sound in the course of one cycle. This depends on the speed of sound, and it can be calculated as the speed of sound divided by the frequency. The speed of sound in seawater varies slightly as discussed below, but a rough figure is 1,500 m/s. Thus, the wavelength of a 100-Hz tone in seawater is 15 m, and the wavelength of a 500 Hz tone is 3 m. A sound with a high frequency has a high tone or pitch, many cycles per second, and each oscillation (cycle) travels a short distance. A sound with a low frequency has a low tone or pitch, few cycles per second, and each oscillation (cycle) travels a long distance. As a reference for the layman, middle C on a piano is about 262 Hz (Richardson et al., 1995b).

Sound tends to follow many paths through the ocean, so that a listener hears multiple, delayed copies of the transmitted signal. Echoes are a familiar example of this phenomenon in air. In order to determine what the paths of sound transmission are, one rule is to seek paths that deliver the sound to the receiver the fastest. These are called acoustic rays. If the speed of sound were constant throughout the ocean, acoustic rays would consist of straight-line segments, with reflections off the surface and the bottom. However, because the speed of sound varies in the ocean, most acoustic rays are curved. Examples of curved acoustic rays can be seen in Figure B-3 (Ray Diagram).

Sound Pressure Propagation

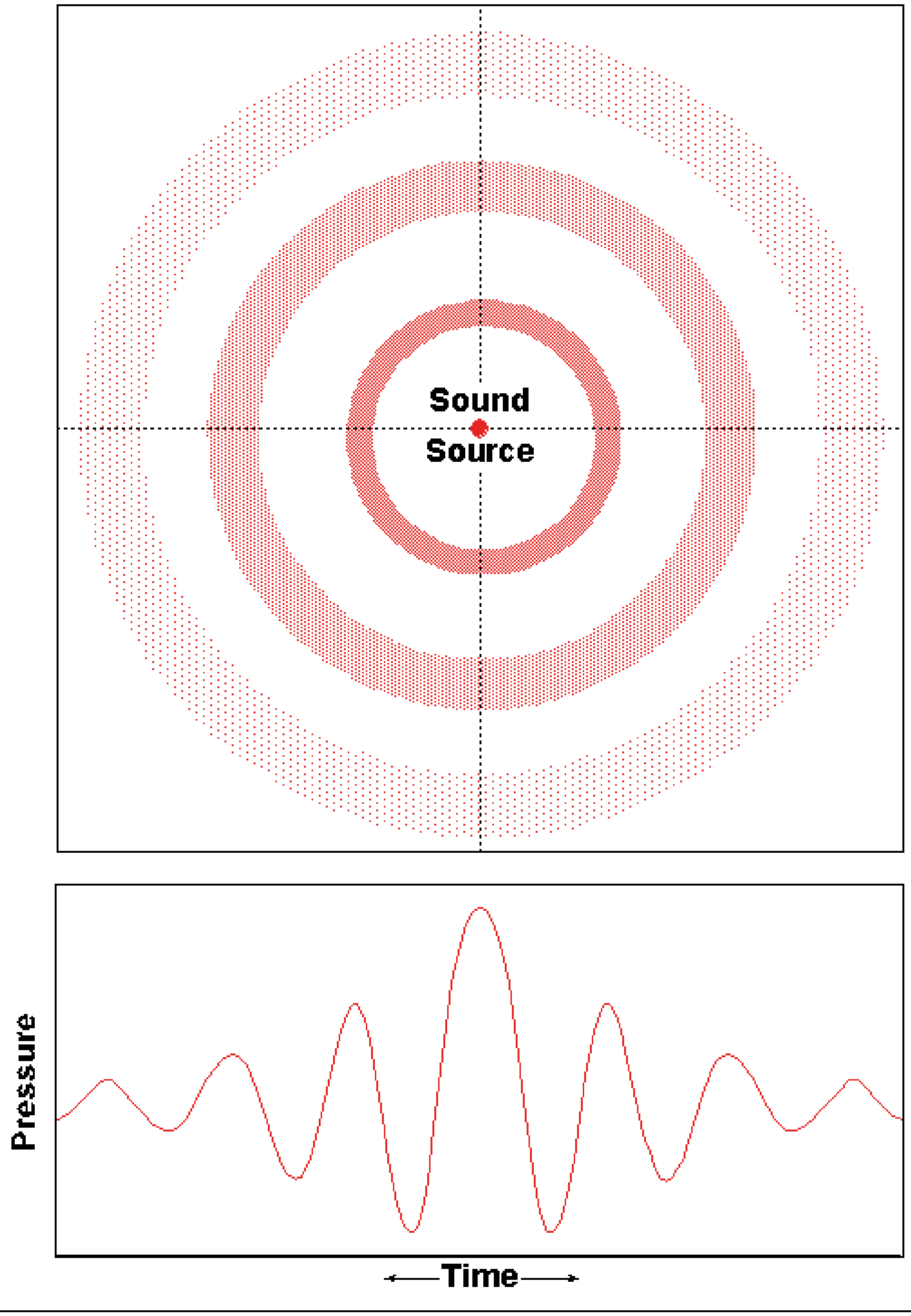


Figure B-1

Pure Tone Sound Wave

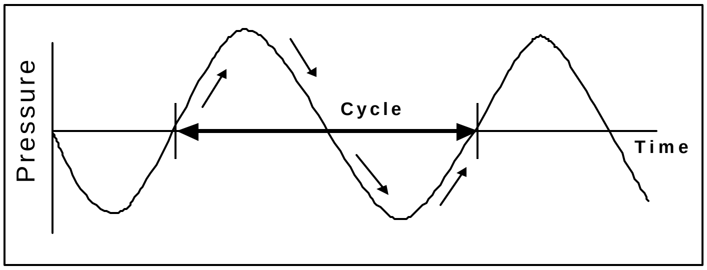
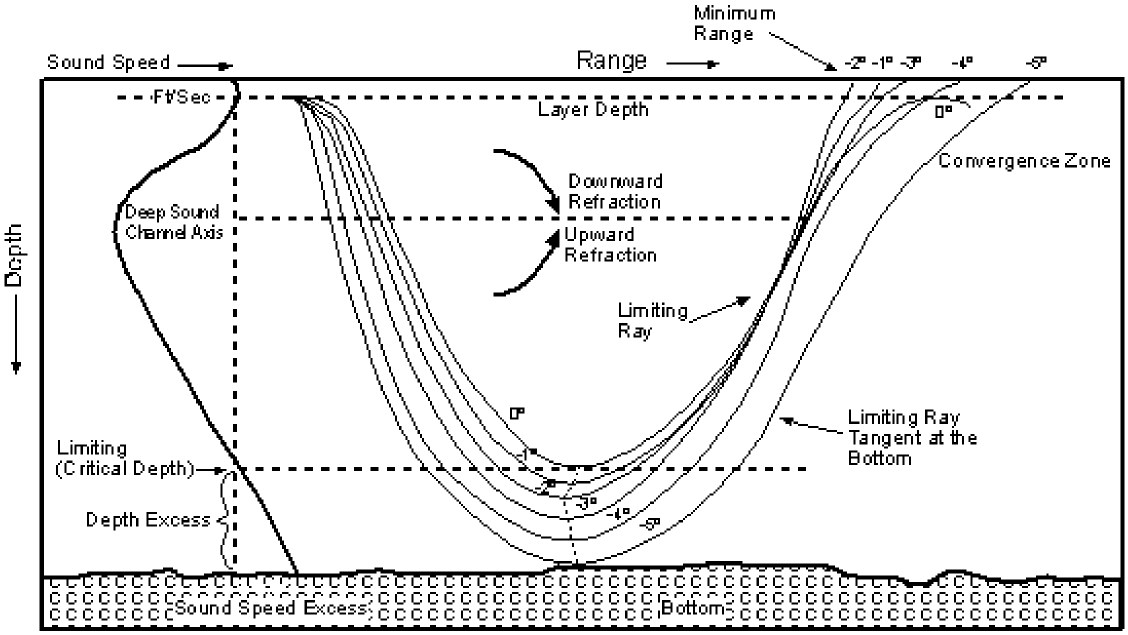


Figure B-2

Ray Diagram

Convergence Zone Propagation and Terminology



Adapted from COMNAVOCEANCOM Tactical Support Manual, 1981.

Figure B-3

B.2 Sound Speed in Seawater

Sound speed in seawater is approximately 1,500 m/s (5,000 ft/s) and varies with water density. Water density is affected by water temperature, salinity (the amount of salt in the water), and depth (pressure). The speed of sound increases as temperature and depth (pressure), and to a lesser extent, salinity, increase.

The variation of sound speed with depth of the water is generally presented by the “sound speed profile (SSP)." This profile varies with geographic latitude, season, and time of day. A typical deep-sea SSP is shown in Figure B-4 (Typical Deep-Sea Sound Speed Profile). The profile may be divided into several layers having different characteristics:

- Just below the sea surface is the *surface layer*, in which the velocity of sound is susceptible to daily and local changes of heating, cooling and wind/wave action.
- Below the surface layer lies the *seasonal thermocline,* characterized by a negative thermal or speed gradient (temperature or speed decreasing with depth) that varies with the seasons.
- Underlying the seasonal thermocline is the *main thermocline,* which is affected only slightly by seasonal changes.
- Below the main thermocline and extending to the sea bottom is the *deep isothermal layer* having a nearly constant temperature (near 4^{o} C), in which the speed of sound increases with depth because of increasing pressure.

In the shallow waters of coastal regions and on the continental shelves, the SSP is greatly influenced by surface heating and cooling, salinity changes, and water currents. As a result, it tends to be irregular and unpredictable, and contains numerous gradients that last over short time and space scales.

When the speed of sound varies gradually either horizontally or vertically, a sound speed gradient exists and sound propagates along curved paths (rather than straight lines). This phenomenon is called *refraction*.

A variation in sound speed with depth is a vertical sound speed gradient. The magnitude of the gradient is the change in speed divided by the change in the linear dimension. The amount of ray bending that occurs is directly related to the magnitude of the gradient, as seen in Figure B-3:

- If the sound speed *increases* with depth, the gradient is said to be *positive*. It is producing a ray curvature that bends *upward* towards the depth of minimum sound speed;

Typical Deep-Sea Sound Speed Profile

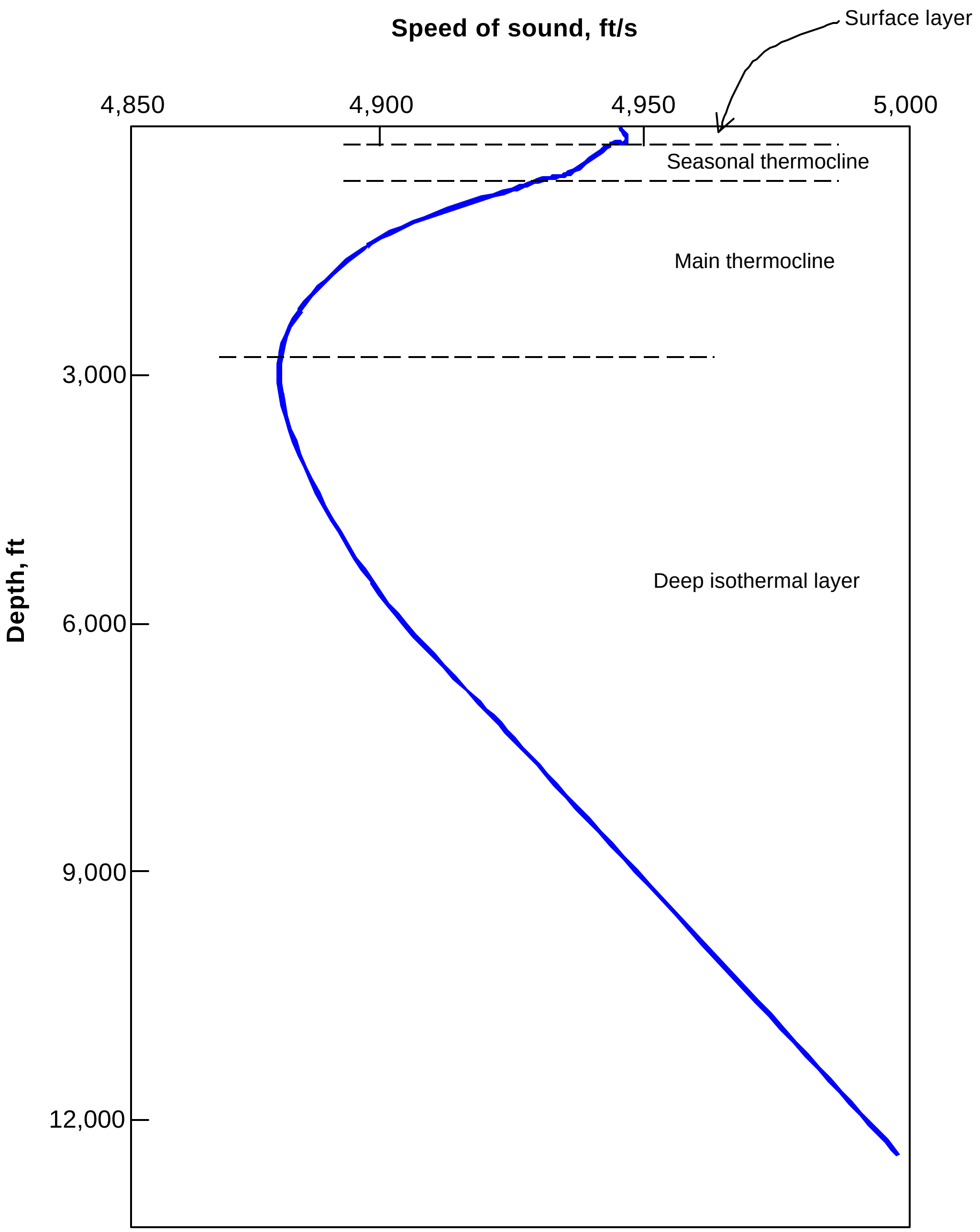


Figure B-4

- If the sound speed *decreases* with depth, the gradient is said to be *negative.* It is producing a ray curvature that bends *downward* toward the depth of minimum sound speed; and

- If the sound speed is the same at all points (i.e., an isovelocity layer exists), sound travels in straight lines.

B.3 Measuring the Intensity of Sound

Sound measurements can be expressed in two forms: *intensity* and *pressure*. The intensity of the sound is the average rate of energy transmitted through a unit area in a specified direction, expressed in watts per square meter (W/m^2). Acoustic intensity is rarely measured directly. Instead, when acousticians refer to intensities or powers, they derive it from ratios of *pressures*. To present sound measurements as ratios of pressures that can be compared to one another, a standard reference pressure needs to be used in the denominator of the ratio. The American National Standard and the international (metric) standard are to use 1 microPascal (µPa) as the reference pressure for underwater sound and 20 µPa as the reference pressure for airborne sound.

Once a reference pressure is chosen, a means of relating different pressure ratios to each other is needed. Since our ears respond logarithmically when judging the relative loudness of two sounds, acousticians adopted a logarithmic scale for sound intensities and denoted the scale in decibels (dB).

All decibel measurements state the ratio between a measured pressure value and a reference pressure value. The logarithmic nature of the scale means that each 10 dB increase is a ten-fold increase in power (e.g., 20 dB is a 100-fold increase, 30 dB is a 1,000-fold increase). Humans perceive a 10 dB increase in noise as a doubling of sound level, or a 10 dB decrease in noise as a halving of sound level. The phrase "sound pressure level" implies a decibel measure and that a reference pressure has been used as the denominator of the ratio.

Comparing decibel values for various noise sources must be done carefully, since those values do not always represent equivalent information. For example, *spectral* values represent the power levels within one-Hertz "slices" whereas *broadband* levels are the total power over a specified bandwidth or portion of the spectrum emitted by a sound source.

B.3.1 Source Level in the Near-Field/Far-Field Regions

One method of forming a very narrow beam of underwater sound is to use a vertical line array (VLA) of individual "point-like" source projectors. The beam is formed by equally spacing these projectors at a distance of about one-half an acoustic wavelength. When operated coherently with each projector turned on at the same time (with the same phase signal, and using the same power level and frequency) the outputs from the projectors combine to form the desired narrow horizontal beam.

This beam, however, is not fully formed for some distance away from the VLA, in the region called the “far-field.” The closer region where the beam is still forming is called the “near-field.” What is physically occurring is that the levels from all of the individual projectors will only finally add together at the same power level and phase when the distance from each projector is approximately the same. Acoustically, this means that the difference in distance from each projector to a point on the horizontal axis, outward from the center of the VLA, must be less than one-quarter an acoustic wavelength. For SURTASS LFA sonar, this condition is satisfied at a range in the “far-field” on the order of hundreds of meters. Only at this point is the full system capability focused in a beam. Because this point is hundreds of meters from the VLA itself, transmission losses (TL) cause the level there to be approximately 40 to 50 dB less than the “effective” source level. “Effective” source level is a theoretical value, hypothetically measured at 1 m from the array on its horizontal axis, calculated from the formula: $SL_E + 20 \text{ Log}_{10}(N)$, where SL_E = SL of an individual projector and N = number of projectors.

Another way of illustrating this phenomenon is to visualize the way individual projectors add up moving outwardly along the horizontal axis of the VLA. At a very short range in the “near-field” (for example, 10 m [33 ft]), the levels from only two or three projectors will be coherently combining, as the others are relatively too far away to contribute an equivalent amount of power. At this example distance of 10 m (33 ft), the level from each of the two center projectors in the VLA would be 195 dB (215 dB – 20 dB of TL due to spherical spreading). Adding these two levels together would produce an on-axis level of 201 dB (195 dB + 6 dB from coherent addition). All of the other 16 projectors are either too far away (i.e., higher TL) or are out of phase, such that they do not coherently add, and do not contribute significantly to the dominant effect of the two nearest projectors. Moving farther outward along the VLA’s horizontal axis, successive projectors begin to coherently add only when the effective distance their sounds must travel equalizes (within one-quarter of an acoustic wavelength) with adjacent projectors, until finally all are in phase at several hundred meters away.

The net effect is a somewhat constant (but slightly decreasing with range) level in the “near-field.” This level is equivalent to the source level of an individual projector, or less. As described above, this region of somewhat constant level results from the offsetting combination of individual projector contributions falling off with distance from the VLA, combined with an offsetting increase in focusing as more projectors coherently add. It is only at distances greater than a few hundred meters that the VLA finally replicates a point source. At this transition point the focused beam level is approximately 20 dB less than the source level of an individual projector.

B.3.2 Comparison of Sound Intensity Measurements in Air Versus In Water

Similarly, comparing sound (or acoustic) intensity levels in air against those in water must be done carefully. First, due to accepted convention, the standard air reference pressure is 20 µPa, as compared to 1 µPa for water, a different of 26 dB (Urick, 1983; Richardson et al., 1995b). This is based on the relationship that:

$$\text{SPL (dB)} = 20 \log (P/P_0)$$
$$\text{SPL (dB)} = 20 \log (20/1)$$
$$\text{SPL (dB)} = 26 \text{ dB}$$

Second, due to the large differences of the impedances of air and water (density, sound velocity product), a greater power (or intensity) level is necessary in air than in water to produce an equivalent intensity level. Acoustic intensity is defined as:

$$I = p^2/\rho c$$

where ρ is the density and c is the sound velocity of the medium. The product (ñc) is known as the specific acoustic impedance and is approximately equal to $1.5\text{x}10^6$ Pa s/m in water and 416 Pa s/m in air (Au et al., 1997). Letting the intensities of the underwater signal be equal to the intensity of the airborne signal then:

$$p_{water}^2/\rho c_{water} = p_{air}^2/\rho c_{air}$$

$$p_{water}^2/p_{air}^2 = \rho c_{water}/\rho c_{air}$$

$$p_{water}^2/p_{air}^2 = 1.5\text{x}10^6 \text{ Pa s/m}/416 \text{ Pa s/m}$$

$$p_{water}/p_{air} = 60$$

$$\text{SPL} = 20 \log (p_{water}/p_{air}) = 20 \log (60)$$

$$\text{SPL} = 35.5 \text{ dB}$$

Combining these two factors for the differences in reference standards and the impedances of air and water, a 61.5 dB difference or, correction factor, between the two scales is required. Therefore, 61.5 dB must be subtracted from a sound level in water to produce an equivalent acoustic pressure in air.

Given the potential for confusion of sound pressure levels in air and those in water, this OEIS/EIS generally avoids cross-media comparisons between air and water. All sound values presented in this OEIS/EIS are water-standard values unless otherwise specified. Also, all references are broadband-level values given in dBs, standardized at 1 microPascal at 1m (dB re

1µPa at 1 m) for source levels (SL), and dB re 1 µPa rms (root mean squared) for pressure level measurements (received levels [RL]).

