STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P.O. BOX 621
HONOLULU, HAWAII 96809

AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
LAND DIVISION
STATE PARKS
WATER RESOURCE MANAGEMENT

RECEIVED
'01 JUL 10 A9:25
OFC. OF ENVIRONMENTAL QUALITY CONTROL

Ref: PB:TC

JUL - 6 2001

File No.: KA-2941

Peter Worcester, Research Oceanographer
University of California, San Diego
Scripps Institution of Oceanography
IGPP 0225
9500 Gilman Drive
La Jolla, California 92093-0225

Dear Mr. Worcester:

SUBJECT: Recommendation for Acceptance of the Final Environmental Impact Statement (FEIS) for Scripps' North Pacific Acoustic Laboratory (NPAL), CDUA KA-2941, North Kauai, Hawaii

We have reviewed this Final Environmental Impact Statement for the North Pacific Acoustic Laboratory, and have found it to meet the requirements of Chapter 343, Hawaii Revised Statutes and Chapter 200 of Title 11, Hawaii Administrative Rules, Environmental Impact Statement Rules. An acceptance report is attached for your information and use.

Aloha,

GILBERT S. COLOMA-AGARAN
Chairman, DLNR

cc: Land Board Members
Kauai District Land Agent
Division of Aquatic Resources
OEQC
EPA
Fish and Wildlife Service
NOAA

2001 FEIS KAUAI
NORTH PACIFIC ACOUSTIC LABORATORY
1 OF 2

FINAL ENVIRONMENTAL IMPACT STATEMENT
FOR THE
NORTH PACIFIC ACOUSTIC LABORATORY
Volume I

Prepared by

Office of Naval Research
800 N. Quincy Street
Arlington, VA 22217-5660

With the cooperation of

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Protected Resources
1335 East-West Highway
Silver Spring, MD 20910

State of Hawaii
(State Accepting Authority)
Department of Land and Natural Resources
1151 Punchbowl
Honolulu, HI 96813

May, 2001

Final Environmental Impact Statement for the North Pacific Acoustic Laboratory

Federal Lead Agency:
Office of Naval Research
800 N. Quincy Street
Arlington, VA 22217-5660

Federal Cooperating Agency:
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Protected Resources
1335 East-West Highway
Silver Spring, MD 20910

State Accepting Authority:
State of Hawaii
Department of Land and Natural Resources
1151 Punchbowl
Honolulu, HI 96813

Applicant:
University of California, San Diego
Scripps Institution of Oceanography
9500 Gilman Drive
LaJolla, CA 92093-0225

Location of Action:
Ocean waters under state and federal jurisdiction west and north of Island of Kauai, State of Hawaii

Abstract

This Final Environmental Impact Statement identifies and analyzes the proposed action and alternatives for the continued operation for five additional years of the low frequency (LF) sound source (including the seabed power cable) previously installed off the north shore of Kauai, Hawaii, for use in Acoustic Thermometry of Ocean Climate (ATOC) research. The proposed action is reuse of the sound source and cable for the North Pacific Acoustic Laboratory (NPAL), a U.S. Navy Office of Naval Research (ONR) basic research project, which 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 action would be carried out by Scripps Institution of Oceanography, University of California, San Diego (Scripps), which is the applicant for necessary state and federal permits, and by the Applied Physics Laboratory of the University of Washington.

Please contact the following person with comments and questions:
Office of Naval Research
c/o Kathleen Vigness Raposa
Marine Acoustics, Inc.
809 Aquidneck Avenue
Middletown, RI 02842
Phone: 401-847-7508

CHANGES MADE TO THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

This document is organized so that changes made to the Draft Environmental Impact Statement (DEIS) in the production of this Final Environmental Impact Statement (FEIS) can be clearly identified. The locations of text changes are indicated with a vertical line in the adjacent right margin. Each change is also numbered so that it can be cross-referenced to its corresponding entry in Appendix G, Changes Made to the DEIS. Except for the edits made in Sections 1.3.3 and 6.1.3 to clarify the Endangered Species Act (ESA) permitting process, the edits made in Sections 4.5.3 and 6.2.3 to reflect new Hawaii legislation passed since the DEIS was out for public review, and edits made to Sections 3.2 and 4.2.1.2.1 to add sei whales as discussed with NMFS in consultation under the ESA, all changes made to the DEIS were in response to comments received or were updates that reflect the progression of the EIS process (e.g. the updates made in Section 1.3.1.1). Copies of all comments and responses are included in Appendix F, DEIS Comments and Responses.

Appendix G includes detailed information about the changes that were made to the text of the DEIS. Each changed section is included in this appendix with deleted text indicated in a strikeout format and new or changed text indicated as both italicized and underlined (*such as this*).

EXECUTIVE SUMMARY

This Executive Summary describes the proposed action and alternatives analyzed in this Environmental Impact Statement (EIS) for the continued operation for five additional years of the low frequency (LF) sound source (including the seabed power cable) previously installed off the north shore of Kauai, Hawaii, for use in Acoustic Thermometry of Ocean Climate (ATOC) research. The proposed action is reuse of the sound source and cable for the North Pacific Acoustic Laboratory (NPAL), a U.S. Navy Office of Naval Research (ONR) basic research project, which 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 action would be carried out by Scripps Institution of Oceanography, University of California, San Diego (Scripps), which is the applicant for necessary state and federal permits, and by the Applied Physics Laboratory of the University of Washington. This EIS presents a detailed description of the proposed project, its facilities, environmental setting, alternatives, potential environmental effects, and mitigation and monitoring measures, in addition to other information required by the National Environmental Policy Act and the Hawaii Environmental Impact Statement Law.

An understanding of the basic principles of subsea sound is important for assessing the material included in this EIS. Therefore, readers unfamiliar with subsea sound are referred to Appendix A for a summary of fundamental knowledge. 1

PURPOSE AND NEED FOR THE PROPOSED ACTION

Acoustic thermometry is a method for obtaining information about the temperature field in the ocean from precise measurements of the travel times of sound pulses transmitted through the ocean. It is also a technique for *acoustic remote sensing* of the ocean interior, in which the properties of the ocean *between* the acoustic sources and receivers are determined, rather than the properties of the ocean *at* the instruments as is the case for conventional thermometers and current meters. Remote sensing of the ocean interior using light or radio waves is not feasible because they travel only a short distance in seawater (up to a few hundred meters for light) before being absorbed. Acoustic thermometry in the ocean is closely related to seismology in the Earth, in which properties of the Earth's interior are inferred from travel times of earthquake waves.

A full understanding of long-range underwater sound transmission in the ocean is important not only for acoustic remote sensing of the ocean interior. It is also important because all users of the ocean environment must rely on acoustic signals to sense their undersea surroundings and to perform the many tasks underwater for which light and other electromagnetic radiation are used in the atmosphere. Sound is used for such basic tasks as measuring ocean depth, locating underwater objects, navigating, and communicating, for example. The fundamental limits to the performance of these tasks are due in part to the effects of small-scale ocean variability on acoustic signals.

The purposes of the proposed action are:

- To perform the second phase of research on the feasibility and value of large-scale acoustic thermometry;
- To study the behavior of sound transmissions in the ocean over long distances; and
- To conduct studies on the possible long-term effects from the sound transmissions on marine life.

The needs to accomplish the proposed action for large-scale acoustic thermometry include:

- Study seasonal and interannual ocean variability associated with phenomena such as El Niño, La Niña and the Pacific Decadal Oscillation;
- Use of acoustic thermometry data in combination with a variety of other data types, including satellite altimeter data, subsurface drifter data, surface drifter data, surface mooring data, and expendable bathythermograph data, to test and constrain computer models of the ocean circulation in order to gain a better understanding of ocean variability and the earth's changing climate;
- Quantitive comparison and contrast of the contributions of each of the various data types to constrain computer models of the ocean circulation; and
- Objective assessment of the value of acoustic methods for remote sensing of the ocean interior as one component of an integrated ocean observing system for ocean weather and climate.

The needs to study long-range underwater sound transmission include:

- Improvement in the understanding of the basic principles of LF, long-range underwater sound transmission (i.e., acoustic propagation) in the ocean;
- Determination of the effects of ocean environmental variability on acoustic signal stability and coherence;
- Study of seasonal and annual variations in acoustic conditions in the North Pacific specifically, and the impact of environmental variability on acoustic propagation more generally; and

- Determination of the fundamental limits to acoustic signal processing at long-range imposed by the ocean environment.

The need to conduct marine mammal monitoring (M3) studies is to:

- Advance the understanding of the potential for long-term effects from the acoustic transmissions, by performing aerial surveys to monitor the distribution and abundance of marine mammals in the vicinity of the sound source.

ENVIRONMENTAL IMPACT ANALYSIS

Under the National Environmental Policy Act and the Hawaii Environmental Impact Statement Law, ONR and Scripps must ensure that the potential environmental effects of the proposed project have been adequately addressed and analyzed. This analysis includes consideration of the project's consistency with land use plans and policies as well as policies and standards of 2
applicable state and federal regulatory requirements. The information and analysis is presented primarily through this EIS, which is prepared in compliance with state and federal law. It will be used by other agencies in determining whether to approve aspects of the project under their specific jurisdiction. Federal, state, and local authorities potentially relevant to review and approval of this project are discussed in detail in Chapters 1 and 6. Required agency approvals are summarized below.

AGENCY	ACTION
National Marine Fisheries Service (NMFS)	Incidental harassment/taking authorization under MMPA/ESA
NMFS	Consultation under ESA, § 7
NMFS	Coordination under Magnuson-Stevens Fisheries Conservation and Management Act
Hawaii Department of Land and Natural Resources	Conservation District Use Permit Approval of Disposition of Land
Hawaii Office of Coastal Zone Management	Federal Consistency Certification
Department of the Navy	Decision to Proceed

DLNR review of Scripps' application for a Conservation District Use Permit is triggered by use of state submerged lands for a portion of the cable route. The land lies within the Resource Subzone of the Conservation District, for which the objective is "to develop, with proper management, areas to ensure sustained use of the natural resources of these areas..." Hawaii Administrative Rule (HAR) § 13-5-13. As discussed in Section 6.2.1, the public purposes and specific characteristics of the scientific research activities provide DLNR with a foundation for finding the project consistent with the objective and specifically allowable uses of the Resource Subzone.

Federal consistency review by the Hawaii Office of Coastal Zone Management (OCZM) is triggered by the project's need to obtain authorization under the Marine Mammal Protection Act. Such authorizations are listed in the State's federally approved Coastal Zone Management Program as a basis for federal consistency review. Scripps has prepared a certification that the proposed project is consistent with the State's Coastal Zone Management Program. This consistency certification includes consideration of each of the program's enforceable policies. The analysis appears in Section 6.2.2 and is supported by information in this EIS.

DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

In this EIS, seven initial alternatives are considered, including the proposed action and the No Action alternatives. The effectiveness of each alternative and its potential to meet the project objectives are compared. After analysis, three alternatives are selected for further study, including the proposed action – continued operation of the Kauai source (Preferred Alternative), No Action, and alternate project site - Midway Island (Midway Alternative). A brief description of each of these final alternatives follows.

Proposed Action - Continued Operation of the Kauai Source (Preferred Alternative)

The Preferred Alternative involves the continued operation for five additional years of the LF sound source (including the seabed power cable) previously installed off the north shore of Kauai, Hawaii, for use in ATOC research. Under the Preferred Alternative, the seabed power cable and sound source would remain in their present locations, and transmissions would continue for the most part with the same signal parameters and approximately the same transmission schedule used in the ATOC project. The typical schedule would consist of six 20-minute (min) transmissions (one every four hours), every fourth day, with each transmission preceded by a 5-min ramp-up period during which the signal intensity was gradually increased, representing an average duty cycle of 2 percent. With the possible exception of short duration testing with duty cycles of up to 8 percent, or equipment failure, this schedule would continue for a period of five years. The signals transmitted by the source have a center frequency of 75 Hertz (Hz) and a bandwidth of approximately 35 Hz (i.e., sound transmissions are in the frequency band of 57.5-92.5 Hz). Approximately 260 Watts of acoustic power are radiated during transmission. At 1 meter (m) (3.3 feet [ft]) from the source, the sound intensity (i.e., source level) is about 195 decibels (dB) referenced to the intensity of a signal with a sound pressure level of 1 microPascal (μPa) (on a "water standard" basis). These signal parameters and source level were found in the ATOC project to provide adequate, but not excessive, signal-to-noise ratios at the receiver ranges of interest.

At the conclusion of the five-year period, the seabed power cable would be abandoned in place, to avoid disturbing sensitive military instrumentation in the vicinity and the environmental impacts associated with removal. The source would be abandoned in place as well, unless it appeared to still be in sufficiently good condition to warrant recovery.

No Action Alternative

Under this alternative, no further activity with the Kauai source would occur beyond that authorized by the current permits, under which the transmissions ended in October 1999. The need for a long-term research project exploring the natural and anthropogenic (man-made) changes in the ocean environment would not be met. Cessation of transmissions would result in a potential loss of critical environmental information, since further data on large-scale ocean temperature and heat content variability on seasonal and interannual time scales would not be obtained from acoustic remote sensing. Furthermore, the data required to objectively assess the value of acoustic thermometry as one component of an integrated ocean observing system would not be acquired. In addition, there would be a loss of information on the distribution, abundance and densities of the Hawaiian humpback whale population that would be obtained from aerial surveys conducted over the next five years, and there would be no data collected on the potential for long-term effects from LF sound transmissions on marine life. Finally, advances in signal processing and the ultimate effectiveness of passive acoustic techniques would not be realized. Without these advances, alternate techniques for detecting quiet acoustic sources would need to be utilized and/or developed.

Alternate Project Site – Midway Island (Midway Alternative)

Under this alternative, the long-range propagation and acoustic thermometry feasibility studies would be undertaken with the source located at a site other than off the north shore of Kauai. Several sites in the North Pacific are evaluated in this EIS, but the acoustic capabilities at Midway Island were considered superior to the other options. Therefore, a sound source and power cable would be placed off the coast of Midway Island, and acoustic transmissions would occur there. While this alternative would allow some study of large-scale acoustic thermometry and long-range acoustic propagation, a source off Midway Island does not have the acoustic capabilities of the Kauai source. In addition, limited baseline data on the marine animals in the vicinity of Midway Island would limit the study of potential long-term effects from the acoustic transmissions.

POTENTIAL ENVIRONMENTAL EFFECTS

As described in detail in the EIS, the environment includes the following major resources: physical, biological, economic, and social. Physical effects include those from construction and/or removal of facilities and potential increases in ambient noise. The physical installations at Midway Island as part of the Midway Alternative, involving the placement of a small sound source and power cable, would be relatively minor and generally are benign from an environmental standpoint. The No Action Alternative and the Midway Alternative would involve the removal of the sound source and cable presently in place off northern Kauai. Since the cable has been on the seafloor for six years, natural processes such as sediment drift are likely to have buried the cable. Removing the cable is therefore likely to disrupt the seafloor environment. In those regions where the cable is not buried, it is possible that new coral may have begun to grow on the cable. The Pacific Missile Range Facility (PMRF) has discovered significant coral growth on many of its underwater cables. In addition, the installation of the Shallow Water Training Range (SWTR) off the northeast coast of Kauai by PMRF complicates the cable recovery task. In terms of the sound fields of the source, all alternatives except the No Action Alternative would add somewhat to the ambient noise levels during transmission periods.

The biological environment potentially affected by the Preferred Alternative includes marine mammals, sea turtles, and fish. There would be limited probability of a direct adverse effect on the benthic biological environment due to sound source and cable installation and/or removal. However, Hawaiian monk seals, a severely endangered species, use the beaches of Midway Island for breeding and pupping, and recent increases in pup survival at Midway suggest that the seals may reestablish the atoll as a major breeding site. Therefore, activities associated with the installation of a power cable at Midway may disrupt their behavior.

Several potential effects due to source transmissions are discussed, including the potential for physical auditory effects, behavioral disruption, habituation, masking, long-term effects, and 3
indirect effects. Analysis of the potential effects on marine mammals was accomplished with results of the California and Hawaii ATOC Marine Mammal Research Programs (MMRPs) and a comprehensive program of underwater acoustical modeling. The ATOC MMRPs were designed to determine the potential effects of the acoustic transmissions on marine mammals and other marine life. Neither MMRP observed any overt or obvious short-term changes in behavior, abundance, distribution, or vocalizations in the marine mammal species studied. Intense statistical analyses revealed some subtle changes in the distance and time between successive humpback whale surfacings (segment length and segment duration), and in the distribution of humpback whales away from the Kauai source and humpback (and possibly sperm) whales away from the California source during transmission periods. Bioacoustic experts concluded that these subtle effects would not adversely affect the survival of an individual whale or the status of the North Pacific humpback whale population (Frankel and Clark, 2000).

In order to estimate the potential for biological risk, a comprehensive program of underwater acoustical modeling was undertaken. The potential for biological risk is a function of an animal's exposure to sound. The parameters used for determining exposure were RL in decibels, length of the signal, and the number of signals received. Therefore, the level of risk for an animal depends on its location in relation to the sound source. In order to determine the potential for risk, threshold standards were established. These threshold standards set the amount of potential risk for a biologically significant behavioral response that affects biologically important activity, such as survival, breeding, feeding and migration, which have a potential to impact on 4
the reproductive success of an animal if an animal received one 1-min signal at that received level. The threshold standards, which were developed into a risk continuum, were based on a comprehensive literature review and the results of recent studies on the effects of LF sound on marine mammals. As explained in detail in Chapter 4, the risk continuum estimates that 95 percent of the marine mammals exposed to a single 1-min ping at 180 dB could incur a temporary threshold shift (TTS); that the risk of disturbing a biologically important behavior is zero below 120 dB; and that 2.5 percent of a population exposed to a single 1-min ping at a RL of 150 dB would experience disturbance of a biologically important behavior. The resulting risk continuum is shown in Figure ES-1.

To quantify the potential for risk, the sound field around the source was estimated using the Navy's standard acoustic performance prediction transmission loss model. These data are input

to the Acoustic Integration Model (AIM) which coupled the acoustic environment with population distribution, abundance, density, general movement and diving profile data for marine mammals in the area. AIM was used to simulate the acoustic exposure for each animal over one 20-min transmission and over one day of transmissions (six 20-min transmissions). To account for animal movement during the 20-min transmission and over one day of transmissions, the NPAL signal was broken up into 1-min pings. The energy an animal received from each of these 5
1-min pings (either 20 1-min pings for one transmission or 120 1-min pings for one day of transmissions) was then summed and the corresponding received level for one 1-min ping (i.e., the single ping equivalent) was calculated. The single ping equivalent was the input into the risk continuum to estimate the potential effects of the NPAL transmissions. Estimates of the percentages of marine mammal populations potentially affected by the Preferred Alternative and the Midway Alternative are displayed in Tables ES-1 and ES-2, respectively. A value of zero means that less than 0.01% (i.e., 0.0001) of the marine mammal population are potentially affected. These results suggest that only humpback whales near Kauai have a chance for disturbance of a biologically important behavior, and no TTS effects are expected with any of the species at either site.

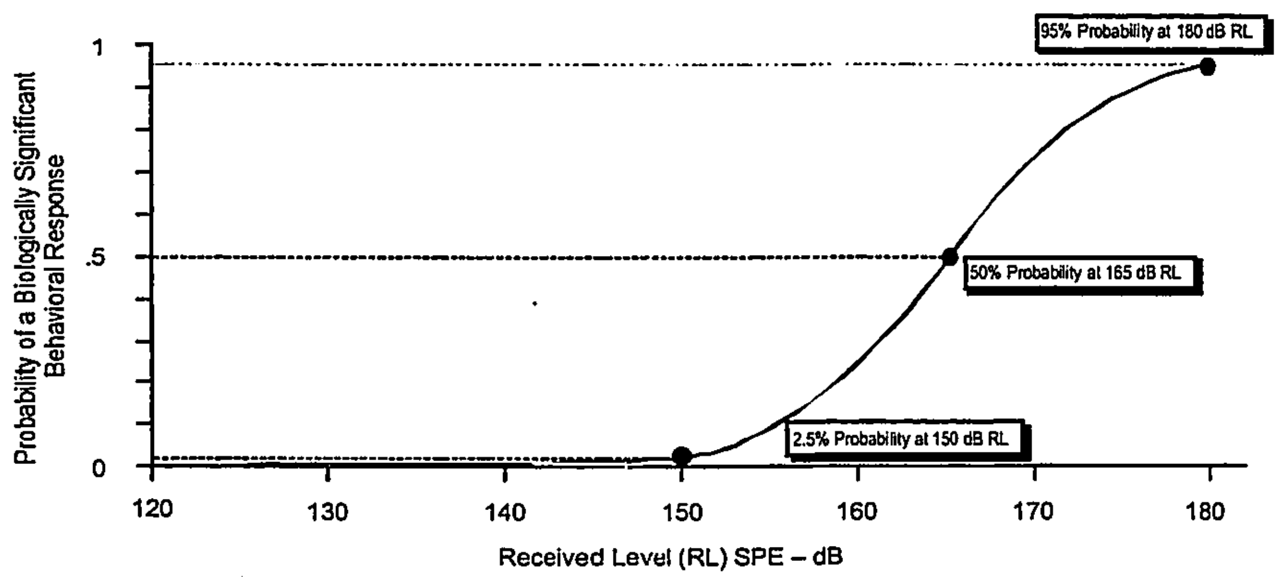


Figure ES-1, Single Ping Equivalent Probability Function

Table ES-1 Percentages of Marine Mammal Populations Potentially Affected by the Preferred Alternative

Marine Mammals	One Transmission		One Day of Transmissions	
	Biologically Significant Behavioral Response (120-180 dB)	TTS (≥ 180 dB)	Biologically Significant Behavioral Response (120-180 dB)	TTS (≥ 180 dB)
humpback whale	0	0	0.01	0
fin whale	0	0	0	0
sperm whale	0	0	0	0
dwarf and pygmy sperm whales	0	0	0	0
Blainville's beaked whale	0	0	0	0
Cuvier's beaked whale	0	0	0	0
short-finned pilot whale	0	0	0	0
fasle killer whale	0	0	0	0
melon-headed whale	0	0	0	0
Risso's dolphin	0	0	0	0
rough-toothed dolphin	0	0	0	0
bottlenose dolphin	0	0	0	0
striped dolphin	0	0	0	0
spotted dolphin	0	0	0	0
spinner dolphin	0	0	0	0
Hawaiian monk seal	0	0	0	0

6

Table ES-2 Percentages of Marine Mammal Populations Potentially Affected by Alternative 3

Marine Mammals	One Transmission		One Day of Transmissions	
	Biologically Significant Behavioral Response (120-180 dB)	TTS (≥ 180 dB)	Biologically Significant Behavioral Response (120-180 dB)	TTS (≥ 180 dB)
blue whale	0	0	0	0
fin whale	0	0	0	0
Bryde's whale	0	0	0	0
minke whale	0	0	0	0
sperm whale	0	0	0	0
dwarf and pygmy sperm whales	0	0	0	0
Blainville's beaked whale	0	0	0	0
Cuvier's beaked whale	0	0	0	0
melon-headed whale	0	0	0	0
Risso's dolphin	0	0	0	0
rough-toothed dolphin	0	0	0	0
bottlenose dolphin	0	0	0	0
striped dolphin	0	0	0	0
spotted dolphin	0	0	0	0
spinner dolphin	0	0	0	0
Hawaiian monk seal	0	0	0	0

Concerning sea turtles, the maximum residence time in the area of the Preferred Alternative is < 24 hours, given their general coastal distribution and known transit speeds. In addition, the maximum dive depths for leatherbacks are > 1000 m (3281 ft). No other species of sea turtle are know to dive > 500 m (1591 ft), and therefore would not be capable of receiving the highest RLs. The measured hearing threshold for green turtles (and by extrapolation, at least the olive ridley, loggerhead, and hawksbill) is only slightly lower than the maximum levels to which these three species could be exposed. It is not believed that a temporary threshold shift would occur at such a small margin over threshold in any species. Therefore, no threshold shifts in green, olive ridley, loggerhead, or hawksbill sea turtles are expected. Because leatherback turtles are morphologically distinct (leathery shell, with minimal calcification of bone), approximating hearing thresholds from data available for the other (hard shell) species is probably inappropriate. However, inasmuch as the density of leatherbacks over the study area is low, but patchy (Eckert, pers. comm., 1994), the fact that only a small percentage of time is spent at depth, the intermittent nature and low duty cycle of the NPAL source, and the fact that the proposed project site is not believed to be a particularly important location of leatherback prey species, any impact should be minimal. Similarly, the potential for short-term behavioral disturbance or displacement of all sea turtle species is unlikely.

Though little information on hearing exists for the particular marine fish species in the vicinity 7
of the proposed sites, sufficient research on fish and their hearing mechanisms allows fish species to be grouped into two categories to estimate potential effects: "specialists" that have specializations that enhance their hearing sensitivity, and "nonspecialists" that do not possess such capabilities. It is speculated that in order for extensive damage to occur, sound levels of 220 to 240 dB (RL) would be needed to injure the ears of nonspecialists. The comparable level for a hearing specialist might be on the order of 50 dB lower. Therefore, the risk of physical harm or injury would be at received levels at or above 180 dB. For the NPAL project, proportionally few fish are expected to be exposed to levels >180 dB, which would occur within a radius of approximately 5 m (18 ft) from the source. In addition, the proposed source site would comprise only a small portion of the range for any fish species. In light of this, plus the low duty cycle and intermittent nature of transmissions, it is concluded that although threshold shifts might occur in a few hearing specialists that are deep divers, the impact on fish populations should be minimal.

One component of the ATOC MMRPs was to investigate potential behavioral changes in three species of rockfish (nonspecialists) in response to the playback of ATOC-like sounds (Klimley and Beavers, 1998). The fish exhibited little movement to 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 for the entire duration of the test and control periods. Consequently, no significant response was observed in rockfish at received levels up to 153 dB. Because sharks are known to be attracted to low frequency signals, they would appear to be one of the best candidates for incurring some level of behavioral disruption due to the NPAL LF source transmissions. However, based on studies by Nelson and Johnson (1972), sharks readily habituated to low frequency, pulsed sounds. Thus, it might be that the attractiveness of the NPAL source transmissions would decline over a period of time, given that the transmission characteristics would be relatively constant at a duty cycle of 2-

8 percent. Thus, it is considered unlikely that NPAL sound transmissions would cause any measurable behavioral disruption to the indigenous fish species.

Socioeconomic effects are considered to range from minor to nonexistent. The Hawaiian Archipelago shelf and slope off north Kauai support an economically valuable range of commercial fisheries utilizing a variety of retrieval methods. However, given the depth of the sound source, the minor extent of the sound fields, the low duty cycle (most of the time only 2 percent), the five-minute ramp-up period that would give all mobile marine animals the opportunity to depart the immediate area of the source if the sound was annoying, and the habitat range of the major commercial, recreational, and subsistence fish species, any potential effect on the economic environment is expected to be negligible. Direct effects of the proposed project would be limited to the beneficial impact of program expenditures on the economy. Direct effect through reduction of tourism could occur if changes in marine mammal abundance or distribution would occur. However, results from the MMRPs demonstrated no overt or obvious short-term changes. No effect is expected on recreational diving since most occurs in the nearshore area.

Potential cumulative effects are not anticipated for the physical, economic, or social environments. The types of actions that might reasonably be considered to have the potential to interact to affect the biological environment in the study area are noise-producing activities: e.g., merchant shipping and other vessel-related activities, recreational water activities, marine and nearshore construction and resort operations, aircraft operations, and research activities that could add cumulative noise stimuli to the marine environment. However, since the Preferred Alternative has minimal potential for effects to the biological environment, it is unlikely to add significantly to conditions in the present or reasonably foreseeable future.

UNRESOLVED ISSUES

The principal unresolved issue presented by the proposed project is the degree to which LF, subsea sounds could potentially affect marine animals over the long-term (NRC 1994, 1996, 2000). Results from the California and Hawaii ATOC MMRPs, which occurred over a time period of two years, are summarized in Chapters 1 and 4. All of the effects detected by the MMRPs were subtle, of short duration, and found only after intensive statistical analyses. Bioacoustic experts concluded that these subtle effects would not adversely impact the survival of an individual whale or the status of the North Pacific humpback whale population (Frankel and Clark, 2000). The proposed project is reuse of the sound source and cable for an additional five years of transmissions. This EIS acknowledges that the current level of knowledge on potential long-term effects is relatively sparse. Chapter 4 summarizes the scientific evidence relevant to this issue and evaluates potential long-term impacts based upon the ATOC MMRPs data and, when necessary, reasonable extrapolations from that data. 8

The project itself is intended to fill information gaps and reduce uncertainty concerning the possible long-term effects of low frequency sounds on marine animals. The benefits of the proposed project could not be fully realized by any of the other alternatives proposed.

MITIGATION AND MONITORING

This EIS has identified mitigation and monitoring measures that would be applied to the Preferred and Midway alternatives. The mitigation measures would minimize the potential effects of NPAL subsea sounds on marine animals by focusing on the operational characteristics of the NPAL sound source. Since the California and Hawaii ATOC MMRPs detected only subtle effects found after intensive statistical analyses, the need to conduct further marine mammal monitoring studies is to advance the understanding of the potential for long-term effects from the acoustic transmissions. The mitigation and monitoring measures to accomplish these objectives are as follows:

Mitigation Measure 1: The sound source would operate at the minimum duty cycle necessary to support the large-scale acoustic thermometry and long-range propagation objectives.

Mitigation Measure 2: Any increases in the duty cycle beyond the nominal 2 percent (with a maximum of 8 percent) would not occur during the peak humpback season (January – April).

Mitigation Measure 3: The sound source would operate at the minimum power level necessary to support large-scale acoustic thermometry and long-range sound transmission objectives.

Mitigation Measure 4: Transmissions from the NPAL sound source would be preceded by a 5-minute ramp-up of the source power.

Mitigation Measure 5: All NPAL vessels and aircraft would be equipped with required air pollution controls.

Mitigation Measure 6: For the Midway Island alternative, the portions of the cable and any protective casing in the nearshore area and surf zone would be designed to minimize the potential for adverse effects.

Mitigation Measure 7: The source cable, and possibly the sound source, would not be removed at the end of the experiment.

Monitoring Measure 1: The focus of the M3 studies is to advance the understanding of the potential for long-term effects of man-made sound on marine mammals by monitoring the distribution and abundance of marine mammals in the vicinity of the sound source.

Monitoring Measure 2: Monitor marine mammal stranding data.

COMPARISON OF ALTERNATIVES

The Preferred Alternative best meets the project objectives for the three components of NPAL. The sound source at Kauai would provide superior acoustic capability for study of both large-scale acoustic thermometry and long-range underwater sound transmission. In addition, further studies of the marine animal species in the vicinity of the Kauai source would be able to build on the data collected during the Kauai ATOC MMRP. A sound source at Midway (Midway

Alternative) would have a more limited acoustic capability and limited baseline marine animal data while the No Action Alternative would offer no possibility for a long-term research project exploring underwater sound transmission and the natural and man-made changes in the ocean environment. Therefore, continued operation of the Kauai source (the Preferred Alternative) best meets the project objectives.

The comparative potential biological effects of the Preferred and Midway alternatives would depend on the relative abundance of sensitive animals at the respective locations. For source transmissions, these differences would be minimal. However, there exists the potential at Midway for disturbance of the breeding and pupping of Hawaiian monk seals during installation of the power cable. The No Action Alternative would have no effects on marine animals, but would not meet the project objectives. The potential for physical effects from the three alternatives are similar, though the Midway Alternative would be worse since it would potentially include removal of the sound source and cable off Kauai and installation of a sound source and cable off Midway Island. The Preferred and Midway alternatives would have comparable socioeconomic effects. The No Action Alternative would not have any socioeconomic effects.

CHANGES MADE TO THE DEIS

This document is organized so that changes made to the DEIS in the production of this FEIS can be clearly identified. The locations of text changes are indicated with a vertical line in the adjacent right margin. Each change is also numbered so that it can be cross-referenced to its corresponding entry in Appendix G, Changes Made to the DEIS. Except for the edits made in Sections 1.3.3 and 6.1.3 to clarify the Endangered Species Act (ESA) permitting process, the edits made in Sections 4.5.3 and 6.2.3 to reflect new Hawaii legislation passed since the DEIS was out for public review, and edits made to Sections 3.2 and 4.2.1.2.1 to add sei whales as discussed with NMFS in consultation under the ESA, all changes made to the DEIS were in response to comments received or were updates that reflect the progression of the EIS process (e.g. the updates made in Section 1.3.1.1). Copies of all comments and responses are included in Appendix F, DEIS Comments and Responses. 9

Appendix G includes detailed information about the changes that were made to the text of the DEIS. Each changed section is included in this appendix with deleted text indicated in a strikeout format and new or changed text indicated as both italicized and underlined (*such as this*).

TABLE OF CONTENTS

VOLUME I

LIST OF FIGURES

LIST OF TABLES

TABLE OF CONTENTS

VOLUME II

THIS PAGE INTENTIONALLY LEFT BLANK

ACRONYMS AND ABBREVIATIONS

AIM	Acoustic Integration Model
APL-UW	Applied Physics Laboratory, University of Washington
ARGO	Argos Global Centre
ARPA	Advanced Research Projects Agency
ATOC	Acoustic Thermometry of Ocean Climate
°C	degrees Celsius
CDF	Cumulative Distribution Function
CDUP	Conservation District Use Permit
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CITES	Convention on International Trade in Endangered Species
cm	centimeters
COE	Corps of Engineers
CORE	Consortium for Oceanographic Research and Education
CZMA	Coastal Zone Management Act
CZMP	Coastal Zone Management Program
dB	Decibel
DBDB	Digital Bathymetric Data Base
deg	degree
DEIS	Draft Environmental Impact Statement
DLNR	Department of Land and Natural Resources of the state of Hawaii
DO	Dissolved Oxygen
DOA	Department of Agriculture
DOC	Department of Commerce
DOH	Department of Health
DOI	Department of the Interior
DOT	Department of Transportation
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ENSO	El Niño Southern Oscillation
EPA	Environmental Protection Agency
ESA	Endangered Species Act
4D	four-dimensional
°F	degrees Fahrenheit
FAD	fish aggregating device
FCMA	Fisheries Conservation and Management Act
FM	Frequency Modulated
fm	fathom

FMP	fishery management plan
ft	feet
GCOS	Global Climate Observing System
GOOS	Global Ocean Observing System
HAPC	habitat areas of particular concern
HAR	Hawaii Administrative Rules
HEPA	Hawaii Environmental Policy Act
HIFT	Heard Island Feasibility Test
HIHWNMS	Hawaiian Island Humpback Whale National Marine Sanctuary
HiTS	Historical Shipping
HORM	Hawaii Ocean Resources Management
HRS	Hawaii Revised Statutes
HURL	Hawaii Undersea Research Laboratory
Hz	Hertz (cycles per second)
in	inches
IPRC	International Pacific Research Center
IWC	*International Whaling Commission*
KCC	Kauai Community College
kg	kilogram
km	kilometers
km/hr	kilometers per hour
kt	knots (nautical miles per hour)
kw	kilowatts
L	Liters
L_{eq}	Level-equivalent
lbs	pounds
LF	Low Frequency
LFS SRP	Low Frequency Sound Scientific Research Program
LOA	Letter of Authorization
LORAN	Long Range Navigation
m	meters
min	minute
MMRP	Marine Mammal Research Program
μPa	micro Pascal
NEPA	National Environmental Policy Act
nm	nautical miles
NMFS	National Marine Fisheries Service
NMML	National Marine Mammal Laboratory
NOAA	National Oceanic and Atmospheric Administration

NOI	Notice of Intent
NPAL	North Pacific Acoustic Laboratory
NSMRL	Naval Submarine Medical Research Laboratory
NWR	National Wildlife Refuge
OAML	Oceanographic and Atmospheric Master Library
OEQC	Office of Environmental Quality Control
OMZ	Oxygen Minimum Zone
ONR	Office of Naval Research
OTTED	Office of Technology Transfer and Economic Development
PDO	Pacific Decadal Oscillation
PE	Parabolic Equation
PEIS	Programmatic Environmental Impact Statement
PMRF	Pacific Missile Range Facility
PMUS	pelagic management unit species
ppt	parts per thousand
PTS	Permanent Threshold Shift
RL	Received Level
rms	root mean squared
ROD	Record of Decision
Scripps	Scripps Institution of Oceanography
SCORP	State Comprehensive Outdoor Recreation Plan
S.E.	Standard Error
SL	Source Level
SMA	Special Management Area
SPE	Single Ping Equivalent
SPL	Sound Pressure Level
SOFAR	SOund Frequency and Ranging
SOSUS	SOund SUrveillance System
SS1	Shore Station 1
SS2	Shore Station 2
SSI	Seafloor Surveys International, Inc.
SST	Sea Surface Temperature
SURTASS LFA	Surveillance Towed Array Sensor System Low Frequency Active
SWFSC	Southwest Fisheries Science Center
SWTR	Shallow Water Training Range
3D	three Dimensional
TL	Transmission Loss
TTS	Temporary Threshold Shift
W	Watt
W/m^2	Watts per square meter

USC	United States Code
USFWS	U.S. Fish and Wildlife Service
XBT	Expendable Bathythermograph

1 PURPOSE AND NEED FOR THE PROPOSED ACTION

This Environmental Impact Statement (EIS) evaluates the potential effects of continued operation for five additional years of the low frequency (LF) sound source (including the seabed power cable) previously installed off the north shore of Kauai, Hawaii, for use in Acoustic Thermometry of Ocean Climate (ATOC) research. The proposed action is reuse of the sound source and cable for the North Pacific Acoustic Laboratory (NPAL), a U.S. Navy Office of Naval Research (ONR) basic research[1] project, which 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.

Acoustic thermometry is a method for obtaining information about the temperature field in the ocean from precise measurements of the travel times of sound pulses transmitted through the ocean. It is also a technique for *acoustic remote sensing* of the ocean interior, in which the properties of the ocean *between* the acoustic sources and receivers are determined, rather than the properties of the ocean *at* the instruments as is the case for conventional thermometers and current meters. Remote sensing of the ocean interior using light or radio waves is not feasible because they travel only a short distance in seawater (up to a few hundred meters for light) before being absorbed. Acoustic thermometry in the ocean is closely related to seismology in the Earth, in which properties of the Earth's interior are inferred from travel times of earthquake waves.

A full understanding of long-range underwater sound transmission in the ocean is important not only for acoustic remote sensing of the ocean interior. It is also important because all users of the ocean environment must rely on acoustic signals to sense their undersea surroundings and to perform the many tasks underwater for which light and other electromagnetic radiation are used in the atmosphere. Sound is used for such basic tasks as measuring ocean depth, locating underwater objects, navigation, and communication, for example. The fundamental limits to the performance of these tasks are due in part to the effects of small-scale ocean variability on acoustic signals.

The proposed action would be conducted by Scripps Institution of Oceanography (Scripps) of the University of California, San Diego, which carried out the first phase of ATOC feasibility research, and by the Applied Physics Laboratory of the University of Washington (APL-UW). Funding would be provided by ONR. Scripps is the applicant for all necessary permits.

[1] Under the Department of Defense Financial Management Regulation, basic research (category 6.1) includes scientific study and experimentation to increase fundamental knowledge and understanding in the physical, engineering, environmental and life sciences related to long-term security needs.

The original ATOC feasibility project demonstrated that acoustic thermometry is a powerful tool for making large-scale oceanic measurements of temperature variability; key results from that study are discussed below. Based on this successful scientific research effort, the Navy recognizes the opportunity to transition this methodology into a second phase of research on large-scale acoustic thermometry.

An understanding of the basic principles of subsea sound is important for assessing the material included in this EIS. Therefore, readers unfamiliar with subsea sound are referred to Appendix A for a summary of fundamental knowledge. 1-1

Proposed Action

Under the proposed action, the seabed power cable and sound source would remain in their present locations, and transmissions would continue with approximately the same signal parameters and transmission schedule used in the ATOC project. The typical schedule during the ATOC project consisted of six 20-minute (min) transmissions (one every four hours), every fourth day, with each transmission preceded by a 5-min ramp-up period during which the signal intensity was gradually increased, representing an average duty cycle of 2 percent. With the possible exception of short duration testing with duty cycles of up to 8 percent, or equipment failure, this schedule would continue for a period of five years. The signals transmitted by the source would have a center frequency of 75 Hertz (Hz) and a bandwidth of approximately 35 Hz (i.e., sound transmissions are in the frequency band of 57.5-92.5 Hz). Approximately 260 Watts of acoustic power would be radiated during transmission. At 1 meter (m) (3.3 feet [ft]) from the source, the sound intensity (i.e., source level) would be about 195 decibels (dB) referenced to the intensity of a signal with a sound pressure level of 1 microPascal (µPa) (on a "water standard" basis). These signal parameters and source level have been found in the ATOC project to provide adequate, but not excessive, signal-to-noise ratios at the receiver ranges of interest.

At the conclusion of the five-year period, the seabed power cable would be abandoned in place. This would have the two-fold benefit of avoiding disturbances to sensitive military instrumentation in the vicinity and the benthic environment. The source would be abandoned in place as well, unless it appeared to still be in sufficiently good condition to warrant recovery.

Purpose

The purposes of the proposed action are:

- To perform the second phase of research on the feasibility and value of large-scale acoustic thermometry;

- To study the behavior of sound transmissions in the ocean over long distances; and

- To conduct studies on the possible long-term effects from the sound transmissions on marine life.

Need

The needs to accomplish the proposed action for large-scale acoustic thermometry include:

- Study seasonal and interannual ocean variability associated with phenomena such as El Niño, La Niña and the Pacific Decadal Oscillation (PDO);

- Use of acoustic thermometry data in combination with a variety of other data types, including satellite altimeter data, subsurface drifter data, surface drifter data, surface mooring data, and expendable bathythermograph (XBT) data, to test and constrain computer models of the ocean circulation in order to gain a better understanding of ocean variability and the earth's changing climate;

- Quantitive comparison and contrast of the contributions of each of the various data types to constrain computer models of the ocean circulation; and

- Objective assessment of the value of acoustic methods for remote sensing of the ocean interior as one component of an integrated ocean observing system for ocean weather and climate.

The needs to study long-range underwater sound transmission include:

- Improvement in the understanding of the basic principles of LF, long-range underwater sound transmission (i.e., acoustic propagation) in the ocean;

- Determination of the effects of ocean environmental variability on acoustic signal stability and coherence;

- Study of seasonal and annual variations in acoustic conditions in the North Pacific specifically, and the impact of environmental variability on acoustic propagation more generally; and

- Determination of the fundamental limits to acoustic signal processing at long-range imposed by the ocean environment.

The need to conduct Marine Mammal Monitoring Studies is to:

- Advance the understanding of the potential for long-term effects from the acoustic transmissions, by performing aerial surveys to monitor the distribution and abundance of marine mammals in the vicinity of the sound source.

The project is proposed by ONR as part of its Ocean Acoustics Program. ONR coordinates, executes and promotes the science and technology programs of the U.S. Navy and Marine Corps through universities, government laboratories, and nonprofit and for-profit organizations. Since its inception in 1946, ONR has been the major sponsor of basic research on ocean acoustics. It has also been a leading sponsor of basic research on the circulation and temperature-salinity structure of the ocean. ONR's purpose in studying the way sound behaves as it travels over long ranges in the ocean and in studying ocean circulation and structure is to increase fundamental understanding of the Navy's operating environment. The Ocean Acoustics Program in particular supports research that examines the physics of the generation, propagation and scattering of narrowband and broadband acoustic waves in the varying ocean environment.

1.1 NORTH PACIFIC ACOUSTIC LABORATORY (NPAL) PROJECT OBJECTIVES

The North Pacific Ocean provides a natural laboratory for the study of both the feasibility and value of large-scale acoustic thermometry and of long-range acoustic propagation. The bathymetry in the North Pacific is relatively benign compared to that in other ocean basins, making very long-range acoustic transmissions possible with little blockage from seamounts, mid-ocean ridges, or other bathymetric features. The North Pacific also contains a large number of existing acoustic receivers installed on the seafloor by the U.S. Navy as part of the Sound Surveillance System (SOSUS) that are available for both acoustic thermometry and propagation studies. Finally, a variety of large-scale oceanographic phenomena occur in the Pacific Ocean, including El Niño/La Niña and the PDO, providing natural test environments.

Continued operation of the sound source for an additional five years would serve to advance the understanding of both large-scale acoustic remote sensing of the ocean and long-range acoustic propagation, as described below. In addition, aerial surveys conducted to monitor the distribution and abundance of marine animals in the vicinity of the sound source would advance the understanding of any potential for longer-term impacts on marine animals. These data would be made available to the public for scientific analyses.

1.1.1 Acoustic Thermometry

The atmosphere and ocean work together to determine the planet's weather and climate. The warming of the eastern tropical Pacific Ocean during the 1997–1998 El Niño, for example, severely affected weather patterns worldwide. The subsequent cooling of the eastern Pacific in late 1998 and 1999 associated with La Niña affected the path of the equatorial jet stream, leading to an increase in the number of hurricanes reaching the east coast of the United States.

Observational systems to monitor the Earth's changing atmosphere have long been in place, driven by the obvious short-term impacts of weather on environment. The U.S. National Weather Service provides the U.S. contribution to a global atmospheric observing system. Given its importance to a variety of human activities, it is surprising that similar systems do not exist for the ocean, except in a very limited and piecemeal way. There is no U.S. "National Ocean Weather Service" charged with routine monitoring of an ocean that fluctuates on all time and space scales. Part of the reason for the absence of a national commitment for routine monitoring of the ocean has been a lack of understanding of the importance of the ocean in determining the planet's weather and climate. Part of the reason for the absence of systems for routinely monitoring the state of the ocean has also been technological. Until very recently the observational tools needed to make routine measurements in the ocean at a reasonable cost simply did not exist. Ships move too slowly and are too expensive to make up a global ocean observing system. With the advent of new technologies, however, the situation has changed. Satellite systems now exist that can routinely monitor sea-surface height on a global basis with a precision of about 2 centimeters (cm) (0.8 inches [in]) root-mean-squared (rms). Drifting subsurface floats that automatically measure profiles of temperature and salinity in the upper ocean and then transmit the data back to shore via satellite have been developed. Oceanographic moorings that measure a variety of oceanographic parameters, send the data back to shore via satellite, and remain in place for years are under development. Acoustic remote sensing of the ocean interior using the techniques of acoustic - thermometry has now been proven to be feasible out to scales of 3000 to 5000 kilometers (km) (1620-2700 nautical miles [nm]).

An increasing appreciation of the importance of the ocean and its variability to human activities, coupled with these technological developments, has led to increasing efforts during the last decade to develop an integrated ocean observing system. The Consortium for Oceanographic Research and Education (CORE), an association of 57 U.S. research institutions, universities, laboratories, and aquariums representing the nucleus of U.S. research and education in the ocean, recently published a position paper entitled "A National Initiative to Observe the Oceans: A CORE Perspective" (http://core.cast.msstate.edu/). In this document CORE identifies one component of an overall integrated ocean observing system to be (emphasis added):

- *A physical oceanography and climate system based on current satellite remote sensing and appropriate elements of the El Niño Southern Oscillation (ENSO), and Argos Global Centre (ARGO) projects, Eulerian arrays,* **acoustic thermometry**, *and data management, assimilation and modeling. This would constitute a substantial US contribution to the international Global Ocean Observing System (GOOS), and particularly its climate module, which is the ocean module of the Global Climate Observing System (GCOS).*

Physical oceanographers are currently largely unable to provide biological oceanographers with information on the varying temperature and salinity structure known to be of importance to marine life and its distribution. Physical oceanographers are also largely unable to provide atmospheric scientists with the information needed to properly include the effects of ocean variability on short-term weather forecasts. The development of the capability to routinely monitor the physical state of the global ocean on a weekly basis would revolutionize oceanography.

The proposed project would allow for the conduct of the second phase of ATOC feasibility research, aimed at making a quantitative assessment of the role which acoustic thermometry can play in an integrated ocean observing system for ocean weather and climate. This second phase requires longer time series of acoustic measurements in order to determine whether the acoustically-derived time series of large-scale ocean temperature and heat content variability prove to be as valuable as expected in studying seasonal and interannual ocean variability associated with phenomena such as El Niño/La Niña and the PDO. It is anticipated that there will be a growing effort to monitor the variability of the North Pacific over the next five years, using a combination of satellite altimeter data, subsurface drifter data, surface drifter data, surface moorings, and XBT data, in addition to acoustic thermometry data. Combining all of these disparate data types in computer models of the ocean circulation will allow testing and refinement of ocean general circulation and climate models in order to gain a better understanding of the earth's changing climate. In addition, using all of these data types together to constrain ocean models would allow quantitative assessments of the contributions of all of the various data types to monitoring the ocean. At the end of five years it is anticipated that the data needed to assess objectively the value of acoustic methods for remote sensing of the ocean interior on large scales would be available.

1.1.2 Long-range Acoustic Propagation

The ocean is largely transparent to sound but opaque to light and radio waves. Sound must be used in the ocean to perform many of the tasks for which electromagnetic signals are used in the atmosphere. Studies of long-range acoustic propagation in the ocean are therefore important in many contexts, from the use of acoustic remote sensing methods for measuring ocean temperatures and currents (acoustic thermometry), to studying undersea volcanoes and earthquakes, to determining marine mammal distributions and behavior, to navigating and communicating underwater, and to locating and tracking underwater objects. Each of these specialized topics relies on a basic understanding of ocean variability and its influence on long-range acoustic propagation.

As sound travels through the ocean, it is refracted (bent) back toward the sound channel axis by the ocean sound-speed structure so that it tends to remain in the sound channel. Sound is also scattered when it passes through small-scale ocean variability, in particular ocean internal waves. Sound breaks up from a single pathway into multiple pathways, or multipaths, due both to the presence of the sound channel and to scattering from the small-scale ocean variability. As a result, received acoustic signals fluctuate in intensity and travel time. The multipath structure of the sound traveling through the ocean from the source to the receiver distorts the signal - reduces the stability and coherence of the signal. The effect is similar to the twinkling of a star in the sky. On clear, still nights, stars seem to stand still; telescopes focus best under these conditions. When the atmosphere is turbulent, stars seem to twinkle; and it is under these conditions that telescopes perform most poorly. They cannot focus on the star unless the turbulence is compensated for in some manner. The same situation occurs with acoustic receivers in the ocean

– ocean telescopes. There is some understanding of how to compensate for atmospheric turbulence; however, the means of applying this or similar compensation to ocean turbulence is not fully understood. Scientists predict that a better understanding of the ocean and how sound propagates through it, that is, a better understanding of how ocean fluctuations distort sound, could substantially improve the ability to focus underwater acoustic receivers.

The proposed project would advance the understanding of the basic principles of LF, long-range acoustic propagation and the effects of environmental variability on signal stability and coherence. The basic scientific issues that arise are due to the complex effects that can occur when acoustic signals propagate to great distances through a turbulent ocean that fluctuates on all time and space scales and when the signals interact with rough surface and bottom boundaries (Worcester, 1998). The ultimate objective is to understand the fundamental limits to acoustic signal processing at long range imposed by ocean processes to enable advanced signal processing techniques to capitalize on the three-dimensional (3D) character of the underwater sound and noise fields. The proposed action would provide an unprecedented opportunity to acquire insight and understanding of seasonal and annual variations in acoustic conditions in the North Pacific specifically, and acoustic and environmental coupling more generally.

1.1.3 Marine Mammal Monitoring Studies

The Marine Mammal Monitoring Studies element of the proposed action is designed to advance the understanding of the potential for long-term effects of the sound transmissions on marine life through the conduct of aerial surveys off the north Kauai coast. Thus, ONR would seek answers to the most important scientific issues surrounding potential long-term effects: animal abundances and distribution. A total of eight aerial surveys would be conducted during each humpback whale season. The Marine Mammal Monitoring Studies would have four components: 1-2

- data analysis: NPAL abundance and distribution data would be statistically analyzed and compared with those data collected during the Kauai ATOC Marine Mammal Research Program (MMRP);
- data reporting: NPAL aerial survey results, data compilations and findings would be published in reports (documents and/or electronic versions);
- data sharing: ONR/Scripps would make all published reports available in the public domain; and
- data monitoring: Marine mammal stranding data in Hawaii would be monitored for any long term trends.

Information from the Marine Mammal Monitoring Studies would be provided annually to NMFS for review.

1.2 BACKGROUND ON ACOUSTIC THERMOMETRY

Two sound sources were installed for the first phase of the ATOC feasibility study, one on Pioneer Seamount off central California and one north of Kauai (Figure 1-1, Location of the ATOC Sound Sources and Receivers). The Pioneer source began transmitting in late 1995 and continued transmissions in accordance with MMRP protocols until it was turned off at the end of 1998. The Kauai source began transmitting in late 1997 and continued transmissions until October 1999, again in accordance with MMRP protocols. The signals transmitted by the sources were received on SOSUS receiving arrays in the North Pacific and, for part of the time, on a vertical receiving array located at Ocean Weather Station Papa (50°N, 145°W). The transmissions from the Pioneer Seamount source were also recorded at various times on vertical receiving arrays located near the Big Island of Hawaii and near Kiritimati (Christmas) Island. A small number of the Pioneer Seamount transmissions were recorded by a receiver off New Zealand. The signals from the Kauai source were also recorded by Russian scientists at a permanent, bottom-mounted receiver located off Kamchatka.

The primary objectives of the first phase of the ATOC feasibility study were to determine (i) the precision with which acoustic methods could be used to measure large-scale changes in ocean temperature and heat content and (ii) the effects, if any, which the acoustic transmissions would have on marine mammals and other marine life. The longer-range goals of ATOC were to use acoustic thermometry data to study seasonal and interannual temperature variability associated with a variety of oceanographic phenomena, such as El Niño/La Niña and the PDO, and to test and improve computer models of ocean circulation. The ultimate goal was to test and refine climate models in order to gain a better understanding of the Earth's changing climate, including the link between global warming and sea level rise.

The basic idea of acoustic thermometry is simple. Sound travels faster in warm water than in cold water. The travel time of a sound signal from a sound source near Hawaii to a receiver near California, for example, will decrease if the intervening ocean warms up, and will increase if the ocean cools down. Acoustic thermometry is feasible because:

- The ocean is nearly transparent to LF sound, so that relatively weak acoustic signals can be detected over distances of many thousands of kilometers using appropriate signal processing techniques; and

- The speed at which sound travels in the ocean depends primarily on temperature. (Sound speed also increases with an increase in salinity, but in the open ocean deep water, salinity normally has only a small effect on the speed (Urick, 1983).)

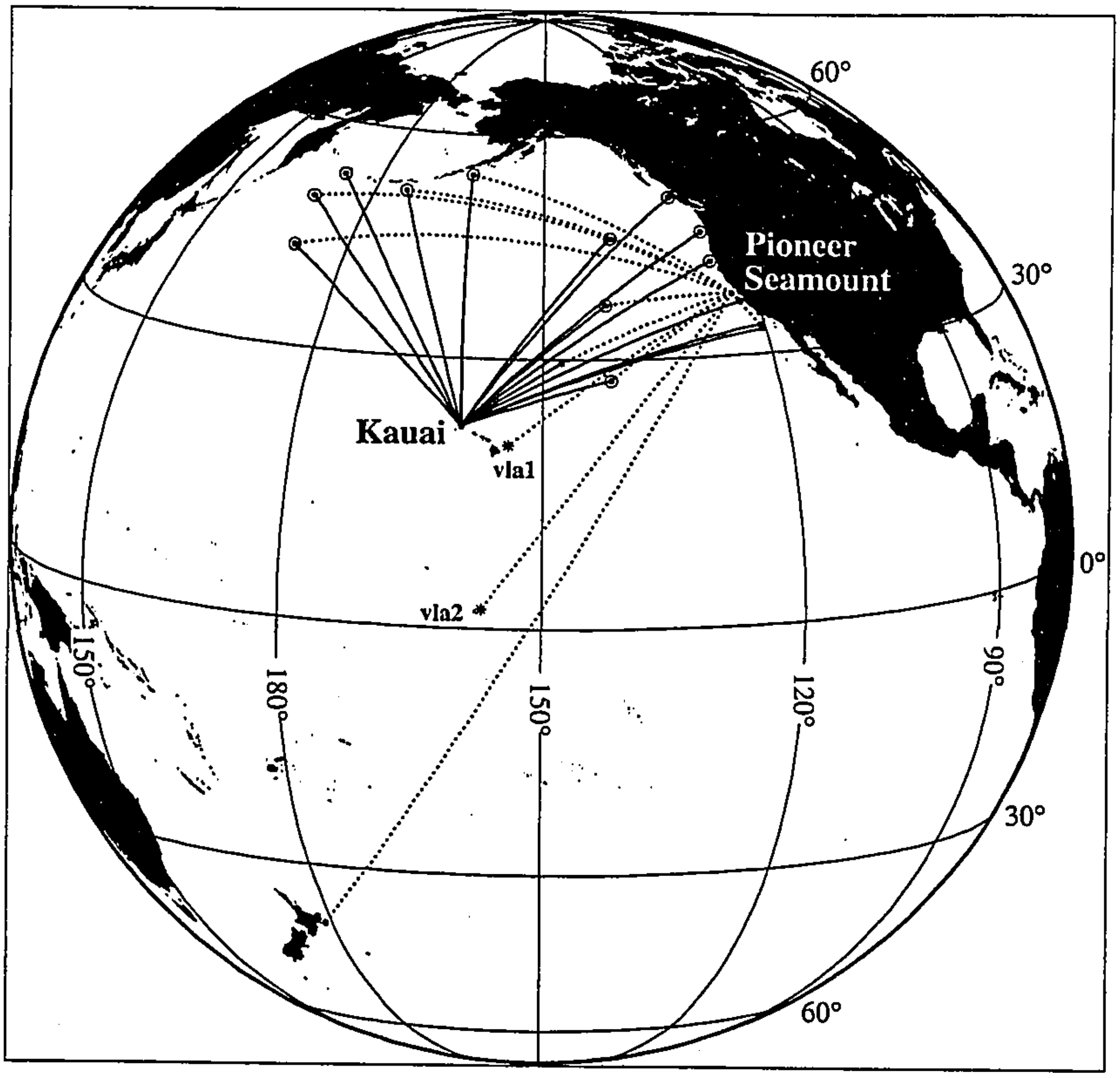


Figure 1-1 Location of the ATOC Sound Sources and Receivers

Acoustic thermometry takes advantage of an acoustic waveguide deep within the ocean that traps and carries sounds over long distances. This waveguide, known as the "sound channel" or SOund Frequency And Ranging (SOFAR) channel, is centered on the ocean depth where the speed of sound is at a minimum. Above the sound channel axis, sound travels faster because the water is warmer; below, sound travels faster because the pressures are greater. Acoustic energy within the sound channel that would otherwise spread outward to higher or lower depths is refracted (bent) back toward the sound channel axis by this difference in speeds. The net effect is that the sound channel serves as a waveguide that transmits underwater sounds efficiently over long distances.

The sound speed minimum varies in depth based upon the temperature profile at a given location. Since surface temperatures tend to decrease toward the poles, the sound channel axis generally is deepest in tropical waters and shallowest in Arctic waters. Typical depths of the sound channel in the Gulf of Alaska, for example, are 100-200 m (330-660 ft), but in warmer areas it is much deeper, on the order of 750-1000 m (2460-3280 ft). On the north shore of Kauai, the sound channel axis is nominally at 800 m (2625 ft), approximately at the depth of the Kauai sound source.

Not all of the acoustic energy travels straight down the axis of the sound channel. Instead, some of the sound waves cycle up close to the ocean surface, where they are bent back down, cross the axis of the channel, and reach close to the ocean floor before being bent back once again toward the surface. By measuring the difference in travel time between sound that traveled a straight course down the axis of the sound channel and that which cycled in waves through various depths of the ocean, scientists can measure how ocean temperatures vary with depth.

Acoustic travel times provide direct 3D measurements of the horizontally and vertically averaged temperature along the paths traversed by the sound, suppressing the effects of small-scale ocean variability that dominate measurements at a point. The great advantage of acoustic thermometry compared to other types of temperature measurements is that such averages are just what are needed to study large-scale ocean variability and long-term trends in ocean temperature. The information obtained is similar to that which would be obtained for the atmosphere by averaging data from many separate weather stations. In addition, mathematical techniques referred to as *inverse methods* are used to infer the horizontal and/or vertical structure of the temperature field by combining travel time data from acoustic signals that have traveled along different paths through the ocean. Information on the structure of the ocean temperature field is needed to understand, for example, how the atmosphere and ocean interact to determine our weather and climate and to study the effects of environmental variability on marine life.

1.2.1 ATOC: Thermometry Results

Analyses of data from the ATOC project demonstrated that acoustic thermometry is a powerful tool for making routine measurements of large-scale ocean temperature variability and heat content, as originally hypothesized. The key results obtained to date are:

(i) Acoustic travel times can be measured with a precision of about 20-30 milliseconds (msec) at 3000-5000 km (1620-2700 nm) ranges. For comparison, the total travel time for an underwater acoustic signal over 5000 km (2700 nm) is nearly an hour. ATOC data measurements proved to be more precise than originally thought possible. The initial concern that acoustic scattering from small-scale ocean structure, such as internal waves, might make accurate measurements of acoustic travel times impossible at 3000–5000 km (1620-2700 nm) ranges proved to be unfounded. Transmissions over these long ranges are needed to measure ocean gyre-scale variability, which is the scale on which ocean climate fluctuations are expected to occur. An ocean gyre is a large, ocean-basin size (on the order of a few thousand kilometers or nautical miles), roughly circular motion of surface water in response to wind forcing. The travel times can then be used to estimate the range- and depth- averaged temperature with a precision of about 0.006 °C (0.01°F) at ranges of 3,000-5,000 km (1620-2700 nm) (Dushaw, 1999; Worcester et al., 1999).

(ii) Range- and depth-averaged temperature estimates made from the acoustic travel-time data are consistent with direct temperature measurements made with instruments lowered from ships (Worcester et al., 1999).

(iii) The observed travel time changes can be clearly related to known ocean processes. The ocean tides are well known from other measurements, and their effect on the acoustic travel times can be predicted, providing what is essentially a large-scale test signal. The measured and predicted travel time fluctuations at tidal frequencies are in excellent agreement out to 5000-km (2700-nm) range. One of the significant sources of LF sound transmission variability related to ocean temperature is seasonal change, with the upper ocean warming during summer and cooling during winter. The ATOC data show corresponding seasonal changes in travel times, as expected, particularly for acoustic paths that travel north of the Subarctic Front, where the seasonal temperature changes extend to significant depths, rather than being confined to a shallow seasonal thermocline (Dushaw et al., 1999).

(iv) The range and depth-averaged temperatures derived from ATOC are consistent with and complementary to related estimates derived from measurements of sea-surface height. The acoustic thermometry data from the Pioneer Seamount source have been used in conjunction with measurements of sea-surface height made by the TOPEX/POSEIDON satellite altimeter to test and constrain a computer model of the ocean circulation in the North Pacific (ATOC Consortium, 1998). Sea-surface height is related to ocean temperature because of thermal expansion. It was found that previous interpretations of sea-surface height variability as being primarily due to ocean temperature changes are inaccurate. The effects on sea-surface height of varying ocean salinity and ocean currents also appear to be significant. This result is important because it affects the way in which sea-surface height data are used to test and constrain ocean circulation models. This result is also important because it means that satellite altimetry data and acoustic thermometry data are complementary, providing independent information on ocean structure. The altimeter has excellent horizontal but poor vertical resolution, and the acoustic data provide information from the ocean interior with moderate vertical resolution but poor horizontal resolution. Both have good temporal (i.e., time-related) resolution. Consistent results for the seasonal heat storage in the ocean are found when the acoustic and altimetry data are combined with a computer model of the ocean general circulation. The two data types are both found to be important in constraining the model, with the combination providing more information than either data type alone.

1.2.2 ATOC: Marine Mammal Research Program Results

The California and Hawaii ATOC MMRPs were designed to determine the potential effects of the acoustic transmissions on marine mammals and other marine life. They consisted of multiple components, including:

- Aerial surveys designed to determine any changes in the abundance and distribution of marine mammals in the vicinity of the Pioneer Seamount source;
- Elephant seal tagging studies designed to determine any changes in elephant seal migratory or diving behavior in response to the Pioneer Seamount source transmissions;
- Playback studies to humpback whales off the Kona-Kohala coast of Hawaii designed to look for behavioral changes in response to ATOC-like sounds prior to the actual ATOC source transmissions north of Kauai;
- Aerial surveys designed to determine any changes in the abundance and distribution of humpback whales north of Kauai when the ATOC source was transmitting compared to measurements made in previous years when the source was not transmitting;
- Visual observations of humpback whale abundance, distribution, and behavior north of Kauai to determine if there were any changes in response to the ATOC transmissions;
- Undersea acoustic recordings made with seafloor data recorders north of Kauai to determine any changes in humpback vocalizations in response to the ATOC transmissions;
- Auditory measurements on small toothed whales (odontocetes) to determine their sensitivity to the frequencies transmitted by the ATOC sources; and
- Playback studies to fish at the Bodega Bay Marine Laboratory designed to look for behavioral changes in response to ATOC-like sounds.

Abundance and distribution. During the MMRPs conducted in both California and Hawaii, there were no observations of overt or obvious short-term changes in the abundance and distribution of marine mammals in response to the transmissions of the ATOC sound sources. No species were observed to vacate the area around the sound sources during transmissions. Intensive statistical analyses of aerial survey data showed some subtle shifts in the distribution of humpback (and possibly sperm) whales away from the Pioneer Seamount source during transmission periods. No statistically significant shifts in distribution were found for any other species of marine mammal. Visual observation data from the Kauai MMRP showed a similar small shift in mean distance of humpback whales away from the Kauai source during transmission periods.

Behavioral measures. During the MMRPs conducted in both California and Hawaii, there were no observations of overt or obvious short-term changes in the behavior of humpback whales in response to the playback of ATOC-like sounds, nor elephant seals or humpback whales in response to to transmissions of the ATOC sound sources. Intensive statistical analyses revealed some subtle changes in the behavior of humpback whales in response to the playback of ATOC-like sounds and to the transmissions of the ATOC Kauai source (Frankel and Clark, 1998; Frankel and Clark, 2000). The study results showed that the distance and time between successive whale surfacings (segment length and segment duration) increased slightly with increasing sound levels. This result is not what would be predicted, in that if the animals were stressed by the sound source, it might be expected that they would remain at the surface longer because of the lower received levels there. Longer dive durations would correspond to increased exposure to the sound source. No statistically significant changes were found in any other behaviors measured. 1-3

Vocalizations. The Hawaii MMRP did not find any overt or obvious short-term changes in the singing behavior of humpback whales in the vicinity of the sound source north of Kauai. No statistically significant changes in the underwater sound output from humpback whales in one of the frequency bands in which they vocalize was found in the vicinity of the Kauai source.

Audiograms. The hearing sensitivity of two species of dolphins to the ATOC sound was measured behaviorally (Au et al., 1997). Audiograms showed that their hearing is poor at the frequencies transmitted by the ATOC sources. The animals would have to be extremely close to an ATOC source simply to be able to detect the transmissions.

Fish. Preliminary playback studies of ATOC-like sounds to fish found no statistically significant responses (Klimley and Beavers, 1998).

All of the effects detected by the MMRPs were subtle and found only after intensive statistical analyses. Bioacoustic experts concluded that these subtle effects would not adversely impact the survival of an individual whale or the status of the North Pacific humpback whale population (Frankel and Clark, 2000). 1-4

1.3 ENVIRONMENTAL IMPACT ANALYSIS

This EIS provides a statement and analysis of the proposed action's potential environmental effects, mitigation measures for avoiding or minimizing effects, and alternatives to the proposed action. This information serves to inform the decision makers of ONR, as lead federal agency, and DLNR, as accepting state agency on the proposed project.

The EIS reflects the full consideration (by ONR, as lead federal agency, and Scripps, as the applicant for a state permit to use state lands in the conservation district) of the proposed project's environmental effects and of alternatives and mitigation measures which may have the potential to reduce adverse effects. This EIS also serves to support and facilitate review of the project by federal, state, and local agencies. The EIS provides information and analysis necessary for participating agencies to review the proposed project. Federal, state, and local authorities relevant to review and approval of this project are discussed in detail in Chapter 6 and summarized below.

AGENCY	ACTION
National Marine Fisheries Service (NMFS)	Incidental harassment/taking authorization under MMPA/ESA
NMFS	Consultation under ESA, § 7
NMFS	Coordination under Magnuson-Stevens Fisheries Conservation and Management Act
Hawaii Department of Land and Natural Resources	Conservation District Use Permit Approval of Disposition of Land
Hawaii Office of Coastal Zone Management	Federal Consistency Certification
Department of the Navy	Decision to Proceed

In connection with the previous Kauai ATOC project and its associated Marine Mammal Research Program (MMRP), a joint federal/state final EIS (May 1995) was prepared by the Advanced Research Projects Agency and NMFS (ARPA and NMFS, 1995b) and accepted by the Hawaii DLNR. Another federal/state final EIS/Environmental Impact Report (EIR) (ARPA and NMFS, 1995a) was prepared for the California ATOC project and its MMRP (April 1995). Both documents are incorporated by reference in their entirety into this EIS. Copies of these earlier documents are available at the locations given in Appendix C.

1.3.1 National Environmental Policy Act

This EIS has been prepared in accordance with the requirements of the National Environmental Policy Act of 1969 (NEPA, 42 USC Sections [§§] 4321-4345) and its implementing regulations (40 CFR Parts 1500 to 1508). The provisions of NEPA apply to major federal actions that may significantly affect the human environment. State and federal environmental review requirements overlap and allow for preparation of a single EIS. Accordingly, the EIS has also been prepared in accordance with the Hawaii EIS Law (Chapter 343, Hawaii Revised Statutes), as discussed in Section 1.3.5, below, and serves as a joint state-federal document.

Under NEPA, ONR, as the program sponsor, is the lead agency for the proposed action. NMFS, part of the Department of Commerce's National Oceanic and Atmospheric Administration

(NOAA), is a cooperating agency. Cooperating agencies are those that have jurisdiction by law or special expertise with respect to environmental impacts from an action proposed by another agency.

1.3.1.1 The EIS Process

The NEPA process for this project began with a Notice of Intent (NOI), which was published in the *Federal Register* on June 15, 1999. Scoping of issues was carried out to gather information about the nature, scope and priority of issues from interested public agencies, persons, and groups. Scoping provided opportunity for written and oral comment. A 30-day period for receipt of written comments was announced in the NOI. A 45-day period was announced in a notice published in the Hawaii Office of Environmental Quality Control Bulletin on August 8, 1999. In addition to the written scoping comments received by ONR, oral comments were invited and received at the following public meetings in Hawaii:

- Hanalei, Kauai, on June 29, 1999
- Lihue, Kauai, on June 30, 1999
- Honolulu, Oahu, on July 1, 1999.

All comments received during the comment period have been considered and are summarized in Section 1.4.

Following the completion of the draft EIS (DEIS), a Notice of Availability (NOA) was published in the *Federal Register* on June 2, 2000, signaling the start of a 45-day period for review and comment upon the DEIS. A 45-day public comment period was also announced in a Notice of Availability published in the Hawaii Office of Environmental Quality Control Bulletin on June 5, 2000. In addition to the written public comments received by ONR, oral comments were invited and received at the following public meetings in Hawaii: 1-5

- Lihue, Kauai, on July 5, 2000
- Honolulu, Oahu, on July 6, 2000
- Kilauea, Kauai, on July 8, 2000

The final EIS incorporated and includes responses to comments submitted within the review period, as well as any other appropriate modifications to the DEIS. The reader is referred to Appendix F for 1) lists of DEIS comment letters received, 2) responses to comments raised by the DEIS, and 3) copies of comment letters, associated response letters, and the public hearing transcript from July 8, 2000 (Participants of the first two meetings did not make any comments, and therefore the transcripts from those meetings were not included).

The final EIS will be available for public review for 30 days. Thereafter, the Navy's final decision on the proposed action will be published in the form of a Record of Decision (ROD) in the *Federal Register*.

1.3.1.2 EIS Scope

The EIS covers the proposed NPAL project through the full five years of operation as well as the proposed abandonment of the cable and sound source in their current seabed locations. Additionally, the EIS reports and analyzes information obtained through the previous ATOC projects in California and Hawaii and the related marine mammal research programs. The discussion of cumulative impacts draws on this information from the earlier ATOC and MMRP work as well as information about other on-going and reasonably foreseeable similar projects.

Several scoping comments have raised the issue of whether a programmatic EIS (PEIS) should be prepared to cover the short-term feasibility work of the proposed NPAL project as well as a possible future long-term ATOC project involving multiple sound source locations. ONR and NPAL project managers have considered this issue in light of applicable standards under NEPA and Hawaii law.

Under NEPA regulations and court decisions, a PEIS may be appropriate in several kinds of situations. One is where an agency is proposing a systematic program of related actions that may generate cumulative impacts on the environment in the affected region. The mere contemplation of a group of related actions is not sufficient to warrant treatment in a PEIS. Rather, there must be an actual proposal or well-defined recommendation, and the affected geographic region must be known. Without information on, for example, location of the possible actions, resources affected, and level of impacts, a meaningful PEIS is not feasible. The central purpose of an EIS, to inform agency decision-making, cannot be furthered by a PEIS lacking in such basic information.

A PEIS is sometimes appropriate in connection with technology research and development programs. The time for such an EIS is when the program has progressed to a stage where specific project proposals have been formulated or widespread licensing or use of the technology is pending. Proposals for a PEIS at an earlier stage in a technology development program have been rejected as infeasible due to lack of sufficient specific information for the disclosures and analysis required under NEPA.

Currently proposed uses of the LF sound source north of Kauai do not provide an appropriate basis for a PEIS. At this stage, managers of the NPAL project are still assessing the prospects for any long-term program. However, such a program or proposal does not yet exist, and there are substantial uncertainties that it ever will. Significant technical and logistical issues remain to be resolved, and funding must be identified for development of specific proposals and their ultimate implementation. A PEIS at this stage could not identify the potentially affected geographic regions, potential levels of impact, or other basic information necessary for meaningful analysis.

1.3.2 Marine Mammal Protection Act

The Kauai sound source is located in an area that is inhabited by marine mammals. While the intensive statistical analysis of Kauai MMRP data revealed some subtle changes in the behavior of humpback whales in response to ATOC-like playback sounds and transmissions of the Kauai ATOC source, the suggested effects do not support the need to request a LOA because they do not indicate a biologically significant behavioral response that affects biologically important activity, such as survival, breeding, feeding and migration, which have a potential to impact on the reproductive success of the animal. None-the-less, Scripps, in coordination with the National Marine Fisheries Service (NMFS), which administers the MMPA have determined to pursue a letter of authorization (LOA) for incidental taking by harassment under 16 U.S.C 1371 because of: the level of controversy associated with NPAL; past history associated with the ATOC effort and the Kauai ATOC EIS; and public interest in the state of Hawaii. An LOA is available when the proposed activity will have no more than a negligible effect on affected stocks, appropriate monitoring and mitigation measures are included, and other standards are met. Concurrent with publication of the DEIS, Scripps commenced the process of applying for a LOA. 1-6

1.3.3 Endangered Species Act

The Kauai sound source is located in an area that is inhabited by species listed as threatened or endangered under the Endangered Species Act (ESA, 16 USC §§ 1531-1543). Continued operation of this sound source would allow continued transmission of acoustic signals in the water column that could potentially cause reactions by listed species. Consequently, two provisions of the ESA are applicable to this project.

Section 1539(a)(2)(B) of the Act provides for authorization of activities that will not appreciably reduce the likelihood of the species' survival and recovery, when impacts are minimized and mitigated and other standards are met. This process is administered by NMFS in conjunction with the MMPA authorization discussed above. 1-7

The potential effect upon listed species will also require consultation among the cognizant federal agencies, under § 7 of the ESA. Upon publication of the DEIS, ONR initiated interagency consultation on June 23, 2000, by submitting to NMFS a Biological Assessment of the proposed action's potential effects on listed species and their designated critical habitat. Consultation concluded with NMFS' issuance of a Biological Opinion on April 26, 2001, addressing the issues of whether the project can be expected to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat.

1.3.4 The Magnuson-Stevens Fisheries Conservation and Management Act

The Magnuson-Stevens Fisheries Conservation and Management Act (16 USC §§ 1801-1861) addresses the sustainability of fish stocks through risk-averse management practices and habitat protection, including the designation of essential fish habitat. Federal agencies must consult with NMFS on activities which may adversely affect essential fish habitat. This issue is being addressed through the NEPA review process (see Section 4.2.5 for the full discussion). There is no indication that the proposed project would reduce the quality and/or quantity of essential fish habitat. 1-8

1.3.5 Hawaii Environmental Review Law

Hawaii law provides two bases for environmental review of proposed projects which require state agency approval and which may significantly affect the environment. The Hawaii Environmental Policy Act (HEPA), Chapter 344, Hawaii Revised Statutes (HRS), establishes the state's environmental policy and provides guidelines for agency decision-making. The Hawaii EIS Law, HRS Chapter 343, provides standards and procedures for the state's environmental review process, including the development and processing of environmental impact statements. Regulations implementing HEPA and the EIS Law are contained in Hawaii Administrative Rules, Title 11, Chapter 200.

An EIS prepared under these authorities must be accepted by the principal state permitting agency before a permit can be issued. In this case, the accepting agency is the Hawaii Department of Land and Natural Resources (DLNR), which has permit authority over state-owned seabed lands underlying the existing power supply cable. Scripps' conduct of the proposed project will require use of these lands to support the cable. Scripps has applied to DLNR for a use permit (see Section 1.3.6), and the application has triggered environmental review under the Hawaii EIS Law. 1-9

The Hawaii EIS Law provides for reliance on a joint federal-state EIS in cases, such as this one, where federal involvement calls for an EIS under NEPA. During early consultation on this project, DLNR advised that a supplementary EIS or full EIS would be necessary for the project. The project sponsors made the decision to prepare a full EIS.

The EIS will support DLNR's consideration of Scripps' application for a conservation district use permit, as well as other state review and consultation processes. See Section 6.2.

An EIS Preparation Notice published in OEQC Bulletin on August 8, 1999, initiated the state environmental review process conducted under Chapter 343, HRS. A 45-day scoping comment period followed and closed at the end of business on September 22, 1999. All comments received within the 45-day public comment period have been considered and are summarized in Section 1.4. Following issuance of the Draft EIS, a 45-day public comment period was provided, which ended on July 24, 2000. All comments received during this comment period were responded to 1-10 and are incorporated into this document. Copies of all comments and responses are included in Appendix F.

1.3.6 Use of Hawaii Conservation District Lands

Use of conservation district lands in Hawaii is controlled by the Hawaii Board of Land and Natural Resources within the Department of Land and Natural Resources (DLNR) under provisions of Chapters 183C and 171, HRS. All state marine waters, defined as waters "extending from the upper reaches of the wash of the waves on shore seaward to the limit of the state's police power and management authority, including the United States territorial sea" (HRS § 190-1.5), are included as conservation district lands. In 1996, the Board issued an after-the-fact conservation district use permit (CDUP) to Scripps for placement of the power cable on the seafloor within the state conservation district. The CDUP requires removal of the cable after completion of the research contemplated by the permit.

Scripps has submitted a CDUP application requesting the Board to approve retention of the cable for the five-year duration of this project, followed by abandonment of the cable in place. Upon consultation among the DLNR and the project applicants, it was determined that issuance of the CDUP as proposed would require renewed review under the Hawaii EIS Law. This EIS will provide the information and analysis necessary for DLNR and the Board to carry out environmental review responsibilities and take action on the permit application. DLNR has determined that a public hearing on the application will be held for receipt of comment from interested agencies, persons, and groups. The scope of DLNR review and applicable criteria are discussed in Chapter 6. Scripps' application to DLNR includes a request for appropriate disposition of seabed lands underlying the power cable, as necessary for continued use and disposition of the cable.

1.3.7 Coastal Zone Management, Federal Consistency Review

Review of the proposed action will be carried out in accordance with the Federal Coastal Zone Management Act (16 USC §§ 1451-1465) and the federally certified Hawaii Coastal Zone Management Program (CZMP). Consistency review is triggered under the Hawaii CZMP by the application for incidental harassment authorization under the MMPA. Scripps has prepared a certification of the project's consistency with the Hawaii CZMP (see Section 6.2.2). The State Office of Planning, Hawaii's designated coastal zone management agency, will review the consistency certification and supporting information and issue the State's concurrence in the certification or objection to the issuance of the MMPA authorization by NMFS.

1.4 SCOPING SUMMARY

The scoping process resulted in requests that several environmental and procedural issues be analyzed in the EIS. All comments have been evaluated in preparation of this EIS. A summary of the principal issues identified during scoping follows:

- **Scope of Project Analyzed:** See Section 1.3.1.2.

- **Need for Project:** Several commenters requested information on why a second phase of research on large-scale acoustic thermometry is necessary and how the information will be used. This issue is addressed in Chapter 1.

- **Alternatives to be Considered:** During the scoping process the question was raised whether the same results could be achieved using alternate methods. Techniques such as satellite altimetry, XBTs dropped from ships of opportunity, computer models and subsurface drifters were suggested. The range of alternatives considered in Chapter 2 responds to this comment.

- **Address Navy's Interest:** A few commenters requested to have the Navy's interest in long-range underwater acoustic propagation and in this project described in detail. This issue is addressed in Chapter 1.

- **Biological Resource Impacts:** A number of commenters were concerned about the potential impacts on biological resources and habitats, including marine mammals, fish, sharks, sea turtles, Hawaiian monk seal, dolphins, migratory birds, invertebrates and coral reefs. These issues are addressed in Chapters 3 and 4.

- **Hawaiian Islands Humpback Whale National Marine Sanctuary:** The question was raised whether the cable crosses the boundaries of the Sanctuary and how potential effects on the Sanctuary will be addressed. This issue is covered in Chapters 3 and 6.

- **Project Duration:** Several commenters requested information on the potential project length, number of sources and long-term plans. These issues are addressed in Chapter 1.

- **Marine Mammal Research Program (MMRP):** A number of interested individuals and organizations were concerned that the MMRP results-to-date were inconclusive and requested that the MMRP continue and be broadened to include additional species, techniques and studies. This is addressed in Chapter 5.

- **Cumulative Impacts:** Several commenters requested that the EIS evaluate the cumulative and indirect impacts, including the effects of other sources of noise. These potential impacts are discussed in Chapter 4.

- **Mitigation Measures:** Several organizations requested that the EIS propose mitigation and monitoring efforts designed to minimize the potential impacts of the proposed action on surrounding resources. These issues are addressed in Chapter 5.

2 DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

This chapter describes a range of alternatives to the proposed project and briefly summarizes the potential environmental consequences of the alternatives. Both primary and secondary alternatives are considered. Primary alternatives generally are considered to be variations of the proposed action, such as the installation of project facilities at an alternate site. Secondary alternatives are those which address the project objectives in another manner, such as with a different technology.

Seven alternatives are described, including the proposed action and the "no action" alternatives. The descriptions in this section focus on the effectiveness of each alternative and its potential to meet the project objectives described in Chapter 1; i.e., 1) to perform the second phase of research on the feasibility and value of large-scale acoustic thermometry; 2) to study the behavior of sound transmissions in the ocean over long distances; and 3) to conduct studies on the possible long-term effects from LF sound transmissions on marine life. Based on this analysis, three alternatives are selected for further study, with their potential environmental effects being evaluated in Chapter 4.

2.1 ALTERNATIVES CONSIDERED AND RATIONALE

The alternatives considered in this section include 1) the preferred alternative (continued operation of Kauai source), 2) no action, 3) additionally restricted source transmission times and modified source operational characteristics of the Kauai source, 4) alternate project site (three such sites are screened, including Midway Island, Johnston Atoll, and Adak Island, Alaska), 5) moored autonomous sources, 6) alternate sensors, and 7) modeling.

Of the seven alternatives considered, the Preferred Alternative, No Action Alternative, and Alternate Project Site-Midway Island (Midway Alternative) have been selected for detailed consideration in Chapter 4.

2.1.1 Proposed Action-Continued Operation of the Kauai Source (Preferred Alternative)

The proposed action involves the continued operation for five additional years of the sound source installed by the ATOC project at its present location, with transmission characteristics similar to those used in the first phase of the feasibility research.

Chapter 1 generally describes the overall program. The presentation here focuses on the existing physical facilities, the proposed operational protocols for the acoustic source, and the resulting sound fields in the ocean. These protocols and sound fields are the principal features of the project that pertain to issues of environmental concern.

2.1.1.1 Kauai Source Specifications

Under this alternative, the sound source and its power cable would remain in their present locations. The sound source is located on the seafloor at a depth of 807 m (2648 ft), approximately 14.8 km (8 nm) north of Kauai at 22°20.94'N, 159°34.18'W. To power the sound source, a seabed power cable was installed to connect the source to a seashore interface cable at the Pacific Missile Range Facility (PMRF), Barking Sands.

• Acoustic Source: Produced by Alliant Techsystems, the ceramic bender-bar acoustic source is roughly 2.1 m (6.9 ft) high by 0.9 m (3.0 ft) in diameter (comparable in size to a large water heater) and weighs 2268 kilogram (kg) (5000 pounds (lbs)). It is contained in a 3.5 m (11 ft) high, galvanized steel tripod frame, illustrated in Figure 2.1-1, Line Drawing of Sound Source. Total weight of this unit in air is 5443 kg (12000 lbs); in water its weight is about 3402 kg (7500 lbs). The tripod frame has a seafloor footprint of 5.95 m^2 (64 ft^2). The source is isolated from the frame with shock mounts. There are three nitrogen gas bottles for pressure compensation, to equalize the internal pressure with the external pressure of the deep ocean. All pressure cases are plated mild steel with double o-ring seals. All exposed electrical cables are protected by encasement within either a protective steel pipe or a rubber hose. All components have a design life in excess of 10 years with a minimum guaranteed design life specification of three years. The acoustic source is a resonant source, which means that it works most efficiently in a narrow frequency band. As a result, the source cannot serve as a "loudspeaker" to broadcast broad spectrum sounds (e.g., tapes of whale calls).

• Seabed Power Cable: The seabed power cable runs at about 100-m (328.1-ft) depth around the northwest side of Kauai before turning north into deeper water near the source (Figure 2.1-2, Approximate Cable Route and Sound Source Site). The cable is approximately 51.5 km (27.8 nm) long with a nominal diameter of 3.18 cm (1.25 in). It is a coaxial, twin conductor, insulated cable. The cable route was selected based upon side-scan sonar bathymetric (seafloor) surveys conducted in March and May of 1993 by Seafloor Surveys International, Inc. (SSI) of Kailua, Hawaii. Survey results are described in the *Final Survey Report for Kauai Acoustic Thermometry of Ocean Climate Site*, SSI 1993. The route was established so as to run the cable along a flat path avoiding cable suspensions and rough surfaces, like coral, and at sufficient depth to not be affected by surface waves.