B.4 Underwater Sound Propagation

To determine the received pressure level of a sound at a distance from its source, the environmental factors that may influence the underwater propagation of sound energy must be addressed. These environmental factors include:

- Transmission loss; and
- Reflection and scattering.

B.4.1 Transmission Loss (TL)

As sound travels through the ocean, the intensity associated with the wavefront diminishes, or attenuates. This decrease in intensity is referred to as propagation loss, also commonly called transmission loss (TL). The total propagation loss is the difference between the intensity of acoustic waves of a specified frequency at a point near a source, and the intensity of the same waves at some distant point. Sound propagation losses are caused by numerous factors, of which the most predominant are absorption losses and spreading losses. These losses occur with every transmission through water.

Sound transmission loss in water depends on the following:

- **Frequency.** Frequency affects attenuation, or how far sound waves travel before losing so much energy they cannot cause the medium to vibrate. High frequency waves are greatly absorbed (have a high attenuation coefficient), and thus propagate, or travel, shorter distances than those at lower frequencies.

- **Spreading**. The spreading of a wavefront causes the total power associated with the wavefront to be distributed over an increasingly large area with a resulting decrease in intensity. This loss is not dependent on frequency.

  In deep, homogenous water, sound initially spreads spherically (*spherical spreading*) and its intensity decreases in proportion to the square of the range. Once sound has propagated to a distance approximately equal to the water depth, it acts as if it is in a duct and propagates cylindrically (*cylindrical spreading*). When this occurs, its intensity decreases in direct proportion to the range.

- **Absorption**. Absorption is the transfer of acoustic energy into heat. In order for sound to propagate through a medium, that medium must be moved. The viscosity of the medium, or its ability to resist flow causes absorption. Sound energy is also

  lost, or absorbed, by the ionic relaxation, or stretching, of the chemical bonds holding the magnesium sulfate ($MgSO_4$) molecules together. Urick (1983) treats the complex mechanism of absorption in seawater in detail.

B.4.2 Reflection and Scattering

When sound waves interact with a hard boundary such as the sea surface, the seafloor, or flora and fauna in the water column, one of two processes can occur. If the boundary is smooth relative to the wavelength of the sound, the sound will be coherently reflected at an angle equal to the angle of incidence as shown in Figure B-5 (Reflection of Sound Energy). However, if the surface is rough compared to the wavelength, sound will be scattered in all directions as depicted in Figure B-6 (Scattering of Sound Energy).

B.5 Acoustic Ray Paths

In order to visualize the propagation of sound in water, acoustic rays can be created which trace the paths of points on the wave front. Rays describe where in space the sound from the source is being sent. The distance between adjacent rays demonstrates the transmission loss due to spreading. Examples of acoustic rays can be seen in the ray diagrams in Figures B-3 and B-7 (Typical Modes of Underwater Sound Propagation).

B.5.1 Surface Ducts

Usually, the top layer of the ocean is well mixed, meaning that it has a constant value for temperature and salinity except in winter or northern latitudes. SURTASS LFA sonar operates below any surface ducts. In the former case, it is really a half duct. Because of the effect of depth (pressure), surface layers exhibit a slightly positive sound speed gradient, and sound rays emitted from a source within this layer will be refracted upward and surface-reflected. Because this characteristic causes acoustic rays to remain in this layer, the surface layer is often called a duct.

In surface ducts, the maximum range of reception (i.e., how far the sound can possibly travel) will depend upon the sound frequency, the SSP, the bottom slope, and depth. As a general rule, surface duct propagation will improve as the layer depth increases. Finally, surface ducts are also limited in range by ocean near-surface water mass variations (i.e., the ocean thermal conditions which supported the duct disappear at some distance, thus no longer trapping the sound).

Reflection of Sound Energy

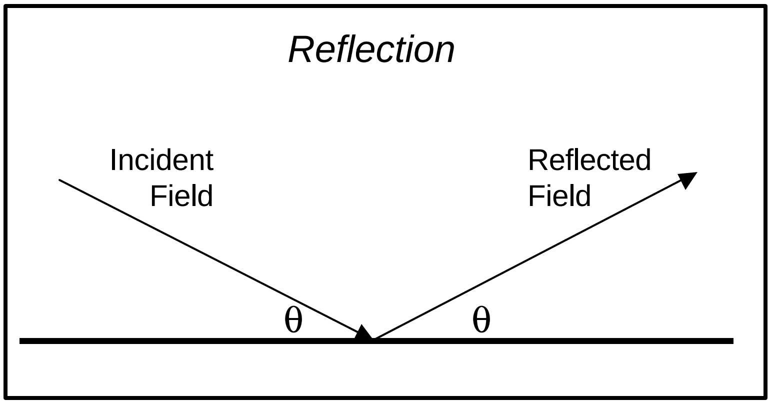


Figure B-5

Scattering of Sound Energy

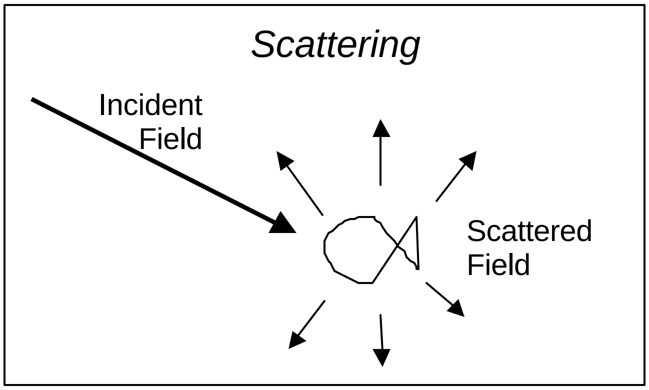


Figure B-6

Typical Modes of Underwater Sound Propagation

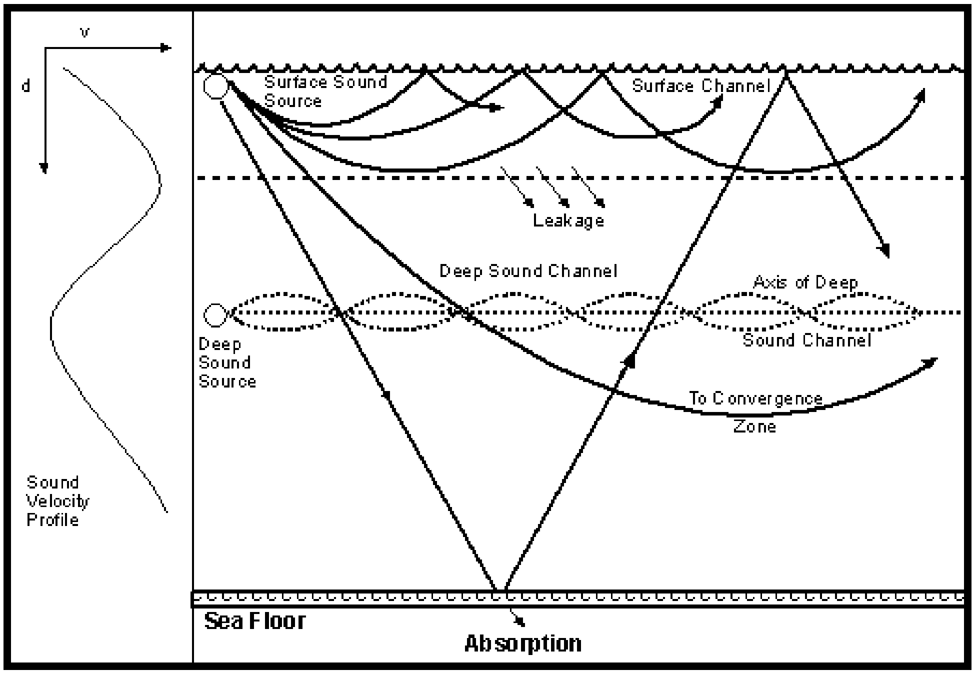


Figure B-7

B.5.2 Sound Channels

Variation of sound velocity with depth causes sound rays to travel in curved paths. A region in the water column where sound speed first decreases with depth to a minimum value, and then increases, is referred to as a sound channel (Figures B-3 and B-7). Above the depth of minimum value, sound rays are bent (refracted) downward; below the depth of minimum value, sound rays are refracted upward; thus, sound rays starting in the channel are trapped. This mode of propagation is called sound channel propagation and allows the least transmission loss along the path, thus resulting in long-range transmission.

B.5.3 Bottom Bounce

Reflections from the ocean bottom can extend propagation ranges. The effect of bottom bounce is to return the sound energy that has been carried downward by refraction into the water column, enabling longer-range transmission (Figure B-7).

At low frequencies, some energy penetrates the sediment layer of seafloor and within this layer is refracted back to the boundary between the water and the seafloor, and is then returned to the water column. At low frequencies this refraction within the seafloor, not reflection, is the predominant mechanism for energy return. At mid- to high-level frequencies (greater than 1,000 Hz), reflection is the predominant mechanism for energy return because energy is reflected off the seafloor, but never enters that layer.

Major factors affecting bottom-bounce transmission include the sound frequency, water depth, angle of incidence, bottom composition, and bottom roughness. A flat ocean bottom produces the greatest accuracy in estimating range and bearing in the bottom-bounce mode.

B.5.4 Convergence Zones

Convergence zones (CZ) are special cases of the sound-channel effect. When the surface layer is thin or becomes downward refracted, regions are created at or near the ocean surface where sound rays are focused, resulting in concentrated high sound levels. The existence of convergence zones depends on the SSP and the depth of the water. Due to downward refraction at shorter ranges, sound rays leaving the near-surface region are refracted back to the surface because of the positive sound speed gradient produced by the greater pressure at deep ocean depths. These deep-refracted rays often become concentrated at or near the surface at some distance from the sound source through the combined effects of downward and upward refraction, thus causing a convergence zone.

Convergence zones may exist whenever the sound speed at the ocean bottom, or at a specific depth, exceeds the sound speed at the source depth. Depth excess, also called sound speed excess, is the difference between the bottom depth and the limiting, or critical depth, as shown in Figure B-3.

Convergence Zones

Convergence Zone Range - Convergence zones vary in range from approximately 18 to 36 nm (33.35 to 66.7 km), depending upon the sound speed profile.

Convergence Zone Width - The width of the convergence zone is a result of complex interrelationships and cannot be correlated with any specific factor. In practice, however, the width of the zone is usually on the order of 5 to 10 percent of the range.

B.5.5 Shallow Water Propagation Paths

In shallow water, propagation is usually characterized by multiple reflection paths off the sea floor and sea surface. Thus, most of the water column tends to become ensonified by these overlapping reflection paths. The bottom properties pertinent to sound transmission in shallow water vary considerably from one geographic region to the next. However, the most common bottom types are: (1) sand; (2) sand and mud; and (3) mud. The three environmental factors that determine sound propagation in shallow water are:

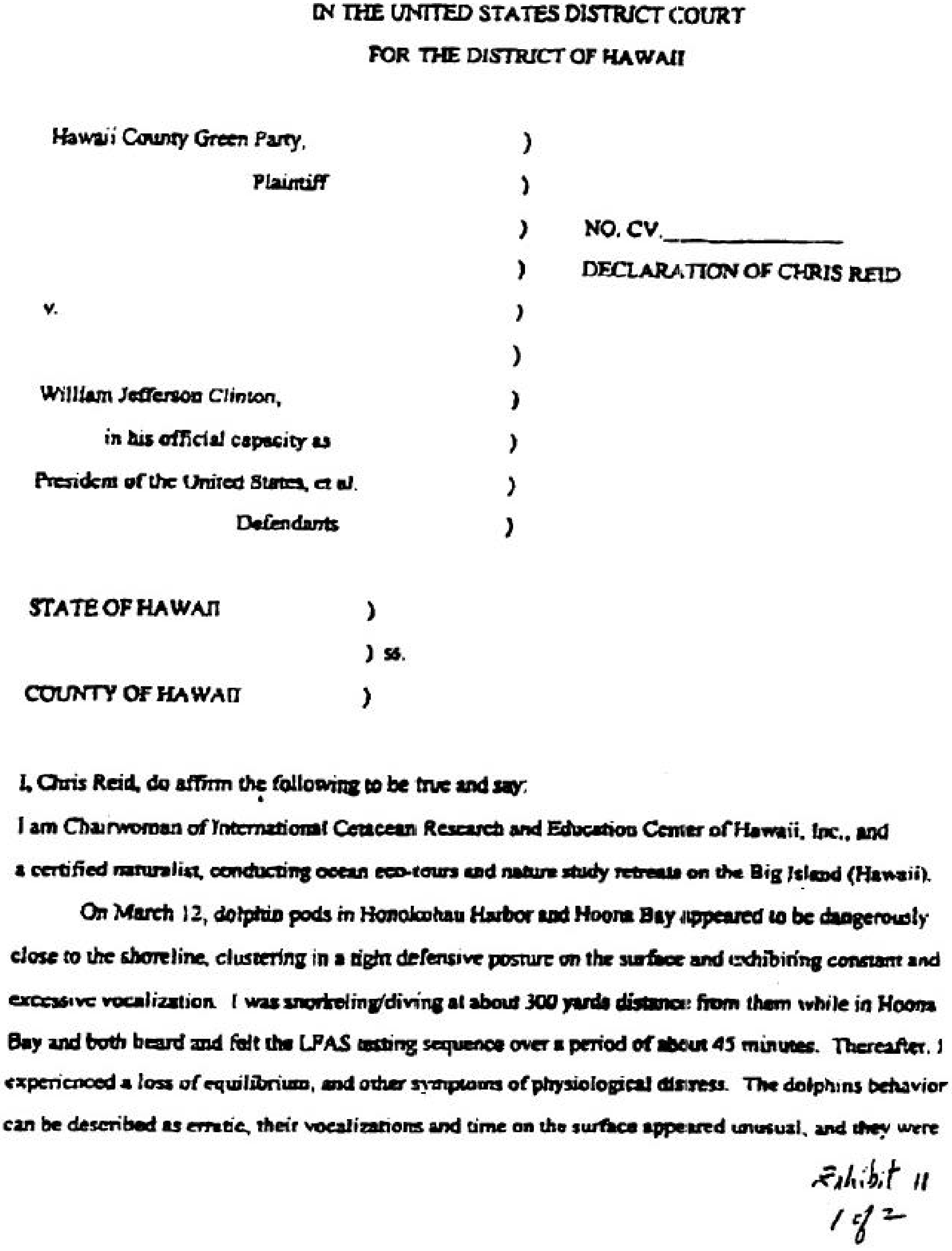
- Seafloor depth and bathymetry;
- SSP variation (particularly in the horizontal); and
- Seafloor and subbottom geoacoustic properties

APPENDIX C

LFS SRP PHASE III
U.S. DISTRICT COURT DECLARATIONS
AND
OTHER INFORMATION

TAB A	Declaration of Chris Reid
TAB B	Chris Reis Updated Declaration
TAB C	Declaration of Barbara Schmid
TAB D	Declaration of Kevin Merrill
TAB E	Declaration of Marsha Green, Ph.D.
TAB F	Declaration of Dr. Kurt Fristrup
TAB G	Declaration of Dr. Joseph R. Mobley
TAB H	Declaration of Eugene T. Nitta
TAB I	NOTICE TO DIVERS
TAB J	Dive Shops and Organizations Notified

TAB A – Declaration of Chris Reid



IN THE UNITED STATES DISTRICT COURT

FOR THE DISTRICT OF HAWAII

Hawaii County Green Party,)
Plaintiff)
) NO. CV.______________
) DECLARATION OF CHRIS REID
v.)
)
William Jefferson Clinton,)
in his official capacity as)
President of the United States, et al.)
Defendants)

STATE OF HAWAII)
) ss.
COUNTY OF HAWAII)

I, Chris Reid, do affirm the following to be true and say:

I am Chairwoman of International Cetacean Research and Education Center of Hawaii, Inc., and a certified naturalist, conducting ocean eco-tours and nature study retreats on the Big Island (Hawaii).

On March 12, dolphin pods in Honokohau Harbor and Hoona Bay appeared to be dangerously close to the shoreline, clustering in a tight defensive posture on the surface and exhibiting constant and excessive vocalization. I was snorkeling/diving at about 300 yards distance from them while in Hoona Bay and both heard and felt the LPAS testing sequence over a period of about 45 minutes. Thereafter, I experienced a loss of equilibrium, and other symptoms of physiological distress. The dolphins behavior can be described as erratic, their vocalizations and time on the surface appeared unusual, and they were

Exhibit 11
1 of 2

TAB A – Declaration of Chris Reid (Continued)

clearly very agitated and defensive. I have logged thousands of hours in the water and on boats observing dolphins over the last ten years, and consider this behavior to be extremely abnormal. As am in excellent health and in similar water conditions almost daily, I can only conclude that my physical discomfort resulted from exposure to the sonar testing.

2. In my attempts to gather information about LFAS technology, I visited the Navy's website and was astonished to discover a "Notice to Divers" which indicated it was to have been circulated widely within the diving community in Kona Coast, Hawaii. My friend, Krista Johnson, wrote a letter and put together information including the notice, a project map from the Environmental Assessment and other pertinent information, and circulated it among the dive operations in Kona, bringing attention to the matter. To the best of my knowledge and belief, the businesses which we approached had not been notified of the tests, and had not been counseled by any medical examiners made available by the Navy. When citizens called the contact telephone listed on the Diver's Notice, the receptionist claimed to know nothing, about it, and offered no further assistance.

3. During the last three weeks, I have been on the ocean on numerous occasions, observing the activities of the whales and dolphins. There has been an acutely obvious change in numbers and behavior. There are far fewer whales present, at a time in the season when they are normally most numerous, and all the whales have been staying at the surface, exhibiting repeated breaching, pectoral slapping, and tail slapping. The customary "fluke-up dive" which we watch for in order to obtain ID photos, and which indicates they are making a deep dive, was seen only twice. I have felt tremendous concern over these extreme alterations in what has been shown to be normal behavior.

Chris Reid

CHRIS REID

DATED: MARCH 18, 1998

Exhibit 11
272

TAB B – Chris Reid Updated Declaration

IN THE UNITED STATES DISTRICT COURT

FOR THE DISTRICT OF HAWAII

KAILUA Inc., dba Body Glove Cruises,)
Plaintiff)
) **NO. CV.**
) **DECLARATION OF CHRIS REID**
v.)
)
William Jefferson Clinton,)
et al.)
Defendants)
)

STATE OF HAWAII)
) **ss.**
COUNTY OF HAWAII)

I, Chris Reid, do affirm the following to be true and say:

I am Chairwoman of International Cetacean Research and Education Center of Hawaii, Inc., and a certified naturalist, conducting ocean eco-tours and nature study retreats on the Big Island (Hawaii).

1. On March 10, spinner dolphin pods in Honokohau Harbor and Hoona Bay appeared to be dangerously close to the shoreline, clustering in a tight defensive posture on the surface and exhibiting constant and excessive vocalization. (In a declaration I filed in NO.CV. 98-00232, I stated that I had the following experience on March 12. I had confused the dates because I was also in the water on the 12th.

Exhibit 12
1 of 3

I have confirmed from the charter boat captain that the events recounted did take place on March 10, as recorded in his logs.) I was snorkeling/diving at about 300 feet distance from them while in Hoona Bay and both heard and felt the LFAS testing sequence over a period of about 45 minutes. (In the declaration mentioned above, I inadvertently stated that I was 300 yards from the dolphins, rather than 300 feet). The dolphins behavior can be described as erratic, their vocalizations and time on the surface appeared unusual, and they were clearly very agitated and defensive. I have logged thousands of hours in the water and on boats observing dolphins over the last ten years, and consider this behavior to be extremely abnormal.

2. After spending 35-45 minutes in the water, I experienced a loss of equilibrium, and other symptoms of physiological distress. As I am in excellent health and in similar water conditions almost daily I can only conclude that my physical discomfort resulted from exposure to the sonar testing. I was examined about 2 hours after my exposure to the LFA, by a medical doctor with whom I had been working prior to the experience. It took more than 24 hours for me to fully recover from the effects of the LFA.

3. In my attempts to gather information about LFAS technology, I visited the Navy's website and was astonished to discover a "Notice to Divers" which indicated it was to have been circulated widely within the diving community in Kona Coast, Hawaii. My friend, Krista Johnson, wrote a letter and put together information including the notice, a project map from the Environmental Assessment and other pertinent information, and circulated it among the dive operations in Kona, bringing attention to the matter. To the best of my knowledge and belief, the businesses which we approached had not been notified of the tests, and had not been counseled by any medical examiners made available by the Navy. When citizens called the contact telephone listed on the Diver's Notice, the receptionist claimed to know nothing about it, and offered no further assistance.