The cable connects the source to an existing seashore interface cable 1.3 km (0.7 nm) offshore at the PMRF, Barking Sands, in about 25 m (82 ft) of water on a seafloor comprised of coarse sand and coral rubble. This area is inside the main offshore reef around this portion of Kauai. The coral rubble extends offshore to depths of 28 to 30 m (92 to 98 ft), and may mark the extent of the more severe bottom disruption due to storm waves, or could be a relic of a lower stand of the sea. Seaward of the coral rubble, the cable crosses a gentle, sandy slope (dipping less than 1 degree (deg)) from approximately 1400-2200 m (4593-7218 ft) offshore. The cable crosses the irregular outer face of the offshore reef in water depths of 45 m to 67 m (148 to 220 ft). This exposed reef is approximately 250 m (820 ft) wide with frequent surge channels (steep-sided, narrow breaks in the reef that have a sandy seafloor). The cable route crosses the reef at a

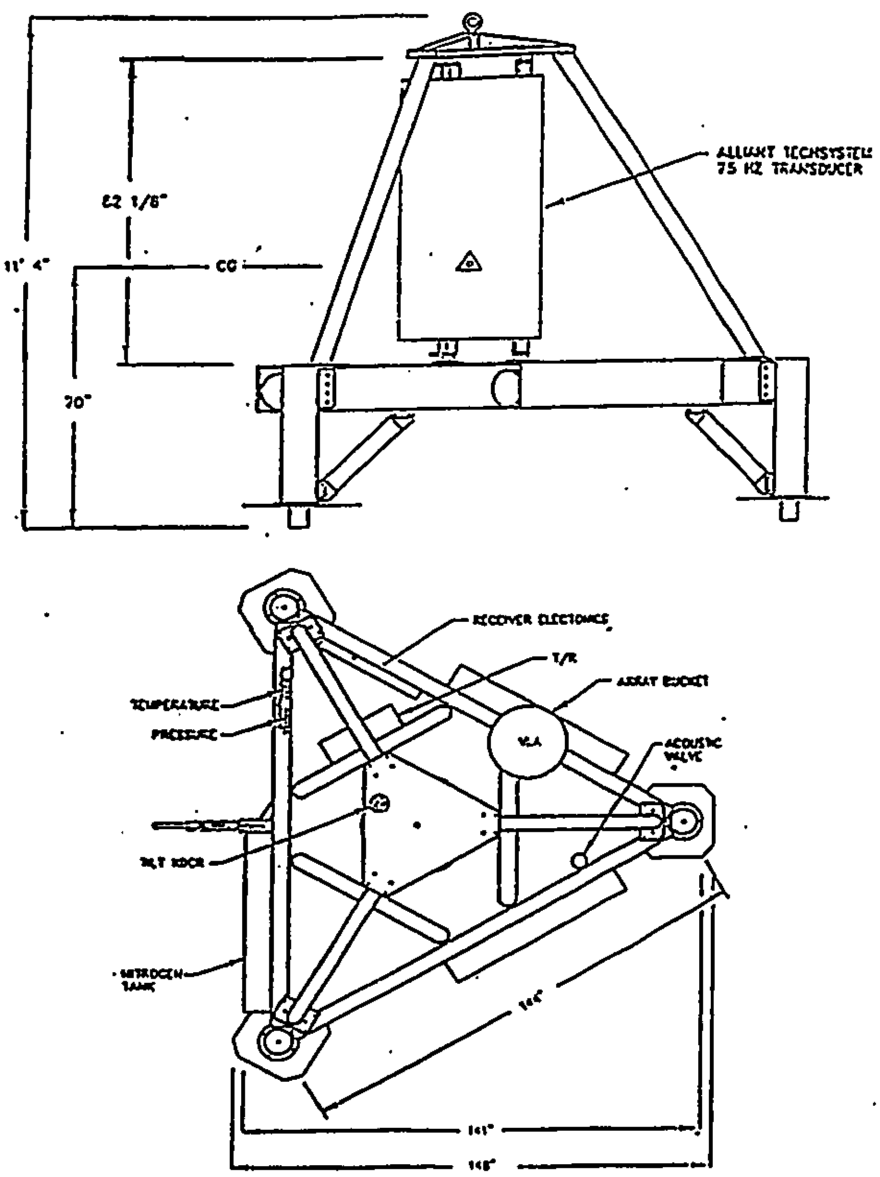


Figure 2.1-1 Line Drawing of Sound Source

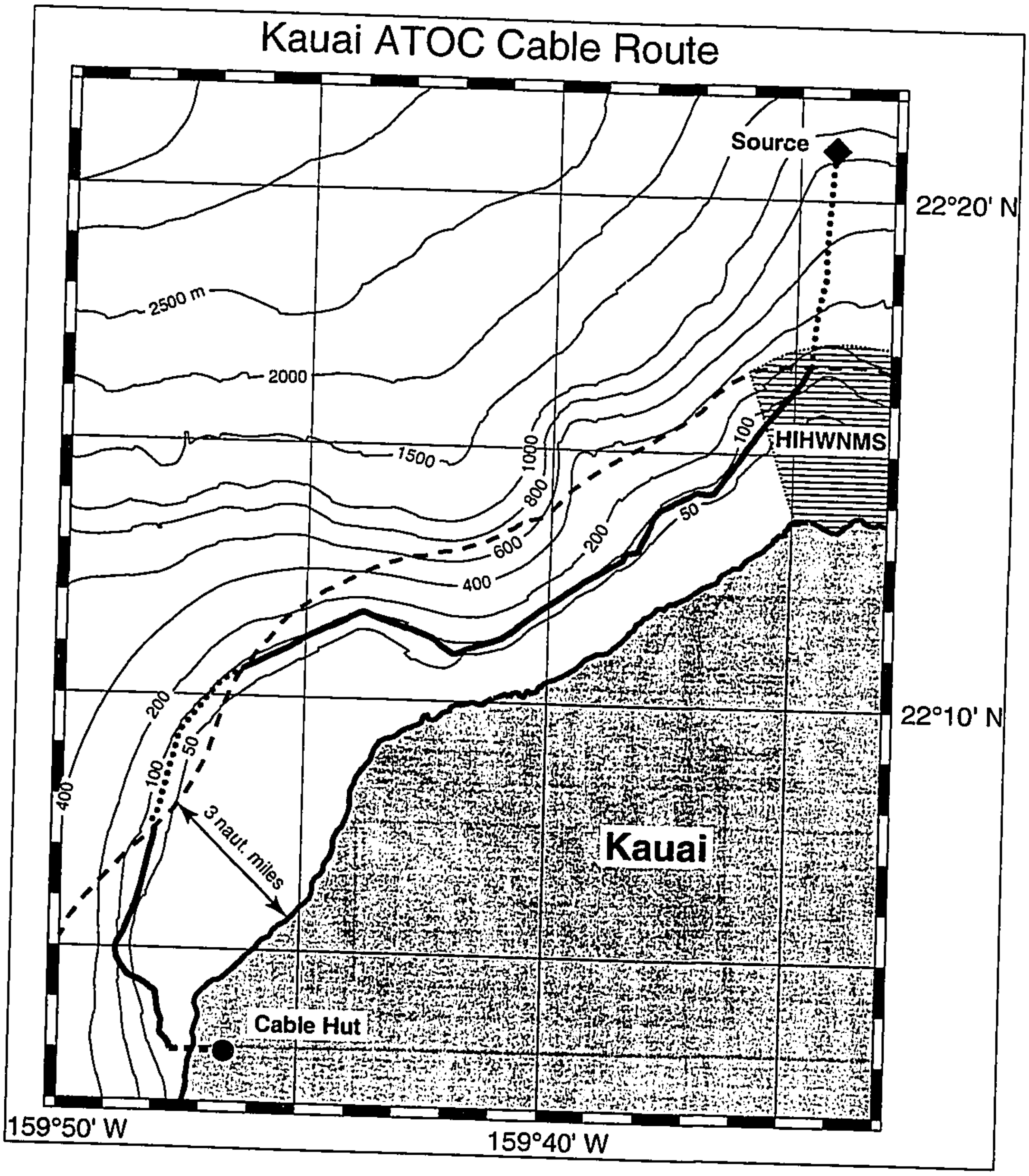


Figure 2.1-2 Approximate Cable Route and Sound Source Site

favorable angle, in one of the largest surge channels in the reef. These surge channels are floored by sand, which is generally mobile and has probably moved to cover the cable.

West of the outer reef the ocean is floored by thick sediments, probably sands, which dip at less than 2 deg to a depth of approximately 85 m (279 ft), then start to dip more steeply into deeper water, and start to approach 15 deg at depths of over 215 m (705 ft). These steep slopes are typical of the upper flanks of the Hawaiian Islands.

The major portion of the cable route runs along the gentle upper slope of the submarine flank of Kauai, with water depths of 75 to 100 m (246 to 328 ft) and slopes of approximately 2 deg. The cable was laid clear of the reef, with about 2-4 percent slack to allow the cable to be naturally buried by the sediment.

After traversing the northwest corner of Kauai at the approximate depths of 70-100 m (230-328 ft), the cable route turns north into deeper waters. The cable runs nearly straight down a fairly gentle (average 4.5 deg with steeper areas up to about 8 deg), sediment-covered slope. Small boulders are scattered in the area from approximately 370-410 m (1214-1345 ft) depth and below 700 m (2297 ft) depth. The cable ends at the source site in approximately 807 m (2648 ft) of water. The bottom slope is about 4 deg.

The cable was installed for the ATOC project in October 1993. By now, natural processes such as sediment drift are likely to have buried the cable, especially in areas where the seafloor is primarily sand. Depending on the characteristics of the sediment, the cable may be lying on the seafloor surface in some areas and buried 2.54 cm (1 in) to 30.5 cm (1 ft) in other areas. By the end of the proposed NPAL project, the cable will have been on the seafloor for approximately 12 years, and can be expected to be even more deeply buried and integrated into the benthic (seafloor) environment. PMRF conducted an ROV survey of cables on the west-northwest side of Kauai in 1995 out to water depths of approximately 300 ft (100 m) (Dick, pers. comm., 2000). Mr. Dick stated that the ATOC cable was encountered during the ROV survey, and that it was buried under sand and barely visible. He said that when the cable was laid, a concerted effort was made to place the cable along the 300 ft (100 m) depth contour where the sediment consists of a prehistoric drowned beach; therefore it is likely that the majority of the cable along this depth contour is buried by sand. Furthermore, the existing seashore interface cable that the ATOC cable was connected to has been in place for approximately 20 years, and photos 2-1 document massive coral growth on that 0.7 nm section (Dick, pers. comm., 2000). Mr. Dick commented that, to depths of approximately 200 ft (61 m), the ATOC cable also has coral growing on it, but not to the same extent since it hasn't been in place as long as the seashore interface cable. Therefore, removal of the cable could result in damage to the coral that has begun to grow on it.

The cable route lies partly within the PMRF Barking Sands, which is operated by the U.S. Navy. Installation of the cable along a relatively shallow route through the PMRF was expected to avoid any interaction with PMRF activities or facilities. In 1998 PMRF training and testing capabilities were expanded with addition of the Shallow Water Training Range (SWTR), which includes sensitive instrumentation in the region of the ATOC cable's southwestern reach. In February 1999 it was learned by ATOC project principals that cables of the SWTR facilities overlie the ATOC cable in seven locations (Figure 2.1-3, PMRF Shallow Water Training Range cables and ATOC cables). When asked to move the facilities to enable recovery of the ATOC cable, PMRF advised that the SWTR cables could not be moved because of the high risk of damaging the cables or in-line sensors during the recovery process, and because of the tremendous costs involved (Letter 26 May 1999, PMRF Executive Officer L. B. Barfoot to Dr. P. Worcester, Scripps).

If left unrecovered on the seafloor, the source and cable would have no effect on the benthic environment. In contrast, recovery would involve disruption of the benthic environment. Therefore, at the conclusion of the proposed five-year period, the cable would be abandoned in place. The source would also be abandoned in place unless it is in sufficiently good condition to warrant recovery.

2.1.1.2 Transmission Characteristics

Transmissions would continue with roughly the same signal parameters and transmission schedule as those used during the first feasibility phase of the ATOC study. Approximately 260 Watts of acoustic power are radiated during transmission. At 1 m (3.3 ft) from the source, the sound intensity (i.e., source level (SL)) is about 195 dB referenced to the intensity of a signal with a sound pressure level of 1 microPascal (μPa) on a "water standard" basis.

Optimum waveform and acoustic signal coding are used to reduce the required source levels. The nominal source waveform is a digital sequence of coded signals that has been optimized for decoding at the distant underwater receivers (Munk et al., 1995). The transmission length of 20 minutes is designed to spread the energy over time, at much lower source levels than if the signals were sent as short, loud pulses of the same total energy. Although the sounds cannot be "heard" in the usual sense over most of the transmission path or at the receivers, they are detected and timed using advanced digital signal processing techniques, similar to those used by NASA to retrieve data from deep space satellites. Since the signal-to-noise ratio at the receiver after appropriate processing is directly proportional to the duration of a transmission, weak but carefully constructed signals of long duration can be extracted from below-ambient noise levels. However, signals of much longer than 20-minute duration lose their coherence, and therefore lose the correlation between signal duration and signal-to-noise ratio. Results from the first phase of the ATOC feasibility study demonstrate that these source characteristics provide adequate, but not excessive, signal-to-noise ratios at the receiver ranges of interest. As a result, the current waveform parameters are designed to optimize reception, thereby reducing the RLs to which marine animals are exposed. 2-2

Following the initial ATOC MMRP Pilot Study, there were six 20-min transmissions (one every four hours), every fourth day, with each transmission preceded by a 5-min ramp-up period, representing an average duty cycle of 2 percent. The ATOC permit further allowed an 8 percent duty cycle for one two-month period during the initial 24-month feasibility phase to investigate the effects of ocean tides and other high frequency ocean property fluctuations.

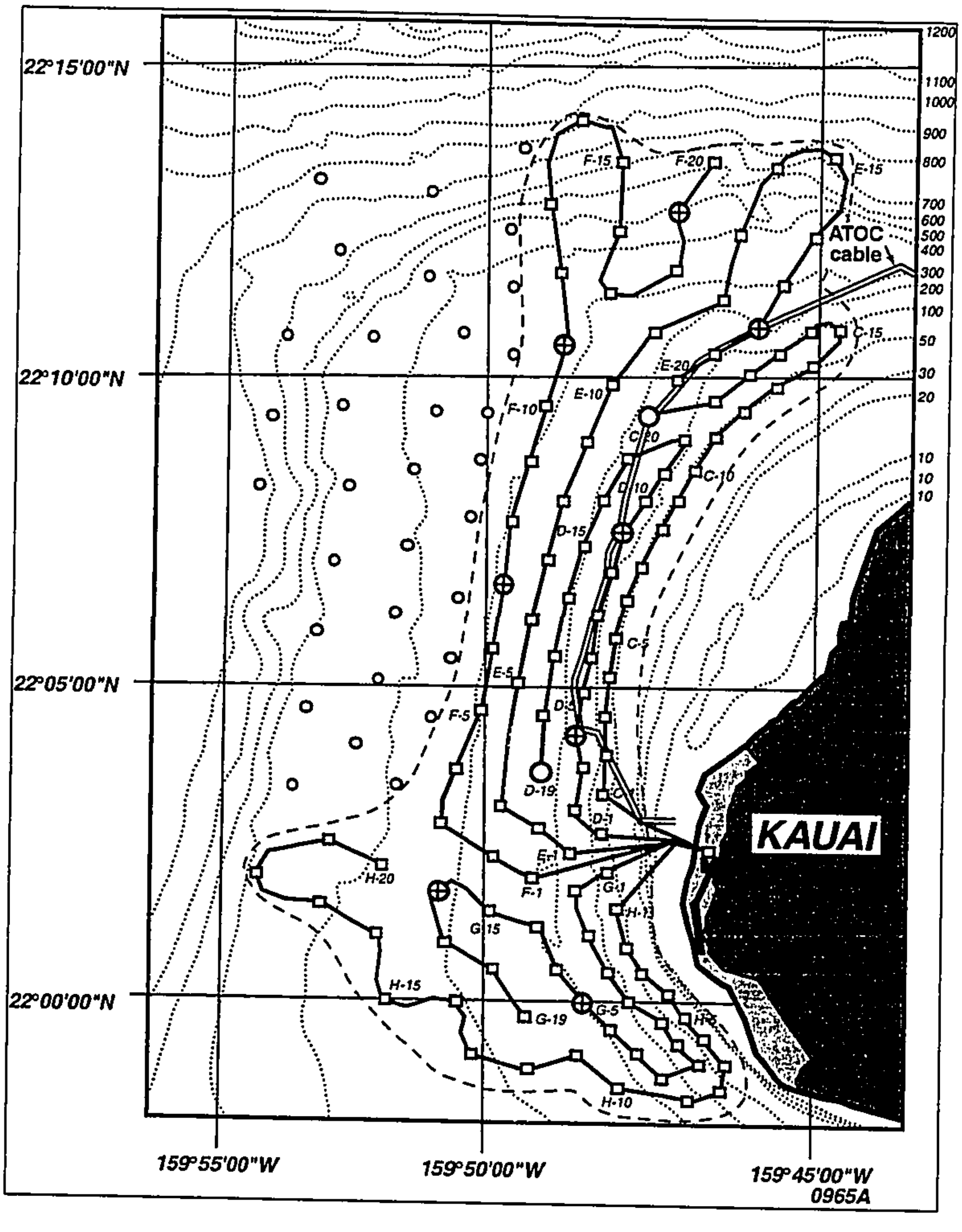


Figure 2.1-3 PMRF Shallow Water Training Range cables and ATOC cables

To provide for short-term long-range acoustic propagation studies, the proposed action includes the possibility of an 8 percent duty cycle for up to 2 months out of each year. The 8 percent duty cycle would not occur during the peak humpback season (January - April).

Mitigation Measure 1: The sound source would operate at the minimum duty cycle necessary to support the large-scale acoustic thermometry and long-range propagation objectives.

Mitigation Measure 2: Any increases in the duty cycle beyond the nominal 2 percent (but maximum of 8 percent) would not occur during the peak humpback season (January – April).

The transmission schedule during the two-month 8 percent duty cycle period would include no single transmission longer than 2 hr in duration. As an example, one possible 8 percent transmission schedule could include 20-min transmissions at four hour intervals every day, instead of every fourth day. Another possible transmission schedule would involve transmitting the 20-min signal on the hour for 24 hours followed by 72 hours of no transmissions, repeated up to 15 times over the two-month 8 percent duty cycle period.

The nominal signals transmitted by the source have a center frequency of 75 Hz and a bandwidth of approximately 35 Hz. Therefore, sound transmissions are in the frequency band of 57.5-92.5 Hz. M-sequence waveforms would be the primary signal transmitted. Additional waveforms in the same frequency band would be transmitted to test their efficiency for long-range propagation, studying parameters such as signal stability and coherence.

Potential effects of the proposed action on marine animals would be monitored by aerial surveys. The potential effects of sounds from the source on marine animals depend upon three factors: 1) the intensity of sounds at various subsurface locations, 2) the location of marine animals in relation to those sounds, and 3) the sensitivity of those animals to the sounds to which they would be exposed. The following discussion addresses the first of these factors – how loud is the source at different locations. Chapter 4 analyzes the second and third factors – what animals might be exposed to the source and how those exposures compare to the sensitivity of those animals to the signals produced.

As discussed above, when the source is operating at full intensity it would produce approximately 260 Watts of acoustic power, resulting in a sound level of 195 dB at one meter from the source. Few, if any, animals would be exposed to the source at this full intensity, since they would need to be immediately adjacent to the source, 807 m (2648 ft) below the surface, during the 2-8 percent of the time the source was transmitting. In consideration of the potential impacts of this sound source on marine animals, it is therefore necessary to estimate the received levels (RL) (i.e., the sound levels at the marine animals' actual locations) based upon these source levels.

A number of models are available to predict sound levels at various distances from the source. The simplest of these models calculate spherical and cylindrical spreading of the sound field with distance. Spherical models are most appropriate in the three dimensional space immediately surrounding the source. Measurements of the sound field near the Kauai source made by the Kauai ATOC Marine Mammal Research Program (MMRP) found that the sound field intensity within about 3 km of the source in fact decreases about as expected assuming spherical spreading of the acoustic signal (Frankel and Clark, 1998). The relative sound intensity therefore decreases rapidly as the sound propagates away from the source, as can be seen in Table 2.1-1.

Table 2.1-1 Relative Sound Intensity vs. Distance *R* From Kauai Source For Spherical Spreading.

Distance (m)	Relative Intensity ($1/R^2$)
1	1
10	$1/(10^2) = 1/100$
100	$1/(100^2) = 1/10{,}000$
1000	$1/(1000^2) = 1/1{,}000{,}000$

Corresponding sound field contours in the immediate vicinity of the source for spherical spreading are shown in Figure 2.1-4, Received Levels in Immediate Vicinity of Kauai Sound Source for Spherical Spreading. A humpback whale diving directly above the source to the deepest known humpback dive depth (240 m (787 ft)) (Hamilton et al., 1997) at the time of source transmission would be exposed to a sound level of 140 dB. However, most humpback whales near Kauai are located well away from the source in areas with water depths of less than 100 m (328.1 ft) (Mobley et al., 1999). Table 2.1-2, Distances from Kauai Sound Source and a Humpback Whale That Give the Same Received Level, compares the distances at which a humpback whale would experience the same received level from the Kauai source and from another humpback whale (assuming a typical source level of 180 dB for the humpback whale (Richardson et al., 1995)). For example, a humpback whale would experience a received level of 140 dB at a maximum dive depth of 240 m (787 ft) directly above the source (i.e., a distance of 550 m (1805 ft) from the source). This is the same received level it would experience at a distance of 100 m (328 ft) from another vocalizing humpback whale. The received levels from the Kauai source are therefore similar to those experienced by humpback whales in their day-to-day activities.

At ranges from the source greater than the source depth, a three-dimensional cylindrical spreading equation is more applicable. Spherical and cylindrical spreading models do not consider the possibility of attenuation or reinforcement of signal propagation paths due to the effects of the transmission medium (sea water) or surrounding features (the most significant of which are the sea bottom and the sea surface). The sea bottom exerts a strong influence on sound, by absorbing and reflecting sound energy, thereby decreasing or increasing the predicted RLs at a particular site distant from the source. Parabolic Equation (PE) acoustic performance models address these effects to produce a more realistic estimate of actual RLs. They also provide the full 3-D field, augmenting the limited measurements. PE model results for the Kauai sound source are depicted in Figure 2.1-5, Parabolic Equation Sound Propagation Plot Towards Kauai (Due South), and Figure 2.1-6, Parabolic Equation Sound Propagation Plot Away From Kauai (Due North). PE model values are used in the remainder of this document to make predictions of RL when needed.

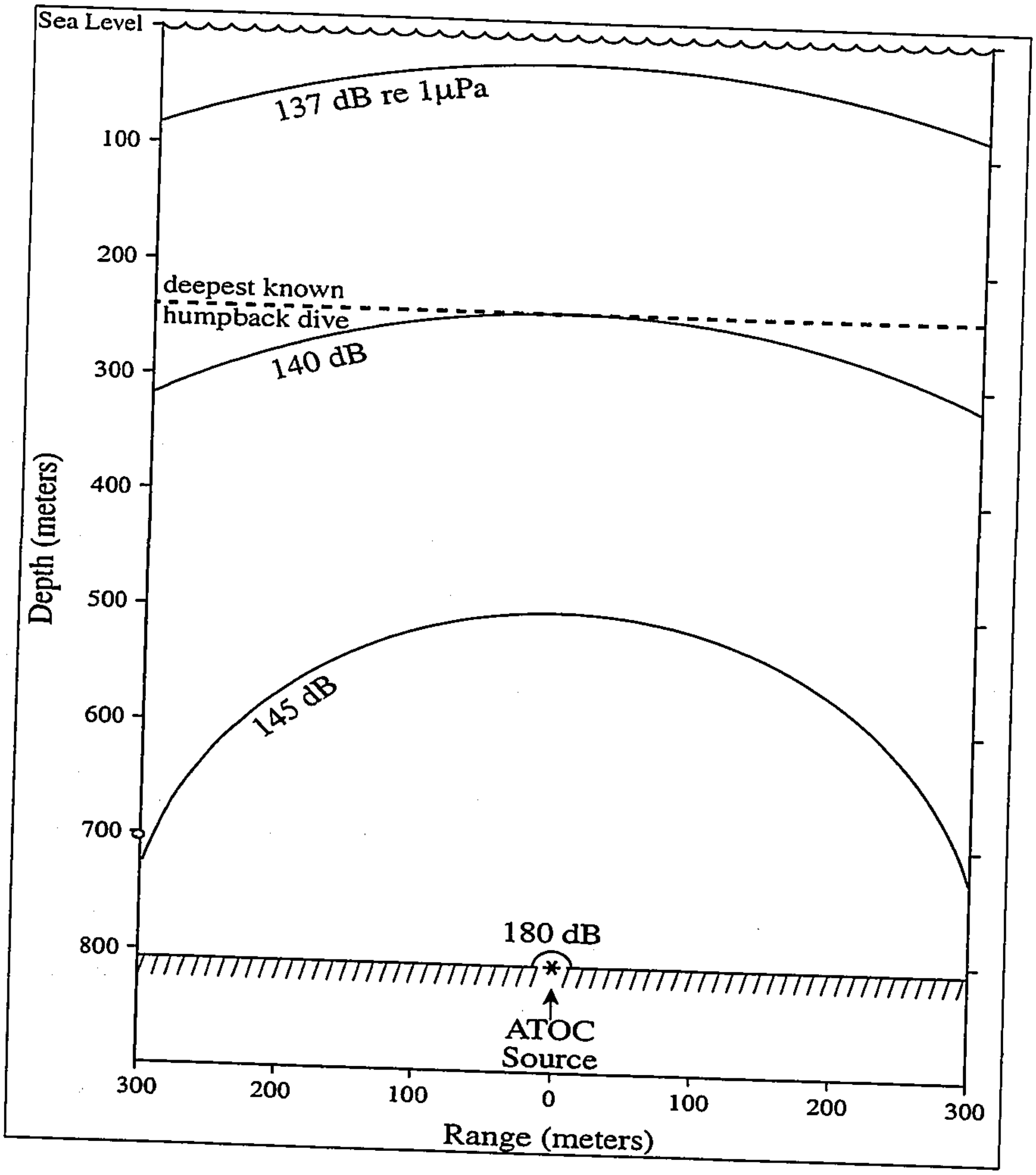


Figure 2.1-4 Received Levels in Immediate Vicinity of Kauai Sound Source For Spherical Spreading

Table 2.1-2 Distances from Kauai Sound Source and a Humpback Whale That Give the Same Received Level

Received Level (dB)	Distance (m)	
	From Kauai Sound Source (SL = 195 dB re 1 μPa)	From Singing Humpback Whale (SL = 180 dB re 1 μPa)
180	6	1
145	300	56
140	550	100
137	750	140

Even PE models have difficulty making accurate predictions of RL as sound travels upslope near shore. To resolve this issue, RL data were collected by the Kauai ATOC MMRP (Frankel and Clark, 2000). The power in the 60-90 Hz band was calculated each second, and the 25th percentile value of each calculation was returned as the received level measurement. The data points displayed in Figure 2.1-7 represent modal estimates of all RLs measured at the given range from the source. Frankel and Clark (2000) found that RL decreases rapidly as the sound travels upslope towards Kauai, as can be seen in Figure 2.1-7 (Measured Received Levels from Kauai Sound Source). Figure 2.1-7 shows the ATOC sound source at 807 m (2648 ft) and the ocean bottom topography heading south from the source towards Kauai. At approximately 3 km (1.6 nm) from the sound source, the water depth is approximately 600 m (1970 ft) and the RL is approximately 125 dB re 1 μPa. At about 6 km (3.2 nm) from the sound source, the water depth is about 300 m (980 ft) and the RL is about 115 dB re 1 μPa. The boundary of the Hawaiian Island Humpback Whale National Marine Sanctuary (HIHWNMS) is located at the 100-fathom (183 m) depth contour, about 7 km (3.8 nm) from the sound source, as seen by the vertical dashed line. The RL within the HIHWNMS is approximately 110 dB. Research conducted off the island of Hawaii during the humpback season estimated ambient noise in the 60-90 Hz band at 105 dB re 1 μPa (Frankel and Clark, 1998), shown in Figure 2.1-7 by the horizontal dashed line labeled winter ambient noise level. It should be noted that in the Wenz curve (Figure 2.1-8, Ambient Noise Spectra (From Wenz, 1962)), heavy shipping was estimated at a spectrum level of 83 dB re 1 μPa, which equates to approximately 98 dB in the 60-90 Hz ATOC frequency band. The estimated ambient noise value of 105 dB was likely elevated by the contributions of humpback whales singing during the winter. Nonetheless, RLs from the sound source are only slightly above the typical background ambient noise level during the winter when humpback whales are present and singing, which means that the signal is barely detectable within the 100-fm contour without specialized computer processing. 2-3

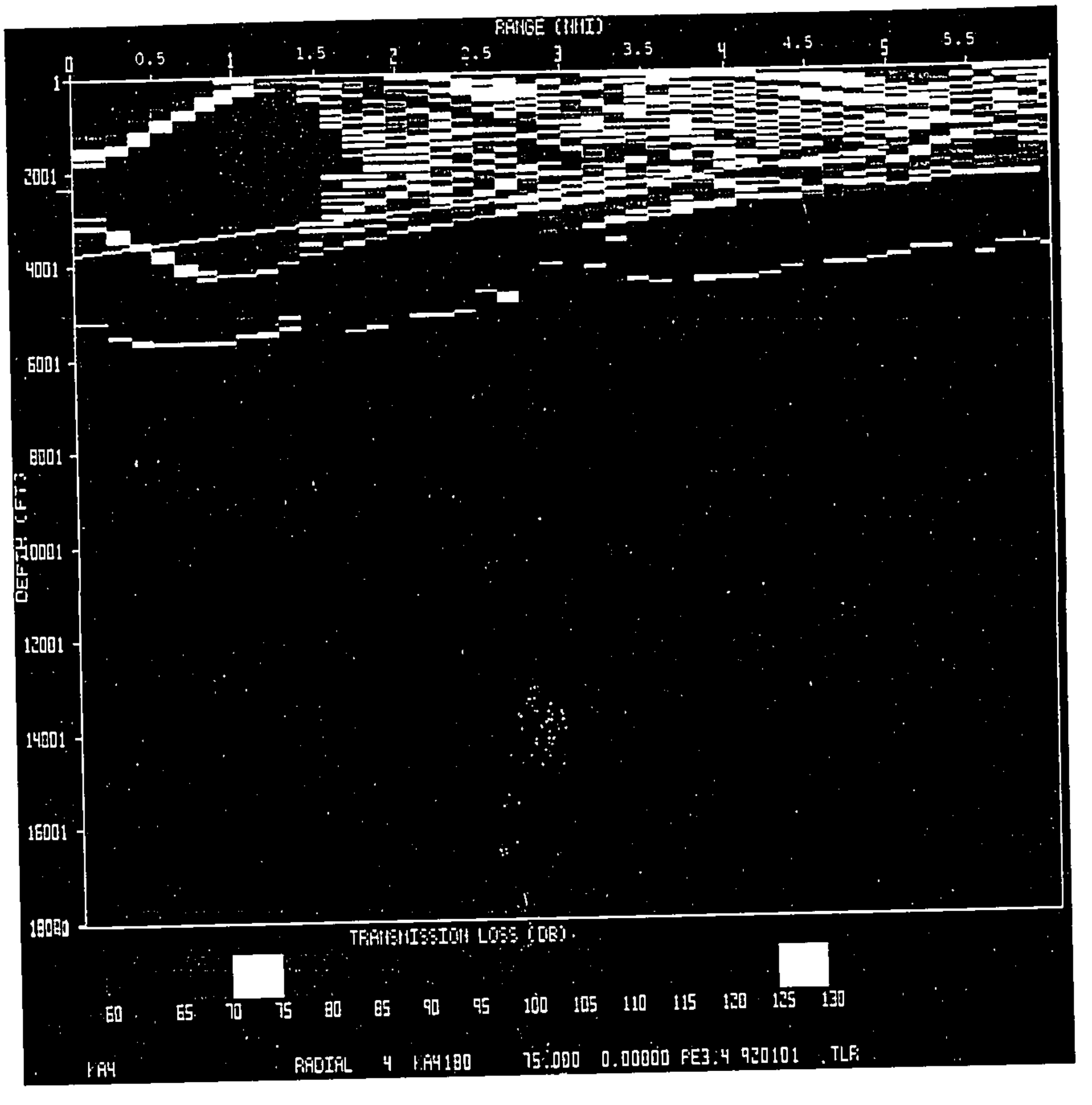


Figure 2.1-5 Parabolic Equation Sound Propagation Plot Towards Kauai (Due South)

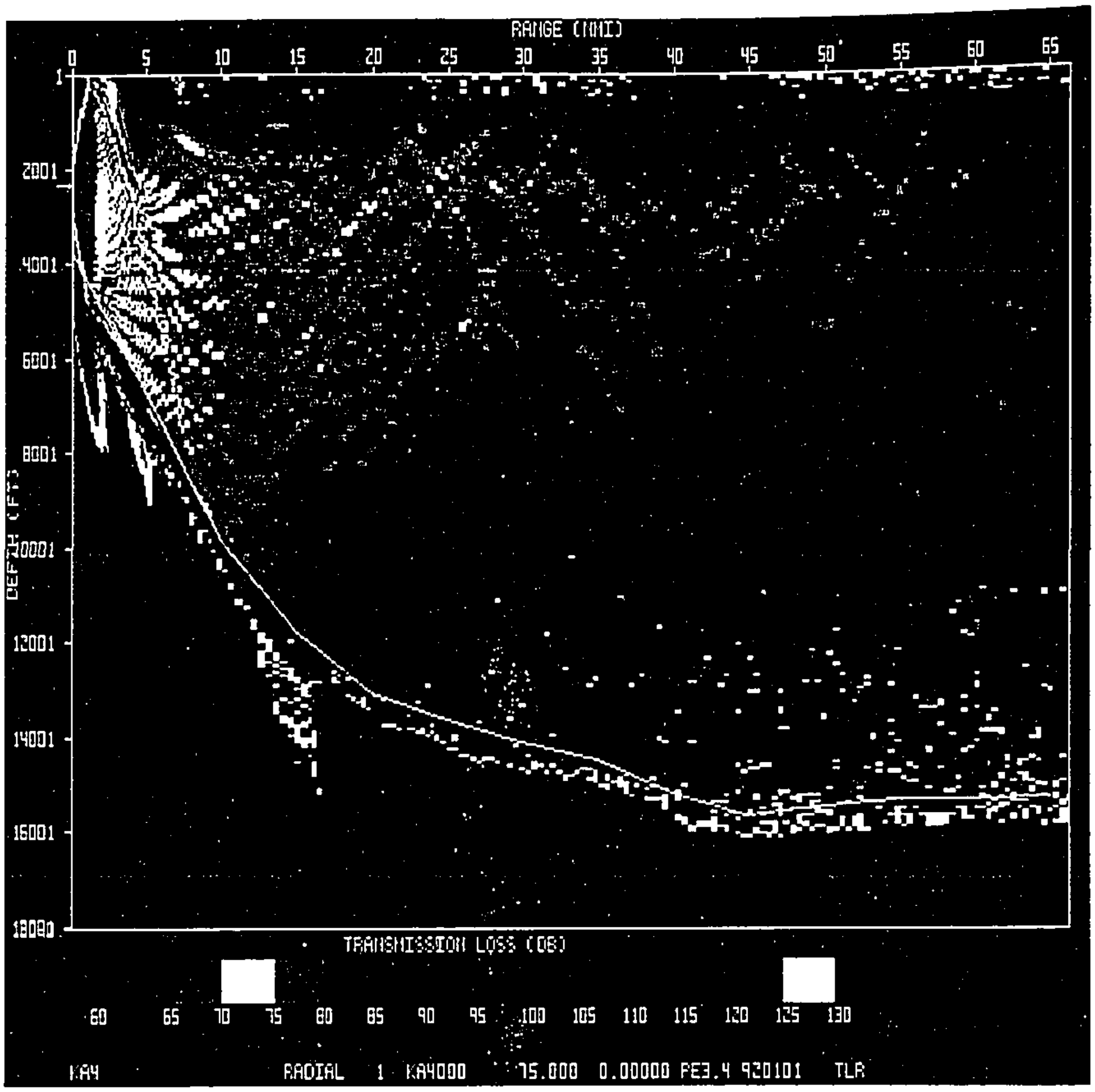


Figure 2.1-6 Parabolic Equation Sound Propagation Plot Away From Kauai (Due North)

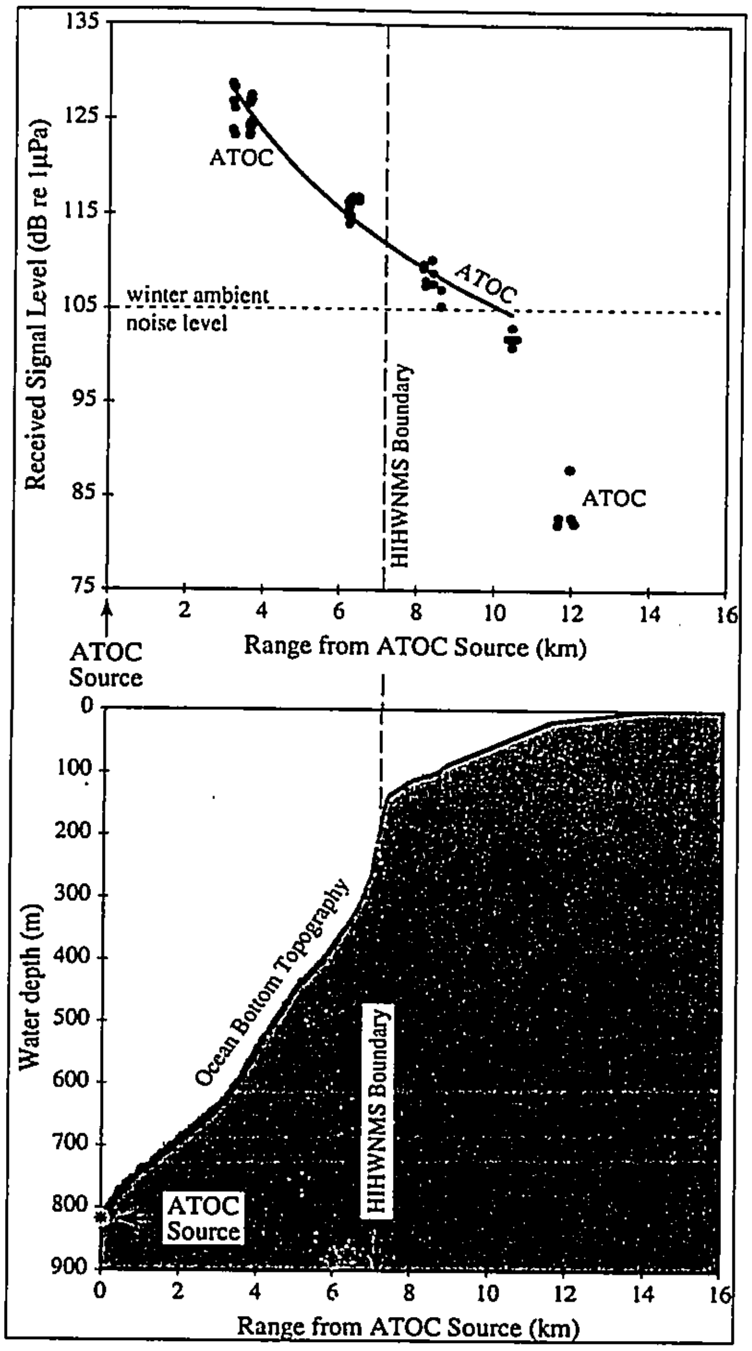


Figure 2.1-7 Measured Received Levels from Kauai Sound Source:

The Kauai ATOC MMRP measured the received levels at various distances from the sound source (measured RLs are represented by the black dots in the upper graph). Coordinating the measured RLs with the ocean bottom topography show in the lower graph, it was observed that RL decreases rapidly as the sound travels upslope towards Kauai.

2.1.2 No Action Alternative

Under this alternative, there would be no further activity with the Kauai source (transmissions ended in October 1999 in accordance with the original permit). Should this alternative be implemented, the need for a long-term research project exploring the natural and anthropogenic (man-made) changes in the ocean environment would not be met. Permanent cessation of transmissions would result in the Navy foregoing the collection of critical environmental information, since further data on large-scale ocean temperature and heat content variability on seasonal and interannual time scales would not be obtained from acoustic remote sensing. Furthermore, the data required to objectively assess the value of acoustic thermometry as one component of an integrated ocean observing system would not be acquired. Finally, advances in signal processing and the ultimate effectiveness of passive acoustic techniques would not be realized. Without these advances, alternate techniques for detecting quiet acoustic sources would need to be utilized and/or developed.

The No Action Alternative would also result in a loss of information on the distribution, abundance and densities of the Hawaiian humpback whale population that would be obtained from aerial surveys conducted over the next five years. Further, there would be no data collected on the potential for long-term effects on marine life of LF sounds generated by shipping, industrial and military activities, and other man-made noise sources.

2.1.3 Additionally Restrict Source Transmission Times and Modify Source Operational Characteristics of the Kauai Source

This alternative would limit sound transmissions to times when potentially vulnerable marine species are not present in the vicinity of the source and would modify source characteristics to potentially reduce effects on marine animals. This subsection specifically analyzes the feasibility and desirability of this alternative in relation to humpback whales.

2.1.3.1 Restrict Source Transmission Times

Based on available information, it appears that some, if not all, mysticetes (or baleen whales, such as humpback whales and blue whales) hear at low frequencies and that sea turtles may also be capable of sound detection at low frequencies. Of all the marine animals in the Kauai area, the most reliable baseline data on migration movements are available on the humpback whale. Their movements throughout the Hawaiian Islands are fairly well understood from aircraft observations. Sufficient information is available that transmissions could be scheduled to avoid the times of the year that they are present in the Hawaiian Archipelago. The sea turtle species most likely to pass through the source sound fields located relatively far offshore are leatherbacks, loggerheads, olive ridleys and greens. Their migratory habits are less well-known than the humpback whales' and thus it would be difficult to alter transmission times to avoid their presence.

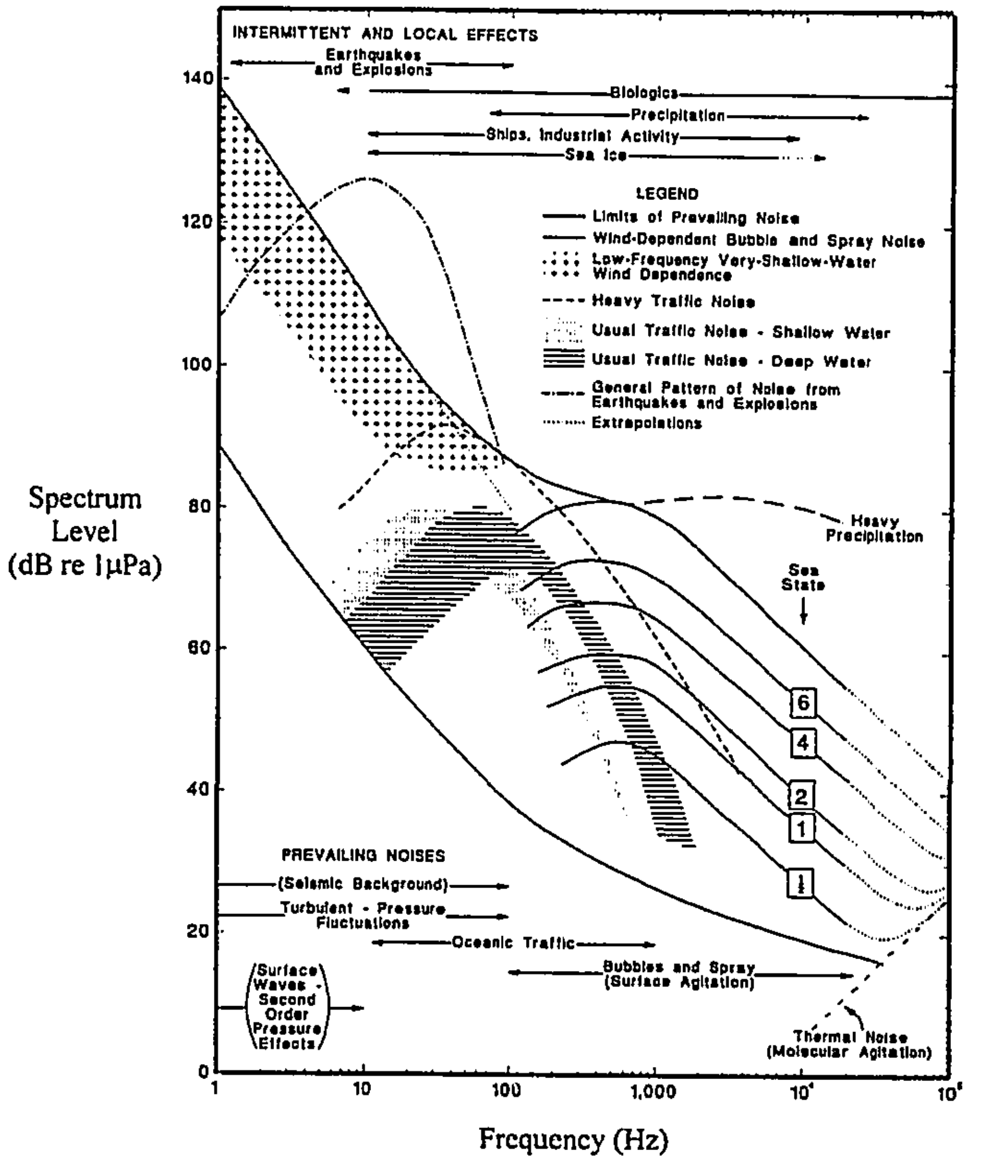


Figure 2.1-8 Ambient Noise Spectra (From Wenz, 1962)

Restricting source transmissions to seasons when humpback whales are not present would severely reduce the utility of both the acoustic thermometry and long-range propagation studies, however, as well as make it essentially impossible to study the possible long-term effects of LF sound transmissions on marine life.

Acoustic Thermometry. To advance our understanding of seasonal and interannual ocean variability associated with phenomena such as El Niño, La Niña and the Pacific Decadal Oscillation (PDO) requires that data be collected throughout the year to obtain information on all aspects of the phenomena of interest. Properly sampling the seasonal variation of the ocean, for example, requires gathering data during all parts of the seasonal cycle. This allows detection of trends and avoids biasing the results. For comparison, long-term temperature trends in the atmosphere are not expected to occur uniformly at all times of day and in all seasons, but rather can occur in much more complex patterns. Long-term increases in global atmospheric temperatures, for example, might occur as an increase in winter temperatures, with summer temperatures remaining relatively unchanged. Continuous time series of temperature are needed in order to understand such complex patterns of change in both the ocean and atmosphere. Continuous time series are also needed to test and constrain computer models of the ocean, whether the data are obtained from acoustic remote sensing, satellites, or other methods, if the models are to be able to accurately reproduce such complex patterns of variability.

If the ocean is sampled at too low a rate or in a sporadic fashion, it is even possible to confuse rapidly changing oceanographic phenomena with slower changes. In the case of the ocean, large-scale variability has time scales from a week to a few months, and so needs to be sampled every few days. The tides are of course even higher frequency, but because their frequencies are well known, one can adequately sample them one day out of every few days. This combination of ocean phenomena led to the sampling scheme used during much of ATOC and proposed for NPAL, consisting of one day with six 20-minute transmissions at four-hour intervals to adequately sample tidal variability, occurring every fourth day to adequately sample ocean mesoscale variability.

Long-Range Underwater Sound Propagation. There is expected to be a large seasonal variation in the ocean sound-speed field along many of the proposed acoustic paths. Furthermore, the impact of small-scale ocean variability, such as internal waves, on long-range transmissions depends on both the background sound-speed field and the energy present in the small-scale ocean variability. The extent to which the ocean internal wave field might vary over large geographic regions and/or from season to season is unknown. Long-range propagation studies must therefore occur at all times of the year to make meaningful assessments of the impact of the full range of environmental variability on acoustic propagation and on the stability and coherence of the received signals.

Marine Mammal Monitoring Studies. Of the marine animals present in the Kauai area, ATOC MMRP researchers selected humpback whales as the indicator species upon which to focus efforts to detect changes in abundance, distribution, and behavior in response to the ATOC transmissions. Humpback whales were chosen because they are believed to have good hearing at the 75 Hz frequency of the ATOC transmissions, because they are relatively easy to study using aerial survey and other methods, and because they are present north of Kauai during winter months in adequate numbers to yield statistically meaningful results. Transmissions during the humpback season are therefore needed to advance the understanding of the potential for long-term effects on marine life from LF acoustic transmissions, using humpbacks as a key indicator species to warn if the transmissions could possibly be having effects on other species that are more difficult to observe.

2.1.3.2 Modify Source Operational Characteristics

Operational characteristics important to potential effects on marine animals include frequency, source power level, waveform, and sound signal transmission length. Each of these characteristics is discussed below. The proposed signal has already been designed to minimize potential effects from these factors.

Frequency. Frequencies outside marine animals' primary communication bands are preferred to minimize the potential for effects on marine life. Low frequencies are required for acoustic energy to traverse great distances across oceanic sound paths. The frequency of 75 Hz is near the center of the spectrum of deep ocean ambient shipping noise, which peaks 20-30 dB higher than spectrum levels at frequencies of 100-1000 Hz where surface wave noise dominates the acoustic background (Figure 2.1-8). Based on known dominant frequencies of whale vocalizations (summarized in Chapter 3), some species produce sounds, and therefore can hear, in this band. Baleen whales also use frequencies below and above the proposed sound frequency, however. Toothed whales (odontocetes) use frequencies above the proposed source frequency. Thus, there would be no tangible benefit relative to potential impacts on marine animal populations by changing the source frequency characteristics. Based on available information, either a higher or lower frequency might be expected to result in the same or increased potential for impacts.

Power Level. Lower power levels are preferred to minimize the potential for effects on marine life. Figure A-1, Kauai Source Power Density Spectrum, in Appendix A, indicates a peak spectrum power output value of 180 dB. The source is capable of a total power output, integrated across the entire 35 Hz bandwidth, of 195 dB re 1 μPa at 1 m from the source. An initial 5-minute stepped ramp-up period currently helps reduce the potential for startling animals and provides them an opportunity to move away from the source. The ATOC MMRPs found only subtle effects that would not be expected to adversely impact the survival of an individual whale or the status of North Pacific whale populations when the source was transmitting at the proposed source level (see further discussion in Chapter 4).

Mitigation Measure 3: The NPAL sound source would operate at the minimum power level necessary to support large-scale acoustic thermometry and long-range sound transmission objectives.

Mitigation Measure 4: Transmissions from the NPAL sound source would be preceded by a 5-minute ramp-up of the source power.

Waveform and Sound Signal Transmission Length. Optimum waveform and acoustic signal coding are used to reduce the required source levels. The nominal source waveform is a digital sequence of coded signals that has been optimized for decoding at the distant underwater receivers (Munk *et al.*, 1995). The transmission length of 20 minutes is designed to spread the energy over time, at much lower source levels, than if the signals were sent as short, loud pulses of the same total energy. Although the sounds cannot be "heard" in the usual sense over most of the transmission path or at the receivers, they are detected and timed using advanced digital signal processing techniques, similar to those used by NASA to retrieve data from deep space satellites. Weak but carefully constructed signals of long duration can be extracted from below-ambient noise levels. As a result, the current waveform parameters are designed to optimize reception, thereby reducing the RLs to which marine animals are exposed.

Each source signal characteristic of the proposed action has been selected for the least potential environmental impact and the maximum scientific utility. Results from the first phase of the ATOC feasibility study demonstrate that these source characteristics provide adequate, but not excessive, signal-to-noise ratios at the receiver ranges of interest.

2.1.4 Alternate Project Site

Under the Alternate Project Site alternative, the long-range propagation and acoustic thermometry feasibility studies would be undertaken with the source located at a site other than off the north shore of Kauai. To put a reasonable bound on possible choices, this subsection first describes the process by which alternate sites were selected for analysis in this EIS.

An initial task in screening alternate sites was the selection of an ocean basin and general source site areas that would best serve both the thermometry and the long-range propagation study objectives. Three factors proved to be particularly important in this regard.

- First, an area is needed with a relatively large number of existing subsea listening arrays (i.e., SOSUS arrays) in order to obtain the greatest number of acoustic pathways from each source, to sample the greatest volume of ocean. Since the North Pacific and North Atlantic basins were heavily instrumented during the Cold War, and listening arrays in the southern hemisphere are much less numerous, a northern hemisphere study area is preferable.

- Second, in comparing the Atlantic and Pacific oceans, it was determined that the mid-Atlantic ridge, which acoustically divides the North Atlantic basin, would complicate the acoustic investigations and limit the ranges over which testing could occur. A North Pacific study area is therefore preferred to avoid these problems.

- Third, the sound channel tends to be deeper at lower latitudes (nearer the Equator). Deeper source locations would reduce the RLs for marine animals in the upper part of the water column. This rationale suggested a lower latitude, temperate or tropical location for the sound source.

Based on these screening factors, the following criteria were developed to compare and contrast possible alternate sites:

- Location within approximately 93 km (50 nm) of a shore station for a cabled source to avoid excessive power loss in the cable.

- Location at or near the deep sound channel axis, to provide efficient coupling of sound energy into this long-distance sound duct and to reduce surface RLs.

- Location at a site with clear acoustic pathways to existing and planned receiver locations (islands or seamounts between sources and receivers block acoustic paths), preferably a site that combines transmission pathways with large seasonal variations (e.g., equatorial source to high latitude (northerly) receivers) and pathways with small seasonal variations (e.g., equatorial source to nearby or equatorial receivers).

- Location at a site that is locally smooth with a steep slope (8-15 deg) in the direction of the receivers (to minimize bottom interactions with the transmitted signal as it propagates away from the source).

- Location at a site with optimum bottom properties (sand sediment over basalt basement is best for good bottom reflection characteristics) and minimum bottom currents (to minimize the potential for source displacement).

- Location in an area with minimal risk of damage due to bottom fishing.

- Location in an area with low potential for environmental consequences.

- Location in an area with minimal abundances of marine life (including but not limited to marine mammals) that might possibly be adversely affected by LF sound.

Potential sites in the Pacific Ocean were comprehensively evaluated by project scientists. One of the key siting criteria was the number of receiving locations that have clear acoustic pathways from the source location. Computer-generated "shadow plots" were created in which the white "spokes" represent those areas that would be in an acoustic shadow. A mid-Pacific site was preferred to an eastern Pacific site since transmissions in the mid-Pacific have the potential to reach both central Pacific and eastern Pacific existing subsea listening arrays (i.e., SOSUS arrays). Because of the bathymetry along the U.S. west coast, west coast listening arrays would not receive transmissions by a west coast source. A shadow plot from a source located on Pioneer Seamount, off the California coast, is included for comparison (Figure 2.1-9, Pioneer Seamount Site Shadow Plot for Bathymetric Features 1000 m (3281 ft) Below the Sound Channel Axis). As shown in Figure 2.1-9, most of the west coast arrays are in shadow. The number of acoustic paths obtained is therefore significantly reduced compared to the number obtained with a mid-Pacific source. The reduction in the number of paths reduces the geographic coverage for acoustic thermometry, as well as the variety of oceanographic environments in which sound transmissions can be studied. Therefore, in order to maximize the number of transmission paths and the geographic coverage of the region, potential sites in the Pacific Ocean were restricted to the mid-Pacific. 2-4

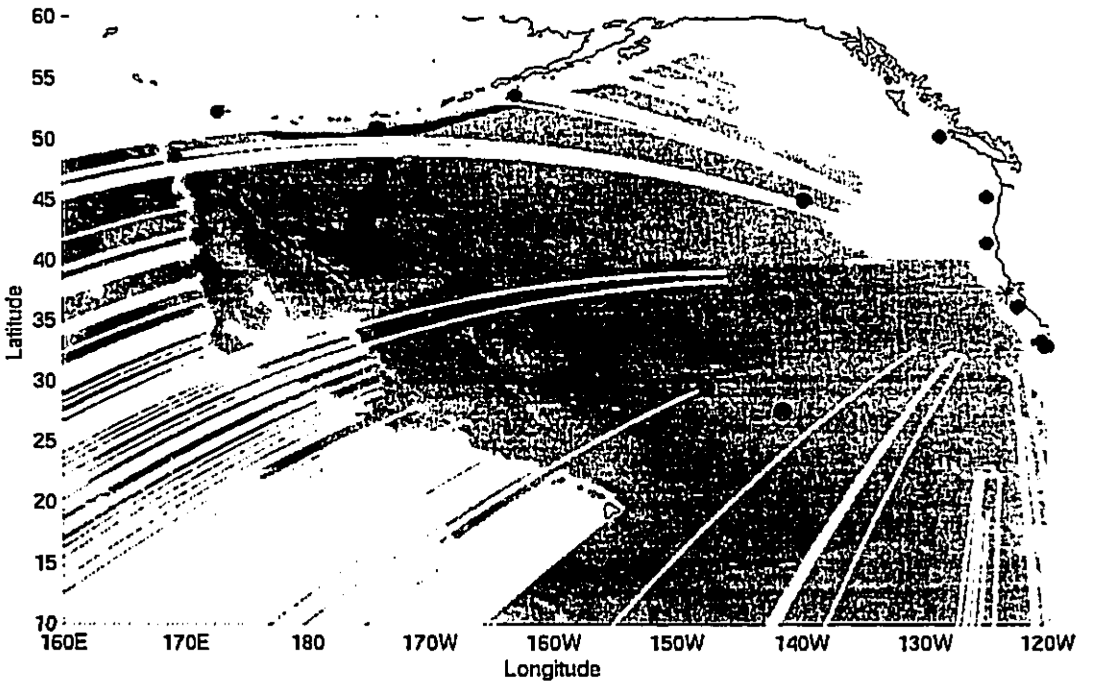


Figure 2.1-9 Pioneer Seamount Site Shadow Plot for Bathymetric Features 1000 m (3281 ft) Below the Sound Channel Axis

In the mid-Pacific, only a few locations are feasible given the sparseness of islands, the fact that many of those islands are uninhabited, and the remoteness of many of those islands. These locations were initially assessed for their ability to provide long-range acoustic paths needed for the viable study of large-scale acoustic thermometry and long-range acoustic propagation. This constituted the first cut of the possible sites and narrowed the field down to the preferred location north of Kauai and the following three alternate locations discussed below:

- Midway Island
- Johnston Atoll
- Adak Island, Alaska

Although the full range of potential mid- and north-Pacific source locations was evaluated during the initial site screening process, Midway Island proved to be the site with the greatest potential and will be the location further evaluated as part of Alternate Project Site Alternative. One of the key siting criteria is the number of receiving locations that have clear acoustic pathways from the source location. Computer-generated "shadow plots" were created for the preferred location north of Kauai (Figure 2.1-10, Kauai Site Shadow Plot for Bathymetric Features 1000 m (3281 ft) Below the Sound Channel Axis) and for the alternate locations. In each case, an acoustic shadow was cast by bathymetric features, such as islands and seamounts, that are 1000 m (3281 ft) or less below the axis of the sound channel. The white "spokes" represent those areas that would be in an acoustic shadow. 2-5

At Midway Island, the deep sound channel axis is located at a depth of approximately 700 m (2296 ft). The shadow plot (Figure 2.1-11, Midway Island Alternate Site Shadow Plot for Bathymetric Features 1000 m (3281 ft) Below the Sound Channel Axis) shows that Midway has relatively clear path coverage to most of the existing receivers. The Midway site has bottom sediment and basement properties that would minimize bottom reflection and refraction of acoustic energy that could block or otherwise interfere with the outgoing transmission paths. Bottom currents should not adversely affect the Midway site nor should there be any significant impact by bottom fishing. Additionally, marine species are not particularly abundant or diverse at Midway Island, reducing the number of animals potentially exposed to the sound and the possibility for significant environmental effects. However, Hawaiian monk seals, a severely endangered species, use the beaches of Midway Island for breeding and pupping, and recent increases in pup survival at Midway suggest that the seals may reestablish the atoll as a major breeding site. Therefore, activities associated with the installation of a power cable may disrupt their behavior. 2-6

Johnston Atoll and Adak Island were considered as possibilities; however, neither will be evaluated as part of this alternative because of their reduced acoustic capabilities. The sound channel axis at Johnston Atoll is approximately 1000 m (3281 ft) deep. However, a shadow plot (Figure 2.1-12, Johnston Atoll Alternate Site Shadow Plot for Bathymetric Features 1000 m (3281 ft) Below the Sound Channel Axis) reveals that almost none of the sound energy transmitted northward reaches receiver sites at Guam, the Aleutians, and the U. S. west coast. 2-7

The proposed site is locally flat and well sloped, with good bottom properties for relatively predictable acoustic reflection/refraction. Bottom currents would be expected to be minimal.

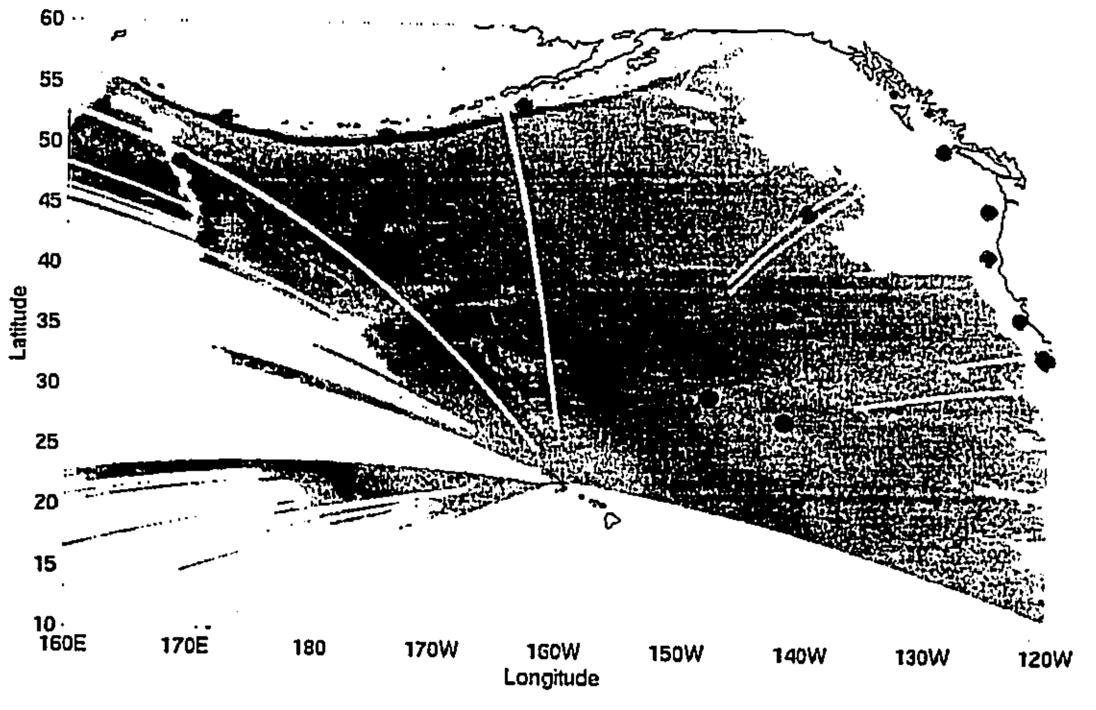


Figure 2.1-10 Kauai Site Shadow Plot for Bathymetric Features 1000 m (3281 ft) Below the Sound Channel Axis 2-8

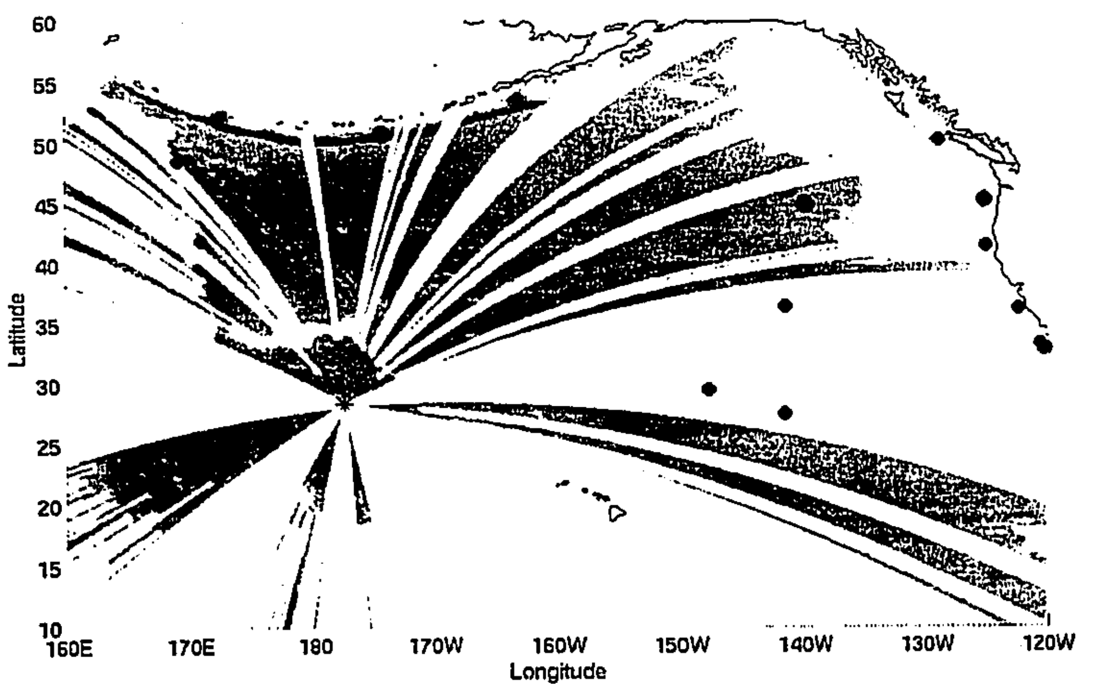


Figure 2.1-11 Midway Island Alternate Site Shadow Plot for Bathymetric Features 1000 m (3281 ft) Below the Sound Channel Axis 2-9

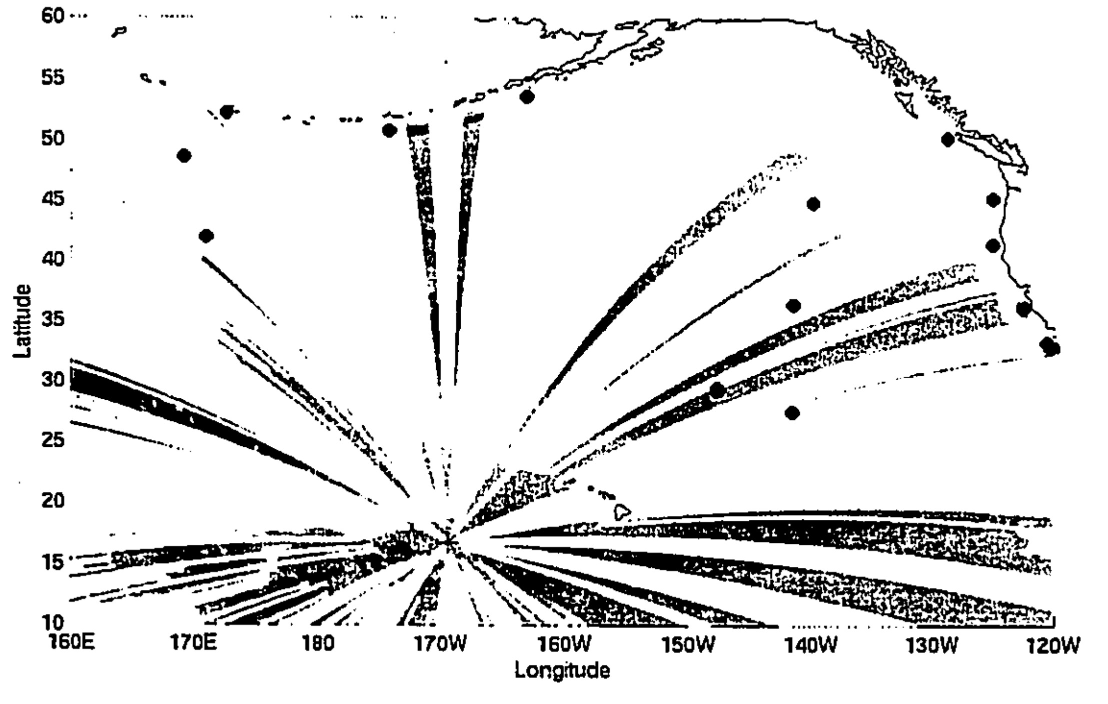


Figure 2.1-12 Johnston Atoll Alternate Site Shadow Plot for Bathymetric Features 1000 m (3281 ft) Below the Sound Channel Axis 2-10

For the Adak Island source, the sound channel axis is at approximately 100 m (328.1 ft) depth, requiring the source to be located much shallower than at more mid-latitude locations. This shallow source depth translates to greater potential risk from commercial fishing activities, and a greater possibility for marine animals to be exposed to the acoustic transmissions. A shadow plot (Figure 2.1-13, Adak Island Alternate Site Shadow Plot for Bathymetric Features 1000 m (3281 ft) Below the Sound Channel Axis) indicates uninterrupted transmission paths to Guam and three existing receiver sites in midocean. This location is on the Aleutian ridge, where the source must be placed on a shallow shelf. The average slope to the south, southwest, and west is about 1-2 deg, much less than desired. Based on available oceanographic data for the region, it's believed that this location would have the greatest potential for undesirably high bottom currents. 2-11

2.1.5 Moored Autonomous Source

This section describes the alternative of using autonomous sources; that is, sound sources which are not attached to shore-based power by cables but are free-standing, powered by large battery assemblies. Such sound sources would be moored to the ocean bottom with weights and held, suspended by floats, at the desired ocean depth.

A conceptual moored autonomous source is depicted in Figure 2.1-14, Conceptual Moored Autonomous Source. The figure shows not only the moored source, but also the long-baseline acoustic navigation system needed to track the movement, or wandering, of the source in a circle of up to 300 m (980 ft) radius around the anchor on the ocean floor due to the influence of tidal and other ocean currents on the mooring. The exact location of the source at the time of each transmission is determined by analyzing changes in the travel times of sound transmissions from transponders located around the mooring at different inclination angles to the source itself (Cornuelle, 1983; Cornuelle, 1985). 2-12

At present, however, there are no acoustic sources designed for autonomous operation that transmit at 75 Hz, that have adequate bandwidth, and that have been demonstrated to operate reliably over long time periods at the high pressures found at 750-900 m (2461-2953 ft) depth in the ocean. The engineering issues that need to be addressed in the development of any such source system include the design of:

- A robust pressure compensation system to allow the source to operate at the high pressures found at depth;

- A battery pack adequate to power the source for deployments lasting a year or more; and

- A mooring system capable of supporting the heavy weights of a LF source and the associated battery pack.

The pressure-compensation system on the existing ATOC sources is designed for installation of the sources at a fixed depth on the bottom. A moored source must be designed to be able to operate over a range of pressures as the mooring moves in response to ocean currents, changing

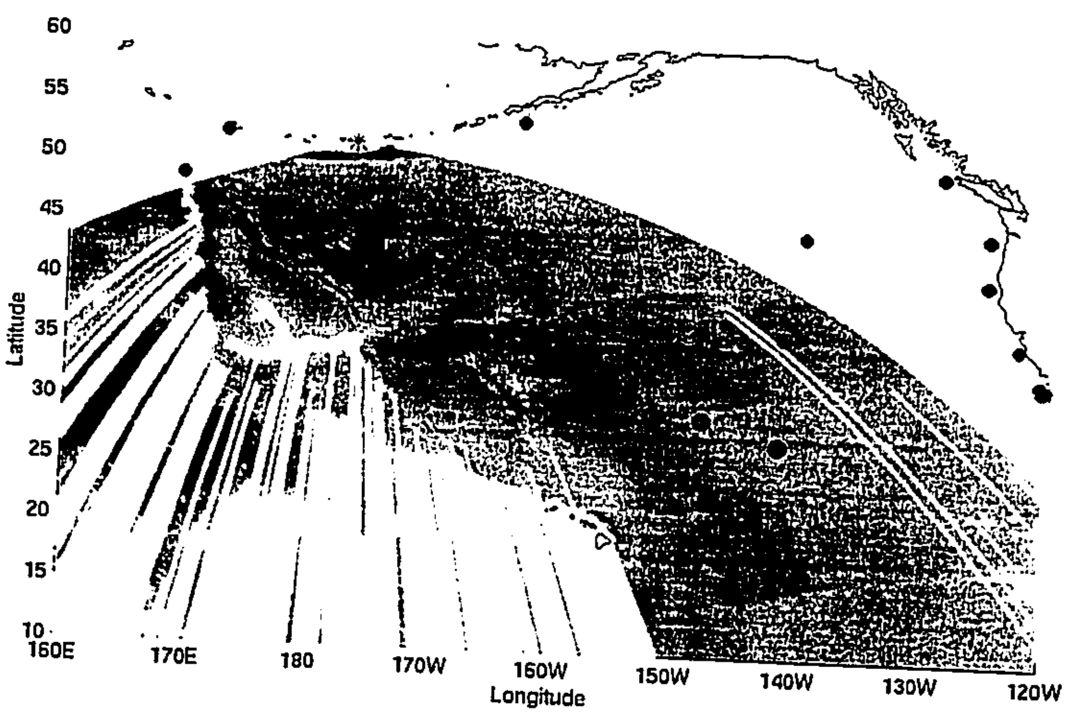


Figure 2.1-13 Adak Island Alternate Site Shadow Plot for Bathymetric Features 1000 m (3281 ft) Below the Sound Channel Axis | 2-13

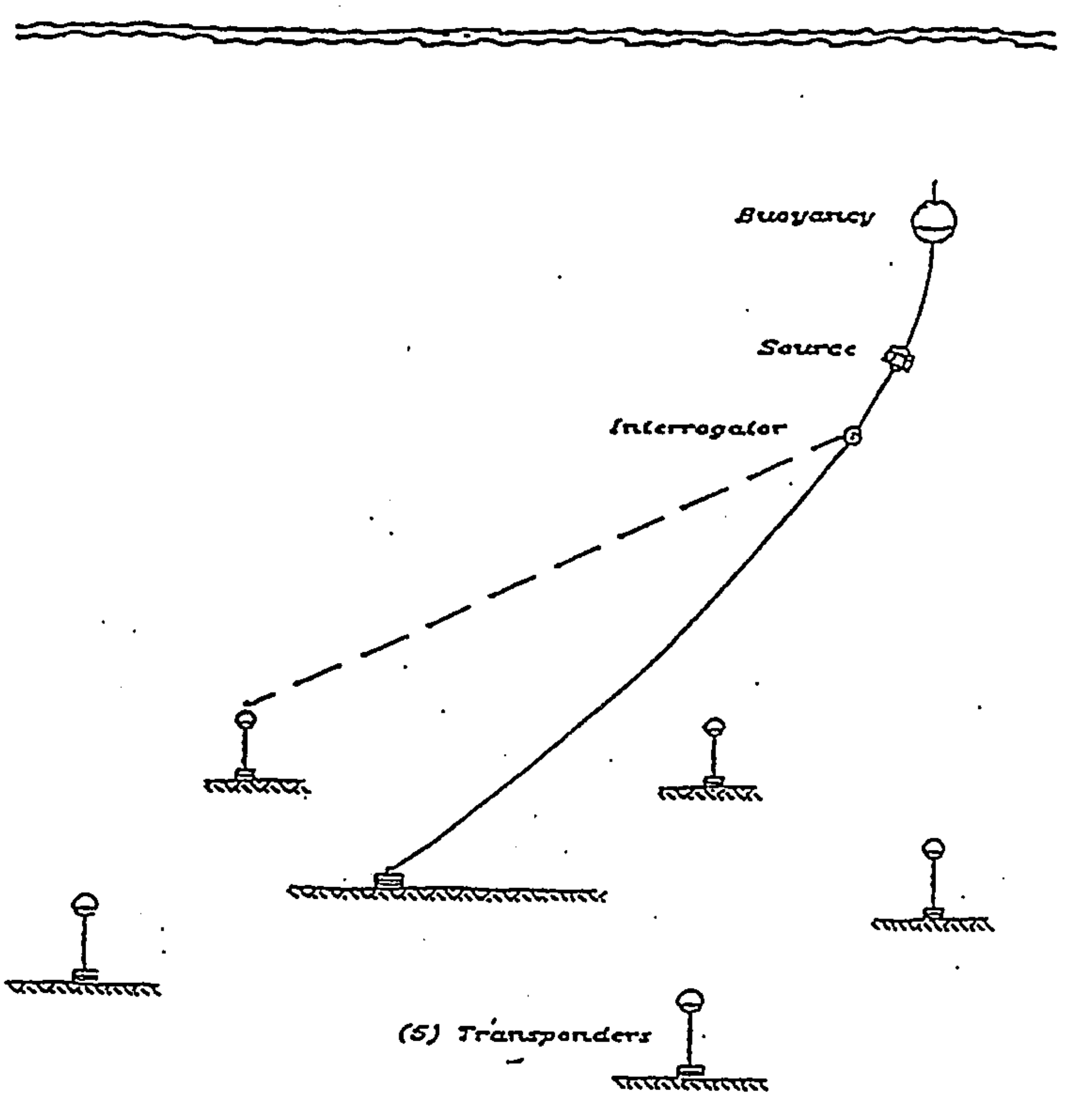


Figure 2.1-14 Conceptual Moored Autonomous Source

| 2-14

the depth of the source. Although such a system is possible, it would need to be designed and its characteristics would depend on the type of acoustic source design implemented.

The design of moored autonomous sources also requires an accurate estimate of required source power levels and duty cycles, since those factors, in turn, dictate battery system requirements. Although battery-powered capability is theoretically available, the energy capacity required to support 20-minute transmissions with a 2 percent duty cycle for one year are formidable. The existing ATOC sources have an efficiency of about 10 percent in converting electrical energy to acoustic energy. At this efficiency, the battery pack would consist of a 2.8 m^3 (100 ft^3) box filled with lithium battery cells and would weigh over 2722 kg (6000 lbs.). (Achievement of better efficiencies, if possible, would reduce these requirements.)The difficult engineering issues discussed above are inherent to the large size and low efficiency typical of LF acoustic sources that operate below 100 Hz. At higher frequencies, sources tend to become smaller and more efficient. One approach that might therefore seem attractive would be to use higher frequency sources for autonomous operation. Commercially available sources exist that operate at about 200 Hz:

- The HX-556 source uses technology similar to that in the existing ATOC sources and can deliver source levels up to 197 dB integrated across a 40-Hz bandwidth from 150 Hz to 190 Hz (center frequency 170 Hz). The HX-556 has a built-in, active-passive pressure compensation system. This type of source is fairly reliable and could potentially operate up to 2 years, using state-of-the-art battery packs, before planned maintenance would be required.

- The HLF-5 source uses hydraulic technology and can deliver source levels up to 192 dB integrated across a 100-Hz bandwidth from 200 Hz to 300 Hz (center frequency 250 Hz). The HLF-5 has a built-in active pressure compensation system. These autonomous sources have been used for many years in ocean acoustic tomography and underwater acoustic propagation experiments involving transmissions out to about 1000-km (540 nm) range and lasting about one year.

Unfortunately, higher frequency sources are at best marginal for transmissions over 3000 – 5000 km (1620 - 2700 nm) paths. Acoustic absorption in the ocean increases as the square of the acoustic frequency, so a 225-Hz signal suffers approximately nine (9) times the absorption loss of the proposed 75-Hz signal. In the Pacific Ocean the volume absorption at 5000-km (2700 nm) range is only 2.1 dB at 75 Hz, but increases to 17.8 dB at 225 Hz. (In the Atlantic Ocean the volume absorption is twice as great as in the Pacific.) The increased absorption loss means that a 225-Hz source in the Pacific would need to have a source level 15.7 dB greater than a 75-Hz source to achieve the same signal-to-noise ratio at 5000-km (2700 nm) range, other factors being equal. Other factors are not equal, however, in that the higher acoustic frequency suffers more from scattering by small-scale ocean variability, such as internal waves, than the proposed 75-Hz signal. This means that the travel-time precision and signal stability at 5000-km (2700 nm) range and 225 Hz would be substantially degraded compared to that achieved at 75 Hz.

The conclusion is that use of higher-frequency sources is not a technically viable option for 3000–5000 km (1620-2700 nm) transmissions. Furthermore, higher frequency transmissions potentially have increased impacts on toothed whale (odontocetes) species, because those species' hearing sensitivity increases with increasing frequency. Finally, use of higher-frequency sources would not address the long-range propagation issues of interest to the U.S. Navy, which are focused on the use of LF sources to detect and track objects at long range underwater.

The principal advantage of moored autonomous sources is the increased flexibility in siting opportunities. They can be located where the water depth exceeds the depth of the sound channel, and they are not constrained by the logistics of shore-based power cable connections. On the other hand, most moored autonomous source locations would probably be located some distance from shore and would create severe logistics problems for any marine mammal monitoring (e.g., staging facilities for aerial observations). Scheduled maintenance and repair functions on any moored autonomous source, located a great distance from logistic port facilities, would likewise be more costly, time-consuming, and generate more engine hydrocarbon byproducts and noises (from the transiting vessel) than sources located closer to shore. Extensive technological developments are required before autonomous sources with the characteristics of the Kauai source are feasible. Since no existing autonomous sources meet the purposes of the proposed action, this alternative will not be carried forward to be further analyzed. Table 2.1-3 summarizes the advantages and disadvantages of a moored autonomous source.

2.1.6 Alternate Sensors

This alternative analyzes the use of satellite measurements of sea surface temperature (SST) and sea surface height to achieve the program objectives. The discussion below concludes that, while these measurements are fairly accurate for the sea surface, they cannot detect ocean thermal variability in the water column, nor are they a viable option for studying long-range propagation, and therefore would not meet the project objectives. Satellite measurements of ocean variability are not a substitute for acoustic measurements, but rather an important adjunct to them and would be assimilated into computer predictions of ocean variability together with acoustic thermometry data.

Satellite sensors offer a number of methods for determining SST. All of these methods rely upon measuring microwave or infrared energy emitted from the sea surface. Generally speaking, the most accurate measurements are derived from satellite sensors that sample a number of microwave and/or infrared frequencies. Also important are the algorithms for deriving temperatures from the measurements of electromagnetic energy. These capabilities are constantly being improved. Currently, the best SST measurements are accurate to approximately ±0.6°C (±1.35°F), if all available infrared channels are used.

An additional technology for measuring ocean variability is the use of satellite-based measurements of sea level. There are two main reasons why mean sea level rises or falls on long time scales (≥5 years). One is thermal expansion or contraction of a few centimeters in the vertical dimension that is in direct response to changes in the mean temperature of the water itself. The other is the result of variations in the amount of water stored as ice in the polar regions. Over long time scales, the latter is by far the larger of the two effects, and accounts for much of the present extent of "drowned" margins of most continents. Another contributing factor in sea level change is earth crustal movement.

Table 2.1-3 Moored Autonomous Source Advantages and Disadvantages.

Advantages	Disadvantages
• Increased flexibility of siting opportunities. • Would avoid problem of acoustic interaction with the bottom that could influence propagation. • Could potentially be placed in areas of low marine animal activity. • Basic mooring and transponder hardware are fairly reliable. • If successful, cost savings over cabled bottom sources could be realized in some situations	• A battery-operated 75-Hz source assembly designed for moored, autonomous operation must be developed and field tested. • New pressure compensation equipment must be designed, developed and field tested. • New source-driving electronics and amplifiers must be designed, developed and field tested. • No capability to modify source level, duty cycle, or other operational parameters once deployed. • Technical risks considered to be high because this technique is as yet untried, so no data base exists on underwater operational reliability, service life, or maintenance requirements for a 75 Hz autonomous source. • Maintenance and repair would be more difficult and costly than cabled bottom sources closer to land. • If source placement is far from land (in hopes of removing it from as much marine animal activity as possible), it would render any monitoring of marine animals infeasible.

Radar altimeters flown in orbiting satellites can measure sea surface height with an accuracy of a few centimeters, so with sufficient sampling repetition, mean sea level can be derived to within about 2 cm (0.79 in). The current limitation on the resolution of satellite altimeters is the degree to which their orbits are known or can be measured. With improvements in modeling and tracking orbits, their precision will certainly increase.

Unfortunately, satellite sensors do not directly measure oceanic properties below the sea surface. Satellite measurements give surface boundary conditions, but due to the impenetrability of seawater to electromagnetic waves, both microwave and infrared, they do not measure ocean variability at depth. Because the combined use of satellite measurements of sea surface height and acoustic measurements of ocean temperature is an integral part of the proposed project, rather than a substitute for the project, and because satellite measurements do not provide data on the effects of ocean variability on long-range acoustic propagation, satellite sensors alone were not selected as a separate, independent alternative for further analysis.

2.1.7 Modeling

This alternative considers the possibility of using existing computer models to predict ocean variability and its effects on acoustic thermometry and long-range acoustic propagation. This section describes propagation models and their limitations. It concludes that the use of computer models alone cannot meet the project objectives because they can only predict, not measure, actual conditions. This section also explains how the project data would be coordinated with models to verify their assumptions and projections, and to improve their reliability. Since the use of models is an integral part of the proposed project, rather than a substitute for the project, models alone were not selected as a separate, independent alternative for further analysis.

The ability to numerically model ocean variability is at a level of development similar to that of weather prediction several decades ago. Modeling of ocean variability presents a greater challenge than numerical weather prediction for two primary reasons. First, significant changes within the ocean occur on a much smaller spatial scale than changes in the atmosphere. While atmospheric weather fronts can span thousands of kilometers, significant features of the "weather" in the ocean can be much smaller, on the order of 50-100 km (27-54 nm), and are, therefore, more numerous. Thus, much higher spatial resolution is required of ocean models than of their atmospheric counterparts.

Second, in the ocean, there are very few pertinent oceanographic data collected for ground-truthing or validating the models. ATOC data from the Pioneer Seamount source have already been used in conjunction with satellite measurements of sea surface height to test and constrain a computer model of the ocean circulation in the North Pacific (ATOC Consortium, 1998). In the process of doing so, it was learned that previous interpretations of sea surface height variability as being primarily due to ocean temperature changes are inaccurate. The effects of varying ocean salinity and ocean currents on sea surface height also appear to be significant. This result is important because it affects the way in which sea surface height data are used to test and constrain ocean circulation models. This result is also important because it means that satellite altimetry data and acoustic thermometry data are complementary, providing independent information on the ocean structure.

The use of computer models alone to predict ocean variability does not address the project objectives. Therefore, this is not analyzed further as a separate alternative. However, the verification of models would be an integral part of the overall project. Additionally, project measurements could serve as an essential element of future model development.

2.2 ALTERNATIVES ELIMINATED FROM DETAILED STUDY

The evaluation of the seven alternatives to the proposed project was conducted based on a list of criteria needed to meet program objectives, described in detail in Chapter 1. After this analysis, four of the alternatives were eliminated outright and three alternatives – the proposed action, no action, and alternate project site (Midway Island) – will be analyzed in detail, with their potential environmental effects being evaluated in Chapter 4. The following is a summary of the alternatives eliminated from further analysis.

2.2.1 Additionally Restrict Source Transmission Times and Modify Source Operational Characteristics

Restricting source transmissions to seasons when humpback whales are not present would severely reduce the validity of the acoustic thermometry and long-range propagation studies. The transmission schedule of the Proposed Action is the minimum necessary to achieve the objectives of the project, and restricting transmissions would impair the usefulness of the data. Furthermore, the signal characteristics have been designed to minimize potential effects on marine animals. Acoustic reception at the receiving sites has proved to be adequate but not excessive. Therefore, reduction in source transmission time or additional modifications to the source operational characteristics such as source level or transmission length, would not meet the project objectives.

In addition, during the first phase of the ATOC feasibility study, it was demonstrated that the current transmission schedule and source operational characteristics did not significantly affect marine species (Mobley et al., 1999). In the vicinity of the Kauai source, there were no significant changes in the abundance of humpback whales north of Kauai from the control periods when the source was not operating, to the experimental periods when it was.

2.2.2 Moored Autonomous Source

Currently, there are no sources designed for autonomous operation that have the characteristics of the Kauai source. Use of an autonomous source that operates at a higher frequency would not meet the objectives of the either the acoustic thermometry or long-range propagation objectives.

2.2.3 Alternate Sensors

Satellite data would be used in conjunction with the project data to predict ocean variability. Satellite measurements alone do not meet the program objectives since they are restricted to sea surface observations.

2.2.4 Modeling

Computer model results alone would be inconclusive because they are a simplification of the ocean with respect to physical processes. The project's data would be incorporated into computer models as benchmarks for verification and validation, with the goal of improving the model's reliability.

2.3 SUMMARY OF RELATIVE RESPONSE OF ALTERNATIVES TO OBJECTIVES

Three alternatives, including the Preferred Alternative, No Action Alternative, and Alternate Project Site – Midway (the Midway Alternative), are selected for further study. The relative response of the alternatives to the project needs, as described in detail in Chapter 1, are key elements in distinguishing among the alternatives. The information in Table 2.3-l, Relative Response of the Alternatives to Project Objectives, supplies the relative response of the alternatives to the acoustic thermometry, long-range propagation, and marine mammal monitoring research objectives. Each project need is listed, and the capacity of each alternative to meet the need is estimated by acoustic oceanographers associated with the NPAL program with the following scale, where H is highest rating and N is the lowest:

- H (fulfills objective to the greatest extent possible),
- M (fulfills objective moderately),
- L (fulfills objective poorly), and
- N (does not fulfills objective).

Table 2.3-1 Relative Response of the Alternatives to Project Objectives

Criteria	Preferred Alternative	No Action Alternative	Midway Alternative
Acoustic Thermometry			
• Study seasonal and interannual ocean variability associated with phenomena such as El Niño, La Niña, and PDO	H	N	M
• Use acoustic thermometry data in combination with a variety of other data types to test and constrain computer models of the ocean circulation in order to gain a better understanding of ocean variability and the earth's changing climate	H	N	M
• Quantitatively compare and contrast the contributions of the various data types to constraining computer models of the ocean circulation	H	N	M
• Objectively assess the value of acoustic methods for remote sensing of the ocean interior as one component of an integrated ocean observing system for ocean weather and climate	H	N	M
Long-range Propagation			
• Improve understanding of the basic principles of LF, long-range acoustic propagation in the ocean	H	N	M
• Determine the effects of ocean environmental variability on signal stability and coherence	H	N	H
• Study seasonal and annual variations in acoustic conditions in the North Pacific specifically, and acoustic and environmental coupling more generally	H	N	M
• Determine the fundamental limits to acoustic signal processing at long-range imposed by the ocean environment	H	N	M
Marine Mammal Monitoring Studies			
• Advance the understanding of the potential for long-term effects from the acoustic transmissions	H	N	L

Relative response objective: H = Fulfills objective to the greatest extent possible
M = Fulfills objective moderately
L = Fulfills objective poorly
N = Does not fulfill objective

THIS PAGE INTENTIONALLY LEFT BLANK

3 AFFECTED ENVIRONMENT

This chapter provides background information for assessing the potential effects of the proposed action on the physical, biological, social, and economic environments of the proposed Kauai site and alternate Midway Atoll site. It provides the framework within which the environmental impacts of the proposed action can be assessed, and also serves as a reference for the evaluation and comparison of alternative actions.

3.1 PHYSICAL ENVIRONMENT

This section addresses the physical characteristics of the alternate site environments that may affect or be affected by the proposed action. A site description is presented first (Section 3.1.1), followed by an overview of meteorology (Section 3.1.2), physical oceanography (Section 3.1.3), water column characteristics including the existing noise setting (Section 3.1.4), and regional geography and geology (Section 3.1.5). Due to the large-scale influence of many environmental features such as currents and winds in the Hawaiian Archipelago, much of the following discussion applies to both the proposed and alternate sites of Kauai and Midway Atoll.

3.1.1 Site Description

The proposed action (preferred alternative) would take place in Hawaiian waters, with the sound source located 14.8 km (8 nm) north of Haena Point, Kauai, at a depth of 807 m (2648 ft). Water depths in the proposed study area range up to 4400 m (14,400 ft), averaging approximately 2800 m (9200 ft), with the greatest depths in the northwest region. The 100-m (328-ft) depth contour is approximately 2 km (1.1 nm) or less from the coast, with the 1000-m (3281-ft) depth contour ranging from as far as 19 km (10.3 nm) (western section of the study area) to as near as 4 km (2.2 nm) (eastern section) offshore.

The alternate site is located offshore of Midway Atoll, which consists of two principal islands (Sand and Eastern Islands) totaling approximately 1434 acres (5.8 km^2) in surface land area (MMC, 1999). The site lies on a 10-km (5.4-nm) diameter circular coral reef platform in the tropical Pacific. Honolulu lies 2,200 km (1,190 nm) to the east-southeast. Control of the atoll was transferred from the U.S. Navy to the U.S. Fish and Wildlife Service in 1996, and Midway Atoll was designated a National Wildlife Refuge. Although the oceanic region in which Midway Atoll lies is relatively unproductive, life on the atoll itself is abundant, with nearly one million nesting seabirds.