4. During the last three weeks, I have been on the ocean on numerous occasions, observing the activities of the whales and dolphins. There has been an acutely obvious change in numbers and behavior. There are far fewer whales present, at a time in the season when they are normally most numerous, and all the whales have been staying at the surface, exhibiting repeated breaching, pectoral

Exhibit 12
2 of 3

TAB B – Chris Reid Updated Declaration (Continued)

slapping, and tail slapping. The customary "fluke-up dive" which we watch for in order to obtain ID photos, and which indicates they are making a deep dive, was seen only twice. I have felt tremendous concern over these extreme alterations in what has been shown to be normal behavior.

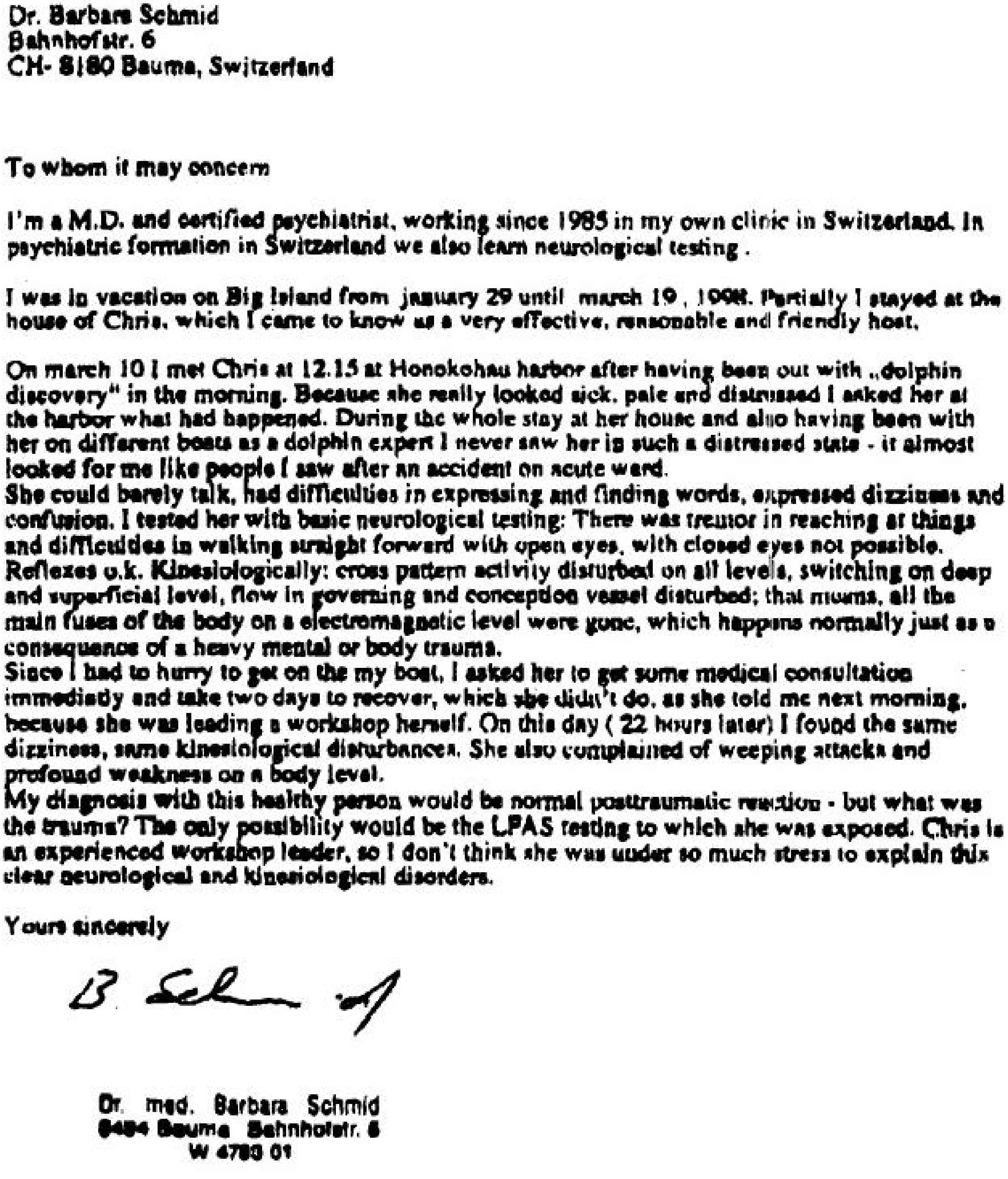
Chris Reid

CHRIS REID

DATED: MARCH 23, 1998

Exhibit 12
3 of 3

Tab C – Declaration of Dr. Barbara Schmid



Dr. Barbara Schmid
Bahnhofstr. 6
CH- 8180 Bauma, Switzerland

To whom it may concern

I'm a M.D. and certified psychiatrist, working since 1985 in my own clinic in Switzerland. In psychiatric formation in Switzerland we also learn neurological testing .

I was in vacation on Big Island from january 29 until march 19 , 1998. Partially I stayed at the house of Chris, which I came to know as a very effective, reasonable and friendly host.

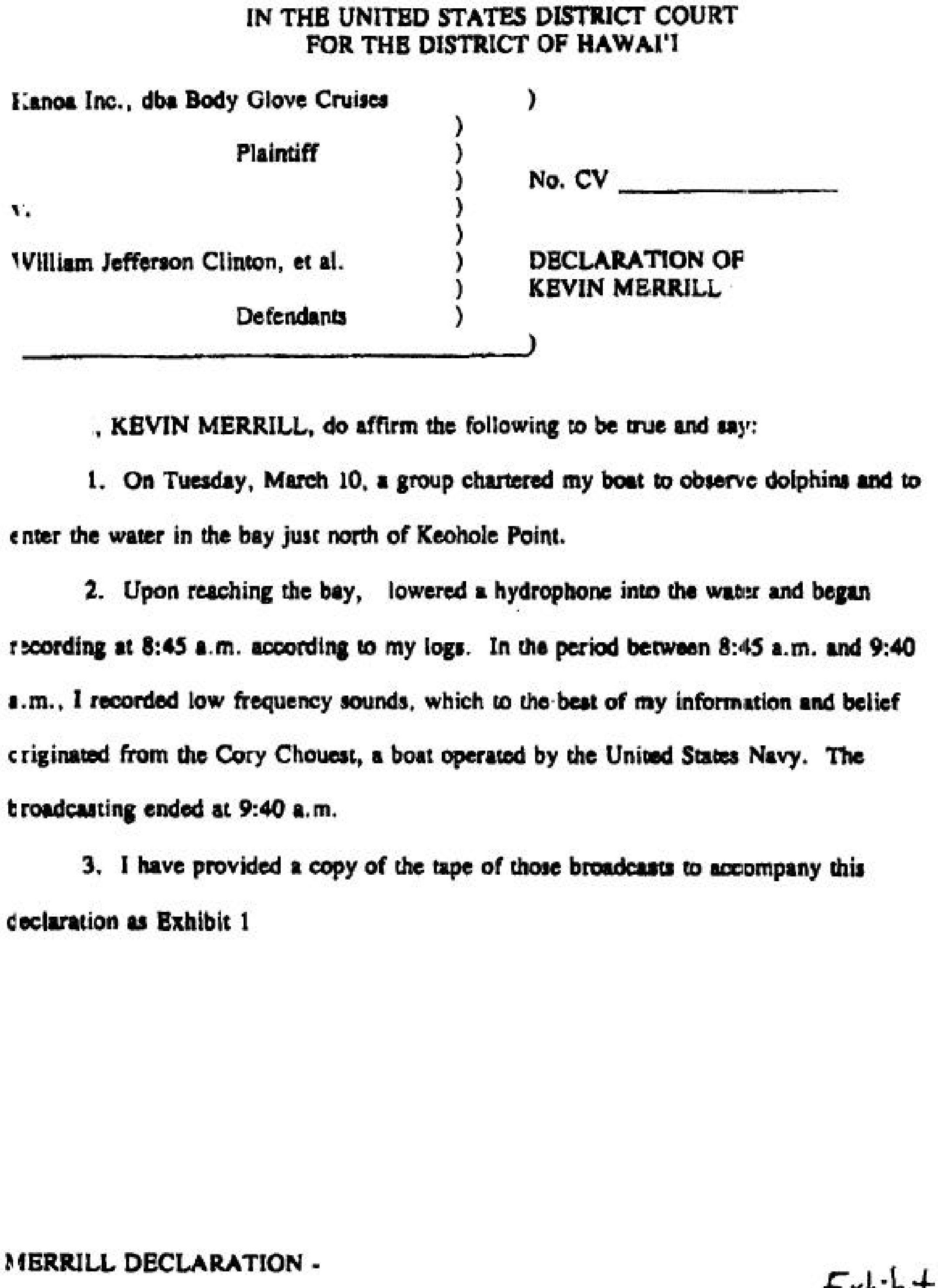
On march 10 I met Chris at 12.15 at Honokohau harbor after having been out with „dolphin discovery" in the morning. Because she really looked sick, pale and distrussed I asked her at the harbor what had happened. During the whole stay at her house and also having been with her on different boats as a dolphin expert I never saw her in such a distressed state - it almost looked for me like people I saw after an accident on acute ward.
She could barely talk, had difficulties in expressing and finding words, expressed dizziness and confusion. I tested her with basic neurological testing: There was tremor in reaching at things and difficulties in walking straight forward with open eyes, with closed eyes not possible. Reflexes o.k. Kinesiologically: cross pattern activity disturbed on all levels, switching on deep and superficial level, flow in governing and conception vessel disturbed; that means, all the main fuses of the body on a electromagnetic level were gone, which happens normally just as a consequence of a heavy mental or body trauma.
Since I had to hurry to get on the my boat, I asked her to get some medical consultation immediatly and take two days to recover, which she didn't do, as she told me next morning, because she was leading a workshop herself. On this day (22 hours later) I found the same dizziness, same kinesiological disturbances. She also complained of weeping attacks and profound weakness on a body level.
My diagnosis with this healthy person would be normal posttraumatic reaction - but what was the trauma? The only possibility would be the LPAS testing to which she was exposed. Chris is an experienced workshop leader, so I don't think she was under so much stress to explain this clear neurological and kinesiological disorders.

Yours sincerely

Dr. med. Barbara Schmid
8494 Bauma Bahnhofstr. 6
W 4780 01

Exhibit 13

TAB D – Declaration of Kevin Merrill



IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF HAWAI'I

Kanoa Inc., dba Body Glove Cruises	)	
Plaintiff	)	No. CV ________________
v.	)	
William Jefferson Clinton, et al.	)	DECLARATION OF KEVIN MERRILL
Defendants	)	

, KEVIN MERRILL, do affirm the following to be true and say:

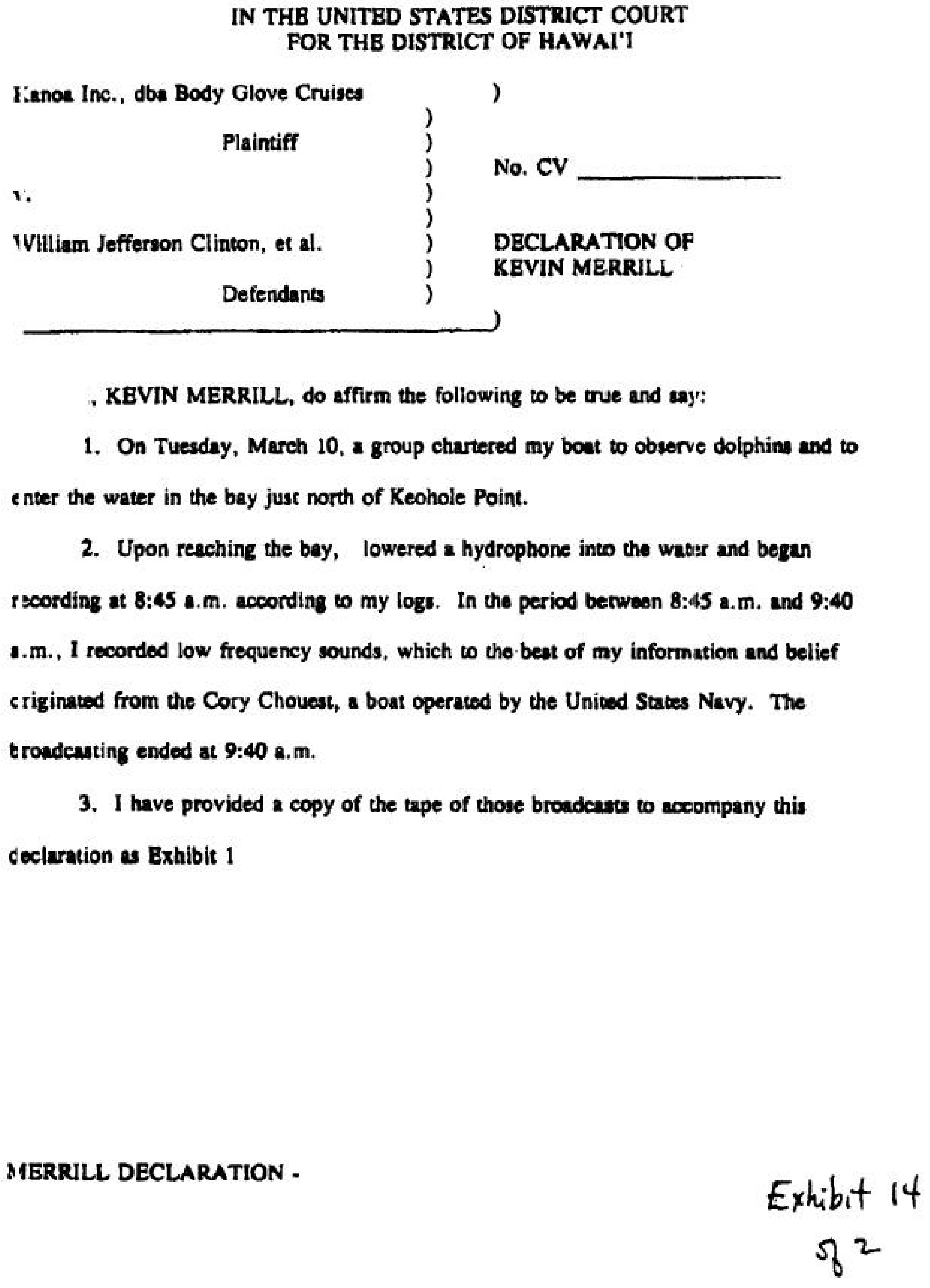
1. On Tuesday, March 10, a group chartered my boat to observe dolphins and to enter the water in the bay just north of Keohole Point.

2. Upon reaching the bay, lowered a hydrophone into the water and began recording at 8:45 a.m. according to my logs. In the period between 8:45 a.m. and 9:40 a.m., I recorded low frequency sounds, which to the best of my information and belief originated from the Cory Chouest, a boat operated by the United States Navy. The broadcasting ended at 9:40 a.m.

3. I have provided a copy of the tape of those broadcasts to accompany this declaration as Exhibit 1

MERRILL DECLARATION -

Exhibit 14
of 2



IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF HAWAI'I

Kanoa Inc., dba Body Glove Cruises)
Plaintiff)
) No. CV ________________
v.)
)
William Jefferson Clinton, et al.) DECLARATION OF KEVIN MERRILL
Defendants)

, KEVIN MERRILL, do affirm the following to be true and say:

1. On Tuesday, March 10, a group chartered my boat to observe dolphins and to enter the water in the bay just north of Keohole Point.

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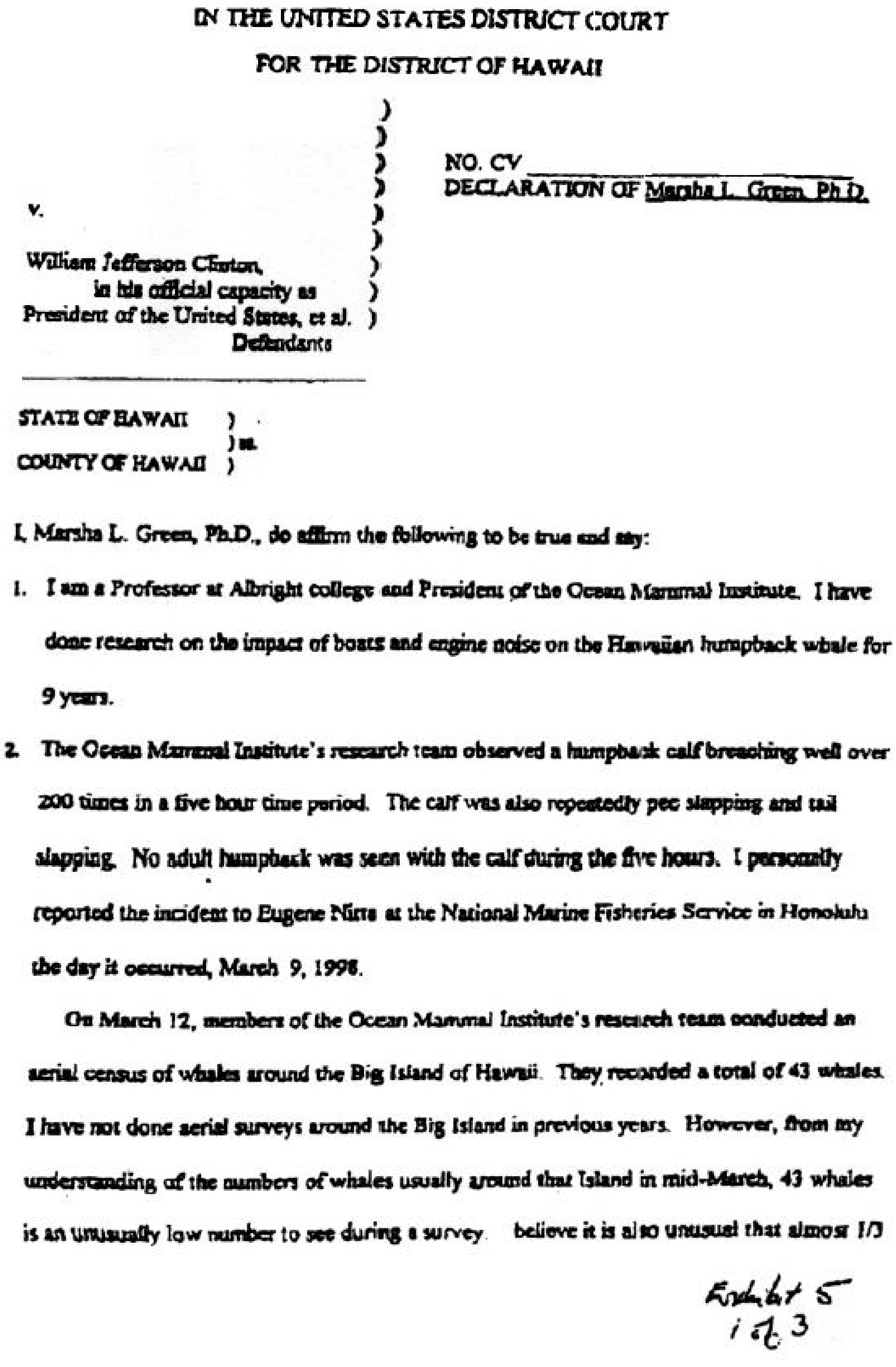
3. I have provided a copy of the tape of those broadcasts to accompany this declaration as Exhibit 1

MERRILL DECLARATION -

Exhibit 14
pg 2

TAB E – Declaration of Marsha L. Green, Ph.D.



IN THE UNITED STATES DISTRICT COURT

FOR THE DISTRICT OF HAWAII

v. William Jefferson Clinton, in his official capacity as President of the United States, et al. Defendants	NO. CV ______________ DECLARATION OF Marsha L. Green, Ph.D.

STATE OF HAWAII)
) ss.
COUNTY OF HAWAII)

I, Marsha L. Green, Ph.D., do affirm the following to be true and say:

1. I am a Professor at Albright college and President of the Ocean Mammal Institute. I have done research on the impact of boats and engine noise on the Hawaiian humpback whale for 9 years.

2. The Ocean Mammal Institute's research team observed a humpback calf breaching well over 200 times in a five hour time period. The calf was also repeatedly pec slapping and tail slapping. No adult humpback was seen with the calf during the five hours. I personally reported the incident to Eugene Nitta at the National Marine Fisheries Service in Honolulu the day it occurred, March 9, 1998.

On March 12, members of the Ocean Mammal Institute's research team conducted an aerial census of whales around the Big Island of Hawaii. They recorded a total of 43 whales. I have not done aerial surveys around the Big Island in previous years. However, from my understanding of the numbers of whales usually around that Island in mid-March, 43 whales is an unusually low number to see during a survey. believe it is also unusual that almost 1/3

Exhibit 5
1 of 3

of the whales (13) spotted were in Hilo Bay. The whales are usually more concentrated on the west side of Hawaii. Only 7 whales were spotted between Kawaihae and the Kona Airport which is prime whalewatching and LFA sonar testing area.

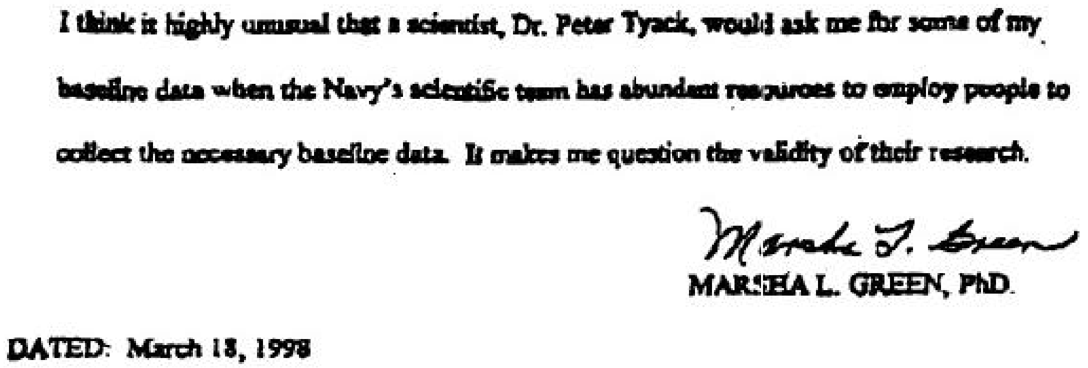
In the "Fact Sheet" issued by the Hawaii DLNR, they state that the Navy's "Scientific Research Program agreed to assist the Ocean Mammal Institute in conducting its own shore-based observation program of the whales during the time of the experiments." No one from the Scientific Research Program contacted me or the Ocean Mammal Institute, about assisting us in any way. In fact, on February 21, 1998 Peter Tyack, working for the Navy, asked me to assist him by letting him use some of our baseline data on the whales before the tests began because "they didn't have very much baseline data." In fact, they actually hindered us in our data collection as Scripps Oceanographic Institute was going to give us sonobuoys to record the LFA sounds. When the Scientific Research Program learned of this, they called Scripps and told them not to give us the sonobuoys.

1. In my 9 years of doing research on the Hawaiian humpback whale, I have never observed or heard about an abandoned calf. Also, I have never observed or heard about a calf or adult breaching well over 200 times in 5 hours. This calf actually breached 215 times during the first 2 hours of observation and breached occasionally after that while pec-slapping and tail slapping repeatedly.

I believe it is unusual that during our aerial survey we saw only 7 whales between Kawaihae and Kona, prime whalewatching area and LFA sonar testing area, and that we saw 13 whales in Hilo Bay - more than usually seen around Hilo.

Exhibit 5
2 of 3

TAB E – Declaration of Marsha L. Green, Ph.D. (Continued)



I think it highly unusual that a scientist, Dr. Peter Tyack, would ask me for some of my baseline data when the Navy's scientific team has abundant resources to employ people to collect the necessary baseline data. It makes me question the validity of their research.

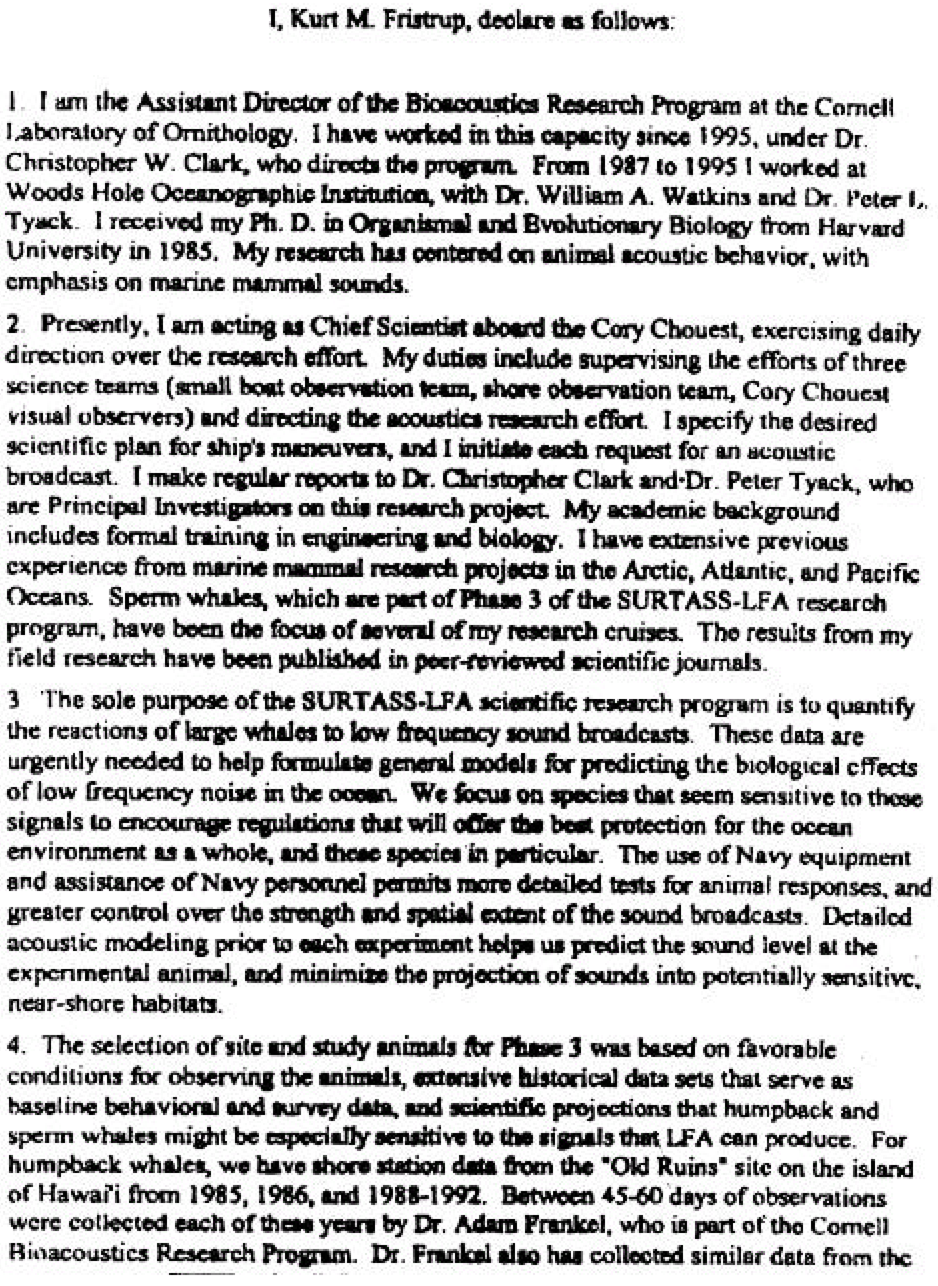
Marsha L. Green

MARSHA L. GREEN, PhD.

DATED: March 18, 1998

Exhibits
3 f 3

TAB F – Declaration of Dr. Kurt Fristrup



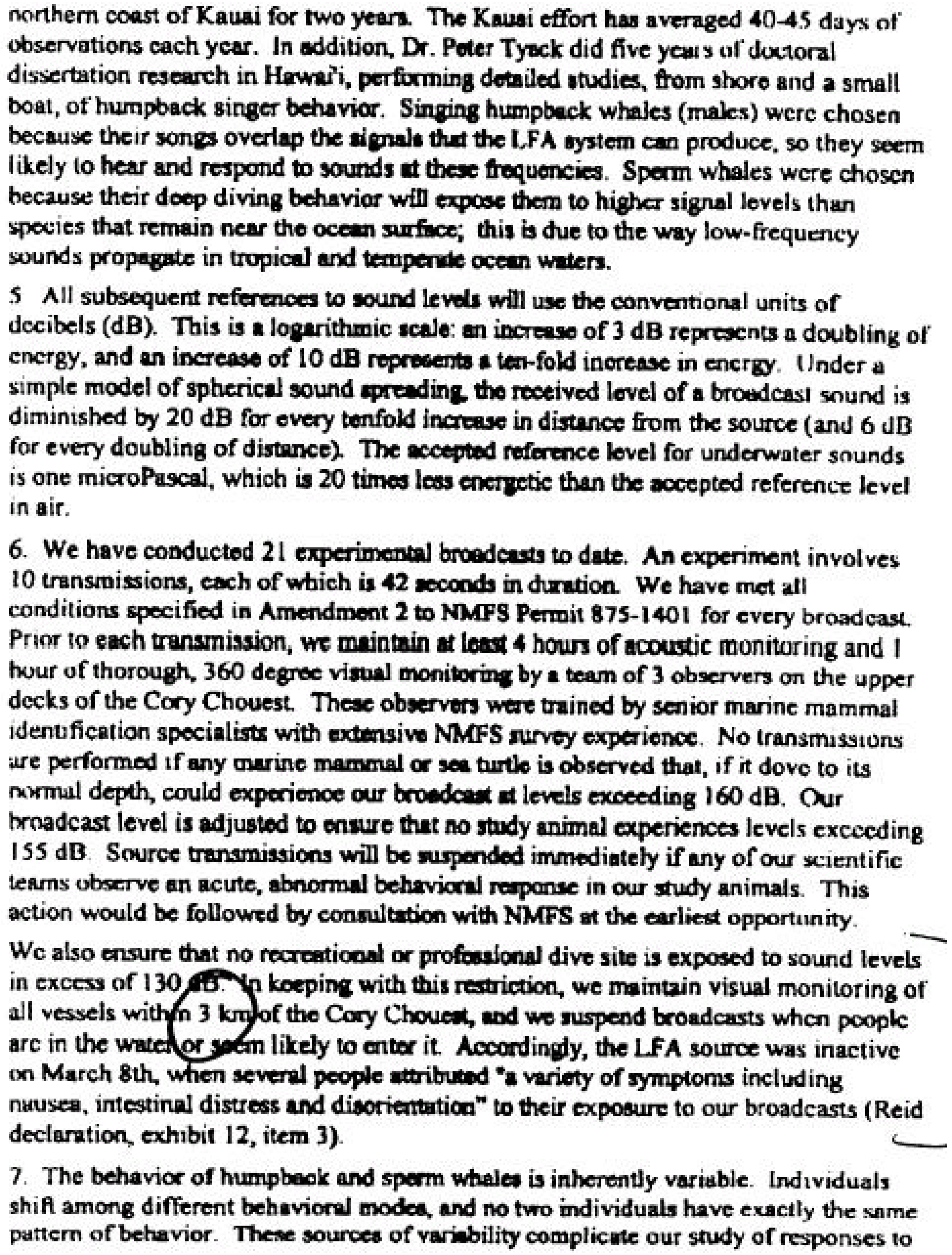
I, Kurt M. Fristrup, declare as follows:

1. I am the Assistant Director of the Bioacoustics Research Program at the Cornell Laboratory of Ornithology. I have worked in this capacity since 1995, under Dr. Christopher W. Clark, who directs the program. From 1987 to 1995 I worked at Woods Hole Oceanographic Institution, with Dr. William A. Watkins and Dr. Peter L. Tyack. I received my Ph. D. in Organismal and Evolutionary Biology from Harvard University in 1985. My research has centered on animal acoustic behavior, with emphasis on marine mammal sounds.

2. Presently, I am acting as Chief Scientist aboard the Cory Chouest, exercising daily direction over the research effort. My duties include supervising the efforts of three science teams (small boat observation team, shore observation team, Cory Chouest visual observers) and directing the acoustics research effort. I specify the desired scientific plan for ship's maneuvers, and I initiate each request for an acoustic broadcast. I make regular reports to Dr. Christopher Clark and Dr. Peter Tyack, who are Principal Investigators on this research project. My academic background includes formal training in engineering and biology. I have extensive previous experience from marine mammal research projects in the Arctic, Atlantic, and Pacific Oceans. Sperm whales, which are part of Phase 3 of the SURTASS-LFA research program, have been the focus of several of my research cruises. The results from my field research have been published in peer-reviewed scientific journals.

3. The sole purpose of the SURTASS-LFA scientific research program is to quantify the reactions of large whales to low frequency sound broadcasts. These data are urgently needed to help formulate general models for predicting the biological effects of low frequency noise in the ocean. We focus on species that seem sensitive to these signals to encourage regulations that will offer the best protection for the ocean environment as a whole, and these species in particular. The use of Navy equipment and assistance of Navy personnel permits more detailed tests for animal responses, and greater control over the strength and spatial extent of the sound broadcasts. Detailed acoustic modeling prior to each experiment helps us predict the sound level at the experimental animal, and minimize the projection of sounds into potentially sensitive, near-shore habitats.

4. The selection of site and study animals for Phase 3 was based on favorable conditions for observing the animals, extensive historical data sets that serve as baseline behavioral and survey data, and scientific projections that humpback and sperm whales might be especially sensitive to the signals that LFA can produce. For humpback whales, we have shore station data from the "Old Ruins" site on the island of Hawai'i from 1985, 1986, and 1988-1992. Between 45-60 days of observations were collected each of these years by Dr. Adam Frankel, who is part of the Cornell Bioacoustics Research Program. Dr. Frankel also has collected similar data from the



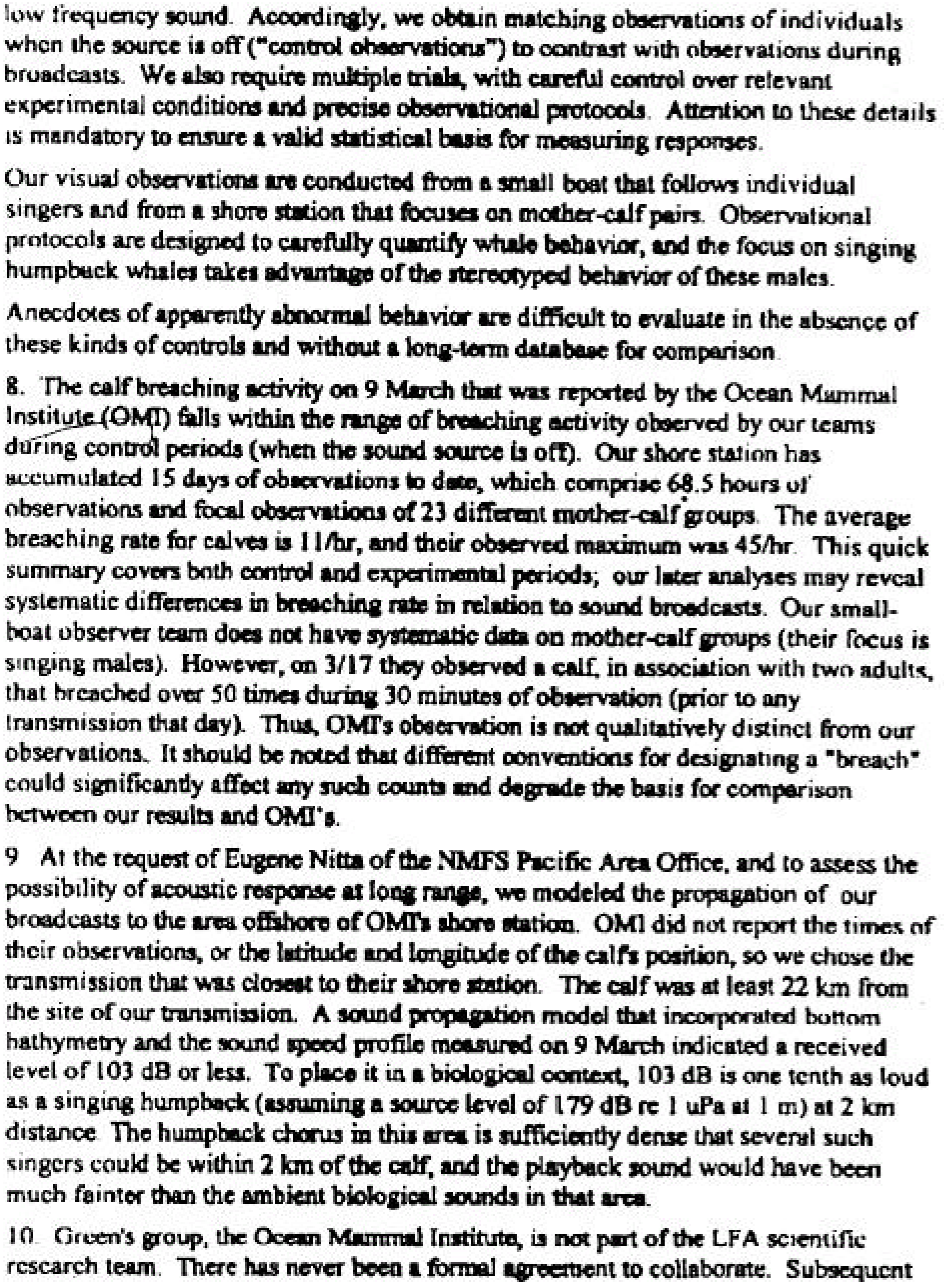
northern coast of Kauai for two years. The Kauai effort has averaged 40-45 days of observations each year. In addition, Dr. Peter Tyack did five years of doctoral dissertation research in Hawai'i, performing detailed studies, from shore and a small boat, of humpback singer behavior. Singing humpback whales (males) were chosen because their songs overlap the signals that the LFA system can produce, so they seem likely to hear and respond to sounds at these frequencies. Sperm whales were chosen because their deep diving behavior will expose them to higher signal levels than species that remain near the ocean surface; this is due to the way low-frequency sounds propagate in tropical and temperate ocean waters.

5 All subsequent references to sound levels will use the conventional units of decibels (dB). This is a logarithmic scale: an increase of 3 dB represents a doubling of energy, and an increase of 10 dB represents a ten-fold increase in energy. Under a simple model of spherical sound spreading, the received level of a broadcast sound is diminished by 20 dB for every tenfold increase in distance from the source (and 6 dB for every doubling of distance). The accepted reference level for underwater sounds is one microPascal, which is 20 times less energetic than the accepted reference level in air.

6. We have conducted 21 experimental broadcasts to date. An experiment involves 10 transmissions, each of which is 42 seconds in duration. We have met all conditions specified in Amendment 2 to NMFS Permit 875-1401 for every broadcast. Prior to each transmission, we maintain at least 4 hours of acoustic monitoring and 1 hour of thorough, 360 degree visual monitoring by a team of 3 observers on the upper decks of the Cory Chouest. These observers were trained by senior marine mammal identification specialists with extensive NMFS survey experience. No transmissions are performed if any marine mammal or sea turtle is observed that, if it dove to its normal depth, could experience our broadcast at levels exceeding 160 dB. Our broadcast level is adjusted to ensure that no study animal experiences levels exceeding 155 dB. Source transmissions will be suspended immediately if any of our scientific teams observe an acute, abnormal behavioral response in our study animals. This action would be followed by consultation with NMFS at the earliest opportunity.

We also ensure that no recreational or professional dive site is exposed to sound levels in excess of 130 dB. In keeping with this restriction, we maintain visual monitoring of all vessels within 3 km of the Cory Chouest, and we suspend broadcasts when people are in the water or seem likely to enter it. Accordingly, the LFA source was inactive on March 8th, when several people attributed "a variety of symptoms including nausea, intestinal distress and disorientation" to their exposure to our broadcasts (Reid declaration, exhibit 12, item 3).

7. The behavior of humpback and sperm whales is inherently variable. Individuals shift among different behavioral modes, and no two individuals have exactly the same pattern of behavior. These sources of variability complicate our study of responses to



low frequency sound. Accordingly, we obtain matching observations of individuals when the source is off ("control observations") to contrast with observations during broadcasts. We also require multiple trials, with careful control over relevant experimental conditions and precise observational protocols. Attention to these details is mandatory to ensure a valid statistical basis for measuring responses.

Our visual observations are conducted from a small boat that follows individual singers and from a shore station that focuses on mother-calf pairs. Observational protocols are designed to carefully quantify whale behavior, and the focus on singing humpback whales takes advantage of the stereotyped behavior of these males.