3.1.2 Meteorology

The mid-Pacific region, including the proposed action and Midway Atoll alternate sites, is dominated by tradewinds from the northeast, with wind speeds occasionally reaching 92 km/hr (50 knots [kt]) and more (Amerson and Shelton, 1976). During winter months, storms traveling from west to east across the North Pacific can generate severe winds (e.g., > 119 km/hr [64 kt]) and large swells along the north shore of Kauai, up to 5-7 m (16.4-23.0 ft) high.

3.1.3 Physical Oceanography

Predominant circulation patterns of the upper waters of the Pacific (including Hawaiian waters) include a clockwise gyre in the North Pacific and a counterclockwise one in the South Pacific, with an equatorial current system located in between (Pickard and Emery, 1982). Offshore surface currents in the vicinity of the Kauai site are dominated by the North Pacific Current system, generally driven by the tradewinds, running from east-to-west, with average speeds of 0.5-1.1 km/hr (0.3-0.6 kt) (DMAH/TC, 1993). Nearshore currents in the proximity of the proposed action site are predominantly tidal in very shallow waters, with average speeds of 0.7-1.7 km/hr (0.4-0.9 kt) (NMFS, 1991). Figure 3.1-1 portrays the general current flow among the Hawaiian Islands.

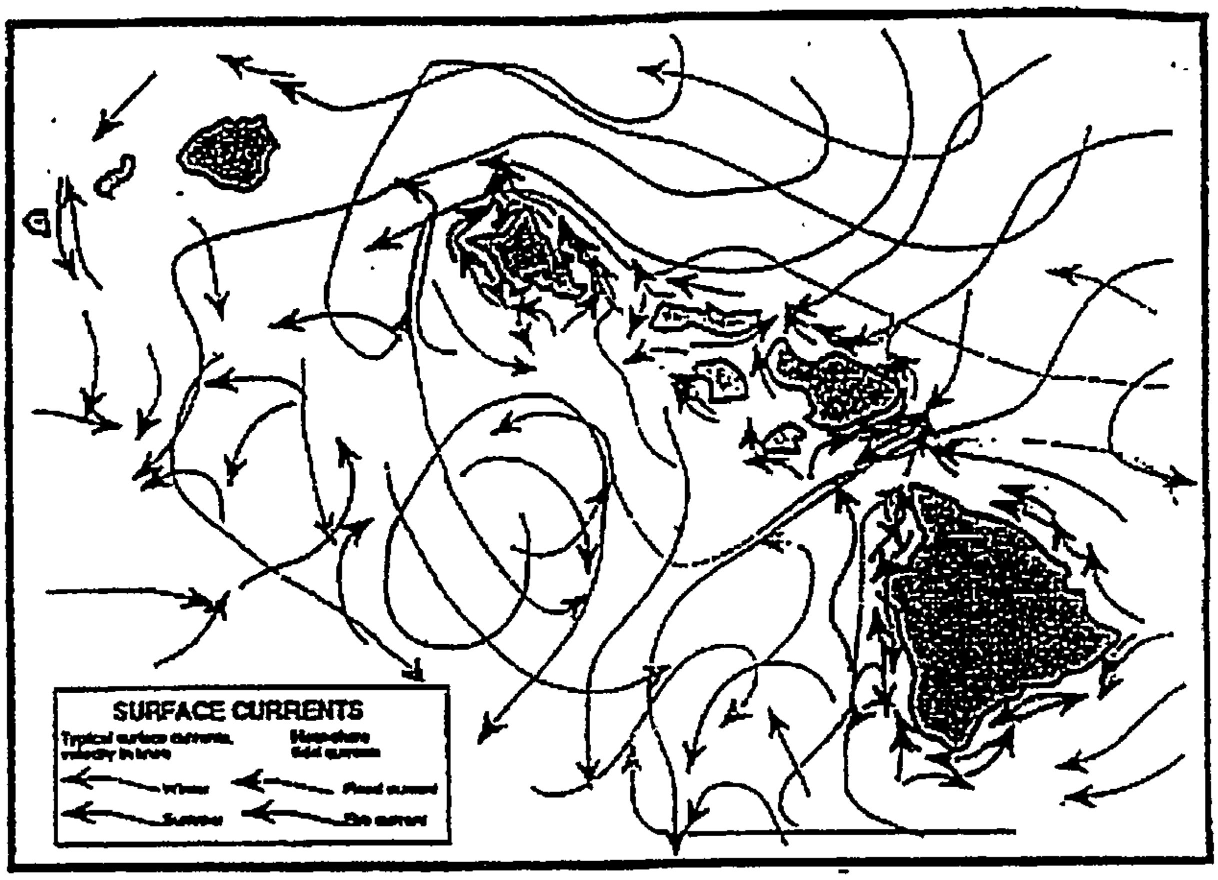
3.1.4 Water Column Characteristics

Water column characteristics of greatest importance to the proposed project are temperature, salinity, ambient noise, and dissolved oxygen (DO). Temperature and salinity are important because they affect the properties of the deep sound channel, representing a key consideration for the acoustic thermometry program and the long-range propagation program. Ambient noise levels are important because they establish the background setting for low frequency sound transmissions. DO is also considered important because it broadly influences the distribution and abundance of many organisms, particularly bottom dwellers within the oxygen minimum zone (OMZ). The proposed action site and the Midway Atoll alternate site are located within the OMZ depth range (200-500 m [656.2-1640.5 ft]) (Pickard and Emery, 1982). Data for other water quality parameters, including light transmittance, pH, and concentrations of trace contaminants (metals, chlorinated and petroleum hydrocarbons, and radionuclides), for the region of both sites are generally lacking. However, it is highly unlikely that the proposed action would have any demonstrable effect on, or be affected by, these parameters (see Chapter 4).

3.1.4.1 Temperature-Salinity Properties

In both study areas, typical temperature versus depth profiles during summer are expected to consist of a surface layer of nearly constant temperature tens of meters (tens to hundreds of feet) thick. Beneath the surface mixed layer is a region of rapidly changing temperatures referred to as the thermocline. Below the thermocline, the water temperature changes gradually with depth, becoming nearly constant again. The depth of the surface layer and the degree of vertical temperature and salinity (density) stratification vary depending on the characteristics and extent of mixing of the various water masses. Surface temperatures in the vicinity of Kauai average 23°C (73.4°F) throughout most of the year (Winn et al., 1993). Temperatures between the surface and 400-m (1310-ft) depth range from 23-10°C (73.4-50°F), decreasing to approximately 5°C (41°F) at 700 m (2300 ft) depth (Winn et al., 1993).

Surface temperatures at Midway Atoll range from 20°C (68°F) to 26°C (78.8°F), and the main thermocline has an average depth of 400-450 m (1312-1477 ft) (Juvik and Juvik, 1998). Below 400 m (1310 ft), water temperatures decrease slowly to approximately 2°C (35.6°F) at 2000 m



(from NOAA, 1994)

Figure 3.1-1 General Current flow among Hawaiian Islands

(6560 ft). Water salinity within 100-m (328.1-ft) depth ranges between 34.6 and 34.8 parts per thousand (ppt), with slightly higher values (slightly >35 ppt) between 100 and 200-m (328 and 656-ft) depth. At 500-m (1640-ft) depth, salinity reaches a minimum value of 34.2 ppt and increases slowly toward 34.7 ppt near the bottom (Juvik and Juvik, 1998).

3.1.4.2 Dissolved Oxygen

DO concentrations are important because they can affect the diversity and abundance of marine organisms. Common features of the DO profiles for 12°N Latitude in the North Pacific are high values (e.g., 4-5 mL/L) close to the surface, a minimum value (e.g., 0-1 mL/L) between 400-500 m (1312.4-1640.5 ft), and higher, but still relatively low values at deeper depths (> 2000 m [6562 ft]). Although there are no site-specific information available for DO levels off Kauai or Midway Atoll, the values there are likely to follow similar trends.

3.1.4.3 Existing Noise Setting

Ambient noise is the existing background noise of the environment (Greene, 1991). The following comprise common sources of ambient noise for the study area:

- Tidal currents and waves;
- Wind and rain over the water surface;
- Water turbulence and infrasonic (extremely low frequency) noise;
- Biological sources; and
- Human-made sounds (ships, boats, low-flying aircraft).

The ambient noise levels from natural sources are expected to vary according to numerous factors, including wind and sea conditions, seasonal biological cycles, and other physical conditions. Noise levels in the project source frequency band can reach 107 dB from natural sounds alone (Figure 2.1-8) (Heindsman et al., 1955).

Noise associated with human sources varies with the characteristics of the specific noise source as well as the distance between the source and the alternate sites. The primary human-made noise source within the study area is expected to be associated with ship and vessel traffic. This includes commercial tankers and container ships transiting to and from ports along the Pacific Rim and the west coast of North America, commercial fishing boats and research vessels, military surface vessels, submarines, and aircraft. Vessel noise is primarily associated with the propeller and propulsion machinery. In general, noise levels increase with vessel size, speed, and load. The following indicate estimated upper bounds of broadband noise levels generally within the low frequency band (<1000 Hz) (Urick, 1983; Natural Resources Defense Council, 1994, 1999):

- Super Tankers (approximately 127 at sea at any time) 187-232 dB
- Freighters, bulk carriers, large tankers (approximately 23,000 at sea at any time) 185-200 dB
- Tankers, merchant ships (approximately 100,000 at sea at any time) 155-190 dB
- Medium-small motor-powered vessels, including fishing boats (hundreds of thousands at sea at any time) 150-160 dB

Noise associated with the passage of vessels and low-flying aircraft is expected to be transient in nature because the sound source typically is moving through the study area. Based on information contained in the Historical Shipping (HiTS) database, the eastern Pacific major tanker shipping lanes have been defined. The average density of vessels (ships per one square degree) at any time in the vicinity of the proposed action site is:

- Merchant Ships: 0.1 to 0.3;
- Tankers: 0.05 to 0.18;
- Large Tankers: 0.003 to 0.005; and
- Super Tankers: 0.002 to 0.003.

These densities are based on data between April and August over recent years. The monthly variability in ship densities among the Hawaiian Islands does not change appreciably (i.e., approximately 20-30%).

In 1987, at least 21,325 vessels called at Hawaiian ports, most of which fall in the categories of commercial fishing boats, tanker/merchant, freighter/large tanker, or super tanker. Based on these data, an average of one vessel would be expected to enter or leave a port in Hawaii every 30 minutes. Thus, a relatively high level of ship traffic can be expected in the vicinity of the study area. The inclusion of military, recreational fishing, and other medium-small size vessels can increase transient noise received levels in the study area to 140 dB and higher in the frequency band of the project source. Vessel movements near the Midway Atoll alternate site are as much as 90% less than in the Hawaiian Islands, with a proportionate decrease in ambient noise levels attributable to such sources.

Ambient noise was measured during the 1996 and 1997-1998 Kauai MMRP research seasons (January through April). The 25th percentile ambient noise level in the 60-90 Hz (ATOC) band was 105 dB re 1 µPa (Frankel and Clark, 1998). This value was measured while singing humpback whales were present, and they appear to have raised the ambient noise level, even though samples with very loud whales were excluded from the analysis. A similar measurement, conducted during the fall of 1997 off Kauai, found that the mean ambient noise level, before whales arrived, was 96 dB re 1 µPa (Frankel and Clark, 2000). 3-1

The sound frequency and ranging (SOFAR) channel (deep sound channel) corresponds to the depth range in which the speed of sound is at a minimum. At depths shallower and deeper than the SOFAR channel, the speed of sound is relatively greater than the channel due to higher temperatures above and relatively greater pressure below. Because the properties of the channel are related to the temperature structure of the water column, the depth of the SOFAR channel varies with location. In the vicinity of the proposed action and Midway Atoll sites, the SOFAR channel occurs at depths between approximately 800 and 1000 m (2625 and 3281 ft).

3.1.5 Regional Geography and Geology

Important regional geography and geology features include seismicity and bottom topography; presence and location of large geologic structures such as submarine canyons and seamounts; and bottom conditions. The physical and chemical conditions of the sediments, including concentrations of major and trace constituents near the proposed action and alternate sites, are not expected to affect or be affected by the proposed action (see Chapter 4).

3.1.5.1 Regional Subsea Geography

The primary divisions of the seafloor are the shore, island shelf, island slope, island rise, and deep-sea bottom. The shallow, inshore areas (<25 m [82 ft] depth) at the Kauai site are comprised of a massive reef with outcrops of beachrock that extend seaward for nearly 1 km (0.54 nm). The main offshore reef, which is comprised of coral rubble and coarse sand extends offshore in depths between 25 and 30 m (82 and 98 ft) (SSI, 1993). Seaward of the coral rubble, large sand ripples extend offshore for nearly 2200 m (7218 ft) at water depths between 30 and 45 m (98 and 148 ft). The exposed reef (between 45 and 67 m [148 and 220 ft] depth) is dissected by frequent surge channels. On the steep shallow slope area (the outer reef between 85 and 215 m [279 and 705 ft] depth), the heads of numerous debris flow channels, canyons, and major submarine slumps are found around the island. Midway is a nearly circular atoll, 10 km (5.4 nm) in diameter, composed of two large and several small islands. It encloses an 8-km (4.3-nm) lagoon. Sand Island is 2.7 km long (1.5 nm) and 13 m (42.7 ft) high. Eastern Island is 1.9 km (1.0 nm) long and 4 m (13.1 ft) high. Both are composed of calcareous sand. The reef forms a nearly continuous wall, except for a break toward the northwest.

3.1.5.2 Seismic Activity

Seismic activity in the Hawaiian Islands is concentrated in the vicinity of the active volcanoes on the island of Hawaii (SSI, 1993). Some earthquakes are related to tectonic subsidence of the islands, with most of this activity also surrounding the island of Hawaii. Generally, seismic activity in the vicinity of both Kauai and Midway Atoll sites is expected to be minimal.

3.1.5.3 Bottom Conditions

The sea bottom at the Kauai site is composed of mixed sand, coral, and basalt throughout. Coral and sand predominates in shallow, near-shore waters of less than 100-m (328-ft) depth. In water depths ranging between 45 and 67 m (148 and 220 ft), the exposed reef is dissected by large sand-bottom surge channels. Erosion-based basaltic sediments are found as water depth increases, with large sand ripples on the western edge of the shelf off Kauai (SSI, 1993).

Midway is a circular atoll, surrounding a sand-bottom lagoon. The outer reef rock rises up to a meter (3.3 ft) above water in some places. Outside the exposed reef, the reefs are composed of coralline algae, coral, and mixed sand, while sandy bottom begins to predominate beyond the outer reef and into the island shelf and slope areas.

3.2 BIOLOGICAL ENVIRONMENT

This section describes the biological environment in the general regions of the proposed action and alternate sites, depending on data availability. The rationale for the selection of marine species to be analyzed for potential effects by the proposed action is discussed.

3.2.1 Species Screening

In order for an animal to be affected by the proposed sound source, the animal must possess (1) some sensory mechanism that allows it to perceive LF sounds or (2) tissue with sufficient acoustic impedance mismatch to be affected by LF sounds. An acoustic impedance mismatch results when two dissimilar media (e.g., seawater and an air-filled cavity) exist side-by-side. The acoustic energy exiting from one medium must be transferred to the other medium. Since the media are dissimilar, the particles in the two media vibrate differently with the same amount of acoustic energy. The difference in the vibrations of these two media may stress or damage any connective tissues or barriers between the two media (Ketten, 1998).

Based on these considerations, a detailed analysis of only those organisms in the proposed or alternate site areas that meet the following criteria was undertaken in this document:

- Does the area receiving sound from the proposed sound source overlap the distribution of this species? If so,

- Are acoustic impedance mismatches large enough to enable LF sound to stress or damage any tissues? 3-2

- Can the species sense LF sound?

Species that did not meet these criteria were excluded from consideration. For example, jellyfish and zooplankton species have no sensory perception mechanism to detect low frequencies (the sound pulse essentially would pass through them without being detected). Therefore, they did not have the potential to be physically affected and so were not evaluated for impacts.

In cases where direct evidence of acoustic sensitivity was 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.

3.2.1.1 Invertebrates

Several invertebrate groups can be 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 LF range used by the sound source. These include plankton, phytoplankton, zooplankton, ichthyoplankton, benthic infauna, demersal epifauna (corals, molluscs, barnacles), and echinoderms (urchins, sea stars, sea cucumbers). Siphonophores and some other jelly plankton do have air-filled bladders, but because of their size, they do not have a resonance frequency sensitive to the low frequencies used.

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'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 (Offutt, 1970). Given these high levels of hearing thresholds, operations of the sound source would not impact on these animals. Therefore, cephalopods and decapods have been eliminated from further consideration because of their poor LF hearing sensitivity.

3.2.1.2 Vertebrates

Vertebrates, especially those species whose bodies contain air-filled cavities (e.g., lungs or sinuses), offer a high acoustic impedance contrast with water, hence are potentially susceptible to the operation of the sound source. In addition, all vertebrates have specialized organs for hearing.

Baleen Whales (Mysticetes)

All 11 species of baleen whales produce LF sounds (summarized in Richardson et al., 1995). Sounds may be used as contact calls, for mating displays, for maintaining the cohesion of the migratory herd, 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 low frequency hearing (Ketten, 1998). 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 seven species of mysticetes, or baleen whales, are known to be frequently or infrequently found in the Kauai and/or Midway Atoll areas. This includes the humpback (*Megaptera novaeangliae*), fin (*Balaenoptera physalus*), blue (*Balaenoptera musculus*), northern right (*Eubalaena glacialis*), sei (*Balaenoptera borealis*), Bryde's (*Balaenoptera borealis*), and minke (*Balaenoptera acutorostrata*) whales. 3-3

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. Odontocetes include dolphins, porpoises, beaked whales, blackfish (long-finned pilot, pygmy killer, false killer, melon-headed, short-finned pilot), killer whales, and sperm whales. Sixteen of these species may potentially inhabit ocean areas where the sound source might operate -- especially several species of pelagic dolphins, beaked whales, sperm whales, and blackfish. Many of these species are known to use high frequency clicks for echolocation (Au, 1993). All 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 (Au, 1993). Like mysticetes, odontocetes depend on acoustic perception and production for communication, food finding, and probably for navigation and orientation.

Pinnipeds

Only one species of pinnipeds are known to inhabit the Hawaiian Islands and Midway Atoll, the Hawaiian monk seal (*Monachus schauinslandi)*. The exact hearing ability of the Hawaiian monk seal is not known, but studies on other phocid species (harbor seal and northern elephant seal) show a generally increasing sensitivity from lower to higher frequencies, with underwater sound detection thresholds of 101.9 dB and 98.3 dB re 1 μPa, respectively (Kastak and Schusterman, 1998).

Sea Turtles

There are seven species of marine turtles. Five of these species are potentially found in the area of Kauai and Midway Atoll. These include the green (*Chelonia mydas*), loggerhead (*Caretta caretta*), hawksbill (*Eretmochelys imbricata*), olive ridley (*Lepidochelys olivacea*), and leatherback (*Dermochelys coriacea)*. It is likely that all species hear LF sound as adults (Ridgway et al., 1969; O'Hara and Wilcox, 1990). Therefore, these five species of sea turtles are considered for evaluation.

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. There are no known fish species that are deaf. Of those studied, many fishes produce vocalizations in the low frequency 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).

Seabirds

There are more than 270 species of seabirds in five orders. There are few data on hearing in seabirds and even less on underwater hearing. Studies with other species have shown that birds are highly 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 are known to occur in the area of the sound source are generally shallow divers (less than 20 m [66 ft]). In addition, seabirds spend a very small fraction of their time submerged, and they can rapidly disperse to other areas if disturbed. Details of the seabirds in the areas of Kauai and Midway Atoll are discussed in Section 3.2.5. However, because these birds are all shallow divers, there should be negligible potential for impact to them, including those that may be listed as threatened, endangered, or special status. For these reasons, seabirds have been excluded from further evaluation.

3.2.2 Marine Mammals

This section provides information on marine mammals residing in, or passing through, the study region. Twenty four marine mammal species, including seven baleen whales (mysticetes), sixteen toothed whales (odontocetes), and one pinniped, may reside permanently or occur seasonally to rarely within the region (Table 3.2-1). 3-4

Mysticete and odontocete sightings within 35 km (18.9 nm) of the Kauai site during the Marine Mammal Research Program (MMRP) aerial surveys are presented in Table 3.2-1. Results of these aerial surveys indicate that humpback whales are one of the most abundant marine mammals in the study area, with a total of 2773 individuals being sighted. A total of 2445 spinner and spotted dolphin (*Stenella* spp.) were recorded, as well as 774 short-finned pilot whales. Observational data were collected from two shore stations in 1994, the Albatross (SS1) at Princeville (47 m [154.2 ft] height), and the Kalalau (SS2) on the Kalalau Trail (140 m [459.3 ft] height). At SS1, 319 humpback pods, totaling over 500 individuals were observed. At SS2, 382 humpback pods, totaling nearly 700 individuals were recorded. Data on marine mammal sightings off Midway Atoll are limited. Because recent surveys have not been conducted in the vicinity of Midway Atoll, most of the occurrences have been historical observations. Humpback whales have not been reported near Midway, although they are seen near the main Hawaiian Islands.

3.2.2.1 Mysticetes

Seven species of baleen whale (humpback, fin, blue, right, sei, Bryde's, and minke) may occur in the Kauai or Midway Atoll area. However, only one, the humpback, is known to be present historically in reasonably large numbers. Humpback whales (*Megaptera novaeangliae*) are abundant in coastal waters of the main Hawaiian Islands from November through April, but have not been reported near Midway Atoll. Fin whales (*Balaenoptera physalus*) and blue whales (*B. musculus*) could possibly occur in the area; however, their distribution and abundance in the region is believed to be uncommon (Balcomb, 1987). Right whales (*Eubalaena glacialis*) and sei whales (*B. borealis*) occur rarely in the Hawaiian Islands area (Herman et al., 1980). Bryde's whales are occasionally seen in the northwest Hawaiian Islands (which includes Midway Atoll) (Leatherwood et al., 1988). Minke whales are sometimes seen around the leeward islands of Hawaii (Leatherwood et al., 1988). 3-5

Table 3.2-1 Marine Mammals Sighted During 1993-1998 Hawaii Statewide Aerial Surveys (Mobley et al., 1999b)

SPECIES	NUMBER OF SIGHTINGS	NUMBER OF ANIMALS	NUMBER OF ANIMALS PER NM[1]	COMMENTS
MYSTICETES				
Humpback whale (*Megaptera novaeangliae*)	1678	2773	0.1028	Note 2
Blue whale (*Balaenoptera musculus*)	0	0	0	
Fin whale (*B. physalus*)	1	3	0.0001	Note 3
Right whale (*Eubalaena glacialis*)	0	0	0	
Bryde's whale (*B. borealis*)	0	0	0	Note 4
Minke whale (*B. acutorostrata*)	0	0	0	Note 4
ODONTOCETES				
Sperm whale (*Physeter macrocephalus*)	21	100	0.0037	
Pygmy or dwarf sperm whale (*Kogia* spp.)	2	5	0.0002	
Spinner/spotted dolphin (*Stenella spp.*)	73	2445	0.0907	
Bottlenose dolphin (*Tursiops truncatus/gilli*)	49	338	0.0125	
Rough-toothed dolphin (*Steno bredanensis*)	8	136	0.0050	
Striped dolphin (*Stenella coeruleoalba*)	2	76	0.0028	
Killer whale (*Orcinus orca*)	0	0	0	Note 5
False killer whale (*Pseudorca crassidens*)	21	324	0.0120	
Pygmy killer whale (*Feresa attenuate*)	0	0	0	Note 6
Short-finned pilot whale (*Globicephala macrorhynchus*)	73	774	0.0287	
Beaked whales (*Ziphius cavirostris, Berardius bairdi, Mesoplodon spp.*)	14	29	0.0011	
Melon-headed whale (*Peponocephala electra*)	3	127	0.0047	Note 7
Risso's dolphin (*Grampus griseus*)	2	13	0.0005	
PINNIPEDS				
Monk seal (*Monachus schauinslandi*)	1	1	0.0000	Note 8
SEA TURTLES				
Loggerhead (*Caretta caretta*)	0	0	0	Note 9
Green (*Chelonia mydas*)	19	23	0.0009	Note 10
Olive ridley (*Lepidochelys olivacea*)	0	0	0	Note 11
Leatherback (*Dermochelys*)	0	0	0	Note 12
Hawksbill (*Eretmochelys impricata*)	0	0	0	Note 13

Notes (following page) in many cases indicate best estimate of stock when few or no animals were sighted during 1993 and 1994 aerial surveys.

Note 1: Estimates determined by dividing the number of animals by total effort (26,966 nm) (Mobley et al., 1999b).

Note 2: 64% of humpbacks sighted during 1993-1998 surveys were in water shallower than 183 m (600 ft) (Mobley et al., 1999b).

Note 3: Single fin whale sighting 2/26/94, 37 km off the northwest shore of Kauai (Mobley et al., 1994).

Note 4: Bryde's and minke whales may be occasionally present in the area of Midway Atoll but are not usually found off Kauai.

Note 5: Although reported from tropical and offshore waters, killer whales are more commonly found in colder waters, typically within 800 km of major continents (Leatherwood and Reeves, 1983).

Note 6: Widely distributed in the tropical Pacific, however, not described as abundant in any area (Leatherwood and Reeves, 1983).

Note 7: Distributed worldwide in tropical and subtropical waters, however, only abundant in the Philippine Sea; everywhere else appears to be rare (Leatherwood and Reeves, 1983).

Note 8: No monk seals sighted during aerial surveys. Single opportunistic sighting within the 200 m depth contour occurred during 1994 shore observation period (1/30-4/15/94) (Smultea et al., 1994).

Note 9: Among the only central Pacific sightings of loggerheads are from Hawaii; four records from 1979-1992 (NMFS and USFWS, 1998d).

Note 10: Listed as unidentified sea turtles from aerial surveys; however, assumed green turtles based on size and location close to shore (all in <100 m (328 ft) depth). 1994 shore observations yielded 78 sightings of (presumed) green turtles, all inside the 200-m (656-ft) depth contour. Because green sea turtle habitat is primarily in nearshore benthic areas, calculating density based on total area surveyed is not applicable.

Note 11: Olive ridley sea turtles are rare throughout the islands of Oceania. In the central Pacific, a single nesting was reported in 1985 on Maui (Balazs and Hau, 1986).

Note 12: Nesting apparently does not occur in Hawaii. Leatherback turtles are regularly sighted in offshore waters (> 1000 m (3281 ft) deep) at the southeastern end of the Hawaiian Archipelago NMFS and USFWS, 1998c).

Note 13: In the Hawaiian Islands, the hawksbill is presently a rare species that is thought to be in immediate danger of local extinction; only known to occur in southern portion of Hawaiian Island chain, mainly in coastal areas of Hawaii, Molokai, and Oahu (19 deg N – 22 deg N). More northerly regions of the chain (22 deg N – 29 deg N) appear to be unsuitable habitats for hawksbill residency and reproduction (NMFS and USFWS, 1998b).

A summary of the frequency range of sounds produced by mysticetes is included as Figure 3.2-1 (Frequency Range of Sounds Produced by Mysticetes). Au et al. (2000) provide a summary of what is known about hearing by mysticetes. No direct data on the underwater hearing range or sensitivity of mysticetes is available. Functional models based on anatomical data indicate that the functional hearing range for mysticetes commonly extends to 20 Hz, with several species expected to hear well into infrasonic frequencies (Ketten, 1998) (Figure 3.2-2). The upper functional range for most mysticetes has been predicted to extend to 20-30 kHz. The playback of biologically meaningful sounds (song, social sounds, and feeding call) to humpback whales estimated a response threshold at broadband received levels of 102 dB re 1 μPa for the feeding call, and 106 dB re 1 μPa for synthetic sound (Frankel et al., 1995).

3-6

The composite audiogram shown in Figure 3.2-2 (Marine Mammal Audiograms) illustrates that the best scientific data suggests that mysticetes have the most sensitive LF hearing of all marine mammals.

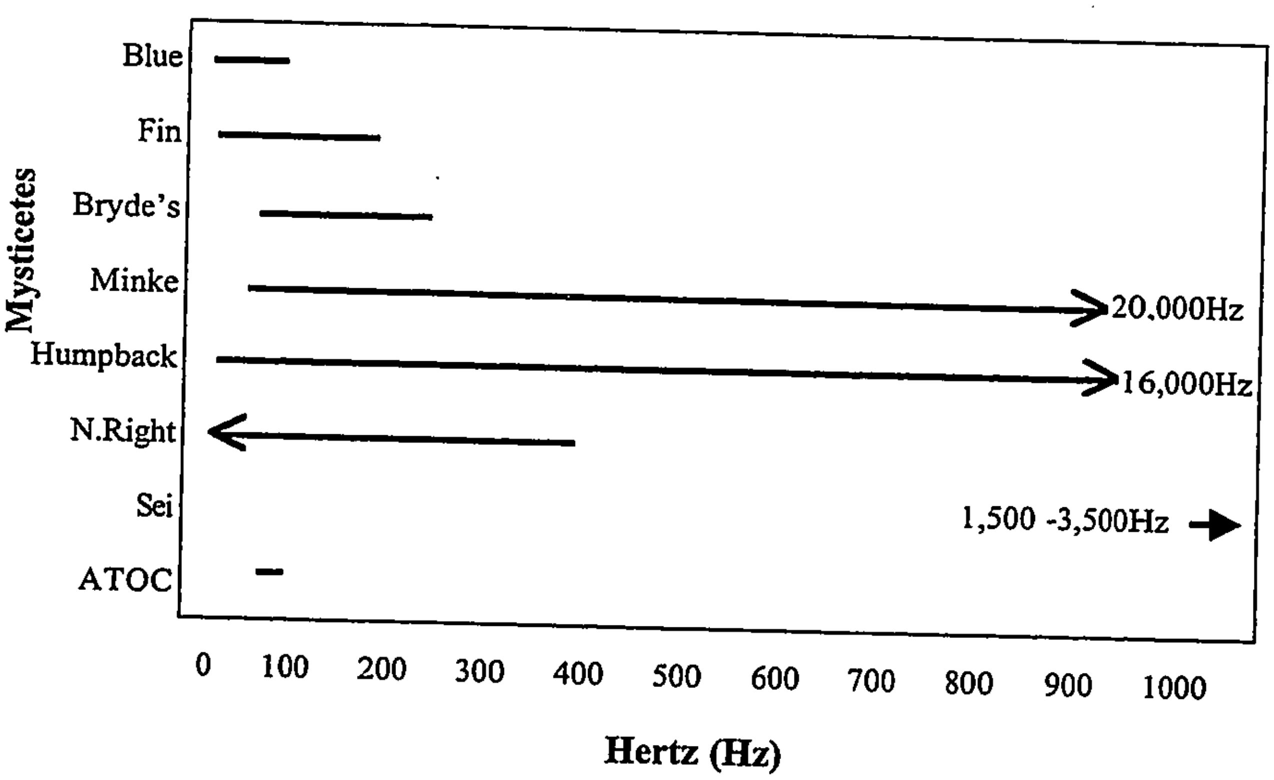


Figure 3.2-1 Frequency Range of Sounds Produced by Mysticetes

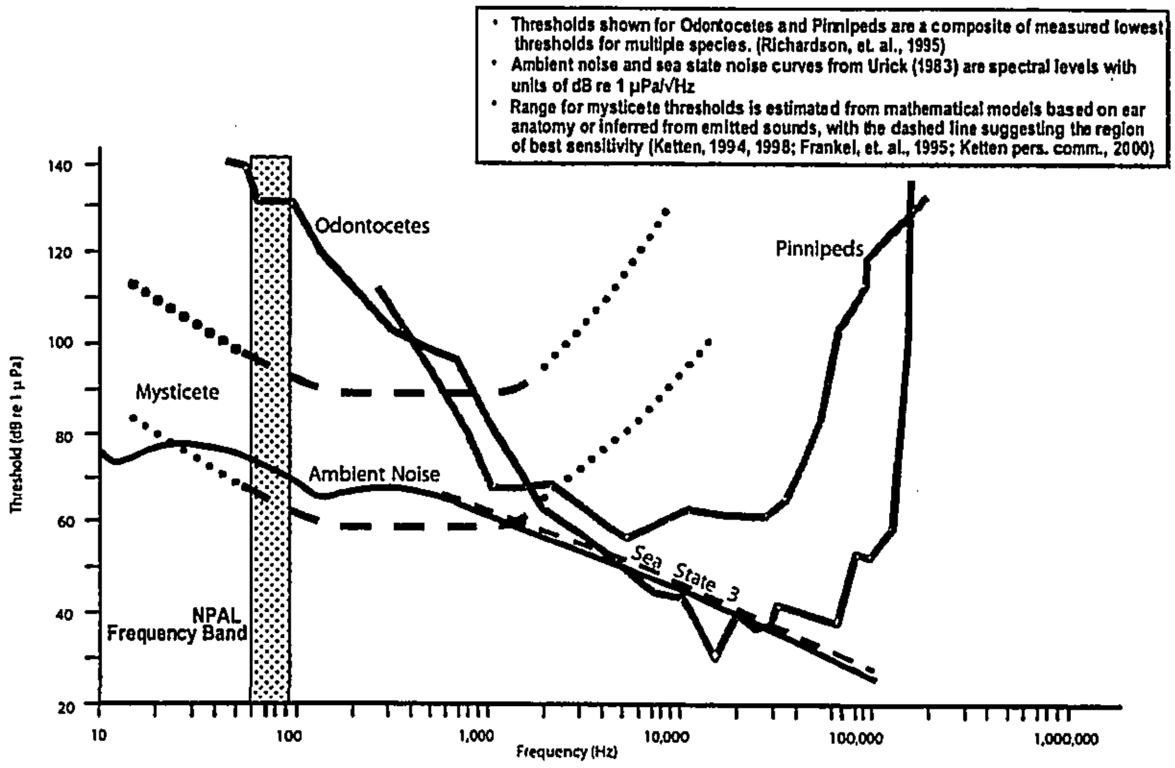


Figure 3.2-2 Marine Mammal Audiograms

Humpback Whales

Humpback whales occur worldwide in both coastal and open ocean areas, with estimated abundances of approximately 6,000 in the North Pacific (Calambokidis et al., 1997; Cerchio, 1998; Mobley et al., 1999c). Estimates of the number of individuals in the Northern Pacific stock have recently risen. Estimates in the 1980's ranged from 1407 to 2,100 (Baker, 1985; Darling and Morowitz, 1986; Baker and Herman, 1987). Photographic resight studies estimate 6,010 animals (S.E. = 474) for the entire North Pacific (Calambokidis et al., 1997). Cerchio (1998) estimated that about 4,000 animals visit Hawaii annually. Aerial surveys conducted between 1976 and 1990 found a significant increase in sighting rates of humpbacks over that time (Mobley et al., 1999a), consistent with the increase in photographic estimates. Finally, aerial survey data using line-transect methodologies were conducted in 1993, 1995 and 1998. Hawaiian population estimates derived from the sighting data in Table 3.2-1 show an increase from 2717 (+/- 608) in 1993, to 3284 (+/- 646) in 1995 and 3852 (+/- 777) in 1998 (Mobley et al., 1999b).

Humpback whales typically migrate between tropical/sub-tropical and temperate/polar latitudes. The whales occupy tropical areas during winter months when they are breeding and calving, and polar areas during the spring, summer, and fall, feeding primarily on small schooling fish and krill (Caldwell and Caldwell, 1983). It is believed that minimal feeding occurs in wintering grounds, such as the Hawaiian Islands (Balcomb, 1987; Salden, 1987). Maximum diving depths for humpbacks are approximately 150 m (492 ft) (but usually <60 m [197 ft]), with a very deep dive (240 m [787 ft]) recorded off Bermuda (Hamilton et al., 1997). They may remain submerged for up to 21 min (Dolphin, 1987). Humpback whales are endangered under the Endangered Species Act (ESA) and protected under the Convention on International Trade in Endangered Species (CITES).

Three sounds are produced by humpback whales: "songs" produced in late fall, winter, and spring by single animals; sounds produced by groups of humpback whales (possibly associated with aggressive behavior among males) on the winter breeding grounds; and sounds produced on the summer feeding grounds. The frequencies of these songs range from 40 Hz or lower, up to 4 kHz, with components of up to 8 kHz (Thompson et al., 1979). Source levels average 155 dB and range from 144 to 174 dB (Thompson et al., 1979). The songs appear to have an effective range of approximately 10 to 20 km. Sounds often associated with possible aggressive behavior by males (Tyack, 1983; Silber, 1986) are quite different from songs, extending from 50 Hz to 10 kHz (or higher), with most energy in components below 3 kHz. These sounds appear to have an effective range of up to 9 km (Tyack and Whitehead, 1983). Sounds are produced less frequently on the summer feeding grounds and are at approximately 20-2000 Hz, with median durations of 0.2-0.8 sec and source levels of 175-192 dB (Thompson et al., 1986).

Humpback whales occur off all eight Hawaiian Islands, but particularly within the shallow waters of the "four-island" region (Kaho'olawe, Molokai, Lanai, Maui), the northwestern coast of the Big Island, and the waters around Niihau, Kauai and Oahu (Wolman and Jurasz, 1977; Herman et al., 1980; Baker and Herman, 1981). The largest concentrations of humpbacks in Hawaiian waters can be found on Penguin Bank west of Molokai (Balcomb, 1987). The whales are generally found in shallow water shoreward of the 100-fathom (fm) (183-m [600-ft]) depth contour (Herman and Antinoja, 1977), although Frankel et al. (1989) reported some vocalizing individuals up to 20 km (10.8 nm) off South Kohala on the west coast of the Big Island, over bottom depths of 1400 m (4593 ft). Cow/calf pairs appear to prefer very shallow water less than 18 m (10 fm [60 ft]) Glockner and Venus, 1983). At Kuili off the Big Island, Smultea (1989) found significantly more cow/calf pairs in water <55 m (180.5 ft) deep. Some results suggest that habitat use patterns of nearshore waters by females and calves near Maui may have changed (decreased), potentially due to increasing vessel and other human activities (Salden, 1988; Glockner-Ferrari and Ferrari, 1990). Figure 3.2-3 depicts the locations of humpback whale sightings during the 1993-1998 MMRP aerial surveys (Mobley et al., 1999b). 3-7

Humpback calves are found most often in the "four-island" region, consisting of Maui, Molokai, Lanai, and Kahoolawe. Statewide aerial surveys conducted between 1993 and 1998 found that 67% of the calves were found in that area (Mobley et al., 1999b). During those surveys, 26,966 nautical miles (49,941 km) of effort were flown and 1,678 pods of humpbacks were seen. Approximately 16% of the calves were seen off Kauai. During shore-based scan samples conducted from Princeville, Kauai, on the north shore in 1994 and 1998, 571 pods were sighted, 17 of which had calves (Frankel, pers. comm.).

Humpback whales are rarely, if ever, seen near Midway Atoll, and it is not thought to support breeding or feeding of this species; thus, the potential for visits to the atoll by humpbacks is low.

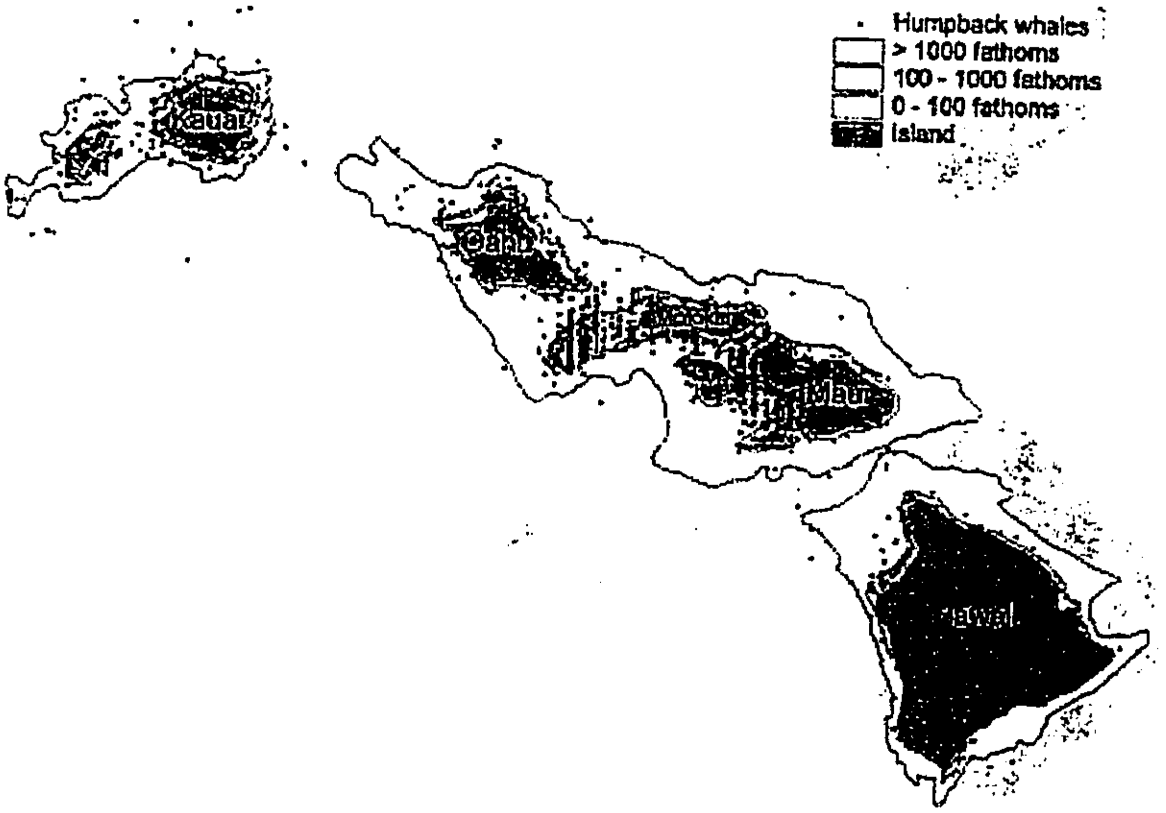


Figure 3.2-3 1993-1998 Sightings of Humpback Whales (Mobley et al., 1999b) 3-8

Fin Whales

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; US Department of Commerce, 1983). They are currently endangered under the ESA and protected under CITES.

Fin whales feed primarily upon planktonic crustaceans, but also take fish and squid (Gambell, 1985; 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, 1985; 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). Dive depths and duration were significantly shorter at night than during the day, presumably in response to the daily vertical migrations of prey schools. An estimate of dive depth based on the acoustical properties of received fin whale calls was 525 m (1722 ft) (Charif et al., submitted). 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).

It is assumed that distribution and movement patterns consist of seasonal migrations between higher latitudes for foraging and lower latitudes for mating and calving (Lockyer, 1984, Mackintosh, 1965). 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 kilometers per hour (km/hr) (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 commonly travel in herds ranging from between 6-12 individuals, to nearly 100 or more (Balcomb, 1987).

Fin whales produce a variety of low frequency 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.; McDonald, pers. comm.; 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 (1994) hypothesized that the fin whale has excellent LF hearing.

Fin whales, while uncommon in tropical waters, may occur within 200 nm (370 km) of Hawaii during winter months, when they disperse throughout the lowest latitudes of their distribution (Balcomb, 1987). A single fin whale sighting occurred approximately 37 km (20 nm) north of Kauai in 1994 (Mobley et al., 1996). No fin whales have been observed near Midway Atoll.

Blue Whales

The blue whale occurs in all oceans of the world. 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 U.S. Department of Commerce, 1983; Maser et al., 1981) 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.

Blue whales grow to lengths of more than 30 m (98.4 ft). 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 km/hr (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 (Lockyer, 1984; Mackintosh, 1965). More recent data indicate that some summer feeding takes 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 km/hr (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). 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 dB (Cummings and Thompson, 1971). 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.). 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 (1994) hypothesized that the blue whale has excellent LF hearing.

Blue whales have never been observed in the Hawaiian archipelago; however, their range could overlap the study area. The range of blue whales also overlaps the Midway Atoll region; however, none have been reported near this site.

Northern Right Whales

Northern right whales occur in both the Atlantic and Pacific oceans. The Northern Pacific population is estimated at 100 animals, making the northern right whale 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 and protected under CITES.

Right whales feed primarily on copepods but sometimes feed 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 northern right whale 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 US, 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 km/hr (0.5-1.9 kt); average speeds in breeding areas ranged from 0-4 km/hr (0-2.2 kt) (Mate et al., 1997).

Maximum source levels for right whale calls have been estimated at 172-187 dB (Cummings et al., 1972; Clark, 1982). Northern right whales 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 the auditory mechanics, Ketten (1994) hypothesized that right whales have excellent LF hearing.

Right whales can be found in nearshore habitats and bays from the Bering Sea to central Baja California. A single right whale was observed in 1979 near Maui (Herman et al., 1980). Right whales are typically observed in temperate and subpolar waters. It is highly unlikely that this species occurs within the Kauai study area. No right whales have ever been reported in the vicinity of Midway Atoll.

Sei Whales

Sei whales are distributed in all of the world's oceans, except the Arctic Ocean. The IWC's Scientific Committee groups all of the sei whales in the entire North Pacific Ocean into one stock (Donovan, 1991). However, some mark-recapture, catch distribution, and morphological research indicates that more than one stock exists; one west of 175°W longitude, one between 175°W and 155°W longitude, and another east of 155°W longitude (Masaki, 1977). Sei whales are typically distributed far out to sea in temperate regions of the world and do not appear to be associated with coastal features (Forney et al., 2000). In the North Pacific Ocean, sei whales have been reported primarily south of the Aleutian Islands, in Shelikof Strait and waters surrounding Kodiak Island, in the Gulf of Alaska, and inside waters of southeast Alaska (Leatherwood et al., 1983). Within the U.S. EEZ, there is a significant lack of information regarding the distribution of sei whales in the eastern north Pacific (see Perry et al., 1999). No sei whales were sighted in the vicinity of the main Hawaiian islands during the ATOC MMRP aerial surveys (Mobley et al., 1999b). In California waters, only one confirmed and five possible sei whale sightings were recorded during 1991, 1992, 1993, and 1996 aerial and ship surveys (Forney et al., 2000). No sightings were confirmed off Washington and Oregon during recent aerial surveys. Sei whales are endangered under ESA and protected under CITES. 3-9

Reproductive activities for sei whales occur primarily in winter. Gestation is about 12.7 months and the calving interval is about 3 years (Rice, 1977). Sei whales in the North Pacific primarily feed on copepods, which make up about 83 percent of their diet, but also feed on euphausiids (13 percent of their diet) (Nemoto and Kawamura, 1977). The balance of their diet consists of squid and schooling fish, including smelt, sand lance, Arctic cod, rockfish, pollock, capelin, and Atka mackerel (Nemoto and Kawamura, 1977). Rice (1977) suggested that the diverse diet of sei whales may allow them greater opportunity to take advantage of variable prey resources, but may also increase their potential for competition with commercial fisheries.

Generally, sei whales make 5-20 shallow dives of 20-30 sec duration followed by a deep dive of up to 15 minutes (Gambell, 1985). The depths of sei whale dives have not been studied, however the composition of their diet suggests that they do not perform dives in excess of 300 m (984 ft).

Under only one or two circumstances have the sounds of sei whales been recorded (Thompson et al., 1979; Richardson et al., 1995). The recorded sounds consist of two phrases of 10-20 0.5- to 0.8-s frequency modulated sweeps in the 1.5- to 3.5-kHz range spaced 0.4-1 s apart. No studies have directly measured the sound sensitivity of sei whales (Croll et al., 1999).

Sei whales are usually found in small groups of up to 6 individuals, but also commonly form larger groupings on the feeding grounds (Gambell, 1985). Sei whale abundance prior to commercial whaling in the North Pacific has been estimated at 42,000 (Tillman, 1977). When commercial whaling for sei whales ended in 1974, the population of sei whales in the North

Pacific had been reduced to between 7,260 and 12,620 animals (Tillman, 1977). Current abundance or trends are not known for stocks in the North Pacific.

Bryde's Whale

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.

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. However, Best (1975) also reported that the offshore population off South Africa bred 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 Bryde's whale vocalizations is not known, 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 the Bryde's whale has excellent LF hearing (Ketten, 1994).

Bryde's whales are very rare around the main Hawaiian Islands, but are somewhat more common around Midway Atoll (Leatherwood et al., 1988).

Minke Whales

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. They have been commercially exploited since at least 1923 (Kellogg, 1931), but global populations appear to be healthy.

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 km/hr (3.2 kt) (Lockyer, 1981). During migration, speeds of up to 25.9 km/hr (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 km/hr (3.3 kt), and 4 hours per day is spent swimming at 25.9 km/hr (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 (Schevill and Watkins, 1972; Winn and Perkins, 1976; Thompson et al., 1979; Leatherwood et al., 1981; Mellinger and Clark, 1997; Gademke, *pers. comm.*). Sounds recorded in the Southern Hemisphere include "whistle series, clanging bell series, clicks, screeches, low frequency grunts, and frequency modulated sweeps" (Leatherwood et al., 1981). The function of minke whale vocalizations is unknown, but they are assumed to be used for communication. There are no data on hearing sensitivity for the minke whale. By comparison to what little is known about Balaenopteran auditory mechanics, it is assumed that the minke whale has excellent LF hearing (Ketten, 1994).

Minke whales are sometimes seen around the northwest islands of Hawaii (Leatherwood et al., 1988).

3.2.2.2 Odontocetes

Sixteen species of toothed whales and dolphins may be found in the Kauai and Midway Atoll areas. Aerial survey sightings within 35 km (18.9 nm) of the Kauai site during the MMRP are listed in Table 3.2-1 (Mobley et al., 1999b).

The following species of odontocetes were sighted in or near the proposed area during surveys conducted between 1993 and 1998 by the University of Hawaii under NMFS permit No. 810: sperm whales (*Physeter macrocephalus*), short-finned pilot whales (*Globicephala macrorhyncus*), beaked whales (*Ziphius cavirostris, Berardius bairdi, and Mesoplodon* spp.), spinner and spotted dolphins (*Stenella* spp.), bottlenose dolphins (*Tursiops truncatus*), and rough-toothed dolphins (*Steno bredanensis*).

Other species believed to inhabit the area include pygmy sperm whales (*Kogia breviceps*), dwarf sperm whales (*Kogia simus*), striped dolphins (*Stenella coeruleoalba*), killer whales (*Orcinus orca*), false killer whales (*Pseudorca crassidens*), pygmy killer whales (*Feresa attenuata*), and melon-headed whales (*Peponocephala electra*). Based on the limited density data available, it is believed that the population abundance of these species is quite small.

A summary of the frequency range of sounds produced by odontocetes is included as Figure 3.2-4 (Frequency Range of Sounds Produced by Odontocetes). Au et al. (2000) provide a summary of what is known about hearing by odontocetes. Audiograms are available for seven odontocete species, most of which are delphinids, but also includes beluga whales and harbor porpoises. There are no published audiograms for sperm or beaked whales. Best sensitivities range from about 20 kHz in killer whales to over 100 kHz in harbor porpoises (Ketten, 1998) (Figure 3.2-2). No odontocete has been shown audiometrically to have acute hearing (<80 dB re 1 µPa) below 500 Hz (Table 3.2-2, Known Underwater Hearing Sensitivities of Odontocetes). 3-10

Sperm Whales

Sperm whales, although listed as endangered, are considered to be the most abundant of the large whale species, numbering an estimated 1,900,000 animals worldwide (Rice, 1989). Berzin (1971) reported that they are restricted to waters deeper than 300 m (984 ft), while Watkins (1977) and Whitehead and Weilgart (pers. comm., 1993) reported that they are usually not found in waters less than 1000 m (3281 ft) deep. While deep water is their typical habitat, sperm whales have been observed near Long Island, NY, in waters of 41-55 m (135-180 ft) (Scott and Sadove, 1997). When found relatively close to shore, sperm whales are usually associated with sharp increases in bottom depth where upwelling occurs and biological production is high, implying the presence of a good food supply (Clarke, 1956). They can dive to depths of at least 2000 m (6562 ft), and may remain submerged for an hour or more (Watkins, 1993). Sperm whales feed primarily on buoyant, relatively slow-moving squid (Clark et al., 1993), but may also eat a variety of fish (Caldwell and Caldwell, 1983). Sperm whales are endangered under ESA and protected under CITES.

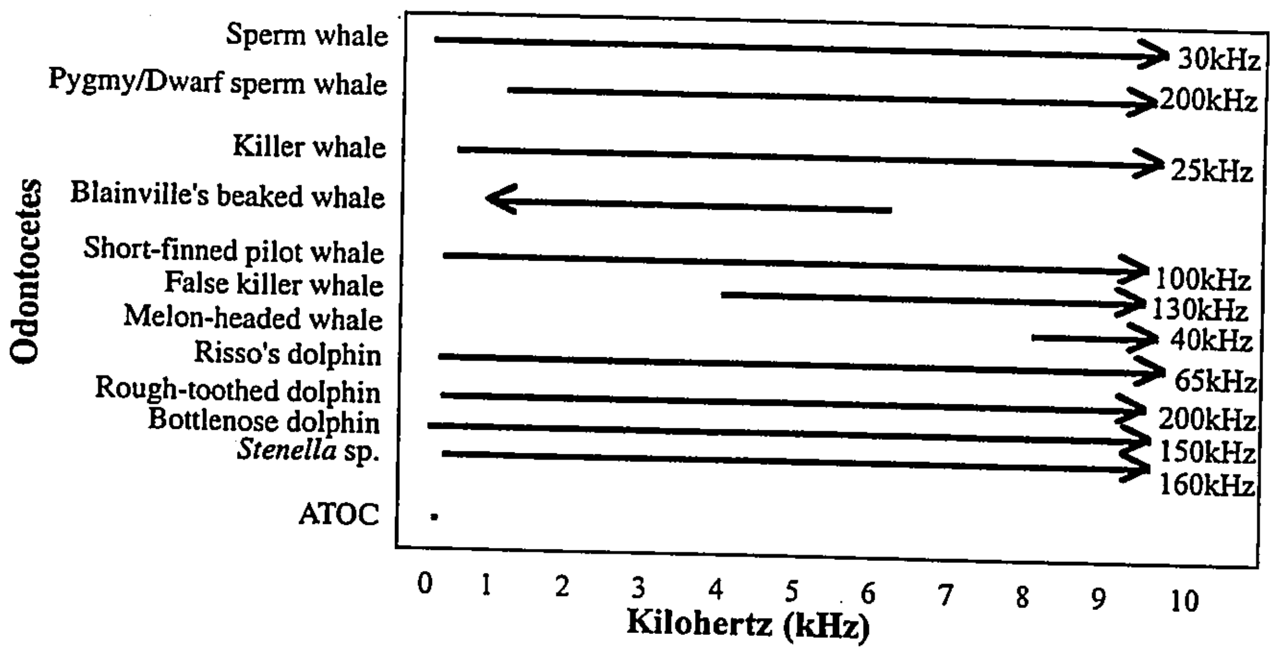


Figure 3.2-4 Frequency Range of Sounds Produced by Odontocetes

Table 3.2-2 Known Underwater Hearing Sensitivities of Odontocetes

Species	Underwater Hearing Sensitivity
Sperm whale (*Physeter macrocephalus*)	- Good hearing sensitivity above 2.5 kHz; lower limit of hearing probably 100 Hz
Pygmy and dwarf sperm whales (*Kogia* sp.)	- Best underwater hearing from 90-150 kHz from auditory brainstem response study
Killer whale (*Orcinus orca*)	- Hear sounds from <0.5 kHz to 105 kHz - Maximum sensitivity (+36 dB re 1 μPa) at 20 kHz
Blainville's beaked whale (*Mesoplodon densirostris*)	- No hearing data available
Cuvier's beaked whale (*Ziphius cavirostris*)	- No hearing data available
Short-finned pilot whale (*Globicephala macrorhynchus*)	- No hearing data available
False killer whale (*Pseudorca crassidens*)	- Hear sounds from <1.0 kHz to 115 kHz - Hearing threshold for 75 Hz pure-tone signal is 140.7 ± 1.2 dB, for ATOC signal is 139.0 ± 1.1 dB
Melon-headed whale (*Peponocephala electra*)	- No hearing data available
Risso's dolphin (*Grampus griseus*)	- Hear sounds from 0.75 kHz to 100 kHz - Hearing threshold for 75 Hz pure-tone signal is 142.2 ± 1.7 dB, for ATOC signal is 140.8 ± 1.1 dB
Rough-toothed dolphin (*Steno bredanensis*)	- No hearing data available
Bottlenose dolphin (*Tursiops truncates*)	- Hear underwater sounds from 0.15 kHz to 135 kHz - Behavioral alterations to 400 Hz signal occurred at RLs of 180 dB; no TTS occurred at RLs of up to 193 dB
Striped dolphin (*Stenella coeruleoalba*)	- Hear sounds from <10 kHz to >100 kHz
Spinner dolphin (*Stenella longirostris*)	- No hearing data available
Spotted dolphin (*Stenella attenuata*)	- No hearing data available
Sources: Richardson et al., 1995; Croll et al., 1999; Szymanski et al., 1999; Au et al., 1997; Schlundt et al., 2000.	

Stock definition (i.e., identification of separate stocks) and stock structure (i.e., sex and age composition associated with future reproductive success) are not well understood in sperm whales, although well established populations occur in each major ocean basin. There also is uncertainty about the methods and models used to estimate historical and present abundances (e.g., International Whaling Commission [IWC], 1988). As such, a full assessment of the status of the individual stocks is not possible at this time. Table 3.2-1 lists the best estimate of sperm whale stock in the Kauai area.

During summer, sperm whales migrate to higher latitudes, with mature males migrating much farther north than females and younger males. In the Pacific Ocean, females and younger whales usually remain in tropical and temperate waters (between 40°N and 45°S Latitude [Rice, 1978]), while males continue north to the Gulf of Alaska, Aleutian Islands, and the Bering Sea, or south to the Antarctic. Females and younger animals may be restricted in their migrations by an intolerance to low water temperatures. Breeding herds are confined almost exclusively to warmer waters, and many of the larger males return to lower latitudes in the winter to breed. Sperm whales in the Pacific Ocean during this time are usually distributed below 40°N Latitude. Historically, sperm whaling grounds in the Pacific south of 40°N Latitude were located around the Hawaiian Islands, among other areas. Sperm whales are considered fairly common around Midway Atoll (Leatherwood et al., 1988).

Pygmy and Dwarf Sperm Whales

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* spp. 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* spp. 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 vocalizations 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., (1990) 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).

Killer Whales

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). None were observed during the MMRP surveys. 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.

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, 1995b). 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 km/hr (3.2-5.4 kt), but they can achieve speeds up to 40 km/hr (22 kt) (Lang, 1966).

Killer whales have perhaps one of the most stable and cohesive animal societies, in which vocalizations play 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 listen underwater to sounds equal to or softer than 120 dB in the range of <500 Hz to 105 kHz (Hall and Johnson, 1972; 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 and Pygmy Killer Whales

False killer whales and pygmy killer whales are found infrequently in Hawaiian waters during all seasons (Balcomb, 1987). Both species travel in groups of half a dozen to over several hundred individuals. Prey for these species include many species taken by humans, such as dolphin fish or mahi mahi (*Coryphaena hippurus*) and squid. False killer and pygmy killer whales likely are able to dive as deep as killer whales, but probably no deeper. Mobley et al. (1999b) reported 324 individuals during the statewide MMRP surveys (Table 3.2-1). No false killer whales or pygmy killer whales have been reported near Midway Atoll.

Pilot Whales

Pilot whales are among the most ubiquitous and numerous of all cetaceans, occurring worldwide in all but polar seas (Balcomb, 1987). Off the Hawaiian Islands, the most abundant pilot whale species is the short-finned pilot whale. This species occurs year-round in Hawaiian waters in herds of 20-40 individuals, with aggregations of over 100 occasionally observed. Radiometric studies have shown that these whales can dive to depths of at least 610 m (2000 ft) (Leatherwood and Reeves, 1983), feeding on squid and fish (Caldwell and Caldwell, 1983). A total of 774 short-finned pilot whales were reported in the 1993-1998 statewide surveys (Mobley et al., 1999b). No pilot whales have been reported off Midway Atoll.

Beaked Whales

Three species of beaked whales, including Baird's, Blainsville's, and Cuvier's beaked whale occur in Hawaiian waters (Balcomb, 1987). Overall, there is much uncertainty about the number and seasonal distribution of beaked whales. While it is extremely unlikely to find Baird's beaked whales around the main Hawaiian Islands, 16 individuals were observed in the 1993-1998 aerial survey effort (Mobley et al., 1999b). In recent years, a few individuals were identified and photographed in Hawaii. Two Blainsville's beaked whales were reported to have stranded on Midway Atoll (Leatherwood et al., 1988). The most widely distributed of all beaked whales, Cuvier's beaked whale, occur year-round in deep offshore Hawaiian waters. Mobley et al. (1999b) reports sightings of 13 Cuvier's beaked whales during the 1993-1998 statewide aerial surveys. Similar to the other beaked whales off Hawaii, Cuvier's beaked whales have only been observed and photographed on rare occasions. Most beaked whales are thought to forage offshore in relatively deep water (Leatherwood et al., 1987; Mead, 1989), diving as deep as 1000 m (3281 ft) (Matsuura, 1943; Pike, 1953; Tomilin, 1957; Balcomb, 1987), feeding on various fish and squid (Balcomb, 1987). Three Cuvier's beaked whales been reported to have stranded on Midway Atoll (Galbreath, 1963).

Melon-headed Whales

Melon-headed whales are poorly-known, small odontocetes. They have a distribution 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).

Bottlenose Dolphins

Bottlenose dolphins are probably the best known of all cetaceans due to their inherent presence around vessels and their high survival rate and adaptability in captivity (Balcomb, 1987). Around Hawaii, there are numerous populations of this species occupying harbors and coastlines. Bottlenose dolphins feed on a wide variety of fish, squid, shrimp, and crab (Caldwell and Caldwell, 1983). They can dive to maximum depths of up to 535 m (1755 ft), remaining submerged for up to 8 min (Kanwisher and Ridgway, 1986). Bottlenose dolphins have been reported near Midway Atoll (Shallenberger, 1981).

Spinner Dolphins

Spinner dolphins (*Stenella longirostris*) are found in tropical oceans throughout the world (Balcomb, 1987). In Hawaiian waters, they gather in large herds at night, offshore and in deep channels between the islands, for feeding. They disperse during the day into smaller groups and move into nearshore resting habitats (Balcomb, 1987). A total of 1596 spinner dolphins were reported during recent 1993-1998 statewide aerial surveys (Mobley et al., 1999b). Feeding habits and diving depths of this species are largely unknown, but it is unlikely they dive deeper than bottlenose dolphin (535 m [1755 ft]). Spinner dolphins are seen regularly around Midway in large numbers (Norris et al., 1994).

Rough-toothed Dolphins

Rough-toothed dolphins are relatively common in the vicinity of the Hawaiian Islands in offshore waters, typically occurring over bottom depths greater than 500 m (1640 ft) (Balcomb, 1987). This species usually travels in groups of 3-4 individuals with sometimes many small groups utilizing one area. Rough-toothed dolphins feed primarily on pelagic invertebrates, such as squid and octopus (Caldwell and Caldwell, 1983). Only 136 rough-toothed dolphins were reported in the 1993-1998 statewide aerial surveys (Mobley et al., 1999b) and were regularly seen from a survey vessel in the vicinity of the ATOC source location (Frankel, pers. obs.). This species is probably capable of diving to relatively moderate depths (e.g., 300 m [984 ft]), based on the type of prey consumed (Balcomb, 1987).

Spotted Dolphins

Several species of spotted dolphins inhabit tropical oceans and seas worldwide (Balcomb, 1987). In the vicinity of the Hawaiian Islands, the most common species of spotted dolphin is *Stenella attenuata*. These dolphins travel in large herds, sometimes exceeding 1000 individuals. They feed primarily in offshore waters on squid and fish (Balcomb, 1987; Caldwell and Caldwell, 1983), and probably are able to dive to moderate depths (e.g., 300 m [984 ft]). Mobley et al. (1999b) reported sighting 849 spotted dolphins in the statewide surveys.
Although little site-specific information exists on most of the above dolphin species in the vicinity of Midway Atoll, it is likely that some of these species are present in offshore waters near the atoll.

3.2.2.3 Pinnipeds

The Hawaiian monk seal or ilio-holo-i-ka-uaua (*Monachus schauinslandi*) is the only pinniped species known to occur within the general study region. This species occurs only in the Hawaiian Islands, where its greatest distribution is in the small, mostly uninhabited chain of islands and atolls stretching 1100 nm (2037 km) northwest of the main Hawaiian Islands, all of 3-11 which except Kure Atoll are included in the Hawaiian Islands National Wildlife Refuge or the Midway Atoll National Wildlife Refuge (USFWS, 1984; Tomich, 1986). Hawaiian monk seals are listed as endangered under the ESA and protected under CITES.

The hearing sensitivity of a young male Hawaiian monk seal was studied at Sea Life Park on Oahu (Thomas et al., 1990). Auditory thresholds from 2 to 48 kHz were measured. The resulting audiogram shows a narrow hearing range than for other tested pinnipeds, with the most sensitive region being from 12 to 28 kHz. Below 8 kHz, the monk seal's hearing was less sensitive than other pinniped species.

More than 90 percent of all pups are born at six major breeding colonies located at French Frigate Shoals, Laysan Island, Pearl and Hermes Reef, Lisianski Island, Kure Atoll, and Midway Atoll (MMC, 1999). Most pups are born between March and May, but pupping has been recorded year-round (U.S. Dept. of Commerce, 1986).

Counts of Hawaiian monk seals have been made since the late 1950s at the atolls, islands, and reefs where they haul out on the northwest Hawaiian Islands (Johanos and Ragen, 1999). Forney et al. (2000) estimates the minimum population size for the species is 1436 seals. Johanos and Ragen (1999) noted that the age composition of animals counted remains skewed towards adults and expressed concern that reproduction would decrease in the near future if older adult females were not replaced by young females reaching reproductive age.

Monk seals are opportunistic foragers, eating prey as they are encountered. Their diet can consist of octopus, spiny lobster, eels, bottom fish, and reef fish (Rice, 1960; Gilmartin, 1983). Recent research (Parrish et al., 2000) fitted 24 adult male seals with a video camera. All documented feeding was directed at demersal and benthic fish, and most prey were caught at depths of 50-100 m (164-328 ft) on the relatively level terraces which are remnant of prehistoric sea-level change. Most of the seals' dives were to the bottom in water 10-100 m (33-328 ft) deep, though 3 of the 24 seals made dives greater than 300 m (984 ft).

On the island of Kauai, "the numbers of adults and numbers of births seem to be clearly on the increase." (Heacock, pers. comm., September 18, 2000). In 1997, Mr. Heacock started the Kauai Monk Seal Watch Program with the cooperation of the county lifeguards, Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS), and NMFS. Though there are no published reports, Mr. Heacock noted that the total count of beached monk seals recorded in 1999 by this program was 10-12, with 1 birth also recorded. In August, 2000, NMFS conducted a statewide aerial survey which observed 17 beached seals for Kauai County (Kauai, Niihau, Lehua Rock and Kalua Rock) and 3 births which were all on the island of Kauai (Heacock, pers. comm., September 18, 2000). NMFS normally multiplies their beach counts of seals by a correction factor of 3 to account for animals that may not be observed to obtain a reasonable estimate of the actual population size.

Hawaiian monk seals are known to breed at the Midway Islands, among other northwest Hawaiian Islands (USFWS, 1984). The colony on Midway was virtually eliminated during the active use by the U.S. Navy. However, the beach count of 24 seals in 1998 was the highest since 1960. Furthermore, 11 pups were born at Midway in both 1997 and 1998. Twenty of the 22 pups were successfully weaned (MMC, 1999). These encouraging findings suggest that the seals at Midway may reestablish the atoll as a major breeding site.

3.2.3 Sea Turtles

Five species of sea turtle occur in the Pacific Ocean near the Hawaiian Islands: the green or honu (*Chelonia mydas*), loggerhead (*Caretta caretta*), leatherback (*Dermochelys coriacea*), hawksbill or èa (*Eretmochelys imbricata*), and olive ridley (*Lepidochelys olivacea*). Hawksbills, leatherbacks, olive ridleys and green sea turtles are listed at the federal and state levels as endangered (Biological Opinion, Appendix H). Loggerhead sea turtles are listed as threatened at the federal and state levels (Biological Opinion, Appendix H) in Hawaiian waters. 3-12

The distribution of each species has been determined from one or more of the following: 1) observations of adult females emerging to nest on beaches and/or adult males basking on beaches or other substrates; 2) observations of turtle tracks, hatchlings, or egg shells on beaches; 3) reports of incidental capture by commercial fisheries; 4) incidental observations by fishermen or other mariners; 5) mark-recapture studies of adult females; and 6) radio and satellite telemetry studies of adult males and females. All five species have worldwide extensive ranges. However, genetic analysis of sea turtles has revealed in recent years (i.e., many published accounts) that discrete non-inter-breeding stocks of sea turtles make up these "worldwide extensive ranges" of the various species. It is generally believed that all sea turtle species spend the first few years of their life in pelagic waters, occurring in driftlines and convergence zones, where they find refuge and food in the items that accumulate in surface circulation features (Carr, 1986, 1987). The most accurate abundance estimates in the study region are for adult female green turtles and hawksbills that nest annually on Hawaiian beaches. Leatherbacks and olive ridleys do not nest regularly, or in great numbers, in the Hawaiian Islands, and loggerheads do not nest in the Hawaiian Islands at all. Table 3.2-1 provides estimates for the potential stocks of these five sea turtle species in the area off the north coast of Kauai.

Green Sea Turtle

The green sea turtle is considered the most abundant sea turtle in Hawaiian waters. Its population consists of an estimated 1400 adult females (NMFS, 1992). Green turtles tagged in the Hawaiian Archipelago rarely are recaptured or observed elsewhere. Notable exceptions are Johnston Atoll, about 1200 km (650 nm) to the southwest (NMFS, 1992); and two recoveries in the western Pacific (one in Japan and one in the northern Philippines) (Balazs, 1983). The lack of recaptures, in addition to research concluding Hawaiian green turtles are genetically distinct (Bowen et al., 1992), suggests that these turtles are essentially restricted (or geographically limited) to this area of the Pacific Ocean.

Green sea turtles primarily occur in coastal waters, where they forage on algae and seagrass (Balazs, 1980; NMFS/SWFSC, 1993), suggesting they are limited to the photic zone (i.e., upper water column through which light may penetrate) surrounding islands and continents. During the breeding season, adult green sea turtles undertake long distance, oceanic migrations from feeding areas located throughout the Hawaiian Archipelago, to nesting beaches at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl Reef and Hermes Reef, Kure Atoll, and Midway Atoll

(Balazs, 1980; NMFS, 1992; Balazs, 1993). Four postnesting female green turtles were fitted with satellite transmitters to monitor their migrations from French Frigate Shoals (Balazs, 1994). All four turtles migrated to Oahu, with three of them traveling south of Kauai, over open ocean. The fourth migrated along the chain of islands, swam toward the southern edge of Kauai, traveled north along the east coast, and then veered off towards Oahu (Balazs, 1994). These are the only green sea turtles that have been tracked and none of them were "Kauai" turtles (i.e., turtles that returned to resident foraging pastures on the island of Kauai). The nearshore waters of Kauai, especially the north shore area, are important habitats for post-pelagic subadult and adult green sea turtles (Balazs, 1980, 1983).

Green sea turtle breeding may occur along oceanic migration routes, but appears to be most concentrated at nearshore nesting beaches from mid-April through early June (Balazs, 1980; NMFS, 1992). Approximately 90% of green turtle nesting in the Hawaiian Islands occurs at French Frigate Shoals, with an estimated 100-250 animals laying eggs along the shore annually between May and September. Average age at first reproduction in the Hawaiian Islands has been estimated to be 25 yrs (NMFS, 1992). From July through October, the hatchlings emerge from nests and swim offshore, where they tend to accumulate in surface driftlines. Juvenile and sub-adult green turtles (35-82 cm [13.8-32.3 in] carapace length) are abundant nearshore Hawaii, Maui, Kaho'olawe, Molokai, Oahu, Kauai, and Niihau Islands (NMFS-Southwest Fisheries Science Center [SWFSC], 1993). Adults are benthic herbivores, suggesting that they are restricted to photic zones (i.e., upper oceanic surface layer through which light may penetrate, corresponding to water depths ranging from the surface to approximately 150-200 m [500-656 ft]) surrounding islands and continents. Because green sea turtles feed in the photic zone and prefer warm water temperatures above 15°C (Eckert, pers. comm., 1994), they are not expected to dive regularly to depths greater than 200 m (656.2 ft) (beyond the photic zone). This species is reported as a relatively regular visitor to Midway Atoll, being observed in the shallow lagoon areas, as well as in offshore habitats but does not appear to breed there (NMFS and USFWS, 1998a).

Hawksbill Sea Turtles

Juvenile, sub-adult, and adult hawksbills occur in Hawaiian waters, but are uncommon. Hawksbills generally are associated with coral reefs or other hard substrate areas, where they forage primarily on sponges (Meylan, 1988). An estimated 12 hawksbills nest on Hawaii and Molokai each year from July through November (NMFS, 1992). Hawksbill migration routes are unknown. No hawksbill turtles have been reported in the vicinity of Midway Atoll, although they may occasionally feed there (NMFS and USFWS, 1998b).

Leatherback Sea Turtles

Adult leatherbacks are commonly sighted in the Pacific Ocean near the Hawaiian Archipelago, primarily over deep, oceanic waters (Wetherall, 1993). They forage on jellyfish and other gelatinous pelagic invertebrates (Leary, 1957; Mortimer, 1981; den Hartog and Van Nierop, 1984) at depths that sometimes correspond with the deep scattering layer (Eckert et al., 1989). This species has been recorded to dive (two occasions) to depths exceeding 1000 m (3281 ft). However, Eckert et al. (1986) reported that the average diving depth and duration of dives for leatherbacks were approximately 62 m (203 ft) and 10 min/dive, respectively. Leatherbacks undertake extensive migrations (Pritchard, 1976), following depth contours (Morreale et al., 1993) for hundreds, or even thousands, of kilometers (nautical miles). Females may nest at several beaches, spatially separated by hundreds of kilometers (nautical miles), within a nesting season. Migratory and reproductive information on leatherbacks, in addition to preliminary results from genetic studies (Dutton, pers. comm. 1993), suggests that they are wide-ranging and not restricted to any one region. There has been an alarming decline in the number of nesting females in Maylasia (1950: 1800 females; 1987: 100 females) (Marquez, 1990). Leatherbacks do not nest regularly in the Hawaiian Islands, although there is one report of an unsuccessful nesting attempt on Maui, and one unconfirmed nesting on Kauai (Eckert, 1993). No leatherback turtles have been reported in the vicinity of Midway Atoll (NMFS and USFWS, 1998c).

Olive Ridley Sea Turtles

Olive ridley sea turtles are not common in Hawaiian waters, although they are the most abundant sea turtle in the eastern Pacific Ocean (Pitman, 1990). They are nomadic migrants that swim hundreds to thousands of kilometers (nautical miles) during migrations (Marquez, 1990), foraging on salps, tunicates, pelagic crustaceans, and other invertebrates (Fritts, 1981; Mortimer, 1981). Olive ridleys spend a large portion of their time at the surface (Byles and Plotkin, 1993; Pitman, 1993), but have been reported to dive to depths of nearly 300 m (984 ft) in the Sea of Cortez (Eckert, pers. comm., 1994). Post-nesting females can travel over 9000 km (4860 m) in 16 months. The reproductive cycle is nearly annual with greater than 60% of the females nesting every year (Eckert, 1993). However, very little is known about the behavior and movements of males (Eckert, 1993).

Most records of this species in Hawaiian waters are of sub-adults stranded after becoming entangled in ocean debris or discarded fishing gear (Balazs, 1985), or captured incidentally by pelagic longline fisheries. There is only one report of a successful nesting in the Hawaiian Islands region, on Maui (Balazs and Hau, 1986). No olive ridleys have been reported in the vicinity of Midway Atoll.

Loggerhead Sea Turtles

Loggerhead sea turtles are large, widespread turtles that feed primarily on benthic invertebrates (Ernst et al., 1994; Bjornal, 1997). Loggerheads reside and nest in subtropical to temperate areas and, in some populations, they have long cross-basin migrations between feeding and nesting areas. 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.

Loggerhead sea turtles are rare in Hawaiian nearshore waters, with only four documented occurrences: two juveniles from the southeastern part of the archipelago, one juvenile removed from the stomach of a tiger shark captured near Kure Atoll, and one adult female sighted near Oahu (Eckert, 1993).

3.2.4 Fish

Hawaiian waters are comprised of a broad range of onshore to offshore habitats, from sandy beaches and rocky tidepools, to coral reefs and submerged basaltic terraces and banks, to pelagic and soft substrate ecosystems. Diverse coral reef and nearshore reef fish, deepwater demersal (bottomfish), and migratory pelagic fish (those that spend part or all of their lives in the water column) are characteristic of these habitats. Epipelagic (surface to approximately 200 m [656 ft] depth), mesopelagic (between 200 and 1000 m [656 and 3281 ft]), and bathypelagic (>1000 m [3281 ft] depth) zones also support a wide variety of fish species, including some which are important components of the Hawaiian Islands commercial and sport fisheries. Section 3.2.4.1 discusses some of the common demersal (bottom-dwelling) species on nearshore and offshore areas in the vicinity of Kauai and Midway Atoll. Common epipelagic, mesopelagic, and bathypelagic species are discussed in Section 3.2.4.2.

3.2.4.1 Demersal Species

Demersal fish are defined as those species living on or near the sea floor. Nearshore habitats and reef fish from approximately 0 to 50 m (0 to 160 ft) depth off the north shore of Kauai were described in 1980, as part of the EIS for the Princeville community development (Grigg and Dollar, 1980). Surveys were conducted from Haena Point to Kilauea Lighthouse. Similar to other islands within the Hawaiian Archipelago, rough basaltic substrates off north Kauai support a diverse tropical reef fish fauna (Grigg, 1993). Common nearshore demersal fish families observed off north Kauai include squirrelfish (Holocentridae); snappers (Lutjanidae) such as Onaga, Ehu, Opakapaka, and Ta'ape; goatfish (Mullidae) such as Weke, Weke-ula, Kumu, Maono, and Moano Kea; and sea chubs (Kyphosidae) (Grigg and Dollar, 1980). The primary diet for most of these species include crustaceans and other benthic invertebrates associated with rock and coral rubble bottoms (Hobson, 1974).

During fish spawning seasons, the northeastern to southern coasts of Kauai support abundant and diverse nearshore reef fisheries (Smith, 1993). The most common fish species include bigeye scad or Akule/Hahalalu, mackerel scad or Opelu, goatfish such as white/green Weke, and squirrelfish or U'u. Although abundance and biomass data are not available for these species, the nearshore reef study area community probably has relatively high fish densities. Additional fish families that contribute to the relatively high diversity include damselfish (Pomacentridae), wrasses (Labridae), parrotfish (Scaridae), surgeonfish (Acanthuridae), and mackerel jacks (Carangidae) (Grigg and Dollar, 1980).

Deepwater demersal fish assemblages between 50 and approximately 400 m (160 and 1310 ft) depths on offshore banks and the deep-reef slopes off Kauai are dominated by snappers and grouper (Serranidae) such as Hapu'upu'u. Densities in these areas are probably relatively high, and deepwater snapper in Hawaii have been commercially exploited since the early part of the century (Haight et al., 1993). Similar to other shelf and slope communities throughout the Pacific ocean, fish densities and biomass decrease as depth increases. Rattails (Macrouridae) and cod (Moridae) are dominant residents of the deepwater complex (including the bathypelagic zone), and comprise the highest biomass in this area. These species feed on a variety of prey, including krill, shrimp, crabs, and small fish (Love, 1991).

The deep-sea benthic fish of the Hawaiian Archipelago, were described by Chave and Mundy (1994). More than 250 benthic fish species were photographed and videotaped by Hawaii Undersea Research Laboratory (HURL) submersibles at depths ranging between 40 and 2000 m (130 and 6560 ft). Most of the species observed occurred close to hard substrates, holes, ledges, or caves. Large schools of fish were observed over sand-bottom habitats in troughs when the bottom currents were strong. Chave and Mundy (1994) found 3 species restricted to the Northwest Hawaiian Islands, although their survey only extended north to French Frigate Shoals. Diversity decreases rapidly with depth from 200 to 400 m (660 to 1310 ft). The deepest species observed were rattails, halosaurids, and congrids (conger eels).

3.2.4.2 Pelagic Species

The surface waters of the ocean to depths of nearly 200 m (660 ft) (epipelagic zone) represent an enormous, although relatively featureless, habitat for fish (Moyle and Cech, 1988). Epipelagic waters are typically well-lighted, well-mixed, and capable of supporting actively photosynthesizing algae. At depths between 200 and approximately 1000 m (660 and 3280 ft) (mesopelagic zone), light decreases rapidly, as does temperature and dissolved oxygen concentrations, while pressure increases. At depths greater than 1000 m (3280 ft) (bathypelagic zone), conditions are characterized by complete darkness, low temperatures, low oxygen concentrations, and great pressure. Each of these zones is distinguished by characteristic fish assemblages.

Epipelagic fish can be distinguished based on two ecological types. Ocean forms are those that spend all or part of their life in the open ocean, while neritic forms spend all or part of their life in shallower waters of the island shelf and island offshore areas (Moyle and Cech, 1988).

Hawaii's pelagic fisheries are relatively small in comparison with other Pacific pelagic fisheries (NMFS, 1991), but comprise a large proportion of the commercial and recreational catch in the state (Pooley, 1993). Off Kauai, higher total landings, including yellowfin tuna or Ahi, are taken on the leeward (southwestern) side of the island (Smith, 1993). Other common epipelagic fish species found off Kauai include jack fish (primarily *Caranx* spp.), bigeye scad, and mackerel scad.

The larger migratory pelagic fish that comprise a substantial part of Hawaii's commercial, recreational, and sport and game fish fisheries include Ahi, albacore (*Thunnus alalunga*), skipjack tuna or Aku (*Katsuwonus pelamis*), blue marlin or A'u (*Makaira nigricans*), striped marlin or A'u (*Tetrapturus audax*), broadbill swordfish or Shutome (*Xiphias gladius*), dolphinfish or mahi mahi (*Coryphaena hippusus* and *C. equiselis*), wahoo or Ono (*Acanthocybium solandri*), shortbill spearfish (*Tetrapturus angustirostris*), sailfish (*Istiophorus platypterus*), and black marlin (*Makaira indica*). Abundance data are not available for most of these species. However, additional information on their contribution to Hawaii's fisheries is discussed in Section 3.3.1.

Most mesopelagic fish species undergo vertical migrations, often moving into the epipelagic zone at night to prey on plankton and other fish (Moyle and Cech, 1988). Mesopelagic species found in Hawaiian waters are similar to those found in other areas of the Pacific. For example, lanternfish (Myctophidae), a common mesopelagic fish family, is represented in the Hawaiian waters by a variety of species including the Honolulu lanternfish (*Myctophum hollandi*). Other species likely include bristlemouths (Gonostomatidae) and some deep-sea smelts (Bathylagidae).

In contrast to mesopelagic fish, bathypelagic species are largely adapted for a sedentary existence in a habitat characterized by low levels of food and no light (Moyle and Cech, 1988). Most of the species occupying the bathypelagic zone also cross into the mesopelagic zone during diurnal vertical migrations. At depths greater than 1000 m, bathypelagic species likely to occur in Hawaiian waters include blackdragons (Idiacanthidae), dragonfish (Melanostomiidae), and tubeshoulders (Searsiidae).

In addition to the most common pelagic species described above, several shark species are common inhabitants of the nearshore and offshore waters off Kauai and in the vicinity of Midway Atoll. Sharks are a diverse group, occupying shallow and deep water habitats worldwide.

Sharks and other species have been an important aspect of Hawaiian culture. For example, the Hawaiian dictionary lists nine Hawaiian Gods that were associated with sharks, with some being revered as influential spirits important to specific geographic areas (Taylor, 1993). Further, it was believed that under certain conditions a deceased relative could be reincarnated in the form of a specific shark known by a special name (Taylor, 1993). For example, a shark could be a guardian spirit or aumakua, or a fishing helper or unihipili.

Some of the most common shark species include pelagic requiem sharks (Carcharhinidae) or mano, thresher sharks (Alopiidae) such as the pelagic thresher mano' ula or laukahi, and mackerel sharks (Lamnidae) such as the great white shark or niuhi (*Carcharodon carcharius*) (NMFS, 1991). While great whites have been taken at depths over 1400 m (4590 ft) (Love, 1991), they occur mainly in continental and island inshore waters where their main prey items occur. In contrast, tiger sharks or niuhi (*Galeocerdo cuvier*) have an ecologically important role as apex predators in the offshore pelagic and deep reef ecosystems. Tiger sharks consume mainly vertebrates, such as sea turtles (Taylor, 1993), but also select various invertebrates such as lobster and squid. Tiger sharks appear to switch foraging strategies from many small prey items to fewer, larger items when they exceed 2 m (6.6 ft) in length (Lowe et al., 1996).

Pelagic requiem sharks such as various species of gray shark are the most common sharks in the main Hawaiian waters. The gray shark most often encountered around Hawaiian reefs is the sandbar shark (*Carcharhinus milberti*) or mano (Hobson and Chave, 1990). These occur in relatively shallow waters and prey on a variety of reef fish (Taylor, 1993). The grey reef shark (*Carcharhinus amblyrhynchos*) and Galapagos shark (*Carcharhinus galapagensis*) are the two other most common reef species (Wetherbee et al., 1996). The galapagos shark is probably the most common reef species off Midway (Taylor, 1993). Other species of sharks, including the whitetipped reef shark (*Triaenodon obesus*) and some species of hammerhead sharks, such as the scalloped hammerhead (*Sphyrna lewini*) or manokihikihi and the smooth hammerhead (*S. zygaena*) are abundant near reefs and in deeper offshore areas throughout the Hawaiian archipelago (Hobson and Chave, 1990) and contribute significantly to the offshore longline fishery (Taylor, 1993). Most of these species feed on various fish and invertebrates, occupying relatively shallow nearshore waters (e.g., less than 100 m [330 ft]). Thresher sharks (*Alopias pelagicus, A. superciliosus, and A. vulpinus*) are found near Kauai and Midway Atoll and are taken commercially in the vicinity of the main Hawaiian Islands, including Kauai. This species ranges in depth from the surface to nearly 150 m (490 ft) (Taylor, 1993).

Sharks at Midway differ in some behavior and distribution when compared to those in the Main Hawaiian Islands. At Midway, reef sharks will form large aggregations near shore. These aggregations may be primarily composed of pregnant females, which do not appear to feed at this time (Taylor, 1993). Tiger sharks will frequently move in close to shore to feed on sea turtle hatchlings, albatrosses and monk seals.

3.2.5 Seabirds

Seabirds are defined as those species, which obtain most of their food from the ocean and are found over water for more than half of the year (Briggs et al., 1987). Because the sound source is located at 807 m (2648 ft) depth and since the low frequency sounds generated are known to attenuate near the surface layer of the ocean and are not transmitted to the air (Figure 2.1-3), seabird species most likely to be affected are those that dive frequently to deep (greater than 20 m [66 ft]) depths. Of the following species that dive in pursuit of their prey, all are thought to be shallow water divers, capable of diving to depths of less than 20 m (66 ft).

The Hawaiian Islands support a diverse group of seabird species. Species common to the Kauai and Midway Atoll study areas include the Pacific golden plover or Kolea (*Pluvialis fulva*), great frigatebird or Iwa (*Fregata minor*), wandering tattler or Ulili (*Heteroscelus incanus*), sooty tern or Ewa'ewa (*Sterna fuscata*), ruddy turnstones or Akekeke (*Arenaria interpres*), wedge-tailed shearwater or Ua'u Kani (*Puffinus griseus*), red-footed booby or 'A (*Sula sula*), red-tailed tropicbird or Koa'e 'ula (*Phaethon rubricauda*), white-tailed tropicbird or Koa'e kea (*Phaethon lepturus dorotheaeare*), brown noddy or Noio Koha (*Anous stolidus*), and Bulwer's petrel or 'Ou (*Bulweria bulwerii*) (HAS, 1978; USFWS, 1999). The Hawaiian dark-rumped petrel (*Pterodroma phaeopygia sandwichensis*), Bonin petrel (*P. hypoleuca*), and Newell's shearwater (*Puffinus auricularis newelli*), are also endemic seabird species.

Black-footed albatross (*Diomedea nigripes*) and Laysan albatross (*D. immutabilis*) occur within the general study area and have been recorded as breeders on Midway Atoll. Albatrosses are large seabirds that feed primarily on squid. Laysan and black-footed albatrosses have resident breeding populations on the larger Hawaiian Islands. Thousands visit Midway Atoll each winter and spring, and are occasionally seen elsewhere on the northwestern Hawaiian Islands. The historical range of the short-tailed albatross includes Hawaiian waters, and the current worldwide population is only about 400 birds, including approximately 85 breeding pairs.

In general, shearwaters, noddies and petrels use many of the Hawaiian Islands for roosting and nesting. Migratory seabirds such as ruddy turnstones, wandering tattlers, and Pacific golden plovers forage for food on the shorelines.

The Kilauea Point National Wildlife Refuge on Kauai contains the largest seabird colony in the main Hawaiian Islands. The refuge is home to Laysan albatross, wedge-tailed shearwaters, red-footed boobies, brown boobies, great frigate birds, red-tailed tropic birds, and white-tailed tropic birds.

In addition to other species listed above, the grey-backed tern (*Sterna fuscata oahuensis*), bristle-thighed curlew or Kioea (*Numenius tahitiensis*), masked booby or `A (*Sula dactylatra personata*), fairy tern (*Gygis alba rothschildi*), black (Hawaiian) noddy (*Anous tenuirostris melanogenys*), and Christmas shearwater (*P. nativitatis*) are considered endemic breeders on Midway.

The short-tailed albatross (*D. albatrus*), brown booby or `A (*Sula leucogaster plotus*), Lesser golden plover or Kolea (*Pluvialus dominica*), bristle-thighed curlew (*Numenius tahitiensis*), ruddy turnstone (*Arenaria interpres*) occur on Midway as migrants or regular visitors, but do not appear to roost there.