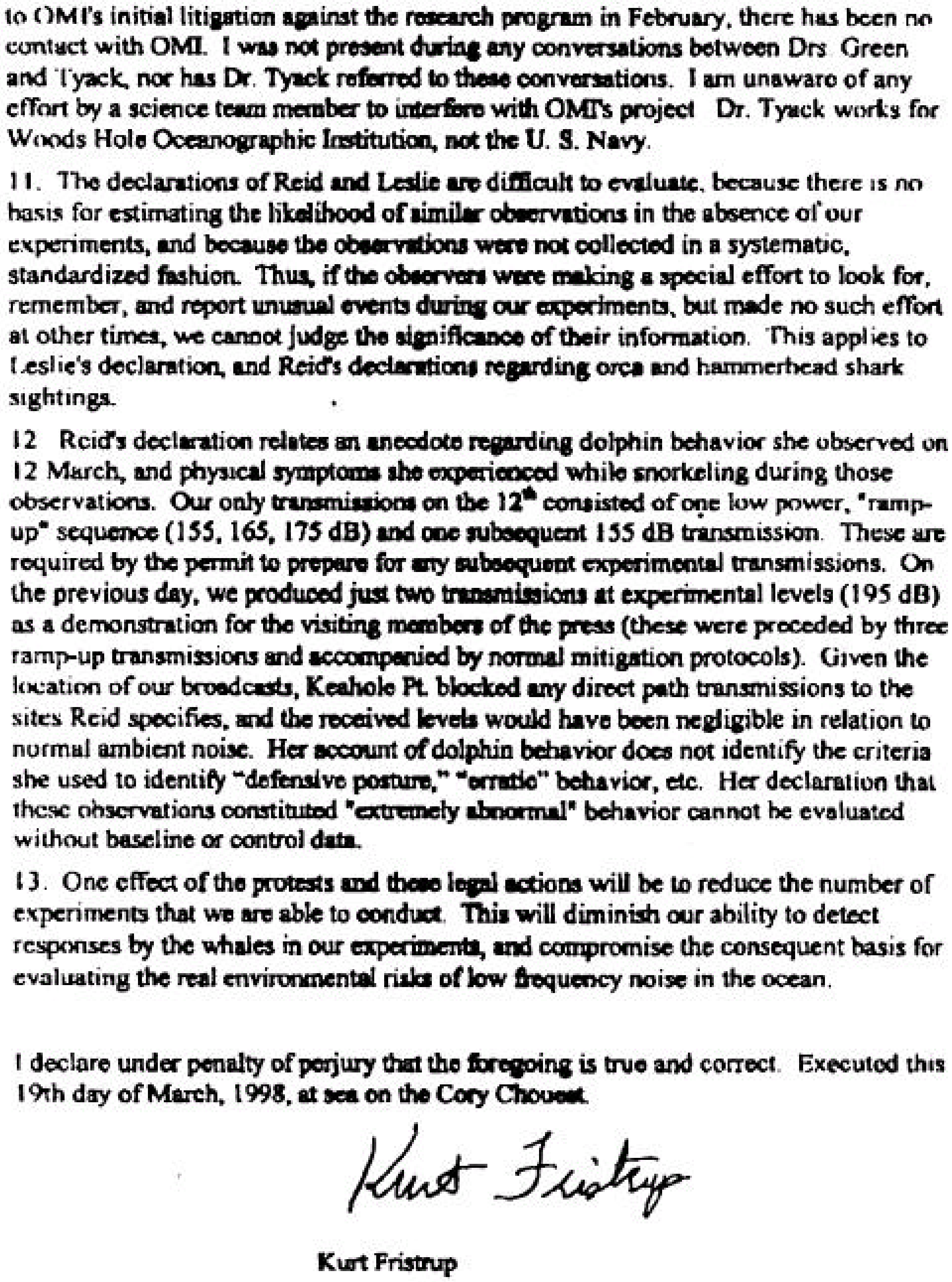
Anecdotes of apparently abnormal behavior are difficult to evaluate in the absence of these kinds of controls and without a long-term database for comparison.

8. The calf breaching activity on 9 March that was reported by the Ocean Mammal Institute (OMI) falls within the range of breaching activity observed by our teams during control periods (when the sound source is off). Our shore station has accumulated 15 days of observations to date, which comprise 68.5 hours of observations and focal observations of 23 different mother-calf groups. The average breaching rate for calves is 11/hr, and their observed maximum was 45/hr. This quick summary covers both control and experimental periods; our later analyses may reveal systematic differences in breaching rate in relation to sound broadcasts. Our small-boat observer team does not have systematic data on mother-calf groups (their focus is singing males). However, on 3/17 they observed a calf, in association with two adults, that breached over 50 times during 30 minutes of observation (prior to any transmission that day). Thus, OMI's observation is not qualitatively distinct from our observations. It should be noted that different conventions for designating a "breach" could significantly affect any such counts and degrade the basis for comparison between our results and OMI's.

9 At the request of Eugene Nitta of the NMFS Pacific Area Office, and to assess the possibility of acoustic response at long range, we modeled the propagation of our broadcasts to the area offshore of OMI's shore station. OMI did not report the times of their observations, or the latitude and longitude of the calf's position, so we chose the transmission that was closest to their shore station. The calf was at least 22 km from the site of our transmission. A sound propagation model that incorporated bottom bathymetry and the sound speed profile measured on 9 March indicated a received level of 103 dB or less. To place it in a biological context, 103 dB is one tenth as loud as a singing humpback (assuming a source level of 179 dB re 1 uPa at 1 m) at 2 km distance. The humpback chorus in this area is sufficiently dense that several such singers could be within 2 km of the calf, and the playback sound would have been much fainter than the ambient biological sounds in that area.

10. Green's group, the Ocean Mammal Institute, is not part of the LFA scientific research team. There has never been a formal agreement to collaborate. Subsequent

TAB F – Declaration of Dr. Kurt Fristrup (Continued)



to OMI's initial litigation against the research program in February, there has been no contact with OMI. I was not present during any conversations between Drs Green and Tyack, nor has Dr. Tyack referred to these conversations. I am unaware of any effort by a science team member to interfere with OMI's project Dr. Tyack works for Woods Hole Oceanographic Institution, not the U. S. Navy.

11. The declarations of Reid and Leslie are difficult to evaluate, because there is no basis for estimating the likelihood of similar observations in the absence of our experiments, and because the observations were not collected in a systematic, standardized fashion. Thus, if the observers were making a special effort to look for, remember, and report unusual events during our experiments, but made no such effort at other times, we cannot judge the significance of their information. This applies to Leslie's declaration, and Reid's declarations regarding orca and hammerhead shark sightings.

12 Reid's declaration relates an anecdote regarding dolphin behavior she observed on 12 March, and physical symptoms she experienced while snorkeling during those observations. Our only transmissions on the 12th consisted of one low power, "ramp-up" sequence (155, 165, 175 dB) and one subsequent 155 dB transmission. These are required by the permit to prepare for any subsequent experimental transmissions. On the previous day, we produced just two transmissions at experimental levels (195 dB) as a demonstration for the visiting members of the press (these were proceded by three ramp-up transmissions and accompanied by normal mitigation protocols). Given the location of our broadcasts, Keahole Pt. blocked any direct path transmissions to the sites Reid specifies, and the received levels would have been negligible in relation to normal ambient noise. Her account of dolphin behavior does not identify the criteria she used to identify "defensive posture," "erratic" behavior, etc. Her declaration that these observations constituted "extremely abnormal" behavior cannot be evaluated without baseline or control data.

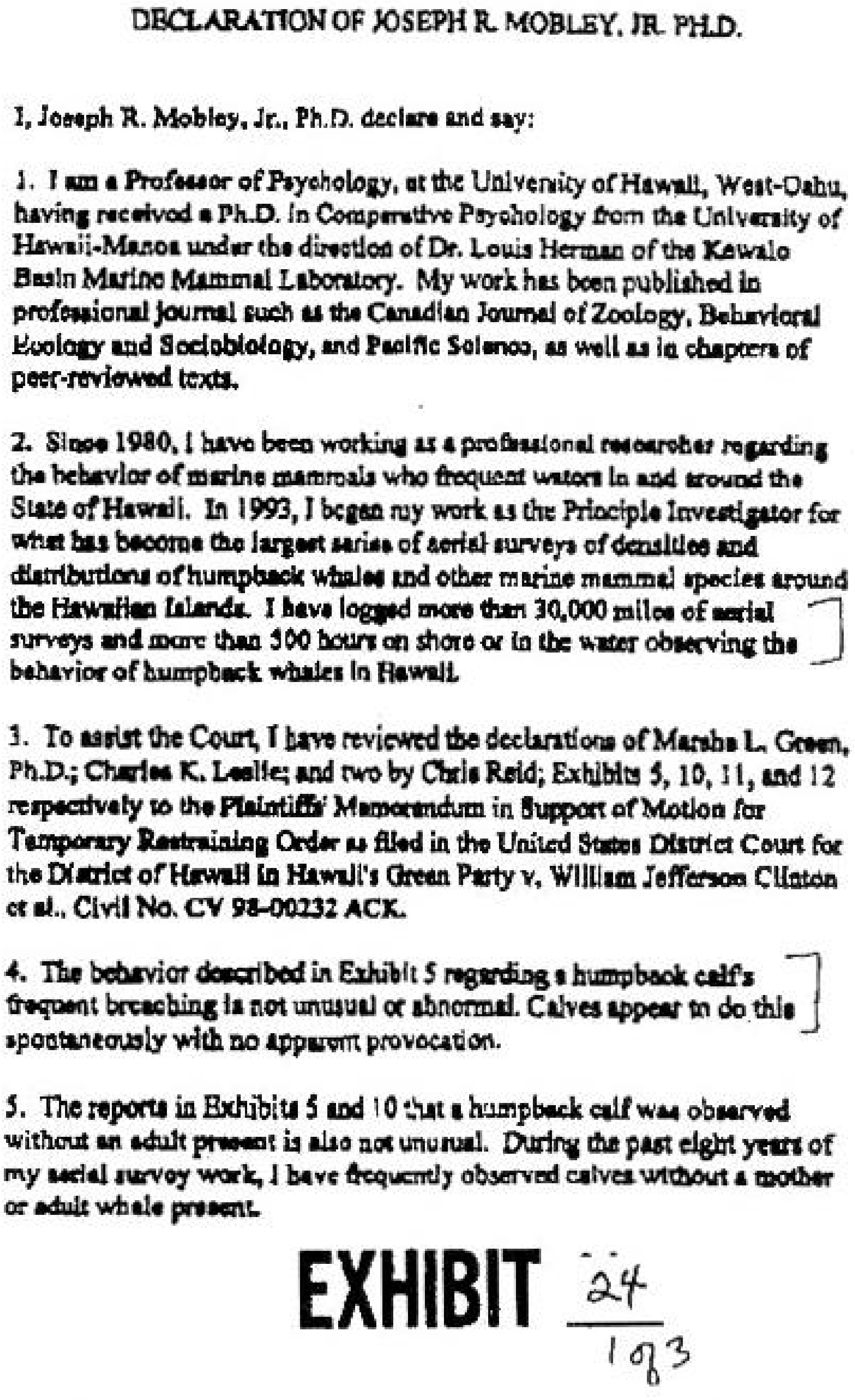
13. One effect of the protests and these legal actions will be to reduce the number of experiments that we are able to conduct. This will diminish our ability to detect responses by the whales in our experiments, and compromise the consequent basis for evaluating the real environmental risks of low frequency noise in the ocean.

I declare under penalty of perjury that the foregoing is true and correct. Executed this 19th day of March, 1998, at sea on the Cory Chouest.

Kurt Fristrup

Kurt Fristrup

TAB G – Declaration of Dr. Joseph R. Mobley



DECLARATION OF JOSEPH R. MOBLEY, JR. PH.D.

I, Joseph R. Mobley, Jr., Ph.D. declare and say:

1. I am a Professor of Psychology, at the University of Hawaii, West-Oahu, having received a Ph.D. in Comparative Psychology from the University of Hawaii-Manoa under the direction of Dr. Louis Herman of the Kewalo Basin Marine Mammal Laboratory. My work has been published in professional journal such as the Canadian Journal of Zoology, Behavioral Ecology and Sociobiology, and Pacific Science, as well as in chapters of peer-reviewed texts.

2. Since 1980, I have been working as a professional researcher regarding the behavior of marine mammals who frequent waters in and around the State of Hawaii. In 1993, I began my work as the Principle Investigator for what has become the largest series of aerial surveys of densities and distributions of humpback whales and other marine mammal species around the Hawaiian Islands. I have logged more than 30,000 miles of aerial surveys and more than 300 hours on shore or in the water observing the behavior of humpback whales in Hawaii.

3. To assist the Court, I have reviewed the declarations of Marsha L. Green, Ph.D.; Charles K. Leslie; and two by Chris Reid; Exhibits 5, 10, 11, and 12 respectively to the Plaintiffs' Memorandum in Support of Motion for Temporary Restraining Order as filed in the United States District Court for the District of Hawaii in Hawaii's Green Party v. William Jefferson Clinton et al., Civil No. CV 98-00232 ACK.

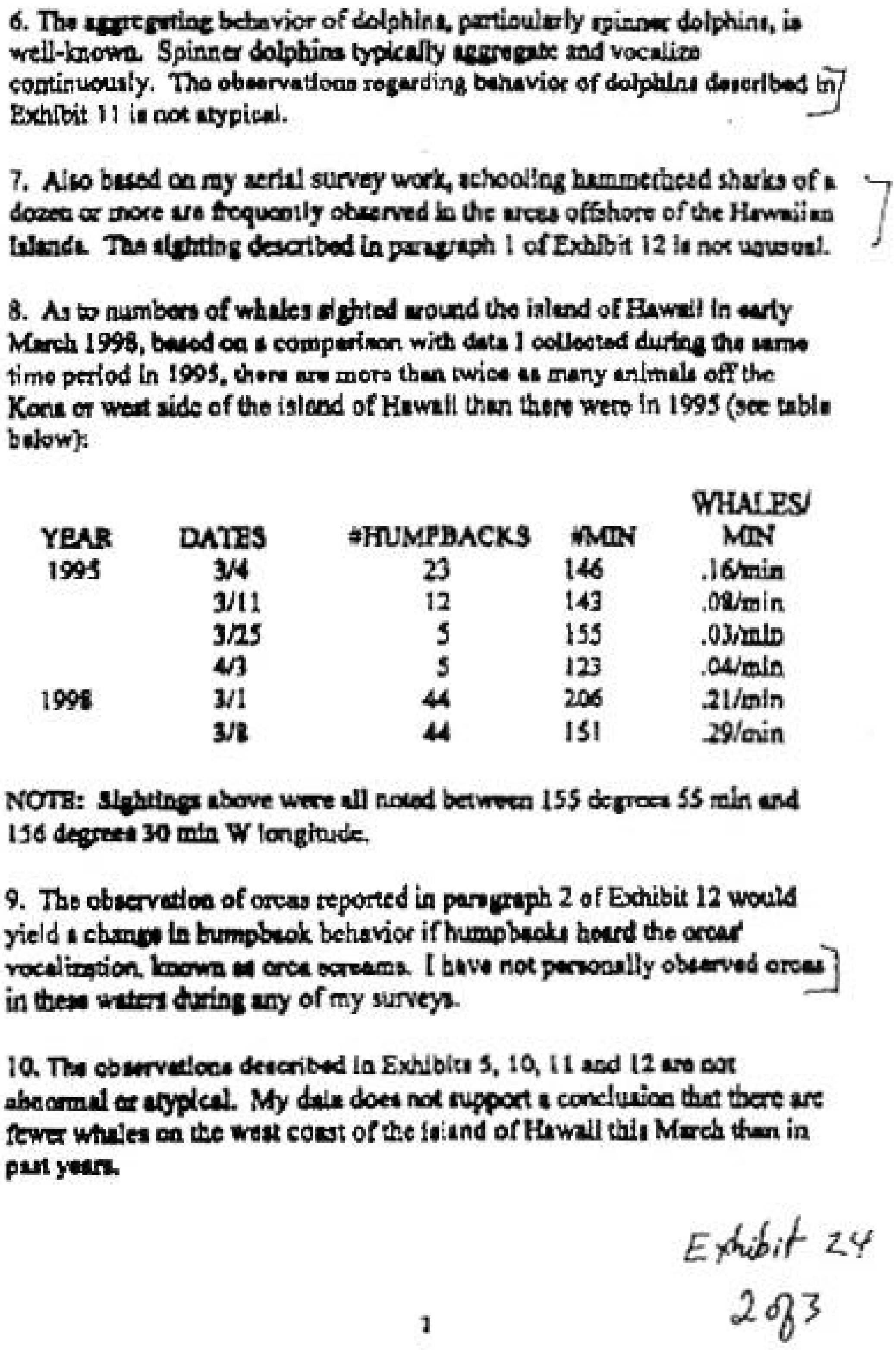
4. The behavior described in Exhibit 5 regarding a humpback calf's frequent breaching is not unusual or abnormal. Calves appear to do this spontaneously with no apparent provocation.

5. The reports in Exhibits 5 and 10 that a humpback calf was observed without an adult present is also not unusual. During the past eight years of my aerial survey work, I have frequently observed calves without a mother or adult whale present.

EXHIBIT 24

1 of 3

TAB G – Declaration of Dr. Joseph R. Mobley (Continued)



6. The aggregating behavior of dolphins, particularly spinner dolphins, is well-known. Spinner dolphins typically aggregate and vocalize continuously. The observations regarding behavior of dolphins described in Exhibit 11 is not atypical.

7. Also based on my aerial survey work, schooling hammerhead sharks of a dozen or more are frequently observed in the areas offshore of the Hawaiian Islands. The sighting described in paragraph 1 of Exhibit 12 is not unusual.

8. As to numbers of whales sighted around the island of Hawaii in early March 1998, based on a comparison with data I collected during the same time period in 1995, there are more than twice as many animals off the Kona or west side of the island of Hawaii than there were in 1995 (see table below):

YEAR	DATES	#HUMPBACKS	#MIN	WHALES/ MIN
1995	3/4	23	146	.16/min
	3/11	12	143	.08/min
	3/25	5	155	.03/min
	4/3	5	123	.04/min
1998	3/1	44	206	.21/min
	3/8	44	151	.29/min

NOTE: Sightings above were all noted between 155 degrees 55 min and 156 degrees 30 min W longitude.

9. The observation of orcas reported in paragraph 2 of Exhibit 12 would yield a change in humpback behavior if humpbacks heard the orcas' vocalization, known as orca screams. I have not personally observed orcas in these waters during any of my surveys.

10. The observations described in Exhibits 5, 10, 11 and 12 are not abnormal or atypical. My data does not support a conclusion that there are fewer whales on the west coast of the island of Hawaii this March than in past years.

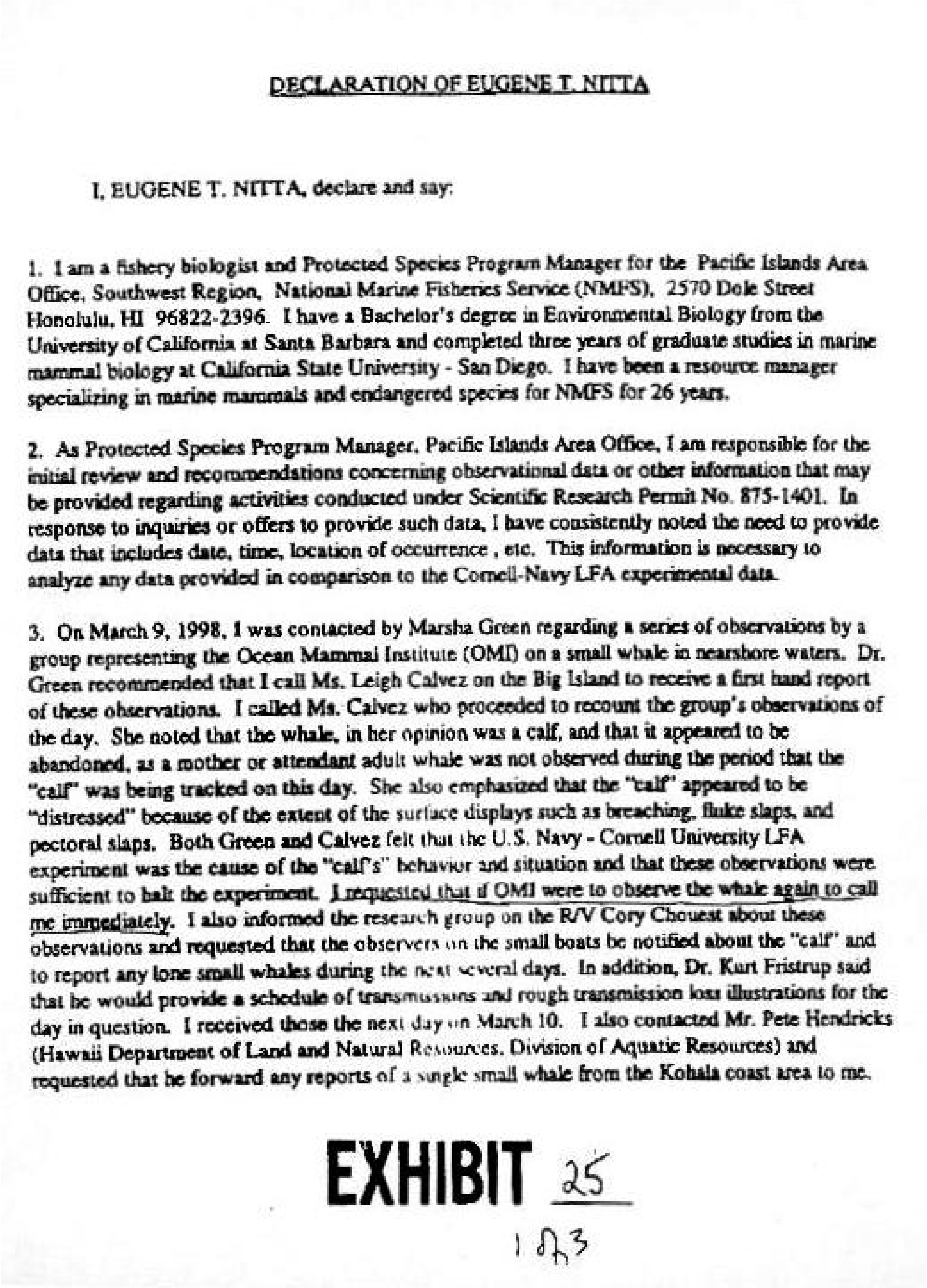
Exhibit 24
2 of 3

I declare under penalty of perjury that the foregoing is true and correct.
Executed this 19th date of March, 1998.