Three of these seabirds are listed as threatened or endangered under the federal ESA (Newell's shearwater [threatened], short-tailed albatross [endangered], and Hawaiian dark-rumped petrel [endangered]). Newell's shearwater and the Hawaiian dark-rumped petrel are also listed under Hawaii's Endangered Species Act. The short-tailed albatross is protected under CITES. Most of the seabird species potentially found in Hawaii are also protected by the Migratory Bird Treaty Act.

Of the above species that dive in pursuit of their prey, all are thought to be shallow water divers, capable of diving to depths of less than 20 m (66 ft). No known deep-diving bird species occur in the Kauai and Midway Atoll study areas. Therefore, seabirds have been excluded from further evaluation.

3.2.6 Threatened, Endangered, and Special Status Species

This section presents information on threatened, endangered, and special status species that may occur in the study area. Table 3.2-3 lists the threatened, endangered and special status species under the federal Endangered Species Act, the Hawaii Revised Statute (HRS) 195D-4 (Endangered Species and Threatened Species), and the Convention on International Trade in Endangered Species (CITES) that may occur in the study area. 3-13

Twelve threatened, endangered, and special status marine species potentially occur within the study areas of Kauai and Midway Atoll (NMFS Biological Opinion, 26 April 2001). These include five mysticetes (blue, fin, sei, northern right and humpback whales), one odontocete (sperm whale), one pinniped (Hawaiian monk seal), and five sea turtles (leatherback, green, olive Ridley, hawksbill, and loggerhead). In addition, the critical habitat of the Hawaiian monk seal includes all beach areas, sand spits and islets, lagoon waters, inner reef waters, and ocean waters out to a depth of 36.6 m (20 fm) around the following: Kure Atoll; Midway Islands, except Sand Island and its harbor; Pearl and Hermes Reef; Lisianski Island; Laysan Island; Maro Reef; Gardner Pinnacles; French Frigate Shoals; Necker Island; and Nihoa Island (50 CFR 226.11).

Table 3.2-3 Threatened, Endangered, and Special Status Species.

Common Name	Scientific Name	Federal Endangered Species Act Status	Hawaiian Endangered Species Act Status	CITES Status
Mysticetes				
Blue whale	*Balaenoptera musculus*	Endangered		Protected
Fin whale	*Balaenoptera physalus*	Endangered	Endangered	Protected
Sei whale	*Balaenoptera borealis*	Endangered		Protected
Humpback whale	*Megaptera novaeangliae*	Endangered	Endangered	Protected
Northern right whale	*Eubalaena glacialis*	Endangered		Protected
Odontocetes				
Sperm whale	*Physeter macrocephalus*	Endangered	Endangered	Protected
Pinnipeds				
Hawaiian monk seal	*Monachus schauinslandi*	Endangered	Endangered	Protected
Sea Turtles				
Green sea turtle	*Chelonia mydas*	Endangered	Endangered	Protected
Leatherback sea turtle	*Dermochelys coriacea*	Endangered	Endangered	Protected
Olive ridley sea turtle	*Lepidochelys olivacea*	Endangered	Endangered	Protected
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered	Endangered	Protected
Loggerhead	*Caretta caretta*	Threatened	Threatened	Protected
Seabirds				
Newell's shearwater	*Puffinus auricularis newelli*	Threatened	Threatened	
Short-tailed albatross	*Diomedea albatrus*	Endangered		Protected
Hawaiian dark-rumped petrel	*Pterodroma phaeopygia sandwichensis*	Endangered	Endangered	

3-14

3.2.7 Marine Sanctuaries and Special Biological Resource Areas

The Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS) was Congressionally designated in 1992 as part of the national system of marine sanctuaries. The Sanctuary specifically recognizes the importance of humpback whales and their winter habitat. One of the sanctuary goals is to gain an accurate description of the total North Pacific humpback population and the number of individuals wintering in Hawaiian waters. The sanctuary was established to provide a mechanism to develop research protocols, allowing for the whale research community and NMFS to work closely together. The sanctuary includes the area from the highwater mark to water depths of approximately 183 m (600 ft) around the islands of Lanai, and the leeward sides of Molokai and Maui; Penguin Bank; from Upolu point to Keahole point on the Big Island; from Puaena Point eastward to Mahie Point, and from the Kapahulu Groin in Waikiki eastward to Makapuu Point on Oahu; and from Kailiu Point to Mokolea Point off Kauai's Kilauea Point National Wildlife Refuge on the north coast. The Kauai acoustic sound source is located at 807 m (2648 ft) depth approximately 7 km (3.8 nm) northwest of the Kauai's Kailiu Point portion of the HIHWNMS.

The Kilauea Point National Wildlife Refuge on Kauai consists of thirty-one acres of cliffs and headlands jutting up to 61 m (200 ft) above the surf. It contains the largest seabird colony and one of the most important seabird nesting sites in the main Hawaiian Islands. It is administered by a resident U.S. Fish and Wildlife Service (USFWS) representative.

Hanalei National Wildlife Refuge includes 917 acres of river bottom land, taro farms, and wooded slopes in the Hanalei River Valley on the northern coast of Kauai. The refuge was established in 1972 to provide essential habitat for Hawaiian waterbirds, including the koloa maoli (Hawaiian duck), 'alae ke'oke'o (Hawaiian coot), 'alae 'ula (Hawaiian moorhen), and ae'o (Hawaiian stilt). Because of past overhunting, introduced predators, and loss of wetlands, these species are endangered. Properly managed taro farms provide a traditional Hawaiian food, and habitat where native waterbirds feed, nest, loaf, and rear their young. The boundary of the refuge does not extend beyond the mouth of the Hanalei River in Hanalei Bay.

The Hawaiian Island National Wildlife Refuge is a chain of eight islands, reefs, and atolls extending 800 miles northwest from the main Hawaiian Islands. Nihoa and Necker Islands, Gardner Pinnacles, and La Perouse Pinnacle are cores of old volcanic cones, with sheer cliffs of basalt and no beaches. Laysan and Lisianski Islands are low, flat, sandy islands surrounded by submerged fringing coral reefs. French Frigate Shoals and Pearl and Hermes Reef are true atolls, each with several small, sandy, partially-vegetated islets within a fringing coral reef. Maro Reef has only two small coral heads protruding from the ocean. Two permanent employees maintain a field station at Tern Island, French Frigate Shoals. The Hawaiian Islands NWR was established in 1909 by Executive Order 1019 of President Theodore Roosevelt. The Order "set apart" the "islets and reefs" of the Hawaiian Islands NWR "as a preserve and breeding ground for native birds." Endangered wildlife of the refuge includes the Laysan duck, Laysan finch, Nihoa finch, and Nihoa millerbird. In addition, almost the entire population of the endangered Hawaiian monk seal and virtually the entire Hawaiian breeding population of threatened green sea turtles inhabit the refuge.

Midway Atoll was transferred from the U.S. Navy to the U.S. Fish and Wildlife Service (USFWS) in 1996. The atoll has since been designated a National Wildlife Refuge. There are about a half million nesting pairs of seabirds on the islands. The monk seal colony is showing signs of recovery. Green sea turtles and spinner dolphins are found in the lagoon. The Phoenix Corporation runs a small ecotourism concession on the island, in partnership with the USFWS. The Oceanic Society is also running ecotourism/research volunteer programs at Midway.

Essential fish habitat (EFH) has been designated in and around Hawaii. Assessment of the EFH is included as Section 4.2.6.

3.2.8 Biological Environment Along the Cable Route

The cable route at the Kauai site extends over island shelf and slope habitats and shallow, sandy bottom subtidal areas (as shallow as 24 m [79 ft]). Regional geography and geology for the Kauai and Midway Atoll sites were previously described in Section 3.1.5. Plants and animals in these areas are highly dependent on the subsea geology and geography described in these sections. The cable for the Kauai source crosses only one reef, offshore from Barking Sands, passing through surge channels in the reef. After crossing the reef area, the cable lies on sand and soft-bottom areas. A similar cable route is expected for the alternate site at Midway Atoll.
Shallow nearshore communities (depths 24-50 m [79-164 ft]) likely are characterized by a variety of fish families, including wrasses (Labridae), goatfish (Mullidae), and damselfish (Pomocentridae). Species within these families comprise complex coral reef communities. Invertebrates likely to occur at these depths include lobster, crab, sea stars, and sea urchins. Reef-building corals likely will dominate the shallow subtidal areas.

In water depths ranging between 45 and 67 m (148 and 220 ft), the cable crosses the outer face of the offshore reef. This part of the reef is dissected by frequent surge channels, which can be characterized as having similar abundances and diversity as nearby adjacent reefs.

Deeper shelf and slope communities can be characterized as moderately diverse habitats. Fish such as tunas, jacks, and scad will predominate. At deeper depths (over the island shelf and slope) off Kauai and Midway Atoll, sandy bottom species such as rattails, skates, and cod-like fish predominate (Chave and Mundy, 1994).

3.3 ECONOMIC ENVIRONMENT

3.3.1 Commercial, Recreational, and Potential Fisheries

Expansion and diversification of pelagic fisheries and growth in some recreational fisheries led to overexploitation of many fishery stocks in Hawaiian waters during the late 1980's and 1990's (Pooley, 1993). However, recent changes in Hawaiian commercial fisheries, such as reduction in limited entry of permits for bottomfish and lobster, moratoria to new longline fishermen, closed seasons and quotas for lobster, and some area closures have improved some fisheries (Pooley, 1993). All of the above changes are aimed at preserving Hawaiian fisheries.

Hawaii's commercial fishery exceeded $50 million in ex-vessel revenues in 1990, based on a total catch of over 22 million pounds (approximately 10 million kg) (Pooley, 1993). The longline tuna fishery accounted for nearly $29 million of this total. During calendar year 1993, Kauai fishermen caught 17,050 kg (37,588 lbs) of fish in Fisheries Statistical Area No. 523, which encompasses the area offshore of the north Kauai coast. Approximately 15,615 kg (34,425 lbs) were caught by trollers and 1255 kg (2,767 lbs) by bottom fishermen (DLNR, 1994).

Most of the commercial fishing in Hawaii is conducted on the submerged shelves, banks, and slopes of the populated islands and the northwestern Hawaiian Islands. Some of the seamounts in the vicinity of the study area support limited fisheries, with substantially less commercial value than nearshore reef areas (MMS, 1987). Although commercial fishing occurs offshore of nearly all the Hawaiian Islands (including Kauai), none (except the rare tuna fishing boat) occurs in the offshore waters near Midway Atoll (MMS, 1987).

Off Kauai, nearshore fisheries target a variety of fish such as bigeye scad, goatfish, surgeonfish, and squirrelfish. These species are easily accessible in small boats throughout the island. A significant fishery for white crab or Kona crab exists off Niihau (Smith, 1993).

The most commonly caught commercial bottomfish in Hawaii are several species of snapper, grouper, and jacks (Pooley, 1993). Lobster are the primary epifaunal invertebrate collected commercially. Pelagic fisheries off Hawaii include marlin, swordfish, sailfish, mahi mahi, and several tuna species. Pelagic sharks also comprise a significant part of the commercial catch, with blue sharks, mako, and threshers taken in the highest numbers.

Hawaii's nearshore fisheries are quite productive; however, a deepwater fishery also exists for snappers and some tuna (Haight et al., 1993). In fact, the nearshore fisheries produce only a small fraction of the total catch as reported from Hawaiian fisheries on an annual basis (Diaz-Soltero, pers. comm., 1995). Some invertebrates, such as pandalid shrimp are collected in commercial traps at depths between 350 and 825 m (1150 and 2710 ft). At these deeper depths, some species of black coral are taken by commercial divers for the coral jewelry industry (Grigg, 1993; Grigg pers. comm., 1994). Black coral is taken by commercial divers off Maui and off the west and southern coast of Kauai. However, it is unlikely that black coral is taken in the Kauai study area.

The distinction between recreational and commercial fisheries in Hawaii's small boat fleets is extremely difficult. This is due to the fact that many commercial fishermen hold full-time and part-time jobs which provide more income than fishing (Pooley, 1993). Furthermore, charter boat captains usually retain their catch for sale at local markets. These issues have lead to many problems in compiling recreational fishery data.

3.3.2 Mariculture/Aquaculture

Mariculture, or aquaculture, is the farming of aquatic or marine organisms, such as fish, molluscs, crustaceans, and algae. It is currently one of the fastest growing industries in Hawaii, with an annual growth rate in revenues of nearly 13% and an estimated income of over $21 million in 1989 (DLNR, 1990). The variety of organisms raised through aquaculture has increased steadily since 1979, currently representing over 35 different species, including marine shrimp, Chinese catfish, tilapia, carp, rainbow trout, abalone, nori, ogo, spirulina, oysters, salmon, and lobster (DLNR, 1990). Potential new species include mahi mahi, Japanese flounder, baitfish, giant clams, limpets, and sea cucumbers. Ceatech USA has recently opened an aquaculture facility near Kekaha to raise shrimp.

3.3.3 Shipping

The Hawaiian Islands serve as a major port for international shipping, with over 91.2 million tons (82.7 billion kg) of freight worth over $124 billion moved between the U.S. West coast, Alaska, Hawaii, and Far East ports in 1987. Of this, about 22.4 million tons (20.3 billion kg) were handled through Hawaiian ports (Corps of Engineers [COE], 1989). This shipping activity involved 21,325 vessel arrivals and departures from Hawaiian ports.

The two major shipping ports of Kauai are Nawiliwili and Port Allen. Vessel arrivals for 1989 were 1079 for Nawiliwili and 100 for Port Allen (COE, 1991). Freight traffic (tons) for Nawilili for the 5-year period 1985-89 was as follows: 1985 (933,477), 1986 (745,396), 1987 (916,422), 1988 (875,753), and 1989 (1,038,452) (COE, 1991).

3.3.4 Military Usage

The Pacific Missile Range Facility (PMRF) is the largest federal government employer on Kauai, with approximately 850 workers, including tenant organizations and civilian contractors (Pham, 1991). The total annual expenditures for PMRF, tenant organizations, and contractors was $72.5 million for 1990. PMRF had a FY 1991 operating budget of $50.1 million, including a payroll of $29.6 million.

The U.S. Navy began building on Midway in 1938. The Naval Air station was commissioned on August 1, 1941. Midway Atoll was first attacked on December 7, 1941, and the famous "Battle of Midway" took place there in 1942. After the war, the U.S. Coast Guard established a LORAN (Long Range Navigation) station on the island in the 1950's. The U.S. Naval air station closed in 1993 and was vacated following cleanup activity in 1997. The atoll has been transferred to the U.S. Fish and Wildlife Service.

The U.S. Navy's Pacific Fleet, including a variety of ships and submarines, is stationed in Hawaii. No daily estimates for the number of ships or submarines likely to occur in the study region are available (P. McClaran, PMRF, pers. comm., 1994); however, based on general activity levels, it can be assumed that ship and submarine traffic in the vicinity of the Kauai and Midway Atoll sites varies between low and moderate activity levels.

3.3.5 Mineral or Energy Development

The most valuable offshore marine minerals resources in the general region of the Hawaiian Islands and Midway Atoll are cobalt-rich manganese crusts and nodules. The existence of these types of resources on Pacific seamounts has been recognized for at least 20 yrs (HDBED, 1987). Recent surveys, although preliminary in nature, indicate a large potentially exploitable resource in various deep-water (800-2400 m [2620-7870 ft]) regions off the Hawaiian Islands and Midway Atoll. Manganese crust coverage within these areas ranges from 0% (areas of thick sediment cover) to 100% (areas of thick crust "pavements"). Coverage for the Hawaiian axis (i.e., nearly 200 km [108 nm] south of Kauai) is approximately 25%, while other areas average nearly 40%. Manganese nodules, which are relatively rich in manganese, cobalt, iron, nickel, and copper, are abundant over vast areas of the seabed at depths between 4000 and 5000 m (13100 and 16400 ft) (HOMRC, 1991). Initial survey results indicate that little, if any, manganese mining would occur in the vicinity of the proposed action site due to its low crust coverage.

3.3.6 Cultural and Historical Resources

There are no known cultural or historical resources within the Kauai study area. The State Department of Land and Natural Resources, Division of Historic Resources Preservation, does not maintain information concerning shipwrecks.

In "pre-contact" Hawaii (prior to 1778), temporal rule of the islands was divided among a number of alii, or chiefs. Each of these had, in theory, unrestricted control over all the resources within his moku or districts (Meller, 1985). The ahupuaa in which the moku was subdivided, usually had attached to them ocean fishing rights, in some instances not only adjacent to their own shores, but spreading out on each side up and down the coast for many miles (Cobb, 1908). Thus, the alii controlled all fishing rights in their jurisdiction.

Managing the ahupuaa were the konohiki or agents of the alii. The konohiki collected a portion of the harvest of both land and ocean resources on behalf of the alii from the hoaaina or tenants, and placed limitations on the uses of the resources, depending on environmental conditions (Meller, 1985).

The U.S. Congress attempted to extinguish all konohiki fishing rights in the Organic Act of 1900. Section Nine of the Act provided for a 2-year period in which the owners of konohiki rights could register claims to a konohiki fishery with the Territorial Courts, or forfeit all claims to those rights (Meller, 1985). Once the claims were filed, it was the intent of the federal and territorial governments to acquire all rights to the registered konohiki fisheries through condemnation (Clay et al., 1981).

There is some uncertainty as to the total number of konohiki fishing areas and how many were registered before 1903. Meller (1985) estimates between 363 and 720 areas existed, but noted that opinions vary on how many were registered, from a low of about 100 to a high of 144. Because of this uncertainty in the number of registered rights, there is no exact figure as to the number in existence today. Khil (1978) puts the estimate for Kauai as follows: number registered, 9; number condemned, 7; number outstanding, 2. These two are both located on the south shore, at Wahiawa and Omao.

Midway Atoll was shelled by Japanese ships on December 7, 1941. The famous "Battle of Midway" took place there. A historic preservation plan to preserve several structures on the atoll is being finalized. 78 structures and objects were placed on the National Register of Historic places. Some preservation tasks are already underway.

3.4 SOCIAL ENVIRONMENT

3.4.1 Recreational Activities and Tourism

Kauai's economy is dominated by tourism and agricultural industries. Federal government employment is also a major contributor to the local economy, as discussed in Section 3.3.4.

The tourism industry and associated travel-related services employ approximately 16,000 people on Kauai (Pham, 1991). Average earnings per job in this industry was approximately $17,900 in 1990 (Pham, 1991). The Hawaii Visitors Bureau (1991) estimated that 1.3 million people visited Kauai in 1990. Visitor expenditures for 1990 were approximately $945 million (Hawaii Visitors Bureau, 1991).

According to Townsend (1991), the major recreational activities on Kauai are fishing, boating, diving, snorkeling, surfing, waterskiing, whale-watching, sea kayaking, parasailing (commercial), and riding pleasurecraft (private and commercial). In 1998, Governor Cayetano closed the Hanalei ocean tour boat industry. A handful of operators were allowed to continue operations on a temporary basis; these operators have sued the State and are continuing to operate under a court order (Utech, 1999). The majority of operators moved their business to the west coast of Kauai, particularly the Port Allen small boat harbor. The results of this shift are that larger vessels are favored because the trip to the Na Pali coast, the main destination for most Kauai ocean tours, is longer from the west coast. 3-15

Direct revenues in 1999 from the respective ocean tours were $0.9 million for whale watching, $17.1 million from snorkeling, and $3.7 million from sunset cruises. The total economic impact from the respective ocean tours was estimated as $1.6 million and 23 jobs for whale watching, $29.3 million and 420 jobs for snorkeling, and $6.4 million and 92 jobs for sunset cruises (Utech, 1999). In April 1999, a large vessel that had operated dinner cruises on Maui shifted to Kauai; however, the total estimate of dinner cruise revenues across these two islands should not be greatly affected by this change (Utech, 1999).

The recent closing of the base at Midway has allowed numerous recreational activities to be offered. Sport fishing, diving and wildlife watching activities now take place on Midway Atoll. Due to its remote location, essentially no commercial fishing occurs in the area, although tuna boats occasionally fish the general region (Environmental Protection Agency [EPA], 1985).

3.4.2 Research and Education

Ocean research and education is extremely important for long-term success of the Hawaii Ocean Resources Management Plan. While most of the research and education activities in Hawaii are centered on Oahu, new marine resource centers and research facilities are being established on or are planned for the neighbor islands (HOMRC, 1991). The only college-level facility presently on Kauai is Kauai Community College (KCC). While KCC does not specialize in marine research, many local public school systems have formal marine education programs.

Modern support facilities at several locations in the Hawaiian Islands, primarily on Oahu, provide researchers with an extensive infrastructure for services such as satellite communication and tracking, marine laboratory analyses, marine surveying and brokering, and ship maintenance facilities. Other institutional facilities for marine research are associated with the U.S. Navy, the University of Hawaii's School of Ocean and Earth Science and Technology, the Law of the Sea Institute, and various federal government agencies, including Marine Minerals Technology Center (Department of the Interior [DOI]), the Pacific Mapping Center (Department of Commerce [DOC]/DOI), and the Center for Tropical and Subtropical Aquaculture (Department of Agriculture [DOA]). Most of these facilities are located on Oahu and the Big Island (NOAA, 1994).

No formal educational facilities exist on Midway Atoll; however, this site has functioned as a research facility for numerous agencies, most notably the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS). The Oceanic Society, a private ecotourism group, has begun funding research on Midway.

3.4.3 Water Contact Sports

Shoreline usage and water contact sports are highly important activities for Hawaii's residents and many tourist industries (HOMRC, 1991). Based on 1985 State Comprehensive Outdoor Recreation Plan (SCORP) statistics, at least 170,000 people swim or sunbathe at beaches or shorelines daily. Further, other daily usage includes almost 23,000 surfers, 25,000 fishermen (from onshore and boats), 3000 canoers and kayakers, 18,000 boaters, and more than 21,000 scuba divers (HOMRC, 1991). Other popular water sports include windsurfing, sailing, and catamaran sailing. Diving and snorkeling are some of the most popular recreational activities in Hawaii, mostly occurring around inshore coral reefs.

Generally, the north coast beaches off Kauai are the best for swimming, snorkeling, and diving in summer, and surfing in winter. Better conditions for swimming and snorkeling along the south coast occur in winter. Many locations on the north coast offer safe swimming, snorkeling, and diving, including Kalihiwai Beach Park, Ke'e, Hanalei Bay, Anini Beach, Haena, and Moloaa (Sunset Book, 1975). Some of the most popular areas on the south coast of Kauai for diving and snorkeling include Poipu Beach, and Kukuiula (AAA Tour Book, 1992).

The recent ecotourism concession brings snorkelers and divers to the nearshore waters around Midway. Sport fishing vessels operate from Midway as well. Snorkeling and diving by researchers likely occurs in the shallow nearshore and lagoon areas.

THIS PAGE INTENTIONALLY LEFT BLANK

4 ENVIRONMENTAL CONSEQUENCES

This chapter forms the scientific and analytical basis for comparing the three alternatives (Preferred Alternative, No Action Alternative, Midway Alternative) presented in Chapter 2. It describes the potential effects of the alternatives on the affected environment described in Chapter 3. The chapter is organized first by resources (i.e., physical environment, biological environment, and socio-economic environment), followed by a discussion of minor and secondary potential effects in a section on "other impacts."

Each subsection analyzes the potential effects of the three alternatives, both individually and cumulatively. Cumulative impacts are those effects on the environment that could potentially result when the proposed action is added to other past, present, and reasonably foreseeable future actions. Mitigation measures for each potential effect are identified, where applicable, and then described in detail in Chapter 5.

4.1 POTENTIAL EFFECTS ON THE PHYSICAL ENVIRONMENT

This section considers the potential effects of the three alternatives on the physical environment. The physical environment includes characteristics of the seafloor (e.g., the composition of sediments, the slope of the seabed) and the surrounding seawater (e.g., salinity, temperature, ambient noise). Potential effects include disturbance of the seafloor through removal of the sound source and cable at Kauai (No Action Alternative and Midway Alternative) and through installation of sound source facilities at Midway Island (Midway Alternative), and the increase in underwater sound levels that would occur during source operations (Preferred Alternative and Midway Alternative). A discussion of potential cumulative effects is also included. The potential effects of the sound source on biological resources are discussed below in Section 4.2.

4.1.1 Potential Direct or Indirect Effects on the Physical Environment

4.1.1.1 Construction and Removal of Facilities

Direct physical impacts of the installation or removal of project facilities would be considered important if they could lead to problems with regard to slope instability, safety or other hazards (including hazards to navigation), threat of release of hazardous substances, or other incompatibilities with the physical environment.

The physical installations associated with the Midway Alternative are relatively minor and generally are benign with respect to the physical environment. The Midway Alternative would involve the placement of a sound source with a footprint of 5.95 m^2 (64 ft^2), with no alteration of the seafloor contours. The cable would need to be laid through the shoreline band, with associated trenching (nominally 1 m [3.3 ft] deep) and the installation of a pipe that would protect the cable from wave action and prevent movement. At deeper depths, the cable would be routed through frequent surge channels in the coral atoll to avoid cable suspensions and coral surfaces. Existing physical structures on Midway Island could probably be used for the shore station, reducing the need for additional development within the national wildlife refuge.

However, activities associated with the maintenance of the shore station, cable, and sound source could potentially increase use of the national wildlife refuge, but on a limited basis.

The No Action Alternative and the Midway Alternative involve the removal of the sound source and cable presently in place off northern Kauai. Since the cable has been on the seafloor for 6 years, natural processes such as sediment drift are likely to have buried the cable, especially in areas where the seafloor is primarily sand. Depending on the characteristics of the sediment, the cable may be lying on the seafloor surface in some areas and buried 2.54 cm (1 in) to 30.5 cm (1 ft) in other areas. Under the Preferred Alternative, the cable will have been on the seafloor for approximately 12 years, and can be expected to be even more deeply buried and integrated into the benthic (seafloor) environment. PMRF conducted an ROV survey of cables on the west-northwest side of Kauai in 1995 out to water depths of approximately 300 ft (100 m) (Dick, pers. comm., 2000). Mr. Dick stated that the ATOC cable was encountered during the ROV survey, and that it was buried under sand and barely visible. He said that when the cable was laid, a concerted effort was made to place the cable along the 300 ft (100 m) depth contour where the 4-1
sediment consists of a prehistoric drowned beach; therefore it is likely that the majority of the cable along this depth contour is buried by sand. Furthermore, the existing seashore interface cable that the ATOC cable was connected to has been in place for approximately 20 years, and photos document massive coral growth on that 0.7 nm section (Dick, pers. comm., 2000). Mr. Dick commented that, to depths of approximately 200 ft (61 m), the ATOC cable also has coral growing on it, but not to the same extent since it hasn't been in place as long as the seashore interface cable. Therefore, removal of the cable could result in damage to the coral that has begun to grow on it.

The cable route lies partly within the PMRF-Barking Sands, which is operated by the U.S. Navy. Installation of the cable along a relatively shallow route through the PMRF was expected to avoid any interaction with PMRF activities or facilities. In 1998, PMRF training and testing capabilities were expanded with addition of the Shallow Water Training Range (SWTR), which includes sensitive instrumentation in the region of the ATOC cable's southwestern reach. In February 1999, ATOC project principals learned that cables of the SWTR facilities overlie the ATOC cable in seven locations (Figure 2.1-3, PMRF Shallow Water Training Range cables and ATOC cables). PMRF has advised that the SWTR cables cannot be moved to enable recovery of the ATOC cable because of the high risk of damaging the cables or in-line sensors during the recovery process, and because of the tremendous costs involved (Letter 26 May 1999, PMRF Executive Officer L. B. Barfoot to Dr. P. Worcester, Scripps).

Mitigation Measure 6: For the Midway Alternative, the portions of the cable and any protective casing in the nearshore area and surf zone would be designed to minimize the potential for adverse effects.

Mitigation Measure 7: For the Preferred Alternative and the Midway Alternative, the source cable, and possibly the sound source, would not be removed at the end of the experiment.

4.1.1.2 Underwater Sound

Generally Hawaii EIS Law and implementing regulations identify the effects of underwater sound as those that result in a substantial increase in the ambient noise levels for adjoining areas. Marine biologists consider that some negative effects due to present-day ocean noise pollution may already be occurring to marine animals. The potential for effects also exists where land use compatibility standards, such as those defined by the State of Hawaii, are exceeded.

Habitat uses by marine organisms and oceanographic acoustic research are the primary noise-sensitive uses in the project vicinity. No human land use incompatibilities or corresponding noise impacts are presented.

In terms of the sound fields of the fixed sources, all alternatives except the No Action Alternative would add somewhat to the ambient noise levels in the vicinity of the sound source during transmission periods. Monitoring aircraft would also add somewhat, on an intermittent basis, to ambient noise levels.

Mitigation Measures 1 & 3: The duty cycle and power levels of the source have been adjusted to the minimum necessary to support research objectives.

4.1.1.3 Other Potential Physical Effects

Source installation, operation, or removal at either of the site alternatives would have no adverse effect on any water column characteristics (temperature, salinity, or dissolved oxygen), or on the regional geology (sediments, seismicity, or bathymetry).

4.1.2 Potential Cumulative Effects on the Physical Environment

NEPA defines a cumulative effect as "…the impact on the environment which results 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. Cumulative impacts can result from individually minor, but collectively significant actions taking place over a period of time." (50 CFR 1508.7) A closely similar definition is included in rules implementing the Hawaii EIS Law.

As mentioned above, the physical environment includes characteristics of the seafloor (e.g., the composition of sediments, the slope of the seabed) and the surrounding seawater (e.g., salinity, temperature, ambient noise). The potential effects of the sound source on biological resources are discussed below in Section 4.2.

4.1.2.1 Construction and Removal of Facilities

Neither the north Kauai or Midway Atoll area is a likely site for new commercial or other subsea cable installations, and development restrictions along the north Kauai coast and on Midway Atoll are likely to prevent substantial future large-scale onshore development. As a result, no major development of facilities similar to or related to the project cable and onshore equipment installations are anticipated.

As discussed above, the potential effects of cable installation and/or removal on the physical environment (for the No Action and Midway alternatives) are expected to be minimal. Thus, it is not anticipated that this action, when added to other past, present, and reasonably foreseeable future actions, would result in cumulative impacts.

4.1.2.2 Underwater Sound

Noise from the source would be expected to add to the ambient noise levels in the vicinity of the source (intermittently during the 2-8 percent of the time the source would be transmitting). Other sources of noise which contribute to the ambient noise levels are either natural (e.g., wind, waves, marine life, seismics) or human-related (e.g., from vessels, aircraft, and onshore and nearshore construction). The potential cumulative effect of noise produced by monitoring aircraft during the course of research would be negligible, contributing less than 1 dB to the total overall ambient noise in the study area while the aircraft are operating.

No other ocean acoustics research activities (past, present, or future) are anticipated to cumulate with potential effects of the NPAL source transmissions on the physical environment. Any effect the ATOC project may have had on ambient noise ceased when transmissions stopped (October, 1999). Furthermore, a single sound source in the mid-Pacific provides adequate coverage to receivers in the eastern and North Pacific for studies of large-scale acoustic thermometry and long-range sound propagation, and additional sources should not be required near Kauai. It can be anticipated that a number of unrelated, regional, short-term, ocean acoustic tomography projects will be conducted at various locations in the North Pacific Ocean over the next five years. The Ocean Acoustic Observatory Federation, for example, deployed an autonomous HLF-5 acoustic source (described in Section 2.1.5) on Hoke Seamount in the eastern North Pacific as part of a system to monitor the California Current. The source was installed in April 1999 and is projected for recovery during May 2000. As a second example, the Farfield Program of the Hawaii Ocean Mixing Experiment is funded by the National Science Foundation to deploy an array of four HLF-5 sources in the central North Pacific to study the role of tidal dissipation in ocean mixing. The plan is to install a triangular array with a fourth source in the center a few hundred kilometers on a side north of the Hawaiian Ridge during May 2001. The entire array would then be picked up and moved south of the Hawaiian Ridge during September 2001. All of the instrumentation would be recovered during April 2002.

In all cases for which definite information is available, the sources operate at significantly higher frequencies (250 Hz for the HLF-5 source) than the proposed NPAL source. They would be located at depths well below the near-surface region, where most of the potentially affected marine species are found, and in mid-ocean locations well outside the coastal zone, in regions where the abundances of potentially affected marine species are very low. The output power level of the HLF-5 sources used in the projects mentioned above is only 132 Watts, 50% of the power level of the ATOC source (192 dB re 1 μPa at 1 m vs. 195 dB re 1 μPa at 1 m). The transmissions typically last only about 2 minutes or less, and the overall duty cycle is typically only about 0.3 percent due to the constraints imposed by the limited battery packs that are feasible for autonomous operation. All of these characteristics are possible because the signals are designed for regional experiments and are not adequate for transmissions over 3000-5000 km ranges, as was discussed in Chapter 2.

The implications are that the individual regional projects would be expected to have only negligible effects on the environment. For the projects described above, the 250-Hz signals would be below the background ambient noise levels at both the Kauai and Midway locations and so no cumulative impacts are anticipated with the transmissions from the proposed NPAL source.

PMRF currently has no environmental authorization to conduct active underwater acoustic tests. Therefore, cumulative effects from their activities are limited to transits of vessels. Since PMRF and its shallow water training range are located approximately 12 nm from the ATOC sound source, the cumulative sound level from the radiated noise of vessels on the range and transmissions from the ATOC sound source would be negligible. Other military training missions involving active sonar occur throughout the Hawaiian Islands, however none are known to occur within 93 km (50 nm) of the Kauai source. In its Draft EIS, geographic restrictions on the employment of the Navy's Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar state that it would not generate a sound field greater than 180 dB within 22 km (12 nm) of any coastline, nor would it exceed 145 dB in the vicinity of known recreational and commercial dive sites. Therefore, none of these military activities should cumulate with the proposed action. 4-2

Other than potential general increases in vessel traffic through the project vicinity, and onshore development of various kinds, no other human activities (past, present, or future) are anticipated to cumulate with potential effects of the source transmissions on the physical environment. Any cumulative effect of past, current, and future human noise-producing activities (e.g., vessel traffic, oceanographic research, military activities) with the short duty cycle of the sound transmissions are expected to be minimal. While human-related sources of noise may increase over time with increases in population, economic activities and resulting traffic levels, any such increase is speculative.

4.2 POTENTIAL EFFECTS ON THE BIOLOGICAL ENVIRONMENT

This section discusses the potential effects of the three alternatives on the biological environment which was described in detail in Chapter 3. Such effects include potential disturbance of the seafloor community through removal of the sound source and cable at Kauai (the No Action and Midway alternatives) and through installation of sound source facilities at Midway Island (the Midway Alternative), and potential effects of the sound source on marine mammals and sea turtles, as well as on fish and diving seabirds that could occur during source operations (the Preferred and Midway alternatives). A discussion of potential cumulative effects is also included.

4.2.1 Potential Direct or Indirect Effects on the Biological Environment

4.2.1.1 Construction and Removal of Facilities

During installation of the sound source and cable in the Midway Alternative, every precaution would be made to avoid contact with coral, since not only would this damage the coral, but it would also damage the cable. It is highly unlikely that any organisms could become entangled in the cable as it was being laid since the cable consists of a single line and there would be no loops or kinks in it. In addition, few, if any, plants or animals living on the seafloor would be damaged by the cable since the cable's diameter is only 3.18 cm (1.25 in). However, Hawaiian monk seals, a severely endangered species, use the beaches of Midway Island for breeding and pupping, and recent increases in pup survival at Midway suggest that the seals may reestablish the atoll as a major breeding site. Therefore, activities associated with the installation of a power cable may disrupt their behavior.

Associated with the No Action and Midway alternatives would be removal of the sound source and some or all of the cable presently located north of Kauai. Removal of these facilities could potentially disrupt organisms living on the seafloor since the cable has probably been buried by sediment over the past 6 years, and removing the cable would displace this sediment. Any plants or animals which have rooted themselves in the sediment would therefore also be displaced. In those regions where the cable is not buried, it is possible that new coral may have begun to grow on the cable. PMRF has discovered significant coral growth on many of its underwater cables.

4.2.1.2 Underwater Sound

The second type of potential effect is that associated with the source transmissions. There is a lack of information regarding large whales because they are difficult to study. In many areas, potential effects must be inferred from incomplete data. The following section must be reviewed with this caveat in mind.

Under the No Action Alternative, no acoustic transmissions would occur. Thus, no potential acoustic effects would result from implementing this Alternative. For the Preferred and Midway alternatives, generally speaking, the range of potential acoustic effects can be summarized as follows:

Death: The potential for death to any marine animal as a result of the proposed research is considered nonexistent.

Direct Damage to Hearing Receptors: At the extreme end of the range of hearing impacts are pressure-induced injuries associated with explosions or blunt cranial impacts that cause an eruptive injury to the inner ear (frequently coinciding with fractures to the bony capsule of the ear or middle ear bones and with rupture of the eardrum). Based on analysis of available data (Chapter 4), no such pressure-induced injuries to hearing structures of marine animals is expected from this project.

Permanent Threshold Shift: A permanent threshold shift (PTS) is, as the name suggests, an increase in the threshold of hearing that is permanent, not temporary (Ketten, 1998). PTS generally occurs as a result of long-term exposures and/or extremely loud noises. Repeated exposures to any signal strong enough to cause temporary threshold shift (TTS) can induce PTS, as well. Based on analysis of available data, no PTSs to marine mammals or sea turtles are expected from this project. The potential for PTS to fish is minimal.

Temporary Threshold Shift: Temporary threshold shift, or TTS, is an increase in an individual animal's hearing threshold in response to a loud sound. All humans typically experience such shifts directly, such as the effect that occurs after leaving a noisy room to a quiet location. For a period of time, the threshold of hearing is increased such that quiet sounds are not perceived. A TTS slowly dissipates so that original hearing abilities return. TTS generally occurs at sound intensities well above threshold hearing levels. In humans the difference between the threshold of hearing and sound intensities that result in TTS is approximately 80 to 100 dB, i.e., a ratio of as much as 10 billion to 1 (Richardson et al., 1995). Based on analysis of the best available data (Ridgway et al., 1997), TTSs are only anticipated for animals venturing very close (within approximately 5-10 m [16-33 ft]) to the sound source.

Behavioral Disruption and Habituation: Sounds can result in behavioral changes in movement patterns that can range from those that are so minor that they can only be detected through sophisticated statistical analysis, to more dramatic actions such as marine mammal breaching, rapid swimming, and temporary or permanent displacement from an area. Infrequent and minor changes in movement directions, for example, may be completely benign, while more frequent or recurrent incidents of interrupted feeding and rapid swimming, if sufficiently frequent and of prolonged duration (e.g., bowhead whales have stopped feeding and fled from approaching boats [Richardson et al., 1986]), could have negative effects on individuals. Behavioral changes generally are not detected for sounds that are barely detectable or perceivable to a marine animal.

Animals that appear to tolerate human-made noise are presumed to be less affected by a noise source. In some cases, this can be attributed to habituation - the potential for an animal over time to become less sensitive to certain types of noise and disturbance to which they repeatedly are exposed and which they come to perceive as non-threatening. However, the presence of marine mammals in an ensonified area does not prove that the population or individual therein is unaffected by the noise, as they may stay in the area despite the presence of noise disturbance if there are no alternate areas that meet their requirements (Brodie, 1981).

Masking: All marine animals have a threshold level below which they cannot hear. In the environment, this threshold is determined by the higher of two levels - the ambient noise level surrounding the animal or the limits of their physical ability to hear. In other words, animals cannot hear sounds that are less intense than background noise at similar frequencies, and sounds louder than background levels can only be heard if the animal is physically capable of doing so. Increases in ambient noise will increase the threshold intensity for detectable sounds (for those animals whose hearing threshold is below those ambient levels). This effect is commonly known as masking. Masking of significant sounds (e.g., calls of other animals, such as predators or prey; sounds of hazards, such as approaching boats, etc.) can occur when the ambient noise levels at similar frequencies increase.

Marine mammals are believed to be well-adapted to coping with a naturally noisy and variable ocean environment, and likely to have tolerance to some increase in masking relative to natural and human-made levels. However, the thresholds of this tolerance currently are unknown and cannot be determined until there is a better understanding of: 1) the vital functional importance to mammals of faint sound signals from the same species, predators, prey, and other natural sources; 2) signal detection abilities of marine mammals in the presence of background noise, including directional hearing abilities at frequencies where masking is an issue; and 3) abilities of marine mammals to adjust the intensities and perhaps frequencies of emitted sounds to minimize masking. It is probable that localized or temporary increases in masking normally cause few problems for marine mammals, with the possible exception of populations that are highly concentrated in an ensonified area. However, a more extensive and continuous noise field could result if a number of noise sources were distributed through a major part of the range of a marine mammal population. Masking might be more of a problem in such cases (Richardson et al., 1991).

All of the discussions below evaluate potential impacts of underwater exposures. It is not anticipated that any impacts would occur as a result of sound transmissions received in air by animals at the surface (e.g., albatrosses, or monk seals with their heads out of the water) because the maximum possible received level in air would be only 74.5 dB directly over the source (SL [195 dB] – TL [20 log (800 m or 2546 ft)=58 dB] – water-to-air correction [62.5 dB], and this level would be attenuated even further by the water/surface interface (i.e., by at least 5-10 dB). It is not anticipated that any animals would respond directly to noises of this magnitude.

Scientific Uncertainty

Prior to the ATOC Project and its associated MMRPs, available information on subsea noise and its biological impact in many cases was incomplete to nonexistent, depending on the species being considered. As summarized in Section 1.2.2, the results of the MMRPs demonstrate no overt or obvious short-term changes in abundance, distribution, or behavior. However, limited data exist to estimate the potential for long-term effects. Consequently, where relevant, this EIS identifies and states the relevance of areas of incomplete or unavailable information, summarizes existing credible scientific evidence relevant to evaluating any potential adverse effects, and evaluates the potential for such impacts based upon theoretical strategies and research methods which are generally accepted in the scientific community.

As set forth below, the NPAL project is not anticipated to result in potentially significant impacts on biological resources. This conclusion is based on available information regarding the species potentially affected, particularly the results of the MMRPs. Potential impacts on biological resources are limited by the relatively temporary nature of the NPAL experimental activities, which will span at most a five-year period of transmissions, and the limited duty cycle of the sound source (on 2-8 percent of the time, off the remaining 92-98 percent). It is also limited by the fact that relatively few of the marine mammals that could inhabit the study area are known to dive to depths that would put them in proximity to sound fields that could disrupt biologically significant behaviors.

For many marine animals, the means of obtaining additional information on adverse effects are unknown, and/or the costs high. The ability to obtain information concerning hearing capabilities and impacts of subsea sounds is in most instances limited by the nature of the animals involved. Large whales only can be studied in the wild, often are rare and difficult to approach, or even find. Therefore, to date, hearing abilities have not been measured directly but instead must be inferred. The sheer number of species also would render a comprehensive survey exorbitantly expensive and unwieldy. The Marine Mammal Monitoring Studies would be designed to obtain much-needed information on the potential for long-term effects.

This EIS contains an expansive analysis, acknowledging the lack of information, stating its relevance to the analysis, summarizing existing evidence, and evaluating the potential effects based on available information. As an integral part of the proposed action, the Marine Mammal Monitoring Studies would attempt to fill several of the gaps in available information concerning potential long-term effects.

4.2.1.2.1 Marine Mammal Species

This section pertains to the marine mammals in the north Kauai and Midway Island coastal regions that were introduced in Chapter 3. It presents information on the potential behavioral and physical auditory effects of low frequency noise on the various species and the potential cumulative impacts of noise from the alternatives in combination with other human-related noise and activities. Conclusions are provided on the potential acoustic effects of the Preferred Alternative and the Midway Alternative based on a literature review, the results of the ATOC MMRPs, and a comprehensive program of underwater acoustical modeling.

As detailed below, the MMRPs' results, the acoustical modeling, and the risk assessment provide an estimate of potential environmental impacts to marine mammals. These potential effects, including TTS, behavioral disruption, habituation, auditory interference by masking, and long-term effects, are described below for the Preferred and Midway alternatives.

California and Hawaii MMRPs Results

The California and Hawaii ATOC MMRPs were designed to determine the potential effects of the acoustic transmissions on marine mammals and other marine life. The following components relate to marine mammals:

- Aerial surveys designed to determine any changes in the abundance and distribution of marine mammals in the vicinity of the Pioneer Seamount source;
- Elephant seal tagging studies designed to determine any changes in elephant seal migratory or diving behavior in response to the Pioneer Seamount source transmissions;
- Playback studies to humpback whales off the Kona-Kohala coast of Hawaii designed to look for behavioral changes in response to ATOC-like sounds prior to the actual ATOC source transmissions north of Kauai;

- Aerial surveys designed to determine any changes in the abundance and distribution of humpback whales north of Kauai when the ATOC source was transmitting compared to measurements made in previous years when the source was not transmitting;
- Visual observations of humpback whale abundance, distribution, and behavior north of Kauai to determine if there were any changes in response to the ATOC transmissions;
- Undersea acoustic recordings made with seafloor data recorders north of Kauai to determine any changes in humpback vocalizations in response to the ATOC transmissions; and
- Auditory measurements on small toothed whales (odontocetes) to determine their sensitivity to the frequencies transmitted by the ATOC sources.

Abundance and distribution. Neither MMRP found any overt or obvious short-term changes in the abundance and distribution of marine mammals in response to the transmissions of the ATOC sound sources. Calambokidis et al. (Costa et al., 1998), surveying the waters in an 80 km by 80 km (43 nm by 43 nm) box centered on the California ATOC source, and Mobley et al. (1999b), surveying the waters within 40 km (22 nm) of the Kauai ATOC source, showed no significant changes in the abundance of humpback and sperm whales from the control periods when the source was not operating, to the experimental periods when it was. Only humpback whales were seen in sufficient numbers in the survey area around the Kauai source to permit quantitative assessments of distributional changes from 1994 (source off) to 1998 (source on). The distance from each sighting to the ATOC source and the distance from each sighting to shore were computed, and the mean distances compared between the two years. The mean distance offshore and distance from source were both slightly greater during 1998; however, these distances were not significant (Mobley, 1999b). Intensive statistical analyses of aerial survey data showed some subtle shifts in the distribution of humpback (and possibly sperm) whales away from the Pioneer Seamount source during transmission periods (Costa et al., 1998). No statistically significant shifts in distribution were found for any other species of marine mammal. Visual observation data from the Kauai MMRP showed a similar small shift in mean distance of humpback whales away from the Kauai source during transmission periods. 4-3

The Hawaiian aerial survey protocol was designed in consultation with National Marine Mammal Laboratory (NMML) in Seattle, Washington, to allow for line transect-based population estimates. Aerial surveys throughout waters adjoining the eight major Hawaiian Islands were performed in 1993, 1995 and 1998. Comparison of the 1993, 1995, and 1998 population estimates for humpback whales show a nearly statistically significant increase on the order of 8 percent annually (Mobley et al., 1999c). Dr. Mobley is currently flying another set of surveys in the 2000 season to increase the accuracy of the population trend data. Independent photo-id based estimates are showing similar rates of increase in the humpback whale population (Calambokidis, 1999).

Behavioral measures. Neither MMRP found any overt or obvious short-term changes in the behavior of humpback whales in response to the playback of ATOC-like sounds, nor elephant seals or humpback whales in response to transmissions of the ATOC sound sources. Northern elephant seals tagged with satellite, swim-speed, time-depth, and acoustic data loggers were released seaward of the operating California ATOC source, and their return to Año Nuevo rookery was studied. No statistically significant changes were found in any behaviors measured 4-4

(Costa et al., 1998). In 1996, the behavioral responses of humpback whales to the playback of ATOC-like signals (maximum received level of 130 dB) were studied. Humpback whales showed no overt responses to these ATOC playbacks (Frankel and Clark, 1998). By contrast, the single playback of a humpback whale feeding call provoked dramatic changes similar to those seen in previous playback experiments (Mobley et al., 1988). In 1998, the behavior of humpback whales during transmissions from the fully-operational Kauai ATOC source was observed from a shore-station on the north coast of Kauai (Frankel and Clark,2000). Intensive statistical analyses revealed some subtle changes in the behavior of humpback whales in response to the playback of ATOC-like sounds and to the transmissions of the ATOC Kauai source (Frankel and Clark, 1998; Frankel and Clark,2000). Both studies found that the distance and time between successive whale surfacings (segment length and segment duration) increased slightly with increasing sound levels. This result is not what would be predicted, in that if the animals were stressed by the sound source, it might be expected that they would remain at the surface longer because of the lower received levels there. Longer dive durations would correspond to increased exposure to the sound source. No statistically significant changes were found in any other behaviors measured.

Vocalizations. The Hawaii MMRP did not find any overt or obvious short-term changes in the singing behavior of humpback whales in the vicinity of the sound source north of Kauai. No statistically significant changes in the underwater sound output from humpback whales in one of the frequency bands in which they vocalize was found in the vicinity of the Kauai source.

Audiograms. Audiograms of two species of dolphins showed that their hearing is poor at the frequencies transmitted by the ATOC sources (Au et al., 1997). The animals would have to be extremely close to an ATOC source simply to be able to detect the transmissions.

All of the effects detected by the MMRPs were subtle and found only after intensive statistical analyses. Bioacoustic experts concluded that these subtle effects would not adversely impact the survival of an individual whale or the status of the North Pacific humpback whale population (Frankel and Clark, 2000).

Acoustic Modeling

- To assess the potential environmental impact of the sound source, it was necessary to predict the sound field that a given species could be exposed to over time. This was a three-part process involving:

- the ability to measure or estimate an animal's location in space and time;

- the ability to measure or estimate the sound field at these times and locations; and

- the integration of these two data sets to estimate the potential impact of the sound source on a specific animal. The computer models used to develop these analyses are described below.

- Next, the relationship was developed between marine mammal exposure to LF sound and the risk of a biologically significant behavioral response that affects biologically important activity, such as survival, breeding, feeding and migration, which have a potential to impact on the reproductive success of the animal. 4-5

- Using the results of acoustic modeling, the potential effects of the LF sound source were assessed in relation to received levels (RLs) and repeated exposure. The development of this risk analysis process (risk continuum) is described below.

The acoustical modeling process for this EIS was accomplished using the Navy's standard acoustic performance prediction transmission loss (TL) model--Parabolic Equation (PE) version 3.4. The results of this model are the primary input to the Acoustic Integration Model (AIM).

Parabolic Equation Model

The PE model is one of the validated acoustic propagation loss models in the Navy's Oceanographic and Atmospheric Master Library (OAML). 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;
- 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, when available, or DBDB 5 otherwise, 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 as a function of range and depth. PE plots for the Preferred Alternative are included in Chapter 2, Figures 2.1-5 and 2.1-6.

Acoustic Integration Model

The AIM was used in this analysis to estimate animal sound exposures. The model is based on accepted scientific methodologies for estimating the potential exposure of marine animals to LF sound. In general terms, AIM simulates:

- Characteristics of marine animals (e.g., species distribution, density, diving profiles, and general movement);
- Sound transmissions (e.g., SL, duty cycle, transmission length); and
- The predicted sound field for each transmission.

Thus, AIM simulates acoustic exposure during a typical NPAL source transmission. Tables 4.2-1, 4.2-2, and 4.2-3, respectively, provide AIM input parameters for animal movement, diving behavior, and distribution, abundance, and density. Abundance estimates for the Hawaiian populations in the vicinity of the Preferred and Midway alternatives are scarce (Barlow et al., 1996). Wade and Gerrodette (1993) estimated the abundance of cetacean populations in the eastern tropical Pacific, but there are limited data for a population estimate in Hawaiian waters. Therefore, the aerial survey data of Mobley et al. (1999b) represent the best available data for distribution and abundance of marine mammals in Hawaiian waters (see Table 3.2-1).

In more detail, AIM is composed of three separate elements. The first element calculates the projected 3D sound field from a description of the source and the environment. 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 nm^2; (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 depth 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 =100 percent).

For the NPAL sound source, in which the typical transmission is 20 min in length, each transmission was divided into 20 1-min "pings," to more accurately represent the animals' diving behavior and movement patterns.

The variability in animal behavior with respect to dive pattern, start location, and course/speed are simulated through the use of random variables. Each animal's turning tendencies (labeled

Table 4.2-1 AIM Input Parameters for Animal Movement

Species	Sites	Swim Speed	Interval of Course Change	Angular Range of Course Change
all animals	both sites	3 knots/ 1.5 m/s	1 minute	360°

Table 4.2-2 AIM Input Parameters for Diving Behavior

Species	Dive Profile Zones (ft/m)							
	Surface	%	Transition	%	Avg 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
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
sperm, beaked whales	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
short-finned pilot, melon-headed 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
Risso's, rough-toothed, bottlenose, striped, spotted, spinner 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
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 4.2-3 AIM Input for Distribution, Abundance, and Density

Site	Species	Abundance Estimate	Site Estimate[1]	Distribution, Abundance, and Density Information
Kauai	humpback whale	3852[2]	305	64% of humpback whales sighted in water less than 182 m (600 ft).
	fin whale	N/A[3]	1	Primarily pelagic, but found along shelf areas during feeding.
	sperm whale	N/A[3]	33	Found at highest density over waters deeper than 1830 m (6000 ft).
	dwarf and pygmy sperm whales	N/A[3]	4	Especially common along continental shelf breaks.
	Blainville's beaked whale	N/A[3]	4	Found at highest density over waters deeper than 1830 m (6000 ft).
	Cuvier's beaked whale	N/A[3]	2	Found at highest density over waters deeper than 1830 m (6000 ft).
	short-finned pilot whale	N/A[3]	160	More common over waters deeper than 1830 m (6000 ft).
	false killer whale	N/A[3]	55	Especially common along continental shelf breaks.
	melon-headed whale	N/A[3]	44	Found at highest density over waters deeper than 1830 m (6000 ft).
	Risso's dolphin	N/A[3]	3	Not common around the Hawaiian Islands. Even distribution across water depths.
	rough-toothed dolphin	N/A[3]	29	Common in offshore waters, typically occurring over bottom depths greater than 500 m (1640 ft).
	bottlenose dolphin	N/A[3]	41	Found in similar densities over all water depths.
	striped dolphin	N/A[3]	17	Not common around the Hawaiian Islands. Even distribution across water depths.
	spotted dolphin	N/A[3]	137	Especially common along continental shelf breaks. Feed primarily in offshore waters.
	spinner dolphin	N/A[3]	210	Found at highest densities in waters less than 1830 m (6000 ft).
	Hawaiian monk seal	1423[4]	16	Found occasionally in waters less than 1000 m (3281 ft), rarely in deeper waters.

4-6

Note 1: Site estimate derived from aerial survey data in Mobley et al. (1999b).
Note 2: Population estimate of humpback whales wintering around the Hawaiian Islands from 1998 aerial survey data (Mobley et al., 1999c).
Note 3: N/A = Not Available. NMFS has not estimated the abundance of the Hawaiian stock for this species (Barlow et al., 1996).
Note 4: Minimum stock estimate (N_{min}) from 1999 NMFS Stock Assessment Report (Forney et al., 1999).

Table 4.2-3 AIM Input for Distribution, Abundance, and Density

Site	Species	Stock Estimate	Site Estimate	Distribution, Abundance, and Density Information
Midway	blue whale	N/A[3]	4[2]	Primarily pelagic, but found along shelf areas during feeding.
	fin whale	N/A[3]	4[2]	Primarily pelagic, but found along shelf areas during feeding.
	Bryde's whale	N/A[3]	21[2]	Found occasionally in waters less than 1000 m (3281 ft), rarely in deeper waters.
	minke whale	N/A[3]	21[2]	Found occasionally in waters less than 1000 m (3281 ft), rarely in deeper waters.
	sperm whale	N/A[3]	27[1]	Found at highest density over waters deeper than 1830 m (6000 ft).
	dwarf and pygmy sperm whales	N/A[3]	3[1]	Especially common along continental shelf breaks.
	Blainville's beaked whale	N/A[3]	4[1]	Found at highest density over waters deeper than 1830 m (6000 ft).
	Cuvier's beaked whale	N/A[3]	2[1]	Found at highest density over waters deeper than 1830 m (6000 ft).
	melon-headed whale	N/A[3]	39[1]	Found at highest density over waters deeper than 1830 m (6000 ft).
	Risso's dolphin	N/A[3]	2[1]	Not common around the Hawaiian Islands. Even distribution across water depths.
	rough-toothed dolphin	N/A[3]	24[1]	Common in offshore waters, typically occurring over bottom depths greater than 500 m (1640 ft).
	bottlenose dolphin	N/A[3]	26[1]	Found in similar densities over all water depths.
	striped dolphin	N/A[3]	12[1]	Not common around the Hawaiian Islands. Even distribution across water depths.
	spotted dolphin	N/A[3]	103[1]	Especially common along continental shelf breaks. Feed primarily in offshore waters.
	spinner dolphin	N/A[3]	136[1]	Found at highest densities in waters less than 1830 m (6000 ft).
	Hawaiian monk seal	1423[4]	21[2]	Found occasionally in waters less than 1000 m (3281 ft), rarely in deeper waters.

Note 1: Site estimate derived from aerial survey data in Mobley et al. (1999b).
Note 2: Site estimate derived from literature cited in species accounts in Chapter 3.
Note 3: N/A = Not Available. NMFS has not estimated the abundance of the Hawaiian stock for this species (Barlow et al., 1996).
Note 4: Minimum stock estimate (N_{min}) from 1999 NMFS Stock Assessment Report (Forney et al., 1999).

"angular range of course change" in Table 4.2-1) are specified, which sets the general character of its meandering. Thus, an animal's simulated track could range from highly predictable (straight) to highly irregular. While the former would apply to migrating animals, the latter might be more applicable to local feeding or social behavior. To incorporate an animal's dive pattern, for each 1-min time step in the 20-min transmission, an animal is given a depth zone according to the user-provided probabilities, and is assigned a random depth within that zone.

The last element is the calculation of sound exposures. The predicted location of each animal at each 1-min time step is used to select the appropriate RL from the modeled sound field described above. A histogram of RLs for each transmission and for a full day of transmissions (a total of six 20-min transmissions) was computed for each animal, as well as summary statistics. This process was repeated for each species in the region, to estimate possible effects of the sound source transmissions.

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, to ensure that the result of the simulation was not unduly influenced by the chance placement of a few animals. The minimum number of animals used was determined by preliminary experiments in order to develop a statistically significant cumulative distribution function (CDF). The CDF specifies the percentage of received transmissions at a given RL or below. The number of animals necessary to maintain statistical significance was modeled for each species in each site scenario as a ratio of the expected densities.

The results of the AIM modeling process are used as the inputs to the risk continuum to determine the potential risk of a biologically significant response that affects biologically important activity, such as survival, breeding, feeding and migration, which have a potential to impact on the reproductive success of the animal. 4-7

Risk Continuum Analysis

Marine mammals exposed to LF sound are potentially at risk for several types of biologically significant impacts, including injury and a biologically significant behavioral response that affects biologically important activity, such as survival, breeding, feeding and migration, which have a potential to impact on the reproductive success of the animal. In assessing this potential risk, two questions must be resolved: 4-8

- 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 to the LF sound source (as calculated in the AIM model) into a 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., 1995; Crocker, 1997).

Effects of Repeated Exposure

There is a very limited basis for determining the potential effects of repeated exposures for marine mammals. Richardson et al. (1995), however, discussed the relationship between repeated exposures of the human ear to impulsive sound, the duration of exposure of the human ear to an intermittent sound, and a temporary threshold shift (TTS) in the subject's hearing. For animals exposed to a signal of duration on the order of 20 min, the risk threshold is lowered by 10 dB per ten-fold increase in the number of 1-min time steps received during the transmission (see below for further discussion on the effects of signal duration). These findings are consistent with qualitative statements by Crocker (1997). Thus, if a ping of level L is repeated N times, the single ping equivalent (SPE) level would be $L + 10\log_{10}(N)$ in dB. For example, using this formula, 10 pings at 120 dB are equivalent to one ping at 130 dB.

While there is no guarantee that marine mammal behavioral responses exhibit patterns similar to human hearing, the human model is the best objective foundation for an assessment. Thus, the $10\log_{10}(N)$ formula is the best available for assessing the potential risk to a marine mammal for 4-9
a biologically significant behavioral response that affects biologically important activity from coherent LF sound like the NPAL sound source transmissions.

The following provides some mathematical details of how quantification of this risk assessment was implemented in the subsequent analysis:

- For each animal in the AIM simulation, the RL at each 1-min time step changed as the animal moved in relation to the sound source;
- A histogram of the RLs was created, and the SPE for each RL bin was calculated;
- These RL bin SPEs were converted into raw acoustic intensities (proportional to the energy 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. This dB value was the overall SPE for that animal.

In this process, a single ping equivalent (SPE) RL is 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 much softer pings is almost the same as the level of the single loud ping.

Determination of Risk Function

Up to now, the definition of biological risk to marine mammals has generally been based on an arbitrary received sound level threshold for individual species. For example, TTS values have 4-10
been used as a threshold. However, the use of a threshold, or step function, assumes that all

animals react to sound in the same manner, and that the same reaction occurs at the same RL for all animals. Therefore, any RL value below the threshold is considered risk-free, and any value above it is considered certain to cause adverse responses by marine mammals.

In contrast, a more realistic approach to assessing biological risk is to use a smooth, continuous function that maps RL to risk. Scientifically, this reflects the research that has been conducted on terrestrial species demonstrating that individuals vary in sensitivity, so if an entire population 4-11
is exposed to a given level of sound, biologically important responses will be observed in a percentage of the population rather than in none of the population or the entire population. For example, in the third phase of the LFS SRP, discussed in greater detail later, some singing humpback whales showed apparent avoidance responses and cessation of song 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. To reflect this varied response between individuals, a curvilinear risk continuum is most accurate. Mathematically, the curvilinear shape of the risk continuum 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.

In order to represent a probability of risk, the function should have a value near zero at very low RLs, and a value near one for very high RLs. One class of functions that satisfies this criterion is *cumulative probability distributions (CDFs)*. In selecting a particular functional expression for risk, several criteria were identified:

- The risk function must be parameterized to focus discussion on regions of uncertainty;
- Parameters must be permitted enough control to allow for accurate fits to experimental data; and
- The risk function should be reasonably convenient for algebraic manipulations.

Therefore, a biological risk function and a risk continuum were developed for this LF sound source (Figure 4.2-1, Single Ping Equivalent Probability Function). Risk varies with both RL and number of exposures. No two individuals would react to sound exposure in the same way. The risk continuum assumes that 95 percent of the marine mammals exposed to a single ping of LF sound at a received level of 180 dB could incur TTS. This threshold is the first of three conservative assumptions underlying the EIS risk assessment. 4-12

The second assumption is that the risk of a biologically significant response that affects biologically important activity is zero below 120 dB. The third assumption is that 2.5 percent of a population exposed to a single ping at a RL of 150 dB would experience a biologically significant behavioral response that affects biologically important activity. The biological risk function and the risk continuum are based on literature reviews and results of the ATOC MMRPs and other recent studies.

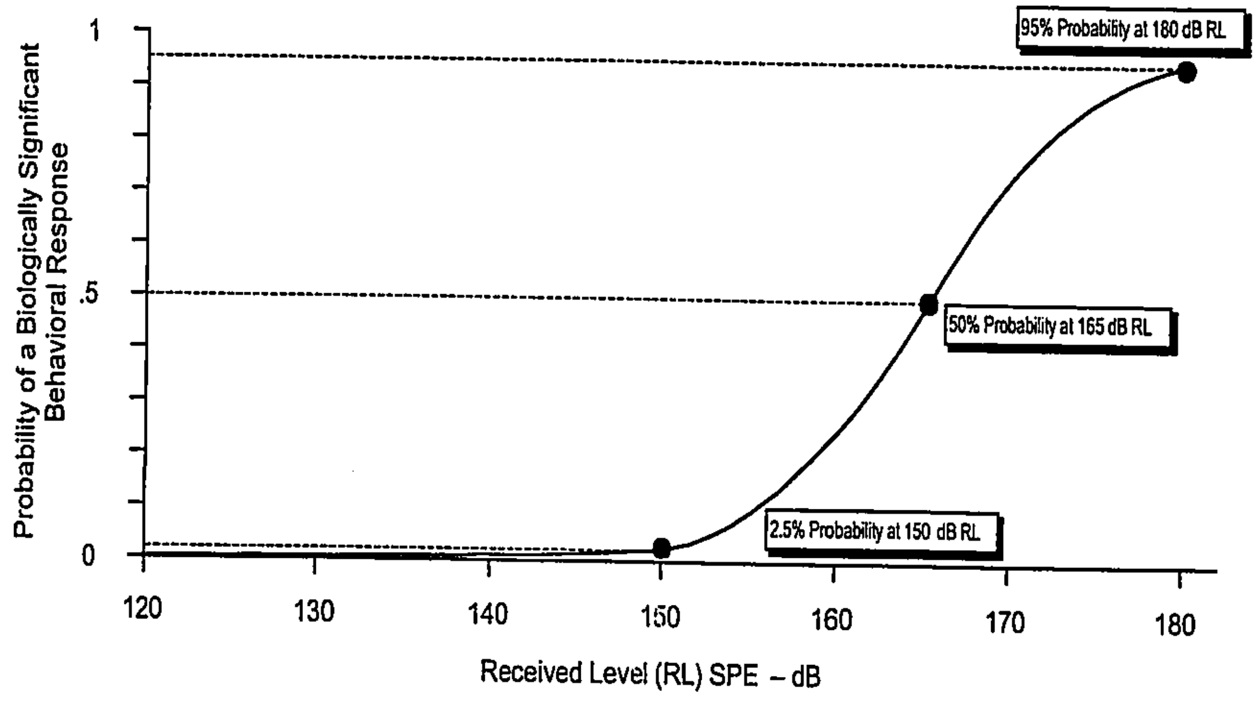


Figure 4.2-1 Single Ping Equivalent Probability Function

The most authoritative study of the effect of underwater sound on small odontocetes at frequencies between 3 and 75 kHz concluded that changes in behavior and temporary shifts in the hearing levels of bottlenose dolphins were observed at the following received levels for 1-sec tones (Ridgway et al., 1997):

Frequency	Change in Behavior	TTS
3 kHz	186 dB	194-201 dB
20 kHz	181 dB	193-196 dB
75 kHz	178 dB	192-194 dB

Since this study occurred in the region of greatest hearing sensitivity for this species, it is believed that the levels identified for behavior change and TTS at 3 kHz would be conservative for small odontocetes below 3 kHz (Ridgway et al., 1999, pers. comm.). Schlundt et al. (2000) expanded on the research described in Ridgway et al. (1997) to include testing at 400 Hz. Behavioral alterations started at RLs of 180 dB for bottlenose dolphins, but no subjects exhibited TTS at levels up to 193 dB. Large odontocetes are considered as sensitive as mysticetes while pinnipeds are believed to be less sensitive than odontocetes to underwater sound. Therefore, the threshold that 95 percent of the small odontocetes and pinnipeds exposed to a single ping of LF sound at 180 dB could incur TTS is even more conservative. 4-13

There are no authoritative studies of TTS or PTS in mysticetes. However, studies of human hearing indicate that the normal process of hearing loss with age can be accelerated by chronic exposure to sounds 80 dB above the absolute threshold of hearing (Richardson et al., 1995). Here, chronic is interpreted as about 8 hours per day for about 10 years. For odontocetes, Au et al. (1997) present data indicating that hearing thresholds are about 140 dB at 75 Hz. Hearing thresholds are not known in mysticetes, but the lowest value is speculated to be 80 dB (Ketten, 1998). This suggests that ten years of exposure to 160 dB RL for 8 hours per day would cause auditory damage. Therefore, estimating that 95 percent of baleen whales will experience TTS after exposure to a 1-min ping at 180 dB is conservative.

In order to understand the significance of the risk of a biologically significant behavioral response that affects biologically important activity, it is necessary to determine how this risk might affect a population of marine mammals, starting with bioacoustic criteria. First, the animal must be able to hear LF sound. Second, the animal must incur a biologically significant behavioral response to the LF sound. Third, any effect must involve a significant behavioral change in a biologically important activity. For LF sound effects on marine mammals, this would relate primarily to survival, feeding, breeding and migration, all of which are essential to the reproductive success of the animal. 4-14

Results from the ATOC MMRPs support the use of 120 dB as the basement value for risk. No overt or obvious short-term changes in behavior, distribution, or abundance in response to source transmissions were found. All of the effects detected by the MMRPs were subtle and found only after intensive statistical analyses.

The third assumption, that 2.5 percent of a population exposed to a single ping at a RL of 150 dB would experience a biologically significant behavioral response that affects biologically 4-15 important activity, is based on results from the recent Low Frequency Sound Scientific Research Program (LFS SRP). Baleen whales became the focus of the three phases of this program because they are thought to have sensitive LF hearing and because of their endangered status and/or prior evidence of avoidance responses to LF sounds. The choice of study sites was based on research data in which the most discriminating techniques could be used and where previous research yielded substantial documentation of undisturbed patterns of behavior and distribution.

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 were considered among the most sensitive pinnipeds to LF sound and are deep divers. The third phase attempted to conduct playbacks with sperm whales, but no animals were encountered during the offshore portions of the cruise schedule. Sperm whales are listed as endangered, and they were suspected to be the toothed whale most sensitive to LF sound since they are the largest. There have also been anecdotal reports of sperm whales being sensitive to manmade transient noise (Watkins et al. 1985; Watkins and Schevill, 1975).

During the first phase of LFS SRP research, there was no pronounced disruption of feeding behavior from whales exposed to RLs from 110 to 153 dB. Over the 19-day period, the distribution of fin and blue whales appeared to be more influenced by the distribution of prey than by the playbacks.

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 on the track plots. The inshore avoidance model - in which most whales avoid exposure to levels of 115 to 125 dB - is not valid for whales in proximity to an offshore source. Rather, these data suggest that avoidance of an offshore source (≥ 4 km [2.2 nm]) would be minor, even at considerably higher RLs.

The third phase of LFS SRP research examined potential effects of LF transmissions on singing humpback whales. In five of 18 playbacks of LF transmissions, the whales stopped singing, 4-16
presumably in response to the playback (Miller et al., 2000). However, during 9 of the 18 playbacks, singing whales exposed to the same levels (RLs ranging from 120 to 150 dB) showed no cessation of song. Further analysis is required to establish how often male humpbacks stop

singing in the absence of the LF transmissions and to evaluate the significance of the song cessation observed during playbacks. Of the whales that did stop singing, there was little response to subsequent pings. Most joined with other whales or resumed singing within less than an hour of the possible response. For six whales where at least one complete song was recorded, on average, humpback whales' songs were 29 percent longer during LF playback, but returned to normal after exposure (Miller et al., 2000). The authors suggest that humpbacks sang longer songs during LF transmissions to compensate for acoustic interference.

Taken together, the three phases of the LFS SRP do not support the predictions that most animals exposed to RLs near 140 dB would exhibit disturbance of behavior and avoid the area. These experiments, which exposed animals to RLs ranging from 120 to 150 dB, elicited only minor, short-term behavioral responses, but not a biologically significant behavior response that affects biologically important activity. 4-17

It should be noted that the signals used during the LFS SRP were approximately 60 seconds in duration on a 10-15 percent duty cycle in the 100 to 500 Hz frequency band. This differs from the signals of the proposed action. The NPAL signal would be in the 57.5-92.5 Hz and would typically operate on a 2 percent duty cycle (which may increase temporarily to 8 percent; see details in Chapter 2). The typical transmissions would be six 20-min transmissions (one every four hours), every fourth day, with each transmission preceded by a 5-min ramp-up period.

In summary, it is important to recall that risk varies with both level and duration. In terms of biological risk, it is important to note that individuals will vary in their pre-exposure hearing sensitivity, in their actual responses, and in the severity of the consequent biological effects (survivorship and reproduction). No two individuals will react to exposure in the same way. The risk continuum estimates that 95 percent of the marine mammals exposed to a single 1-min time step at 180 dB could suffer a risk of TTS. The second assumption is that the risk of a biologically significant behavioral response that affects biologically important activity is zero below 120 dB. The third assumption is that 2.5 percent of a population exposed to a single ping at a RL of 150 dB would experience a biologically significant behavioral response that affects biologically important activity. Based on the above discussion, this is a conservative estimate. 4-18

Sample Model Run

The following example is intended to provide an insight into the PE and AIM models 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 4.2-2 (Risk Analysis Flowchart). These elements are described in detail in the following examples.

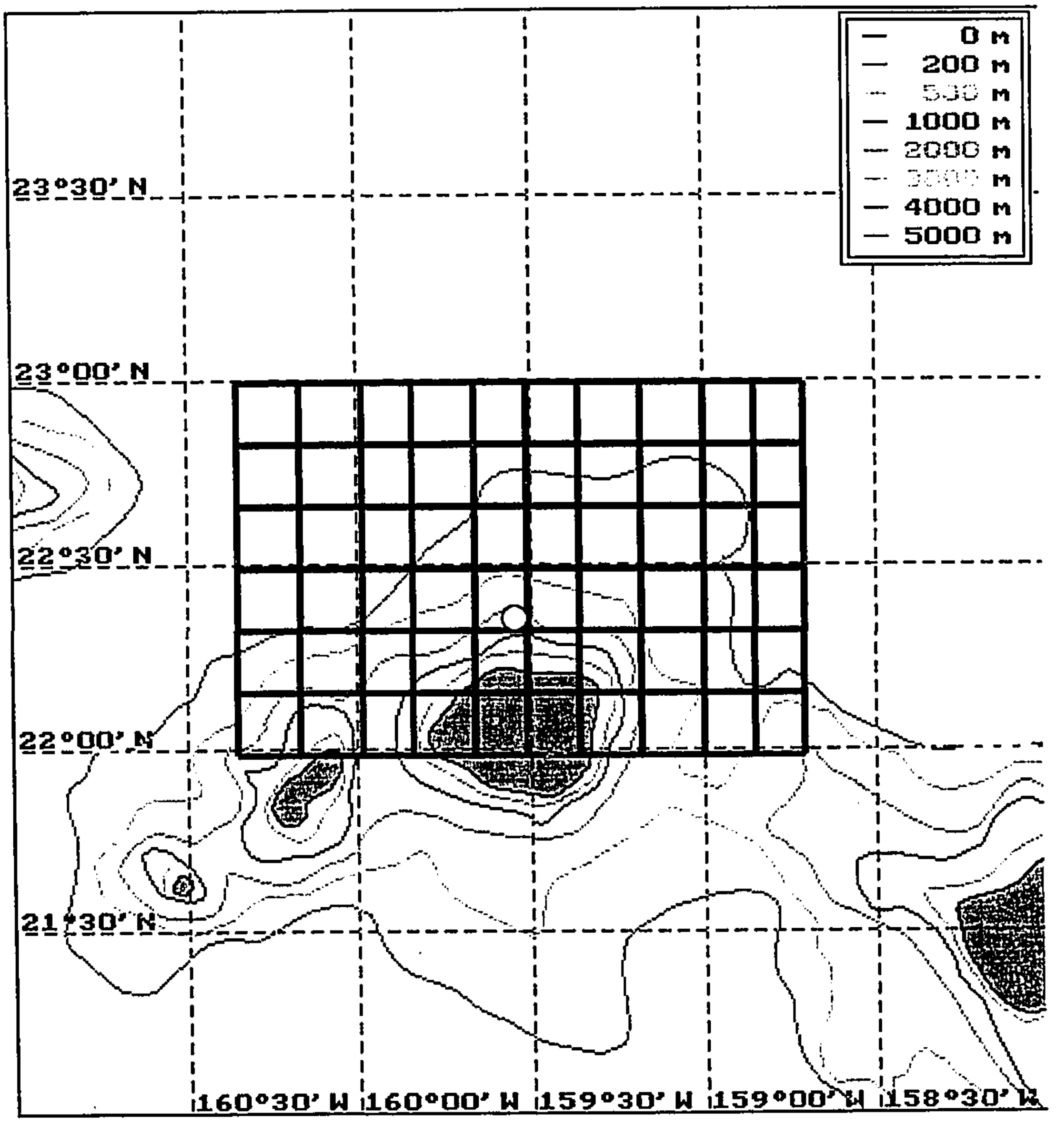


Figure 4.2-3 Proposed Kauai Site

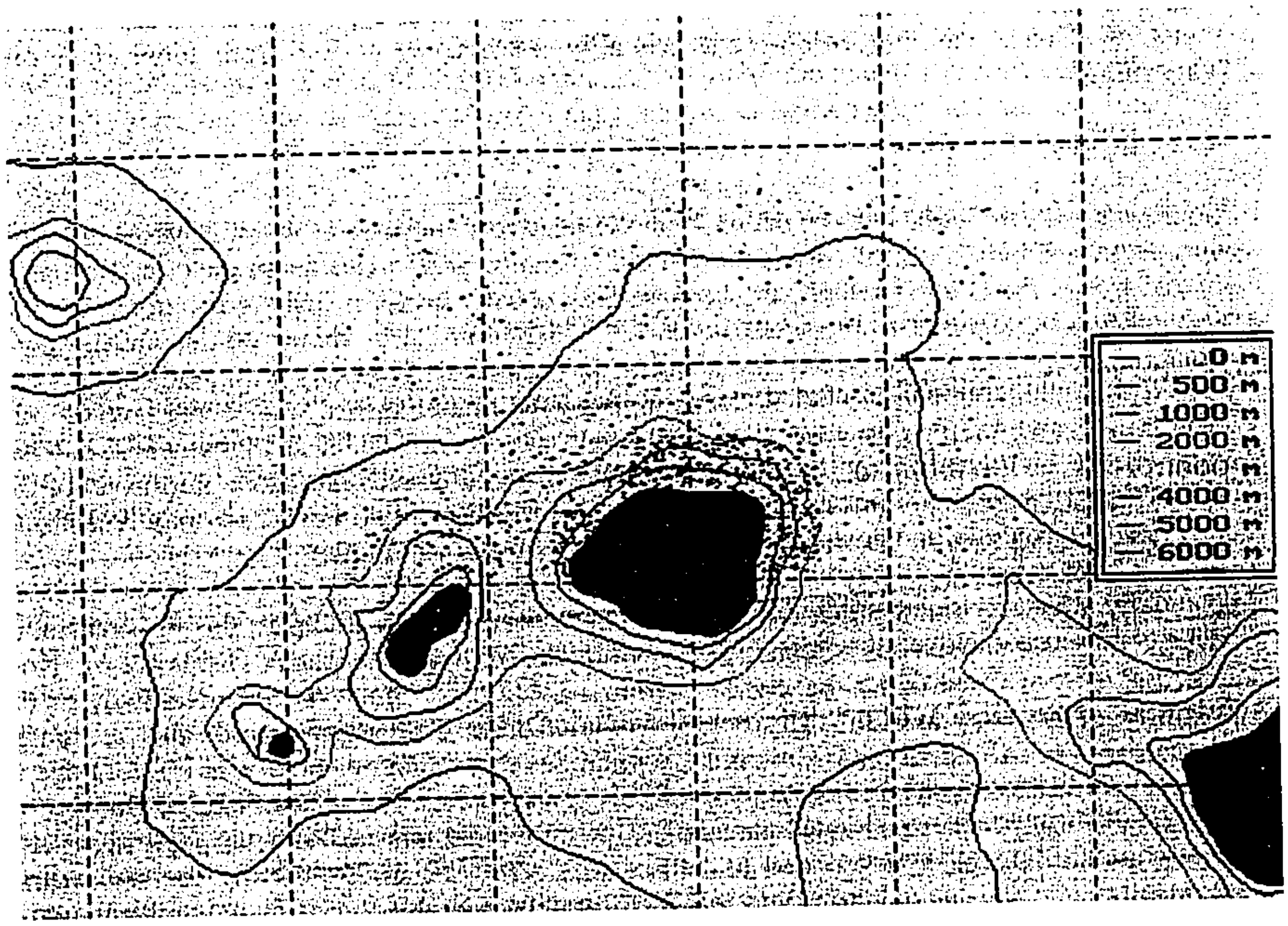


Figure 4.2-4 Initial Humpback Whale Positions

Acoustic modeling and the risk continuum estimated the potential for biologically significant reactions. For the Preferred Alternative, only humpback whales that remain in the vicinity of the sound source for a full day of transmissions may potentially experience any effect from the source transmissions. As stated previously, humpback whales typically travel parallel to the coast of Kauai, and therefore would probably not receive sound from more than one transmission.

The Midway Alternative

Some general conclusions can be drawn from the relative abundance of various marine mammal species in relationship to the NPAL sound field. The mysticete expected in greatest abundance in the area is the Bryde's whale, and because they usually prefer nearshore locations, few are expected to be exposed to received levels > 120 dB. Similarly, sperm whales are the most common deep-diving odontocetes in the area, but because they usually prefer offshore waters (i.e., greater than 4000 m [12700 ft]), few are expected to be exposed to received levels > 120 dB. A much higher abundance of Hawaiian monk seals is expected near Midway Island, since this species prefers the small, mostly uninhabited chain of islands and atolls northwest of the main Hawaiian Islands. In fact, it is believed that the Hawaiian monk seal may reestablish Midway Atoll as a major breeding site (see Chapter 3 for further details).

Acoustic modeling and the risk continuum analysis were used to estimate the percentages of marine mammal populations potentially affected by the Midway Alternative (Table 4.2-6). Note that the species listed under the marine mammal column are those species potentially in the vicinity of Midway Island. The column labeled One Transmission provides estimated percentages of individual marine mammal populations that could potentially be affected due to SPE levels <180 dB and ≥180 dB for one 20-min transmission. The column labeled One Day of Transmissions provides estimated percentages of individual marine mammal populations that could potentially be affected due to SPE levels <180 dB and ≥180 dB for six 20-min transmissions. A value of zero means that less than 0.01% of the marine mammal population is potentially affected.

Acoustic modeling and the risk continuum estimated the potential for biologically significant reactions. No effects from source transmissions at Midway Island are expected. As seen in the results from the MMRPs, no obvious or overt short-term changes in behavior, distribution, or abundance in response to source transmissions were found. However, subtle effects were detected for humpback whales (and possibly sperm whales) after intensive statistical analyses.

Table 4.2-6 Percentages of Marine Mammal Populations Potentially Affected by the Midway Alternative

Marine Mammals	One Transmission		One Day of Transmissions	
	Biologically Significant Behavioral Response (120-180 dB)	TTS (≥ 180 dB)	Biologically Significant Behavioral Response (120-180 dB)	TTS (≥ 180 dB)
blue whale	0	0	0	0
fin whale	0	0	0	0
Bryde's whale	0	0	0	0
minke whale	0	0	0	0
sperm whale	0	0	0	0
dwarf and pygmy sperm whales	0	0	0	0
Blainville's beaked whale	0	0	0	0
Cuvier's beaked whale	0	0	0	0
melon-headed whale	0	0	0	0
Risso's dolphin	0	0	0	0
rough-toothed dolphin	0	0	0	0
bottlenose dolphin	0	0	0	0
striped dolphin	0	0	0	0
spotted dolphin	0	0	0	0
spinner dolphin	0	0	0	0
Hawaiian monk seal	0	0	0	0

Potential for Habituation

Habituation was defined by Richardson et al. (1991) as the development of reduced response when there is repeated or continuous exposure to a stimulus and when the stimulus is not accompanied by anything that the animal "perceives" as threatening. Based on results from the ATOC MMRPs, there is no potential for observed habituation in marine mammals since no overt or obvious short-term changes were observed.

Potential for Masking

Virtually no specific information is available about the nature and effects of masking under field conditions nor about the adaptations that marine mammals may use to reduce masking by low frequency sounds. Masking processes in baleen whales are not amenable to laboratory study, and no data on hearing sensitivity are available for these species. Yet, as noted previously, mysticetes and other marine mammals likely are well-adapted to coping with some increase in masking as a result of natural and human-made noise. However, since baleen whales are assumed to be sensitive to low frequency sound, the maximum radius of audibility of low frequency industrial noise for these species is to be determined by background noise levels. As noted earlier, it is not currently possible to determine with any level of quantitative precision the potential consequences of elevated background noise levels, particularly when they are temporary and local.

Masking as a result of human-made noise can interfere with the detection of acoustic signals, such as communication calls, and other environmental sounds that may be important to marine mammals and, at least in theory, a source of noise will be surrounded by a region within which masking may occur. However, the size of this zone is highly variable, even for a single marine mammal and a single type of noise. The maximum radius of masking depends on several factors. Among the most important of these is the received level of the noise relative to the original signal.

For an animal close to a source of human-made noise, the noise level would be high and the animal would be able to hear only nearby animals. For an animal farther from an industrial site, the noise level would be lower and the animal would be able to hear calls from more distant animals. The same arguments apply to detection of other environmental sounds that may be of interest to the animals.

Dramatic reductions in maximum potential radius of communication could result if ambient noise levels are increased by 10-20 dB throughout that range, while other factors (e.g., the animals' directional hearing ability, and the directionality of the noise source[s]) remain relatively constant. Species that may communicate acoustically over long distances, such as some baleen whales, would be most seriously affected. There is little information about the functions of most marine mammal calls. Hence, it is impossible to predict the effects of a reduction in the range to which these calls are detectable. Payne and Webb (1971) suggested that some baleen whales use powerful low frequency calls to communicate over very long distances. However, there is no evidence that whales respond to one another over ranges greater than about 20-25 km (11-13 nm) (Watkins, 1981), but this may be largely a result of limited observation methods (Richardson, pers. comm., 1994).

During the proposed sound transmissions (mostly 2 percent of the time), sound levels (in the 57.5-92.5 Hz band) in the vicinity of the source, and out to a radius of approximately 10 km (5.4 nm) towards shore (Figure 2.1-7), could be greater than average ambient levels (see discussion of ambient noise in Chapter 2). At these times, masking of communication calls and other environmental sounds which may be important to mysticetes could occur in some portion of the ensonified area if those sounds are in the same band as the NPAL source. Species in the vicinity of the Preferred or Midway Alternatives that have the potential to be masked (see Figure 3.2-1 for summary of mysticete vocalizations) include blue, fin, sei, Bryde's, minke, northern right, and humpback whales. However, there is virtually no information about the nature and effects of masking under field conditions, nor about the adaptations that marine mammals may use to reduce masking effects. Most relevant data on masking have come largely from studies of high frequency echolocation by toothed whales. The importance to mysticetes of barely-detectable calls from distant conspecifics is unknown, so the biological significance of masking of faint calls is, likewise, unknown, and may be minor or negligible at most times (Richardson, pers. comm., 1994). Thus, the extent to which masking may occur, or the extent to which mysticetes might be affected by such masking is unknown. 4-22

For species with broad spectrum hearing, presumed to be the case for mysticetes, masking from a narrowband source, such as NPAL, may be incomplete. Moreover, the relatively short transmission times and low duty cycle mean that the source only would mask sounds for brief periods; sounds longer than this would not be completely masked (e.g., a ship approaching from a distance). Therefore, in light of the number of mysticetes that may be exposed and the relatively brief and intermittent nature of the NPAL source transmissions, masking effects are uncertain, but presumed to be minor for both alternatives.

Based on studies of high frequency echolocation by toothed whales, echolocation signals are subject to masking by high frequency noises. However, echolocation would not be masked by most industrial noises (or NPAL sound transmissions), which tend to be concentrated at low frequencies. Significant masking only occurs for frequencies similar to those of the masking noise (Richardson et al., 1991).

Studies on captive odontocetes by Au et al. (1974, 1985) indicated that some species may use various processes to reduce masking effects (e.g., adjustments in echolocation signal intensity and/or frequency as a function of background noise). However, since echolocation and communication signals are of higher frequencies, they will not be masked by noises that are concentrated at low frequencies.

Although low frequency hearing has not been studied in many odontocete species, those species that have been tested (white whale, killer whale, false killer whale, and bottlenose dolphin) exhibit low audiometric and behavioral sensitivity to low frequency sound. It is not clear whether sperm and pilot whale vocalizations were masked by the 1991 Heard Island Feasibility Test (HIFT) acoustic signals, or if those species simply stopped emitting sounds during the test (Bowles et al., 1994). Vocalization cessation would be expected with sperm whales because they frequently become silent in the presence of human-made noise (Watkins and Schevill, 1975; Watkins et al., 1985). Thus, for sounds dominated by low frequency components, the maximum radius of audibility for most odontocete species often may be determined by their hearing sensitivity, rather than the background noise level. It appears, therefore, that with the possible exception of the sperm and pilot whale and bottlenose dolphins (see Figure 3.2-3 for summary of odontocete vocalizations), the potential for increased masking for any odontocete, as a result of the proposed sound transmissions, is expected to be minimal. 4-23

Potential for Long-term Effects

According to Richardson et al. (1991), it is rarely possible to identify the specific cause of an apparent long-term effect (e.g., prolonged displacement), and even the occurrence of displacement can be difficult to detect. However, there are a few reports of probable or possible long-term displacements of marine mammals from local areas in which underwater noise was presumably a major factor. The best documented of these reports was the abandonment by gray whales of a calving lagoon in Baja California for several years, and their return after vessel traffic diminished (Gard, 1974; Reeves, 1977; Bryant et al., 1984). Apparent distribution changes of humpback whales around Maui, as a result of human activity, are discussed below.

Changes in marine mammal use of an area may be quite slow and difficult to detect, given the long lifetimes of most marine mammals and the slow rate of change in habitat quality in many areas. Most of the research directed specifically at this topic has been done in the past 15 yrs. If marine mammals did react to noise from human activities by reduced use of certain areas, there would, in many cases, be insufficient reliable and systematic information to document the trend. In contrast, it is rather straightforward to document cases where marine mammals remain in an ensonified area. Thus, cases of partial or even complete abandonment of disturbed areas may be more common than available evidence indicates (Richardson et al., 1991).

Surveys were done in 1984 to determine the effects of noise on gray whales that calve and breed in San Ignacio Lagoon, Mexico (Jones et al., 1994). Regression analysis of the high gray whale counts in the years 1978-82 and 1985 indicated that, during that seven year period, the maximum number of whales present in the lagoon increased an average of 4.5 percent/yr. The study results suggested that the noise-effect studies conducted in 1984 caused both single whales and cow-calf pairs to abandon or avoid the lagoon, but most, if not all, of the whales returned and used the lagoon in 1985, as they had during the 1978-82 timeframe. The 1984 noise-effect studies consisted of continuous long-term underwater playbacks of the following sounds: killer whale, oil-drilling rig, outboard motor, gray whale vocalizations, and a calibration test tone. Source levels ranged from 70 dB (200 Hz) up to 145 dB (2.5 kHz), and the ambient noise levels measured in the lagoon were quite high, at 94-110 dB (mostly in the 2-5 kHz frequency band).

Although the potential significance of permanent displacement is difficult to determine, Richardson et al. (1991) speculated that in an area of small size relative to range, where the density of animals is low, and similar to the densities in many other areas, it is unlikely to be critical either to individuals or to the population. They noted, however, that effects of displacement would be more problematical in areas consistently used by high concentrations of animals or areas important to a small, but critical component or function of the population (e.g., mothers with calves, or mating).

Animals that appear to tolerate human-made noise are presumed to be less affected by the noise (e.g., through habituation) than are others whose behavior is changed overtly, sometimes with displacement. However, as noted by Richardson et al. (1991), the presence of marine mammals in an ensonified area does not prove that the population or individuals therein are unaffected by the noise (i.e., the number of animals in the ensonified area may be only a fraction of the numbers that would have been there in the absence of the noise). Also, as noted earlier, marine mammals may stay in an area despite the presence of a noise disturbance if there are no alternative areas that meet their requirements (Brodie, 1981). In response to such situations, animals may experience stress, causing physiological responses. Although such responses may increase an animal's ability to cope with various situations (Turner, 1965; Russell, 1966; Selye, 1973), chronic activation of these physiological mechanisms eventually could lead to harmful physiological effects (Selye, 1973).

According to Richardson et al. (1991) only one study of noise-induced stress in marine mammals has been conducted. Thomas et al. (1990) measured plasma catecholamines (elevated levels often found in stressed mammals) in captive white (beluga) whales before and after exposure to playbacks of recorded semi-submersible drillrig noise. Although noise exposure did not lead to elevated levels of catecholamines in the animals' blood, Richardson et al. (1991) note that the significance of the study results is unknown, especially in view of the short durations of noise exposure. The long-term health effects of chronic noise exposure are unknown, although it appears that marine mammals do exhibit some of the same stress symptoms as terrestrial mammals (Thomson and Geraci, 1986; St. Aubin and Geraci, 1988). Studies of terrestrial mammals have shown that physiological reactions, such as elevated heart rate, may occur even in the absence of overt behavioral responses (MacArthur et al., 1979).

In summary, the potential for adverse impacts from long-term exposures to the NPAL sound fields is unknown. The following mitigation measures have therefore been adopted:

Mitigation Measures 1 & 3: The duty cycle and power levels of the NPAL source have been adjusted to the minimum necessary to support research objectives, so that potential long-term impacts to marine mammals would be minimized.

Monitoring Measure 1: The focus of the Marine Mammal Monitoring Studies is to advance the understanding of the potential for long-term effects of man-made sound on marine mammals by monitoring the distribution and abundance of marine mammals in the vicinity of the sound source.

Potential for Indirect Effects

Indirect effects include those effects that potentially could be caused by the proposed action and are later in time, or farther removed in distance, but would still be reasonably foreseeable. The principal indirect effect in this case would be any potential impact on the food chain that ultimately could affect marine mammals in the vicinity of the study area.

Althougn rare, isolated incidents of serendipitous feeding by humpback whales in Hawaiian waters have been observed by researchers (Diaz-Soltero, pers. comm., 1995). Humpbacks are known to feed almost continuously during summer months in North Pacific (high latitude) and Arctic waters on one species in particular, the red euphausiid shrimp *(Euphausia pacifica)*, commonly called krill, but also on schools of mackerel, sand lance, capelin, and herring (Jurasz and Jurasz, 1979). The NPAL project would be conducted from the seafloor north of Kauai or near Midway Atoll, and would have no effect on the primary food species of humpbacks in the North Pacific and Arctic regions and, consequently, no effect on their food chain.

The sperm whale, pygmy sperm whale and dwarf sperm whale prey primarily on mesopelagic squids; the latter two also ingest some fish, octopus and crustaceans. The main food for pilot and beaked whales is squid and fish (e.g., rockfish, mackerel). The dolphins' staple food is usually squid or fish (e.g., anchovies, hake). Killer whales prey on almost any palatable marine organism of any size. Virtually all oceanic cetaceans, pinnipeds, seabirds, sea turtles (particularly leatherbacks), fish (especially herring and salmon), and even their own kind can be considered prey.

The common prey species for the Hawaiian monk seal are benthic and reef-dwelling fish and invertebrates, including flatfish, scorpenids, eels, octopuses, and spiny lobsters (Reeves et al., 1992). If low frequency sound transmissions were to affect any of these prey species, depending on the extent to which their availability might be altered, there could be negative consequences to the pinniped population in the Hawaiian Islands. However, since at most only a very minor portion of the range (within approximately 8 m [180 dB sound field] of the source site) of these prey species would be affected, indirect impacts would likely be minimal.

4.2.1.2.2 Sea Turtles

Chapter 3 discusses the species of sea turtles that have been sighted in or near the proposed study area. The maximum residence time within the area of the proposed action alternative for sea turtles is estimated to be <24 hrs. This is based on the limited population data available for the Hawaiian Island/mid-Pacific area, coupled with the expected average transit speeds for sea turtles (0.65 m/sec [2 ft/sec] for leatherbacks; approximately 1 m/sec [3.2 ft/sec] for loggerheads and olive ridleys) (Eckert, pers. comm., 1994). These estimates apply primarily to leatherbacks, loggerheads and olive ridleys that would be most likely to pass through the sound fields located relatively far offshore. Green turtles spend most of their time associated with coastal features after taking up residence at foraging pastures, although satellite tagging studies indicate a migratory pathway north of Kauai for some of the turtles tagged at French Frigate Shoals (see Chapter 3).

Potential direct and indirect effects of low frequency sound on sea turtles, such as physical auditory effects, behavioral disruption, long-term effects, masking, and adverse impacts on their food chain (indirect effects), are discussed below.

Hearing Capabilities of Sea Turtles

Sea turtles do not have an auditory meatus or pinna that channels sound to the middle ear, nor do they have a specialized tympanum (eardrum). Instead, they have a cutaneous layer and underlying subcutaneous fatty layer, that function as a tympanic membrane. The subcutaneous fatty layer receives and transmits sound to the extracolumella, a cartilaginous disk, located at the entrance to the columella, a long, thin bone that extends from the middle ear cavity to the entrance of the inner ear or otic cavity (Ridgway et al., 1969). Sound arriving at the inner ear via the columella is transduced by the bones of the middle ear. Sound also arrives by bone conduction through the skull. Low frequency sounds at high source levels also can be detected by vibration-sensitive touch receptors in various other parts of the turtle's body (Bowles, pers. comm., 1994).

Sea turtle auditory sensitivity is not well studied, though a few preliminary investigations suggest that it is limited to low frequency bandwidths, such as the sounds of waves breaking on a beach. The role of underwater low frequency hearing in sea turtles is unclear. It has been suggested that sea turtles may use acoustic signals from their environment as guideposts during migration and as a cue to identify their natal beaches (Lenhardt et al., 1983).

Ridgway et al. (1969) used aerial and mechanical stimulation to measure the cochlea in three specimens of green turtle, and concluded that they have a useful hearing span of perhaps 60-1000 Hz, but hear best from about 200 Hz up to 700 Hz, with their sensitivity falling off considerably below 200 Hz. The maximum sensitivity for one animal was at 300 Hz, and for another was at 400 Hz. At the 400 Hz frequency, the turtle's hearing threshold was about 64 dB in air (approximately 126 dB in water). At 70 Hz, it was about 70 dB in air (approximately 132 dB in water). This has led Eckert (pers. comm., 1994) to conclude that green turtles could possibly hear the source transmissions if they were located in the sound field corresponding to 132 dB received level (<3 km (1.6 nm) radius around the source site) during one of the transmission periods. Ridgway (pers. comm., 1994) doubts that the 75 Hz, 195 dB source at 850 m (2700 ft) depth could be a direct cause of injury to green turtles, but that the potential for behavioral disruption (e.g., migration orientation) is less certain (Balazs, pers. comm., 1995).

Lenhardt et al. (1983) applied audiofrequency vibrations at 250 Hz and 500 Hz to the heads of loggerheads and Kemp's ridleys submerged in salt water to observe their behavior, measure the attenuation of the vibrations, and assess any neural-evoked response. These stimuli (250 Hz, 500 Hz) were chosen as representative of the lowest sensitivity area of marine turtle hearing (Wever, 1978). At the maximum upper limit of the vibratory delivery system, the turtles exhibited abrupt movements, slight retraction of the head, and extension of the limbs in the process of swimming. Lenhardt et al. (1983) concluded that bone-conducted hearing appears to be a reception mechanism for at least some of the sea turtle species, with the skull and shell acting as receiving surfaces.

More recently, Lenhardt (1994) used a water-coupled speaker and accelerometers to determine the behavioral effects of low frequency sounds (20-80 Hz, 175-180 dB) on captive loggerheads held in a 1 m (3.2 ft) deep circular tank. Turtles responded by swimming towards the surface at the onset of the sound, presumably to lessen the effects of the transmissions.

There are no underwater audiogram data available for leatherbacks. Because they are morphologically distinct (leathery shell, with minimal calcification of bone), approximating hearing thresholds from data available for the other (hard shell) species is probably inappropriate.

Potential for Physical Auditory Effects

Extrapolation from human and marine mammal data to turtles may be inappropriate given the morphological differences between the auditory systems of mammals and turtles. However, as stated above, the measured hearing threshold for green turtles (and by extrapolation, at least the olive ridley, loggerhead, and hawksbill) is only slightly lower than the maximum levels to which these three species could be exposed. It is not believed that a temporary threshold shift would occur at such a small margin over threshold in any species. Therefore, no threshold shifts in green, olive ridley, loggerhead, or hawksbill sea turtles are expected.

Given the lack of audiometric information, the potential for temporary threshold shifts among leatherback turtles must be classified as unknown. Moreover, only generalized information is available concerning the distribution of leatherbacks, but they are known to be present in the project area, they tend to prefer continental slope areas, and they can dive deeply. Therefore, despite the lack of direct information, it is presumed that leatherbacks are capable of being exposed to sound levels that could cause temporary threshold shift. However, inasmuch as the density of leatherbacks over the study area is low, but patchy (Eckert, pers. comm., 1994), the fact that only a small percentage of time is spent at depth, the intermittent nature and low duty cycle of the NPAL source, and the fact that the proposed project site is not believed to be a particularly important location of leatherback prey species, any impact should be minimal.

Potential for Behavioral Disruption

Based on the conclusions of Lenhardt et al. (1983), and O'Hara and Wilcox (1990), low frequency acoustic sound transmissions at source levels of 141-150 dB could potentially cause increased surfacing behavior and deterrence from the area near the sound source. The potential for increased surfacing behavior could place turtles at greater risk from vessel collision and potentially greater vulnerability to natural predators. Deterrence from the area could result in temporary or permanent displacement of individuals. However, to encounter received levels of 140 dB, a turtle would have to dive to depths greater than 300 m (955 ft), and be located inside the 140 dB isopleth (equating to 0.372 km^3 (0.06 nm^3 volume around source), not depart the area during the 5-min ramp-up period, and remain there during the source transmission, which has a maximum duty cycle of 8 percent. Thus the potential for short-term behavioral disruption or displacement of sea turtles is considered unlikely.

Potential for Masking

Any potential role of long-range acoustical perception in sea turtles has not been studied and is unclear at this time; anecdotal information suggests that the acoustic signature of a turtle's natal beach might serve as a cue for nesting returns. However, the concept of sound masking is difficult, if not impossible, to apply to sea turtles.

Although low frequency hearing has not been studied in many sea turtle species, those that have been tested, for the most part, exhibit low audiometric and behavioral sensitivity to low frequency sound. Thus, for sounds dominated by low frequency components, the maximum radius of audibility for most sea turtles may often be determined by their hearing sensitivity, rather than the background noise level. It appears, therefore, that if there were the potential for the proposed sound transmissions to increase masking effects of any sea turtle species, it would be expected to be minimal.

Moreover, any sounds that the proposed source might mask are not expected to be particularly significant from the standpoint of turtles. The relatively short transmissions and low duty cycle of the source means that it would mask sounds only for brief periods; sounds longer than this would not be completely masked (such as a ship approaching from a distance). Many sounds of concern (including ship noise which can be a signal of a collision hazard) are broad spectrum signals with components in the frequency range that turtles are known to hear; the NPAL source's narrow bandwidth, low frequency transmissions would not completely mask these sounds. If the NPAL source would create masking effects, existing ship traffic already would be creating masking effects to a much greater degree (ship sounds are much higher surface sound levels than the proposed source); there is no evidence of a significant effect from current noise sources, but it must be recognized that such effects would be exceedingly difficult to observe.

Given the lack of direct evidence, it is presumed that masking effects on sea turtles may occur, but it is anticipated any effects would be minor.

Potential for Long-term Effects

Discussion of the potential for and, ramifications of, long-term effects with respect to marine mammals is relevant to sea turtles, as well. In light of the available data on sea turtles' audiometric sensitivity to low frequency sound, the potential for long-term effects on sea turtles is believed to be minimal, with the possible exception of leatherbacks. However, inasmuch as the density of leatherbacks over the study area is low, but patchy (Eckert, pers. comm., 1994), the fact that only a small percentage of time is spent at depth, the intermittent nature and low duty cycle of the NPAL source, and the fact that the proposed project site is not believed to be a particularly important location of leatherback prey species, any effect should be minimal.

Potential for Indirect Effects

Indirect effects include those effects that could be caused by the proposed action and are later in time, or farther removed in distance, but would still be reasonably foreseeable. The principal indirect effect in this case would be the potential impact on the food chain that could ultimately affect any of the species of sea turtle in the vicinity of the study area. The following lists the common prey species for the sea turtles that could be expected in the study area (Márquez, 1990):

- Leatherback sea turtle: cnidarians (gelatinous zooplankton), tunicates (filter feeders), and jellyfish.

- Green sea turtle: none during neritic phase (food items include coastal algae and seagrasses); during pelagic phase they are carnivorous and feed on various invertebrates (jellyfish, etc.).

- Loggerhead sea turtle: juveniles and subadults are omnivorous (pelagic crabs, mollusks, and jellyfish) (other food items include near-surface/surface vegetation); adults are generalist carnivores (nearshore benthic [seafloor] invertebrates).

- Olive ridley sea turtle: salps, pelagic crustaceans, and other invertebrates.

- Hawksbill: corals, tunicates, sponges (food items include algae).

The proposed project would have no impact on coastal algae, seagrasses, or invertebrates that turtles feed on, and there would be, therefore, no indirect impacts expected. In addition, the proposed source site is not known to be a significant feeding area for any sea turtle species.

4.2.1.2.3 Fish

Chapter 3 discusses the species of fish that inhabit the waters in the vicinity of Kauai and Midway Atoll. This section provides an analysis of the potential direct and indirect effects of low frequency sound on fish, such as physical auditory effects, behavioral disruption and habituation, masking, long-term effects, and adverse impacts on their food chain (indirect effects). Little information on hearing exists for marine species in the vicinity of the proposed sites. However, data on similar groups of fish may provide relevant comparison.

Hearing Capabilities and Sound Production of Fish

The greatest body of acoustic data have been collected on bony fish, while virtually nothing is known of hearing in jawless fish (Popper and Fay, 1993). Furthermore, most of the audiometric data collected on fish are for freshwater species. The few data for those fish that do inhabit the study area indicate that their best hearing frequencies do not occur below 100 Hz.

Various species may detect and process sound in different ways, depending on taxonomic, anatomical, behavioral and physiological variations among species (Popper and Coombs, 1982; Popper, 1983; Schellart and Popper, 1992). These differences in species may include:

- their peripheral auditory structures,
- the acoustic characteristics of their usual environment, or
- their taxonomic grouping.

Most species for which hearing has been studied are teleost fish. Among the teleosts, the species with the best hearing capabilities are members of the series Otophysi. Otophysans represent about 6000 species that include goldfish, carp, minnows, catfish and knifefish. In the otophysans, the gas-filled swimbladder (normally used for buoyancy compensation) is coupled with the inner ears via a series of bones, called the Weberian ossicles. This arrangement is believed to enhance hearing sensitivity and bandwidth (von Frisch, 1938; Dijkgraaf, 1949; Poggendorf, 1952; Kleerekoper and Roggenkamp, 1959). Among all fish species, the otophysans have the best known adaptation for hearing (Popper and Fay, 1993). All species without Weberian ossicles are referred to as "non-otophysans."

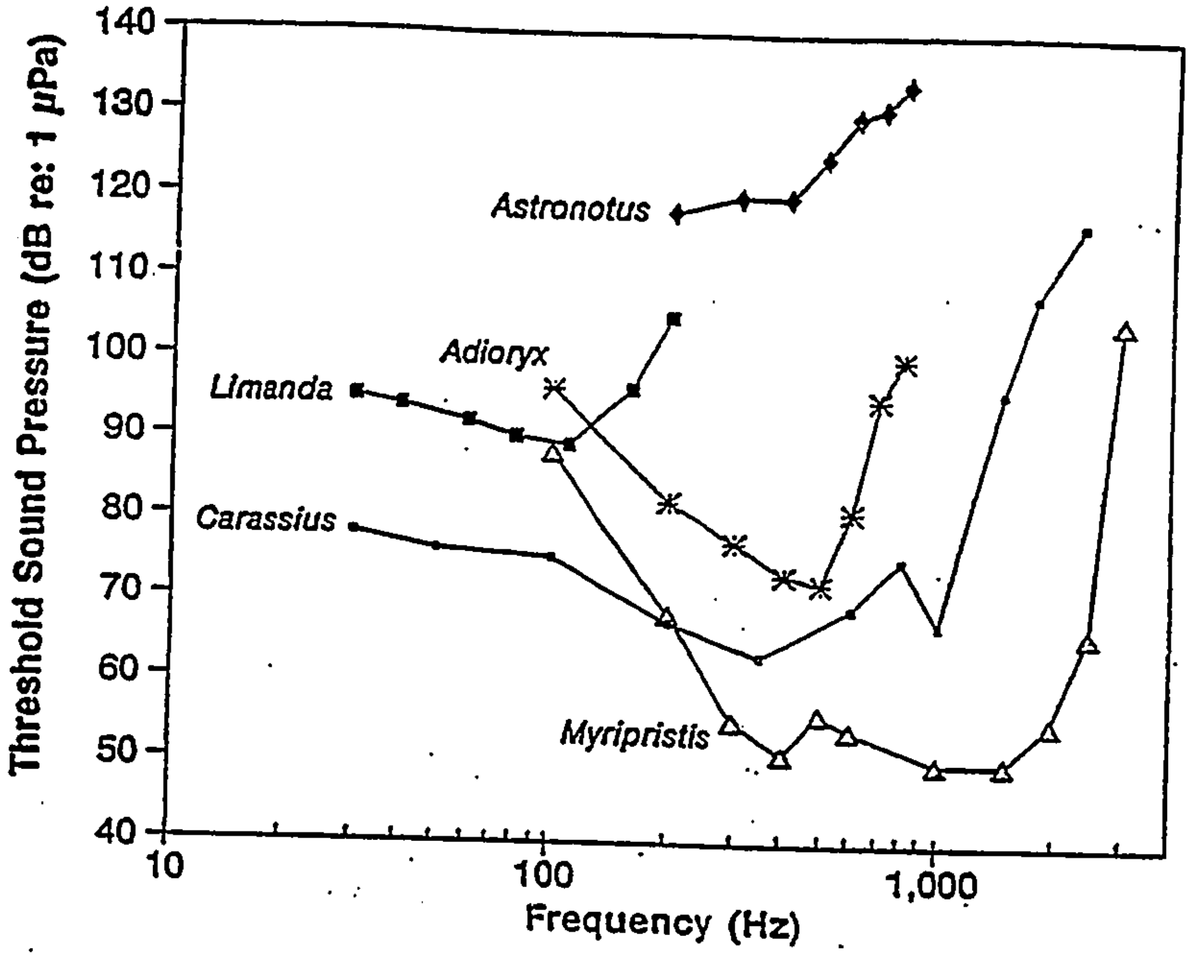
Fish (including otophysans) that have specializations that enhance their hearing sensitivity have been referred to as hearing "specialists;" whereas, those that do not possess such capabilities are termed "nonspecialists." The former tend to have a wider hearing bandwidth and greater sensitivity than the latter. Also, the limited behavioral data available suggest that frequency and intensity discrimination performance may not be as acute in nonspecialists as in specialists (Fay, 1988a).

The primary species of fish expected to inhabit the proposed study area include demersal (bottom-dwelling) and pelagic (water column-dwelling) fish. Based on available audiograms, it appears that, with the exception of sharks, which are discussed below, local fish should have their best hearing sensitivity in the 200-800 Hz frequency bandwidth (Hastings, 1990, 1991).

Audiograms have been determined for over 50 fish (mostly freshwater) (Fay, 1988a). The general pattern from the data indicates that hearing specialists detect sound pressure with greater sensitivity (as low as 55 dB at 400 Hz) and in a wider bandwidth (up to 3 kHz) than the nonspecialists. Figure 4.2-5 (Behavioral Audiograms for Several Fish Species) includes behavioral audiograms for two hearing specialists (a goldfish (*Carassius auratus*) and a squirrelfish (*Myripristis kuntee*)), two nonspecialists that have a swimbladder (another squirrelfish (*Adioryx xantherythrus*) and the oscar (*Astronotus ocellatus*)), and one nonspecialist without a swimbladder (lemon sole, *Limanda limanda*). Note that thresholds are expressed as sound pressure levels because that is the measurable quantity (an acoustic particle velocity sensor does not exist for underwater measurements), although this is strictly correct only for the hearing specialists that respond in proportion to sound pressure. In best absolute sensitivity, 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, 1973). It is not yet clear whether the thresholds for the nonspecialists should be expressed in terms of sound pressure or particle motion amplitudes. Nevertheless, this potential anomaly would not alter the utility of the estimates, as any errors would only serve to raise the threshold levels of the nonspecialist fish.

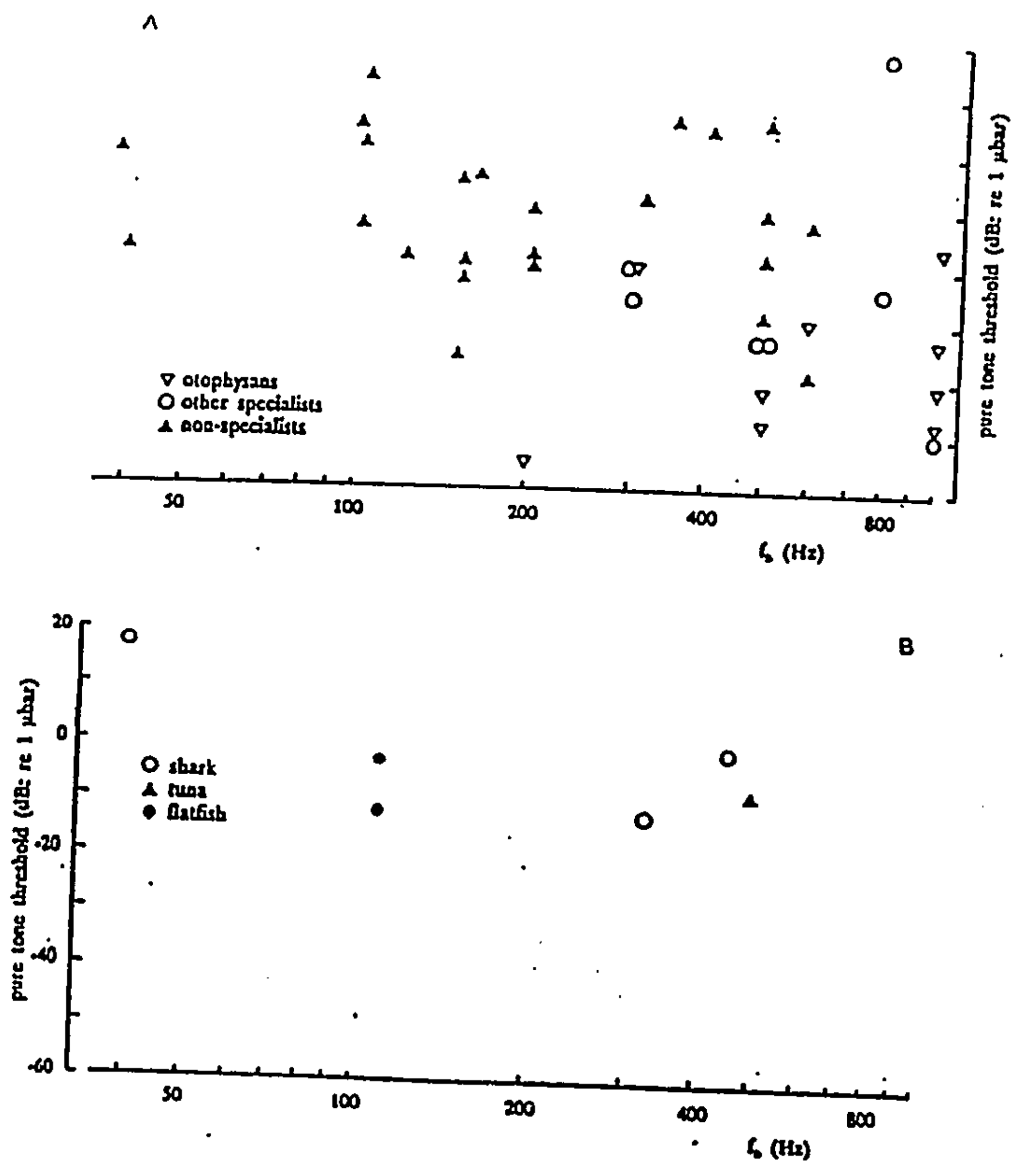
Figure 4.2-6 (Relationship Between Best Hearing Frequency and Hearing Threshold) depicts the relationship of best hearing frequency vs. threshold for a number of fish species with and without swimbladders. Note that in the 50-100 Hz range for swimbladder fish, the best sensitivity (threshold) is about 80 dB (-20 dB + 100 dB = 80 dB); and for those without a swimbladder (particularly sharks), the threshold moves up to the range of 100-120 dB (via extrapolation). Therefore, measured hearing thresholds in fish span a broad range, from as low as 78 dB in goldfish, to 120 dB or higher in yellowfin tuna. There are, however, very few studies of threshold shifts in fish as a response to low frequency sounds. One such U.S. study involved experiments to ascertain the response of salmonoids to low frequency sound (approximately 200-800 Hz, various source levels below 150 dB) and their ability to hear at these frequencies--tied to the use of low frequency sound to direct winter-run chinook salmon and steelhead away from pumping facilities and agricultural diversions (Estrada, pers. comm., 1995). The results of these tests have not yet been published. Extrapolation from human or marine mammal data (which has served as the basis in previous sections for the generally conservative assumption that a 150 dB level or greater is necessary to produce a temporary threshold shift) may be inappropriate given the morphological differences involved. It is assumed, however, that some threshold shifts in fish could occur as a result of NPAL source transmissions. This is because some fish may reside in the immediate vicinity of the NPAL source, and at least a portion have relatively sensitive hearing.

As for sound production in fish, Myrberg (1981) stated that more than 50 fish families produce some kind of sound. The context in which sound production occurs varies greatly from species to species. Many examples have been reviewed by Fine et al. (1977) and Myrberg (1981). Myrberg noted that sounds are commonly produced by fish when they are alarmed or presented with noxious stimuli. These responses are usually intense and have a sudden onset, like signals used by both terrestrial and aquatic animals to startle animal receivers (e.g., nearby predators). Sounds also accompany the reproductive activities of numerous fish species, males being the most active producers. Sound activity often accompanies aggressive behavior in fish, usually



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 4.2-5 Behavioral Audiograms for Several Fish Species



(From Fay (1988a), Abbott (1973) and Jerko et al. (1989). (A) Relation between best frequency and corresponding pressure threshold for swimbladder teleost fish. (B) as A, for six actinopterygian species without swimbladder (3 sharks, 1 tuna, 2 flatfish). Note: Add 100 to Y-Axis values to convert to dB re 1 microPascal.

Figure 4.2-6 Relationship Between Best Hearing Frequency and Hearing Threshold

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 (Hawkins and Myrberg, 1983). The marine biological scientific community is in agreement that more research into low frequency sound production in fish species needs to be conducted.

Sharks are also of interest due to their presumed low frequency sound detection capability. It is apparent that sharks generally do not detect sounds above 1 kHz and that, in most cases, their best sensitivity is to signals below 300 Hz (Popper and Fay, 1977). Sensitivity in lemon and horn sharks is best at about 40 Hz (Nelson, 1967; Kelly and Nelson, 1975). Popper and Fay noted that distinctions between vibration and sound detection are probably not meaningful in a consideration of the shark auditory system.

Figure 4.2-7 (Sound Pressure Thresholds for Three Shark Species) depicts audiograms for three shark species: horn shark (*Heterodontus francisci*), lemon shark (*Negaprion brevirostris*), and bull shark (*Carcharhinus leucas*)(Fay, 1988). Note that the most sensitive hearing for the frequency band 50-100 Hz is attributed to the lemon shark, but its threshold is only about 96-99 dB. The other sharks that have been studied have thresholds 120 dB or higher at frequencies comparable to the NPAL source.

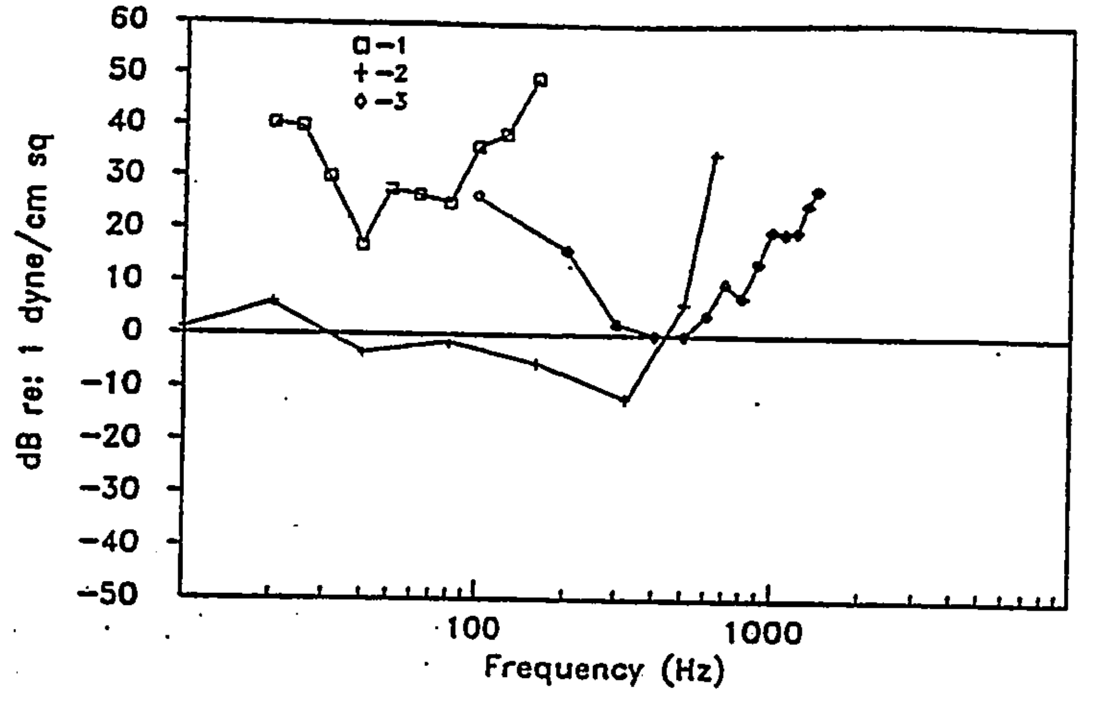
Potential for Physical Auditory Effects

Hastings et al. (1996) studied the effects of intense sound stimulation on the ear and lateral line of a nonspecialist fish (e.g., *Astronotus ocellatus,* the oscar). 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 sound at 300 Hz and 180 dB for one hour. There was no apparent damage with other frequencies, sounds with shorter duty cycles, or shorter stimulation time. Moreover, the only apparent damage was found four days after stimulation. The interpretation of these results was that exposure to a high intensity sound has the potential to damage the ear of fish. However, many caveats accompanied this interpretation, including that fact that:

- The sound had to be continuous;
- It had to last at least one hour; and
- The tissue had to be examined several days after the end of stimulation.

Hastings et al. (1996) further pointed out that this study was the most highly controlled and quantified of any of the few studies on the effects of intense sounds on fish. Consequently, the results must be interpreted and/or extrapolated to other species with the utmost caution.

Additional studies suggest that intense sound may result in limited 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 hearing specialist, to pure tones at 250 and 500 Hz at 204 and 197 dB, respectively, and found some indications of 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



1- *Heterodontus francisci* - horn shark (Kelly and Nelson, 1975)
2- *Negaprion brevirostris* - lemon shark (Banner, 1967)
3- *Carcharhinus leucas* - bull shark (Kritzler and Wood, 1961)

References:

Banner, A. (1967) Evidence of sensitivity to acoustic displacements in the lemon shark *Negaprion brevirostris* (Poey). In P.H. Cahn (ed), Lateral Line Detectors. Indiana University Press. Bloomington, pp. 265-273.

Kelly, J.C., Nelson, D.R. (1975) Hearing thresholds of the horn shark, *Heterodontus francisci*. J. Acoust. Soc. Amer. 58, 905-909.

Kritzler, H., Wood, L. (1961) Provisional audiogram for the shark, *Carcharhinus leucas*. Science 133, 1480-1482.

Figure 4.2-7 Sound Pressure Thresholds for Three Shark Species

(*Gadus morhua*) were destroyed when exposed to sounds at several frequencies from 50 to 400 Hz at 180 dB for 1-5 hours.

In analyzing the results of their study and that of the few previous studies, Hastings et al. (1996) suggested that sounds 90 to 140 dB above the threshold of a fish would potentially be needed to injure the inner ear of a fish. This suggestion was corroborated 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 speculating that extensive injury would require more energy. Thus, it was speculated that in order for extensive damage of the hair cells of the otolith organs to occur, sound levels 220 to 240 dB (RL) would be needed to injure the ears of nonspecialists. The comparable level for a hearing specialist might be on the order of 50 dB lower (assuming that the threshold for the oscar is about 50 dB higher than for the goldfish as shown in Figure 4.2-5). The risk of physical harm or injury would be at received levels at or above 180 dB. For the NPAL project, proportionally few fish are expected to be exposed to levels >180 dB, which would occur within a radius of approximately 5 m (18 ft) from the source. In addition, the proposed source site would comprise only a small portion of the range for any fish species. In light of this, plus the low duty cycle and intermittent nature of transmissions, it is concluded that although threshold shifts might occur in a few hearing specialistis that are deep divers, the impact on fish populations should be minimal.

The question of possible impact on fish from imposing a resonant frequency on their swimbladders also should be addressed. A few experimental studies of those fish possessing swimbladders (e.g., Sand and Enger, 1973; Popper, 1974) showed that the resonant frequency of the swimbladder is considerably above the frequency of best hearing, and thus probably does not determine the shape of the audiogram. For example, the swimbladder of the codfish, closely examined by Sand and Hawkins (1973), has a natural frequency of pulsation well above the hearing range of the fish (best hearing frequency is approximately 160 Hz), and is almost, but not quite, critically damped. Therefore, it is not expected that resonance plays a significant role in response to low frequency sounds such as the NPAL source.

Potential for Behavioral Disruption and Habituation

For fish species, behavioral disruption refers to cessation of resting, feeding, or social interactions; changes in horizontal and/or vertical movement throughout the water column; and avoidance of the sound field area. Avoidance may mean movement from a site of normal habitation, rapid response swimming toward or away from the sound source, or some combination of these actions.

One component of the ATOC MMRPs was to investigate potential behavioral changes in response to the playback of ATOC-like sounds (Klimley and Beavers, 1998). They played back a 75 Hz phase-modulated signal (37.5 Hz bandwidth) to three species of rockfish (nonspecialists) in a 15 x 2 m (50 x 7 ft) pen in Bodega Bay, California. The fish exhibited little movement to 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.

In almost all observations of behavioral disruption, little or no information has been obtained about the duration of the period of altered behavior subsequent to the disturbance (Richardson et al., 1991). Thus, what little information is available almost always pertains to short-term (minutes or, at most, hours) changes in behavior. Studies have strongly suggested that the noise produced by fishing vessels and their associated gear often results in avoidance by just the animals they wish to harvest (Maniwa, 1971). Continuous underwater construction noise, when within the hearing range, and at reasonably high levels, also can result in fish moving out of the affected regions (e.g., a 500-600 Hz received level of 90 dB at approximately 160 m (509 ft) from the source) (Konagaya, 1980).

The best sensitivity range of the majority of the fish expected in the north Kauai offshore region should be in the 200-800 Hz frequency band. Thus, it is considered unlikely that NPAL sound transmissions would cause any measurable behavioral disruption to the indigenous fish species.

Sharks are difficult to study under laboratory conditions, but (as stated above) several studies have found that they are probably sensitive to both sound pressure, and particle velocity or displacement (similar to goby, perch, ruff, toadfish, tautog, and tuna), and show a similar low sensitivity and narrow bandwidth of frequencies in their hearing range (Banner, 1967; Nelson, 1967; Kelly and Nelson, 1975). As a relative example, Myrberg (1978) reported that a silky shark (*Carcharhinus falciformis*) withdrew from a 300 Hz, 155 dB source level sound at 10 m (32 ft) range. He also noted that a lemon shark (*Negaprion brevirostris*) responded to a 300 Hz sound at 130 dB source level from about 100 m (328 ft) distance. Behavioral evidence indicates that sharks detect underwater sound at low frequencies (<1 kHz), and that certain signals (particularly in the 20-80 Hz range) can attract sharks (Popper, 1977). The effect of pulse intermittency and pulse-rate variability on the attraction of five species of reef sharks to low frequency, pulsed sounds was studied at Eniwetok Atoll, Marshall Islands, during January 1971 (Nelson and Johnson, 1972). The species of shark tested were:

- Gray reef (*Carcharhinidae menisorrah*)
- Blacktip reef (*C. melanopterus*)
- Silvertip (*C. albimarginatus*)
- Lemon (*Hemigaleops fosteri*)
- Reef whitetip (*Triaenodon obesus*)

Three artificial test sounds of identical frequency bandwidth (25-500 Hz) but different pulse characteristics were used, as follows:

- Sound 1: 10 pulses/sec, continuous
- Sound 2: 10 pulses/sec, intermittent
- Sound 3: 15-7.5 decreasing pulses/sec, intermittent

30-sec sequences were repeated ten times to comprise single 5-min playback periods.

A total of 253 sharks were seen during 45 sound playback periods, while 44 sharks were seen during 45 corresponding control periods. Response intensities of attracted individuals, coded in relationship to speed and proximity to the sound speaker, were highest for Sound 3, somewhat less for Sound 2, and least for Sound 1. More importantly, sharks exhibited both intradaily (within the span of one day) and interdaily (over the span of more than one day) habituation to all three sounds during the course of the experiment. Nelson and Johnson (1972) concluded that the attractive value of low frequency, pulsed sounds to sharks clearly is enhanced by intermittent presentation, and that such intermittency contributes more to attractiveness than does pulse-rate variability.

Because sharks are known to be attracted to low frequency signals, they would appear to be one of the best candidates for incurring some level of behavioral disruption due to the NPAL LF source transmissions. However, based on the Nelson and Johnson (1972) studies cited above, sharks readily habituated to low frequency, pulsed sounds. Thus, it might be that the attractiveness of the NPAL source transmissions would reduce over a period of time, given that the transmission characteristics would be more constant and at a duty cycle of 2-8 percent.

Potential for Masking

The same general principles concerning masking discussed at the beginning of Section 4.2 also apply to fish and sharks. As noted, the maximum radius of influence of noise on a fish is the distance from the sound source at which the noise can barely be detected. This distance is determined by either the hearing sensitivity of the animal, or the background noise level present. To date, there have been only a few studies of auditory masking in fish, and these offer minimal useful data for comparison. Tavolga (1967) was the first to study the effects of noise on pure-tone detection in two non-ostariophysine species. He reported that the masking effect is generally a linear function of masking level, and is independent of frequency. His measurements of tonal thresholds at the edges of a masking band centered at 500 Hz for the blue-striped grunt (*Haemulon sciurus*) elicited tentative suggestions of the existence of critical bands for fish, as in mammals.

Buerkle (1968) addressed directly the question of critical bandwidths in fish, emphasizing five frequency bands within the 20-340 Hz region. It is clear from his data that in fish, as in mammals, masking is most effective in the frequency region of the signal, and that some filtering must be occurring in the fish's auditory system. Chapman and Hawkins (1973) conducted studies on cod, haddock, and pollack in the ocean off the Scottish coast, the results of which showed that masking of hearing thresholds (approximately 78-85 dB in the frequency range 57.5-92.5 Hz) by ambient noise, although negligible in calm sea conditions, invariably occurred at higher sea states. In summary, it appears that masking effects may be even more complex in fish than in terrestrial vertebrates due to the possibility of multiple receptor systems (Popper and Fay, 1973).

Sharks, which rely on highly developed prey detection skills, have exhibited the use of hearing to interpret the sounds of their prey (Banner, 1972; Myrberg et al., 1972; Nelson and Johnson, 1972; Myrberg et al., 1976; Nelson and Johnson, 1976). Such distance-related sensing systems can be affected through masking due to ambient noise levels. Nelson and Johnson (1970) measured the difference in a lemon shark's audio threshold to a 300 Hz, 130 dB source caused by sea state 1 and 2 to be 2 dB, and the difference caused by light vs. heavy vessel traffic (at sea state 1) to be 18 dB. This equated to differences in masking ranges of 45 m (143 ft) for sea states 1 vs. 2, and 110 m (350 ft) for light vs. heavy boat/ship traffic.

Masking effects would be most significant for those species that have critical bandwidths at the same frequencies as the NPAL source, and that do not have other frequency bands of use. This would appear to be the most applicable to sharks. For the three species of shark that audiograms are available (horn, lemon, bull), hearing thresholds at 75 Hz ranged from 99-130 dB, equating to potential masking areas of radius 5 km (2.7 nm) to approximately 300 km (162 nm). However, at a 2-8 percent duty cycle, it is anticipated that masking would be minor and temporary (92-98 percent of the time a shark would be able to perceive prey through low frequency sounds, and effective masking would only occur for environmental sounds shorter than the 20 min NPAL transmission period, that happened to fall within that 20 min window).

Potential for Long-term Effects

According to Richardson et al. (1991), it is rarely possible to identify the specific cause of any apparent long-term effect (e.g., displacement), and even the occurrence of displacement can be difficult to detect. It is noted, however, that there are a few reports of probable or possible long-term displacements of marine mammals from local areas in which underwater noise was presumably a major factor. Thus, it is possible the same could occur in the case of fish.

If fish do react to noise from human activities by reduced use of certain areas, there is insufficient reliable and systematic data collected to document the trend. In contrast, it is relatively easy to document cases where fish remain in ensonified areas. Thus, cases of partial, or even complete, abandonment of disturbed areas may, in fact, be more commonplace than expected (Richardson et al., 1991), which could impact the local economy.

Although the potential significance of permanent displacement is difficult to determine, Richardson et al. (1991) speculated that in an area where the density of animals is low, and similar to the densities in many other areas, it is unlikely to be critical either to individuals or to the population. They note, however, that effects of displacement would be more problematic in areas consistently used by higher concentrations of animals or areas important to a small but critical component or function of the population (e.g., reproduction).

Animals that appear to tolerate human-made noise are presumed to be less affected by the noise (e.g., through habituation) than are others whose behavior is changed overtly, sometimes with displacement. However, as noted by Richardson et al. (1991), the presence of animals in an ensonified area would not necessarily prove that the population is unaffected by the noise (i.e., the number of animals in the ensonified area may be only a fraction of the numbers that would have been there in the absence of the noise). Also, as noted earlier with regard to marine mammals (Brodie, 1981), fish, like marine mammals, may remain in an area despite the presence of noise disturbance if there are no alternative areas that meet their requirements.

From the results of Klimley and Beavers (1998), in which rockfish did not move away from RLs of 153 dB, the potential for any adverse long-term impacts to fish from NPAL sound transmissions would be expected to be minimal.

Potential for Indirect Effects

The principal indirect effect on fish and sharks would be any potential impact on the food chain that could ultimately impact fish (as a predator), or other species (in the context that certain fish are their prey) in the vicinity of the study area.

Migratory pelagic fish often feed on smaller fish and zooplankton (e.g., in the deep scattering layer), while sharks usually prey on larger fish, marine mammals, and sea turtles. Thus, any impact of the source on prey populations in the vicinity of the study area could possibly cause indirect effects on fish and marine mammals that rely on that food source. Since the potential for effects on fish is expected to be minimal, the potential for indirect effects on the food chain would also be minimal.

4.2.2 Potential Cumulative Effects on the Biological Environment

4.2.2.1 Potential Cumulative Effects of Construction/Removal

Hawaiian monk seals, a severely endangered species, use the beaches of Midway Island for breeding and pupping, and recent increases in pup survival at Midway suggest that the seals may reestablish the atoll as a major breeding site. Therefore, activities associated with the installation of a power cable may disrupt their behavior. Hawaiian monk seals are wary of human activity along the shore, as has been seen in declines in their abundance at inhabited islands. Since Midway Island is a national wildlife refuge, it offers one of the few protected shorelines for the Hawaiian monk seal.

There would be limited probability of a direct adverse effect on the benthic biological environment due to sound source and cable installation and/or removal. Since there is limited bottom trawling for demersal fish in the waters off Kauai and Midway Island, there would be a limited potential for a cumulative impact on the benthic biological environment.

4.2.2.2 Potential Cumulative Effects of Underwater Sound

4.2.2.2.1 Potential Cumulative Effects of Underwater Sound on Marine Mammals

The types of actions that might reasonably be considered to have the potential to interact to affect marine mammals in the study area are noisy activities: e.g., merchant shipping and other vessel-related activities, recreational water activities, marine and nearshore construction and resort operations, aircraft operations, and military and research activities that could add cumulative noise stimuli to the marine environment. The discussions below also account for Marine Mammal Monitoring-related aerial surveys.

• Merchant shipping and other vessel-related activities: In addition to the potential for vessel collisions, noise from ships and boats is a cause for concern in relationship to impacts on marine mammals.

Vessel size, hull construction, speed, mode of operation, and state of maintenance, among other things, influence ship noise levels. Large vessels generally produce more sound than small vessels; fully loaded (or towing/pushing) ships produce more sound than partially full or empty ships; speed increases noise in both loaded and unloaded vessels; and older or more poorly maintained vessels generate more noise than newer or well-maintained vessels. Source levels in the strongest third-octave band may range from 150-160 dB for outboards and other small vessels, to 185-205 dB for supertankers and large container ships (Richardson et al., 1991). Supertankers or other large ships may create potentially disturbing noise for many kilometers around the vessel (Tyack, 1989). The most significant source of noise in many waters, cavitation (bubbles) produced by ship propellers, may be impossible to eliminate. Physical oceanographic factors (Payne and Webb, 1971; Watkins and Goebel, 1984) and submarine topography influence sound propagation and, therefore, the distance at which sound might affect a whale's behavior (NMFS, 1991).

Short-term disturbance of humpback whales by vessels has been investigated in Alaska (Baker et al., 1982, 1983; Kreiger and Wing, 1984; Baker et al., 1988) and in Hawaii (Bauer and Herman, 1986). Observed responses to vessels included attempts to move away, changes in patterns of breathing and diving and occasional displays of possibly aggressive behavior. Baker et al. (1983) described the responses of whales to vessels as follows: 1) "horizontal avoidance" of vessels 2-4 km (1-2 nm) away, characterized by faster swimming with few long dives; and 2) "vertical avoidance" of vessels from 0-2 km (0-1 nm) away, during which whales swam more slowly, but spent more time submerged. Other responses observed, such as trumpeting (Watkins, 1967) or breaching (Whitehead, 1985), lobtailing, or flipper slapping may sometimes indicate disturbance, but may also signify general excitability (Baker et al., 1988). The significance of the extra energy costs incurred by whales responding in these ways is not known. Whales appear to respond less to vessels when actively feeding (Baker et al., 1988) or energetically involved in any other behavior (Hall, 1982).

Responses of Hawaiian humpback whales to vessel traffic were monitored over two winter seasons during 1983-1984 off Maui, Hawaii. A variety of vessel characteristics including vessel numbers, speed, and proximity were associated with changes in whale behaviors, including swimming speed, respiration, and social behaviors. Smaller pods and pods with a calf were more affected than larger pods. A case study suggested that a calf could be so sensitized by the passby of a large vessel, that it subsequently breached in response to noise from a smaller boat engine which previously elicited no behavioral change. The overall results (although differing with categories of whales; e.g., singers, single adults, mothers, calves) suggested that humpbacks often avoid (e.g., by increased frequencies of surfacing without blows and dives initiated without raised flukes) or, in some cases, exhibit direct threat behaviors toward vessels at distances of 0.5-1 km (0.27-0.54 nm) away. These findings, in conjunction with similar results from summering humpbacks in Alaskan waters, indicated disturbance of humpback whales at both winter and summer ranges. The researchers concluded that although substantial short-term effects were noted, the potential long-term negative consequences of such short-term stress (e.g., on fertility) could not be assessed (Bauer, 1986; Bauer and Herman, 1986). It should also be noted that humpback whales may not respond to noise or other stressors until some threshold level is exceeded.

Richardson et al. (1991) summarizes that marine mammals show wide within-species variations in sensitivity to human-made noise. They sometimes continue their normal activities in the presence of high levels of human-made noise, while at other times members of the same species exhibit strong avoidance at much lower noise levels. This apparent variability is partly attributable to variations in physical factors, specifically the characteristics of the human-made noise, its attenuation rate, and the background noise level. However, the variability in responses is also partly attributable to real differences in the sensitivity of different animals, or of the same animal at different times. Some of these differences are associated with differences in activities (e.g., resting vs. feeding vs. socializing), age and sex differences, habitat effects, habituation, and residual individual variation. Thus, the radius of responsiveness varies widely among individuals, between locations, and over time. No single criterion of disturbance will apply to all circumstances, even for a particular type of animal and a particular human activity.

Northern right whales have shown lack of responsiveness to boat noise in the Cape Cod area during mating or surface feeding (Mayo and Marx, 1990). Watkins (1986) found that northern right whales generally moved slowly, but consistently away from passing ships, often dived quickly when disturbed, and were consistently quiet when disturbed. Right whales seen from whale-watching vessels tend to orient away from the vessels when first spotted, but not when last seen (Kraus, in Atkins and Swartz, 1989).

There have been virtually no detailed, calibrated behavioral studies on the reactions of fin, blue and minke whales to vessel noise. However, reactions of these three species to vessel traffic while they were summering in the St. Lawrence estuary have been described in three studies (1973-75, 1979, 1980). During the first two-year period, 232 vessel-whale encounters were opportunistically observed (Mitchell and Ghanime, 1982). In about 15 percent of the cases, the animal(s) departed the vicinity of the boat/ship noise immediately. About 85 percent of the time, they remained in the area, but most changed direction abruptly or dove to avoid close approach by the vessel. When whales remained (probably within range of the vessel sound field), surfacing and respiration patterns did not change in any consistent way.

Based on the second study, Edds and Macfarlane (1987) found that fin whales avoided most vessels by slight changes in heading, or by increasing the duration and speed of underwater travel. Edds and Macfarlane also believed that low frequency vessel noise masked some fin social sounds, and higher frequency outboard motor noise masked minke whale sounds. However, they did continue to vocalize in the presence of vessel noise (Edds, 1988).

The behavior of fin and blue whales was observed in the third study, during 1980. Macfarlane (1981) noted that the manner of approach, rather than the boat size or distance, seemed critical--a slow approach, even by a large boat, usually caused little reaction; but fast, erratic approaches to blue whales reportedly caused flight reactions, separation of a pair, shorter series of respirations, and temporary movement out of the area.

Many odontocetes appear to be generally tolerant of ships and boats (although sperm and beaked whales generally attempt to avoid vessels), and attraction to boats by some toothed whale species is fairly common. Bottlenose dolphins, for example, frequently approach boats, swimming in their bow and stern waves (Shane et al., 1986), and are frequently seen in heavily trafficked ship channels (Braham et al., 1980; Shane, 1980).

Avoidance of vessels can occur, however, depending upon circumstances (e.g., when the animals are confined by ice or shallow water or when vessels are associated with harassment). Irvine et al. (1981), for example, reported that bottlenose dolphins previously captured for research purposes and later released, subsequently fled at the capture boat's return. Flaherty (1981), Barlow (1985), Silber et al. (1988), and Polocheck and Thorpe (1990) reported that harbor porpoises tend to avoid vessels. Silber et al. (1988) reported that the Gulf of California harbor porpoise surfaces for briefer periods when a boat is nearby, often exhibiting "rolling" behavior and respiring only once or twice per surfacing when near a boat. According to Kruse (1985), killer whales may change behavior when a vessel is within 400 m (1273 ft) range. Papastavrou et al. (1989) found that sperm whales were not appreciably disturbed by a small motorized vessel when it was operated in a non-aggressive manner. However, Whitehead et al. (1990) observed startle reactions during attempts to closely approach sperm whales. Watkins and Schevill (1975) and Watkins et al. (1985) found that sperm whales ceased emitting pulsed sounds when exposed to high frequency noise pulses (3-13 kHz) from ship pingers and sonars; although higher frequency pulses (>35 kHz) caused no reaction. As noted above, sperm whales have also exhibited reactions to high received levels (approximately 100 dB) of submarine sonar signals at 3.5 kHz (Watkins et al., 1993).

Collisions between boats and toothed whales apparently are not common, although they do occur. According to Reynolds (1985), vessel propellers were responsible for occasional bottlenose dolphin deaths in the Gulf of Mexico, and sperm whales have been victims of ship collisions as well (Slijper, 1962).

Few authors have described responses of pinnipeds to boats or ships; again, most of the published reports are anecdotal in nature.

Northern fur seals reportedly are quite tame when first encountered by a ship, but will avoid the vessel if it engages in seal hunting for a day or more in the same area (Kajimura in Johnson et al., 1989). Kajimura suspected that, once sensitized in this way, fur seals showed repeat avoidances at distances as great as 1.8 km (1 nm). California sea lions tolerate close and frequent approaches by vessels in shipping lanes, and sometimes congregate around fishing boats (Bigg and Burns in Johnson et al., 1989).

In California, small boats that approach harbor seals within about 100 m (328 ft) frequently cause them to depart their haul-out sites; less severe disturbances often cause alert reactions without leaving (Bowles and Stewart, 1980; Allen et al., 1984; Osborn, 1985). In some places where there are many boats, harbor seals apparently habituate (Johnson et al., 1989). In England, some harbor seals, as well as gray seals, permit close approach by tour boats that repeatedly visit seal haul-out locations (Bonner, 1982), suggesting that the animals habituate to sounds from these specific tour vessels.

There are no published details on collisions between monk seals and ships, boats, or thrillcraft in the northern Kauai offshore area. However, it is expected that these incidents may occur from time to time.

- Recreational water activities: Increased vessel traffic and a significant increase in human activities off the coast of almost all the main Hawaiian Islands since the 1940's and 50's appears to have resulted in decreased numbers of humpbacks in those areas. Herman (1979) noted that humpback density "tends to be inversely related to the concentration of human population on shore or human-related offshore marine activities." Similarly, Kaufman and Wood (1981) stated that "usage of the observation area [varied] inversely with the amount of daily boat traffic."

Glockner-Ferrari and Ferrari (1985) reported that parasailing operations (involving towing a person in a parachute harness behind a high-speed motorboat) in combination with jet skis, inter-island hydrofoils, and other boat traffic in the Lahaina-Kaanapali area, have resulted in humpbacks abandoning preferred nearshore resting areas. Green and Green (1990) also reported a reduction in whale sightings in their study area as a result of parasail operations.

Based on the above information, albeit limited in detail and geographical scope, it would appear that there may be some correlation between increased recreational water activities in the Hawaiian Islands and lower numbers of mysticetes in proximity to those activities.

- Marine and nearshore construction and nearshore resort operations: According to Shallenberger (1978), noise, vibration, and turbidity associated with construction (e.g., pile driving, blasting, dredging, filling, etc.) at or near shoreside may cause whales to abandon an area. Bowhead whales tolerate some dredging noise, but are displaced when dredge noise is sufficiently strong (Richardson et al., 1990).

Cetaceans, all of which remain in the water throughout their lifetime, are presumably less susceptible to nearshore disturbances caused by increased human presence (e.g., during construction or nearshore resort operations) than are pinnipeds that haul out on land. However, gray whales summering close to shore near St. Lawrence Island, Alaska, have been reported to move away when humans appear or move about on the shoreline (Sauer, 1963).

Major facilities, such as hotels and condominiums, located nearshore often generate noise from air conditioning equipment, swimming pool pumping systems, inc. into the ocean environment. Townsend (1991) used the Kaanapali, Maui area as an example in this regard, noting that it has over six major resort hotels and at least six condominium complexes containing shoreside swimming pools, networks of fountains and waterfalls, and large ventilation and air conditioning systems, and contributes to large numbers of swimmers in the nearshore zone.

The potential for impacts on mysticete habitat due to nearshore resort operations would most likely be related to small boat (thrillcraft, parasailing, fishing, whale-watching), and small aircraft (whale-watching, etc.) operations that occur in proximity to the animal(s). The possible effects of these resort activities on the whales' environment have not been directly assessed to date. However, as stated above, it has been reported that parasailing operations, in combination with jet skis, inter-island hydrofoils, and other boat traffic in the Lahaina-Kaanapali area, have resulted in humpbacks abandoning preferred nearshore resting areas. There has been some increase in humpback numbers since the recent ban on thrillcraft in the area (Ferrari, pers. comm., 1994).

• Aircraft operations: Aircraft are known to affect whales; however, Shallenberger (1978), Herman et al. (1980), and others found that whales did not react consistently to aircraft. Aircraft flying as high as 305 m (1000 ft) can elicit responses from whales, while aircraft at half that height sometimes do not. Factors that are known or suspected to affect reactions to aircraft include the loudness of the engines, lateral distance from the aircraft to the animal, speed of the aircraft, wind speed, wave height, water depth, distance from shore, and the age, sex, number, and activities of the whales.

In Hawaiian waters, inter-island commuter traffic and small private planes are the major sources of potential aerial disturbance. These planes fly regularly among all the islands, often crossing areas of high whale concentrations at altitudes of 305 m (971 ft) and less. Pilots occasionally divert from their flight path to circle whales so that passengers can view or photograph them. Helicopter tour operators also disturb humpback whales by flying low or hovering in their vicinity (Tinney, 1988). Noise from low-flying aircraft has apparently declined in the past few years, in response to greater awareness and recognition of the potential for disturbing whales.

Noise from military airplanes and other government exercises also are potential sources of disturbance. In Hawaii, aerial exercises are executed with planes from Hickam Air Force Base and Kaneohe Marine Corps Air Station on Oahu. Herman et al. (1980) suggested that humpback whales arriving in Hawaiian waters may be disturbed by military aircraft flying low over portions of the Alenuihaha Channel between the islands of Hawaii and Maui.

In general, whale reactions to aircraft overflights vary depending on their activities and situations. Whales engaged in feeding or social behavior generally exhibit little reaction to aircraft that are not directly overhead or casting a shadow over them, whereas mother/calf pairs or whales in confined or shallow waters sometimes appear to be comparatively responsive. Bel'kovich (1960) and Kleinenberg et al. (1964) reported that white whales did not react to an aircraft flying at 500 m (1591 ft). However, when the aircraft descended to 150-200 m (477-636 ft), they dove for longer periods, had shorter surface intervals, and sometimes swam away. Feeding white whales were reportedly less prone to disturbance, whereas lone animals dove even when the aircraft was at 500 m (1591 ft). Dohl et al. (1983) reported strong reactions (i.e., diving immediately and remaining submerged for long periods of time) by Baird's and Cuvier's beaked whales to a medium-sized Pembroke aircraft approaching or passing overhead at 60-305 m (191-971 ft) altitudes. However, sperm whales appeared unaware of a Cessna 310 observation aircraft overhead at 152 m (484 ft) altitude (Gambell, 1968).

There has been little systematic study of the reactions of pinnipeds to aircraft overflights, but many opportunistic, anecdotal reports are available for pinnipeds hauled out on land or ice. In general, pinnipeds hauled out for pupping or molting appear to be the most susceptible to adverse effects resulting from disturbance by airplanes (Bowles and Stewart, 1980). The strongest reactions (e.g., rushing into the water, in severe cases resulting in abandonment and mortality of pups) appear to be elicited by low-flying aircraft, aircraft that are nearly overhead, aircraft exhibiting abruptly changing sounds, and helicopters versus fixed-wing aircraft (Salter, 1979). There is some evidence that they react more strongly to helicopters than fixed-wing aircraft (Johnson, 1977), but the lack of measured sound levels in these instances make this postulation uncertain.

There is no indication that single or occasional aircraft overflights cause long-term displacement of marine mammals.

• Military and research activities: Limited military activities occur in the vicinity of the Kauai source. PMRF currently has no environmental authorization to conduct active underwater acoustic tests. Other military training missions involving active sonar occur throughout the Hawaiian Islands, however none are known to occur within 93 km (50 nm) of the Kauai source. In its Draft EIS, geographic restrictions on the employment of the Navy's Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar state that it would not generate a sound field greater than 180 dB with 22 km (12 nm) of any coastline, nor would it exceed 145 dB in the vicinity of known recreational and commercial dive sites. Therefore, none of these military activities should cumulate with the proposed action.

No other ocean acoustics research activities (past, present, or future) are anticipated to cumulate with potential effects of the NPAL source transmissions on the physical environment. Any effect the ATOC project may have had on ambient noise ceased when transmissions stopped (October, 1999). Furthermore, a single sound source in the mid-Pacific provides adequate coverage to receivers in the eastern and North Pacific for studies of large-scale acoustic thermometry and long-range sound propagation, and additional sources should not be required near Kauai. It can be anticipated that a number of unrelated, regional, short-term, ocean acoustic tomography projects will be conducted at various locations in the North Pacific Ocean over the next five years. The Ocean Acoustic Observatory Federation, for example, deployed an autonomous HLF-5 acoustic source (described in Section 2.1.5) on Hoke Seamount in the eastern North Pacific as part of a system to monitor the California Current. The source was installed in April 1999 and is projected for recovery during May 2000. As a second example, the Farfield Program of the Hawaii Ocean Mixing Experiment is funded by the National Science Foundation to deploy an array of four HLF-5 sources in the central North Pacific to study the role of tidal dissipation in ocean mixing. The plan is to install a triangular array with a fourth source in the center a few hundred kilometers on a side north of the Hawaiian Ridge during May 2001. The entire array would then be picked up and moved south of the Hawaiian Ridge during September 2001. All of the instrumentation would be recovered during April 2002.

In all cases for which definite information is available, the sources operate at significantly higher frequencies (250 Hz for the HLF-5 source) than the proposed NPAL source. They would be located at depths well below the near-surface region, where most of the potentially affected marine species are found, and in mid-ocean locations well outside the coastal zone, in regions where the abundances of potentially affected marine species are very low. The output power level of the HLF-5 sources used in the projects mentioned above is only 132 Watts, 50% of the power level of the ATOC source (192 dB re 1 μPa at 1 m vs. 195 dB re 1 μPa at 1 m). The transmissions typically last only about 2 minutes or less, and the overall duty cycle is typically only about 0.3 percent due to the constraints imposed by the limited battery packs that are feasible for autonomous operation. All of these characteristics are possible because the signals are designed for regional experiments and are not adequate for transmissions over 3000-5000 km ranges, as was discussed in Chapter 2.

The implications are that the individual regional projects would be expected to have only negligible effects on the environment. For the projects described above, the 250-Hz signals would be below the background ambient noise levels at both the Kauai and Midway locations and so no cumulative impacts are anticipated with the transmissions from the proposed NPAL source.

In summary, the project's incremental contribution to any cumulative impacts from other sources of subsea sounds or developments that affect the marine environment in the vicinity of the proposed project are speculative. Although continued increases in vessel traffic can be predicted, other effects (such as a shift to quieter vessels, changes in traffic patterns such as those that might result from redirecting Alaskan oil shipments from California to Asia via Hawaii, etc.) could mitigate or eliminate these increases. Additional knowledge gained from the MMRP, particularly if impacts deserving of governmental control are discovered, could result in measures to reduce subsea noise impacts through a shift in vessel traffic patterns, vessel noise standards, or similar measures. No additional mitigation measures beyond those already identified are proposed to address cumulative impacts.

4.2.2.2.2 Potential Cumulative Effects of Underwater Sound on Sea Turtles

Activities that potentially could be considered to interact in a cumulative sense on sea turtle species that might inhabit or travel through the proposed study area include: 1) merchant shipping and other vessel-related activities, and recreational water activities (as a result of the potential for vessel collisions); and 2) aircraft operations. The discussions below also account for Marine Mammal Monitoring-related aerial surveys.

- Merchant shipping and other vessel-related activities: There are no published details on collisions between sea turtles and ships, boats, or thrillcraft in the north Kauai or Midway Atoll areas. In fact, very few authors have described responses of sea turtles to ships or boats; with most of these being anecdotal in nature. However, it is expected that such incidents do occur from time to time, particularly since these species do spend time close to the coast, where fishing and pleasure boating is most prevalent.

The potential concern in this case would be that, if sea turtles were able to hear the acoustic signal, it could possibly cause them to modify their natural behavior and spend more time at the surface where they would be more susceptible to predators and collisions with vessels. Based on one of the few calibrated experiments to determine auditory capability in sea turtles, in-air data has been extrapolated to derive a green turtle's hearing threshold (in water) at 132 dB at 70 Hz. Using this value as a benchmark, the potential for a sea turtle to be influenced by a source transmission can at least be bounded to some extent. In this case, for the turtle to be exposed to sound levels ≥132 dB, it would have to be almost directly over the source location at the sea surface, or to be exposed to sound levels >138 dB, it would have to be located deeper than 150 m (477 ft) and within 700 m (2227 ft) range from the source proper. Added to these positional criteria are the facts that the source would operate for only 2-8 percent of the time and that there would always be a 5-min ramp-up period leading up to full power operation, so that if the animal did hear the sound, and found it annoying, it could swim away. Thus, it appears that the potential for source noise to affect the behavior of a sea turtle, such that it would be placed in greater peril at the surface from collisions with merchant shipping and other vessel-related activities, or to greater predation, is possible, but probably minimal. As these findings are based on the aforementioned extrapolation, if the assumptions are incorrect (i.e., hearing thresholds are lower), a proportional increase in the radius of audibility would result.

- Aircraft operations: There have been no systematic studies of the reactions of sea turtles to aircraft overflights and even anecdotal reports are scarce. Balazs and Ross (1974) dealt with the effect of aircraft noise on sea turtles in terrestrial habitat. It seems reasonable to expect that noise from aircraft, both fixed- and rotary-wing, could be heard by a sea turtle at or near the surface, and cause it to alter its normal behavior pattern. Any potential change in cumulative effect of aircraft noise in the study area due to the addition of Marine Mammal Monitoring aerial surveys is unknown, although presumed to be very minimal. The potential change in cumulative effect due to the addition of Marine Mammal Monitoring aerial survey flights (maximum 4 flights per year) is expected to be minimal.

4.2.2.2.3 Potential Cumulative Effects of Underwater Sound on Fish

Activities that could potentially be considered to interact cumulatively to affect fish species off the north coast of Kauai or Midway Atoll include noise-generating activities: merchant shipping, commercial fishing, and recreational water sports, as well as direct exploitation of fish species by commercial fisheries. The discussions below also account for Marine Mammal Monitoring-related aerial surveys.

Since the level of ambient noise produced by endemic activities cannot be changed, any potential cumulative effects caused by the addition of NPAL sound transmissions are likely to depend, in part, to the degree that fish habituate to repeated noise exposure.

However, noise increases from other potential future sources are speculative; there are no known projects or trends that would have noise impacts cumulating with the NPAL sound transmissions. Any potential for increases of commercial fishing in the area are speculative. As discussed in this EIS, direct impacts to most marine animals are expected to range from minor to negligible. No significant impacts are anticipated when the current project is added to other cumulative changes in the environment.

4.2.3 Threatened, Endangered and Special Status Species

Table 3.3-2 lists the thirteen threatened, endangered, or special status marine species that could occur offshore Kauai or Midway Atoll. The three mysticetes (blue, fin, and humpback whales), one odontocete (sperm whale), and one pinniped (Hawaiian monk seal) are addressed in Section 4.2.1.2.1. The five sea turtles (green, leatherback, olive ridley, hawksbill, and loggerhead) are addressed in Section 4.2.1.2.2. As concluded in those sections, potential effects on these species is low to moderate. There is no potential for effects on the three seabirds (Newell's shearwater, short-tailed albatross, and the Hawaiian dark-rumped petrel) as discussed in Section 3.3.5.

4.2.4 Marine Sanctuaries and Special Biological Resource Areas

There are two categories of marine sanctuaries and special biological resource areas: 1) offshore areas, and 2) nearshore areas. The former includes the Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS) and the Hawaiian Islands National Wildlife Refuge.

As discussed in Chapter 6, the proposed project is consistent with the management plan for the HIHWNMS. The Hawaiian Islands NWR consists of eight islands, reefs, and atolls extending about 800 miles northwest from the main Hawaiian Islands. The closest component to the Kauai source is Nihoa Island, approximately 300 km (162 nm) away. Pearl and Hermes Reef are closest to Midway, at a distance of approximately 200 km (108 nm). At such great distances, there would be no effect on the Hawaiian Islands NWR from either the Preferred or Midway alternatives. As discussed in Chapter 3, of the seabirds that dive in pursuit of their prey, all are thought to be shallow water divers, capable of diving to depths of less than 20 m (66 ft). No known deep-diving bird species occur in the Kauai and Midway Atoll study areas.

Nearshore areas include the Kilauea Point National Wildlife Refuge on the north coast of Kauai, Hanalei National Wildlife Refuge, and the Midway Atoll National Wildlife Refuge. These areas are so close to the shoreline (where project source sound fields would be highly attenuated) that no potential effects from source transmissions are anticipated on any species found therein. During installation of the power cable at Midway, every precaution would be made to avoid contact with coral, since not only would this damage the coral, but it would also damage the cable. It is highly unlikely that any organisms could become entangled in the cable as it was being laid since the cable consists of a single line and there would be no loops or kinks in it. In addition, few, if any, plants or animals living on the seafloor would be damaged by the cable since the cable's diameter is only 3.18 cm (1.25 in). However, Hawaiian monk seals, a severely endangered species, use the beaches of Midway Island for breeding and pupping, and recent increases in pup survival at Midway suggest that the seals may reestablish the atoll as a major breeding site. Therefore, activities associated with the installation of a power cable may disrupt their behavior.

In summary, no direct, indirect, or cumulative effects on offshore marine sanctuary resources are expected. For nearshore special biological resource areas, there is the potential for disrupting Hawaiian monk seals on the shores of Midway during installation of the power cable, but no other impacts are expected. Since the seabirds species that occur in the Kauai and Midway Atoll study areas are not deep divers, they would not be affected.

4.2.5 Essential Fish Habitat

In the waters in and around Hawaii, essential fish habitat (EFH) has been designated by the Western Pacific Regional Fishery Management Council (the Council). In essence, the designations consist of the depth ranges within the exclusive economic zone (EEZ) of certain life stages of some fishery management plan (FMP) species. In addition, the Council identified habitat areas of particular concern (HAPC). The following description includes those components which are in the vicinity of the main and northwest Hawaiian Islands.

For adult and juvenile bottomfish species (Table 4.2-7), the water column and all bottom habitat from the shorelines of all islands to a depth of 400 m (1312 ft) are designated EFH, encompassing the steep drop-offs and high relief habitats that are important for bottomfish. EFH for bottomfish eggs and larvae includes the water column extending from the shoreline to the outer boundary of the EEZ to a depth of 400 m (1312 ft).

The seamount groundfish complex consists of three species (pelagic armorheads, alfonsins, and ratfish). These species dwell at 200-600 m (656-1969 ft) on the submarine slopes and summits of seamounts. EFH for the adult life stage of the seamount groundfish complex includes all waters and bottom habitat bounded by 29°-35°N, 171°E-179°W between 80-600 m (262-1969 ft). EFH for eggs, larvae and juveniles is the epipelagic zone (<200 m [656 ft]) of all waters bounded by 29°-35°N, 171°E-179°W.

Table 4.2-7 Management Unit Species Complexes for Bottomfish

EFH Complex		Common Name	Scientific Name
Bottomfish	**Shallow-water species** (0-100 m [0-328 ft])	Uku	*Aprion virescens*
		Thicklip trevally	*Pseudocaranx dentex*
		Lunartail grouper	*Variola louti*
		Blacktip grouper	*Epinephelus fasciatus*
		Ambon emperor	*Lethrinus amboinensis*
		Redgill emperor	*L. rubrioperculatus*
		Giant trevally	*Caranx ignoblis*
		Black trevally	*C. lugubris*
		Amberjack	*Seriola dumerili*
		Taape	*Lutjanus kasmira*
	Deep-water species (100-400 m [328-1312 ft])	Ehu	*Etelis carbunculus*
		Onaga	*Etelis coruscans*
		Opakapaka	*Pristipomoides filamentosus*
		Yellowtail Kalekale	*P. auricilla*
		Yelloweye opakapaka	*P. flavipinnis*
		Kalekale	*P. sieboldii*
		Gindai	*P. zonatus*
		Hapupuu	*Epinephelus quernus*
		Lehi	*Aphareus rutilans*
Seamount Groundfish		Armorhead	*Pseudopentaceros richardsoni*
		Ratfish/butterfish	*Hyperoglyphe japonica*
		Alfonsin	*Beryx splendens*

Based on the known distribution and habitat requirements of adult bottomfish, the Council designated all escarpments and slopes between 40-280 m (131-919 ft) as HAPC.

The species complex designations for the pelagic management unit species (PMUS) are marketable species, non-marketable species, and sharks (Table 4.2-8). EFH for PMUS was designated as the waters from the shoreline to the outer limit of the EEZ to a depth of 1,000 m (3281 ft). Although many of these species are found at depths of less than 200 m (656 ft), bigeye tuna are abundant at depths in excess of 400 m (1312 ft) and swordfish have been tracked to depths of 800 m (2625 ft). In addition, the vertically-migrating mesopelagic (<1000 m [3281 ft]) fishes and squids are important prey items for PMUS. EFH for eggs and larvae has been designated as the epipelagic zone (<200 m [656 ft]) from the shoreline to the outer limit of the EEZ.

Table 4.2-8 Species Complexes for Pelagic Management Unit Species

EFH Complex		Common Name	*Scientific Name*
Marketable	**Temperate Species**	Striped marlin	*Tetrapurus audax*
		Bluefin tuna	*Thunnus thynnus*
		Swordfish	*Xiphias gladius*
		Albacore	*Thunnus alalunga*
		Mackeral	*Scomber* spp.
		Bigeye	*Thunnus obesus*
		Pomfret	family Bramidae
	Tropical Species	Yellowfin	*Thunnus albacares*
		Kawakawa	*Euthynnus affinis*
		Skipjack	*Katsuwonus pelamis*
		Frigate and bullet tunas	*Auxis thazard, A. rochei*
		Blue marlin	*Makaira nigricans*
		Slender tunas	*Allothunnus fallai*
		Black marlin	*Makaira indica*
		Dogtooth tuna	*Gymnosarda unicolor*
		Spearfish	*Tetrapturus* spp.
		Sailfish	*Istiophorus platypterus*
		Mahimahi	*Coryphaena hippurus, C. equiselas*
		Ono	*Acanthocybium solandri*
		Opah	*Lampris* spp.
Unmarketable		Oilfish	family Gempylidae
		Pomfret	family Bramidae
		Crocodile shark	
Sharks		Requiem sharks	family Carcharinidae
		Thresher sharks	family Alopiidae
		Mackeral sharks	family Lamnidae
		Hammerhead sharks	family Sphyrnidae

For HAPC, the Council designated the water column down to 1000 m (3281 ft) that lies above all seamounts and banks within the EEZ that are shallower than 2000 m (6562 ft). Because the PMUS are highly migratory, the areas outside the EEZ in the western Pacific region are designated by the Council as "important habitat." Vast areas outside the EEZ (the Council's limit of jurisdiction) provide essential spawning, breeding, and foraging habitat.

The crustacean species assemblages include the spiny and slipper lobsters complex and the Kona crab complex (Table 4.2-9). The EFH for spiny lobster larvae is the water column from the shoreline to the outer limit of the EEZ down to a depth of 150 m (492 ft). The EFH for juvenile and adult spiny lobster is designated as the bottom habitat from the shoreline to a depth of 100 m (328 ft). All banks in the northwest Hawaiian Island chain with summits less than 30 m (98 ft) were designated as HAPC.

Precious corals may be divided into deep-water and shallow-water species, and these are the assemblages used to designate EFH (Table 4.2-10). The six known beds of precious coral were designated as EFH, including: Keahole Point (Island of Hawaii), Makapuu (Oahu), Kaena Point (Oahu), Wespac (between Necker and Nihoa Islands), Brooks Bank (among northwest Hawaiian Islands), and 180 Fathom Bank (among northwest Hawaiian Islands). In addition, the Council designated three black coral beds as EFH: between Milolii and South Point on Hawaii, Auau Channel between Maui and Lanai, and the southern border of Kauai. Four of these were designated as HAPC: Makapuu, Wespac, Brooks Bank, and Auau Channel. No precious coral EFH or HAPC exist in the vicinity of the Preferred Alternative or the Midway Alternative. As discussed in Section 4.1, the physical installations associated with the Midway Alternative are relatively minor. The power cable would need to be laid through the shoreline band, with associated trenching (nominally 1 m [3.3 ft] deep) and the installation of a pipe that would protect the cable from wave action and prevent movement. At deeper depths, the cable would be routed through frequent surge channels in the coral atoll to avoid cable suspensions and coral surfaces. The installation of the power cable and sound source associated with the Midway Alternative would not result in slope instabilities or other incompatibilities with the physical environment, and therefore should have no direct adverse effect on any EFH. The No Action and Midway alternatives include the removal of the sound source and some or all of the power cable presently in place north of Kauai. Since the cable has been on the seafloor for 6 years, natural processes such as sediment drift are likely to have buried the cable, especially in areas where the seafloor is primarily sand. If the cable is buried, removing it would disrupt the overlying sediment. Physical installations and/or removals associated with the No Action and Midway Alternatives may temporarily disrupt the seafloor; however, since the cable has a nominal diameter of 3.18 cm (1.25 in), removing it is unlikely to have an adverse direct effect on any identified EFH.

As discussed in Section 3.2.1, Section 4.2.1.2.3, and Section 4.2.2.2.3, transmissions from the NPAL sound source would not have direct, indirect, site specific, or habitat wide individual, cumulative, or synergistic impacts. Consequently, there is no indication that either the Preferred Alternative or Midway Alternative would reduce the quality and/or quantity of EFH.

Table 4.2-9 Species Complexes for Crustacean Management Unit Species

EFH Complex	Common Name	*Scientific Name*
Spiny and Slipper Lobster	Hawaiian spiny lobster	*Panulirus marginatus*
	Spiny lobster	*P. penicillatus, P.* sp.
	Ridgeback slipper lobster	*Scyllarides haanii*
	Chinese slipper lobster	*Parribacus antarticus*
Kona Crab	Kona crab	*Ranina ranina*

Table 4.2-10 Species Complexes for Precious Coral Management Unit Species

EFH Complex	Common Name	*Scientific Name*
Deep-water Precious Corals (300-1500 m [984-4922 ft])	Pink coral	*Corallium secundum*
	Red coral	*C. regale*
	Pink coral	*C. laauense*
	Midway deepsea coral	*C.* sp. nov.
	Gold coral	*Gerardia* sp.
	Gold coral	*Callogorgia gilberti*
	Gold coral	*Narella* spp.
	Gold coral	*Calyptrophora* spp.
	Bamboo coral	*Lepidisis olapa*
	Bamboo coral	*Acanella* spp.
Shallow-water Precious Corals (20-100 m [66328 ft])	Black coral	*Antipathes dichotoma*
	Black coral	*Antipathis grandis*
	Black coral	*Antipathes ulex*

4.3 POTENTIAL EFFECTS ON THE ECONOMIC ENVIRONMENT

This section addresses the potential effects of the proposed action on Kauai's and Midway Island's economic environments. Direct effects evaluated in this section are the potential for increased economic activity due to the project. Indirect effects refer to the potential effects should any adverse impacts on marine mammals or other species discussed above occur.

4.3.1 Potential Direct and Indirect Effects on the Economic Environment

The Hawaiian Archipelago shelf and slope off north Kauai support an economically valuable range of commercial fisheries utilizing a variety of retrieval methods. In 1990, a combined total of approximately 10 million kg (22 million lbs) of fish, with an ex-vessel value exceeding $50 million was landed at the ports of Hawaii. Given the depth of the sound source, the minor extent of the sound fields, the low duty cycle (most of the time only 2 percent), the five-minute ramp-up period that would give all mobile marine animals the opportunity to depart the immediate area of the source if the sound was annoying, and the habitat range of the major commercial, recreational, and subsistence fish species, any potential effect on the fishery-based economic environment is expected to be negligible. See Sections 3.3.4 and 4.2.1.2.3.

Direct effects of the proposed project would be limited to the beneficial impact of program expenditures on the economy. These include payrolls for labor incurred, expenditures for supplies and equipment, and other monies spent.

Marine mammals are no longer a direct economic resource for Hawaii, and they are almost all protected from exploitation. Commercial fishing is an important economic activity, but it is not anticipated that the sound transmissions would have a material adverse impact on fish, as discussed above. Direct effects on the economy through reduction of tourism could occur if changes in marine mammal abundance or behavior would occur. However, results from the Kauai MMRP demonstrated that no overt or obvious short-term change in abundance, distribution, or behavior occurred as a result of the sound transmissions.

Because of the absence of whale watching at the Midway Atoll alternate site, no direct or indirect economic impacts would be anticipated from those alternatives.

Generally, the direct economic effect of the project would be minor, but beneficial, resulting from increased economic activity due to payrolls and support expenditures.

4.3.2 Potential Cumulative Effects on the Economic Environment

• Merchant shipping and other vessel-related activities: There should be no impact on any tourist industry economic base related to merchant shipping or other vessel-related activities.

• Recreational water activities: The same conclusions apply to the potential for acoustic sound transmissions changing the cumulative effect of this activity. There should be no impact on the economy of tourism (from recreational water activities) due to the adoption of either alternative.

• Aircraft operations: The addition of acoustic sound transmissions into the environment would cause no potential change in the cumulative effect of aircraft noise in the area. Further, there would be no expected change in any cumulative effect due to the addition of aerial surveys and observations. Therefore, there should be no impact on any economic base related to aircraft operations.

In summary, the potential impacts on the economic environment from the proposed action would not be expected to contribute to cumulative adverse impacts.

4.4 POTENTIAL EFFECTS ON THE SOCIAL ENVIRONMENT

Any potential effect on the social environment would be related to the human environment, as discussed below.

4.4.1 Potential Direct and Indirect Effects on the Human Environment

The following discussion addresses potential impacts to the human environment in the following areas:

• Population dynamics: No potential direct or indirect effect on population dynamics would be expected due to either of the alternatives being implemented.

• Educational institutions: The results of the NPAL research would be published and therefore available to local teachers, students, and interested community members. From 5 to 10 scientists, most from Hawaii marine science educational institutions, would be involved in aerial surveys as part of the Marine Mammal Monitoring Studies.

• Recreational and leisure activities: Whale, dolphin, monk seal, and sea turtle-watching, and sport fishing have already been covered previously. The only other human activity that could potentially be affected by the proposed acoustic source sound transmissions would be recreational diving. The potential for effects is expected to be minimal since most recreational diving occurs in the nearshore region. The following discussion is provided:

Low frequency sound transmitted in the vicinity of humans underwater could potentially produce either a physiological reaction or an aversion reaction. A recent study was conducted by ONR and Naval Submarine Medical Research Laboratory (NSMRL) in conjunction with a consortium of university and medical laboratories (Cudahy et al., 1999). Its purpose was to develop guidance for safe exposure limits for recreational and commercial divers exposed to LF sound, primarily in the frequency range of 100 to 500 Hz. Computer modeling and animal and human studies were performed.

The study concluded that the maximum intensity (sound pressure level) of 157 dB did not produce any physiological evidence of damage in human subjects. Furthermore, there was only a two percent aversion reaction by divers at a level of 148 dB. Cudahy et al., therefore, 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 divers. Therefore, this study set the intensity criteria for recreational and commercial divers at 145 dB.

Since most human diving activity of the north Kauai and Midway coasts takes place within 2 km (1 nm) of the shoreline, there would be no potential adverse effect.

4.4.2 Potential Cumulative Effects on the Human Environment

The following refers to potential cumulative effects on the human environment in the Kauai or Midway Atoll source areas.

• Population dynamics: Because there would be no potential direct or indirect effects expected, no potential cumulative effect on population dynamics would be expected due to either of the alternatives being implemented.

• Educational institutions: Based on the proposed action's plans, the potential for any cumulative effect on educational (and environmental) establishments would be expected to be only positive in nature.

•Recreation and leisure activities: The potential cumulative effects of the alternatives on mysticete, odontocete, pinniped, or sea turtle watching, and sport fishing have been addressed previously. The section above concluded that the potential direct and indirect effects on human diving activities would be virtually nonexistent. Therefore, it should be considered that any potential for any alternative altering the cumulative effects on human divers in the future would also be negligible.

4.5 OTHER POTENTIAL IMPACTS

Although potential habitat and biological resources impacts are the principal area of concern and the focus of this EIS, a number of other potential effects are presented by the proposed project and its alternatives. These include aircraft traffic (Marine Mammal Monitoring activities), construction/removal impacts (laying cable, installing the source, etc. associated with the No Action and Midway alternatives), consistency with land use plans and policies (discussed below in Chapter 6), cultural and historical resource impacts (potential presence of shipwrecks, etc., at the facility site), visual impacts, employment, population and public services (researchers and others doing work on Kauai or Midway), air pollution (from vessel and aircraft activities), energy impacts, and cumulative impacts of the proposed action.

These additional effects are each discussed briefly below. Where applicable, the effects presented by alternatives will also be addressed. Except where otherwise noted, additional effects from the no action alternative are assumed to be nonexistent. Any additional mitigation measures are identified.

4.5.1 Potential Increases in Vessel and Aircraft Traffic

A project will generally be considered to have major transportation impacts if it will add measurably to existing traffic levels, or add to traffic levels that currently exceed system capacities. Currently, small vessels and aircraft operate in the vicinity of the proposed action site, but those traffic levels are well below the carrying capacity of local airways.

During monitoring, minor increases would occur in aircraft traffic off the north Kauai and Midway Island coasts (maximum total 30 days of flight operations). Since the source would be powered from shore, it would not require routine maintenance that would result in increased vessel trips. All NPAL aircraft trips are well within the capacity of the local airways, and do not constitute a significant impact.

The Midway Alternative would result in greater levels of vessel traffic than the preferred alternative, since a sound source at Midway would have to be installed.

4.5.2 Potential Direct Construction and Maintenance Impacts

No construction would occur as part of the Preferred or No Action alternatives. The source for the Midway Alternative would be constructed in Seattle, Washington and would be transported to the source site. Other than minor vessel traffic and resulting air pollution, installation and maintenance of the source would not result in any environmental impacts. No alteration to the seabed would occur.

4.5.3 Cultural and Historical Resources

Under federal regulations implementing the National Historic Preservation Act, analysis of impacts is limited to certain potential effects on certain historic properties. See 16 USC 470 and 36 CFR §§ 800.1-800.16. Historic properties are defined as prehistoric or historic districts, sites, buildings, structures, or objects which are included in, or eligible for inclusion in the National Register of Historic Places. It also includes properties of traditional religious and cultural importance to Native Hawaiians that meet the National Registry criteria. The potential effects in question are those which would alter the characteristics of the historic property that qualify the property for inclusion in the National Register. An adverse effect would occur, for example, where the activity would involve demolition, destruction, relocation, or alteration of a historic property.

As described in Section 3.3.6, a literature and archival review was performed for the proposed project area off the north shore of Kauai and off Midway Atoll. No impacts to prehistoric or historic sites, cultural resources, structures or objects included in or eligible for inclusion in the National Register are anticipated.

Some shipwrecks are recorded in the general vicinity of the north Kauai offshore area and in the vicinity of Midway Atoll (see Section 3.3.6). The precise locations of most of these are unknown. However, the immediate area of the Kauai source site has been thoroughly studied and no shipwrecks are located within at least 10 km (5.4 nm) radius. Baseline analysis of the Midway Atoll site alternative also reveals no known shipwrecks within at least a 10 km (5.4 nm) radius.

ONR has also considered the possibility that the proposed activity could affect a historic property of traditional cultural or religious importance to Native Hawaiians. However, no such properties were identified in the area potentially affected by the project. See Section 6.2.3.

ONR has also considered the question of whether the proposed activity could affect cultural practices of the community or state. No such potentially affected practices were identified during scoping or review of the draft EIS. The issue of whether traditional practices associated with fishing could be affected was considered. As set forth in sections 4.2.1.2.3 and 4.3.1, the evidence does not support a conclusion that there would be such an effect. 4-24

4.5.4 Potential Visual Impacts

Visual impacts are generally considered serious if they violate applicable guidelines relating to visual quality, critically alter the existing natural views including changes in natural terrain, or if they seriously change the existing visual quality of the region or eliminate visual resources.

Since all Kauai onshore facilities will be either underground or in existing buildings at PMRF, no visual impacts will result. Furthermore, the source power cable is tied into an existing Navy cable, such that there is no additional visual impact. For the Midway Atoll alternative, the only potential visual impact would be related to the section of the cable, enclosed by pipe, from the surf line to the landfall, which would be considered to be minimal, given the minor scope of the facilities and the existing setting.