JOSEPH R. MOBLEY, JR.

Exhibit 24
393

TAB H – Declaration of Eugene T. Nitta



DECLARATION OF EUGENE T. NITTA

I, EUGENE T. NITTA, declare and say:

1. I am a fishery biologist and Protected Species Program Manager for the Pacific Islands Area Office, Southwest Region, National Marine Fisheries Service (NMFS), 2570 Dole Street Honolulu, HI 96822-2396. I have a Bachelor's degree in Environmental Biology from the University of California at Santa Barbara and completed three years of graduate studies in marine mammal biology at California State University - San Diego. I have been a resource manager specializing in marine mammals and endangered species for NMFS for 26 years.

2. As Protected Species Program Manager, Pacific Islands Area Office, I am responsible for the initial review and recommendations concerning observational data or other information that may be provided regarding activities conducted under Scientific Research Permit No. 875-1401. In response to inquiries or offers to provide such data, I have consistently noted the need to provide data that includes date, time, location of occurrence , etc. This information is necessary to analyze any data provided in comparison to the Cornell-Navy LFA experimental data.

3. On March 9, 1998, I was contacted by Marsha Green regarding a series of observations by a group representing the Ocean Mammal Institute (OMI) on a small whale in nearshore waters. Dr. Green recommended that I call Ms. Leigh Calvez on the Big Island to receive a first hand report of these observations. I called Ms. Calvez who proceeded to recount the group's observations of the day. She noted that the whale, in her opinion was a calf, and that it appeared to be abandoned, as a mother or attendant adult whale was not observed during the period that the "calf" was being tracked on this day. She also emphasized that the "calf" appeared to be "distressed" because of the extent of the surface displays such as breaching, fluke slaps, and pectoral slaps. Both Green and Calvez felt that the U.S. Navy - Cornell University LFA experiment was the cause of the "calf's" behavior and situation and that these observations were sufficient to halt the experiment. I requested that if OMI were to observe the whale again to call me immediately. I also informed the research group on the R/V Cory Chouest about these observations and requested that the observers on the small boats be notified about the "calf" and to report any lone small whales during the next several days. In addition, Dr. Kurt Fristrup said that he would provide a schedule of transmissions and rough transmission loss illustrations for the day in question. I received those the next day on March 10. I also contacted Mr. Pete Hendricks (Hawaii Department of Land and Natural Resources, Division of Aquatic Resources) and requested that he forward any reports of a single small whale from the Kohala coast area to me.

EXHIBIT 25

1 of 3

4. During discussions with Dr. Joe Mobley (University of Hawaii-West Oahu) I was informed that he would be monitoring the LFA experiment for the State of Hawaii during this week and would also be talking with Dr. Tom Norris, who was apparently assisting Marsha Green in recording offshore of the OMI observation site near Lapakahi State Park. I requested that Dr. Mobley attempt to obtain the data and observations from March 9 from Dr. Norris. On March 13, 1998 I spoke with Tom Norris and found that he was not that intimately involved with the shore station operation. He recommended that I discuss the observations with Bev (no last name) who gave essentially the same account as Ms. Calvez. I then requested a copy of their data and observations of that day.

5. I did not receive copies of the OMI data until receipt of a facsimile on March 18, 1998, which are illegible in some cases. I have attempted to call the OMI contingent on the Big Island to have them resend it but there was no answer as of 6:00 p.m. March 18, 1998.

6. On March 17, 1998, I received a facsimile copy of a letter (also addressed and sent to Ann Terbush, National Marine Fisheries Service) from Lanny and Mary Rose Sinkin requesting that the National Marine Fisheries Service (NMFS) suspend activities under Scientific Research Permit No. 875-1401. The allegations in this letter are similar to those included in their motion for a Temporary Restraining Order filed on March 18, 1998, in the U.S. District Court, District of Hawaii.

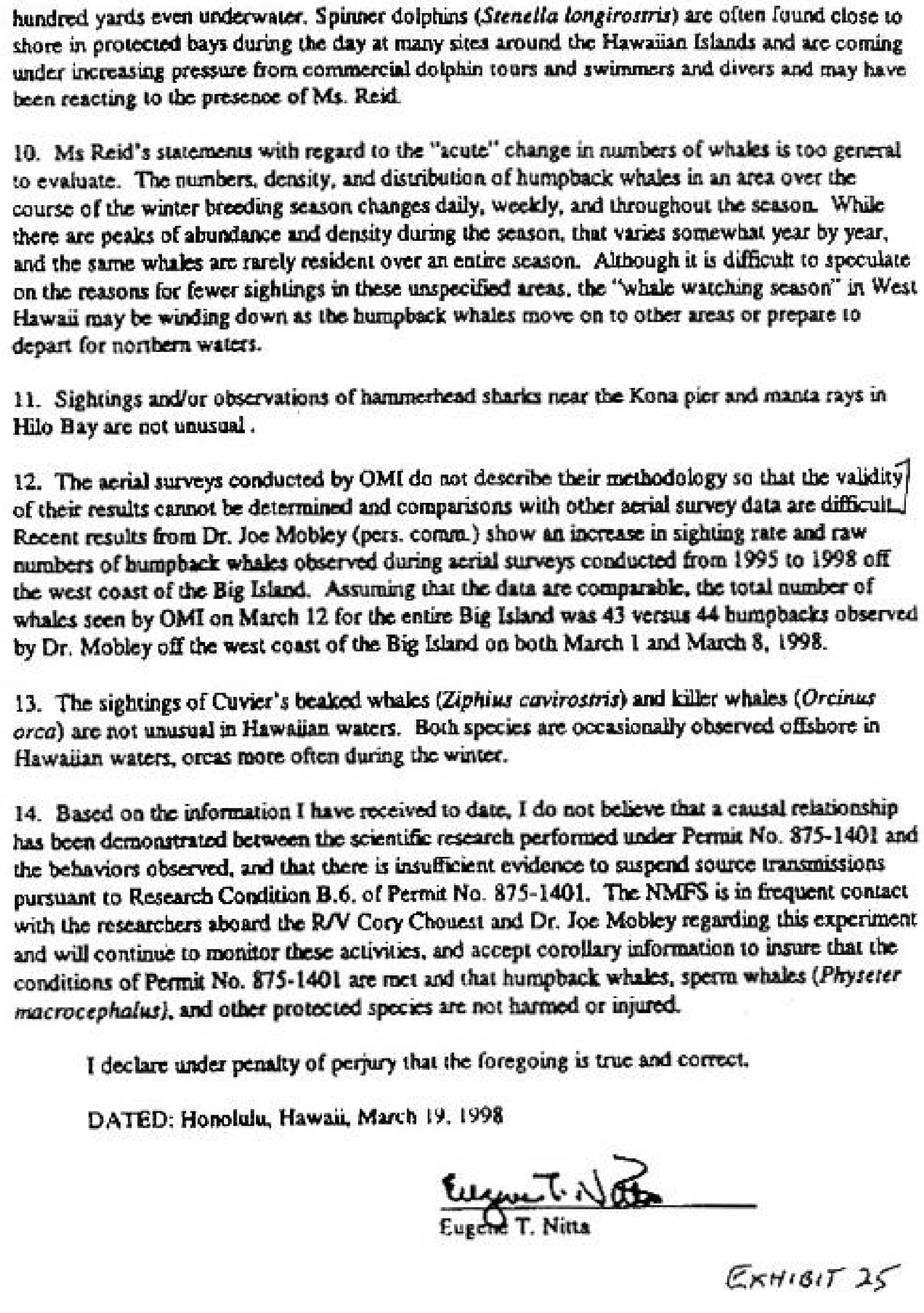
7. The following constitutes my preliminary assessment of the situation with the "calf" on March 9, 1998. Humpback whale calves often exhibit surface and aerial behavior, and it is not unusual to observe a calf breaching 20 to 30 times in succession. Pectoral fin slapping and tail slaps are also common. This type of behavior may continue for hours depending upon the age and size of the whale. Yearling whales also often exhibit this behavior and may be difficult to distinguish from large calves of the year from a distance. The OMI observations indicate that they were unable to determine if the mother was present in the vicinity of the "calf," thereby assuming that the "calf" was abandoned. There is no reasonable way to determine if the "calf" was abandoned, orphaned, otherwise separated from its mother, reunited with its mother, or if the whale was a small yearling whale as no further reports or sightings of a lone small whale have been received.

8. The affidavit from Charles Leslie regarding the "lone baby whale" seen on March 2, 1998, does not specify the duration of the observation, which might have been insufficient to locate a resting mother.

9. The affidavit of Chris Reid describes the behavior of dolphins of unspecified species in a nearshore area in the vicinity of Hoona Bay and Honokohau Harbor. There is no estimate given of how far the dolphins were from shore, no description of "a tight defensive posture," or what constitutes "constant and excessive vocalizations." There is also no comparison of normal "surface time" with "unusual time on the surface." If the dolphins were in Honokohau Harbor as described, that in itself would be enough to result in a condensed pod composition and vocalizations reacting to the vessel traffic in the Harbor. A defensive or aggressive posture of a spinner dolphin as described by Norris et al. (1985) may be difficult to see from the surface and may not be recognized as such by an inexperienced observer, especially from a distance of 300

EXHIBIT 25

2[illegible]3



hundred yards even underwater. Spinner dolphins (*Stenella longirostris*) are often found close to shore in protected bays during the day at many sites around the Hawaiian Islands and are coming under increasing pressure from commercial dolphin tours and swimmers and divers and may have been reacting to the presence of Ms. Reid.

10. Ms Reid's statements with regard to the "acute" change in numbers of whales is too general to evaluate. The numbers, density, and distribution of humpback whales in an area over the course of the winter breeding season changes daily, weekly, and throughout the season. While there are peaks of abundance and density during the season, that varies somewhat year by year, and the same whales are rarely resident over an entire season. Although it is difficult to speculate on the reasons for fewer sightings in these unspecified areas, the "whale watching season" in West Hawaii may be winding down as the humpback whales move on to other areas or prepare to depart for northern waters.

11. Sightings and/or observations of hammerhead sharks near the Kona pier and manta rays in Hilo Bay are not unusual.

12. The aerial surveys conducted by OMI do not describe their methodology so that the validity of their results cannot be determined and comparisons with other aerial survey data are difficult. Recent results from Dr. Joe Mobley (pers. comm.) show an increase in sighting rate and raw numbers of humpback whales observed during aerial surveys conducted from 1995 to 1998 off the west coast of the Big Island. Assuming that the data are comparable, the total number of whales seen by OMI on March 12 for the entire Big Island was 43 versus 44 humpbacks observed by Dr. Mobley off the west coast of the Big Island on both March 1 and March 8, 1998.

13. The sightings of Cuvier's beaked whales (*Ziphius cavirostris*) and killer whales (*Orcinus orca*) are not unusual in Hawaiian waters. Both species are occasionally observed offshore in Hawaiian waters, orcas more often during the winter.

14. Based on the information I have received to date, I do not believe that a causal relationship has been demonstrated between the scientific research performed under Permit No. 875-1401 and the behaviors observed, and that there is insufficient evidence to suspend source transmissions pursuant to Research Condition B.6. of Permit No. 875-1401. The NMFS is in frequent contact with the researchers aboard the R/V Cory Chouest and Dr. Joe Mobley regarding this experiment and will continue to monitor these activities, and accept corollary information to insure that the conditions of Permit No. 875-1401 are met and that humpback whales, sperm whales (*Physeter macrocephalus*), and other protected species are not harmed or injured.

I declare under penalty of perjury that the foregoing is true and correct.

DATED: Honolulu, Hawaii, March 19, 1998

Eugene T. Nitta

Eugene T. Nitta

EXHIBIT 25

NOTICE TO DIVERS

The United States Navy is providing the following notice to persons who plan to dive in the vicinity of the Kona Coast of the big island of Hawaii between 25 February and 31 March 1998.

The U. S. Navy, Cornell University, and Wood's Hole Oceanographic Institution will be conducting scientific tests involving the use of a low frequency active sonar (LFA) system in this region. An active sonar system is one that transmits a sound into the ocean, then listen for the return echoes to detect underwater objects. The LFA frequency range, 100 to 500 cycles per second, is roughly a two-octave range centered over middle C on a piano.

It is possible that divers off the Kona coast may hear the LFA transmissions, which can sound like a whale call. Although the sound is somewhat unusual, the transmissions pose no threat to the safety of divers. This notice is being provided to alleviate any diver concern in the event that the LFA signals are heard during the course of a dive.

Sound transmissions will be intermittent. The sound will last less than one minute, followed by no transmission for five minutes. The sonar will only function during daylight hours.

Further information on the LFA sonar system is available on the Navy Chief of Naval Operations environmental web-site http://www.n4.hq.navy.mil/n45.html. Click on the virtual file cabinet and look for articles related to LFA.

Questions or comments regarding the test can be addressed to LCDR Barbara Paul at 808-471-8666 or 808-471-8608, fax 808-471-7220.

PLEASE DISTRIBUTE THIS NOTICE WIDELY WITHIN THE DIVING COMMUNITY IN KONA COAST HAWAII.

TAB J Dive Shops and Organizations Notified

Jack's Diving Locker
75-5819 Alii Dr.,Coconut Grove
Market Pl.
Kailua Kona , HI 96740

Ocean Sports Waikoloa
HC02 Box 5000
Kohala Coast , HI
96743

Breeze Hawaii Diving
74-5543 Kaiwi Ste 115
Kailua-Kona , HI
96740

Jack's Diving Locker
75-5819 Alii Drive
Kailua-Kona , HI
96740

Nautilus Dive Center
382 Kamehameha Avenue
Hilo , HI
96720

Kona Coast Skin Diver Ltd.
74-5614 Palani Rd
Kailua Kona , HI 96740

Red Sail Sports
69-425 Waikoloa Beach Dr., c/o
Hilton Waikoloa Vlg.
Kamuela , HI 96743

Eco-Adventures
75-5744 Alii Drive
Kailua-Kona , HI
96740

Kona Coast Divers
74-5614 Palani Road
Kailua-Kona , HI
96740

Planet Ocean Watersports
200 Kanoelehua Avenue, Unit 8
Hilo , HI
96720

La Gracd De Kong
P.O. Box 390132
Kailua Kona , HI
96739

Aloha Dive Company
73-4617 Kohanaiki Rd PO Box 4454
Kailua-Kona , HI
96745

Fair Wind, Inc.
78-7130 Kaleiopapa Street
Kailua-Kona , HI
96740

Manta Ray Dives of Hawaii
78-128 Ehukai Street
Kailua-Kona , HI
96740

Sea Paradise Scuba, Inc.
78-7128 Kaleiopapa Road
Kailua-Kona , HI
96740

Professional Association of Dive Instructors
1251 E. Dyer Rd #100
Santa Ana CA 92705
Tel 714-540-7234/ext 538
Fax 714-540-2609
POC: Bob Coleman
e-mail bccol@msn.com

Nautional Association of Underwater Instruction
PO Box 1460
Montclair CA 91763-1250
Tel 909-621-5501
Fax 909-621-6405
Mike Williams
mikew@earthlink.net

Divers Alert Network
3100 Tower Blvd.
Suite 1300
Durham NC 27707-2563
Tel 919-684-2948
Fax 919-480-6630
Dan Orr, Director of Operations
orr00002@mc.duke.edu

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APPENDIX D

SENSITIVITY ANALYSIS OF THE RISK FUNCTION CURVE

Appendix D
Sensitivity Analysis of the Risk Function Curve

Currently, the risk continuum for the SURTASS LFA Sonar OEIS/EIS estimates the risk to marine mammals exposed to the SURTASS LFA signals in the 119 to 180 dB re 1 µPa range. The effects of these signals on four species of marine mammals, up to received levels of 155 dB, were investigated and reported on previously (Technical Report 1). However, the lack of empirical data in the received level range of 155 to 180 dB is an issue. This paper will present a sensitivity analysis of the risk continuum, to determine the range of possible effects of errors in the risk continuum parameters.

The OEIS/EIS risk continuum function corresponds to a dose-response function in a typical pharmacological risk assessment. Of particular importance in this case is the proportion of doses, or received ping levels, that exceed 155 dB because of the lack of data on responses >155 dB.

As an example, the species modeled for Sites 1 and 28 were examined and a series of histograms were prepared (One example is shown in Figure D-1. Figure D-6 at the end of this appendix presents the remaining histograms for the two sites). The percentage of exposures >155 dB are shown in Table D-1. At Site 1, blue whales receive a sizeable portion (12.8%) of their pings > 155 dB. The other species receive much lower percentages of pings >155 dB, and, therefore, are much less likely to be affected by uncertainty in the risk assessment. The predictions for Site 28 found that northern right, fin, sei and minke whales have >5% of their received pings in excess of 155 dB.

The risk function curve used in the OEIS/EIS (Figure D-2) is primarily based on four parameters:

- Basement value for risk (B parameter) – the value (119 dB for this study) below which the risk is so low that calculations are not practical;
- 95% Level (K parameter) – the level at which there is a 95% probability of a significant change in a biologically important behavior;
- Mid point – the sound level corresponding to a 50% probability of a response (165 dB);
- Tuning parameter – this essentially determines how steeply the curve transitions from basement value to 95% value.

The derivation of the first two parameters (the basement and 95 percent values) is explained in detail in Subchapters 1.4 and 4.2 of the OEIS/EIS. A sensitivity analysis of the risk function curve was undertaken with respect to the remaining two values.

D.1 Tuning Parameter

If the tuning parameter is reduced, the slope of the risk assessment function becomes flatter, increasing the predicted risk at low to moderate sound levels and reducing it at sound levels between 165 and 180 dB. The resulting curve is shown in green in Figure D-3, with the original curve shown in blue for reference. This manipulation leads to an increased risk estimate because most animals receive sound levels lower than 165 dB (Table D-1). At first examination, this may seem to represent a more conservative approach than the original curve. However, because the flattened curve reduces the risk estimate for animals exposed to sound levels in excess of 165 dB, this approach may not be desirable.

If the tuning parameter is simply doubled, the risk function (shown in red in Figure D-4) becomes very close to a step function, essentially a two-level transition between risk and no risk. The purpose of the risk function approach is to move away from this dichotomy toward a realistic assessment of risk. Results from the Low Frequency Sound Scientific Research Program (LFS SRP) phase II research show that whales (in this case, gray whales) do scale their responses with received level, further discrediting a dichotomous approach. Finally, the steeper curve leads to a lower predicted risk estimate, since most animals receive a lower sound level (Table D-1). Therefore, this approach also does not seem appropriate.

D.2 Fifty Percent Response Point

The most appropriate, and conservative, approach may be to shift the 50% response point downwards. This was done by shifting the midpoint downward by 5 dB (from 165 to 160 dB). A new risk function was calculated and is presented in red in Figure D-5. A 5-dB drop in the midpoint is the largest change possible without becoming substantially inconsistent with the existing data for exposure levels in the 150-155 dB range.