4.5.5 Employment, Population, and Public Services

A project generally will be considered to have a major impact on population, employment and housing if it will induce substantial growth or concentration of population, displace a large number of people, or conflict with the housing and population projects and policies set forth in applicable land use plans. The monitoring team would consist of 5-10 personnel, most of which are either affiliated with or stage their research efforts from the University of Hawaii. In comparison to the overall level of employment opportunities in Hawaii and Midway Atoll, and current population levels, this additional employment and population is minor. In addition, no measurable effects on public services, such as police, fire protection, schools, and housing, are anticipated to result from the proposed project.

4.5.6 Potential Air Pollution

A project will be considered to have a serious impact on air quality if it will cause or contribute substantially to existing or projected air quality violations, or result in the exposure of a sensitive population to substantial pollution concentrations. Locating the source site at Midway Atoll would require installation of a power cable and sound source by vessels, and would increase air pollution impacts as compared to the Preferred Alternative. Aircraft traffic associated with either the Preferred or Midway alternatives will generate some air pollution, but at levels well below those that would cause or contribute to air quality violations. Since this air pollution would occur at locations where current air quality conditions are good to excellent, no adverse effects would be expected to result from either alternative. Neither the Preferred or Midway Alternative is located in an air quality non-attainment or maintenance area.

Mitigation Measure 5: All NPAL vessels and aircraft would be equipped with required air pollution controls.

4.5.7 Potential Hazardous Materials and Wastes

None of the alternatives involves use of hazardous materials or would produce any hazardous wastes.

4.5.8 Relationship Between Local Short-term Uses of the Human Environment and the Maintenance and Enhancement of Long-term Productivity

NEPA and the Hawaii EIS Law require consideration of the relationship of short-term uses and long-term productivity. Generally speaking, this consideration is less applicable to projects, such as the proposed alternative, which would not exploit resources over the short term at the expense of long-term environmental values.

The proposed action would not result in adverse environmental effects that would have the potential for permanently altering the physical, biological, economic, or social resources of Hawaii. Project activities would not result in environmental effects that could permanently narrow the range of beneficial uses of the environment by Kauai residents, or pose any long-term risks to the health, safety, or general welfare of the public.

The proposed project would result in local short-term increases in air traffic as part of the monitoring, but these would be virtually negligible.

The project would result in minor short-term changes in the local marine acoustic environment as a result of the operation of the sound source. As discussed in Chapter 4 of this EIS, the operation of the sound source would not adversely affect the maintenance and enhancement of long-term productivity of the environment.

The proposed monitoring program would have the potential for beneficial biological, economic and social effects in the long-term. Results would help to quantify the marine animal inventory for the proposed study area. The proposed project could provide important information supporting government policies and regulations to curb global warming.

As stated in the discussion of project objectives (Chapter 1), there are important purposes and needs for proceeding with the project at this time in order to provide long-range underwater acoustic propagation studies and acoustic remote sensing of the ocean required for analysis of seasonal and annual variations in North Pacific acoustic conditions and by climate prediction models for measuring global climate change. Proceeding with the project at this time would not foreclose options to implement alternative global climate change study methodologies in the future.

4.5.9 Irreversible and Irretrievable Commitments of Resources

NEPA and the Hawaii EIS Law require consideration of the irreversible and irretrievable commitments of resources as a result of proposed projects.

Because the proposed project would utilize existing equipment and installations, it would not constitute any irreversible or irretrievable commitment of nonrenewable or depletable environmental resources of the area off the north shore of Kauai, other than the small amount of materials and energy expended during performance of the monitoring efforts (e.g., aircraft fuel expenditure, and standard office and research product usage).

Additionally, the proposed project does not present the potential for an accident, such as nuclear or chemical, affecting the quality of the environment.

The Midway Atoll alternative would involve increased vessel and other usage of fuels, and construction materials because of the required installation of the sound source, cabling, and facilities at Midway, resulting in a somewhat greater impact as compared to the proposed action.

4.5.10 Natural or Depletable Resource Requirements and Conservation Potential

For the proposed alternative, aircraft operations would use relatively small amounts of fuel. In addition, power for the source would be supplied from the onshore grid. Those power requirements, when the source is operating, would be less than 2 kilowatts (kw) input (due to power line losses and inefficiencies, the source would produce an acoustic output of approximately 260 watts). Taking into account the relatively low duty cycle of the source, the electricity requirements to power the source would be substantially less than that of an average single-family home.

Anticipated energy requirements of the proposed project would be well within the energy supply capacity of the Kauai fuel supply and power grid. No new power generation capacity or energy supply facilities would be required for any proposed activities. No other natural or depletable resources would be required at Kauai because of the use of existing facilities.

At Midway Atoll various structural materials for fabrication of the acoustic source system, fuels, and minor amounts of natural or depletable resources would be required because of the installation of the sound source, cabling, and facilities.

4.5.11 Unavoidable Adverse Effects; Unresolved Issues

As set forth in Chapter 4, the proposed project and monitoring are not anticipated to result in adverse effects on biological resources. This conclusion is based in part upon the available information regarding the marine animal species that could potentially be affected, which is analyzed extensively in Chapter 4. It is further known that the animals that may be exposed to the project source sounds are currently exposed to noise sources of comparable or greater intensity, particularly from commercial shipping and recreational boating. The importance of potential effects on biological resources is also limited by the temporary nature of the proposed experimental activities, which would span at most a five-year period of transmissions, and the limited duty cycle of the source (on only 2% of the time, off the remaining 98%, for most of the experimental period).

There are no other material adverse impacts of the proposed project.

The principal unresolved issue presented by the proposed project is the degree to which LF, subsea sounds could potentially affect marine animals over the long-term (NRC 1994, 1996, 2000). Results from the California and Hawaii ATOC MMRPs, which occurred over a time period of two years, are summarized in Chapters 1 and 4. All of the effects detected by the MMRPs were subtle, of short duration, and found only after intensive statistical analyses. 4-25

Bioacoustic experts concluded that these subtle effects would not adversely impact the survival of an individual whale or the status of the North Pacific humpback whale population (Frankel and Clark, 2000). The proposed project is reuse of the sound source and cable for an additional five years of transmissions. This EIS acknowledges that the current level of knowledge on potential long-term effects is relatively sparse. Chapter 4 summarizes the scientific evidence relevant to this issue and evaluates potential long-term impacts based upon the ATOC MMRPs data and, when necessary, reasonable extrapolations from that data.

The project itself is intended to fill information gaps and reduce uncertainty concerning the possible long-term effects of low frequency sounds on marine animals. The benefits of the proposed project could not be fully realized by any of the other alternatives proposed.

4.5.12 Growth-inducing Impacts of the Proposed Action

Because the proposed project is a scientific research project, as opposed to a land development project (e.g., infrastructure, commercial or residential development), the project would not result in any appreciable growth-inducing effects. The proposed project could foster some economic activity as a result of the use of aircraft for survey purposes. However, this activity would not likely be of such magnitude that it would stimulate the establishment of new businesses, population growth, or the construction of additional housing. In addition, there are no project characteristics which are likely to remove obstacles to population growth or encourage or facilitate other activities that could affect the environment, either individually or cumulatively. Most of this activity would utilize existing economic resources (labor, business, etc.) in Kauai.

4.6 CONCLUSION

In summary, the Kauai source best meets the NPAL program objectives while offering the least potential for effects on the environment. The Midway Alternative has inferior acoustic capabilities for the study of large-scale acoustic thermometry and long-range propagation. In addition, there exists limited baseline data on which the Marine Mammal Monitoring could study the potential for long-term effects. Potential effects from acoustic transmissions are similar at both sites, but there exists the potential at Midway for disruption of the breeding and pupping of Hawaiian monk seals during installation of the power cable. Therefore, the Preferred Alternative, including the continued operation of the sound source installed by the ATOC project at its present location, with transmission characteristics similar to those used in the first phase of the feasibility research, is the proposed action.

THIS PAGE INTENTIONALLY LEFT BLANK

5 MITIGATION AND MONITORING

This chapter describes mitigation and monitoring measures that would be applied to the proposed project.

Mitigation, as defined by the Council on Environmental Quality (CEQ), includes measures to avoid the impact altogether by not taking a certain action or parts of an action or to minimize potential effects by limiting the degree or magnitude of a proposed action and its implementation. As presented throughout the document, several mitigation measures have been proposed as part of the alternatives. These measures described below would mitigate the potential effects of NPAL subsea sounds on marine animals by focusing on the operational characteristics of the NPAL sound source.

The California and Hawaii ATOC MMRPs were designed to determine the potential effects of the acoustic transmissions on marine mammals and other marine life, focusing on short-term effects. As described in Chapter 1, all of the effects detected by the ATOC MMRPs were subtle and found only after intensive statistical analyses. Therefore, the need to conduct further marine mammal monitoring studies is now to advance the understanding of the potential for long-term effects from the acoustic transmissions. The measures to accomplish this objective are described below.

5.1 MEASURES TO MITIGATE THE SOUND SOURCE

Several mitigation measures were identified throughout this EIS that would minimize the potential effects of the NPAL sound source. These measures are summarized as follows:

Mitigation Measure 1: The sound source would operate at the minimum duty cycle necessary to support the large-scale acoustic thermometry and long-range propagation objectives.

Transmissions would continue with roughly the same transmission schedule as that used during the first feasibility phase of the ATOC study. The proposed nominal duty cycle would be six 20-min transmissions (one every 4 hours), every fourth day, with each transmission preceded by a 5-min ramp-up period, representing an average duty cycle of 2 percent.

Mitigation Measure 2: Any increases in the duty cycle beyond the nominal 2 percent (with a maximum of 8 percent) would not occur during the peak humpback season (January – April).

To provide for short-term long-range acoustic propagation studies, the proposed action includes the possibility of an 8 percent duty cycle for up to two months out of each year. The 8 percent duty cycle would not occur during the peak humpback whale season (January – April).

Mitigation Measure 3: The sound source would operate at the minimum power level necessary to support large-scale acoustic thermometry and long-range sound transmission objectives.

Lower power levels are preferred to minimize the potential for effects on marine life. Figure A-1, Kauai Source Power Density Spectrum, indicates a peak spectrum power output value of 180 dB. The source is capable of a total power output, integrated across the entire 35 Hz bandwidth, of 195 dB re 1 μPa at 1 m from the source. In addition, the transmission length of 20 minutes is designed to spread the energy over time, at much lower source levels, than if the signals were sent as short, loud pulses of the same total energy. The ATOC MMRPs found only subtle effects that would not be expected to adversely impact the survival of an individual whale or the status of North Pacific whale populations when the source was transmitting at the proposed source level

Mitigation Measure 4: Transmissions from the NPAL sound source would be preceded by a 5-minute ramp-up of the source power.

An initial 5-minute stepped ramp-up period currently helps reduce the potential for startling animals and provides them an opportunity to move away from the source before transmissions at the maximum power level begin.

Mitigation Measure 5: All NPAL vessels and aircraft would be equipped with required air pollution controls.

Locating the source site at Midway Atoll would require installation by vessels while Marine Mammal Monitoring Studies for both alternatives would include aerial surveys.

Mitigation Measure 6: For the Midway Alternative, the portions of the cable and any protective casing in the nearshore area and surf zone would be designed to minimize the potential for adverse effects.

Mitigation Measure 7: For the Preferred Alternative and the Midway Alternative, the source cable, and possibly the sound source, would not be removed at the end of the experiment.

5.2 MONITORING TO PREVENT LONG-TERM EFFECTS TO MARINE ANIMALS

The following monitoring measures to prevent adverse changes in distribution and abundance to marine animals would be conducted as a component of the proposed action:

Monitoring Measure 1: The focus of the Marine Mammal Monitoring Studies is to advance the understanding of the potential for long-term effects of man-made sound on marine mammals by monitoring the distribution and abundance of marine mammals in the vicinity of the sound source.

During the years 1993-98, aerial surveys of marine mammals resident in the waters surrounding Kauai were performed as part of the ATOC Marine Mammal Research Program (ATOC MMRP), with focus on endangered humpback whales. Data were collected during the humpback winter breeding season (Feb-Apr) for a total of three baseline years when the Kauai ATOC source was not transmitting (1993, 1994, and 1995) and for one year when it was 5-1 transmitting (1998). An additional year of baseline surveys was conducted in the area off the north shore of Kauai during the 2001 humpback winter breeding season.

In order to maintain a basis of comparison with previous Kauai surveys, the proposed survey protocol would follow the protocol used in the earlier 1993-98 surveys (Mobley et al., 1999b). North-south tracklines spaced 7 nm apart would be projected within a 40-km radius of the ATOC source (Figure 5-1, Tracklines Used During the 1998 ATOC MMRP Aerial Surveys). One or two additional lines spaced 3.5 nm apart would be added in the immediate vicinity of the Kauai source. Sightings of all marine mammal and sea turtle species would be made by two experienced observers, one on each side of the aircraft. Sightings would be called to a data recorder who would note the species sighted, number of individuals, presence or absence of a calf, angle to the sighting, and any apparent reaction to the aircraft. Additionally, GPS locations and altitude (measured by a radar altimeter) would be automatically recorded at 30-sec intervals and whenever a sighting is made.

The NPAL project proposes to conduct eight surveys from February through early April. The surveys would be scheduled eight days apart to match the NPAL transmission schedule. Based on an average of seven humpback sightings per survey observed during the 1998 season, and assuming a moderate sized effect due to the NPAL transmissions, eight surveys should produce a minimum of 56 sightings of humpback whales, which would result in an estimated power of .80 (i.e., there would be an 80% probability of detecting a change in distribution if an effect is present) (Welkowitz et al. 1991). The estimate of 56 sightings is presumed to be a minimum, given previously reported evidence that the Hawaiian wintering population of humpback whales is increasing (Mobley et al., 1999a;1999c).

As described in detail in Chapter 1, the purpose of the Marine Mammal Monitoring and Studies is to conduct studies on the possible long-term effects from sound transmissions on marine life. Annual reports of the results obtained would include numbers and locations of all marine mammal and sea turtle sightings. The annual report would be submitted to NMFS as part of the LOA permitting process, with copies submitted to the Hawaii Department of Land and Natural Resources and the HIHWNMS. For humpback whales, any apparent avoidance reactions in response to the NPAL source would be assessed by examining distance from the source to each sighting as well as distance offshore, based on GPS position data.

The Marine Mammal Monitoring and Studies would also continue to monitor for acute, short-term effects, even though none were observed during the ATOC MMRP. Visual aerial surveys are capable of detecting the following acute or short-term effects:

- Animal dead or disabled (primary capability)
- Increase in number of beached animals (potential/limited capability)
- Increase in number of animals struck by vessels (potential/limited capability)
- Repeated/prolonged activity (blowing, time on surface, etc.) (potential/limited capability)
- Abnormal number of animals present/absent (primary capability)
- Abnormal mother-calf activity (potential/limited capability)

If at any time a Marine Mammal Monitoring and Studies team member positively identifies the occurrence of an acute or short-term effect, the information would be immediately communicated to the Marine Mammal Monitoring and Studies leader (Dr. J. Mobley, University of Hawaii). If the leader ascertains that an acoustic transmission (i.e., during the 5-min ramp-up or the 20-min transmission) coincided with the observed effect, he would contact the Barking Sands shore termination site and Scripps, and suspend source operations immediately until further notice. The leader would collate all pertinent information relative to the incident and contact NMFS to inform them of the situation. NMFS, in consultation with the leader, would make the determination as to the severity of the situation, based upon the knowledge of the species type, the animal's location relative to the source, the source level at the time of the incident, the estimated received level at the animal, whether there were any other noise sources in the vicinity, etc. Based upon analysis of the information supplied, NMFS would recommend that one of the following options be executed:

- Continue experiment as planned;
- Continue experiment with modifications to maximum source level or duty cycle; or
- Suspend experiment pending consultation with NMFS

Regardless of the decision, within 24 hours, a written summary of the incident would be forwarded to ONR, Scripps, and NMFS.

Monitoring Measure 2: Monitor marine mammal stranding data.

Coordination with the local marine mammal stranding network would be conducted to detect any long-term trends.

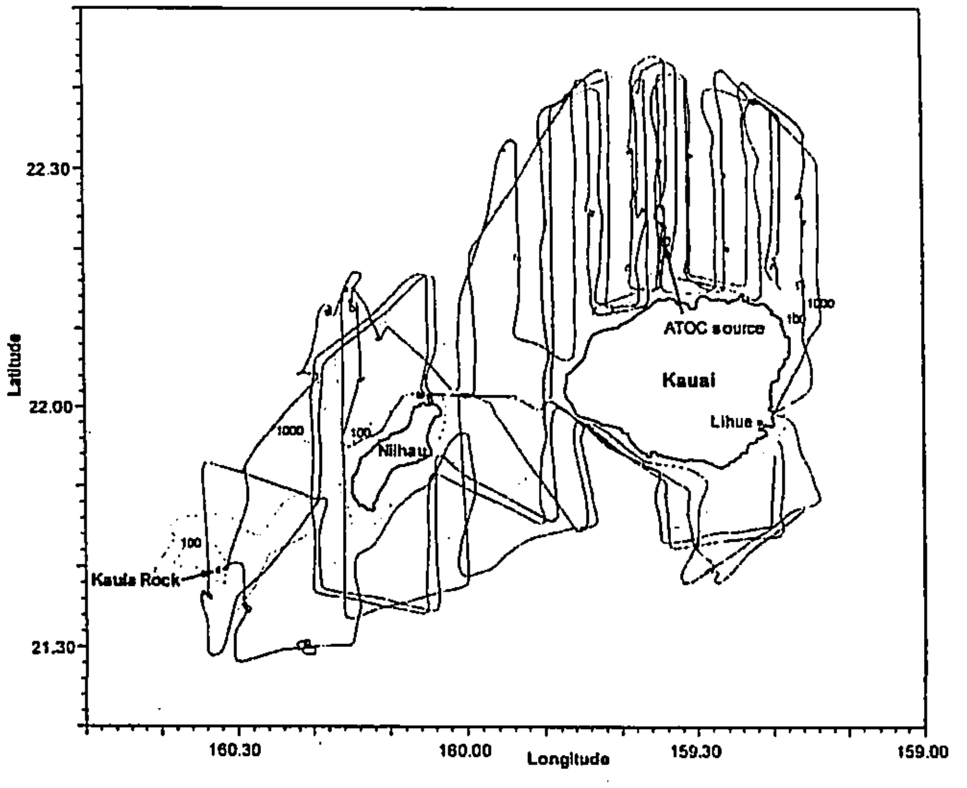


Figure 5-1 Tracklines Used During the 1998 ATOC MMRP Aerial Surveys
North-south tracklines were placed 13 km apart to cover a 40-km radius around the ATOC source. Tracklines for the Marine Mammal Monitoring and Studies for the NPAL project would be based on the same design as shown here.

THIS PAGE INTENTIONALLY LEFT BLANK

6 RELATIONSHIP OF THE PROPOSED ACTION TO FEDERAL, STATE AND LOCAL PLANS, POLICIES AND CONTROLS

This chapter addresses the federal, state, and local environmental review programs that do, or may, apply to the proposed action (Preferred Alternative). Project facilities and activities will be implemented in accordance with applicable federal laws and regulations and with state and local laws, regulations, programs, plans, and policies as applicable. Scripps is the applicant for governmental approvals and is the coordinator of the overall program. Environmental review programs applicable to the proposed project are summarized in Chapter 1.

This section first considers applicable federal programs for incidental harassment and take authorizations under the Marine Mammal Protection Act and Endangered Species Act, interagency consultation under the Endangered Species Act, coordination under the Magnuson-Stevens Fisheries Conservation Act, federal consistency review under the Coastal Zone Management Act, and permits under the Rivers and Harbors Act. Next this section considers State of Hawaii programs for use and disposition of state seabed lands in the conservation district, review of Scripps' certification of consistency with the Hawaii Coastal Zone Management Program, and other state and local programs.

6.1 FEDERAL PROGRAMS

This section addresses federal environmental authorities and programs which have been determined to apply to the proposed project.

6.1.1 NEPA

This EIS has been prepared and provided for public review in accordance with the Council on Environmental Quality regulations implementing NEPA (40 CFR Part 1500-1508).

6.1.2 Marine Mammal Protection Act

The Marine Mammal Protection Act (MMPA, 16 U.S.C. 1361-1421h) places a moratorium on the taking of marine mammals, without authorization. The term "take" means to harass, hunt, capture or kill, or attempt to harass, hunt capture or kill any marine mammal. The statute also defines the term "harassment" to mean any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild; or (ii) has the potential to 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. (16 U.S.C. 1362) Results of the ATOC Marine Mammal Research Programs (see Sections 1.2.2 and 4.2.1.2.1) indicated only subtle effects after intensive statistical analysis. Although the suggested effects do not support the need to request a LOA because they do not indicate a biologically significant behavioral response, Scripps, in coordination with the National Marine Fisheries Service (NMFS), has decided to pursue a letter of authorization (LOA) for incidental taking by harassment because 6-1 of: the level of controversy associated with NPAL; past history associated with the ATOC effort and Kauai ATOC EIS; and public interest in the state of Hawaii.

Section 1371(a)(5) directs the Secretary of Commerce to allow, upon request, the incidental (but not intentional) taking by harassment of small numbers of marine mammals by U.S. citizens who engage in a specified activity (exclusive of commercial fishing) if criteria are met. The taking must (1) have only 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. Before issuing a letter of authorization (LOA) for incidental harassment, the Secretary must issue regulations setting forth the permissible methods of taking and the requirements for monitoring and reporting any taking.

Following publication of the DEIS, Scripps petitioned the Secretary for adoption of necessary regulations and applied for an LOA to take marine mammals incidentally through operation of the Kauai sound source. 6-2

6.1.3 Endangered Species Act

The Endangered Species Act (ESA, 16 USC §§ 1531-1543) protects wildlife species, including marine mammals and fish, which have been listed as threatened or endangered. Such species cannot be "taken" in United States waters or upon the high seas by anyone subject to United States jurisdiction unless authorization has been obtained under the ESA.

The ESA defines "take" to mean harass, harm, pursue, hunt, shoot, impound, kill, trap, capture, or collect, or attempt any such conduct. "Harass" is defined by regulation to mean an intentional or negligent act or omission which creates the likelihood of injury to wildlife, annoying it to such an extent as to significantly disrupt normal behavior patterns including, but not limited to, breeding, feeding, or sheltering. 50 CFR § 17.3.

The Kauai sound source is located in an area inhabited by species that have been listed as threatened or endangered under the ESA. Continued operation of this sound source would allow continued transmission of acoustic signals in the water column that could cause behavioral reactions by listed species. Because such reactions could come within the ESA definition of "take," the proposed action is subject to provisions of the Act.

The ESA applies to the proposed project in two separate respects. First is the interagency consultation process of § 7 of the Act. Under § 7, federal agencies must consult with the responsible wildlife agency, U.S. Fish and Wildlife Service and/or NMFS, on actions that may affect the existence of threatened or endangered species or adversely modify their critical habitat. In this instance, through discussions with the concerned agencies, it has been learned that all potentially affected species are under the authority of NMFS, either directly or through cooperative procedures with USFWS.

In preparation for the consultation process, NMFS was requested to provide compilations of listed, proposed, and candidate threatened and endangered species within that agency's cognizance, including their known temporal and spatial movements, and compilations of designated or proposed critical habitats of these species (see Appendix B).

The DEIS served as the basis for development of a Biological Assessment, which is the required foundation for § 7 consultation. Upon completion of the DEIS and the filing of notice in the Federal Register, consultation in accordance with § 7 was requested. Following consultation, NMFS issued its Biological Opinion on April 26, 2001, concluding that the proposed action is not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat. 6-3

The ESA also applies to the proposed project through the statute's provisions for authorization of incidental taking of listed species. Such authorizations are available where any taking is incidental to, and not the purpose of, a lawful activity and adequate provision is made for minimizing and mitigating impacts. A conservation plan is required in conjunction with review of the request for authorization.

With respect to marine mammals, where NMFS conducts review under the previously described MMPA letter of authorization and ESA § 7 consultation processes, NMFS also carries out the ESA incidental take review. Similarly, because of overlapping jurisdiction with USFWS, NMFS carries out review of proposals involving listed sea turtles.

6.1.4 Rivers and Harbors Act § 10

The proposed action includes the utilization of an existing sound source located offshore 14.7 km (7.9 nm) north of Haena Point on the north shore of Kauai and an existing subsea power transmission cable, which connects to an existing cable approximately 1.3 km (0.7 nm) offshore Barking Sands and follows a 51.5 km (27.8 nm) course around the northwest side of the island to the source site.

The U.S. Army Corps of Engineers (COE) was consulted concerning permitting requirements for the initial construction and installation. These facilities required authorization under § 10 of the Rivers and Harbors Act (33USC § 403) because they were considered by the COE to be structures and involved work in navigable waters of the U.S. Notification of use of § 10 nationwide permits #5 (installation of scientific measurement devices) and #6 (survey activities involving disturbance of the seafloor) was given on August 29, 1994.

The proposed project would not involve placement of any other structures or conduct of construction work within navigable waters. Consequently, the COE has confirmed that no additional authorization under the Rivers and Harbors Act would be required.

6.1.5 Magnuson-Stevens Fisheries Conservation and Management Act

The Magnuson-Stevens Fisheries Conservation and Management Act (FCMA, 16 USC §§ 1801-1861) addresses the sustainability of fish stocks through risk-averse management practices and habitat protection, including the designation of essential fish habitats. The FCMA is implemented by the Secretary of Commerce, acting through NMFS. Under § 1855(b) of the Act, federal agencies must coordinate with NMFS regarding any action that may adversely affect essential fish habitat (EFH) which has been formally designated in the fishery management plan for the affected region. Interim final regulations implementing EFH programs appear at 50 CFR §§ 600.805-.930.

As described in detail in Section 4.2.5, for the Hawaiian Islands area of the Western Pacific Region, NMFS has designated EFH in four categories (bottomfish, pelagic fish, crustaceans, precious coral). In essence, the EFH encompasses the water column from the shoreline to the outer limit of the exclusive economic zone (EEZ, 200 miles). Physical installations and/or removals associated with the No Action and Midway Alternatives may temporarily disrupt the seafloor; however, since the cable has a nominal diameter of 3.18 cm (1.25 in), removing it is unlikely to have an adverse effect on any identified EFH. As discussed in Section 4.2.5, transmissions from the NPAL sound source would not have direct, indirect, site specific, or habitat wide individual, cumulative, or synergistic impacts. Consequently, there is no indication that the proposed project will reduce the quality and/or quantity of EFH.

6.1.6 Coastal Zone Management Act, Federal Consistency Review

The Federal Coastal Zone Management Act (CZMA, 16 USC §§ 1451-1465) establishes a voluntary program for federal-state cooperation and coordination in matters affecting the coastal zone. Under the CZMA, each state may develop its own coastal management program and once the program is federally approved, certain federal and federally permitted activities must meet standards of consistency with the program. The requirement applies to activities within or outside the coastal zone which affect any land or water use or natural resource of the coastal zone. The state may list in its program the categories of federal approvals which will be subject to consistency review. Under § 1456(c)(3) of the CZMA and its implementing regulations (15 CFR § 930.57), an activity requiring such a federal approval must comply with and be conducted in a manner consistent with the enforceable policies of the approved state program.

The Hawaii Coastal Zone Management Program includes permits and licenses issued by NMFS under the MMPA, a category which would include the letter of authorization for incidental harassment of marine mammals, discussed in Section 6.1.2. As applicant for the authorization, Scripps has prepared a certification of the NPAL project's consistency with the Hawaii Coastal Zone Management Program. The consistency certification is supported by the information and analysis in this EIS. The consistency submittal will be reviewed by Hawaii's designated coastal zone management agency, the Office of Planning, a part of the Hawaii Department of Business, Economic Development, and Tourism. Under CZMA § 1456(c)(3), the State may concur with, or object to, the certification of consistency. An objection would bar NMFS' issuance of authorization under the MMPA to conduct research. A state objection is subject to appeal to the Secretary of Commerce.

6.1.7 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.

Native Hawaiian populations, as well as low-income persons, on the north shore of Kauai practice subsistence fishing in the waters surrounding Kauai. The fish species expected in the study area, the potential for acoustic impact on those species, the potential for economic effects on fishing, and the potential for interference between the proposed source and the fish aggregating device (FAD), respectively, have been discussed (Section 3.2.4, Section 4.2.1.2.3, Section 4.3.1 and Section 6.2.4, respectively). There is unlikely to be an adverse effect on subsistence fishing and no disproportionately high or adverse effect on the human environment of minority and low-income populations.

6.1.8 Protection of Children

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." Evaluation of the proposed action has determined that the project would not disproportionately affect children because of its at-sea location as well as the lack of project impacts on human users of the sea and shoreline. See Sections 4.3 and 4.4.

6.2 REVIEW BY THE STATE OF HAWAII

This section considers Hawaii and local environmental plans, programs, and authorities that apply to the proposed project. State agency actions on the proposed project can be expected to include:

- Conservation District Use Permit Program: review and action on permit application by Hawaii Department of Land and Natural Resources;

- Hawaii Coastal Zone Management Program: review and action on Scripps' federal consistency certification by Hawaii Office of Planning, Department of Business, Economic Development and Tourism.

Beginning in April of 1999, Scripps representatives met and conferred with representatives from a number of state agencies, including Department of Land and Natural Resources, Office of

Environmental Quality Control, and Department of Business, Economic Development and Tourism concerning programs and regulatory requirements applicable to the NPAL project. Discussions were also held with representatives of the Department of Health, the Office of Hawaiian Affairs, the Historic Preservation and Aquatic Resources Divisions of DLNR, and the County of Kauai. On the basis of these discussions and review of relevant authorities, Scripps has undertaken the steps called for in connection with state programs discussed in this section.

6.2.1 Conservation District Use Authorization: DLNR

Chapter 183C, Hawaii Revised Statutes (HRS), establishes a permit program within the Department of Land and Natural Resources (DLNR) for use of "state marine waters." The statute defines that term as waters "extending from the upper reaches of the wash of the waves on shore seaward to the limit of the state's police power and management authority, including the United States territorial sea." (HRS § 190-1.5.) The geographic extent of state marine waters has been subject to debate. State jurisdiction as recognized by the federal government extends to three nautical miles. For certain purposes of international law, the U.S. territorial sea has been extended by executive order to 12 nm. The U.S. Exclusive Economic Zone extends seaward to 200 nm. The effect of these factors on claims regarding the state jurisdiction seaward of the islands remains unresolved.

The sound source and portions of the power supply cable lie seaward of the three-mile sea. Apart from considerations concerning geographic jurisdiction, and in recognition of the State of Hawaii's interest in the full range of the project's activities, the application for a conservation district use permit (CDUP) has included information on the entire complement of facilities proposed to be used.

Scripps' CDUP application seeks DLNR approval for continued use of the power supply cable for the five-year duration of the NPAL research. The application also requests authorization to leave the cable in place at the conclusion of the NPAL research.

Approximately 37 km (20 nm) of the cable lie within the three-mile sea and within the Resource Subzone of the Conservation District. Under DLNR regulations, the Resource Subzone objective is "to develop, with proper management, areas to ensure sustained use of the natural resources of those areas..."Hawaii Administrative Rules (HAR) § 13-5-13. Under HAR §§ 13-5-22 - 24, relevant identified land uses in the subzone are:

- Data collection, research, education, and resource evaluation which does not involve a land use, which involves a land use with incidental disturbance from installation of equipment (e.g., rain gauges or meteorological towers), or involves a land use causing ground disturbances (e.g., exploratory wells)
- Aquaculture
- Artificial reefs

- Astronomy facilities
- Marine construction, dredging, filling on submerged lands
- Mining and extraction
- Moorings and aids to navigation
- Public purpose uses by the State of Hawaii or the counties to fulfill a mandated governmental function, activity, or service for public benefit and in accordance with public policy and the purpose of the conservation district
- Transportation systems, public utility transmission facilities, and other such land uses undertaken by non-governmental entitles which benefit the public and are consistent with the purpose of the conservation district
- Sanctuaries
- Demolition, removal, alteration of existing structures, facilities, equipment
- Operations, repair, maintenance, or renovation of existing facilities or equipment which are different from the original permit

Decision on the application will be made by the Board of Land and Natural Resources (Board). To approve the application, the Board must find the project consistent with the criteria noted in the Administrative Rules 13-5-30C.

Several of the identified land uses provide the Board with the foundation for a finding of consistency. The proposed project involves data collection, research, education, and resource evaluation and is designed to serve important public purposes through advancement of research on global climate change, underwater acoustics, and marine mammals. Given its sponsorship by a federal agency and participation by representatives of the University of Hawaii, this project may also qualify as a "public purpose" use. The proposal would use the seabed lands to transmit electric power for a use beneficial to the public. Further, the proposal is to use an existing facility, the cable, for a proposed project different from the project covered by the earlier CDUP.

For approval of the application, the Board must also find that: (1) the applicant has the capacity to carry out the entire project, and (2) the proposed project is clearly in the public interest upon consideration of the overall economic, social, and environmental impacts. Applicant Scripps is a part of the University of California. Scripps has demonstrated its capacity to carry out the NPAL project through successful completion of the previous ATOC research projects in California and

Hawaii as well as numerous other research projects in locations around the world. Grant funding for this project is provided by ONR. The public interest values of the NPAL research objectives have been discussed previously (See Chapter 4). No economic or social impacts have been identified from the continued use of state seabed lands for the sound source power cable. Approximately five years of MMRP studies in connection with the California and Hawaii ATOC projects has shown no adverse impacts on marine mammals. Environmental impacts directly attributable to the cable would be diminished if the cable were abandoned in place, as requested, rather than removed from the seafloor. (See Section 4.1.1.1.) For these reasons, the Board could find, upon consideration of the overall economic, social, and environmental impacts of the proposed project, that it is in the public interest.

Condition 7 of the ATOC Project CDUP requires removal of the cable after termination of the project (extended by permit amendment to September 30, 2001). Because the NPAL Preferred Alternative would abandon the cable in place after conclusion of the research, the Board may choose to consider the proposal under HAR § 13-5-42, which provides for a deviation from any condition of a Conservation District Use Permit only when the proposal is supported b a satisfactory written justification covering four standards. The EIS sets forth the information called for by each of these standards, as follows. 6-4

(1) The deviation is necessary because of the lack of practical alternatives. The presence of the cable on the seabed much longer than originally contemplated, the new information concerning environmental damage from removal of the cable, and the intervening presence of sensitive Navy facilities overlying the ATOC cable have eliminated removal of the cable as a practical alternative. Sections 2.1.1.1 and 4.1.1.1.

(2) The deviation shall not result in any substantial adverse impacts to natural resources. Section 2.1.1.1 provides information on the cable and the natural resources along its route and concludes that, if left on the seafloor, the cable would have no effect on the benthic environment. However, Sections 2.1.1.1 and 4.1.1.1 indicate that removal of the cable could have adverse impacts to natural resources.

(3) The deviation does not conflict with the objective of the subzone. The objective of the Resource Subzone, where the relevant portion of the cable is located, is "to develop, with proper management, areas to ensure sustained use of the natural resources of those area…." Given the benign nature of the cable resting on the seabed (Section 2.1.1.1), the proposed use of these lands for this purpose and to enable the proposed scientific research is consistent with the subzone's objective.

(4) The deviation is not inconsistent with the public health, safety, or welfare. Information and analysis in Sections 2.1.1.1 and 4.1.1.1 demonstrate that abandoning the cable in place would meet this standard.

This EIS and supplementary information provided to DLNR in conjunction with the permit application provide the foundation for substantive evaluation of the project by DLNR staff and the

Board. Permit application review and action by the Board will bring together input from other state and local agencies with authority relevant to the project. A public hearing on the application will provide a forum for the Board to consider additional testimony by interested public participants before taking action on the application.

In conjunction with the CDUP application, Scripps has also requested Board approval of an appropriate disposition of the seabed lands underlying the cable to enable abandonment of the cable after completion of the NPAL research. HRS Chapter 171 makes provision for disposition of public lands through lease, license, easement, permit, or sale.

Applying provisions of Chapter 171 in connection with several recently approved CDUPs for permanent installation of cables on state subterranean and seabed lands in the Resource Subzone, the Board has authorized the following dispositions: (i) a perpetual, non-exclusive easement for use of 9.1 acres of land at, and offshore of Spencer Beach Park, Hawaii (CDUP HA-2903, transpacific submarine fiber optic telecommunications system [Southern Cross Cable Network], GTE Hawaiian Telehone International); (ii) an easement and a construction right-of-entry for installation on lands at, and offshore of Kahe Beach, Oahu (CDUP OA 2949, Southern Cross Cable Network, GTE.) In another recent similar decision, on CDUP OA-2938 for AT&T Corporation's Japan-U.S. Cable Network, the Board approved installation of cable at, and offshore of Makaha Beach Park, Oahu, using existing easements for telecommunications cables. In that case, the DLNR staff reported that after investigation it had confirmed that issuance of direct, non-exclusive easements for cable systems on public lands is the most efficient and economically productive land disposition. In contrast, the issuance of leases for public lands requires prior approval from the Governor and the Legislature, and in some cases, a public auction is required.

If the NPAL project application is approved by the Board, the approval will also include the Board's determination as to the appropriate disposition of the seabed lands.

6.2.2 Coastal Zone Management Program: Federal Consistency Review

Hawaii's Coastal Zone Management Program (CZMP) has been approved by the Secretary of Commerce under the Federal Coastal Zone Management Act of 1972. The State thus has authority under the Act, as described in Section 1.3.7, to review federal permit activities conducted within or outside the state's designated coastal zone which affect land or water use or natural resources of the coastal zone. State review of consistency submittals is carried out by Hawaii's designated coastal management agency, the State Office of Planning, within the Department of Business, Economic Development, and Tourism.

The Hawaii CZMP lists permits and licenses under the MMPA as a category of authorization likely to affect the coastal zone and subject to consistency review. Consequently, in connection with its application to NMFS for incidental harassment authorization under the MMPA, Scripps has prepared and will submit to the state Office of Planning a certification of the consistency of the proposed project (Preferred Alternative) with the Hawaii CZMP.

In connection with the original ATOC study, a consistency certification was submitted by Scripps and reviewed by the State. The State's concurrence in that certification anticipated that all ATOC facilities would be removed at the end of the experiment. The current project proposes leaving the cable and possibly the sound source on the seabed. State Office of Planning concurrence with the new consistency certification, in effect, would modify the State's previous consistency action.

Scripps' certification of consistency for the NPAL project (Preferred Alternative) is supported by the information and analysis provided in this EIS. The EIS contains a detailed description of the proposed project, as well as information and analysis on impacts, mitigation measures incorporated into the project, and project alternatives. The EIS also contains information on the results of the original ATOC feasibility study and the Marine Mammal Research Program which was carried out in conjunction with the ATOC project. 6-5

Scripps prepared and submitted a certification of the project's consistency with the Hawaii Coastal Zone Management Plan to the Hawaii Office of Planning, Department of Business Economic Development and Tourism. This certification is supported primarily by the information and analysis contained in this EIS. The objectives and policies of the Hawaii CZMP are stated at HRS section 205A-2. In addition, the CZMP incorporates the Hawaii Ocean Resources Management Plan, which provides a policy framework for State management of ocean and coastal uses and resources. Relevant portions of the Hawaii CZMP and related information and analysis appear below.

Hawaii Coastal Zone Management Program Discussion and Analysis

Introduction

The NPAL project would involve use of low frequency sound transmissions to carry out research on long-range underwater sound transmission as well as further feasibility research on acoustic thermometry of ocean climate. Detailed descriptions are provided in Chapters 1 and 2. Under the Preferred Alternative, the research would utilize the existing sound source on the seabed approximately 14.8 km (8nm) north of Haena Point, Kauai, and the existing cable connecting the sound source with a power supply at Pacific Missile Range Facility. The project would span five years and would utilize the same general transmission parameters as were used in the original ATOC feasibility study conducted during 1997-1999. The project would include a program for monitoring and study of any effects on marine mammals.

Discussion and Analysis

The objectives and policies of the Hawaii CZMP are stated at HRS § 205A-2. Each of these program elements has been considered in evaluating the consistency of the proposed federal action with the CZMP, as summarized below. In addition, Scripps has considered the relationship of the proposed project to the Hawaii Ocean Resources Management Plan. Developed in 1991 by a broad-based group representing commercial, recreational, environmental, research, and governmental interests, the Plan states a policy framework for State management of ocean and coastal uses and resources. In 1995, the Hawaii Legislature assigned to the CZMP agency the responsibility for coordinating implementation of the Plan, and it has since been incorporated into the Hawaii CZMP.

Recreational Resources

Objective: Provide coastal recreational opportunities accessible to the public.

Relevant policies implementing this objective focus on coordination of coastal recreation planning and management, and providing coastal recreational opportunities by protecting coastal resources important to recreation, including shoreline parks, water quality, and use of waters suitable for recreation. As discussed below, the project is consistent with these provisions.

At least three whale-watching boats operate off Kauai where some humpback whales wintering in Hawaiian waters may be seen close to shore between December and April. As discussed in Chapter 4, the proposed project is not expected to have any negative effects on recreational viewing or photographing of humpback whales.

During the project, humpback whales would be closely monitored for any potential effect of the sound transmissions on their distribution and abundance. Monitoring activities would include visual surveys by air. Results from the Marine Mammal Monitoring Studies would be provided annually to NMFS for review. Thus, no negative impacts on recreational whale-watching are expected to occur.

The proposed action is not expected to have any negative impacts on recreational divers since the source is located 14.8 km (8 nm) off the coast of Kauai in 807 m (2650 ft) of water. By extrapolation of available human underwater hearing threshold data (Hamilton, 1957; Smith, 1965; Hollien et al., 1967) down to 75 Hz, the minimum audibility level of 108 dB is derived - a level that would seldom be exceeded at local diving locations, which are mainly close to shore. In a recent study on the effects of LF sound on recreational divers, Cudahy et al. (1999) determined the maximum safe exposure to underwater sounds between 100 and 500 Hz to be 145 dB re 1 μPa at 1 m. With the sound source at 807 m (2650 ft), the sound pressure level of 145 dB would be at a depth of approximately 500 m (1640 ft), which is well below reasonable dive depths. Therefore, it is expected that few, if any, divers would even hear, much less be affected by, the source transmissions.

The acoustic source, associated cable, and the transmission of underwater signals would all occur approximately 14.8 km (8 nm) off the north coast of Kauai and along the offshore cable route, and would not be near or interfere with any State or County park, dedicated public right-of-way, perennial stream, sandy beach, or swimming or surfing area, and would not affect the shoreline.

Scientific data obtained from the project has the potential to provide valuable information to assist with management decisions needed to implement measures to protect coastal parks and beaches. The proposed research would be expected to contribute to understanding of ocean climate changes, which may assist in shoreline management decisions designed to protect recreational beaches. The loss of island beaches due to erosion was documented in a 1992 study prepared for the Hawaii Coastal Zone Management Program, Beach Management Plan with Beach Management Districts (Hwang and Fletcher, 1992). Sea level rise, which may be linked to ocean climate change, was identified as a possible cause. This is discussed further under "Coastal Hazards," below.

Historic Resources

Objective: Protect, preserve, and where desirable, restore, those natural and man-made historic and pre-historic resources in the CZM area that are important in Hawaiian and American history and culture.

The proposed project site is not located within a historic/cultural district, nor does it include any historic property listed on, or nominated to the Hawaii or National Register of historic places. The proposed project will not be within or near a Hawaiian fishpond or historic settlement area. Although shipwrecks are thought to be present along the northern Kauai shore, a side-scan sonar survey for the location of the cable and sound source did not reveal the presence of any shipwrecks or other historic or archeological resources on the ocean floor. See further discussion at Section 3.3.6.

Therefore, the proposed project would have no foreseeable impact on historic or pre-historic cultural resources.

Scenic and Open Space Resources

Objective: Protect, preserve, and where desirable, restore or improve the quality of coastal scenic and open space resources.

The proposed project would not alter any visual or scenic resources or public views along the shoreline.

The project consists of the continued use of a sound source and a power cable on the ocean floor, none of which is visible above water. No construction would occur onshore or in or on waters seaward of the shoreline. Accordingly, no component of the proposed action would abut a scenic landmark or be adjacent to an undeveloped parcel, nor would it be visible between the nearest coastal roadway and the shoreline.

Monitoring activities would involve a slight temporary increase in airplane traffic, which would be visually indistinguishable from the current uses of the project area.

Coastal Ecosystems

Objective: Protect valuable coastal ecosystems from disruption and minimize adverse impacts on all coastal ecosystems.

This CZMP objective and the relevant implementing policies call for preserving coastal ecosystems, promoting water quality planning and management, and improving the technical basis for natural resource management. The proposed project does not involve any earthwork, dredge, fill, or any discharge into coastal waters and would not affect water quality. No portion of the project would be located within the Shoreline Setback Area or any Marine Life Conservation District or Natural Area Reserve.

The transmission of low frequency sound through coastal waters has previously raised concern about possible degradation of the marine ecosystem and, most specifically, about adverse effects on those marine mammals capable of hearing sound at the frequencies to be used in the research. As more fully discussed in Chapter 4, the Kauai and California MMRP research found no basis for these concerns. During approximately five years of close monitoring, no adverse effects were detected. The current project would continue transmissions within the same general parameters used during the MMRP studies. Marine mammal monitoring would continue, with the emphasis shifting from intensive observations of individual animal behavior to monitoring of longer-term factors such as distribution and abundance.

The proposed project would provide data on ocean climate, which affects coastal ecosystems. These data would be available to resource management agencies, as well as educational and scientific institutions and the public. The information obtained by this project has the potential to improve the technical basis for resource management decisions.

Economic Uses

Objective: Provide public or private facilities and improvements important to the State's economy in suitable locations.

This CZMP objective and its implementing policies focus on concentration of coastal-dependent development in areas designated for such use when feasible or, when not feasible and when the development is important to the state's economy, allowing location in other areas, provided that adverse environmental effects are minimized.

The proposed action is for the continued use of an existing seabed power cable and sound source. By using existing facilities, the proposed project would avoid the need to install additional equipment. The existing facilities are located on submerged lands designated as a Conservation District, Resource Subzone, and the proposed uses are consistent with objectives and specifically allowed uses of those areas.

To the extent that the CZMP calls for examination of the project's importance to the state economy and the minimization of adverse effects on the environment, the following considerations are relevant.

The direct economic effect of the project would occur primarily through employment of Hawaiian personnel and purchases of supplies and services during the course of the monitoring studies. From 5 to 10 scientists, most from the Hawaii marine science community, would be involved in aerial surveys as part of the monitoring activities.

The project's longer-term economic importance to Hawaii lies in its furtherance of the State's policy of fostering research and education based upon Hawaii's natural ocean laboratory. The project could attract other ocean research and education activities to Hawaii, but any such effect is uncertain and cannot be quantified at this time.

Coastal Hazards

Objective: Reduce hazard to life and property from tsunami, storm waves, stream flooding, erosion, and subsidence.

This objective and the implementing relevant policies focus on reducing coastal hazards by developing and communicating information on ocean climate-related factors, including flood, erosion, and subsidence hazards, which jeopardize development along Hawaii's coasts. Other policies concern avoidance of locating development in hazardous areas.

If warming of the earth's climate is underway, rising sea level can be expected, resulting in flooding and erosion in coastal areas. However, the question of whether global warming is underway is complex and controversial. Computer models of global warming have had to rely on assumptions, rather than actual measurement, of ocean temperatures on a basin scale. The models and their projections have thus been subject to criticism and have not provided a compelling basis for formulation of policy for dealing with global climate change issues.

Acoustic thermometry of ocean basins would provide the precise temperature measurements needed for effective computer modeling of global climate change. As further discussed in Chapter 1, the Kauai project would test the feasibility of this concept for larger-scale, longer-term application. The project would thus be consistent with the CZMP policy concerning development of information on ocean climate-related hazards.

Given that the project's sound source and cables are offshore and all operations will be conducted offshore, the project would present no conflict with policies concerning location of development away from areas prone to coastal hazards.

Managing Development

Objective: Improve the development review process, communication, and public participation in the management of coastal resources and hazards.

This objective and its implementing policies focus on the development review process, seeking to utilize law in managing coastal zone development, to facilitate timely processing, and to understandably communicate development impacts to the public.

The consistency review process is being carried out concurrently with other environmental review processes applicable to the project. These are the LOA application review by NMFS under the MMPA, ESA § 7 consultation by NMFS, and CDUP review by the Hawaii DLNR. The key environmental information and analysis for these processes are contained in this EIS. The EIS also serves as the basis for the federal consistency certification. Accordingly, the requirements of the other relevant environmental laws are integrated into the analysis under the state and federal coastal zone management authorities.

Other aspects of the regulatory review process began in the early stages of project planning. ONR and Scripps representatives first consulted with NMFS concerning this project in April, 1999. Over the next few months, informal consultation with concerned state and federal agencies was carried out. The Notice of Intent (NOI) to prepare an EIS was published in the Federal Register on June 15, 1999. Public hearings on the proposed project were held at Hanalei, Kauai (June 29, 1999); Lihue, Kauai (June 30, 1999); and Honolulu (July 1, 1999). After submission of a permit application to DLNR, an EIS Preparation Notice was published in the Hawaii OEQC Bulletin of August 8, 1999. Comments from the public received by mail and at the hearings are reviewed and addressed in the draft EIS. Following completion of the draft EIS, a Notice of Availability (NOA) was published in the Federal Register on June 2, 2000, and in the Hawaii Office of Environmental Quality Control Bulletin on June 5, 2000. Public hearings on the DEIS were held at Lihue, Kauai (July 5, 2000); Honolulu (July 6, 2000); and Kilauea, Kauai (July 8, 2000). Comments from the public received by mail and at the hearings are reviewed and addressed in the final EIS. 6-6

Through these means, timely and understandable information has been provided to the public about possible project impacts, consistent with these provisions of the CZMP.

Public Participation

Objective: Stimulate public awareness, education, and participation in coastal management.

Policies related to this objective focus on providing information to the public on coastal management issues and engaging the public in dialogue and advising on these issues.

These policies are implemented, in part, through the EIS process, including the various public notices, public scoping meetings, public hearing, and public comment and response on coastal management issues associated with the proposed project. The results of the NPAL research would be published and therefore available to local teachers, students, and interested community members.

Beach Protection

Objective: Protect beaches for public use and recreation.

These policies focus on locating shoreline development to preserve open space, minimize damage to structures, and prohibit or minimize shoreline erosion protective structures. These provisions were recently added to the CZMP and reflect the increasingly serious problem of beach erosion on all Hawaiian Islands. In recent DLNR workshops on this subject, information was presented showing that over the past 70 years, about 25 percent of Oahu's beaches have been narrowed or lost to erosion. On Maui, the loss is nearly 30 percent.

The proposed project would not involve any shoreline structures. However, a central goal of the acoustic thermometry research component of the project is to gain information on global climate change which, in turn, will assist in constructing more accurate climate change models. These are necessary for development of effective strategies for addressing climate-related phenomena such as beach erosion.

Marine Resources

Objective: Implement the State's Ocean Resources Management Plan.

The policies in this CZMP sector reflect the substantive scope of the Hawaii Ocean Resources Management Plan (HORM Plan), calling for stewardship in the protection, use, and development of marine and coastal resources, research and study to increase understanding of the ocean, research and development of new ocean technologies, and partnership with federal agencies in sound management of ocean resources within the United States exclusive economic zone (EEZ, which extends 200 miles from shore).

The HORM Plan was the outgrowth of 1988 legislation which mandated the drafting of a plan for coordinating a consistent ocean policy framework for the various state and local agencies with responsibility for ocean and coastal resources. In addition to recommending a new governance structure for ocean management decisions in the State, the Plan identifies ten issue areas and states objectives, policies, and implementing actions for each which are to guide agency ocean management decisions. While the Plan has no direct regulatory effect, it provides assistance in the implementation of applicable regulatory programs and, as previously noted, is a component of the Hawaii CZMP.

Provisions of the HORM Plan which have particular relevance to the NPAL project are noted below.

Ocean Research and Education

The drafters of the HORM Plan emphasized the importance of ocean research and education, adopting policies to strengthen Hawaii's national and international competitiveness in attracting funds in these fields, to mitigate user conflicts between research and non-compatible uses so that research projects are not jeopardized, and to foster stewardship attitudes. The drafters identified ocean research and education as major determinants of the Plan's long-term success.

The proposed project furthers several of these objectives, particularly those focused on attracting ocean research programs and increasing public awareness. Hawaii's stature as a natural laboratory for ocean research is strengthened by the selection of Kauai over California as the site of the second phase of the acoustic thermometry feasibility studies as well as ONR's underwater sound transmission studies. Results of the thermometry research would be written up in national and international scientific journals, as occurred with the first ATOC feasibility study. Results of the research would also be made available to Hawaiian educational and scientific institutions, as well as to the general public. During humpback whales' seasonal presence in Hawaiian waters, as part of the proposed project, from 5 to 10 University of Hawaii scientists would conduct aerial surveys to monitor the animals' distribution and abundance around the Island of Kauai. This information, too, would be made available for educational and scientific use. Both the public review of the project prior to implementation, and the publication of results after completion would increase public awareness of Hawaii's ocean resources.

Marine Ecosystem Protection

The HORM Plan lays a foundation for agency management decisions which are protective of marine and coastal ecosystems, and which protect and enhance marine species and areas of exceptional resource value. As discussed above, in connection with the marine ecosystems policies of the CZMP, the NPAL project would not degrade potentially affected ecosystems. Findings of the MMRP showed that concerns about possible adverse effects on marine mammals and fish were unfounded. See Chapter 4.

Fisheries

The HORM Plan provides the policy foundation for State management of fisheries on a sustainable fisheries basis and avoidance of user conflicts. Implementation of the NPAL project is not expected to have effects inconsistent with these policies. Fishery resources in the project area are discussed in Section 3.2.4, and potential effects on these resources are discussed beginning in Section 4.2.4. These potential effects are identified as minor and limited to a small zone around the sound source (at approximately 807-m [2650-ft] depth). Habitat for stocks targeted by commercial, subsistence, and recreational fishing is at substantially less depth. The absence of user conflicts associated with this project is discussed in Sections 4.3.1 and 4.4. The issue of possible effects on the behavior of fish around the FAD located north of Hanalei is discussed in Section 6.2.4.

Beaches and Coastal Erosion

In furtherance of the objective of a State management system to prevent beach loss and protect shoreline property, Policy J of the HORM Plan is to "plan for climate change, sea level rise, and emerging issues." The proposed acoustic thermometry research has the potential to provide essential information on ocean variability, which on longer time scales reflects changes in ocean temperature and the potential for global climate change. This information would be made available to the scientific and regulatory communities, and therefore could aid in the implementation of Policy J. This is discussed further in Section 6.2.1 on Coastal Hazards.

The proposed project would have no impact on any of the HORM Plan's objectives, policies, or implementing actions of the Harbors, Waste Management, Fisheries, Aquaculture, Energy, and Marine Minerals sectors.

6.2.3 Historic Resources Preservation and Cultural Practices 6-7

The State's historic resources preservation program is carried out by the Division of Historic Resources Preservation within DLNR. The Division has advised that it has no record of shipwrecks or other possible historic resources in marine waters around the islands. In connection with the ATOC project, program officials advised that they had no knowledge of historic resources in the vicinity of the proposed action. The Division gave notice that no field check was required because the Division believed that the ATOC project would have no effect on significant historic resources due to its offshore location (14.7 km [8 nm] offshore). In connection with the current proposal, the Division has been queried and has advised that no new information has been developed regarding possible historic resources in the area of the proposed project.

ONR and Scripps have also considered the effect of regulations implementing the National Historic Preservation Act, which were revised recently to increase protections for historic properties of traditional cultural or religious importance to Native Hawaiians. 36 CFR §§ 800.1-800.16. These procedures apply to federal undertakings which may cause effects on historic "properties" which meet specified criteria for inclusion in the National Register of Historic Places. The effects in question must be ones that alter the property's characteristics that qualify it for National Register eligibility. The procedures do not address broad, general areas or practices not connected with a specific historic property.

In considering these standards together with the nature of the proposed project, its impacts as discussed in this EIS, and its location in the open ocean nearly 8 nm north of Kauai, ONR and Scripps have determined that the proposed project does not have the potential to cause effects on any historic property. Similarly, Scripps and ONR have concluded that there will be no effects upon community cultural practices which may be associated with marine species. The conclusion is based upon the location and nature of the project and upon the evidence, as cited in sections 4.2.1.2.1, 4.2.1.2.2, and 4.2.1.2.3, that the sound transmissions can be expected to have no significant effect upon marine mammals, fish, or other marine species. Nevertheless, opportunity has been provided for potentially interested Native Hawaiian groups to comment on the proposed project in the context of well publicized public scoping meetings in Hanalei and Lihue, Kauai, and in Honolulu. The Office of Hawaiian Affairs (OHA) was invited to comment early in the EIS preparation process and advised that it would reserve comments for the draft EIS. Copies of the draft EIS were provided to OHA (Honolulu and Kauai offices) and the Hawaiian Civic Club of Kauai. 6-8

6.2.4 Division of Aquatic Resources, DLNR

Responsibility for management of state fisheries aquatic resources lies with the Aquatic Resource Division of DLNR. The Division has no permit requirement that affects this project. During the previous project review, the Division's comments expressed support for research leading to greater knowledge of the ocean and its marine life, but questioned why additional ocean thermal data is needed. The Division also commented that its fish aggregating device (FAD) north of Kauai was sufficiently distant from the proposed sound source site (approximately 16 km [8.6 nm]) to avoid any interference with FAD anchors and cables. The Division stated that it was unknown how the sound pulses might affect the behavior of fish around the FAD, because little was known about the potential effects of low frequency sound on fish. See discussion of fish resources and potential effects at Sections 3.2.4 and 4.2.1.2.3. The Division was notified of the currently proposed project and the intended preparation of an EIS but has not provided comment. Because the project would utilize the same equipment and facilities, the previous comments are assumed to remain in effect.

6.2.5 Division of Land Management, DLNR

During review of the ATOC project, DLNR's Division of Land Management concluded that the Division had no objections to the project because the proposal did not affect present or future Land Management programs. The Division was notified of the currently proposed project but has not provided comment.

6.2.6 Hawaii Department of Transportation

The Hawaii Department of Transportation (DOT) has jurisdiction over state submerged lands and must give approval for activities and installations which might interfere with navigation. Under HRS, Chapter 266, this review occurs within the context of the DLNR permit review process. Given the depth at which the project equipment is located, it had no effect previously on navigation and should be expected to have no effect on navigation during the proposed project. For the previous project, DOT notified DLNR that the project did not appear to have any discernible impact on the State's commercial harbor facilities or operations. DOT was notified of the currently proposed project but has not yet commented.

6.2.7 Water Quality And Noise Regulation: Department Of Health

Hawaii Department of Health (DOH) has authority in relation to aquatic resources under HRS Chapter 342D, 11 HAR Chapter 54 (water quality standards), and other state authorities. Under Chapter 342F, DOH regulates certain noise pollution, not including noise in State marine waters. These statutes and rules are part of the State's Coastal Zone Management Program authorities network, and the DOH can participate in implementation of these authorities through the federal consistency review process. Similarly, DOH can implement the aquatic resource policies and standards through recommendations to DLNR on CDUP applications.

The DOH is also the state agency which implements water quality certification under § 401 of the Clean Water Act, applying the state water quality certification standards. The authority for § 401 review arises in connection with any federal permit for discharge into navigable waters of the United States (defined by § 502(8) of the Clean Water Act to extend three miles seaward from the shore). Because no federal discharge permit was required for the previous project, the State gave notice that § 401 certification was not needed. In connection with the current proposal, DOH representatives advised during early informal consultation that the previous agency determinations would remain in effect.

During review of the previous project, DOH indicated that, given the uncertainty at that time about potential effects of low frequency sound on aquatic life and the availability of findings on this issue at the conclusion of the MMRP, it was premature for DOH to make a determination regarding possible applicability of other water and noise-related authorities of DOH. DOH was provided with copies of MMRP reports and findings and has raised no further concerns about potential effects of low frequency sound on aquatic life.

The state water quality standards of 11 HAR Chapter 54, establish classifications for marine waters and marine bottom ecosystems and define compatible uses and criteria. All portions of the cable fall within the areas classified as "Open Coastal Waters" (shore to 183 m [600 ft]) or "Oceanic [deeper] Waters" (§ 11-54-07). The cable route begins at a depth of 24 m (79 ft) offshore from Barking Sands, runs seaward around the northwest side of the island at depths of 73 to 108 m (240 to 354 ft), and terminates at the source site at approximately 807 m (2650 ft).

Approximately three-fourths of the cable route lies offshore between Hikimoe Valley and Makahoa Point, and is therefore in an area designated as Class AA Open Coastal Waters. The regulatory objective is to maintain such areas in their natural, pristine state as nearly as possible, with an absolute minimum of pollution or alteration of water quality. The project cable, involving no pollution or alteration of water quality, is compatible with this objective. Among the uses protected in Class AA waters is oceanographic research. Use of the cable to transmit power is part of the proposed oceanographic research activities.

Less stringent standards apply in the deep Oceanic Waters, which are in the Class A Open Coastal Waters. The Cable between Barking Sands and Hikimoe Valley, as well as the cable's northern terminus and the source are in Class A waters. In such waters, any use is allowed as long as it is compatible with protection and propagation of fish, shellfish, and wildlife, and with recreational uses.

Of the marine bottom types addressed by the water quality standards, only soft bottom community (defined as occurring at 2 to 40 m [6.6 to 131 ft]) occurs along the immediate cable route. The point of connection with the existing cable offshore from Barking Sands is at 24-m (79-ft) depth, in an area of sandy and coral rubble bottom. Abandonment of the cable in place would be considered to be of negligible impact on the seafloor, since it was laid in place during October 1993, and it is assumed that the greatest portion of it is now buried by sand. Abandonment of the source would also be of negligible impact on the seafloor since it was installed in July 1997 and is at such a deep depth.

From the point of connection offshore from Barking Sands, the cable route moves into deeper water, passing along sandy surge channels that transect the outer reef. At 45 to 67 m (148 to 220 ft), this reef is too deep to be included in the marine bottom types addressed by state water quality standards. Even so, the cable route avoids the coral, because it is important to run the cable over stable and relatively flat seabed, minimizing cable suspensions that could cause stress and breakage.

Potential effects of the sound transmissions upon the aquatic environment are discussed in Chapter 4. The program for mitigating potential adverse effects upon aquatic life is described in Chapters 2 and 5 of this EIS. With these mitigation measures, the project is not expected to have any adverse effects in relation to State goals for protection of aquatic resources, as reflected in HRS Chapters 342D and 344.

6.2.8 County Of Kauai: Special Management Area Requirements Under the Shoreline Protection Act; County General Plan and Development Plans

In connection with the previous Kauai ATOC project, the County of Kauai provided written notice that, because the project would be located seaward of the County's Special Management Area (SMA), a special management area permit under HRS 205A would not be required. The County exercised no other authority in relation to the project. In connection with the currently proposed project, the County has again provided written notice that, due to the location of the project seaward of the Special Management Area, no Special Management Area permit would be required.

6.3 HUMPBACK WHALE RECOVERY PLAN

In 1991, NMFS approved a Recovery Plan for the endangered humpback whale. Under provisions of the ESA, recovery plans are prepared to foster and guide the recovery of species listed as endangered. The Recovery Plan is not a regulatory or management program. Instead, it recommends goals for recovery efforts and provides background information for decision-making affecting humpback whales.

The Recovery Plan recommends goals and actions for: (1) maintaining and enhancing the habitats of humpback whales; (2) identifying and reducing death, injury, or disturbance to the whales caused by humans; (3) performing research to evaluate progress toward recovery goals; and (4) implementing the Recovery Plan through improved administration and coordination.

The proposed project's consistency with these goals can be evaluated, in part, in light of the findings of the Marine Mammal Research Programs (MMRPs), which were conducted in connection with the previous California and Hawaii ATOC research projects. The MMRPs showed no incompatibility between the low frequency acoustic transmissions as used in the ATOC research and Recovery Plan objectives of reducing death, injury, and disturbance to humpback whales. MMRP monitoring showed no overt, short-term changes in the behavior of individual whales nor in the species' abundance or distribution. (See further discussion of MMRP findings at Sections 4.2.1.2.1 and of humpback whales at Section 3.2.)

The Marine Mammal Monitoring Studies proposed in connection with the current project would augment the MMRP information on humpback whales with a continued program of aerial surveys and data analysis. Principal objectives would be to monitor species distribution and abundance in areas potentially affected by the acoustic transmissions. The resulting information can be expected to further the Recovery Plan objective of research to evaluate progress toward recovery. Particularly relevant is Goal 3.5, calling for information on habitat use to determine management actions.

Several of the goals of the Recovery Plan require more information on the current acoustic regime of the humpback habitat. Goal 1.14 calls for detailed descriptions of physical and biological characteristics of current habitats, including "acoustic characteristics." Goal 1.3111 focuses on the need to reduce "noise disturbance" in Hawaiian waters; although it is hesitant about recommending additional noise research because of the expense and possible ambiguous results and, therefore, emphasizes reduction of human-produced underwater noise as more direct and cost-effective than additional research.

The proposed project would involve an increase in underwater sound on a 2-8 percent duty cycle in the area. The change would be closely similar to the increase in underwater sound associated with the previous ATOC research and studied by the MMRP. Intensive statistical analyses through the MMRP revealed some subtle changes in the behavior of humpback whales in response to ATOC sound transmissions. The study results showed that the distance and time between successive whale surfacings increased slightly with increasing sound levels. (See Section 4.2.1.2.1.) Whether this subtle effect may constitute a "noise disturbance" within the contemplation of the Recovery Plan Goal 1.3111 would appropriately be weighed in light of what is known about the potential effects of low frequency sound on humpbacks as well as the value of the Marine Mammal Monitoring research in providing information to assess more accurately the potential for impacts of noise and implement Goal 1.3111 to reduce noise disturbance in Hawaii. Consideration of this issue may also 6-9 encompass comparative sound levels of noise-producing sources in the north Kauai area, including whale-watching vessels, recreational and commercial fishing power boats, thrillcraft, and low-flying aircraft.

The Recovery Plan also encourages public education about humpback whales and international cooperation in conserving the whale and its habitat. Goals include mutual exchange of information between nations (Goal 1.73), effective communications with groups interested in marine affairs (Goal 4.3), and increased public education (Goal 4.9). The Marine Mammal Monitoring Studies planned as part of the NPAL project further these goals by gathering and sharing of humpback distribution and abundance data.

6.4 HAWAIIAN ISLANDS HUMPBACK WHALE NATIONAL MARINE SANCTUARY

The Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS) was established in 1992 as part of the national system of marine sanctuaries. The primary purpose of the designation is to protect the humpback whale and its habitat. A management plan adopted in 1997, and amended in 1999, established sanctuary boundaries and management procedures for the sanctuary. 15 CFR §§. 922.180-922.187.

In the Kauai area, the HIHWNMS includes the submerged lands and waters from the Kilauea Point National Wildlife Refuge (Kailiu Point) out to the 100-fathom (fm) (183-m) isobath, eastward to Mokolea Point. A small section of the cable lies within the sanctuary boundaries. No changes in location or use of this cable are proposed in connection with the project. At the project's conclusion the cable would be abandoned in place, avoiding the seafloor disturbance that could be associated with removal of the cable.

Based on measurements made during the Kauai ATOC MMRP, the sound field at the sanctuary boundary is about 110 dB. Thus some increase in ambient noise levels <115 dB could be expected in a portion of the sanctuary during sound transmissions.

The humpback whale and its habitat are the only resources included for protection and management under the HIHWNMS management plan. The plan relies on existing regulation under federal and state law to carry out the protections and management measures. Additionally, federal agencies must consult with the Secretary of Commerce or designee on any actions, internal or external to a National Marine Sanctuary (including private activities authorized by licenses, leases, or permits), that is "likely to destroy, cause the loss of, or injure, any sanctuary resource." 16 USC § 1434(d). In connection with the proposed action, there is no expectation of any destruction, loss or injury of any sanctuary resource, within, or outside of the sanctuary.

THIS PAGE INTENTIONALLY LEFT BLANK

GLOSSARY

A

acoustic propagation = the transmission of acoustic energy through a medium, such as seawater.

acoustic remote sensing of the ocean = scientific methods for obtaining information about the properties of the ocean from sound transmissions through it, giving information on ocean temperature, water velocities, etc., between the acoustic sources and receivers, rather than the properties of the ocean at the instruments.

acoustic thermometry = a method for obtaining information about the temperature field in the ocean from precise measurements of the travel time of sound pulses transmitted through the ocean; a special case of the more general technique of ocean acoustic tomography.

air standard = the reference pressure for measuring airborne sound (20 microPascals).

algorithm = a formula for solving a problem.

ambient noise = the background noise in the ocean due to wave action, rainfall, biologics, etc.

atoll = a coral reef in the shape of a ring or horseshoe enclosing a lagoon.

audiogram = graphical representation of an animal's hearing ability; based on measured data.

B

basalt = black or dark gray rock of volcanic origin

bathymetry = the surface features of the seafloor, such as seamounts, ridges, trenches and underwater volcanoes; underwater topography

benthic = of or found on the seafloor

broadband level = total acoustic power level over a specified bandwidth (e.g., the bandwidth between 100 Hz and 200 Hz).

C

coaxial cable = an electrical cable consisting of a conducting tube surrounding a central conductor and separated from it by an insulating material.

constrain computer models = to use data obtained from the observation of natural processes to update computer models which simulate the process (e.g., weather forecasts are generated using computer models of the atmosphere that are routinely updated using data obtained from the worldwide network of weather stations)

cylindrical spreading = the rate at which acoustic intensity decreases for acoustic energy that has filled the water column from the seafloor to the sea surface and is now traveling away from the sound source in only two dimensions; this is a simple approximation for acoustic propagation from a sound source when the range from the source is greater than the depth of the water in that area. See spherical spreading.

D

decibel = a unit used to express the relative difference in acoustic power between signals, equal to ten times the common logarithm of the ratio of the two signal intensities.

duty cycle = the percentage of time an instrument is on.

E

electromagnetic wave = a wave propagated through a medium (such as air or seawater) by simultaneous periodic variation in the electric and magnetic field intensity at right angles to each other and to the direction of propagation. The electromagnetic spectrum includes radio waves, microwaves, infrared, visible and ultraviolet radiation, X rays, gamma rays, and cosmic rays (in order of decreasing wavelength).

expendable bathythermograph (XBT) = an instrument dropped from ships and aircraft to measure ocean temperature as a function of depth at one location.

El Niño/Southern Oscillation (ENSO) = a combined oceanographic and atmospheric phenomenon which results in unusually warm surface water in the eastern tropical Pacific off the coast of South America

Eulerian arrays = arrays of instruments, such as moored temperature sensors and current meters, which are located at fixed positions on the Earth; see also surface mooring.

F

G

gyre = the wind-driven ocean circulation is divided into large gyres that are roughly circular or elliptical in shape and stretch across the entire ocean: subtropical gyres extend from the equatorial current system to the maximum westerlies in the wind field near 50° latitude, and subpolar gyres extend poleward of the maximum westerlies

gyre scale = ocean-basin size (on the order of a few thousand kilometers or nautical miles).

H

I

infrared radiation = electromagnetic waves of length greater than visible light but less than microwaves (between 7.6×10^{-5} cm and 0.1 cm). Infrared radiation is perceived as heat and is used in some cooking devices, for therapeutic heat treatments, and for photography in fog or darkness. See microwave.

infrasonic noise = sounds below the spectrum of human hearing (i.e., less than 20 Hz) interannual = occurring between years (e.g., "interannual variations" are changes which occur from one year to the next.)

internal waves = wave motions occurring in the ocean interior, rather than at the ocean surface, in which water particles move up and down in wavelike motions relative to a fixed depth; internal waves occur because the density of the ocean increases with depth, so that a water particle that is displaced from its equilibrium depth experiences a force that tends to return it to that depth

J

K

L

La Niña = an oceanographic phenomenon that that is the reverse of El Niño; unusually cold water is present in the eastern tropical Pacific off the coast of South America, while unusually warm water is present in the western tropical Pacific

large-scale acoustic thermometry = the application of acoustic thermometry to measure ocean temperatures on large, ocean-basin scales (on the order of a few thousand kilometers or nautical miles).

LORAN station = a location known by navigators that transmits radio signals to navigate by.

low-frequency, long-range acoustic propagation in the ocean = low frequency refers to sound which is between 1-1000 Hertz; long-range refers to distances on the order of 1,000-5,000 kilometers; acoustic propagation is the transmission of sound energy through a medium, such as seawater

M

M-sequence waveform = a sine wave with a series of phase reversals

microPascal = the Pascal is the international unit for pressure, analagous to pounds per square inch in English units; 1 microPascal is one-millionth of a Pascal; the reference pressure used for underwater sound is 1 microPascal and for airborne sound is 20 microPascals.

microwave = an electromagnetic wave of wavelength less than 10 m (especially one between 1 m and 1 cm) in the radio-frequency range that are used as carrier waves in telephone and television transmissions. See infrared radiation.

N

narrowband level = acoustic power level within a "narrow" bandwidth, often 1 Hz, as opposed to broadband (e.g., broadband could refer to a bandwidth between 100 Hz and 200 Hz, whereas narrowband could refer to a bandwidth between 150 Hz and 151 Hz). See spectral level.

O

ocean acoustic tomography = a method in which measurements of various properties of acoustic propagation through the ocean are used to infer the temperature, water velocity, and other physical properties of the ocean; a method for acoustic remote sensing of the ocean interior.

P

Pacific Decadal Oscillation (PDO) = a pattern of sea-surface temperature variability in the North Pacific Ocean, in which approximately decade-long periods when the eastern North Pacific is cooler than normal and the western North Pacific is warmer than normal alternate with decade-long periods when the eastern North Pacific is warmer than normal and the western North Pacific is cooler than normal

Parabolic Equation (PE) models = acoustic propagation models that include the possibility of attenuation or reinforcement of signal propagation paths due to the effects of the transmission medium (sea water) or surrounding features (the most significant of which are the sea bottom and the sea surface).

phase-coded signal = an acoustic signal that has a known series of phase reversals, thereby allowing the signal to be easily extracted with a computer from the background ambient noise when it is received

Q

R

ramp-up = an initial period of acoustic source operation during which the signal intensity is gradually increased

root-mean-squared = a measure of the deviation of the values of a quantity from zero

S

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.

satellite altimeter = a satellite which measures the height of the sea surface

signal-to-noise ratio (SNR) = the ratio between the received level of the underwater acoustic signal and the surrounding ambient noise level; high SNR allows for easy detection and processing of the desired signal, the opposite applies to low SNR.

signal parameters = the characteristics of an acoustic signal, including such features as source level, duration of the signal, frequency of the signal, etc.

SOFAR channel = sound frequency and ranging channel, which is centered on the ocean depth where the speed of sound is at a minimum (sound channel axis).

sound channel axis = the ocean depth where the speed of sound is at a minimum; above this depth, sound travels faster because the water is warmer, below sound travels faster because the pressures are greater. Thus, acoustic energy is refracted (bent) back toward the axis by this difference in speeds, essentially causing an acoustic waveguide (SOFAR channel) that transmits sounds underwater efficiently over long distances.

sound pressure level (SPL) = twenty times the logarithm of the ratio of the underwater pressure to the reference pressure, in decibels, at a specific point in the ocean; usually measured in decibels referenced to 1 microPascal (root-mean-squared).

sound receiver = an instrument which converts sound energy into electrical energy

sound source = an instrument which converts electrical energy into sound energy

source level = the intensity of a sound source at a range of 1 meter (3.28 ft); usually measured in decibels referenced to the intensity of a signal with a sound pressure level of 1 microPascal

spectral level = *acoustic power level within a one-Hertz "slice" of a bandwidth (e.g., the spectral* level at 150 Hz is the acoustic power level within the bandwidth between 149.5 Hz and 150.5 Hz).

spherical spreading = the rate at which acoustic intensity decreases for acoustic energy traveling away from a sound source uniformly in all directions; this is a simple approximation for acoustic propagation from a sound source until the range from the source is greater than the depth of the water in that area. See cylindrical spreading.

Subarctic Front = a rapid change in temperature and salinity separating the subtropical ocean gyre from the subpolar ocean gyre, much as a front in the atmosphere separates warm and cold air masses; see also gyre

subsurface drifter = an instrument which is located below the surface of the ocean which moves with the ocean currents and makes measurements of the physical properties of that water body over time

surface drifter = an instrument located at the ocean surface which moves with the ocean currents and makes measurements of the physical properties of that water body over time

surface mooring = a mooring with an anchor on the seafloor and a float on the surface connected by wire rope or other line; instruments attached to a surface mooring are essentially stationary in the ocean and make measurements of the physical properties of the ocean which pass by the instruments

surge channel = a steep-sided, narrow break in a line of coral reef that typically has a sandy seafloor

T

test computer models = to compare the output of a computer model which simulates a process with observational data collected on the process

thermocline = the depth range in the ocean over which temperature decreases rapidly from warm, near-surface temperatures to cold, deep temperatures

thermometry = see acoustic thermometry

tomography = see ocean acoustic tomography

U

V

W

water standard = the reference pressure for measuring underwater sound (1 microPascal).

X

Y

Z

Literature Cited

AAA Tourbook. 1992. Hawaii: Where to go, what to see, where to stay, where to dine. Annual Travel Guide of the American Automobile Association. 128 pp.

Agler, B. A., R. L. Schooley, S. E. Frohock, S. K. Katona, and I. E. Seipt. 1993. Reproduction of photographically identified fin whales *(Balaenoptera physalus)* from the Gulf of Maine. J. Mammal 74: 577-587.

Allen, S. G., D. G. Ainley, G. W. Page and C. A. Ribic. 1984. The effect of disturbance on harbor seal haul out patterns at Bolinas Lagoon, California. Fish. Bull. U.S. 82(3):493-500.

Alling, A. K. and R. Payne. 1991. *In:* Leatherwood, S. (ed.). Song of the Indian Ocean blue whale, *Balaenoptera musculus.* Special issue on the Indian Ocean sanctuary.

Amerson, A. B. Jr. and P. C. Shelton. 1976. The natural history of Johnston Atoll, Central Pacific Ocean. Atoll Res. Bull. 192. 479 pp.

ARPA and NMFS. 1995a. Final Environmental Impact Statement/Environmental Impact Report for the California Acoustic Thermometry of Ocean Climate Project and its associated Marine Mammal Research Program (Scientific Research Permit Application [P557B]). Advanced Research Projects Agency, Arlington, VA and National Marine Fisheries Service, Silver Spring, MD. 2 Vol. Var. Pag. April 1995.

ARPA and NMFS. 1995b. Final Environmental Impact Statement/Environmental Impact Report for the Kauai Acoustic Thermometry of Ocean Climate Project and its associated Marine Mammal Research Program. Advanced Research Projects Agency, Arlington, VA and National Marine Fisheries Service, Silver Spring, MD. 2 Vol. Var. Pag. May 1995.

Atkins, N. and S. L. Swartz (eds.). 1989. Proceedings of the workshop to review and evaluate whale watching programs and management needs, November 14-16, 1988, Monterey, CA. Center for Mar. Conserv., Washington, DC. 53 p.

ATOC Consortium. 1998. Ocean climate change: Comparison of acoustic tomography, satellite altimetry, and modeling. Science. 281:1327-1332.

Au, W. W. L., R. W. Floyd, R. H. Penner, and A. E. Murchison. 1974. Measurement of echolocation signals of the Atlantic bottlenose dolphin, *Tursiops truncatus* Montagu, in open waters. J. Acoust. Soc. Am, 56, 1280-90.

Au, W. W. L., D. A. Carder, R. H. Penner and B. L. Scronce. 1985. Demonstration of adaptation in beluga whale echolocation signals. J. Acoust. Soc. Am. 77(2):726-730.

Au, W. W. L., P. Nachtigall, and J. L. Pawloski. 1997. Acoustic effects of the ATOC signal (75 Hz, 195 dB) on dolphins and whales. Journal of the Acoustical Society of America. 101:2973-2977.

Au, W. W. L., A. N. Popper, R. R. Fay. 2000. Hearing by Whales and Dolphins. Springer Handbook of Auditory Research, Vol. 12. Springer-Verlag. 384 p.

Awbrey, F. T., J. A. Thomas, W. E. Evans, and S. Leatherwood. 1982. Ross Sea killer whale vocalizations: Preliminary description and comparison with those of some northern hemisphere killer whales. Rep. Int. Whal. Comm. 32: 667-660.

Bain, D. E. 1989. An evaluation of evolutionary process: Studies of natural selection, dispersal, and cultural evolution in killer whales (*Orcinus orca*). Ph.D. dissertation, University of California, Santa Cruz.

Bain, D. E., B. Kriete, and M. E. Dahlheim. 1993. Hearing abilities of killer whales (*Orcinus orca*). J. Acoust. Soc. Am. 94(Part 2): 1829.

Baird, R. W., L. M. Dill, and M. B. Hanson. 1998. Diving behavior of killer whales. Abstracts of the World Marine Mammal Science Conference, Monaco. January 1998.

Baird, R. W., A. D. Ligon, and S. K. Hooker. 2000. Sub-surface and Night-time Behavior of Humpback Whales off Maui, Hawaii: A preliminary report. Report prepared by the Hawaii Wildlife Fund, Paia, HI. 18 pp.

Baker, C. S. 1985. The behavioral ecology and populations structure of the Humpback Whale (*Megaptera novaeangliae*) in the central and eastern Pacific. Dissertation for the University of Hawaii at Manoa.

Baker, C. S. and L. M. Herman. 1981. Migration and local movement of humpback whales through Hawaiian waters. Can. J. Zool. 59:460-469.

Baker, C. S. and L. M. Herman. 1987. Alternative population estimates of humpback whales (*Megaptera novaeangliae*) in Hawaiian waters. Canadian Journal of Zoology. 65:2818-2821.

Baker, C. S., L. M. Herman, B. G. Bays and W. S. Stifel. 1982. The impact of vessel traffic on the behavior of humpback whales in southeast Alaska: 1981 season, Report to the National Marine Mammal Laboratory, Seattle, Wash.

Baker, C. S., L. M. Herman, B. G. Bays and G. B. Bauer. 1983. The impact of vessel traffic on the behavior of humpback whales in southeast Alaska 1982 season. Rep. from Kewalo Basin Mar. Mamm. Lab., Honolulu, HI, for U.S. National Mar. Mamm. Lab., Seattle, WA. 30 p. plus Figures and Tables.

Baker, C. S., A. Perry and G. Vequist. 1988. Humpback whales of Glacier Bay, Alaska. Whalewatcher, Fall 1988:13-17.

Balazs, G. H. 1980. Synopsis of biological data on the green sea turtle in the Hawaiian Islands. NOAA Tech Memo. NMFS-SWFC-7, 141 p.

Balazs, G. H. 1983. Recovery records of adult green turtles observed or originally tagged at French Frigate Shoals, Northwestern Hawaiian Islands. U.S. Dept. Comm., NOAA Tech Memo. NMFS-SWFSC-36. 42 pp.

Balazs, G. H. 1985. Impact of ocean debris on marine turtles: entanglement and ingestion. p. 387-429. *In:* R.S. Shomura and H.O. Yoshida (eds.). Proceedings of the workshop on the fate and impact of marine debris. U.S. Dept. Comm. NOAA Tech Memo., NMFS-SWFC-54.

Balazs, G. H. 1993. A potential method for evaluating post-release survival of hooked sea turtles in pelagic habitats. *In:* Research plan to assess marine turtle hooking mortality: Results of an expert workshop held in Honolulu, Hawaii. Nov. 16-18, 1993.

Balazs, G. H. 1994. Homeward bound: satellite tracking of Hawaiian green turtles from nesting beaches to foraging pastures. Proceedings of the 13th Annual Workshop on Sea Turtle Biology and Conservation.

Balazs, G. H. and S. Hau. 1986. Geographic distribution: *Lepidochelys olivacea* in Hawaii. Herpetol. Rev. 17(2):51.

Balazs, G. H. and E. Ross. 1974. Observations on the pre-emergence behavior of the green turtle. Copeia 1974 (4):986-988.

Balcomb, K. C. 1987. The whales of Hawaii, including all species of marine mammals in Hawaiian and adjacent waters. Mar. Mam. Fund Pub., San Francisco, CA. 99 pp.

Banner, A. 1967. Evidence of sensitivity to acoustic displacements in the lemon shark, *negraprion brevirostris* (Poey). *In:* P.H. Cahn, (ed), Lateral Line Detectors. Indiana University Press, Bloomington. pp. 265-273.

Barlow, J. 1985. Distribution and abundance of harbor porpoise along the coasts of California, Oregon, and Washington based on ship surveys. *In*: Abstr. 6th Bien. Conf. Biol. Mar. Mamm., Nov 1985, Vancouver, B.C.

Barlow, J., K. A. Forney, P. S. Hill, R. L. Brownell Jr., J. V. Carretta, D. P. DeMaster, F. Julian, M. S. Lowry, T. Ragen, and R. R. Reeves. 1996. U.S. Pacific Marine Mammal Stock Assessments: 1996. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-248. 224 pp.

Bauer, G. B. 1986. The behavior of humpback whales in Hawaii and modifications of behavior induced by human interventions. PhD. Dissertation, Univ. Hawaii, Honolulu.

Bauer, G. B. and L. M. Herman. 1986. Effects of vessel traffic on the behavior of humpback whales in Hawaii. Rep from Kewalo Basin Mar. Mamm. Lab., Univ. of Hawaii, Honolulu, for U.S. National Mar. Fish. Serv., Honolulu, HI. 151 p.

Bel'kovich, V. M. 1960. Some biological observations on the white whale from aircraft. Zool. Zh. 39(9):1414-1422. NOO-T-403, U.S. Naval Oceanographic Office, Washington, DC. 14 p. NTIS AD-6935830.

Berzin, A. A. 1971. "Kashalot [The sperm whale]". Izdat. "Pischevaya Promyshelennost." Moscow. English translation, 1972, Israel Program for Scientific Translations, Jerusalem.

Best, P. B. 1960. Further information on Bryde's whale (*Balaenoptera edeni* Anderson) from Saldanha Bay, South Africa. Nor. Hvalfangst-Tid 49: 201-215.

Best, P. B. 1975. Status of Bryde's whale (*Balaenoptera edeni*). FAD Advisory Committee on Marine Resources Research, Marine Mammal Symposium.

Bjorndal, K. A. 1997. Foraging ecology and nutrition of sea turtles. *In:* Lutz, P. L. and J. A. Musick (eds.). The biology of sea turtles.

Bonner, W. N. 1982. Seals and man: a study of interactions. Univ. Wash. Press, Seattle, WA. 170 p.

Bowen, B. W., A. B. Meylan, J. P. Ross, C. J. Llupus, G. H. Balazs, and J. C. Avise. 1992. Global population structure and natural history of the green turtle *(Chelonia mydas)* in terms of matriarchal phylogeny. Evolution 46(4):865-881.

Bowles, A. E. and B. S. Stewart. 1980. Disturbances to the pinnipeds and birds of San Miguel Island, 1979-1980. p. 99-137. *In:* J. R. Jehl Jr., and C. F. Cooper (eds.): Potential effects of space shuttle sonic booms on the biota and geology of the California Channel Islands: Research Reports. Tech. Rep. 80-1, Center for Mar. Stud., San Diego State Univ. 246 p.

Bowles, A. E., M. Smultea, B. Wursig, D. P. DeMaster, and D. Palka. 1994. Relative abundance and behavior of marine mammals exposed to transmissions from the Heard Island Feasibility Test. JASA 96(4):2469-2484.

Braham, H. W., W. M. Maequette, T. W. Bray and J. S. Leatherwood (eds.). 1980. The Bowhead Whale: Whaling and Biological Research. Marine Fisheries Review, 42:9-10, I-96.

Breese, D. B. and B. R. Tershy. 1993. Relative abundance of cetacea in the Gulf of California. Mar Mamm Sci 9:319-324.

Briggs, K. T., D. G. Ainley, D. R. Carlson, D. B. Lewis, W. B. Tyler, L. B. Spear, and L. A Ferris. 1987. California Seabird Ecology Study, Volume I: Feeding Ecology of California Nesting Seabirds. Final Report to the U.S. Minerals Management Service by the Institute of Marine Sciences, University of California, Santa Cruz, CA. 153 pp.

Brodie, P. F. 1981. Energetic and behavioral considerations with respect to marine mammals and disturbance from underwater noise. p. 287-290. *In*: N. M. Peterson (ed.). The questions of sound from icebreaker operations: The proceedings of a workshop. Arctic Pilot Proj., Calgary, Alb. 350 p.

Bryant, P. J., C. M. Lafferty and S. K. Lafferty. 1984. Reoccupation of Laguna Guerrero Negro, Baja California, Mexico, by gray whales. p. 375-387. *In*: M. L. Jones et al. (eds.). The gray whale *Eschrichtius robustus*. Academic Press, Orlando, FL. 600 p.

Budelmann, B. U. and J. Z. Young. 1994. Directional sensitivity of hair cell afferents in the Octopus statocyst. J. Exp. Biol. 187: 245-259.

Buerkle, U. 1968. Relation of pure tone thresholds to background noise level in the Atlantic cod *(Gadus morhua)*. J. Fish. Bd. Canada 25, 1155-1160.

Byles, R. A. and P. T. Plotkin. 1992. Comparison of the migratory behavior of the congeneric turtles *Lepidocchelys olivacea* and *L. kempii*. *In:* B. A. Schroeder and B. E. Witherington (compilers). Proceedings of the Thirteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Tech. Memo. NMFS-SEFSC-341, 281 pp.; 1994, p. 391.

Calambokidis, J. 1999. Status and trends of humpback whales in the North Pacific. 13[th] Biennial Conf. on Biol. of Mar. Mam., Wailea, Hawaii. Nov 28 – Dec 3, 1999.