This adjusted curve (shown in red in Figure D-5) represents an across-the-board increase in predicted risk at all received levels (e.g., at 160 dB RL, risk increases from 25% to 50%). This increase must be analyzed in context with animal distributions and abundances. In this sense risk levels were recalculated using the more conservative curve and compared to the original values. The original abundance and distribution data are taken from Table 4.2-10 of the Draft OEIS/EIS.

Table D-2 shows that the predicted risk for the shifted curve (Figure D-5), with geographic mitigation monitoring only, increased from 1.19% to 1.59%. The probability of exposure to sound levels $\geq$ 180 dB did not change, since the 95% parameter remained constant. Using the more sensitive curve, the predicted risk when using both geographic and monitoring mitigation increased from 0.82% to 1.17%.

The technique of altering only the midpoint parameter represents a conservative approach. By altering only this one parameter, the entire curve was shifted downwards 5 dB. The predicted risk in the 150-155 dB region has increased, but is not substantially inconsistent with data from the LFS SRP. If one attempted to both shift the midpoint and flatten the risk function curve, then predictions for the 150-155 dB range would rise to a level that would be substantially inconsistent with the results from the LFS SRP. Therefore, this approach would not be valid.

In conclusion, it appears that the conservative approach adjustment of the risk function produces only a slight increase in the predicted response at low received sound levels (and no increased risk at exposures ≥ 180 dB).

D.3 Conclusions

This examination supports the premise that the risk function (four parameters) used in the OEIS/EIS is valid for the analysis intended. Table D-2 presents the effects of altering the dose-response model (risk continuum) in several ways to consider uncertainties in the model.

Table D-1

Pings Exceeding 155 dB (Sites 1 and 28)

Species	Percentage of pings > 155 dB	
	Site 1	Site 28
Blue whale	12.8%	
Humpback whale	1%	
Gray whale	0%	
Northern right whale	0%	7.8%
Pelagic dolphins	2.5%	3.2%
Fin whale		6.9%
Sei whale		10.8%
Minke whale	0%	9.1%
Beaked whale		1.2%
Pilot whale		1.4%
Sea lions	1%	

Table D-2

Effects of Curve Manipulations on Risk Estimates

Type of Curve	Mid-point Shift (dB)	Slope Multiplier	Potential for Effects (with geographic mitigation only)	Potential for Effects (with geographic and monitoring mitigation)
Original curve (Figure D-2)	0	1	1.19	0.82
Halved tuning parameter (Figure D-3)	0	0.5	2.3	1.72
Doubled tuning parameter (Figure D-4)	0	2	1.03	0.66
Shifted mid-point (Figure D-5)	-5	1	1.59	1.17

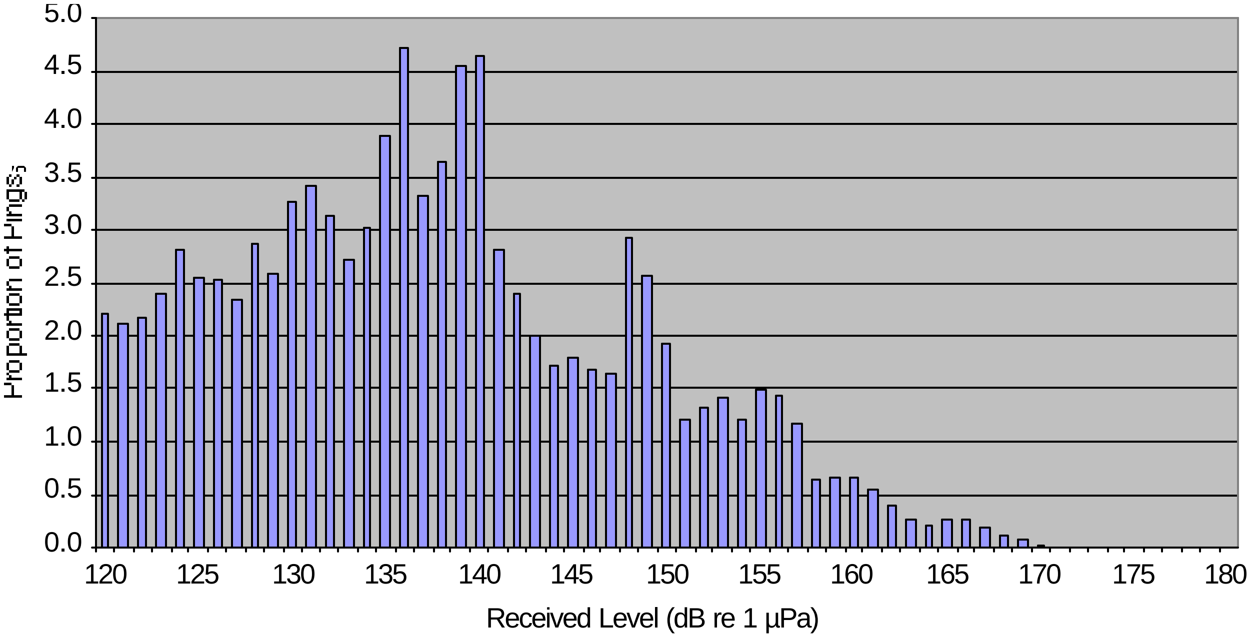


Figure D-1: Fin Whale Ping Received Levels for Site 28

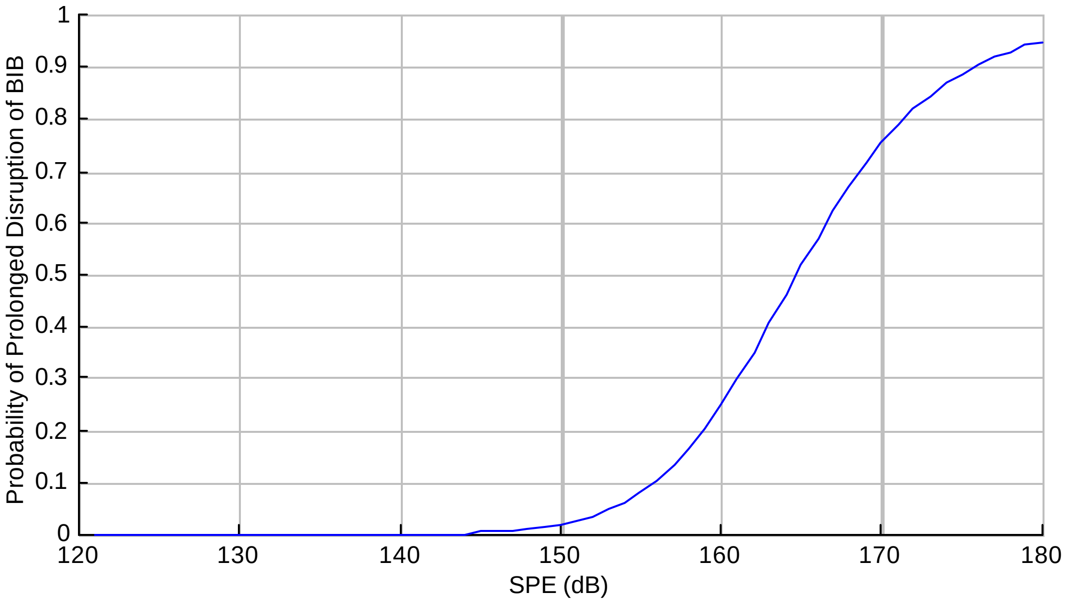


Figure D-2 OEIS/EIS Risk Function

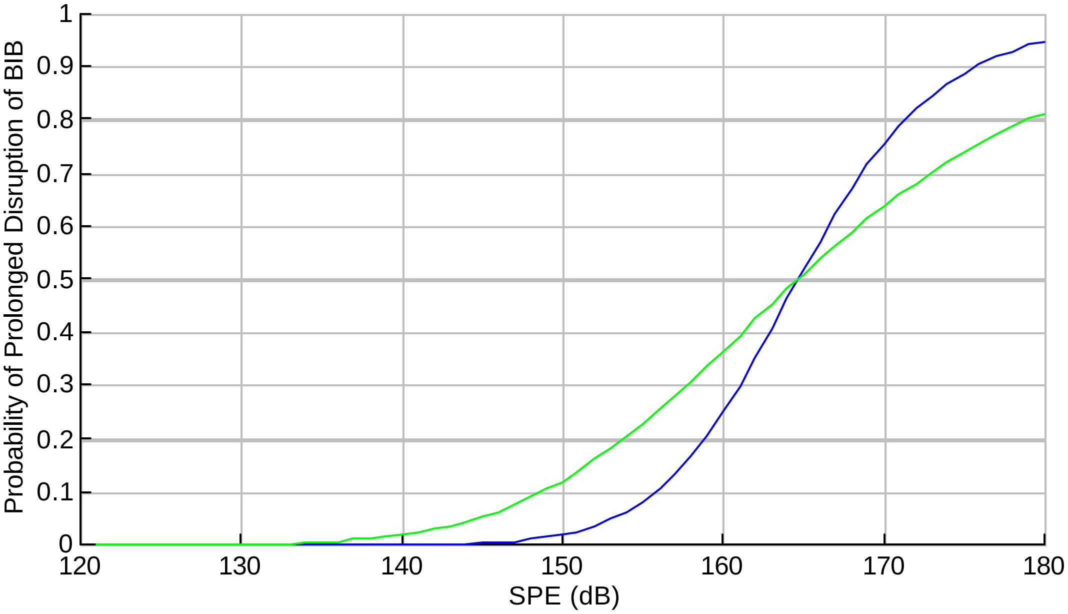


Figure D-3 Risk Function with Reduced Tuning Parameter

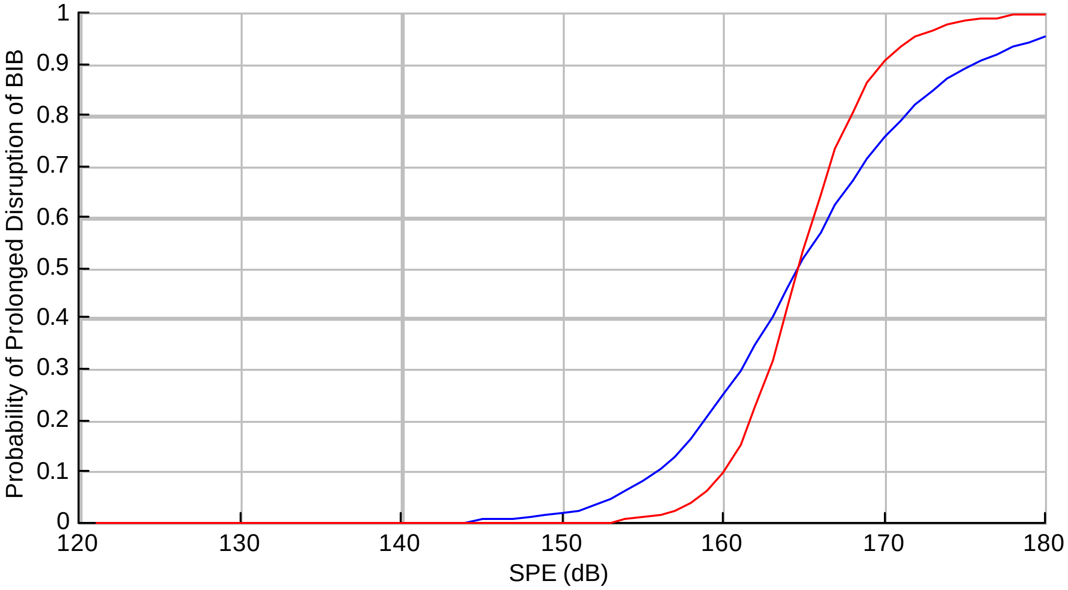


Figure D-4: Risk Function with Doubled Tuning Parameter

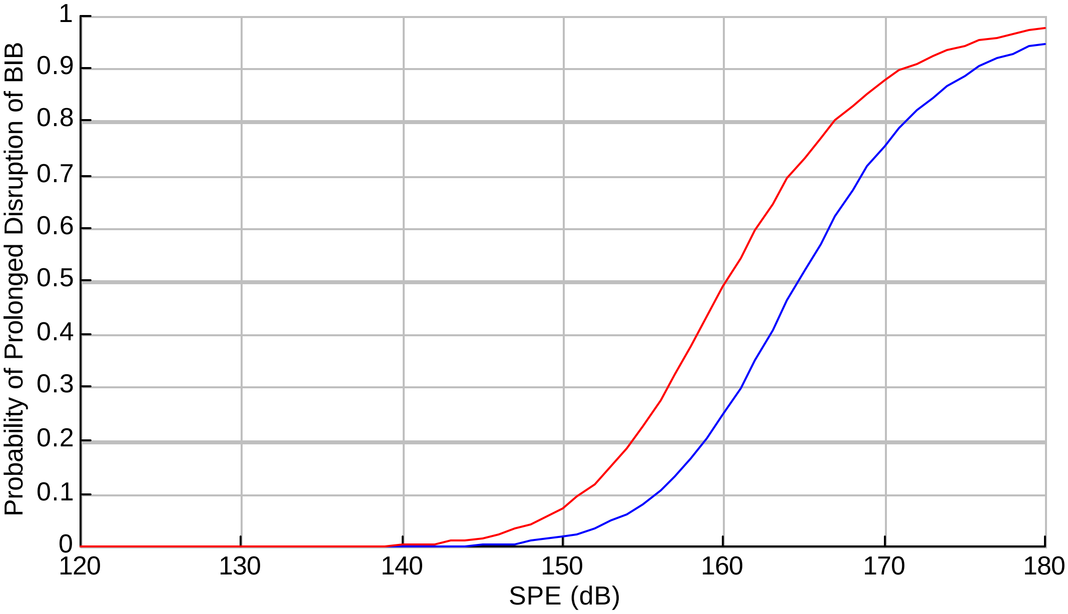
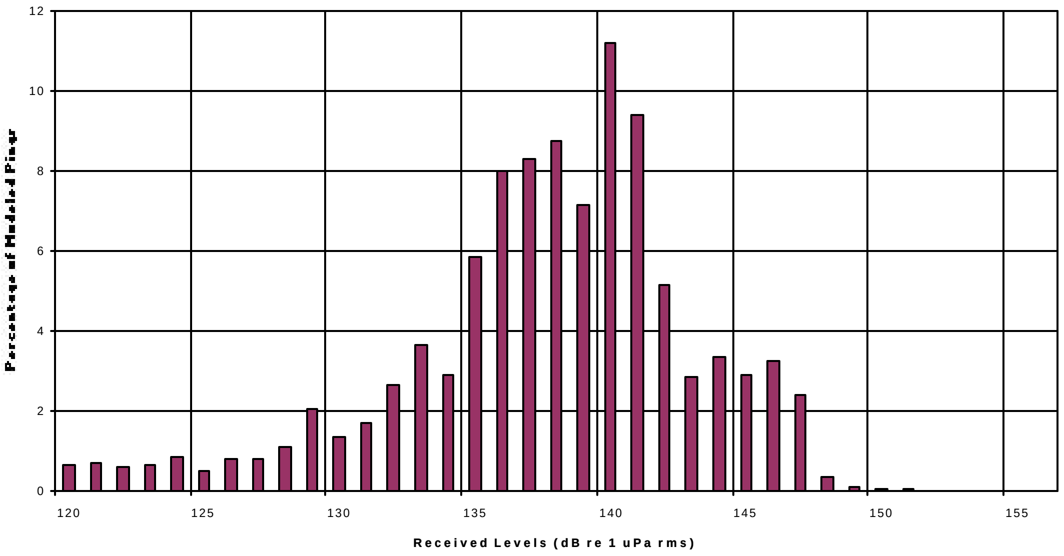


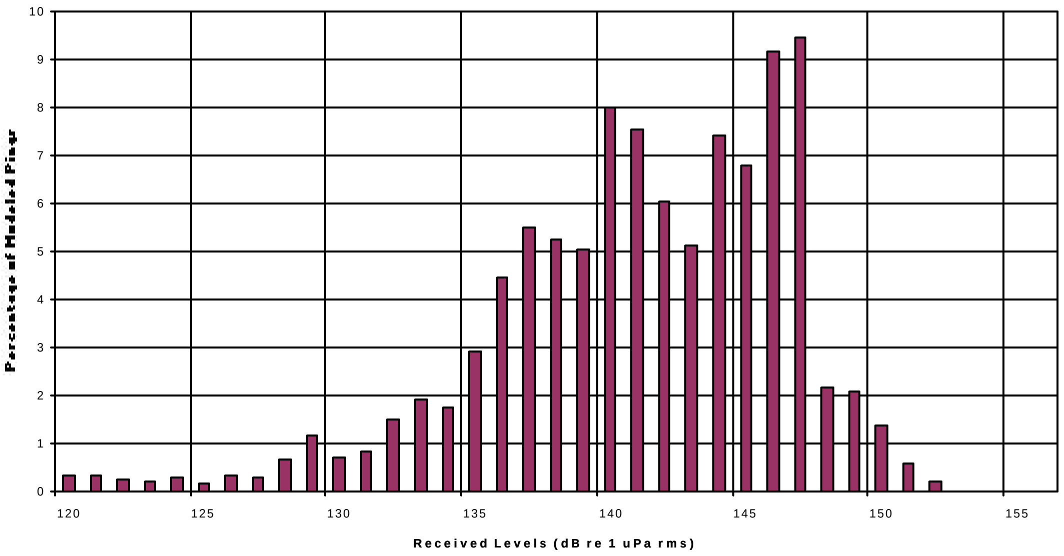
Figure D-5: Risk Function with Shifted Mid-point

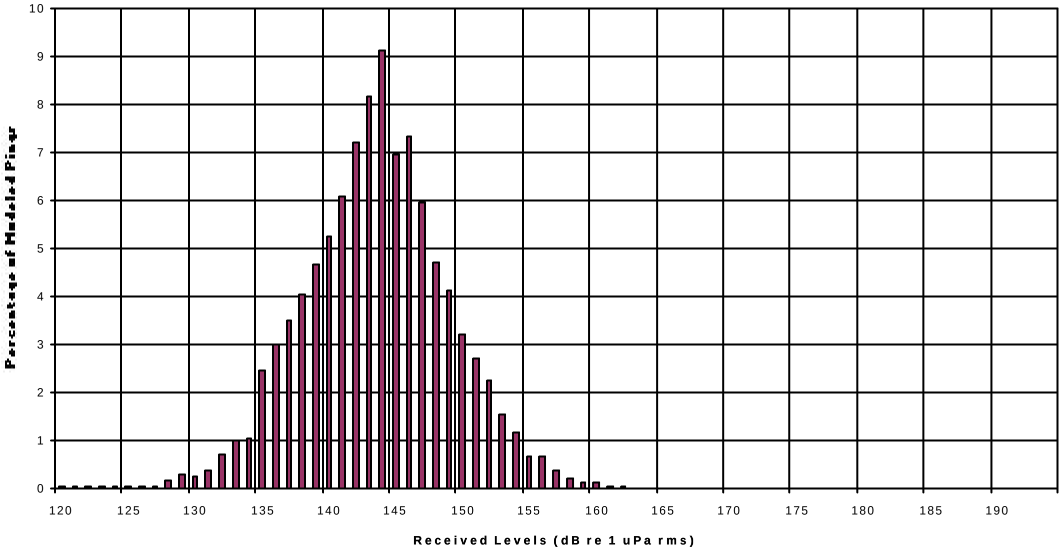
Figure D6: Received Level Histograms

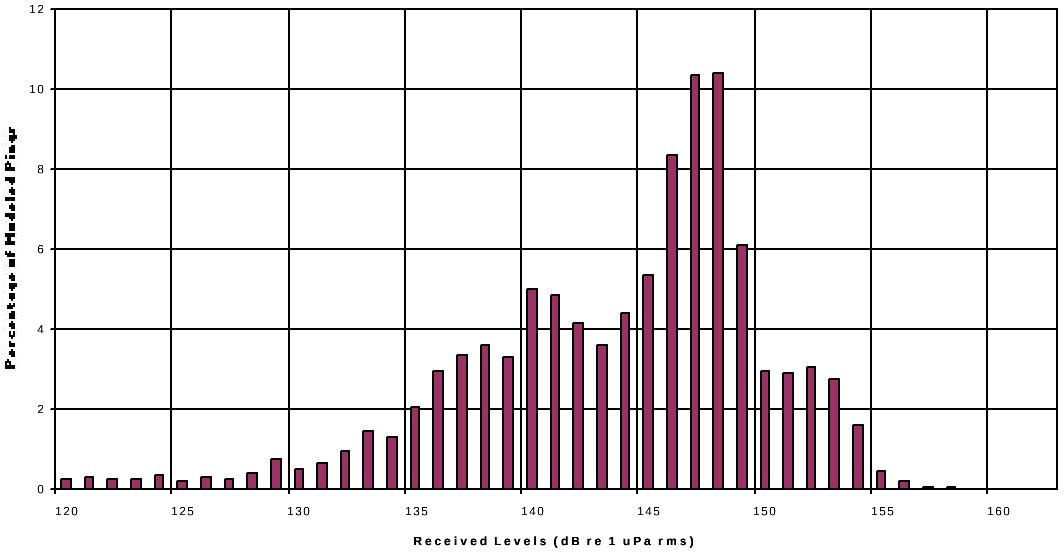
Site #1 Northern Right Whales Received Levels

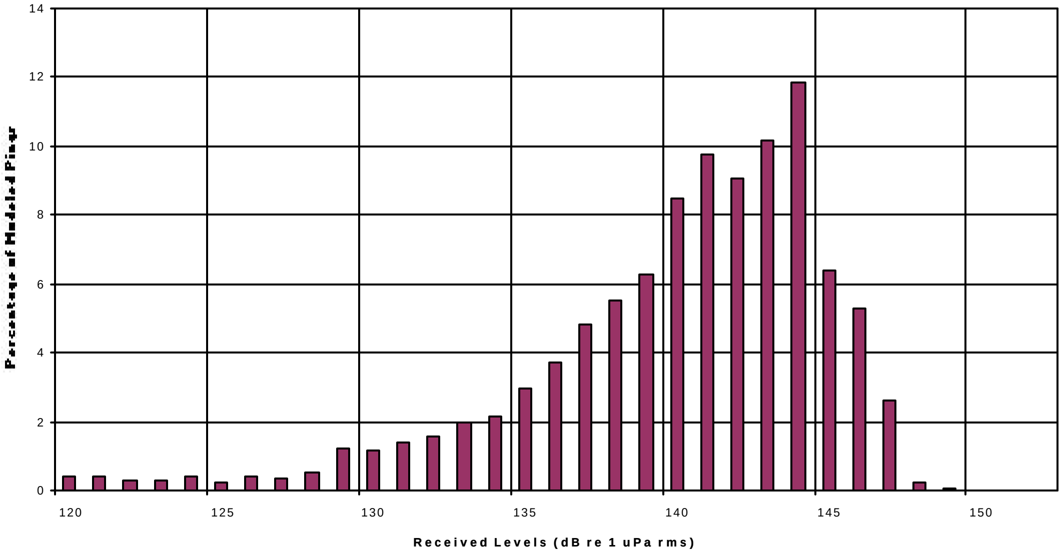


Site #1 Minke Whales Received Levels

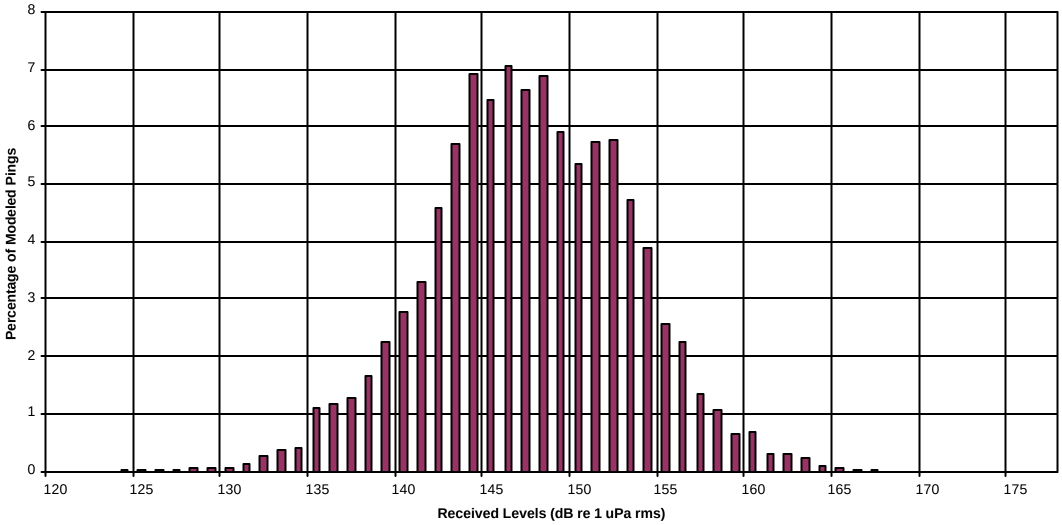



Site #1 Pelagic Dolphins Received Levels

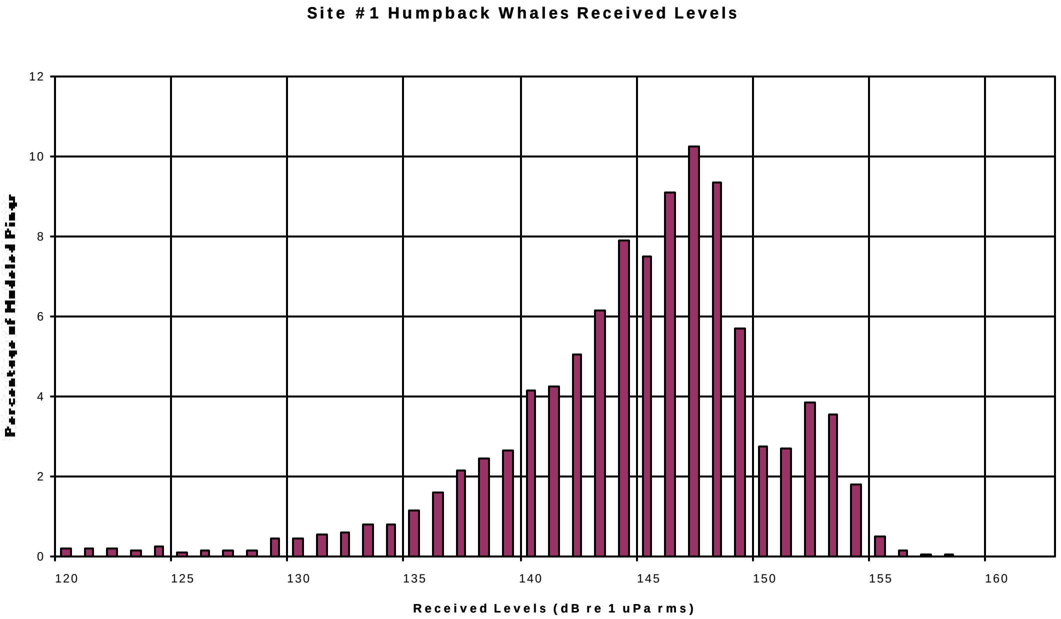

Site #1 Northern Sea Lions Received Levels

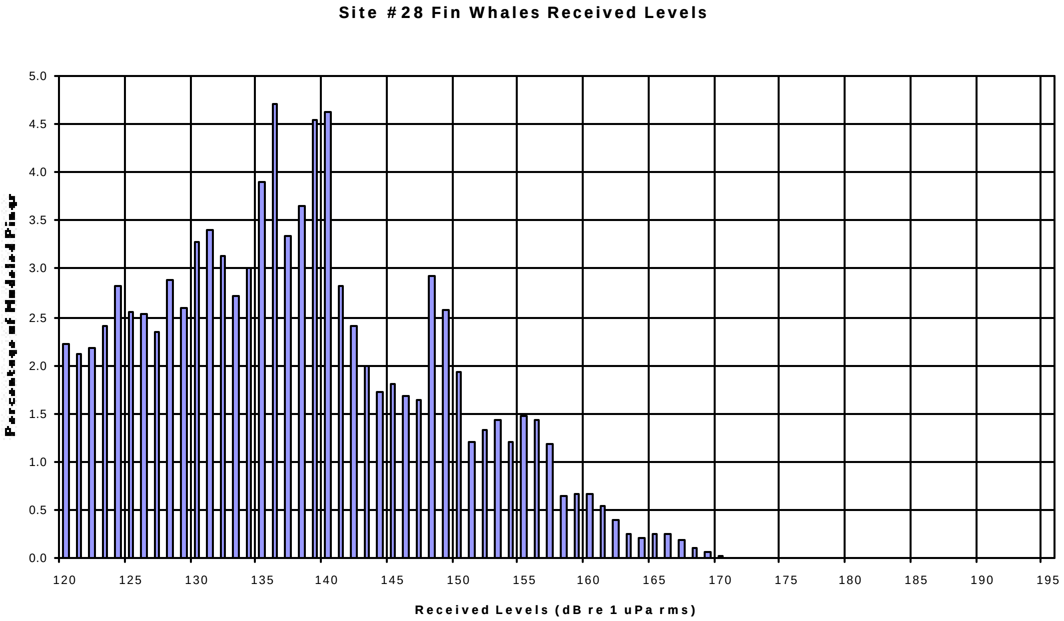


Site #1 Gray Whales Received Levels

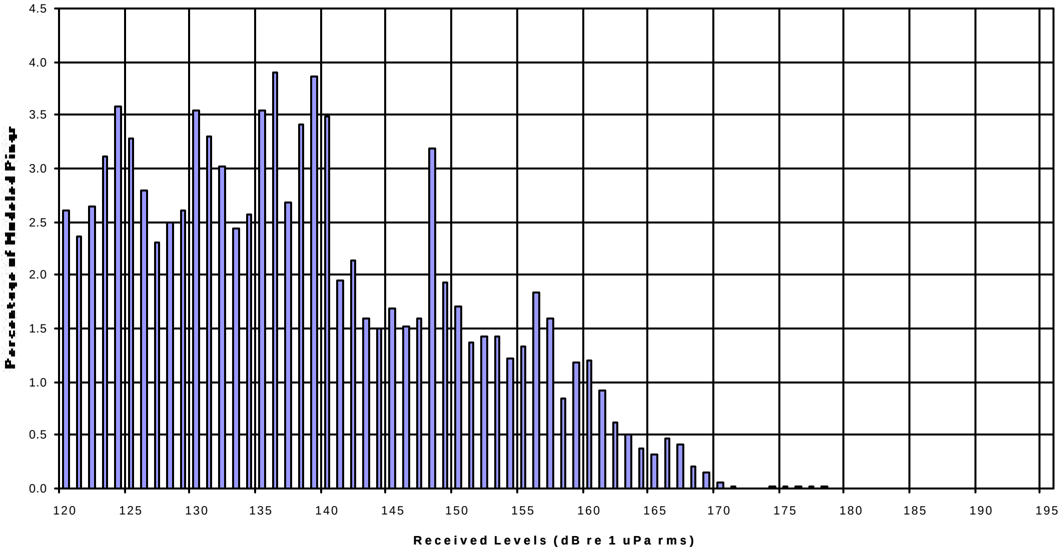


Site #1 Blue Whales Received Levels

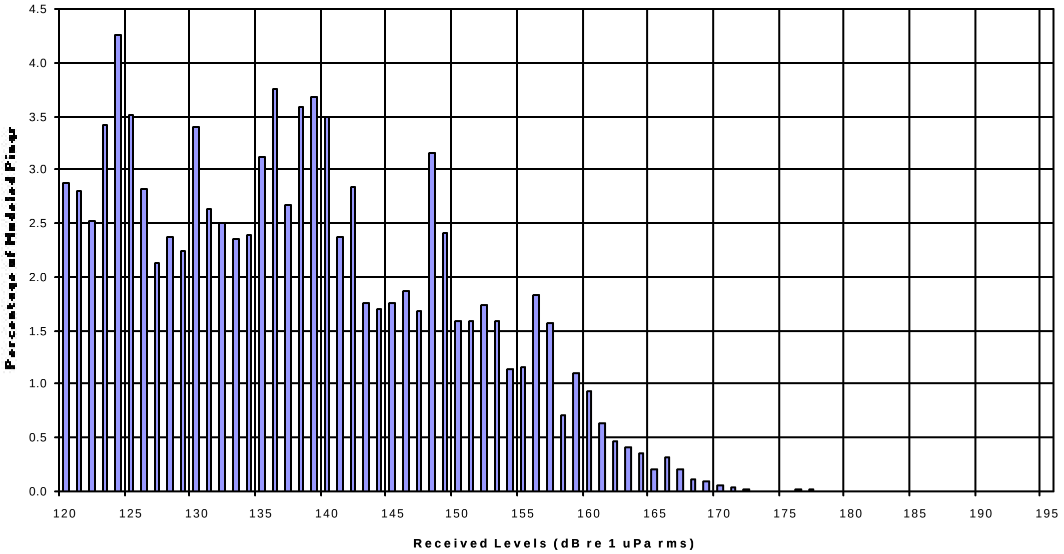

Site #1 Humpback Whales Received Levels

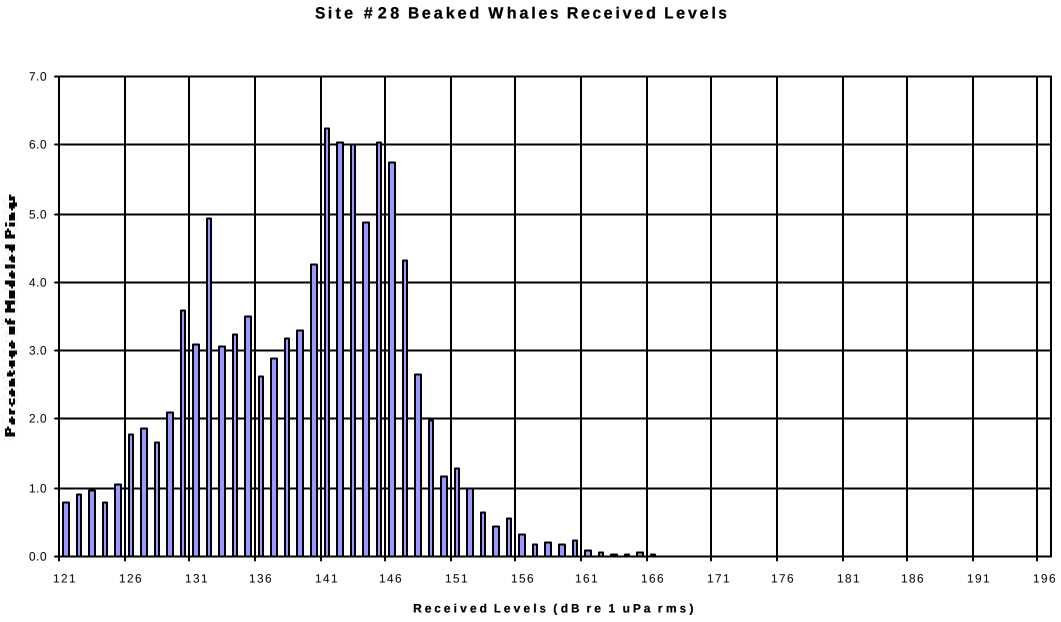

Site #28 Fin Whales Received Levels

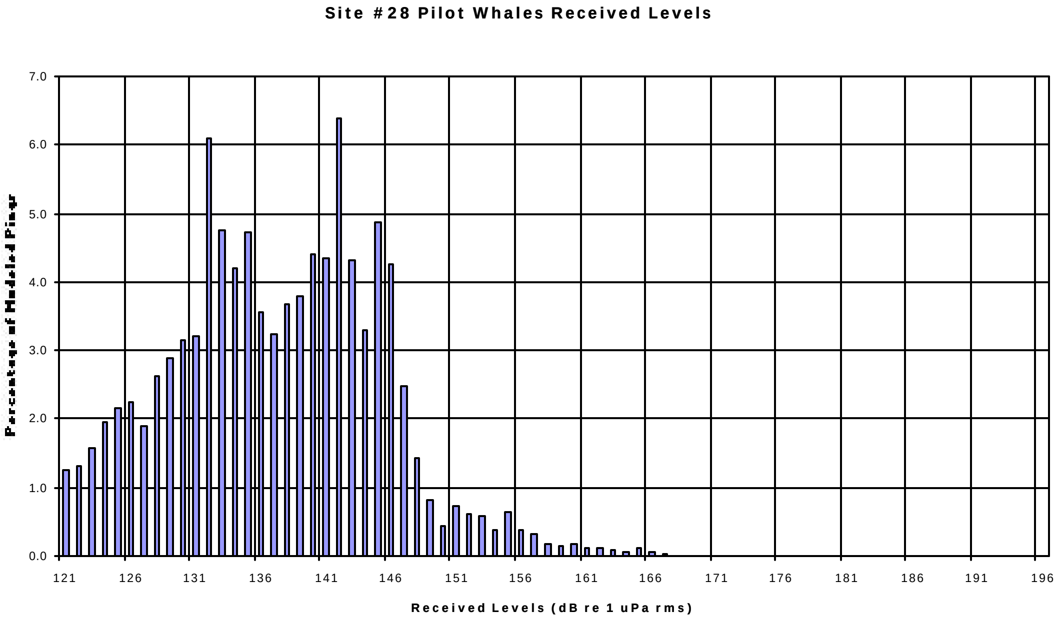
Site #28 Sei Whales Received Levels

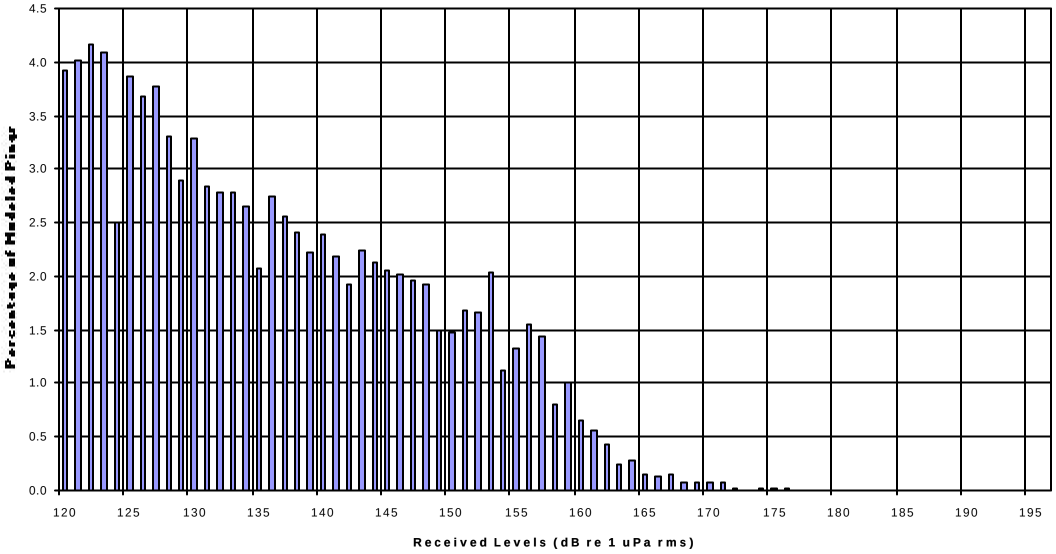


Site #28 Minke Whales Received Levels

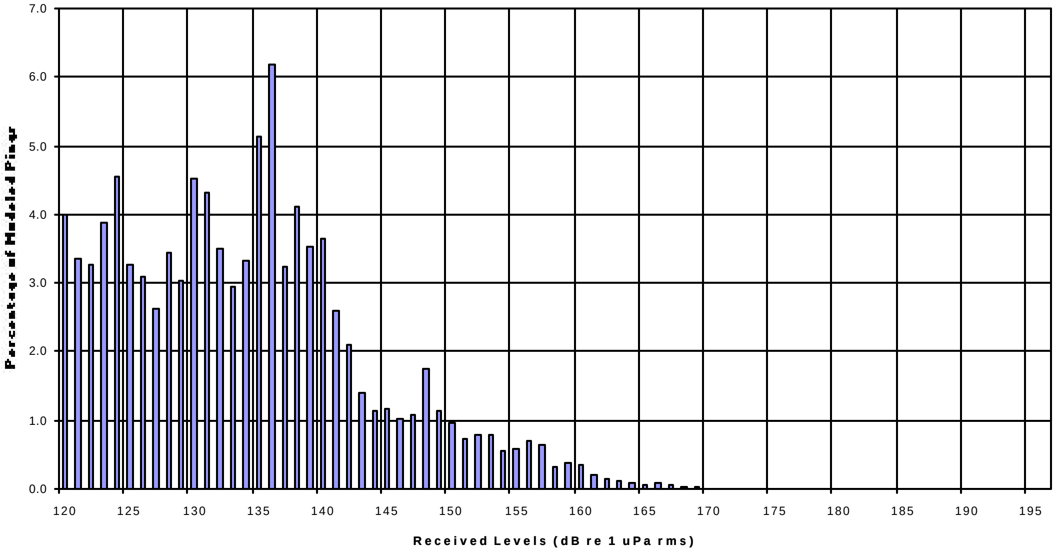



Site #28 Beaked Whales Received Levels


Site #28 Pilot Whales Received Levels



Site #28 Northern Right Whales Received Levels



Site #28 Pelagic Dolphins Received Levels