Calambokidis, J., G. H. Steiger, J. M. Straley, L. M. Herman, S. Cerchio, D. R. Salden, M. Yamaguchi, F. Sato, J. Urbán, J. Jacobsen, O. V. Ziegesar, K.C. Balcomb, C. M. Gabriele, M. E. Dalheim, N. Higashi, S. Uchida, J. K. B. Ford, Y. Miyamura, P. L. Guevara, S. A. Mizroch, L. Schlender, and K. Rasumssen. 1997. Abundance and population structure of humpback whales in the North Pacific basin. National Marine Fisheries Services, Southwest Fisheries Science Center, La Jolla, CA

~~Calambokidis, J., T. E. Chandler, D. P. Costa, C. W. Clark, and H. Whitehead. 1998. Effects of the ATOC sound source on the distribution of marine mammals observed from aerial surveys off central California. WMMSC, Monaco. Jan. 1998.~~

Caldwell, D. K. and M. C. Caldwell. 1983. Whales and Dolphins. Pages 767-812. In: Alfred A. Knopf (ed.). The Audubon Society Field Guide to North American Fishes, Whales and Dolphins. Alfred A. Knopf, Inc., New York, NY.

Carder, D., S. Ridgway, B. Whitaker, and J. Geraci. 1995. Hearing and echolocation in a pygmy sperm whale *Kogia*. Abstracts of the 11[th] Biennial Conference on the Biology of Marine Mammals, Orlando, FL. December 1995.

Carr, A. 1986. Rips, FADS, and little loggerheads. BioScience 36:92-100.

Carr, A. 1987. New perspectives on the pelagic stage of sea turtle development. Conservation Biology 1:103-121.

Cerchio, S. 1998. Estimates of humpback whale abundance off Kauai, 1989-1993: Evaluating biases associated with sampling the Hawaiian Islands breeding assemblage. Mar. Ecol. Prog. Ser. 175: 23-34.

CETAP. 1982. A characterization of marine mammals and turtles in the mid- and north Atlantic areas of the U.S. outer continental shelf. Cetacean and Turtle Assessment Program, University of Rhode Island. Final Report, Contract #AA51-CT8-48. Bureau of Land Management, Washington, DC.

Chapman C. J. and A. D. Hawkins. 1973. A field study of hearing in the cod, *Gadus morhua* L. J. Comp. Physiol. 85:147-167.

Charif, R. A., D. K. Mellinger, K. J. Dunsmore, and C. W. Clark. Submitted. Source levels and depths of fin whale *(Balaenoptera physalus)* vocalizations from the eastern North Pacific.

Chave, E. H. and B. C. Mundy. 1994. Deep-sea fish of the Hawaiian archipelago, Cross Seamount and Johnston Atoll. Pac. Sci. 48(4):367-409.

Clark, C. W. 1982. The acoustic repertoire of the southern right whale, a quantitative analysis. *Anim. Behav. 30(4): 1060-1071.*

Clark, C. W. and R. Charif. 1998. Monitoring the occurrence of large whales off North and West Scotland using passive acoustic arrays. Society of Petroleum Engineers (SPE). SPE/UKOOA European Environmental Conference, Aberdeen, Scotland. April 1997.

Clark, C. W. and K. Fristrup. 1997. Whales '95: A combined visual and acoustic survey of blue and fin whales off southern California. Rep Int Whal Comm 47: 583-600.

Clark, C. W., C. J. Gagnon and D. K. Mellinger. 1993. Whales '93: Application of the Navy IUSS for low-frequency marine mammal research. Invited paper, abstract published in Tenth Biennial conference on the Biology of Marine Mammals abstracts, 11-15 Nov. 1993., Galveston, TX. (Abstract)

Clarke, R. 1956. Sperm whales of the Azores. Discovery Rep. 28, 237-298.

Clay, G. S., S. Broder, R. Turner, D. Kitaoka, G. Rhodes and D. Yamase. 1981. Ocean Leasing for Hawaii. Aquaculture Development Program, Department of Planning and Economic Development, Honolulu.

Cobb, J. N. 1908. Hawaiian fishery rights. American fishery society transactions, V.37. United States Bureau of Fisheries, Washington, DC.

Cornuelle, B. 1983. Inverse methods and results from the 1981 ocean acoustic tomography experiment, Ph.D. dissertation, Massachusetts of Technology and Woods Hole Oceanographic Institution, 359 pp.

Cornuelle, B. 1985. Simulations of acoustic tomography array performance with untracked drifting sources and receivers. Journal of Geophysical Research. 90:9079-9088.

Costa, D. P., D. E. Crocker, D. M. Waples, P. M. Webb, J. Gedamke, D. Houser, P. D. Goley, B. J. LeBoeuf, and J. Calambokidis. 1998. The California Marine Mammal Research Program of the Acoustic Thermometry of Ocean Climate experiment. In: Conference Proceedings of California and the World Ocean '97: Taking a look at California's ocean resources: an agenda for the future. O. T. Magoon et al. (eds). American Society of Civil Engineers, Reston, VA. Pp. 1542-1553.

Cox, M., P. H. Rogers, A. N. Popper, and W. M. Saidel. 1986a. Frequency regionalization in the fish ear. J. Acoust. Soc. Am. Suppl 1, 79: S80.

Cox, M., P. H. Rogers, A. N. Popper, and W. M. Saidel. 1986b. Anatomical effects of intense tone simulation in the ear of bony fish. J. Acoust. Soc. Am. Suppl 1, 80: S75.

Cox, M., P. H. Rogers, A. N. Popper, W. M. Saidel, and R. R. Fay. 1987. Anatomical effects of intense tone simulation in the goldfish ear: Dependence on sound pressure level and frequency. J. Acoust. Soc. Am. Suppl 1, 89: S7.

Crocker, M. J. 1997. Encyclopedia of acoustics.

Croll, D. A., B. R. Tershy, A. Acevedo, and P. Levin. 1999. Marine vertebrates and low frequency sound. Technical Report for LFA EIS. Marine Mammal and Seabird Ecology Group, Institute of Marine Sciences, University of California, Santa Cruz. CA.

Cudahy, E., E. Hanson, and D. Fothergill. 1999. Summary Report on the Bioeffects of Low Frequency Waterborne Sound. Technical Report 3 for the Overseas Environmental Impact Statement and Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar. Department of the Navy, Chief of Naval Operations. March 1999.

Cummings, W. C. 1985. Bryde's whale *Balaenoptera edeni* (Anderson, 1878). *In:* Ridgway, S.H. and R. Harrison (eds.). Handbook of marine mammals. Vol. 3. The sirenians and baleen whales.

Cummings. W. C. and P. O. Thompson. 1971. Underwater sounds from blue whale, *Balaenoptera musculus*. J. Acoust. Soc. Am. 50(4, Pt. 2): 1193-1198.

Cummings, W. C., J. F. Fish, and P. O. Thompson. 1972. Sound production and other behavior of southern right whales, *Eubalena* (sic) *glacialis*. Trans. San Diego Soc. Nat. Hist. 17(1): 1-13.

Darling, J. D., and Morowitz, H. 1986. Census of Hawaiian humpback whales (*Megaptera novaeangliae*) by individual identification. Can. J. Zool. 64: 105-111.

Dick, Mike of Pacific Missile Range Facility. Personal Communication with Ms. Kathleen Vigness Raposa on September 14, 2000.

Diercks, K. J., R. T. Trochta, C. F. Greenlaw, and W. E. Evans. 1971. Recording and analysis of dolphin echolocation signals. J. Acoust. Soc. Am. 49(6): 1729-1732.

Diercks, K. J., R. T. Trochta, and W. E. Evans. 1973. Delphinid sonar: Measurement and analysis. J. Acoust. Soc. Am. 54(1): 200-204.

Dijkgraaf, S. 1949. Versuche über Schallwahrnehmung bei Tintenfischen. Naturwissenschaften 50:50.

DLNR (Hawaii Department of Land and Natural Resources). 1990. Aquaculture in Hawaii. Aquaculture Development Program. Honolulu, HI.

DLNR (Hawaii Department of Land and Natural Resources). 1994. Letter from Mr. Walter Ikehara, Aquatic Biologist, to Mr. Paul Kawamoto, Aquatic Program Manager, dated Sept. 6, 1994.

DMAHTC Pub. 152. 1993. Sailing directions (Planning Guide) for the North Pacific Ocean. Defense Mapping Agency, Hydrographic/Topographic Center, Washington, DC.

Dohl, T. P., R. C. Guess, M. L. Dunman, and R. C. Helm. 1983. Cetaceans of Central and Northern California, 1980-83: Status, Abundance, and Distribution. MMS Contract # 14-12-0001-29090. University of California, Santa Cruz, CA.

Dolphin, W. F. 1987. Ventilation and dive patterns of humpback whales, *Megaptera novaeangliae*, on their Alaskan feeding grounds. Can. J. Zool. 65(1):83-90.

Donovan, G. P. 1991. A review of IWC stock boundaries. Rep. Int. Whal. Commn. Special Issue 13: 39-68.

Dushaw, B. D. 1999. Inversion of multimegameter range acoustic data for ocean temperature. IEEE J. Oceanic Eng. 24:215-223.

Dushaw, B. D., B. M. Howe, J. A. Mercer, R. C. Spindel, and T. G. B. the ATOC Group (A. B. Baggeroer, C. Clark, J. A. Colosi, B. D. Cornuelle, D. Costa, B. D. Dushaw, M. Dzieciuch, A. M. G. Forbes, B. M. Howe, D. Menemenlis, J. A. Mercer, K. Metzger, W. H. Munk, R. C. Spindel, P. F. Worcester, C. Wunsch). 1999. Multimegameter-range acoustic data obtained by bottom-mounted hydrophone arrays for measurement of ocean temperature. IEEE J. Oceanic Eng. 24:203-214.

Eckert, K. L. 1993. The biology and population status of marine turtles in the North Pacific Ocean. NOAA/NMFS Tech. Mem. SWFSC 186.

Eckert, S. A., D. W. Nellis, K. L. Eckert and G. L. Kooyman. 1986. Diving patterns of two leatherback sea turtles *(Dermochelys coriacea)* during internesting intervals at Sande Point, St. Croix, U.S. Virgin Islands. Herpetologica 42(3):381-388.

Eckert, S. A., K. L. .Eckert, P. Ponganis, and G. L. Kooyman. 1989. Diving and foraging behavior of leatherback sea turtles (*Dermochelys coracea*). Can. J. Zool. 67:2834-2840.

Edds, P. L. 1982. Vocalizations of the blue whale, *Balaenoptera musculus*, in the St. Lawrence River. J Mammal 63: 345-347.

Edds, P. L. 1988. Characteristics of finback *Balaenoptera physalus* vocalizations in the St. Lawrence Estuary. Bioacoustics 1: 131-149.

Edds, P. L. and J. A. F. Macfarlane. 1987. Occurrence and general behavior of ballaenopterid cetaceans summering in the St. Lawrence Estuary, Canada. Can. J. Zool. 65:1363-1376.

Edds, P. L., D. K. Odell, and B. R. Tershy. 1993. Vocalizations of a captive juvenile and free-ranging adult-calf pairs of Bryde's whales, *Balaenoptera edeni*. Mar Mamm Sci 9: 269-284.

Ellison, W. T., K. S. Weixel and C. W. Clark. 1993. Variation in received levels from man-made low frequency underwater noise sources as a function of diving animal depth. J. Acoust. Soc. Am. 94(3), 1850(A).

Enger, P. S. 1981. Frequency discrimination in teleosts - central or peripheral? *In:* Tavolga, W.N., A.N. Popper, and R.R. Fay (eds.). Hearing and sound communications in fish.

Ernst, C. H., R. W. Barbour, and J. E. Lovich. 1994. Turtles of the United States and Canada, 2nd Edition.

Evans, P. G. H. 1987. The natural history of whales and dolphins. Facts on File, Inc., 460 Park Ave. South, NY, NY.

Evans, W. E. 1973. Echolocation by marine delphinids and one species of fresh-water dolphin. J. Acoust. Soc. Am. 54: 191-199.

Fay, R. R. 1988. Hearing in Vertebrates: A Psychophysics Handbook. Hill-Fay Associates, Winnetka, IL. 621 pp.

Fine, M. L., H. E. Winn, and B. L. Olla. 1977. Communication in fishes. *In:* How animals communicate; Sebeok, T. A. (ed). Indiana University Press, Bloomington, pp. 472-518.

Flaherty, C. 1981. Apparent effects of boat traffic on harbor porpoise (*Phocoena phocoena*). p. 35. *In*: Abstr. 4th Bienn. Conf. Biol. Mar. Mamm., San Francisco. Dec 1981.

Folkow, L. and A. Blix. 1993. Daily changes in surfacing rates of minke whales (*Balaenoptera acutorostrata)* in Norwegian waters. Rep. Int. Whal. Commn. 43: 311-314.

Ford, J. K. B. 1989. Acoustic behavior of resident killer whales (*Orcinus orca*) off Vancouver Island, British Columbia. Can. J. Zool 67: 727-745.

Ford, J. K. B. and H. D. Fisher. 1983. Group specific dialects of killer whales *(Orcinus orca)* in British Columbia. *In:* Payne, R. (ed.). Communication and behavior of whales. AAAS Sel. Symp. 76.

Forney, K. A., M. M. Muto, and J. Baker. 1999. U.S. Pacific Marine Mammal Stock Assessments: 1999. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-SWFSC-282. 62 pp.

Forney, K. A., J. Barlow, M. M. Muto, M. Lowry, J. Baker, G. Cameron, J. Mobley, C. Stinchcomb, and J. V. Carretta. 2000. U.S. Pacific Marine Mammal Stock Assessmemts: 2000. ~~DRAFT~~. NOAA Technical Memorandum. NOAA-TM-NMFS-SWFSC-300.

Frankel, A. S. and C. W. Clark. 1998. Results of low-frequency playback of M-sequence noise to humpback whales, Megaptera novaeangliae, in Hawaii. Can. J. Zool. 76:521-535.

Frankel, A. S., and C.W. Clark. ~~1999a~~2000. Behavioral responses of humpback whales *(Megaptera novaeangliae)* to ~~operational~~ *full-scale* ATOC signals. ~~Can. J. Zool.~~ *J. Acoust. Soc. Am. 108(4):* 1930-1937.

~~Frankel, A. S., and C. W. Clark. 1999b. Factors affecting distribution and abundance of humpback whales off the North Shore of Kauai. In prep.~~

Frankel, A. S., J. R. Mobley Jr., and L. M. Herman. 1995. Determining auditory thresholds in free-ranging cetaceans using biologically meaningful sound. In: R. A. Kastelein, J. A. Thomas, P. Nachtigall (eds.), Sensory Processes of Aquatic Animals. Pp. 55-70. De Spil Publishers, Woerden, Netherlands.

Frankel, A. S., C. W. Clark, L. M. Herman, C. M. Gabriele, M. A. Hoffhines, T. R. Freeman, and B. K. Patterson. 1989. Acoustic Location and tracking of wintering humpback whales *(Megaptera novaeangliae)* off South Kohala, Hawaii. In Proceedings of the Eighth Biennial Conference on the Biology of Marine Mammals

Fritts, T. H. 1981. Pelagic feeding habits of turtles in the Eastern Pacific. Mar. Turtle Newsl. 17:4-5.

Gagnon, C. J. and C. W. Clark. 1993. The use of U.S. Navy IUSS passive sonar to monitor the movement of blue whales. Abstracts of the 10th Biennial Conference on the Biology of Marine Mammals, Galveston, TX. November 1993.

Galbreath, E. C. 1963. Three beaked whales stranded on the Midway Islands, central Pacific Ocean. J. Mamm. 44: 442-423.

Gambell, R. 1968. Aerial observations of sperm whale behavior. Norsk Hvalfangst-tidende. 57(6):126-138.

Gambell, R. 1985. Sei whale *Balaenoptera borealis* (Lesson, 1828). *In:* Ridgway, S.H. and R. Harrison (eds.). Handbook of marine mammals. Vol. 3: The sirenians and baleen whales.

Gard, R. 1974. Aerial census of gray whales in Baja California lagoons, 1970 and 1973, with notes on behavior, mortality and conservation. Calif. Fish & Game 60(3):132-143.

Gaskin, D. E. 1972. Whales, dolphins, and seals; with special reference to the New Zealand region.

Gaskin, D. E. 1982. The ecology of whales and dolphins.

Gilmartin, W. G. 1983. Recovery plan for the Hawaiian monk seal, *Monachus schauinslandi.* (Written by Gilmartin in cooperation with the Hawaiian Monk Seal Recovery Team.) Southwest Region, Natl., Mar. Fish. Service, NOAA, 29 pp.

Glockner, D. A. and S. Venus. 1983. Determining the sex of humpback whales *(Megaptera novaeangliae)* in their natural environment. *In:* Communication and behavior of whales, R. S. Payne (ed.), pp 447-464, AAAS Selected Symposia Series, Boulder, CO. Westview Press.

Glockner-Ferrari, D. A. and M. J. Ferrari. 1985. Individual identification, behavior, reproduction and distribution of humpback whales *(Megaptera novaeangliae)* in Hawaii. Marine Mammal commission contract Report No. MMC-83/06. Accession No. PB85-200772 NTIS, Springfield, VA.

Glockner-Ferrari, D. A., and M. J. Ferrari. 1990. Reproduction in the humpback whale *(Megaptera novaeangliae)* in Hawaiian waters 1975-1988: The life history, reproductive rates and behavior of known individuals identified through surface and underwater photography. *In:* Individual Recognition of Cetaceans: Use of Photo-Identification and other Techniques to estimate population parameters. *Edited by* P. S. Hammond, S. A. Mizroch and G. P. Donovan. International Whaling Commission, Cambridge. pp. 161-170.

Green, M. L. and R. G. Green. 1990. The Impact of Parasail Boats on the Hawaiian Humpback Whale (*Megaptera novaeangliae*). Unpublished Manuscript.

Greene, C. R. Jr. 1991. Ambient Noise. Chapter 4, *In:* Effects of Noise on Marine Mammals. Report 90-0093. Prepared by LGL Ecological Research Associates under Contract No. 14-12-0001-30362 for the U.S. Department of Interior, Minerals Management Service, Herndon, VA.

Grigg, R. W. 1993. Precious coral fishes off Hawaii and U.S. Pacific Islands. Mar. Fish., Rev. 55(2):50-60.

Grigg, R. W. and S. J. Dollar. 1980. Environmental impact assessment of nearshore life at Princeville, Kauai. (App. H). 38 pp.

Haight, W. R., D. R. Kobayashi and K. B. Kawamoto. 1993. Biology and management of deepwater snapers of the Hawaiian Archipelago. Mar. Fish. Rev. 55(2):20-27.

Hall, J. D. 1982. Prince William Sound, Alaska: humpback whale population and vessel traffic study. Final Report, Contract No. 81-ABG-00265. NMFS, Juneau Management Office, Juneau, Alaska. 14 p.., 4 fig.

Hall, J. D. and C. S. Johnson. 1972. Auditory thresholds of a killer whale *(Orcinus orca)* Linnaeus. J. Acoust. Soc. Am. 51: 515-517.

Hamilton, P. K., G. S. Stone, and S. M. Martin. 1997. Note on a deep humpback whale (*Megaptera novaeangliae*) dive near Bermuda. Bulletin of Marine Science. 61:491-494.

Hamilton, P. M. 1957. Underwater Hearing Thresholds, J. Acoust. Soc. Am, 29:792-794.

den Hartog and Van Nierop. 1984. Committee on Low-Frequency Sound and Marine Mammals Ocean Studies.

HAS (Hawaii Audubon Society). 1978. Hawaii's Birds. Published by the Hawaiian Audubon Society, Honolulu, HI. 96 pp.

Hastings, M. C., A. N. Popper, J. J. Finneran, and P. J. Lanford. 1996. Effects of low-frequency underwater sound on hair cells of the inner ear and lateral line of the teleost fish *(Astronotus ocellatus)*. J. Acoust. Soc. Am. 99(3): 1759-1766.

Hawkins, A. D. and A. A. Myrberg, Jr. 1983. Hearing and sound communication under water. *In:* B. Lewis (ed.) Bioacoustics: A comparative approach. New York: Academic Press, pp. 347-405.

HDBED (Hawaii Department of Business and Economic Development). 1987. Mining Development Scenario for Cobalt-Rich Manganese Crusts in the Exclusive Economic Zones of the Hawaiian Archipelago and Johnston Island. Hawaii Department of Planning and Economic Development, Ocean Resources Branch and Minerals Management Service. Contribution No. 38.

Heacock, Don of Kauai DLNR Aquatic Resources. Personal Communication with Dr. Joseph Mobley, September 18, 2000.

Heindsman, T. E. R., R. H. Smith and A. D. Ameson. 1955. Effect of rain upon underwater noise levels. J. Acoust. Soc. Am. 27:378.

Herman, L. M. 1979. Humpback whales in Hawaiian waters: A study in historical ecology. Pacific Sci. 33(1):1-15.

Herman, L. M. and R. C. Antinoja. 1977. Humpback whales in Hawaiian waters: Population and pod characteristics. Sci. Rep. Whales Res. Inst. (Tokyo) 29:59-85.

Herman, L. M., C. S. Baker, P. H. Forestell and R. C. Antinoja. 1980. Right whale *Balaena glacialis* - sightings near Hawaii: a clue to the wintering grounds? 2:271-275.

Hirschorn, M. (ed.). 1982. IAC Noise Control Reference Handbook, Section F, et seq citing OSHA Noise Exposure Standards, 85dBA for hearing conservation programs and 90dBA for engineering noise controls. (Author note: 90dBA corresponds to heavy downtown traffic noise.)

Hobson, E. and E. H. Chave. 1990. Hawaiian reef animals. University of Hawaii Press, Honolulu, HI, 137 pp.

Hobson, E. S. 1974. Feeding relationships of teleostean fishes on coral reefs in Kona, Hawaii. Fish. Bull. 72:915-1031.

Hoelzel, A. R. and R. W. Osborne. 1986. Killer whale call characteristics: implications for cooperative foraging strategies. *In:* Kirkevold, B.C. and J.S. Lockard (eds.). Behavioral biology of killer whales.

Hollien, H., J. F. Brandt and C. Thompson. 1967. Underwater hearing thresholds in man. Communications Sciences Laboratory, Univ. of Florida, Report No. 3, April 1, 1967. (Also in J. Acoust. Soc. Am, 42:966-971, under Brandt and Hollien.)

HOMRC (Hawaii Ocean and Marine Resources Council). 1991. Hawaii Ocean Resources Management Plan. Technical Supplement.

Horwood, J. W. 1981. Results from the IWC/IDCR minke whale marking and sighting cruise 1979/80. Rep Int Whal Commn 31: 287-315.

Hoyt, E. 1981. The whale called killer.

Hwang, D. and C. Fletcher. 1992. Beach Management Plan with Beach Management Districts. Hawaii Coastal Zone Management Program, Office of State Planning. 29-44.

Irvine, A. B., M. D. Scott, R. S. Wells and J. H. Kaufmann. 1981. Movements and activities of the Atlantic bottlenose dolphin, *Tursiops truncatus*, near Sarasota, Florida. Fish. Bull. U.S. 79:671-688

Jefferson, T. A. and N. B. Barros. 1997. *Peponocephala electra.* Mammal Spec 553: 1-6

Jefferson, T. A., P. J. Stacey, and R. W. Baird. 1991. A review of killer whale interactions with other marine mammals: Predation to co-existence. Mammal Rev 21: 151-180.

Jefferson, T. A., S. Leatherwood, and M. A. Webber. 1993. FAO species identification guide. Marine mammals of the world.

Johanos, T. C. and T. J. Ragen. 1999. The Hawaiian Monk Seal in the Northwestern Hawaiian Islands, 1997. NOAA Technical Memorandum NMFS. NOAA-TM-NMFS-SWFSC-262.

Johnson, B. W. 1977. The effects of human disturbance on populations of harbor seals. p. 422-432. *In:* Environmental assessment of the Alaskan continental shelf. Annu. Rep. Princ. Invest. Vol. 1. U.S. Dep. Comm. NOAA/OCSEAP. NTIS PB-280934/1.

Johnson, C. S., M. W. McManus and D. Skaar. 1989. Masked tonal hearing thresholds in the beluga whale. J. Acoust. Soc. Am. 86(6):2651-2654.

Jones, M. L., S. L. Swartz and M. E. Dahlheim. 1994. Census of gray whale abundance in the San Ignacio Lagoon: A follow-up study in response to low whale counts recorded during an acoustic playback study of noise-effects on gray whales. Final Report, MMC Contract #MM2911023-0.

Jurasz, C. M. and V. P. Jurasz. 1979. Feeding modes of the humpback whale *(Megaptera novaeangliae)*, in Southeast Alaska. Sci. Rep. Whales Res. Inst. 31:69-83.

Juvik, S. P., and J. O. Juvik. 1998. Atlas of Hawaii. 3rd ed. University of Hawaii Press, Honolulu, HI. p. 333.

Kanwisher, J. W. and S. H. Ridgway 1986. The physiological ecology of whales and porpoises. Sci Am. No. 248:111-119.

Kasamatsu, F., S. Nishiwaki, and H. Ishiwaka. 1995. Breeding areas and southbound migrations of southern minke whales, *Balaenoptera acutorostrata*. Mar Ecol Prog Ser 119: 1-10.

Kastak, D., and R. J. Schusterman. 1998. Low-frequency amphibious hearing in pinnipeds: methods, measurements, noise, and ecology. J. Acoust. Soc. Am. 104(4), 2216-2228.

Kaufmanns, G. and K. Wood. 1981. Effects of boat traffic, air traffic, and military activity on Hawaiian humpback whales. P. 67 *In:* Abstracts of the 4th Biennial Conference on the Biology of Marine Mammals, December 1981, San Francisco, CA.

Kellog, R. 1931. Whaling statistics for the Pacific coast of North America. J. Mammal 12: 73-77.

Kelly, J. C. and D. R. Nelson. 1975. Hearing thresholds of the horn shark, *Heterodontus fancisci*. J. Acoust. Soc. Amer. 58:905-909.

Ketten, D. R. 1994. Overview marine mammal hearing potential for acoustic trauma. Statement to NMFS, Pa. concerning ATOC Marine Mammal Research Program Permit Request, Apr. 94.

Ketten, D. R. 1998. Marine mammal auditory systems: a summary of audiometric and anatomical data and its implications for underwater acoustic impacts. NOAA Technical Memorandum NMFS: NOAA-TM-NMFS-SWFSC-256.

Khil, J. 1978. Evolution of Sea Fishery Rights and Regulation in Hawaii and their Implications for Conservation. Preliminary Draft, Honolulu.

Kleerekoper, H and P. A. Rogenkamp. 1959. An experimental study of the effect of the swimbladder on hearing sensitivity in *Ameiurus nebulosus nebulosus* (LeSueur). Can. J. Zool. 37, 1-8.

Kleinenberg, S. E., A. V. Yablokov, B. M. Belkovich and M. N. Tarasevich. 1964. *Beluga* (Delphinapterus leucas): Investigation of the Species. Jerusalem: Israel Program for Scientific Translations. (First published in Russian, 1964.)

Klimley, A. P., and S. C. Beavers. 1998. Playback of acoustic thermometry of ocean climate (ATOC)-like signal to bony fishes to evaluate phonotaxis. Journal of the Acoustical Society of America. 104:2506-2510.

Konagaya, T. 1980. The sound field of Lake Biwa and the effects of construction sound on the behavior of fish. B. Jap. Soc. Sci. Fish. 46:129-132.

Krieger, K. J. and B. L. Wing. 1984. Hydroacoustic surveys and identification of humpback whale forage in Glacier Bay, Stephens Passage, and Frederick sound, southeastern Alaska, summer, 1983. NOAA Tech. Memo. NMFS F/NWC-66. 60 p.

Kruse, S. L. 1985. Movements of killer whales in Johnstone Strait, B.C. *In*: Abstr. 6th Bien. Conf. Biol. Mar. Mamm., Nov. 1985, Vancouver, B.C.

Lang, T. G. 1966. Hydrodynamic analysis of cetacean performance. *In:* Norris, K.S. (ed.). Whales, porpoises, and dolphins.

Leary, T. R. 1957. A Schooling of leatherback turtles, *Dermochelys coriacea*, on the Texas coast. Copeia 3:232.

Leatherwood, S. and R. R. Reeves. 1983. The Sierra Club handbook of whales and dolphins. San Francisco, Sierra Club Books.

Leatherwood, S., and R. R. Reeves. 1989. Aerial survey for false killer whales off Hawaii, June 1989. U.S. Marine Mammal Commission.

Leatherwood, S. L., D. K. Caldwell, and H. E. Winn. 1976. Whales, dolphins, and porpoises of the western North Atlantic: a guide to their identification. NOAA Technical Report, National Marine Fisheries Service, Circular 396.

Leatherwood, S., J. A. Thomas, and F. T. Awbrey. 1981. Minke whales off northwestern Ross Island. Antarct. J. 16: 154-156.

Leatherwood, S., B. S. Stewart and P. A. Folkens. 1987. Cetaceans of the Channel Islands National Marine Sanctuary: A status Report. National Marine Sanctuary Program, NOAA Channel Islands National Marine Sanctuary. 66 pp.

Leatherwood, S., R. R. Reeves, W. F. Perrin, and W. E. Evans. 1988. Whales, dolphins and porpoises of the eastern North Pacific and adjacent Arctic waters. Dover Publication, New York, NY. p. 245.

Lenfant, C. 1969. Physiological properties of blood of marine mammals. *In:* Andersen, H.T. (ed.). The biology of marine mammals.

Lenhardt, M. L. 1994. Brief presented at the 14th annual symposium on sea turtles biology and conservation, March 1-5, 1994 at Hilton Head Island, SC

Lenhardt, M. L., S. Bellmund, R. A. Byles, S. W. Harkins, and J. A. Musick. 1983. Marine turtle reception of bone-conducted sound. Virginia Inst. of Mar. Sci. and Medical College of Virginia.

Lockyer, C. 1981. Growth and energy budgets of large baleen whales from the Southern Hemisphere. Mammals in the Seas. Vol. 3. Food and Agricultural Organization Fisheries Series 5: 379-487.

Lockyer, C. 1984. Review of baleen whale (Mysticeti) reproduction and implications for management. Rep. Int. Whal. Comm., Spec Issue 6: 27-50.

Love, M. S. 1991. Probably more than you want to know about fishes of the Pacific coast. Really Big Press. Santa Barbara, CA. 215 pp.

Lowe, C. G., B. M. Wetherbee, G. L. Crow, and L. Albert. 1996. Ontogenetic dietary shifts and feeding behavior of the tiger shark, Galeocerdo cuvier, in Hawaiian waters. Environmental Biology of Fishes 47: 203-211.

MacArthur, R. A., R. H. Johnson and V. Geist. 1979. Factors influencing heart rate in free-ranging bighorn sheep: A physiological approach to the study of wildlife harassment. Ca. J. Zool. 57(10):2010-2021.

MacDonald, C. D. and H. E. Deese. 1994. The Economic Potential of Hawaii's Ocean Industries. *In:* MTS '94 Proceedings, September 7-9, 1994. Marine Technology Society, Washington, D.C.

McDonald, M. A., J. A. Hildebrand, and S. C. Webb. 1995. Blue and fin whales observed on a seafloor array in the northeast Pacific. J. Acoust. Soc. Am. 98: 712-721.

Macfarlane, J. A. F. 1981. Reactions of whales to boat traffic in the area of the confluence of the Saguenay and St. Lawrence Rivers, Quebec. Inpubl. MS. 50 p.

Mackintosh, N. A. 1965. The stocks of whales.

Mackintosh, N. A. and J. F. G. Wheeler. 1929. Southern blue and fin whales. Disc Rep 1: 257-540.

Malme, C. I., P. R. Miles, C. W. Clark, P. Tyack, and J. E. Bird. 1983. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior/Phase I. BBN Rep. 563. Rep. from Bolt, Beranek, & Newman, Inc. Cambridge, MA, for U.S. Minerals Management Serv., Anchorage, AK. Var. pag. NTIS PB 86-174174.

Malme, C. I., P. R. Miles, C. W. Clark, P. Tyack, and J. E. Bird. 1984. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior/Phase II: January 1984 migration. BBN Rep. 586. Rep. from Bolt, Beranek, & Newman, Inc. Cambridge, MA, for U.S. Minerals Management Serv., Anchorage, AK. Var. pag. NTIS PB 86-218377.

Malme, C. I., P. R. Miles, G. W. Miller, W. J. Richardson, D. G. Roseneau, D. H. Thomson and C. R. Greene, Jr. 1989. Analysis and ranking of the acoustic disturbance potential of petroleum industry activities and other sources of noise in the environment of marine mammals in Alaska. BBN Rep. 6945; OCS Study MMS 89-0006. Rep. from BBN Systems & Technol. Corp., Cambridge, MA, for U.S. Minerals Manage. Serv., Anchorage, AK. Var. pag. NTIS PB90-188673.

Maniwa, Y. 1971. Effects of vessel noise in purse seining. *In:* Kristjonnson, H. (ed.). Modern fishing gear of the world.

Markussen, N. H., M. Ryg, and C. Lydersen. 1992. Food consumption of the NE Atlantic minke whale (*Balaenoptera acutorostrata*) population estimated with a simulation model. ICES J. Mar. Sci. 49: 317-323.

Marquez, M. R. 1990. FAO Species Catalog. Vol. 11 Sea Turtles of the World. An annotated and illustrated catalogue of sea turtle species known to date. FAO Fisheries Synopsis. No. 125, Vol. 11. Rome, FAO. 81 p.

Masaki, Y. 1977. The separation of the stock units of sei whales in the North Pacific. Rep. Int. Whal. Commn. Special Issue 1: 71-79.

Maser, C., B. R. Mate, J. F. Franklin, and C. T. Dyrness. 1981. Natural history of Oregon coast mammals. US Department of Agriculture, For. Ser. Gen. Tech. Rep. PNW-133, Portland, OR.

Mate, B. R., S. L. Nieukirk, and S. D. Kraus. 1997. Satellite-monitored movements of the northern right whale. J. Wildl Manage 61: 1393-1405.

Mate, B. R., S. L. Nieukirk, R. S. Mesecar, and T. J. Martin. 1992. Application of remote sensing for tracking large cetaceans: Atlantic right whales. Report Contract No. 14-12-0001-30411, U.S. Minerals Management Service.

Matsuura, Y. 1943. Kaiju [marine mammals] tennensha, Tokyo.

Mayo, C. A. and M. K. Marx. 1990. Surface foraging behavior of the North Atlantic right whale, *Eubalaena glacialis*, and associated zooplankton characteristics. Can. J. Zool. 68(10):2214-2220.

Mead, J.G. 1989. Beaked whales of the genus *Mesoplodon*. pp 349-430. *In:* S.H. Ridgway and R. Harrison (eds.), Handbook of marine mammals, Vol. 4. Academic Press Ltd.

Meller, N. 1985. Indigenous Ocean Rights in Hawaii. Honolulu: Sea Grant College Program. UNIHI-SEAGRANT-MP-86-01.

Mellinger, D. K. and C. W. Clark. 1997. Methods for automatic detection of mysticete sounds. Mar. Freshwater Behav. Physiol. 29:163-181.

Meredith, G. N. and R. R. Campbell. 1988. Status of the fin whale, *Balaenoptera physalus*, in Canada. Can Field-Nat 102: 351-368.

Meylan, A. B. 1988. Spongivory in hawksbill turtles: A diet of glass. Science, 239:393-395.

Millais, J. G. 1906. The mammals of Great Britain and Ireland. Vol. III.

Miller, P. J. O., N. Biassoni, A. Samuels, and P. L. Tyack. 2000. Whale songs lengthen in response to sonar. Nature 405: 903.

Mitchell, E. D. (ed.). 1975. Review of biology and fisheries for smaller cetaceans. Report of the meeting on smaller cetaceans in Montreal, April 1-11, 1974. J. Fish Res Bd Can 32: 889-983.

Mitchell, E. D. and L. Ghanimé. 1982. Evidence of whale-vessel interaction - north shore of the St. Lawrence Estuary. p. 3-1 to 3-32 *In:* Analysis of whale observations from the St. Lawrence Estuary. Rep. from André Marsan & Assoc. for Can. Dep. Fish. Oceans, Arctic Pilot Proj., and Can. Dep. Supply Serv.

MMC (Marine Mammal Commission). 1999. Annual Report to Congress: Calendar Year 1998. Marine Mammal Commission.

MMS (Minerals Management Service). 1987. Proposed Marine Mineral Lease Sale in the Hawaiian Archipelago and Johnston Island Exclusive Economic Zones. Draft Environmental Impact Statement. Minerals Management Service and Hawaii Department of Planning and Economic Development. Honolulu, HI.

Mobley, J. R., P. H. Forestell and R. Grotefendt. 1994. Results of 1993 aerial surveys in Hawaiian waters. 1993 ATOC Marine Mammal Research Program: Annual report to Advanced Research Projects Agency.

Mobley, J. R., M. Smultea, T. Norris and D. Weller. 1996. Fin whale sighting north of Kauai, Hawaii. Pac. Sci. **50**: 230-233.

Mobley, J. R., G. B. Bauer and L. M. Herman. 1999a. Changes over a ten-year interval in the distribution and relative abundance of humpback whales (*Megaptera novaeangliae*) wintering in Hawaiian waters. Aq. Mamm. 25: 63-72.

Mobley, J. R., R. A. Grotefendt, P. H. Forestell, and A. S. Frankel. 1999b. Results of Aerial Surveys of Marine Mammals in the Major Hawaiian Islands (1993-1998): Report to the

Acoustic Thermometry of Ocean Climate Marine Mammal Research Program (ATOC MMRP). Cornell University Bioacoustics Research Program, Ithaca, NY

Mobley, J. R., R. A. Grotefendt, P. H. Forestell, S. S. Spitz, E. Brown, G. B. Bauer, and A. S. Frankel. 1999c. Population estimate for Hawaiian humpback whales: results of 1993-198 aerial surveys. 13th Biennial Conf. on Biol. of Mar. Mam., Wailea, Hawaii. Nov 28 – Dec 3, 1999.

Mobley, Dr. Joseph of University of Hawaii. Personal Communication with Ms. Kathleen Vigness Raposa, September 14, 2000.

Morreale, S. J., E. A. Standora and F. V. Paladino. 1993. Leatherback migrations along deepwater bathymetric contours. *In:* B.A. Schroeder and B.E. Witherington Compilers, Proceedings of the thirteenth annual symposium on sea turtle biology and conservation. NOAA Tech. Memo. NMFS-SEFSC-341, 281 pp.; 1994, 0. 109-110.

Mortimer, J. A. 1981. Feeding ecology of sea turtles. *In:* Biology and conservation of sea turtles. K. A. Bjorndal (ed.). Smithsonian Inst. Press, Washington, DC., p. 103-109.

Moyle, P. B. and J. J. Cech Jr. 1988. Fishes, an Introduction to Ichthyology. Prentice Hall, Englewood Cliffs, NJ. 559 pp.

~~Myers, J. J., C. H. Holm and R. F. McAllister. 1969. Handbook of Ocean and Underwater Engineering. Prepared under the auspices North American Rockwell Corporation. McGraw-Hill Book Co., NY.~~

Myrberg, A. A., 1978. Underwater sound - its effect on the behavior of sharks. *In:* Sensory biology of sharks, skates and rays. E.S. Hodgeson, R.F. Mathewson (eds.), U.S. Government Printing Office, Washington DC., pp. 391-417.

Myrberg, A. A. 1981. Sound communication and interception in fishes. *In:* Hearing and sound communication in fishes, Tavolga, W.N., Popper, A.N. and Fay, R.R. (eds.), Springer-Verlag, New York. pp. 395-425.

Myrberg, A. A. Jr., S. J. Ha, S. Walewski and J. C. Banbury. 1972. Effectiveness of acoustic signals in attracting epipelagic sharks to an underwater sound source. Bull. Mar. Sci., 22:926-949.

Myrberg, A. A., C. R. Godron and A. P. Klimley, 1976. Attraction of free ranging sharks by low frequency sound, with comments on its biological significance. *In:* Sound reception in fish. A. Schuiif, A.D. Hawkins (eds.), Elsevier, Amsterdam, pp. 205-228.

National Research Council (NRC). 1994. Low-Frequency Sound and Marine Mammals: Current Knowledge and Research Needs. National Academy Press. Washington, D.C.

National Research Council (NRC). 1996. Marine Mammals and Low-Frequency Sound: Progress Since 1994 – An Interim Report. National Academy Press. Washington, D.C.

National Research Council (NRC). 2000. Marine Mammals and Low-Frequency Sound: Progress Since 1994. National Academy Press. Washington, D.C.

Natural Resources Defense Council (NRDC). 1994. The sound and the fury: The controversy over ocean noise pollution. The Amicus Jour., Fall 1994. p. 19-23.

Natural Resources Defense Council (NRDC). 1999. Sounding the depths: supertankers, sonar, and the rise of undersea noise. Natural Resources Defense Council. NRDC Publications Dept., 40 West 20th St., New York, NY.

Nature Conservancy Council. 1979. Proposals concerning the cetacea.

Nelson, D. R. 1967. Hearing thresholds, frequency discrimination and acoustic orientation in the lemon shark, *Negaprion brevirostris,* (Poey). *Bill. Mar. Sci.* 17:741-768.

Nelson, D. R. and R. H. Johnson. 1970. Acoustic studies on sharks. Rangiroa Atoll, July, 1969. Tech Rpt. 2, ONR, No. N00014-68-C-0318. 15 pp.

Nelson, D. R. and R. H. Johnson. 1972. Acoustic attraction of Pacific reef sharks: Effect of pulse intermittency and variability. Comp. Biochem. Physiol., 42:85-95.

Nelson, D. R. and R. H. Johnson. 1976. Some recent observations on acoustic attraction of Pacific reef sharks. *In:* sound reception in fish, A. Schuiif and A. D. Hawkins (eds.). Elsevier, Amsterdam,. pp. 229-239.

Nemoto, T. and A. Kawamura. 1977. Characteristics and food habits and distribution of baleen whales with special reference to the abundance of North Pacific sei and Bryde's whales. Rep. Int. Whal. Comm., Spec. Issue 1: 80-87.

Nishiwaki, M. 1952. On the age determination of Mystacoceti, chiefly blue and fin whales. Sci Rep. Whales Res. Inst. 7: 87-119.

Nishiwaki, M. 1972. General biology. *In:* Ridgway, S.H. (ed.). Mammals of the sea: Biology and medicine.

NMFS (National Marine Fisheries Service). 1991. Status of the Pacific oceanic living marine resources of interest to the USA for 1991. NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-165.

NMFS. 1992. Interim recovery plan for Hawaiian sea turtles. Prepared by the Hawaiian Sea Turtle Recovery Team. National Marine Fisheries Service, Honolulu Laboratory. NMFS Admin. Rep. H-92-01.

NMFS/SWFSC (Southwest Fisheries Science Center). 1993. Research plan to assess marine turtle hooking mortality: G.H. Balazs and S.G. Pooley, eds. Results of an expert workshop held in Honolulu, HI. November 16-18, 1993. National Marine Fisheries Service, Honolulu Laboratory. NMFS Admin. Rep. H-93-18.

NMFS and USFWS (U.S. Fish and Wildlife Service). 1998a. Recovery Plan for U.S. Pacific Populations of the Green Turtle (Chelonia mydas). National Marine Fisheries Service. Silver Spring, MD.

NMFS and USFWS. 1998b. Recovery Plan for U.S. Pacific Populations of the Hawksbill Turtle (*Eretmochelys imbricata*). National Marine Fisheries Service. Silver Spring, MD.

NMFS and USFWS. 1998c. Recovery Plan for U.S. Pacific Populations of the Leatherback Turtle (*Dermochelys coriacea*). National Marine Fisheries Service, Silver Spring, MD,

NMFS and USFWS. 1998d. Recovery Plan for U.S. Pacific Populations of the Loggerhead Turtle (*Caretta caretta*). National Marine Fisheries Service, Silver Spring, MD.

Norris, K. S., B. Würsig, and R. S. Wells. 1994. The Spinner Dolphin. *In:* The Hawaiian Spinner Dolphin. *Edited by* K. S. Norris, B. Würsig, R. S. Wells and M. Würsig. Univ. Calif. Press, Berkeley. pp. 14-30.

Norris, K. S. and J. H. Prescott. 1961. Observations on Pacific cetaceans of Californian and Mexican waters. Univ Calif Publ Zool 63(4): 291-402.

Norris, K. S., B. Würsig, R. S. Wells, and M. Würsig. 1994. The Hawaiian spinner dolphin.

Offutt, G. C. 1970. Acoustic stimulus perception by the American lobster *(Homarus Americanus)* (Decapoda). Experientia 26:1276-1278.

O'Hara, J. and J. R. Wilcox, 1990. Avoidance responses to loggerhead turtles, Caretta caretta, to low frequency sound. Amer. Soc. of Ichthyologists and Herpetologists. p. 564-567.

Ohsumi, S. 1978. Bryde's whales in the North Pacific in 1976. Rep Int Whal Commn 28: 277-287.

Omura, H. 1958. North Pacific right whale. Sci. Rep. Whales Res. Inst. 13: 1-52.

Omura, H. 1959. Bryde's whales from the coast of Japan. Sci. Rep. Whales Res. Inst. 14: 1-33.

Omura, H., S. Ohsumi, T. Nemoto, K. Nasu, and T. Kasuya. 1969. Black right whales in the North Pacific. Sci. Rep. Whales Res. Inst. 21: 1-78.

OPNAVINST 5090.1B. 1994. Environmental and Natural Resources Program Manual. Department of the Navy, Chief of Naval Operations (N45), Washington, DC. 1 Nov 94.

Osborn, L. S. 1985. Population dynamics, behavior, and the effect of disturbance on haulout patterns of the harbor seal *Phoca vitulina richardsi* elkhorn Slough, Monterey Bay, CA. B.A. thesis, Depts. Envir. Stud. & Biol., Inuv. Calif., Santa Cruz. 75 p.

Papastavrou, V., S. C. Smith and H. Whitehead. 1989. Diving behavior of the sperm whale, *Physeter macrocephalus*, off the Galapagos Islands. Can. J. Zool. 67(4):839-846.

Parrish, F. A., M. P. Craig, T. J. Ragen, G. J. Marshall, and B. M. Buhleier. 2000. *Identifying diurnal foraging habitat of endangered Hawaiian monk seals using a seal-mounted video camera. Marine Mammal Science.* 16(2): 392-412.

Patterson, B. and G. R. Hamilton. 1964. Repetitive 20 cycle per second biological hydroacoustic signals at Bermuda. *In:* Tavolga, W.N. (ed.) Marine bioacoustics.

Payne, R. and D. Webb. 1971. Orientation by means of long range acoustic signaling in baleen whales. Ann. N.Y. Acad. Sci. 188:0110-141.

Perry, S. L., D. P. DeMaster, G. K. Silber. 1999. The Great Whales: History and status of six species listed as endangered under the U.S. Endangered Species Act of 1973. Marine Fisheries Review 61(1): 1-73.

Pham, T. D. 1991. Hawaii Department of Business, Economic Development, and Tourism.

Piatt, J. F. and D. A. Methven. 1992. Threshold foraging behavior of baleen whales. Mar. Ecol. Prog. Ser. 84:205-210.

Piatt, J. F., D. A. Methven, A. E. Burger, R. L. McLagan, V. Mercer and E. Creelman. 1989. Baleen whales and their prey in a coastal environment. Can. J. Zool. 67:1523-1530.

Pickard, G. L. and W. J. Emery. 1982. Descriptive physical oceanography, an introduction. Pergamon Press. 249 pp.

Pike, G. C. 1953. Two records of *Berardius bairdii* from the coast of British Columbia. J Mammal 34: 98-104.

Pitman, R. L. 1990. Pelagic distribution and biology of sea turtles in the Eastern Tropical Pacific, p. 143-148. *In:* Richardson, T. H., J. I. Richardson, and M. Donnelly (compilers). Proc. Tenth An. Workshop on Sea Turtle Bio. and Conserv. U.S. Dep. Commer., NOAA Tech Memo NMFS-SEFC-278.

Pitman, R. L. 1993. Sea turtle associations with flotsam in the eastern Pacific Ocean. *In:* M. Salmo and J. Wyneken (compilers). Proceedings of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFC-302; 1992, p. 94.

Poggendorf, D. 1952. Die absoluten Hörschwellen des Zwergwelses *(Amiurus nebulosus)* und Bieträge zur Physik des Weberschen Apparatus der Ostariophysen. Z verg Physiol 34:222-257.

Polocheck, T. and L. Thorpe. 1990. The swimming direction of harbor porpoise in relationship to a survey vessel. Rep. Int. Whal. Comm. 40:463-470.

Pooley, S. G. 1993. Hawaii's marine fisheries: some history, long-term trends, and recent developments. Mar. Fish. Rev. 55(2):7-19.

Popper, A. N. 1974. The response of the swimbladder of the goldfish (*Carassius auratus*) to acoustic stimuli. J. Exp. Biol. 60:295-304.

Popper, A. N. 1983. Organization of the inner ear and auditory processing. *In:* R. G. Northcutt and R. E. Davis (eds.). Fish Neurobiology, Vol. I: Brain stem and sense organs. Univ. of Michigan Press., Ann Arbor, pp. 125-178.

Popper, A. N. and S. Coombs. 1982. The morphology and evolution of the ear in actinopterygian fishes. Amer. Zool. 22:311-328.

Popper, A. N. and R. R. Fay. 1973. Sound detection and processing by teleost fishes, a critical review. J. Acoust. Soc. Amer. 53:1515-1529.

Popper, A. N. and R. R. Fay. 1977. Structure and function of the elasmobranch auditory system. Amer. Zool. 17:443-452.

Popper, A. N. and R. R. Fay. 1993. Sound detection and processing by fish: critical review and major research questions. Brain. Behav. Evol. 41:14-38.

Pritchard, P. C. H. 1976. Post-nesting movements of marine turtles (Cheloniidae and Dermochelyidae) tagged in the Guianas. Copeia 4:749-754.

Ray, G. C., E. Mitchell, D. Wartzok, V. Koxicki, and R. Maiefski. 1978. Radio tracking of a fin whale (*Balaenoptera physalus*). Science 202: 521-524.

Reeves, R. R. 1977. The problem of gray whale (*Eschrichtius robustus*) harassment at the breeding lagoons and during migration. U.S. Mar. Mamm. Comm. Rep. MMC-76/06. 60 p. NTIS PB 272506.

Reeves, R. R., B. S. Stewart, and S. Leatherwood. 1992. The Sierra Club handbook of seals and sirenians.

Reilly, S. B. and V. G. Thayer. 1990. Blue whale (*Balaenoptera musculus*) distribution in the eastern tropical Pacific. Mar Mamm Sci 6: 265-277.

Reynolds, J. E., III. 1985. Evaluation of the nature and magnitude of interactions between bottlenose dolphins, *Tursiops truncatus*, and fisheries and other human activities in coastal areas of the southeastern United States. MMC-84/07. Rep. from Eckerd College, St. Petersburg, FL, for U.S. Mar. Mamm. Comm., Washington, DC. 38 p. NTIS PB86-162203.

Rice, D. W. 1960. Population dynamics of the Hawaiian monk seal. Jour. of Mammal. 41:376-385.

Rice, D. W. 1977. Synopsis of biological data on the sei whale and Bryde's whale in the eastern North Pacific. Rep. Int. Whal. Commn. Special Issue 1: 92-97.

Rice, D. W. 1978. Blue whale. *In:* Haley, D. (ed.) Marine mammals of the Eastern North Pacific and Arctic waters.

Rice, D. W. 1989. Sperm whale, *Physeter macrocephalus* (Linneaus, 1758). *In:* Ridgway, S.H. and R. Harrison (eds.). Handbook of marine mammals. Vol. 4. River dolphins and the larger toothed whales.

Richardson, W. J., B. Würsig and C. R. Greene, Jr. 1986. Reactions of bowhead whales, *Balaena mysticetus*, to seismic exploration in the Canadian Beaufort Sea. J. Acoust. Soc. Am. 79(4):1117-1128.

Richardson, W. J., B. Wursig and C. R. Greene, Jr. 1990. Reactions of bowhead whales, *Balaena mysticetus*, to drilling and dredging noise in the Canadian Beaufort Sea. Mar. Envir. Res. 29(2):135-160.

Richardson, W. J., C. R. Greene, Jr., C. I. Malme and D. H. Thompson. 1991. Effects of noise on marine mammals. OCS Study MMS-90-0093; LGL Rep. TA834-1. Rep. from LGL Ecol. Res. Assoc., Inc., Bruan, TX, for U.S. Minerals Manage. Serv., Atlantic OCS Reg., Herndon, VA 462 p. NTIS PB91-168914.

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

Ridgway, S. H. 1986. Diving by cetaceans. *In:* Brubakk, A.O., J.W. Kanwisher, and G. Sundnes (eds.). Diving in animals and man.

Ridgway, S. H., E. G. Wever, J. G. McCormick, J. Palin and J. H. Anderson. 1969. Hearing in the giant sea turtles. J. Acoust. Soc. Am., 59, Suppl. 1. S46.

Ridgway, S. H., D. A. Carder, R. R. Smith, T. Kamolnick, C. E. Schlundt, and W. R. Elsberry. 1997. Behavioral responses and temporary shift in masked hearing threshold of bottlenose dolphins, *Tursiops truncatus*, to 1-second tones of 141 to 201 dB re 1 μPa. Technical Report 1751, July 1997. Naval Command, Control and Ocean Surveillance Center, RDT&E Division, San Diego, CA.

Rivers, J. A. 1997. Blue whale, *Balaenoptera musculus*, vocalizations from the waters off central California. Mar. Mamm. Sci. 13: 186-195.

Russell, J. A. 1966. The adrenals. p 1121-1146 *In*: T. C. Ruch and H. D. Patton (eds.). Physiology and biophysics. W.B. Saunders, Philadelphia, PA. 1242 p.

St. Aubin, D. J. and J. R. Geraci. 1988. Capture and handling stress suppresses circulating levels of thyroxine (T4) and Triiodothyronine (T3) in beluga whales *Delphinapterus leucas*. Physiol. Zool. 61(2):170-175.

Salden, D. R. 1987. An observation of apparent feeding by a sub-adult humpback whale off Maui. Eighth Biennial Conference on the Biology of Marine Mammals. Pacific Grove, CA. p. 58.

Salden, D. R. 1988. Humpback whale encounter rates offshore of Maui, Hawaii. J. Wildl. Manage. **52**: 301-304.

Salter, R. E. 1979. Site utilization, activity budgets, and disturbance responses of Atlantic walruses during terrestrial haul-out. Can. J. Zool., 57:1169-80.

Sand, O. and A. D. Hawkins. 1973. Acoustic properties of the cod swimbladder. J. Exp. Biol. 58: 797-820.

Sand, O. and P. S. Enger. 1973. Evidence for an auditory function of the swimbladder in the cod. J. Exp. Biol., 59:405-414.

Santoro, A. K., K. L. Marten, and T. W. Cranford. 1989. Pygmy sperm whale sounds (*Kogia breviceps*). Abstracts of the 8th Biennial Conference on the Biology of Marine Mammals, Pacific Grove, USA. December 1989.

Sauer, E. G. F. 1963. Courtship and copulation of the gray whale in the Bering Sea at St. Lawrence Island, Alaska. Psychol. Forsch. 27:157-174.

Schellart, N. A. M. and A. N. Popper. 1992. Functional aspects of the evolution of the auditory system of actinopterygian fish. *In:* Comparative evolutionary biology of hearing (ed. by D.B. Webster, R.R. Fay and A. N. Popper. Springer, NY pp. 295-322.

Schevill, W. E. and W. A. Watkins. 1966. Sound structure and directionality in Orcinus (killer whale). Zoologica 51: 71-76.

Schevill, W. E. and W. A. Watkins. 1972. Intense low-frequency sounds from an Antarctic minke whale, *Balaenoptera acutorostrata*. Breviora 388: 1-8.

Schlundt, C. E., J. J. Finneran, D. A. Carder, S. H. Ridgway. 2000. Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whale, *Delphinapterus leucas*, after exposure to intense tones. J. Acoust. Soc. Am. 107(6): 3496-3508.

Scott, T. M., and Sadove, S. S. 1997. Sperm Whale, *Physeter macrocephalus*, sightings in the shallow shelf waters off Long Island, New York. Mar. Mamm. Sci. **13**: 317-320.

Selye, H. 1973. The evolution of the stress concept. Am Sci. 61:692-699.

Sergeant, D. E. 1977. Stocks of fin whales, *Balaenoptera physalus,* in the North Atlantic Ocean. Rep. Int. Whal. Comm. 27: 460-473.

Shallenberger, E. E. 1978. Activities possibly affecting the welfare of humpback whales. p. 81-85 *In*: K.S. Norris and R.R. Reeves (eds.), Report on a workshop on problems related to humpback whales (*Megaptera novaeangliae)* in Hawaii. Rep. from Sea Life Inc., Makapuu Pt., HI, for U.S. Mar. Mamm. Comm., Washington, DC MMC-77/03. 90 p. NTIS PB-280794.

Shallenberger, E. W. 1981. The status of Hawaiian cetaceans. U.S. Department of Commerce. NTIS Report MMC-YY 23.

Shane, S. H. 1980. Occurrence, movements and distribution of bottlenose dolphins, *Tursiops truncatus*, in southern Texas. Fish. Bull., U.S., 78:593-601.

Shane, S. H., R. S. Wells and B. Würsig. 1986. Ecology, behavior and social organization of the bottlenose dolphin: A review. Mar. Mamm. Sci. 2(1):34-63.

Silber, G. K. 1986. The relationship of social vocalizations to surface behavior and aggression in the Hawaiian humpback whale (*Megaptera novaeangliae*). Can. J. Zool. 64:2075-2080.

Silber, G. K., M. W. Newcomer and G. J. Barros. 1988. Observations on the behavior and ventilation cycles of the vaquita, *Phocoena sinus*. Mar. Mamm. Sci. 4(1):62-67.

Slijper, E. J. 1962. Whales. Hutchinson & Co., London. 511 p.

Smith, M. K. 1993. An ecological perspective on inshore fisheries in the main Hawaiian Islands. Mar. Fish. Rev. 55(2):34-49.

Smith, P. F. 1965. Bone conduction, air conduction, and underwater hearing. U.S. Naval Submarine Medical Center, Memorandum Report No. 65-12, 8 Oct. 65.

Smultea, M. A. 1989. Habitat utilization patterns of humpback whales off West Hawaii. Report to the Marine Mammal Commission, Contract No. T6223925-9.

Smultea, M. A., T. R. Kieckhfer and A. S. Frankel. 1994. ATOC-MMRP shorebased observation of humpback whales and other marine mammals and sea turtles: A preliminary draft report.

Spero, D. 1981. Vocalizations and associated behavior of northern right whales *Eubalaena glacialis*. Abstracts of the 4th Biennial Conference on the Biology of Marine Mammals, San Francisco, CA, December 1981.

SSI (Seafloor Surveys International, Inc.). 1993. Cable route selection survey for the Acoustic Thermometry of Ocean Climate (ATOC) California Site. Final Report. Prepared by Applied Physics Laboratory, Univ. of Washington. Seattle, WA. 17 pp.

Steiner, W. W., J. H. Hain, H. E. Winn, and P. J. Perkins. 1979. Vocalizations and feeding behavior of the killer whale (*Orcinus orca*). J. Mammal. 60(4): 823-827.

Strong, C. S. 1990. Ventilation patterns and behavior of balaenopterid whales in the Gulf of California, Mexico. MS thesis, San Francisco State University, CA.

Sunset Book. 1975. Hawaii: A guide to all the islands. Sunset Books and Magazines. Lane Publishing Co., Menlo Park, CA

Szymanski, M. D., D. E. Bain, K. Kiehl, S. Pennington, S. Wong, and K. R. Henry. 1999. Killer whale (*Orcinus orca*) hearing: Auditory brainstem response and behavioral audiograms. J. Acoust. Soc. Am. 106(2): 1134-1141.

Tavolga, W. N. 1967. Masked auditory thresholds in teleost fishes. *In:* Marine Bio-Acoustics, edited by W.N. Tavolga, Pergamon Press, Oxford, England, Vol. 2, pp. 233-245.

Taylor, L. 1993. Sharks of Hawaii: Their biology and cultural significance. University of Hawaii Press, Honolulu, HI. 126 pp.

Tershy, B. R. 1992. Body size, diet, habitat use and social behavior in *Balaenoptera* whales. J. Mammal 73: 477-486.

Tershy, B. R., D. Breese, and C. Strong. 1990. Abundance, seasonal distribution, and population composition of balaenopterid whales in the Canal de Ballenas, Gulf of California, Mexico. Rep. Int. Whal. Comm., Spec. Issue 12: 369-375.

Tershy, B. R., G. A. Acevedo, D. Breese, and C. S. Strong. 1993. Diet and feeding behavior of fin and Bryde's whales in the central Gulf of California, Mexico. Rev Inv Cient 1 (No Esp SOMEMMA 1): 31-38.

Thomas, J. A., S. Leatherwood, W. E. Evans, J. R. Jehl, and F. Awbrey. 1981. Ross Sea killer whale distribution, behavior, color pattern, and vocalizations. Antarctic J. US 15: 157-158.

Thomas, J. A., P. W. B. Moore, P. E. Nachtigall, and W. G. Gilmartin. 1990. A new sound from a stranded pygmy sperm whale. Aquat. Mamm. 16: 28-30.

Thomas, J. A., R. A. Kastelein and F. T. Awbrey. 1990. Behavior and blood catecholamines of captive belugas during playbacks of noise from an oil drilling platform. Zoo Biol. 9(5):393-402.

Thomas, J., P. Moore, R. Withrow, and M. Stoermer. 1990. Underwater audiogram for a Hawaiian monk seal (Monachus schauinslandi). J. Acoust. Soc. Am. 87(1): 417-420.

Thompson, P. O. and W. A. Friedl. 1982. A long term study of low frequency sounds from several species of whales off Oahu, Hawaii. Cetology 45: 1-19.

Thompson T. J., H. E. Winn, and P. J. Perkins. 1979. Mysticete sounds. *In:* Winn, H. E. and B. L. Olla (eds.). Behavior of Marine Animals. Vol. 3. Cetaceans.

Thompson, P. O., W. C. Cummings and S. J. Ha. 1986. Sounds, source levels, and associated behavior of humpback whales, Southeast Alaska. J. Acoust. Soc. Am. 80(3):735-740.

Thompson, P. O., L. T. Findley, and O. Vidal. 1992. 20-Hz pulses and other vocalizations of fin whales, *Balaenoptera physalus*, in the Gulf of California, Mexico. J. Acoust. Soc. Am. 92: 3051-3057.

Thomson, C. A. and J. R. Geraci. 1986. Cortisol, aldosterone, and leucocytes in the stress response of bottlenose dolphins, *Tursiops truncatus*. Can. J. Fish. Sci. 43(5):1010-1016

Tillman, M. F. 1977. Estimates of population size for the North Pacific sei whale. Rep. Int. Whal. Commn. Special Issue 1: 98-106.

Tinney, R. T. 1988. Review of information bearing upon the conservation and protection of humpback whales in Hawaii. Rep. for U.S. Mar. Mamm. Comm., Washington, DC 56 p. NTIS PB88-195359.

Tomich, P. Q. 1986. Mammals in Hawaii. A synopsis and notational bibliography. Second edition. Bishop Mus. Press, Honolulu, HI. 375 pp.

Tomilin, A. G. 1957. Cetacea. *In:* Heptner, V.G. (ed.). Mammals of the USSR and adjacent countries. Vol. 9. Israel Program for Scientific Translations, Jerusalem, 1967.

Townsend, R. T. 1991. Conservation and protection of humpback whales in Hawaii: an update. Marine Mammal Commission Contract #T75132495.

Turner, C. D. 1965. General endocrinology, 4th ed. W.B. Saunders, Philadelphia, PA 579 p.

Tyack, P. 1993. Reactions of bottlenose dolphins, *Tursiops truncatus*, and migrating gray whales, *Eschrichtius robustus*, to experimental playback of low frequency manmade noise. Invited paper for Acous. Soc. Amer. special session on "Effects of Noise on Marine Mammals". Acous. Soc. Amer., Denver, CO, 6 Oct. 93.

U.S. Army Corps of Engineers (USCOE). 1989. Proposed maintenance dredging: Public Notice PODCO MD-90, December 1, 1989.

U.S. Army Corps of Engineers (USCOE). 1991. Waterborne Commerce of the U.S. Calendar Year 1989. Part 4.

U.S. Department of Commerce, National Oceanographic and Atmospheric Administration, National Marine Fisheries Service. 1983. Marine Mammal Protection Act of 1972. Annual Report 1982-1983. Washington, DC.

U.S. Department of Commerce. 1983. Draft management plan and environmental impact statement for the proposed Hawaii Humpback Whale National Marine Sanctuary. NOAA, Office of Ocean and Coastal Resource management, Sanctuary Programs Division, and Hawaii Department of Planning and Economic Development, Washington, DC.

U.S. Department of Commerce. 1986. Final environmental impact statement proposed designation of critical habitat for the Hawaiian monk seal in the northwestern Hawaiian Islands. Terminal Island, CA: National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Urick, R. J. 1983. Principles of underwater sound, 3rd ed. McGraw-Hill, New York. 423 p.

USFWS and NMFS. 1998. Consultation Handbook: Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act (Final). U. S. Fish and Wildlife Service and National Marine Fisheries Service. March, 1998. Whales off the North Shore of Kauai. In prep.

USFWS. 1984. Endangered species bulletin. Vol. 9, No. 4.

Utech, D. 1999. Valuing Hawaii's Humpback Whales: The economic impact of humpbacks on Hawaii's ocean tour boat industry. Report prepared for the Hawaiian Islands Humpback Whale National Marine Sanctuary. 36 pp.

Von Frisch, K. 1938. The sense of hearing in fish. Nature, 141:8-11.

Wade, P. R. and T. Gerrodette. 1993. Estimates of cetacean abundance and distribution in the eastern tropical Pacific. Rept. Int. Whal. Comm. 43: 477-493.

Watkins, W. A. 1967. Air-borne sounds of the humpback whale, *Megaptera novaeangliae*. J. Mammal. 48(4):573-578.

Watkins, W. A. 1977. Acoustic behavior of sperm whales. Oceanus. 2:50-58.

Watkins, W. A. 1981. Activities and underwater sounds of fin whales. Sci. Rep. Whales Res. Inst. 33: 83-117.

Watkins, W. A. 1986. Whale Reactions to Human Activities in Cape Cod Waters. Marine Mammal Science. 2(4) 251-262.

Watkins, W. A. and W. E. Schevill. 1972. Sound source location by arrival-times on a non-rigid three-dimensional hydrophone array. Deep-Sea Res. 19: 691-706.

Watkins, W. A. and W. E. Schevill. 1975. Sperm whales (*Physter catodon*) react to pingers. Deep-Sea Research 22: 123-129.

Watkins, W. A., K. E. Moore, P. Tyack. 1985. Sperm whale acoustic behaviors in the southeast Caribbean. Cetology 49: 1-15.

Watkins, W.A., P. Tyack, K.E. Moore, and J.E. Bird. 1987. The 20-Hz signals of finback whales (Balaenoptera physalus). J. Acoust. Soc. Am. 82(6): 1901-1912.

Watkins, W. A., M. A. Dahr, K. M. Fristrup and T. J. Howald 1993. Sperm whales tagged with transponders and tracked underwater by sonar. Mar, Mamm. Sci. 9(1):55-67.

Watkins, W. A., M. A. Daher, A. Samuels, and D. P. Gannon. 1997. Observations of *Peponocephala electra*, the melon-headed whale, in the southeastern Caribbean. Carib. J. Sci. 33: 34-40.

Welkowitz, J., *Ewen, R.B., and Cohen, J. 1991. Introductory statistics for the behavioral sciences (4th ed.) New York: Harcourt Brace Jovanovich Publishers.*

Wenz, G. M. 1962. Acoustic Ambient Noise in the Ocean: Spectra and Sources. J. Acoust. Soc. Am., Vol 34, p. 1936.

Wetherall, J. A., G. H. Balazs, R. A. Tokunaga and M. Y. Y. Yong. 1993. Bycatch of marine turtles in North Pacific high-seas driftnet fisheries and impacts on the stocks. *In:* Ito, J. et al. (eds.). INPFC Symposium on biology, distribution, and stock assessment of species caught in the high seas driftnet fisheries in the North Pacific Ocean, Bulletin No. 53 (III), p. 519-538. Int. North Pac. Fish. Comm., Vancouver, Canada.

Wetherbee, B. M., G. L. Crow, and C. G. Lowe. 1996. Biology of the Galapagos shark, Carcharhinus galapagensis, in Hawaii. Environmental Biology of Fishes. **45.**: 299-310

Wever, E. G. 1978. The reptile ear. Princeton Univ. Press, Princeton, NJ.

Whitehead, H. 1985. Humpback whale songs from the North Indian Ocean. *Invest. Cetacea.* 17:157-162.

Whitehead, H., J. Gordon, E. A. Mathews and K. R. Richard. 1990. Obtaining skin samples from living sperm whales. Mar. Mamm. Sci. 6(4):316-326.

Willis, P. M. and R. W. Baird. 1998. Status of the dwarf sperm whale, *Kogia simus*, with special reference to Canada. Can Field-Nat 112: 114-125.

Winn, H. E. and P. J. Perkins. 1976. Distribution and sounds of the minke whale, with a review of mysticete sounds. Cetology 19: 1-12.

Winn, C., R. Lukas, D. Karl and E. Firing. 1993. Hawaii Ocean Time-Series Data Report. 1991. University of Hawaii, School of Ocean and Earth Science Technology (SOEST). Tech. Report 93-3.

Winn, H. E., J. D. Goodyear, R. D. Kenney, and R. O. Petricig. 1994. Dive patterns of tagged right whales in the Great South Channel. Cont Shelf Res 15: 593-611.

Wolman, A. A. and C. M. Jurasz. 1977. Humpback whales in Hawaii: Vessel census, 1976. Mar. Fish. Rev. 39(7):1-5.

Worcester, P. F. 1998. Report on the Office of Naval Research Long-range Propagation Workshop, University of California, San Diego, 3-4 March 1997. Scripps Institution of Oceanography Reference Series 98-8.

Worcester, P. F., B. D. Cornuelle, M. A. Dzieciuch, W. H. Munk, B. M. Howe, J. A. Mercer, R. C. Spindel, J. A. Colosi, K. Metzger, T. G. Birdsall, and A. B. Baggeroer. 1999. A test of basin-scale acoustic thermometry using a large-aperture vertical array at 3250-km range in the eastern North Pacific Ocean. Journal of the Acoustical Society of America. 105:3185-3201

Yano, K. and M. E. Dahlheim. 1995a. Behavior of killer whales *Orcinus orca* during longline fishery interactions in the southeastern Bering Sea and adjacent waters. Fisheries Science (Tokyo) 61: 584-589.

Yano, K. and M. E. Dahlheim. 1995b. Killer whale, *Orcinus orca*, depredation on longline catches of bottomfish in the southeastern Bering Sea and adjacent waters. Fish Bull 93: 355-372.

Yochem, P. K. and S. Leatherwood. 1985. Blue whale *Balaenoptera musculus* (Linnaeus, 1758). *In:* Ridgway, S.H. and R. Harrison (eds.). Handbook of marine mammals. Vol. 3. The sirenians and baleen whales.

THIS PAGE INTENTIONALLY LEFT BLANK

Distribution List

Representative Neil Abercrombie 1502 Longworth House Office Building Washington, DC 20515-1101	Robin W. Baird, Ph.D. 2747 South Kihei Rd., C201 Kihei, HI 96753
Paul Achitoff Earthjustice Legal Defense Fund 223 S. King Street #400 Honolulu, HI 96813	Neil Bajwa 63 Spring Valley Lane Pittsburgh, PA 15238
Nicole Adimey 1988 Pahoehoe Street Koloa, HI 96756	Scott Barnes Glenwood Drive Redlands, CA 92373
Sean Adler 14 N. Omega Bay La Marque, TX 77568	Dr. Robert Basham 3479 River Path San Antonio, TX 78230
Senator Daniel K. Akaka 720 Hart Senate Office Building United States Senate Washington, DC 20510-1103	Ron Bass P.O. Box 106 Puunene, HI 96784
Peter Allan 306 Potomac Drive Basking Ridge, NJ 07920-3123	Ruth Ann Bates 1865 Olinda Road Makawao, HI 96768
Robert Amato P.O. Box 835 Kapaa, HI 96746	Jacqueline Baum-Pence 7229 Capps Crossing Rd Grizzly Flat, CA 95636
Mr. Bruce Anderson Department of Health 1250 Punchbowl Honolulu, HI 96813	Karen Bayne Tetra Tech 180 Howard Street, Suite 150 San Francisco, CA 94105
Manuel Andrade Div. of Conservation & Res. Enforce. 1151 Punchbowl Street, Room 311 Honolulu, HI 96813	Carmen Bazua UH Marine Sciences Bldg. Rm 434A 1000 Pope Rd Honolulu, HI 96822
Ms. Kellie Araki Hawaiian Islands Humpback Whale National Marine Sanctuary 6700 Kalaniana'ole Highway, Suite 104 Honolulu, HI 96825	Kim Beasley Clean Islands Council 179 Sand Island Access Road Honolulu, HI 96819
Melissa F. Armstrong 7970 SW 24th Pl., Apt. #102 Davie, FL 33324	Dr. Sallie Beavers P.O. Box 4992 Kailua-Kona, HI 96745
Whitlow Au HIMB/ SOEST/ UH Manoa Honolulu, HI 96822	Diana Bennett P.O. Box 6220 144 Holmes Big Bear Lake, CA 92315
Heidi Benson Pure Planet Products P.O. Box 4281 West Sedona, AZ 86340	Gena Bouquet 1710 Destry Lane Cottonwood, AZ 86326

Dr. Carl Berg Hawaiian Wildlife Tours PO Box 681 Kilauae, HI 96754	Jasmine Bourque 16 Ayers Court Falmouth, ME 04105
Kelly A. Bergeron 2924 Sheffield Lane Woodward, OK 73801	CAPT James A. Bowlin Commanding Officer Pacific Missile Range Facility Kekaha, HI 96752-0128
Mark Berman Earth Island Institute 300 Broadway, Suite 28 San Francisco, CA 94133-4529	David Boynton P.O. Box 187 Hanalei, HI 96714
George F. Birchard P.O. Box 558 Lawai, HI 96765	William & Joan Bramsch 3888 Via Miralesta Dr. St. Louis, MO 63125
Catherine Black 327 Ilihau St. Kailua, HI 96734	Brian Branstutter 1129 Ala Moana Blvd. Honolulu, HI 96814
Beau Blair PO Box 421 Hanalei, HI 96714	Katherine Brede 2826 Hunter Mill Rd. Oakton, VA 22124
David W. Blane, Director Office of State Planning, P.O. Box 2359 Honolulu, HI 96804	Bill Brooks P.O. Box 2160 Kailua Kona, HI 96745
Dennis A. Boardman Attorney at Law 6025 NE 16th St. Portland, OR 97211	Donna Brown 19 Hale Malia Place Lahaina, HI 96761
Nathan Boddie 3070 Greenville Rd. LaGrange, GA 30241	Linda G. Bruckner 46-231 Heeia Street Kaneohe, HI 96744
Doug Bold Helix International 9 Piedmont Lane Palmyra, VA 22963	Terry Bunch 17119 W Bernardo Dr #106 San Diego, CA 92127
Michaela Boudreaux P. O. Box 57 Kapaa, HI 96746	Nancy Bushnell Kauai Community College 3-1901 Kaumualii Highway Lihue, HI 96766
Lara Butler 5648 Keapana Rd. Kapaa, HI 96746	Ed Coll P.O. Box 2320 Puhi, HI 96766
Ms. Lisa S. Butler 16034 Yarnell Street Sylmar, CA 91342-1010	Kathryn D. Colter 9234 13th Ave. NW Seattle, WA
Mary Jane Caldwell 3501 Kehala Drive Kihei, HI 96753	Isis Conseur P.O. Box 1103 Kilauea, HI 96754

Helen & Colleen Carr P.O. Box 217 Big Oak Flat, CA 95305	Linda A. Cook P.O. Box 953 Kealakekua , HI 96750
Lynn Carroll Code PMS 400 2531 Jefferson Davis Highway Arlington, VA 22242	Aubrey Cooke A-30 Dallas Road Victoria, BC Canada V8V 2N7
Mr. Kelvin Char National Marine Fisheries Office 1601 Kapiolani Blvd #1110 Honolulu, HI 96814-4700	James Coon Trilogy Cruises 2114 Naalae Road Kula, HI 96790
Chief of Naval Operations 2000 Navy Pentagon Attn: Ms. Carol Bloemker (N45) Washington, DC 20350-2000	Kevin Correll 525 W. Penn. Ave. Wernersville, PA 19565
Chief of Naval Operations 2000 Navy Pentagon Attn: Mr. Frank Stone (N45) Washington, DC 20350-2000	Alison Craig 1129 Ala Moana Blvd. Honolulu, HI 96814
Chief of Naval Operations 2000 Navy Pentagon Attn: LCDR Rebecca Gilchrist (N45) Washington, DC 20350-2000	Nancy Crom 577 Western Ave Albany, NY 12203
Clarence Ching 64-823 Mamalahoa Hwy. Kamuela, HI 96743	Andrea Cronrod Box 646 Hanapepe, HI 96716
Mr. Raymond Chuan Kauai Friends of the Environment PO Box 1183 Hanalei, HI 96714	Dee Crowell Dept of Planning,County of Kauai 4444 Rice Street, Suite 235 Lihue, HI 96766
George Ciervo Jr. RR 2 Box 4053 Pahoa, HI 96778	Henry Curtis Life of the Land 76 North King Street, Suite 203 Honolulu, HI 96817
Dr. Christopher Clark Cornell Laboratory of Ornithology 159 Sapsucker Woods Road Ithaca, NY 14850	L. Jamie Dack 3730 Main St. Jamestown, MO 65046
Simone Cole 77-6557 Alii Drive Kailua-Kona, HI 96740	Michael Daly Lovelink P.O. Box 1629 Hanalei, HI 96714
Lotus & Sun Dancer 808-446-9178 Maui	Bill Devick DLNR Division of Aquatic Resources 1151 Punchbowl Honolulu, HI 96813
Diane Daniells Hanalei Community Association PO Box 789 Hanalei, HI 96714	Pamela Glendinning Diaz 67 Pocantice St. Sleepy Hollow, NY 10591

Evelyn de Buhr P.O. Box 158 Hanalei, 96714	Mike Dick PO Box 1117 Kalaheo, HI 96741
L. De SIO 800 N. Quincy Street Arlington, VA 22217-5660	Donna J. Dickinson 1951 Revolutionary Ct. Pheonixville, PA 19460
Mark Deakus 1129 Ala Moana Blvd. Honolulu, HI 96814	Judy Dietel 45 Bardwell Street So. Hadley, MA 01075
Lynne Delabre 1394 41st Avenue San Francisco, CA 94122	Sarah Dolman Alexander House James Street West Bath BA1 2BT UNITED KINGDOM
Janine Denny P.O. Box 433 Lawai, HI 96765	Michael Douglas 3560 Kaweonui Road Princeville, HI 96722
Dept. of Business, Econ. Dev. & Tourism Energy, Resources & Technology Division 235 South Beretania Street, 5th Floor Honolulu, HI 96813	Rev. P. D. Draper 254 Garden Lane Sarasota, FL 34242
Dept. of Health Env. Planning Office P.O. Box 3378 Honolulu, HI 96801	Margaret Dupree National Marine Fisheries Office 1601 Kapiolani Blvd #1110 Honolulu, HI 96814-4700
Department of the Navy ATTN: Code 203DH Commander, LANTNAVFACENGCOM 1510 Gilbert Street Norfolk, VA 23511-2699	Earthjustice Legal Defense Fund Attn: Michael Sherwood 180 Montgomery St., Ste. 1725 San Francisco, CA 94104-4209
Dept. of Transportation 869 Punchbowl Street Honolulu, HI 96813	Tom Eisen (Traver Carroll) Planning Branch, DLNR P.O. BOX 621 Honolulu, HI 96809
Dept. of Trans. Services 650 South King Street Honolulu, HI 96813	Environmental Defense Fund Attn: Rod Fujita 5655 College Avenue Oakland, CA 94618
Kathleen Erickson 2992 N. Miller Rd. #117 Scottsdale, AZ 85251	Emily A. Gardner 1905 Iwi Way Honolulu, HI 96816
David Farrel United States Environmental Protection Agency 75 Hawthorne Street San Francisco, CA 94105-3901	Roger Gentry NOAA Office of Protected Resources 1315 East-West Highway Silver Spring, MD 20910
Mark Farrell 4210 Monterey Rd. #57 San Jose, CA 95111	Dr. Bob Gisiner, Code 335 Office of Naval Research 800 N. Quincy Street Arlington, VA 22217-5660

Bruce Fehring P.O. Box 565 Kilauea, HI 96754	Ms. Helen M. Golde NOAA/Sanctuaries and Reserves Division 1305 East-West Highway Silver Spring, MD 20910
Mary Fishbach 4433 Colbath Ave. Sherman Oaks, CA	Roberta Goodman 101 Kilua Road Hilo, HI 96720
Tyler Forman 1212 E. Minnezona Ave. Phoenix, AZ 85014	Erin Graue
Dr. Adam S. Frankel Marine Acoustics 901 North Stuart Street, Suite 708 Arlington, VA 22203-1821	Marta Greenleaf 2 Jefferson Rd. Scarsdale, NY 10583
Stephanie Fried P.O. Box 520 Waimanalo, HI 96795-0520	William Greenleaf 2 Jefferson Rd Scarsdale, NY 10583
William A. Friedl 271 Awakea Road Kailua, HI 96734-3448	Ron Greenspun 248 Pomona Ave. #4 Long Beach, CA 90803
Jeffri H. Frontz 310 Walhalla Rd. Columbus, OH 43202-1444	N. G. Gregory 19 Pembroke Ave. Hove, Sussex BN3 5DB Great Britain
Susan B. Fruchter NOAA Program Office 14th and Constitution Ave. NW Washington, DC 20230	Elinor A. Gunter Stop LFAS Worldwide Network
Margie Fyfe 455 Point Breeze Rd Flemington, NJ 08822	Walter Haas 267 Kamokila Rd. Kapaa, HI 96746
Marina Gagliardi 9945 Robbins Dr. #103 Beverly Hills, CA 90212	Douglas B. Hackett 82-955 Aka Ala St. Captain Cook, HI 96704
James Hager P.O. Box 132 Hanapepe, HI 96716	D. Grant Haynes P.O. Box 174 Fayetteville, AR 72702
Qivian Hager P.O. Box 2149 Kapaa, HI 96746	Don Heacock DLNR Division of Aquatic Resources 3060 Eiwa Street Lihue, HI 96766
Donna Hampson 59 Atherton Street Ayer, MA 01432-1701	Linda Hecht P.O. Box 3199 Sedona, AZ 86340
Hanalei Community Association P.O. Box 789 Hanalei, Kauai, HI 96714	Lea Heimerman 606 Juniper Court Redlands, CA 92374
Isaac D. Harp 880 Front Street #791 Lahaina, Hawaii 96761	Paul Henson U. S. Fish and Wildlife Service 300 Ala Moana Blvd., Room 3-122 Box 50088 Honolulu, HI 96850

Dr. June Harrigan-Lum Department of Health 919 Ala Moana Blvd., 3rd Floor Honolulu, HI 96814	Dr. Louis Herman Kewalo Basin Marine Mammal Lab 1129 Ala Moana Blvd Honolulu, HI 96814
James Harrington 318 N. Whipple Fort Bragg, CA 95437	Stephen Herrington P.O. Box 401 Eldorado Springs, CO 80025
Siobhan Harrington 13201 Clayton Road St. Louis, MO 63131	Don Hibbard DLNR Historic Preservation District 601 Kamokila Blvd, Room 555 Kapolei, HI 96707
Elliott Harris 3115 Diamond Head Road, Apt. C Honolulu, HI 96815	Sherri Hiraoka 2550 Campus Road Crawford Building Room 317 Honolulu, HI 96822
Kathy Harter 1088 Bishop St., #1301 Honolulu, HI 96813	Gwendolyn Hjelmstad 16636 North 35th Street Phoenix, AZ 85032
Hawaiian Homes Comm. Dept. of Hawaiian Home Lands P.O. Box 1879 Honolulu, HI 96805	Alanna Hobbs 1129 Ala Moana Blvd Honolulu, HI 96814
Hawaii Maritime Associates 758 Kapahulu Ave. #422 Honolulu, HI 96816	Matt Hoberg 406 Falcon Drive Kennett Square, PA 19348
Kazu Hayashida State of Hawaii Dept. of Transportation 869 Punchbowl St Honolulu, Hawaii 96813-5097	Ken Hollinshead NOAA/Ofc. of Protected Resources 1315 East-West Highway, Bldg. 3 Silver Spring, MD 20910
Rebecca Hommon Navy Region Hawaii 517 Russell Street, Suite 110 Pearl Harbor, HI 96860-4884	Kathryn W. Inouye Makai Village Partnership Vendor 1001 Bishop Street, Suite 1570 Honolulu, HI 96813
Honolulu Star Bulletin City Editor P.O. Box 31000 Honolulu, HI 96849	Bianca Isaki 1306A Artesian Street Honolulu, HI 96826
Gary L. Hoover P.O. Box 384014 Waikoloa, HI 96738	Bob Jacobson P.O. Box 900 Kurtistown, HI 96760
Tina Horowitz 4701 Pine Street M8 Philadelphia, PA 19143	Barbara Jarvis 808-822-7627
Mary Hudson Attorney at Law 436 14th Street Oakland, CA 94612	Pat Jenkins The Garden Island Newspaper 3137 Kuhio Highway Lihue, HI 96766
Monte Hull 2149-B Puu Rd. Kalaheo, HI 96741	Eva Johanos 2965 Woodlawn Dr. Honolulu, HI 96822

Eve Hutchison Rt. 1 Box 22C Vici, OK 73859	Tim Johns Board of Land & Natural Resources 1151 Punchbowl Honolulu, HI 96813
Charley Ice 98-633 Kilinoe Aiea, HI 96701	Arthur Johnson, Barbara Lee Johnson, Barbara Johnson 8 Grandview Court Huttonville, Ontario L0J 1BO CANADA
J. Douglas Ing Attorney at Law 999 Bishop Street, 23rd Floor Honolulu, Hawaii 96813	Robin Johnson CA 92234
Renee Ingram P. O. Box 1655 Hanalei, HI 96714	Vickie L. Johnson, J.D. 2717 Seville Blvd., #5108 Clearwater, FL 33764
Bob Inouye Pacific Missile Range Facility P.O.Box 128 Kekaha, HI 96752	Guy G. Jones 2000 S. Melrose Dr. #112 Vista, CA 92083
Senator Daniel K. Inouye State of Hawaii 722 Hart Building Washington, DC 20510-1102	Rey Jonsson 1655 Ihiloa Loop Honolulu, HI 96821
Susan Jordan League for Coastal Protection 805 23rd Street Manhattan Beach, CA 90266	Kevin Kelly 2440 Campus Rd. #403 Honolulu, HI 96822
Anjanette Kalb 319 Hancock St., #19 Laramie, WY 82072	Lizbeth Kendall Pacific Whale Foundation 101 North Kihei Rd. Kihei, HI 96753
Jeff Kalback P.O. Box 51000 Eleele, HI 96705	William Kennison 896 Lower Main Street Wailuku, Hawaii 96793
Adrian Kamalii 267 Molokai Akau Kahului, HI 96732	Penny Khaled Lot 263 2463 Gulf To Bay Blvd. Clearwater, FL 33765
Anna Kaohelaulii 45-403 Koa Kahiko Street Kaneohe, HI 96744	Donna Killian 210 S. Harris, Box 53 Manson, WA 98831
Dr. Risa, and David Boulton Kaparo 1191 Kuhio Hwy, Ste. 293 Kapaa, HI	Cindy Knapman University of Hawaii Ocean Policy Program Honolulu, HI 96822
Kauai County Engineer Dept. of Public Works 4444 Rice Street Lihue, HI 96766	Professor Ken Knight Centre for Sustainable Environmental Mgmt 44 Hertford Avenue London SW14 8EQ

Kauai Dept. of Water, Manager 3498 Pualoke Street Lihue, HI 96766	Donald Knowles Office of Protected Resources, NMFS 1315 East-West Hwy, Rm 13130 Silver Spring, MD 20910
Gregory Kaufman Pacific Whale Foundation 101 North Kihei Road Kihei, HI 96753	Craig Knox P.O. Box 272105 Concord, CA 94527
Christopher Kehoe P. O. Box 1103 Kilauea, HI 96754	Russell Kokubun Hawaii County Dept. of Planning 25 Aupuni St. Rm. 109 Hilo, HI 96720
Rosemary A. Kekoa 95-326 Kaloapau St. #134 Mililani, HI 96789-1262	Marsha Kolter 24303 SE 37th Pl. Issaquah, WA 98029
Thomas R. Keller Office of the Attorney General 425 Queen St., Ste 300 Honolulu, HI 96813	Paula Edwards Kressley P.O. Box 1275 Hanalei, HI 96714
Donna Kellogg 25955 SW Stafford Rd Wilsonville, OR 97070-9724	Chris Kubiak 650 Center Drive PSD Pearl Harbor, HI 96860-4100
Mayor Maryanne Kusaka Office of the Mayor 4444 Rice Street, Suite 235 Lihue, HI 96766	Eliza Linser 4431-5 Kale Pl. Lihue, HI 96766
Sky Landis P.O. Box 1648 Kapaau, HI	Kawika Liu 2505 C La'i Rd. Honolulu, HI 96816
Commander, LANTNAVFACENGCOM Attn: 2033JH 1510 Gilbert Street Norfolk, VA 23511-2699	Dr. Ellen Livingston Office of Naval Research, Code 321 OA 800 N. Quincy Street Arlington, VA 22217-5660
Denis R. Lau Dept. of Health, Environmental Mgmt. Div. Clean Water Branch 919 Ala Moana Blvd, Rm 301 Honolulu, HI 96814-4920	Leonard D. Logan P.O. Box 1428 15-1466 Kahakai Blvd. Pahoa, HI 96778
Ernest Lau County of Kauai Department of Water 4398 Pua Loke Street P.O. Box 1706 Lihue, HI 96766-5706	Barbara London 2523 43rd Ave. San Francisco, CA 94116
Stefan Laug Sartoriusstr.19 D-70469 Stuttgart stefan@silent-light.de	Georgina Lopez-Gonzalez Rio Sena No.4 Fracc. Pathe Queretaro, QRO. CP 76020 Mexico
Donna Lee P.O. Box 581 Kalaheo, Kauai HI 96741	Daniel Lovejoy P.O. Box 1592 Kealakekua, HI 96750

Sam Lee DLNR 3060 Eiwa Street, Room 306 Lihue, HI 96766	Cheryl Lowell-Obatake P.O. Box 366 Lihue, HI 96766
Sam Lemmo Planning Branch, DLNR PO Box 621 Honolulu, HI 96809	Dr. Craig MacDonald DBEDT-Ocean Resources Branch P.O. Box 2359 Honolulu, HI 96804
William Lennan II US Army Engineering District, Honolulu Bldg. 230 Fort Shafter, HI 96858-5440	Colette Machado Office of Hawaiian Affairs 711 Kapiolani Blvd., 5th Floor Honolulu, HI 96813
Joan Levy BodyMind & Breath Center P.O. Box 160 Kapaa, HI 96746	Donna MacIver 55 Washington Ave. N. White Plains, NY 10603
Cliff Libed P.O. Box 935 Wailuku, HI 96793	Dr Cheryl Magill *Stop LFAS Worldwide Network* 209-315-9373
Timothy Mahar 285 Payne St., 21B Destin, FL	Susan McGuire 4317 18th Avenue South Minneapolis, MN 55407
Ryan Manro 1614 Navajo Point Place Henderson, NV 89014-2931	Naomi McIntosh Humpback Natl Marine Sanctuary 6700 Kalanianaole Hwy. Ste. 104 Honolulu, HI 96825
James Maragos 300 Ala Moana Blvd. #5231 Honolulu, HI 96850	Barbara Meadows 2140 Awihi Pl. #4 Kihei, HI
Debra March P.O. Box 1672 Hanalei, HI 96714	Harold H. Meheula, Sr. 1743-A Wilhelmina Rise Honolulu, HI 96816-3337
L. Marina and C. Cabanilla Maza PO Box 61458 Honolulu, HI 96839-1458	Dr. Jim Mercer University of Washington 1013 N.E. 40th Street Seattle, Washington 98105
Marine Mammal Commission 4340 East-West Highway, Room 905 Bethesda, MD 20814	Bob Meyers P. O. Box 929 Kalaheo, HI 96741-0929
D.L. Marrin P.O. Box 272 Hanalei, HI 96714	Ms. Jackie Miller University of HI Environmental Ctr 2500 Campus Road , Crawford 317 Honolulu, Hi 96822
Cynthia Marshall P.O. Box 1775 Solana Beach, CA 92075	Ms. Patty Miller DOE – Teleschool Branch 1122 Mapunapuna St. #201 Honolulu, HI 96819
Colbert M. Matsumoto Matsumoto LaFountaine & Chow 700 Bishop Street, Suite 1100 Honolulu, HI 96813	Richard A. Miller P.O. Box 1456 Hanalei, HI 96714-1456

James Keli'ipio Kaea Mawae, Jr. P.O. Box 145 Hoolehua, Molokai, HI 96729	Patsy Mink 2135 Rayburn House Office Building Washington, DC 20515-1102
Charles Kauluwehi Maxwell, Sr. 157 Alea Place Pukalani, HI 96768	Dr. Joseph R. Mobley, Jr. University of HI, W. Oahu 96043 Ala Ike Pearl City, HI 96782
Mara Mayo HCR1 Box 4620 Keaau, HI 96749	Marshall Mock Kauai Community College 3-1901 Kaumualii Highway Lihue, HI 96766
Moksha McClure P.O. Box 1091 Hanalei, HI 96714	Ed Moen 701 Springdale Street Mount Horeb, WI 53572
Lynn McCrory PO Box 1455 Hanalei, HI 96714	Maya Moiseyev 669 Ashbury St. San Francisco, CA 94117
Larry Morningstar P.O. Box 1257 Kilauea, HI 96754	Alicia Nation 13469 Shelter Drive Rapid City, SD 57702
Myrica Morningstar P.O. Box 358 Kilauea, HI 96754	Imakakoloaihenenui Nauha Modesto, CA (submitted by Larry Morningstar)
Michael Morosey 2600 Langford Road North Collins, NY 14111	NAWC Weapons Division ATTN: Alex Stone Code 529600E 521 Ninth Street Point Mugu, CA 93042-5001
Kimberly Morrill 1617 Kingman Ave. San Jose, CA 95128	Nathan Nazdrowicz 115 Great Circle Rd. Newark, DE 19711-2335
Nanea Morris P.O. Box 273353 Fort Collins, CO 80527	Dr. P. Neil 3890 Kamehameha Rd. #8 Princeville, HI 96722
Harold Morse Honolulu Star Bulletin P.O. Box 31000 Honolulu, HI 96849	Joseph M., Noonan President Planetary Partners #9 Sixth Street Plum Island, MA 01951
Vida N. Mossman Public Affairs Officer Pacific Missile Range Facility Kekaha, HI 96752-0128	Alexandra Norton 505-455-1945
Judith Muir Polperro Dolphin Swims P.O. Box 11 Blairgowrie, VIC 3942 Australia	Richard Norton 505-455-1943
Sharon Mullane 4084 Redwood Ave. #4 Los Angeles, CA 90066	Office of Planning 235 South Beretania Street, 6th Floor Honolulu, HI 96813
Walter Munk MC 0225	Mary J. Osborn 360-387-6321

Paul Nachtigall Marine Mammal Research Program P.O. Box 1106 Kailua, HI 96734	Kealii Pang 3204 Carlos Long Street Honolulu, HI 96816-3102
John Nakagawa Hawaii Coastal Zone Mgmt Program P.O. Box 2359 Honolulu, HI 96804-2359	COL Donald R. Pawlowski US Army Corps of Engineers CEPOD-DE Bldg 230, Ft. Shafter Honolulu, HI 96858-5440
Tracie Naranjo 91-822 Koalipehu Place Ewa Beach, HI 96706	Barbara Peck P. O. Box 1197 Hanalei, HI 96714
Jessalyn Nash 17925 Coleman Valley Occidental, CA 95465	Saundra Pendleton 27422 Lindvog Rd NE Kingston, WA 98346
James Pennaz Dept of Army, Civil Works Technical Branch U.S. Army Engineer District Honolulu Fr. Shafter, Hawaii 96858-5440	Trish Regan P.O. Box 171 Captain Cook, HI 96704
Maria Petrak-Rajput Rudolf-Koeplg. 5/1/7 1220 Vienna, Austria	Susan Reghi P.O. Box 1548 Hanalei, HI 96714
Susan Pico P. O. Box 1250 Hanalei, HI 96714	Region IX Administrator, US EPA 75 Hawthorne Street San Francisco, CA 94105
Kathee Pizzi 6002 Crittenden Ave. Indianapolis, IN 46220	Lourdes Resperger Arnoldgasse 2/5/64 Vienna, Austria
Bruce Pleas P.O. Box 721 Waimea, HI 96796	Becki Retzlaff 622 W. Forest Ave. #38 Detroit, MI 48201
Claire Poertner 600 Moss Point Cove Court Debary, FL 32713	Joel Reynolds Natural Resources Defense Council 6310 San Vicente Blvd., Suite 250 Los Angeles, CA 90048
Richard Poirier DBEDT –Office of Planning P.O. Box 2359 Honolulu, HI 96804	Linda & Craig Robertson 2558 Maianroyal Street Mississauga, Ontario Canada L5L 1C9
Pamela Polland 808-878-3220 COAST PO Box 88 Kula, HI 96760	Barbara Robeson P.O. Box 369 Hanalei, HI 96714
Cathy Presmyk Mail Code 0006	Mr. Bill Roome Environmental Public Affairs Officer Commander, Navy Region Hawaii Pearl Harbor, Hawaii 96860
Rosemary Pritzker 17739 Cold Creek Ln. St. Ignatius, MT 59865	Liz Rourdol P.O. Box 685 Kilauea, HI 96754
Mahalia Pugatch 101 Woodland Road Fairfax, CA 94930	Pat Rundstrom Rd. 56 – 69B Espanola, NM 87532

Deborah M. Raiter P.O. Box 895 Captain Cook, HI 96704	Genevieve Salmonson, Director Office of Environmental Quality Ctrl. 235 South Beretania Street, Suite 702 Honolulu, HI 96813
Barry Raleigh University of Hawaii, POST 802 1680 East-West Rd. Honolulu, HI 96822	Bobbie Sandoz 1221 Victoria Street, # 301 Honolulu, HI 96814
Peter Rappa University of Hawaii, Environmental Center 2550 Campus Road, Crawford 317 Honolulu, HI 96822	Johanna Santer 732 Rosewood Dr. Palo Alto, CA 94303
Cynthia Schlosser 173 Meador Way SE Atlanta, GA 30315	Lanny Sinkin P.O. Box 944 Hilo, HI 96721
Ramona Schreiber NOAA Program Office 14th and Constitution Ave. NW Washington, DC 20230	D. William Sinnett 2615 NE 359th Street Washougal, WA 98671-8218
Dr. Bob Schroeder Western Pacific Regional Fishery Mgmt. Council 1164 Bishop Street, Ste 1405 Honolulu, HI 96813	Heidi Sittinger P.O. Box 1412 Kealakekua, HI 96750
Gary A. Schwartz 16 Finalee Avenue Asheville, NC 28803	Cha Smith 1615 Mahani Loop Honolulu, HI 96819
Lori Sgambati 636 West 238th Street Bronx, NY 10463-1400	Judy Smith Monographs Acquisition Service Colorado State University Libraries Fort Collins, CO 80523-1019
Melissa Ann Shaw, D.V.M. 4-1191 Kuhio Hwy. Kapaa, HI 96746	Robert P. Smith United States Fish and Wildlife Service Pacific Islands Ecoregion 300 Ala Moana Blvd., Room 3122 Honolulu, HI 96850
Kimberlie E. Sheldon 9131 Guinea Rd. Hayes, VA 23072	Glenn Soma Harbors Division Planning Office 79 S. Nimitz Highway Honolulu, HI 96813
John Sibert UH Marine Sciences Bldg. Rm. 612 1000 Pope Rd Honolulu, HI 96822	Sunil Somalwar 1015 S. Park Ave. Highland Park, NJ 08904
Stephanie Siegel CNN Interactive 1 CNN Center, 10th Floor South Atlanta, GA 30303	Anthony Sommer 3501 Rice St., Ste 200-A Lihue, HI 96766
Ramona Silva 1191 Kuhio Hwy., Suite 143 Kapaa, HI 96746	Dieter Sommer An der Waldpromenade 6 Steina, 37441, Germany

Adrienne Arabian Simidian 160 Seven Hills Lake Drive RR 14, Box 55 Carmel, NY 10512	Cheryl D. Soon Department of Transportation Services City and County of Kauai 711 Kapiolani Blvd., Suite 1200 Honolulu, HI 96813
Dr. Jeffrey Simmen Office of Naval Research, Code 321 OA 800 N. Quincy St. Arlington, VA 22217-5660	Averiet Soto P.O. Box 809 Lawai, HI 96765
SOUTHWESTNAVFACENGCOM Attn: Ann Rosenberry Code 5SPR South Bay Area Focus Team 2585 Callagan Hwy, Bldg 99 San Diego, CA 92136-5500	Melissa Stevenson 2988 Buhach Rd. Merced, CA 95340
Jean Souza P.O. Box 3390 Lihue, HI 96766	Jill Strawder 5536 Winthrop Ave. Indianapolis, IN 46220
Jeremiah Spence 914 E. 32nd St., Apt. 103 Austin, TX 78705-2721	Richard Sugiyama 4486 Kauwila St. Kapaa, HI 96746
Clay Spikes MAI 901 North Stuart St, Ste 708 Arlington, VA 22203-1821	Ashley Summers P.O. Box 541 Hanalei, HI 96714
Ariel Spilsbury Box 1746 Nohane (?), HI	Ms. Ivana Sustersic Office of Naval Research 800 N. Quincy Street Arlington, VA 22217-5000
Bob Spindel Applied Physics Laboratory University of Washington 1013 NE 40th Street, Rm 606 Seattle, WA 98105	Dr. Claud Sutcliffe Mediation Center of Molokai P.O. Box 1708 Kaunakakai, HI 96748
Joshua Stanbro P.O. Box 118 Holualoa, HI 96725	Edward S. Syrjala P.O. Box 149 Centerville, MA 02632
Mike Stanton Atlantis Submarines 74-381 Kealakehe Parkway Kailua-Kona, HI 96740	Victoria Takamine 98614 Kaimu Loop Aiea, HI 96701
Lynne Starke 83-5572 Middle Keei Road Captain Cook, HI 96704	Matt Taylor 314 Norgulf Rd. Reisterstown, MD 21136-1119
Department of Land and Natural Resources Historic Preservation District Kakuhihewa Building, Room 555 601 Kamokila Blvd. Kapolei, HI 96707	Jan TenBruggencate Honolulu Advertiser Kauai Bureau PO Box 524 Lihue, HI 96766

Carl M. Stepath P. O. Box 549 Hanalei, HI 96714	Tetra Tech Em, Inc. ATTN: Twe Lan 1881 Campus Commons Drive, Suite 200 Reston, VA 20191
Scott Gerard Stephen 1833 West Bernice Chicago, IL 60613	Karuna Thal 1321 Kiowai Pl. Kapaa, HI 96746
Penny Thomas P.O. Box 970 Captain Cook, HI 96704	Alan Waltner UC Office of the General Counsel 1111 Franklin Street, 8th Floor Oakland, CA 94607
Marcia Thompson Code 427, NFESC 1100 23rd Avenue Port Hueneme, CA 93043	Water Res. Research Ctr., UHM Holmes Hall, Room 283 2540 Dole Street Honolulu, HI 96822
Allen Tom Hawaiian Islands Humpback Whale National Marine Sanctuary 726 S. Kihei Road Kihei, HI 96753	Joe Watson P.O. Box 856 Hanalei, HI 96714
LCDR Michael D. Tosatto Coast Guard Law Enforcement 300 Ala Moana Blvd. Honolulu, HI 96850	Peggy Watson P.O. Box 856 Hanalei, HI 96714
Pat Tummons Environment Hawaii 282 Ululani Hilo, HI 96720	Joe Weichman 959 Princeton Street Santa Monica, CA 90403
John R. Twiss, Jr. Marine Mammal Commission 4340 East-West Highway, Room 905 Bethesda, MD 20814	Lindy Weilgart c/o Hal Whitehead Dalhousie University Halifax Nova Scotia B3H 4J1 CANADA
Mr. Dean Uchida Lands Division, DLNR P.O. Box 621 Honolulu, HI 96809	Breana Wheeler 1119 Stanyan St. San Francisco, CA 94117
Healani Waiwai'ole 3408 'Eono St. Lihu'e, HI 96766-1026	Jeanne Wheeler HCR 65, Box 77 Ojo Sarco, NM 87521
James Walsh Atlantis Submarines 658 Front Street #175 Lahaina, HI 96761	David Lopez Wheelock 8709 Corran Ferry Ln. Austin, TX 78735
Dr. Jeff Walters Division of Aquatic Resources, DLNR 1151 Puchbowl St. #330 Honolulu, HI 96813	Robert E. White Hawaii Ocean Industry Aloha Tower, 5th Floor 1 Aloha Tower Driver Honolulu, HI 96813

LTC Wally Z. Walters US Army Corps of Engineers, CEPOH Bldg 230, Ft. Shafter Honolulu, HI 96858-5440	Will Wilcox P. O. Box 1031 Hanalei, HI 96714
Panther Wilde At Home Here 3134 Kuhio Hwy., PMB 31 Lihue, HI 96766	Morgan Paul Williams P. O. Box 12 Anahola, HI 96703
Dr. Robert Wilder Pacific Whale Foundation Kealia Beach Plaza, Suite 21 101 North Kihei Road Kihei, HI 96753	Dr. Carl Wunsch Department of Earth, Atmospheric and Planetary Sciences Massachusetts Institute of Technology Cambridge, MA 02139
Ann Young Code N4654B Commander-in-Chief, U.S. Atlantic Fleet 1562 Mitscher Avenue, Suite 250 Norfolk, VA 23551-2487	George P. Young P.E. Chief, Regulatory Branch Department of the Army U.S. Army Engineer District, Honolulu Fort Shafter, HI 96858-5440
G. Yuan University of Hawaii SOEST/IPRC 2444 Dole Street Honolulu, HI 96822	Rosemarie Zellers 1017 Walker Dr. NE Albuquerque, NM 87112

THIS PAGE INTENTIONALLY LEFT BLANK

List of Preparers

Rex Andrew Applied Physics Laboratory University of Washington 1013 N. E. 40th Street Seattle, WA 98105-6698	Acoustic modeling
Breck Betts Scripps Institution of Oceanography Institute of Geophysics and Planetary Physics University of California-San Diego LaJolla, CA 92093-0225	Graphics editor
Adam Frankel, Ph.D. Marine Acoustics, Inc. 901 N. Stuart Street, Suite 708 Arlington, VA 22203	Technical editor
Wallace Handfield Marine Acoustics, Inc. 901 N. Stuart Street, Suite 708 Arlington, VA 22203	References
Kenneth Hollingshead National Marine Fisheries Service National Oceanic and Atmospheric Admin. 1315 East-West Highway Silver Spring, MD 20910	Cooperating agency representative; marine mammal permitting specialist
Mary Hudson, Attorney at Law. 436 14th Street, Suite 1300 Oakland, CA 94612	Legal editor
Doug Ing Watanabe, Ing & Kawashima 999 Bishop Street, 23rd Floor Honolulu, HI 96813	Legal consultant
Stanley Labak Marine Acoustics, Inc. 901 N. Stuart Street, Suite 708 Arlington, VA 22203	Acoustic modeling

James Mercer, Ph.D. Applied Physics Laboratory University of Washington 1013 NE 40th Street Seattle, WA 98105-6698	Principal Investigator
Joseph Mobley, Jr., Ph.D. Social Sciences University of Hawaii-West Oahu 96-129 Ala Ike Pearl City, HI 96782	Technical editor
Susie Pike Scripps Institution of Oceanography Institute of Geophysics and Planetary Physics University of California-San Diego LaJolla, CA 92093-0225	Technical editor and process manager
Jeffrey Simmen, Ph.D. Office of Naval Research 800 N. Quincy Street Arlington, VA 22217-5660	Program manager
Clayton H. Spikes Marine Acoustics, Inc. 901 N. Stuart Street, Suite 708 Arlington, VA 22203	Process manager
Ivana Sustersic, Attorney at Law Office of Naval Research 800 N. Quincy Street Arlington, VA 22217-5660	Legal editor
Kathleen Vigness Raposa Marine Acoustics, Inc. 809 Aquidneck Avenue Middletown, RI 02842	Editor-in-chief
Peter Worcester, Ph.D. Scripps Institution of Oceanography University of California-San Diego 9500 Gilman Drive LaJolla, CA 92093-0225	Principal Investigator

APPENDIX A

FUNDAMENTALS OF SUBSEA SOUND

APPENDIX A

FUNDAMENTALS OF SUBSEA SOUND

An understanding of the principles of sound measurements is important for evaluating the various decibel values presented in this EIS. This appendix summarizes the factors most directly pertinent to the analysis in this document.

Sound measurements can be expressed in two forms: *intensity* and *pressure*. The intensity of the sound is the average rate at which energy is 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. 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 the ear responds 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 - 20 dB is a 100-fold increase, 30 dB is a 1000-fold increase. A 60-dB difference therefore represents a million-fold power difference. 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.

Comparing decibel values for various noise sources must be done carefully, since those values do not always represent equivalent information. It is particularly important to distinguish "spectral" from "broadband" measurements, and to distinguish "water standard" from "air standard" values.

Spectral values represent the power levels within one Hertz (cycle per second) "slices" of an acoustic frequency spectrum; Figure A-1, Kauai Source Power Density Spectrum, is an example of such a measurement, showing the power levels within each one-Hertz portion of the normal ATOC transmission spectrum. Broadband levels are the total power over a specified bandwidth or portion of the spectrum emitted by a sound source; in Figure A-1, for example, the broadband power level would be equivalent to the total area under the spectral curve. This is the reason why the ATOC source has a peak spectral value of approximately 180 dB, and a total power level of 195 dB.

Given the potential for confusion, this EIS generally avoids cross-media comparisons between air and water. All sound values presented in this EIS are water-standard values unless otherwise specified.

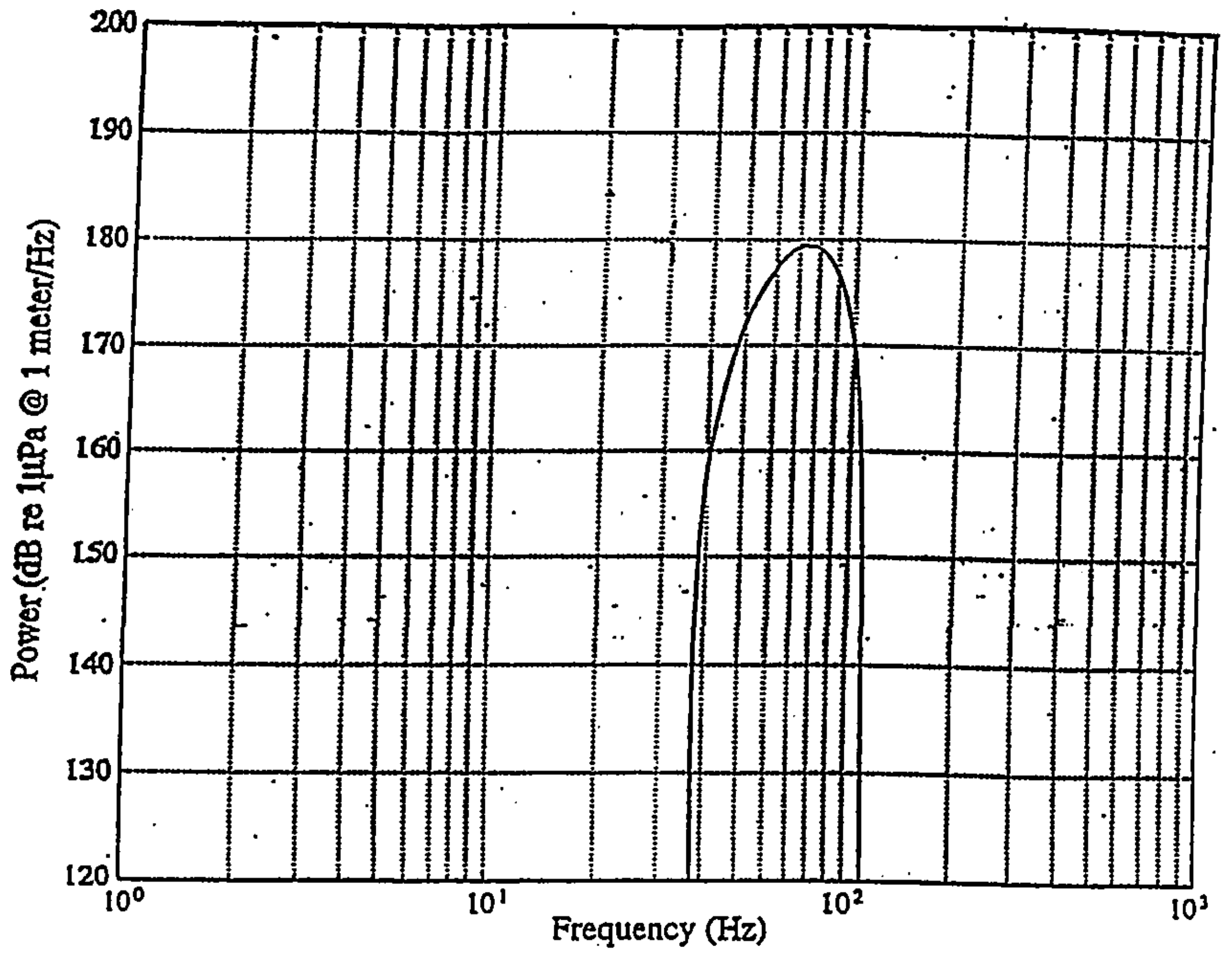


Figure A-1 Kauai Source Power Density Spectrum

APPENDIX B

CORRESPONDENCE

THIS PAGE INTENTIONALLY LEFT BLANK

Correspondence Letters Included In Appendix B

Date	From	To	Regarding	Page
1 Jun 1999	Dr. Jeffrey Simmen, ONR	Ms. Hilda Diaz-Soltero, Office of Protected Resource, NMFS	Invitation for NMFS to become a cooperating agency in preparation of EIS	B-3
13 Oct 1999	Mr. Donald R. Knowles, Office of Protected Resources, NMFS	Dr. Jeffrey Simmen, ONR	NMFS agrees to be a fully cooperating agency in preparation of the EIS	B-5
1 Oct 1999	Dr. Jeffrey Simmen, ONR	Mr. Donald R. Knowles, Office of Protected Resources, NMFS	Requesting compilation of listed, proposed, and candidate threatened and endangered species for Section 7 consultation	B-7
7 Feb 2000	Mr. Donald R. Knowles, Office of Protected Resources, NMFS	Dr. Jeffrey Simmen, ONR	Provided compilation of listed, proposed, and candidate threatened and endangered species for Section 7 consultation	B-8
2 Mar 2000	Ms. Dee M. Crowell, Planning Director, County of Kauai	Dr. Peter Worcester, Scripps	Proposed NPAL project does not require a County of Kauai Special Management Area permit	B-11
2 Jun 1999	Dr. Peter Worcester, Scripps	Ms. Maryanne Kusaka, Mayor of Kauai	Requesting county confirmation that proposed NPAL project would not implicate any elements of the county general plan or development plans or require a Special Management Area permit	B-13
1 Dec 1999	Dr. Peter Worcester, Scripps	Ms. Maryanne Kusaka, Mayor of Kauai	Requesting county confirmation that proposed NPAL project would not implicate any elements of the county general plan or development plans or require a Special Management Area permit	B-17
16 May 2000	Dr. Peter Worcester, Scripps	Mr. Denis R. Lau, Clean Water Branch, Department of Health	The State's water quality certification process applicability to the proposed NPAL project	B-19

24 May 2000	Ms. Mary L. Hudson, Attorney at Law for Scripps	Mr. George Young, Operations Branch, U.S. Army Corps of Engineers	Applicability of the Rivers and Harbors Act and Section 404 of the Clean Water Act to the proposed NPAL project	B-21
16 Jun 2000	Mr. George P. Young, Regulatory Branch, Department of the Army	Dr. Peter Worcester, Scripps	Department of the Army permit not required for the Preferred Alternative described in the NPAL EIS	B-23
16 Aug 2000	Mr. Gary Gill, Department of Heath, State of Hawaii	Dr. Peter Worcester, Scripps	No comments on NPAL DEIS	B-24
14 Jul 2000	Mr. Don Hibbard, State Historic Preservation Officer, DLNR, State of Hawaii	Dr. Peter Worcester, Scripps	Concur with "no effects" on significant historic sites, as detailed in NPAL DEIS	B-25
27 Jun 2000	Mr. Ernest Y. W. Lau, Department of Water, County of Kauai	Dr. Peter Worcester, Scripps	No comments on NPAL DEIS	B-26
21 Jul 2000	Ms. Cheryl D. Soon, Department of Transportation Services, City and County of Honolulu	Dr. Peter Worcester, Scripps	No comments on NPAL DEIS	B-27
23 Jun 2000	Dr. Jeffrey Simmen, ONR	Mr. Donald R. Knowles, Office of Protected Resources, NMFS	ONR submits Biological Assessment; requests initiation of formal consultation under Section 7 of the ESA	B-28

DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
800 NORTH QUINCY STREET
ARLINGTON, VA 22217-5660

IN REPLY REFER TO

Ser 53
1 JUNE 99

Ms. Hilda Diaz-Soltero
Director, Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway, SSMC #3
Silver Spring, MD 20910

Dear Ms. Diaz-Soltero:

The Office of Naval Research, in conjunction with the University of California, San Diego, Scripps Institution of Oceanography is in the process of preparing an environmental impact statement (EIS) in connection with the proposed continued operation of the Kauai acoustic sound source installed by the Acoustic Thermometry of Ocean Climate (ATOC) Project. The source is located approximately 8 nm north of Kauai, mounted on the seafloor at a depth of 807 meters. In accordance with discussions between NMFS Ken Hollingshead and Scripps representatives on April 8, 1999, Scripps will also be requesting a Letter of Authorization to incidentally harass a small number of marine mammals in the vicinity of the project.

Scripps currently has the permits and authorizations necessary to continue source operations through October 1999. At that time, the source will have been in operation for approximately two years, providing a unique time series of acoustic signal receptions.

During the two year feasibility period, the associated Marine Mammal Research Program ((MMRP) has studied the possible effects of the sound source on the relative abundance, distribution and behavior of the humpback whales in the surrounding area. Results from the studies indicate that there were no acute short-term effects of the transmissions on marine mammals, and that the effects that were detected were not believed to be biologically significant.

In preparation for the task ahead, ONR would like to formalize the working relationship with NMFS with respect to the preparation of the EIS for the continuation of the Kauai sound source. ONR therefore invites NMFS to become a "cooperating agency," under 40 CFR 1501.6, for the preparation of the EIS. We also request that you designate one or more persons to serve as point(s) of contact with ONR and Scripps in the upcoming process. Ideally, that person would be available over the next year, by which time we hope to complete a record of decision in this matter.

ONR and Scripps also recognize that an Endangered Species Act consultation may be necessary. We look forward to NMFS assistance in determining the appropriate scope and timing of any such consultation, if necessary.

Ser 53
1 JUNE 99
Page Two

We appreciate your cooperation in this matter. If you have any questions regarding the proposed research, feel free to contact Dr. Peter Worcester (SIO) at (619) 534-4688 or Dr. Jeff Simmen (ONR) at (703) 696-4204.

Sincerely,

Jeff Simmen

Cc: Peter Worcester, SIO

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, Maryland 20910

OCT 13 1999

Mr. Jeff Simmen
Department of the Navy
Office of Naval Research
800 North Quincy Street
Arlington, Virginia 22217

COPY FOR YOUR INFORMATION

Dear Mr. Simmen:

Thank you for your letter requesting the National Marine Fisheries Service (NMFS) to participate as 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 proposed continued operation of the Kauai acoustic sound source installed by the Acoustic Thermometry of Ocean Climate (ATOC) Project.

We support the Office of Naval Research's (ONR) determination to prepare a DEIS on this activity and agree to be a cooperating agency in the preparation of the DEIS. In cooperating with ONR on this activity, NMFS will have several roles, including (1) to provide the documentation on marine mammals and endangered marine species necessary for completion of the DEIS, (2) to review and comment during the document's preparation, and (3) to issue an incidental small take authorization under section 101(a)(5)(A) of the Marine mammal Protection Act (MMPA). NMFS will also consult with ONR for this activity under section 7 of the Endangered Species Act (ESA).

NMFS agrees to be a fully cooperating agency in the preparation of the DEIS, however, because of our regulatory role under the MMPA and ESA, 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 the document when it is released to the general public, and to provide ONR with comments at that time, if appropriate.

2

If you have questions or need additional information, please contact Mr. Kenneth Hollingshead, at (301) 713-2055, extension 128.

Sincerely,

Don Knowles

Donald R. Knowles
Director
Office of Protected Resources

3

cc: F/PR; F/PR(R); F/PR2-Hollingshead
PR2:KEN:301/713-2055:10/13/99:PH:G\PR2\KEM\JEFFSIMMEN.LTR

DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
800 NORTH QUINCY STREET
ARLINGTON, VA 22217-5660

IN REPLY REFER TO
5000
Ser 321/288/99
01 October 1999

Mr. Donald R. Knowles
Director, Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20901

Dear Mr. Knowles,

The Office of Naval Research (ONR) is in the process of preparing an environmental impact statement (EIS) in connection with the continued operation of the sound source installed by the Acoustic Thermometry of Ocean Climate (ATOC) project. This sound source is located approximately 8 nautical miles (14.8 kilometers) north of Kauai at 22°20.94'N, 159°34.18'W, in the central Pacific Ocean. The National Marine Fisheries Service (NMFS) has been requested to be a cooperating agency under 40 CFR 1501.6 for the preparation of this EIS.

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 needed for an area surrounding the sound source location (noted above). We would appreciate getting the above information by 1 November 1999, if possible, so that we can keep the EIS process on schedule.

If you have any questions or comments, please contact me at 703-696-4204 or (by e-mail) at simmenj@onr.navy.mil.

Sincerely,

Jeffrey Simmen

DR. JEFFREY SIMMEN
Program Manager
Ocean Acoustics Program

Copy to:
Scripps Institution of Oceanography (Dr. Peter Worcester, Ms. Susie Pike)
MAI (C. Spikes, K. Vigness)

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, Maryland 20910

FEB 7 2000

Dr. Jeffrey Simmen
Program Manager
Ocean Acoustics Program
Office of Naval Research
Department of the Navy
800 North Quincy Street
Arlington Virginia 22217-5660

Dear Dr. Simmen:

This responds to your letter requesting, pursuant to Section 7 of the Endangered Species Act (ESA), assistance in providing compilations of listed, proposed, and candidate threatened and endangered species under the jurisdiction of the National Marine Fisheries Service (NMFS), including known temporal and spatial movements; and compilations of designated or proposed critical habitats for these listed species. The project under consideration by the Office of Naval Research (ONR) is the continued operation of the sound source installed by the Acoustic Thermometry of Ocean Climate (ATOC) Project. In that regard, we understand that ONR is in the process of preparing an environmental impact statement (EIS) in connection with this project.

NMFS data indicates that the following listed species may occur in the project area (8 nautical miles north of Kauai, HI).

<u>List of Species That May Occur in the Project Area</u>

Common Name	Scientific Name	Status
Fin whale	Balaenoptera physalus	E
Humpback whale	Megaptera novaeangliae	E
Sperm whale	Physeter macrocephalis	E
Blue whale	Balaenoptera musculus	E
Hawaiian monk seal	Monachus schauinslandi	E
Leatherback sea turtle	Dermochelys coriacea	E
Olive ridley sea turtle	Lepidochelys olivacea	E
Green sea turtle	Chelonia mydas	E
Loggerhead sea turtle	Caretta caretta	T
Hawksbill turtle	Eretmochelys imbricata	E
Critical Habitat		
Hawaiian monk seal	Monachus schauinslandi	E

There are no proposed or candidate species in the area of your project nor is there any proposed critical habitat.

The additional information that you have requested regarding known temporal and spatial movements and other biological information can be found in two documents written previously on the ATOC source. These include a final EIS on the Kauai Source (Advanced Research Projects Agency and NMFS, 1995) and the 1995 Biological Opinion on funding the Kauai source and the issuance of a Scientific Research Permit under section 104 of the Marine Mammal Protection Act (enclosed).

If you have any questions regarding statements made in this letter please contact Mr. Craig Johnson or Mr. Kenneth Hollingshead of my staff. They can be contacted at 301-713-1401 and 301-713-2055, ext 128, respectively.

Sincerely,

Don Knowles

Donald R. Knowles
Director
Office of Protected Resources

Enclosure

THIS PAGE INTENTIONALLY LEFT BLANK

MARYANNE W. KUSAKA
MAYOR

DEE M. CROWELL
PLANNING DIRECTOR

SHEILAH N. MIYAKE
DEPUTY PLANNING DIRECTOR

TELEPHONE (808) 241-6677
FAX (808) 241-6699

PLANNING DEPARTMENT

March 2, 2000

University of California, San Diego
Scripps Institution of Oceanography
ATOC Project Office
IGPP 0225
La Jolla, CA 92093-0225

Attention: Peter Worcester

Subject: Special Management Area (SMA) Requirements
Acoustic Thermometry of Ocean Climate (ATOC) Project
Hanalei, Kauai, Hawaii

Dear Mr. Worcester:

This letter is being sent to confirm that the proposed second phase of the ATOC project as described in your letter dated December 1, 1999 (attached) will not require a County of Kauai SMA Permit. According to your letter the second phase will use the existing ATOC source and cable located approximately eight miles off the north shore of Kauai, and would not require additional construction or equipment installation. Twenty minute transmissions would be conducted every four hours, one day out of four.

Since the project will be located in ocean waters, makai of the shoreline, an SMA Permit or other approvals from our office will not be required. However, as noted in the attached January 4, 1995 letter to the State Department of Land and Natural Resources regarding phase I of the project, the potential impacts of the sound transmissions on marine life are of concern.

Please contact George Kalisik of my staff at 241-6677 if you have any questions.

Sincerely,

Dee M. Crowell
Planning Director

Kapule Building • 4444 Rice Street, Suite 473 • Lihu'e, Kaua'i, Hawai'i 96766
AN EQUAL OPPORTUNITY EMPLOYER

MARYANNE W. KUSAKA
XXXXXXXXXXXXXXXX
MAYOR

COUNTY OF KAUAI
PLANNING DEPARTMENT
4444 RICE STREET, SUITE 473
LIHUE, KAUAI, HAWAII 96766

DEE M. CROWELL
PLANNING DIRECTOR

XXXXXXXXXXXX
DEPUTY PLANNING DIRECTOR

TELEPHONE (808) 241-6677
FAX (808) 241-6699

January 4, 1995

State of Hawaii
Department of Land and Natural Resources - OCEA
P. O. Box 621
Honolulu, HI 96809

Attention: Roy Schaefer

Subject: Conservation District Use Application KA-2734
Acoustic Thermometry of Ocean Climate (ATOC)
Offshore, North Shore, Kauai

Thank you for the opportunity to comment on the above referenced application. The project will be located in ocean waters makai of the shoreline, and therefore outside of the County of Kauai Special Management Area (SMA). An SMA Permit will not be required.

Although the project will be located outside of the SMA, we are concerned with the potential impacts of the sound transmissions on marine life. It is noted that the Marine Mammal Research Program will evaluate the potential effects of the transmissions on marine mammals and sea turtles. Impacts on other marine life also should be considered. If significant adverse impacts on marine life are noted, mitigation measures should be provided, or the project should be reevaluated.

Please contact George Kalisik of my staff at 241-6677 if you have any questions.

Sincerely,

Dee M. Crowell
Planning Director

c: Andrew Forbes, Scripps Institution of Oceanography

UNIVERSITY OF CALIFORNIA, SAN DIEGO

UCSD

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO

SANTA BARBARA • SANTA CRUZ

CECIL H. AND IDA M. GREEN
INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS
SCRIPPS INSTITUTION OF OCEANOGRAPHY
LA JOLLA, CALIFORNIA 92093-0225

TELEPHONE: (619) 534-4688
FAX: (619) 534-6251
E-MAIL: pworcester@ucsd.edu

June 2, 1999

Mayor Maryanne Kusaka
4444 Rice Street, Suite 235
Lihue, Kauai, HI 96766

Subject: Acoustic Thermometry of Ocean Climate (ATOC) Project

Dear Ms. Kusaka,

I'm writing to bring you up-to-date on the status of and plans for the future of the ATOC project. As you may remember, in 1996 we were granted a DLNR Conservation District Use Permit (KA-2734), which allowed ATOC source transmissions through February 23, 1999, with an additional six months to remove the cable. We also received a DLNR Land Division Revocable Permit (No. S-7048), which operates concurrently with the CDUP. In November 1998, the Board of Land & Natural Resources approved an amendment to the CDUP allowing source transmissions through October 31, 1999 so that the ATOC Marine Mammal Research Program (MMRP) could complete 24 months of research as originally proposed. Therefore, as the expiration of the permits and the end of the first phase of the feasibility study nears, we wanted to provide you with the latest information about the project's findings and our plans.

We now have hard data on the precision with which acoustic methods can be used to measure changes in ocean temperature and heat content, as well as on the effects of the acoustic sources on marine mammals and other marine life. We have found that we can measure acoustic travel times much more accurately than anticipated, and have already used some of the thermometry data in conjunction with satellite altimetry data and found them to be complementary in providing important independent information on ocean structure and circulation. Relating to the effects on marine mammals, the MMRP has not observed any obvious or acute responses to the operational ATOC sound. They have found small changes in the distribution of humpbacks and sperm whales around the Pioneer Seamount source and a slight increase in the distance and time between successive surfacings of humpbacks close to the Kauai source with increasing sound levels, however these effects were found only after intensive statistical analysis and are not believed to represent biologically significant responses. Currently, no other statistically significant effects associated with source operations have been detected in any of the MMRP research efforts, including the aerial surveys and elephant seal work off California, the playback of ATOC-like sounds to humpbacks off the Kona-Kohala coast, the pilot study north of

Kauai during the 1997–1998 humpback season, and the playbacks to fish at the Bodega Bay Marine Laboratory.

Based upon the results that we have obtained to-date, we are now in a vastly different position than when the ATOC project first began, and have decided to seek the new permits needed to allow us to continue to operate the Kauai source for an additional five years. We view this extension of the research period as the second phase of the ATOC feasibility study. This phase, which requires a longer time series of data, will allow us to study seasonal and internal variability associated with a variety of oceanographic phenomena, such as El Nino/La Nina and to constrain and test ocean circulation models. This phase will make use of the existing ATOC source and cable located approximately eight miles off the north shore of Kauai, and would not require additional construction or equipment installation. We envision using roughly the same 2% duty cycle that we used during the first phase, which consists of 20-minute transmissions, preceded by a 5-minute ramp-up, every four hours on one day out of four.

We are just beginning the environmental review process, which will include the preparation of an EIS/EIR. We tentatively plan to seek a Letter of Authorization from the National Marine Fisheries Service to allow incidental harassment of small numbers of marine mammals over the five-year period in connection with the operation of the source. In addition, we plan to seek a CDUP from DLNR to allow us to leave the cable in place on State Submerged Lands.

As we begin preparation of our Conservation District Use Permit application, we are requesting county confirmation that the proposal will not implicate any elements of the county general plan or development plans or require a Special Management Area permit. As before, the project will be located entirely outside the County of Kauai Special Management Area. (See attached letter dated January 4, 1995.)

I have enclosed a reprint of an article published in Scripps Institution of Oceanography's Explorations magazine, entitled "Listening to the Ocean's Temperature," that I thought you might find interesting. It appears that I will be in Hawaii for meetings during the week of June 28 and would like to meet with you at that time, if possible. I will try and contact you in the near future to see if we can arrange such a meeting. In the meantime, please feel free to call me at (619) 534-4688 if you have any questions or would like any additional information.

Sincerely yours,

Peter Worcester
Research Oceanographer
ATOC Principal Investigator

Enclosures

cc: D. Crowell, Planning Director
J. Mercer, APL
C. Spikes, K. Vigness, MAI
M. Hudson, D. Ing, A. Waltner

THIS PAGE INTENTIONALLY LEFT BLANK

UNIVERSITY OF CALIFORNIA, SAN DIEGO

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO   SANTA BARBARA • SANTA CRUZ

CECIL H. AND IDA M. GREEN
INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS
SCRIPPS INSTITUTION OF OCEANOGRAPHY (0225)

LA JOLLA, CALIFORNIA 92093-0225

December 1, 1999

Mayor Maryanne Kusaka
4444 Rice Street, Suite 235
Lihue, Kauai, HI 96766

Subject: Acoustic Thermometry of Ocean Climate (ATOC) Project

Dear Ms. Kusaka,

I'm writing to follow up on our June 2, 1999 letter and our June 30, 1999 meeting regarding the plans for the future of the ATOC project.

As discussed in our meeting, based upon the research results that we have obtained to-date, we have decided to seek the new permits needed to allow us to continue to operate the Kauai source for an additional five years. This second phase will make use of the existing ATOC source and cable located approximately eight miles off the north shore of Kauai, and would not require additional construction or equipment installation. We envision using roughly the same 2% duty cycle that we used during the first phase, which consists of 20-minute transmissions, preceded by a 5-minute ramp-up, every four hours on one day out of four.

We began the environmental review process with the submission of a Conservation District Use Permit (CDUP) application on June 21, 1999. The application was accepted on July 26, 1999 and we are currently in the process of preparing an EIS/EIR. As previously requested in our June 2, 1999 letter, and in accordance with the provisions of Chapter 205A, HRS relating to the Special Management Area (SMA) requirements, we are requesting written confirmation that the proposal will not implicate any elements of the county general plan or development plans or require a Special Management Area permit. As before, the project will be located entirely outside the County of Kauai Special Management Area. (See attached letter dated January 4, 1995.)

Your cooperation in this matter would be greatly appreciated. If you have any questions, please feel free to contact me at (858) 534-4688.

Sincerely yours,

Peter Worcester
Research Oceanographer
ATOC Principal Investigator

Enclosure

cc: D. Crowell, Planning Director
J. Mercer, APL
C. Spikes, K. Vigness, MAI
M. Hudson, D. Ing,

UNIVERSITY OF CALIFORNIA, SAN DIEGO

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO — SANTA BARBARA • SANTA CRUZ

CECIL H. AND IDA M. GREEN
INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS
SCRIPPS INSTITUTION OF OCEANOGRAPHY (0225)

LA JOLLA, CALIFORNIA 92093-0225

May 16, 2000

Denis R. Lau, Chief
Clean Water Branch
Department of Health
919 Ala Moana Blvd.
Honolulu, HI 96814

Re: Scripps Institution of Oceanography, University of California, San Diego
North Pacific Acoustic Laboratory Project

Dear Mr. Lau:

I am writing to apprise you of the current proposal by Scripps Institution of Oceanography, University of California, San Diego to carry out additional research using the low frequency sound source and power cable previously installed in ocean waters off Kauai in connection with the Acoustic Thermometry of Ocean Climate (ATOC) project.

The current project, known as the North Pacific Acoustic Laboratory (NPAL), will be funded by the Office of Naval Research (ONR) and carried out by Scripps in conjunction with the Applied Physics Laboratory of the University of Washington. The NPAL project involves the continued operation of the sound source for an additional five years in order to perform (1) the second phase of research on the feasibility and value of large-scale acoustic thermometry; (2) long-range underwater sound transmission studies; and (3) studies on the possible long-term effects of the sound transmissions on marine life. The sound transmissions will adhere to approximately the same transmission parameters as in the ATOC work. The research will be carried out under incidental take authorizations pursuant to the federal Marine Mammal Protection Act and the Endangered Species Act.

The NPAL project will not involve installation of any new equipment, modification of the existing equipment, or discharge of any fill into the ocean. Accordingly, the project will require no permit under either the Rivers and Harbors Act or Section 404 of the Clean Water Act. We are enclosing a copy of our correspondence with the U. S. Army Corps of Engineers confirming these points. In the absence of any such permits, we understand that the State's water quality certification process will not apply to the project. This conclusion is in keeping with discussions between our attorney, Mary Hudson, and Mr. Larry Lau of the Office of the Attorney General, who is being provided with a copy of this letter.

A joint state-federal EIS is being prepared by ONR, as lead federal agency, and Scripps, as applicant to the Department of Land and Natural Resources for a Conservation District Use Permit. The draft EIS is expected to be published in the near future and will be sent to your office for review and comment.

Please feel free to contact me if you have any questions or would like to discuss the NPAL project. I can be reached at (858) 543-4688.

Sincerely,

Peter Worcester
Research Oceanographer

Enclosure

Distribution:
Larry Lau, OAG
G. Young, ACOE
J. Nakagawa, HCZMP
J. Simmen, I. Sustersic, ONR
C. Presmyk, UCSD
J. Mobley, UH
A. Waltner, UCGC
M Hudson, D. Ing

Mary L. Hudson
ATTORNEY AT LAW

May 24, 2000

George Young, Chief, Operations Branch
U.S. Army Corps of Engineers, Honolulu Branch
Building 230
Ft. Shafter, HI 96858-5440

Re: Scripps Institution of Oceanography: North Pacific Acoustic Laboratory Project

Dear Mr. Young:

This letter follows up on our telephone conversation of 4 February 2000 concerning the proposal by the Scripps Institution of Oceanography, University of California, to carry out the North Pacific Acoustic Laboratory (NPAL) project in ocean waters off the north shore of Kauai. The proposed action involves retaining in place and reusing the seabed power cable and sound source previously installed and used by the Acoustic Thermometry of Ocean Climate (ATOC) project. The NPAL project would continue operation of the sound source for an additional five years in order to perform (1) the second phase of research on the feasibility and value of large-scale acoustic thermometry; (2) long-range underwater sound transmission studies; and (3) studies on the possible long-term effects of the sound transmission on marine life. At the conclusion of the five-year period, the seabed power cable, and possibly the sound source, would be abandoned in place.

The acoustic source is located approximately 8 nm north of Hanalei Kauai, at a depth of 2,648 feet. The subsea power cable runs from the source approximately 27 nm around the west side of the island and connects to a preexisting seashore cable interface 0.7 nm offshore from the Pacific Marine Research Facility at Barking Sands. Installation of this equipment was carried out in 19993-95 pursuant to nationwide permits # 5 and # 6, issued under Section 10 of the Rivers and Harbors Act.

The NPAL project will not involve installation of underwater equipment or modification or moving of the existing equipment described above. The project will not involve and backfill, bedding, or other in-water construction activities. Nor will it involve any discharge of fill into the ocean. In the absence of any such activities, it is understanding, based upon my review of relevant permit authorities and my discussion with you, that neither NWP 5 nor NOW 6 apply to the NPAL project. Similarly, none of the other nationwide permits issued under the Rivers and Harbors Act and Section 404 of the Clean Water Act applies to the NPAL project.

436 14th Street, Suite 1300, Oakland, California 94612 □ (510) 465-4494 □ Fax (510) 496-3311

Scripps, and its funding agency, Office of Naval Research (ONR), are in the process of meeting various regulatory requirements. Scripps and ONR are preparing a joint state-federal EIS. Release of the draft EIS is anticipated in the very near future, and your office will be provided with a copy. At the federal level, Scripps will be applying to National Marine Fisheries Service (NMFS) for a permit for incidental take through harassment of a small number of marine mammals, under the Marine Mammal Protection Act (16 U.S.C. section 1371 (a)(5)(D). Consultation between NMFS and ONR is anticipated under Section 7 of the Endangered Species Act.

At the state level, Scripps has applied for a conservation district use permit from the Department of Land and Natural Resources (DLNR). Consultation with DLNR's Office of Historic Resources Preservation has been carried out. No affected resources were identified. As with the earlier ATOC project, in the absence of a federal permit under Section 404 of the Clean Water Act, the State's water quality certification requirements under Section 401, administered by the Department of Health, do not apply. The application for incidental take authorization under the MMPA does trigger federal consistency review under the Federal Coastal Zone Management Act, and Scripps is preparing a consistency certification for review by the Hawaii Coastal Zone Management Program.

If you have any questions or would like to discuss this matter further, please call me at the number below or contact Susie Pike in the NPAL project office (858) 534-8031. Thank you for your assistance.

Sincerely,

Mary L. Hudson,
For Scripps Institution of Oceanography

cc: Dennis Lau, DOH
Larry Lau, AG
John Nakagawa, HCZMP

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FORT SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF

June 16, 2000

Regulatory Branch

Dr. Peter Worchester
University of California, San Diego
Scripps Institution of Oceanography
9500 Gilman Drive, IGPP 0225
La Jolla, CA 92093

Dear Dr. Worchester:

This letter responds to your request for a review of the Draft Environmental Impact Statement (DEIS) titled *North Pacific Acoustic Laboratory*, dated May 2000. Based on the information provided in the DEIS I have determined that a Department of the Army permit will not be required for this project if the Kauai preferred alternative is selected, since there will be no construction in the navigable waters of the United States. If however the Midway Atoll alternative is selected, a Department of the Army permit will be required from the U.S. Army Corps of Engineers, Honolulu Engineer District for any in-water construction, including laying cable.

If you have any questions concerning this matter, please contact William Lennan of my staff at (808)438-6986 or FAX (808)438-4060 and reference File No. 200000214.

Sincerely,

for George P. Young, P.E.
Chief, Regulatory Branch

Copies Furnished:
Office of Environmental Quality Control, 235 South Beretania, Suite 702, Honolulu, Hawaii 96813
Department of Land and Natural Resources, P.O. Box 621, Honolulu, Hawaii 96809, Attn: Tom Eisen
Marine Acoustics, Inc., 809 Aquidneck Avenue, Middletown, RI 02842, Attn: Kathleen Vigness Raposa

BENJAMIN J. CAYETANO
GOVERNOR OF HAWAII

BRUCE S. ANDERSON, Ph.D., M.P.H.
DIRECTOR OF HEALTH

STATE OF HAWAII
DEPARTMENT OF HEALTH
P.O. BOX 3378
HONOLULU, HAWAII 96801

In reply, please refer to:
File:

August 16, 2000

00-112/epo

Dr. Peter Worcester
Research Oceanographer
University of California, San Diego
Scripps Institution of Oceanography
9500 Gilman Drive
IGPP 0225
La Jolla, California 92093

Dear Dr. Worcester:

Subject: Draft Environmental Impact Statement (DEIS)
North Pacific Acoustic Laboratory
Kauai, Hawaii

Thank you for allowing us to review and comment on the subject document. We do not have any comments to offer at this time.

Sincerely,

GARY GILL
Deputy Director
Environmental Health Administration

c: OEQC
DLNR
Marine Acoustics, Inc.

BENJAMIN J. CAYETANO
GOVERNOR OF HAWAII

STATE OF HAWAII

DEPARTMENT OF LAND AND NATURAL RESOURCES

HISTORIC PRESERVATION DIVISION
Kakuhihewa Building, Room 555
601 Kamokila Boulevard
Kapolei, Hawaii 96707

TIMOTHY E. JOHNS, CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTIES
JANET E. KAWELO

AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
CONSERVATION AND RESOURCES
ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
LAND
STATE PARKS
WATER RESOURCE MANAGEMENT

July 14, 2000

Dr. Peter Worester
University Of California, San Diego
Scripps Institution of Oceanography
9500 Gilman Drive
IGPP 0225
La Jolla, California 92093

LOG NO:25779 ✓
DOC NO: 0007NM04

Dear Dr. Worester:

SUBJECT: National Historic Preservation Act Review, Section 106 Compliance--Draft EIS North Pacific Laboratory and Appendix B and D (UCSD-Scripps Institution of Oceanography) Kauai

Thank you for the submission of the DEIS. We agree with the DEIS, that no known shipwrecks exist in the project area. Since no construction will take place on land and, existing buildings will be used, then the project will have no adverse effect on significant historic sites. If subsurface activity is required, then mitigation will be required. If the underwater work, discovers inadvertent historic sites, all work will stop in the immediate area. The State Historic Preservation Office should be contacted at (808) 742-7033, so that appropriate mitigation action can be taken. Therefore, we concur with your "no effect" determinations for this project.

If you have any questions, please call Nancy McMahon 742-7033.

Aloha,

DON HIBBARD, Administrator
State Historic Preservation Officer

NM:dnm

c: Tom Eisen, DLNR
Kathleen Vigness Raposa, Marine Acoustics, Inc. 809 Aquidneck Ave, Middeltown, RI 02842
National Oceanic and Atmospheric Administration, National Marine Fisheries Service, 1315 East-West Highway, Silver Spring, MD 20910

DEPARTMENT OF WATER

County of Kauai

"Water has no Substitute -- Conserve It!"

June 27, 2000

University of California, San Diego
Scripps Institution of Oceanography
9500 Gilman Drive
IGPP 0225
La Jolla, CA 92093

Dear Dr. Worcester:

Subject: Draft Environmental Impact Statement (DEIS) for North Pacific Acoustic Laboratory, formerly the Acoustic Thermometry of Ocean Climate Project, Phase II, Location Kauai, Hawaii

We have no comments to this DEIS.

Sincerely,

for/ Ernest Y. W. Lau
Manager & Chief Engineer

cc: OEQC
DLNR, Tom Eisen
Marine Acoustics, Inc., Kathleen Vigness Raposa

KA/san
D\san\docs\wrp\aoki\ea-undrwtr_acousics

— 4398 Pua Loke Street, Lihue, Kauai, Hawaii or P. O. Box 1706, Lihue, HI 96766-5706 —
Phone No. (808) 245-5400 – Administration FAX No. (808) 246-8628 – Engineering/Fiscal/Shop FAX No. (808) 245-5813

DEPARTMENT OF TRANSPORTATION SERVICES
CITY AND COUNTY OF HONOLULU
PACIFIC PARK PLAZA • 711 KAPIOLANI BOULEVARD, SUITE 1200 • HONOLULU, HAWAII 96813
TELEPHONE: (808) 523-4529 • FAX: (808) 523-4730

JEREMY HARRIS
MAYOR

CHERYL D. SOON
DIRECTOR

JOSEPH M. MAGALDI, JR.
DEPUTY DIRECTOR

TPD6/00-02776R/02856R
TPD6/00-03218R

July 21, 2000

Dr. Peter Worcester
University of California, San Diego
Scripps Institution of Oceanography
9500 Gilman Drive
IGPP 0225
La Jolla, California 92093

Dear Dr. Worcester:

Subject: North Pacific Acoustic Laboratory

In response to your letters, the draft environmental impact statement and two addenda prepared for the subject project were reviewed. We do not have any comments regarding these documents.

Should you have any questions regarding this matter, please contact Faith Miyamoto of the Transportation Planning Division at (808) 527-6976.

Sincerely,

CHERYL D. SOON
Director

cc: Mr. Tom Eisen, Department of Land and Natural Resources
Ms. Kathleen Vigness Raposa, Marine Acoustics, Inc.

DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
800 NORTH QUINCY STREET
ARLINGTON, VA 22217-5660

IN REPLY REFER TO

Ser 110
23 June 2000

From: Office of Naval Research
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 NORTH PACIFIC ACOUSTIC LABORATORY

Ref: (a) Draft Environmental Impact Statement for the North Pacific Acoustic Laboratory (NPAL), May 2000

Encl: (1) Biological Assessment for the North Pacific Acoustic Laboratory

1. The Office of Naval Research (ONR) requests initiation of formal consultation under Section 7 of the Endangered Species Act for the continued operation for five additional years of the low frequency sound source (including the seabed power cable) previously installed off the north shore of Kauai, Hawaii, for use in Acoustic Thermometry of Ocean Climate (ATOC) research as described in Enclosure (1). The enclosed Biological Assessment details 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. NPAL is an ONR basic research project that would combine the following three components: (1) a second phase of research on the feasibility and value of large-scale acoustic thermometry; (2) long-range underwater sound transmission studies; and (3) marine mammal monitoring and studies. Under the proposed action, the seabed power cable and sound source would remain in their present locations, and transmissions would continue with approximately the same signal parameters and transmission schedule used in the ATOC project. At the conclusion of the five-year period, the seabed power cable would be abandoned in place. The source would be abandoned in place as well, unless it appeared to still be in sufficiently good condition to warrant recovery. The proposed action would be conducted by Scripps Institution of Oceanography of the University of California, San Diego, which carried out the first phase of ATOC feasibility research, and by the Applied Physics Laboratory of the University of Washington. Funding would be provided by ONR.

Ser 110
23 June 00
Page Two

3. We look forward to receiving your Biological Opinion on this project. Please direct all inquiries regarding this request to Dr. Jeffrey Simmen at (703) 696-4204.

Dr. Jeffrey Simmen

Jeffrey Simmen

Ocean Acoustics Program
Office of Naval Research

cc: Peter Worcester

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX C

PUBLIC LIBRARY DISTRIBUTION LIST

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX C

PUBLIC LIBRARY DISTRIBUTION LIST

In connection with the previous Kauai ATOC project and its associated Marine Mammal Research Program (MMRP), a joint federal/state final EIS (May 1995) was prepared by the Advanced Research Projects Agency and NMFS (ARPA and NMFS, 1995b) and accepted by the Hawaii DLNR. Another federal/state final EIS/Environmental Impact Report (EIR) (ARPA and NMFS, 1995a) was prepared for the California ATOC project and its MMRP (April 1995). Copies of these earlier documents are available at the following locations:

Aina Haina Public Library
5246 Kalanianaole Highway
Honolulu, HI 96821

Hawaii Kai Public Library
249 Lunalilo Home Rd.
Honolulu, HI 96825

Hawaii State Library
Hawaii Documents Center
478 South King St.
Honolulu, HI 96813

Kaimuki Public Library
1041 Koko Head Ave.
Honolulu, HI 96816

Kailua Public Library
239 Kuulei Rd.
Kailua, HI 96734

Kalihi-Palama Public Library
1325 Kalihi St.
Honolulu, HI 96819

Kaneohe Public Library
45-829 Kamehameha Highway
Kaneohe, HI 96744

Library for the Blind & Physically Handicapped
402 Kapahulu Ave.
Honolulu, HI 96815

McCully-Moiliili Public Library
2211 South King St.
Honolulu, HI 96826

Pearl City Public Library
1138 Waimano Home Rd.
Pearl City, HI 96782

Salt Lake-Moanalua Public Library
648 Ala Lilikoi St.
Honolulu, HI 96818

Waikiki-Kapahulu Public Library
400 Kapahulu Ave.
Honolulu, HI 96815

University of Hawaii
Hamilton Library
2559 The Mall
Honolulu, HI 96822

Hilo Public Library
300 Waianuenue
Hilo, HI 96720

Kahului Public Library
90 School St.
Kahului, HI 96732

Kailua-Kona Public Library
75-I38 Hualalai Rd
Kailua-Kona, HI 96740

Liliha Public Library
1515 Liliha St.
Honolulu, HI 96817

Manoa Public Library
2716 Woodlawn Dr.
Honolulu, HI 96822

Wailuku Public Library
251 High St.
Wailuku, HI 96793

Kapaa Public Library
1464 Kuhio Highway
Kapaa, HI 96746

Lihue Public Library
4344 Hardy St.
Lihue, HI 96766

Lanai Public & School Library
P.O. Box 550
Lanai City, HI 96763

~~Hanapepe Public Library~~
~~P.O. Box B~~
~~Hanapepe, HI 96716~~

~~Kapaa Public Library~~
~~1464 Kuhio Highway~~
~~Kapaa, HI 96746~~

~~Lihue Public Library~~
~~4344 Hardy St.~~
~~Lihue, HI 96766~~

~~Molokai Public Library~~
~~P.O. Box 395~~
~~Kaunakakai, HI 96748~~

Kihei Public Library
35 Waimahaihai St.
Kihei, HI 96753

Lahaina Public Library
680 Wharf St.
Lahaina, HI 96761

Hanapepe Public Library
P.O. Box B
Hanapepe, HI 96716

Koloa Public & School Library
P.O. Box 9
Koloa, HI 96756

Waimea Public Library
P.O. Box 397
Waimea, HI 96796

Molokai Public Library
P.O. Box 395
Kaunakakai, HI 96748

~~Koloa Public & School Library~~
~~P.O. Box 9~~
~~Koloa, HI 96756~~

~~Waimea Public Library~~
~~P.O. Box 397~~
~~Waimea, HI 96796~~

~~Lanai Public & School Library~~
~~P.O. Box 550~~
~~Lanai City, HI 96763~~

APPENDIX D

SCOPING COMMENTS AND RESPONSES

THIS PAGE INTENTIONALLY LEFT BLANK

Table of Contents of Appendix D

Scoping Letters and Associated Response Letters Included In Appendix D

17 Aug 1999	Rev. P. D. Draper	Office of Naval Research	Scoping comments	D-23
19 Jun 2000	Dr. Peter Worcester, Scripps	Rev. P. D. Draper	Response to scoping comments	D-24
24 Aug 1999	Mr. Guy G. Jones	Office of Naval Research	Scoping comments	D-25
19 Jun 2000	Dr. Peter Worcester, Scripps	Mr. Guy G. Jones	Response to scoping comments	D-26
15 Sep 1999	Ms. Kathleen Vigness	Dr. Robin W. Baird	Deadline for providing scoping comments	D-27
13 Aug 1999	Mr. Joel R. Reynolds, Natural Resources Defense Council and Ms. Susan Jordan, League for Coastal Protection and Observer, ATOC Marine Mammal Research Advisory Board	Office of Naval Research	Scoping comments	D-29
22 Jun 2000	Dr. Peter Worcester, Scripps	Mr. Joel R. Reynolds, Natural Resources Defense Council and Ms. Susan Jordan, League for Coastal Protection	Response to scoping comments	D-40
21 Sep 1999	Mr. Timothy E. Johns, DLNR, State of Hawaii	Office of Naval Research	Scoping comments	D-43
21 Jun 2000	Dr. Peter Worcester, Scripps	Mr. Timothy E. Johns, DLNR, State of Hawaii	Response to scoping comments	D-45
22 Sep 1999	Mr. Allen T. Tom, Sanctuary Director, Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS)	Office of Naval Research	Scoping comments	D-46
21 Jun 2000	Dr. Peter Worcester, Scripps	Mr. Allen T. Tom, Sanctuary Director, HIHWNMS	Response to scoping comments	D-48
22 Sep 1999	Ms. Kellie Araki, Sanctuary Advisory Council (SAC) Coordinator, HIHWNMS	Office of Naval Research	Scoping comments	D-49
21 Jun 2000	Dr. Peter Worcester, Scripps	Ms. Kellie Araki, SAC Coordinator, HIHWNMS	Response to scoping comments	D-52
7 Sep 1999	Dr. Louis Herman, Conservation Committee, Chair, HIHWNMS	Office of Naval Research	Scoping comments	D-53

21 Jun 2000	Dr. Peter Worcester, Scripps	Dr. Louis Herman, Conservation Committee, Chair, HIHWNMS	Response to scoping comments	D-54

THIS PAGE INTENTIONALLY LEFT BLANK

BENJAMIN J. CAYETANO
GOVERNOR

FILE COPY

GENEVIEVE SALMONSON
DIRECTOR

STATE OF HAWAII
OFFICE OF ENVIRONMENTAL QUALITY CONTROL
235 SOUTH BERETANIA STREET
SUITE 702
HONOLULU, HAWAII 96813
TELEPHONE (808) 586-4186
FACSIMILE (808) 586-4186

August 10, 1999

Mr. Tim Johns, Chair
Department of Land and Natural Resources
P.O. Box 621
Honolulu, Hawaii 96809

Dear Mr. Johns:

Subject: EIS Preparation Notice for the ATOC Phase II, Kauai

Thank you for the opportunity to review the subject document. We have the following questions and comments.

1. The Draft EIS should be prepared in accordance with Chapter 343, Hawaii Revised Statues and its accompanying rules Title 11, Chapter 200, Hawaii Administrative Rules.

2. Please consult the following agencies in the preparation of the EIS:

   a) Office of Hawaiian Affairs
   b) University of Hawaii Environmental Center

Should you have any questions, please call Jeyan Thirugnanam at 586-4185.

Sincerely,

Genevieve Salmonson
Director

c: Scripps Institution

16034 Yarnell Street
Sylmar, CA 91342-1010
towhee@moose-mail.com

February 2, 2000

Office of Naval Research
C/O Kathleen Vigness
Marine Acoustics
901 Stuart St., Suite 708
Arlington, VA 22203

Subject: Harmful Effects of Navy LFAS

I am taking the time to personally convey to you my intense concem about the harmful effects of Navy LFAS to marine mammals. Scientific studies suggest the following marine-mammal responses to noise:

- ✓ Ear or lung damage
- ✓ Temporary or permanent hearing loss
- ✓ Disorientation/loss of direction
- ✓ Stranding
- ✓ Violent, aggressive behavior
- ✓ Panic/stress
- ✓ Movement away from migration path, feeding, or breeding grounds
- ✓ Inability to hear quieter sounds like predators or prey when loud sound is on
- ✓ Death or disease of prey
- ✓ Change in breath rate, swimming speed, direction, dive speed, dive depth
- ✓ Stoppage of use of their own active sonar for hours or days.

Please consider the grave consequences of allowing LFAS to continue; these consequences reside **outside** the Navy's charter.

Thank you for considering my concern.

Respectfully,

Lisa S. Butler

UNIVERSITY OF CALIFORNIA, SAN DIEGO

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

CECIL H. AND IDA M. GREEN
INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS
SCRIPPS INSTITUTION OF OCEANOGRAPHY (0225)

LA JOLLA, CALIFORNIA 92093-0225

June 19, 2000

Ms. Lisa S. Butler
16034 Yarnell Street
Sylmar, CA 91342-1010

Dear Ms. Butler,

We have received your letter regarding your concerns about the harmful effects of Navy LFAS. Your comment was received by the North Pacific Acoustic Laboratory (NPAL) project, which is not affiliated with the Navy Low Frequency Active (LFA) Program.

Comments regarding the LFA program should be directed to:
Mr. J.S. Johnson
Attn: SURTASS LFA Sonar OEIS/EIS Program Manager
901 North Stuart Street, Suite 708
Arlington, VA 22203

NPAL, formerly known as the Acoustic Thermometry of Ocean Climate (ATOC) Project Phase II, is a basic scientific research program that proposes to retain in place and reuse the power cable and sound source installed north of Kauai for an additional five years in order to 1) perform the second phase of research on the feasibility and value of large-scale acoustic thermometry; 2) study the behavior of sound transmissions in the ocean over long distances; and 3) conduct studies on the possible long-term effects from the sound transmissions on marine life. The source is located on the seafloor at a depth of 807 meters (2648 ft.), approximately 8 nautical miles (14.8 km) north of Kauai at 22°20.94'N, 159° 34.18'W.

The NPAL project is funded by the Office of Naval Research (ONR) and will be carried out by Scripps Institution of Oceanography, University of California San Diego, in conjunction with the Applied Physics Laboratory of the University of Washington.

By now, you should have received your copy of the NPAL Draft Environmental Impact Statement (DEIS). The results of the Marine Mammal Research Program (MMRP) conducted in conjunction with the ATOC project are included in the NPAL DEIS Chapter 1.2.2 and the potential environmental consequences of the action are evaluated in Chapter 4.

If you have further questions or comments regarding NPAL, feel free to contact Susie Pike or myself at (858) 534-8031.

Sincerely,

Dr. Peter Worcester
Research Oceanographer

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Islands Ecoregion
300 Ala Moana Boulevard, Room 3122
Box 50088
Honolulu, Hawaii 96850

In Reply Refer To: LLLW

AUG 13 1999

ATTN: Office of Naval Research
C/O Kathleen J. Vigness
Marine Acoustics, Inc.
901 N. Stuart St.
Suite 708
Arlington, VA 22203

Re: Notice to Prepare an Environmental Impact Statement for Continued Operation of the Sound Source Installed by the Acoustic Thermometry of Ocean Climate (ATOC) Project North of Kauai, Hawaii.

Dear Ms. Vigness:

The U.S. Fish and Wildlife Service (Service) has reviewed the June 15, 1999, Federal Register notice that you intend to prepare an Environmental Impact Statement (EIS) for the project referenced above. The project is sponsored by the Office of Naval Research. This letter has been prepared under the authority of and in accordance with provisions of the National Environmental Policy Act of 1969 [42 U.S.C. 4321 *et seq.*; 83 Stat. 852], as amended, the Fish and Wildlife Coordination Act of 1934 [16 U.S.C. 661 *et seq.*; 48 Stat. 401], as amended, the Endangered Species Act of 1973 [16 USC 1531 *et seq.*; 87 Stat. 884], as amended (ESA), and other authorities mandating Service concern for environmental values. Based on these authorities, the Service offers the following comments for your consideration.

The project involves continued use of the sound source installed for the ATOC project north of Kauai, Hawaii. The sound source would remain at its present location, and transmissions would continue with the same signal parameters and approximately the same transmission schedule (six 20-minute transmissions every fourth day). The purpose of the project is to determine the precision with which acoustic methods could be used to measure large-scale changes in ocean temperature and heat content.

The Service recommends that the draft EIS address potential project-related impacts to Federal trust resources, including species and habitats protected under the ESA, species and habitats occurring within the Hawaiian Islands National Wildlife Refuge (NWR) and Midway Atoll NWR, migratory birds, and coral reef ecosystems. We also recommend that the draft EIS address potential impacts to native Hawaiian species and habitats.

The draft EIS should propose mitigation measures to avoid unnecessary impacts and minimize unavoidable impacts to these resources. For example, we recommend that consideration be given to avoidance of the primary breeding seasons of sea turtles and marine mammals to reduce adverse project-related impacts to their successful reproduction. We also recommend that the National Marine Fisheries Service be contacted for recommendations concerning resources under their jurisdiction.

The Service appreciates the opportunity to provide this early technical assistance, and we look forward to reviewing a copy of the draft EIS when it is available. If you have questions regarding these comments, please contact Fish and Wildlife Biologist Lorena Wada by telephone at (808) 541-3441 or by facsimile transmission at (808) 541-3470.

Sincerely,

Donald Palawski

For Robert P. Smith
Pacific Islands Manager

cc: NMFS-PIAO, Honolulu
USEPA, Honolulu
DOFAW, Hawaii
CZMP, Hawaii

UNIVERSITY OF CALIFORNIA, SAN DIEGO

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO   SANTA BARBARA • SANTA CRUZ

CECIL H. AND IDA M. GREEN
INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS
SCRIPPS INSTITUTION OF OCEANOGRAPHY (0225)

LA JOLLA, CALIFORNIA 92093-0225

June 19, 2000

Mr. Robert P. Smith
Pacific Islands Manager
U.S. Department of the Interior
Fish and Wildlife Service
300 Ala Moana Boulevard, Room 3122
Honolulu, HI 96850

Dear Mr. Smith,

We have received your letter offering comments for consideration in the preparation of the Draft Environmental Impact Statement (DEIS) for the continued operation of the sound source installed by the Acoustic Thermometry of Ocean Climate (ATOC) Project.

The North Pacific Acoustic Laboratory (NPAL), formerly known as ATOC Phase II, is a basic scientific research program that proposes to retain in place and reuse the power cable and sound source installed north of Kauai for an additional five years in order to 1) perform the second phase of research on the feasibility and value of large-scale acoustic thermometry; 2) study the behavior of sound transmissions in the ocean over long distances; and 3) conduct studies on the possible long-term effects from the sound transmissions on marine life. The source is located on the seafloor at a depth of 807 meters (2648 ft.), approximately 8 nautical miles (14.8 km) north of Kauai at 22°20.94'N, 159° 34.18'W.

The NPAL project is funded by the Office of Naval Research (ONR) and will be carried out by Scripps Institution of Oceanography, University of California San Diego, in conjunction with the Applied Physics Laboratory of the University of Washington.

By now, you should have received your copy of the NPAL Draft Environmental Impact Statement (DEIS). In that document, we have evaluated potential project-related impacts on all applicable species in Chapter 4, and described the proposed mitigation measures in Chapter 5. Also, as recommended, we have consulted with the National Marine Fisheries Service. A full description of the federal, state and local review programs that do, or may, apply to the proposed action is included in Chapter 6.

If you have further questions or comments regarding NPAL, feel free to contact Susie Pike or myself at (858) 534-8031.

Sincerely,

Dr. Peter Worcester
Research Oceanographer

Bobbie Sandoz, MSW
1221 Victoria Street, Suite 301 · Honolulu, Hawaii 96814
Phone 808 524-6775 · Fax 808 538-0423 .

To:	KATHY VIGNESS, OFFICE OF NAVAL RESEARCH MARINE ACOUSTICS INC 901 N. STUART STREET, SUITE 708 ARLINGTON, VA 22203
FROM:	BOBBIE SANDOZ
SUBJECT:	SCOPING COMMENTS
DATE:	7/8/99
PAGES (*Including Cover Sheet*): 2	

I recently attended a public meeting conducted by the ATOC research team in Honolulu, Hawaii. In addition to the concerns and requests for Scoping I raised in the meeting, I would like to register some additional areas I believe require Scoping before reintroducing any sonar whatsoever in Hawaiian waters.

•Obtain peer review of all research provided by the Navy-funded research team for both ATOC and LFAS studies used to promote the view that sonar is safe for marine mammals and other sea life.

•Provide definite proof that no marine life will be affected in any way by sonar, including turtles, fish, coral, and plankton as well as the dolphins and whales.

•Provide definite proof that no humans in the water when sonar is turned on will suffer any ill effects from being exposed to the sound.

•Establish precisely what happens to dolphin and whale hearing when exposed to incremental levels of sonar sound. Also, establish that the hearing of turtles is not damaged.

•Clarity whether cetacean movement away from the sound source is the primary signal that dolphins and whales will use to let us know that they experience stress when sonar sounds are sent into their ocean home or if they are experience the more subtle symptoms of post traumatic stress. For example, since humans often don't leave their homes during or following an earthquake, departure may not be the primary way stress is indicated. Instead, humans experience less visible, but extremely uncomfortable and persistent post traumatic stress symptoms such as anxiety, difficulty with sleep, less socializing and sexual activity, depression, and elevated heart and breathing rates. In view of this, it's imperative that researchers prove that dolphins and whales are not also experiencing on-going, highly distressing yet subtle symptoms before continuing to flood their home with sonar sound.

•Establish definite value for a study of water temperatures in the ocean in terms of what exactly will be learned that is of clear value, what can be done with the information that is learned, and how it will be of help to society.

•Also provide definite proof that something can be done about rising ocean temperatures and global warming if it is learned that temperatures are, in fact, rising.

•Provide proof beyond any doubt that sonar used in a federal marine sanctuary is not a violation of the definition of the mission of the sanctuary to provide protection to the marine life in that sanctuary.

Sincerely,

Bobbie Sandoz

Bobbie Sandoz

UNIVERSITY OF CALIFORNIA, SAN DIEGO

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO   SANTA BARBARA • SANTA CRUZ

CECIL H. AND IDA M. GREEN
INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS
SCRIPPS INSTITUTION OF OCEANOGRAPHY (0225)

LA JOLLA, CALIFORNIA 92093-0225

June 20, 2000

Ms. Bobbie Sandoz
1221 Victoria Street, Suite 301
Honolulu, HI 96814

Dear Ms. Sandoz,

We have received your letter dated July 8, 1999 registering additional concerns and requests for scoping the North Pacific Acoustic Laboratory (NPAL) Draft Environmental Impact Statement (DEIS). The NPAL project, formerly known as the Acoustic Thermometry of Ocean Climate (ATOC) Project Phase II, is a basic scientific research program that proposes to retain in place and reuse the power cable and sound source installed north of Kauai for an additional five years in order to 1) perform the second phase of research on the feasibility and value of large-scale acoustic thermometry; 2) study the behavior of sound transmissions in the ocean over long distances; and 3) conduct studies on the possible long-term effects from the sound transmissions on marine life. The source is located on the seafloor at a depth of 807 meters (2648 ft.), approximately 8 nautical miles (14.8 km) north of Kauai at 22°20.94'N, 159° 34.18'W.

The NPAL project is funded by the Office of Naval Research (ONR) and will be carried out by Scripps Institution of Oceanography, University of California San Diego, in conjunction with the Applied Physics Laboratory of the University of Washington.

By now, you should have received your copy of the NPAL Draft Environmental Impact Statement (DEIS). The following information responds to points raised in your letter.

You requested peer review of all research provided by the ATOC and LFAS research teams. Since we are not affiliated with the LFAS project, we can only respond with information regarding the ATOC Marine Mammal Research Program (MMRP). Several papers resulting from the ATOC MMRP have already appeared in peer-reviewed journals. The Kauai MMRP research team has submitted two additional papers for publication that are currently undergoing review. ATOC MMRP investigators plan to submit several additional papers in the near future. The results of the ATOC MMRP are summarized in the DEIS Chapter 1.2.2

You requested that the potential impacts on whales, dolphins, fish, coral, plankton, and on human divers be addressed in the EIS. Chapter 3 provides background information for assessing the potential effects of the proposed action on the physical and biological environments of the proposed Kauai site and the alternate Midway Atoll site. Chapter 4 then analyzes these potential effects, both individually and cumulatively.

You requested information on whether cetacean movement away from the source is the primary sign that the animals were stressed. The ATOC MMRP consisted of multiple components designed to measure possible changes in abundance, distribution, behavior, and vocalizations in response to the transmissions, as discussed in DEIS Chapter 1.2.2. There was never any intent to rely solely on changes in distribution to assess possible impacts from the transmissions.

You requested information on how the study of ocean temperatures using acoustic methods will be of help to society and whether anything can be done about the rising ocean temperatures. Information regarding the purpose and need for the project are provided in Chapter 1, which also includes background information on acoustic thermometry and past ATOC thermometry results.

Finally, as requested, information regarding possible effects on the Hawaiian Islands Humpback Whale National Marine Sanctuary is provided in Chapter 4.2.4.

Thank you for your interest in our project. If you have further questions or comments regarding NPAL, feel free to contact Susie Pike or myself at (858) 534-8031.

Sincerely,

Dr. Peter Worcester
Research Oceanographer

Pacific Whale Foundation
101 North Kihei Road
Kihei, Hawaii
96753
Phone (808) 879-8811
Fax (808) 879-2615
E-mail: rwbaird@is.dal.ca

September 15, 1999

Office of Naval Research
c/o Kathleen J. Vigness
Marine Acoustics, Inc.
901 N. Stuart St., Suite 708
Arlington, VA 22203

Dear Ms. Vigness,

I am writing to provide comments in regards to the ATOC EIS being prepared under the Hawaiian Environmental Policy Act, as part of the scoping process. There are a number of protected species of sea turtles and cetaceans which regularly inhabit nearshore waters in the Hawaiian Islands, including hawksbill and green sea turtles, *pantropical spotted*, bottlenose, and spinner dolphins, as well as false killer, short-finned pilot, and humpback whales. I understand that a research program focused on humpback whales in association with the ATOC source, and that information will be presented on potential impacts on humpbacks. However, given the other protected species which use the area, it is clear that information on potential impacts on these species should be addressed in the EIS. Is information available on the population sizes or trends for these species of odontocetes and sea turtles in the area? In addition, an evaluation of the power of the previous marine mammal studies to identify impacts, if these impacts exist, should be presented. I am particularly concerned about available sample sizes for different tests, sample sizes that would be required to detect changes in behavior, as well as the validity of using shore-based observations to examine behavior of animals at great distances from shore (which I understand was the case for numbers and reactions of humpback whales around the ATOC sound source).

Given the presumed uncertainty in population sizes, trends and threats for the protected species noted above, as well as the potential for both short- and long-term impacts from the introduction of anthropogenic sounds into the marine environment, if the ATOC project is to proceed, it is clear that a multi-species marine mammal monitoring program is needed.

Sincerely,

Robin W. Baird, Ph.D.
Research Director, Pacific Whale Foundation
Post-doctoral Fellow, Dalhousie University

cc: A. Terbush, Office of Protected Resources

UNIVERSITY OF CALIFORNIA, SAN DIEGO

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO

SANTA BARBARA • SANTA CRUZ

CECIL H. AND IDA M. GREEN
INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS
SCRIPPS INSTITUTION OF OCEANOGRAPHY (0225)

LA JOLLA, CALIFORNIA 92093-0225

June 20, 2000

Robin W. Baird
Dalhousie University
Halifax, Nova Scotia
Canada B3H 3J5

Dear Robin,

Thank you for your September 15, 1999 comment letter concerning the proposed North Pacific Acoustic Laboratory (NPAL), formerly known as the Acoustic Thermometry of Ocean Climate (ATOC) Project Phase II. By now, you should have received your copy of the NPAL Draft Environmental Impact Statement (DEIS). The following information responds to points raised in your letter.

You requested that the potential impacts on species other than the humpback whales be addressed in the DEIS. Chapter 3 provides background information for assessing the potential effects of the proposed action on the physical and biological environments of the proposed Kauai site and the alternate Midway Atoll site. Chapter 4 then analyzes these potential effects, both individually and cumulatively.

You also requested further evaluation of the Marine Mammal Research Program (MMRP) results that were obtained during the previous ATOC project period. These results are included in the DEIS Chapter 1.2.2.

Finally, as requested, information regarding the proposed mitigation and monitoring plans are provided in Chapter 5.

We appreciate your interest in our project. If you have further questions or comments regarding NPAL, feel free to contact Susie Pike or myself at (858) 534-8031.

Sincerely,

Dr. Peter Worcester
Research Oceanographer

Office of Naval Research
C/O Kathleen Vigness
Marine Acoustics, Inc.
901 Stuart St., Suite 708
Arlington, Virginia 22203

Dear Office of Naval Research,

I am writing because I am concerned for the whales. I strongly urge you to do anything within your power to curtail activities which could damage the lives of whales, including sonar tests. These tests are making a large amount of noise, resulting in health set backs and other negative outcomes in whales. I am very concerned, please do everything in your power to change this.

Thank you,

Rosemary Pritzker

UNIVERSITY OF CALIFORNIA, SAN DIEGO

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

CECIL H. AND IDA M. GREEN
INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS
SCRIPPS INSTITUTION OF OCEANOGRAPHY (0225)

LA JOLLA, CALIFORNIA 92093-0225

June 20, 2000

Ms. Rosemary Pritzker
17739 Cold Creek Lane
St. Ignatius, MT 59865

Dear Ms. Pritzker,

We have received your letter regarding sonar tests and your concern for the whales. Your comment was received by the North Pacific Acoustic Laboratory (NPAL) project, formerly known as the Acoustic Thermometry of Ocean Climate (ATOC) Project Phase II. NPAL is a basic scientific research program that proposes to retain in place and reuse the power cable and sound source installed north of Kauai for an additional five years in order to 1) perform the second phase of research on the feasibility and value of large-scale acoustic thermometry; 2) study the behavior of sound transmissions in the ocean over long distances; and 3) conduct studies on the possible long-term effects from the sound transmissions on marine life. The source is located on the seafloor at a depth of 807 meters (2648 ft.), approximately 8 nautical miles (14.8 km) north of Kauai at 22°20.94'N, 159° 34.18'W.

The NPAL project is funded by the Office of Naval Research (ONR) and will be carried out by Scripps Institution of Oceanography, University of California San Diego, in conjunction with the Applied Physics Laboratory of the University of Washington.

By now, you should have received your copy of the NPAL Draft Environmental Impact Statement (DEIS). The results of the Marine Mammal Research Program (MMRP) conducted in conjunction with the ATOC project are included in the NPAL DEIS Chapter 1.2.2 and the potential environmental consequences of the action are evaluated in Chapter 4.

If you have further questions or comments regarding NPAL, feel free to contact Susie Pike or myself at (858) 534-8031.

Sincerely,

Dr. Peter Worcester
Research Oceanographer

A - 30 Dallas Road
Victoria, British Columbia
Canada V8V 2N7
(250) 380 1092

Office of Naval Research
c/o Kathleen Vigness
Marine Acoustics, Inc.
901 Stuart Street, Suite708
Arlington, VA 22203

Ref. Low Frequency Radiation Sickness (LFRS)

Dear Kathleen Vigness,

I am writing to acquaint you with my shocking physical condition for which I firmly believe, you and the activities of your department are responsible. My condition has rapidly deteriorated since shortly before and during the visit of the aricraft carrier John C. Stennis to Victoria, B.C. from July 28, 1999 to August 2, 1999 when the carrier was anchored only 2 1/2 niles from my apartment on a bearing of 225 degrees, True.

For three years I have suffered from a low rumbling "sound", with accompanying vibrations of the body caused by the low frequency currents transmitted by your below surface, active sonar and the associated ground stations that are reaching me and thousands of other sufferers who are unfortunate enough to live on the low frequency polluted waters of Juan de Fuca Strait, the approaches, and Puget Sound. The enclosed map will illustrate just a few of them..

Since July 11, 1999, the vibration that has robbed me of the use of my legs has moved up though my stomach to my chest and since about July 28 is affecting my arm muscles resulting in difficulty with writing and shaving. Furthermore, my left hand is losing its grip.

Should your transmisssions continue unabated, I can expect to be a quadraplegic by the time your mandate for reckless, irresponsible experimentation in Kauaii ends in October, 1999.

Now that you have achieved your objective at such a terrible cost of human suffering, authoritative action should be taken now by the Office of Naval Research so that this iniquitous persecution, and torture, indefinitely prolonged , be terminated for ever.

Very sincerely, Aubrey Cooke

Aubrey Cooke

CC Brian Phillips
Director of Radiation Health
210 4940 Canada Way
Burnaby, B.C. Canada V5G 4K6
Ph. (604) 660 6630

Note. BERNARD McCARRON is the founder of the James Bay Low Frequency Radiation Sickness Association. Aubrey Cooke is a member.
B.W. McCarron

That Sound's Still Draggin'

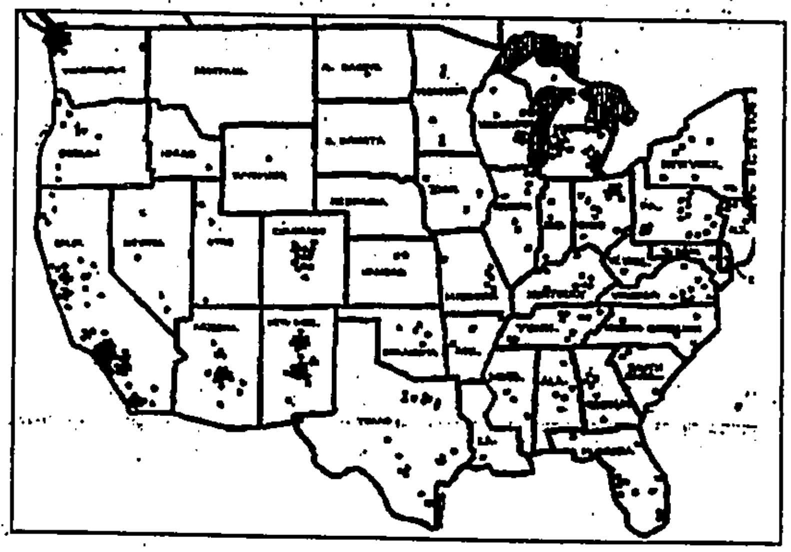
By Bernard McCarron

Since May of 1997, I have written from time to time about my search for the *Sound Dragon*. The source of the ever-present *sound*, "like a diesel motor idling" could not be determined. My search took me through every level of our political and health care systems to no avail. Yet, through *hearers* of the *sound*, I learned that it could be detected by means of sensitive instruments. It was identified as extra-low-frequency sound affecting about 2% of the population. Through the use of the internet, I have learned that the *sound* permeates the northern hemisphere. The map below resulted from the research of one *hearer*. Unaided, she discovered 368 locations of the *sound* in mainland U.S.A. 2%

You see in the top left hand corner of the map below, that she also received phone calls from Alaska: Fairbanks and Anchorage. I have had 30 calls from the Greater Victoria area. Not so surprising when you note how close we are to the cluster in Washington State. A call from White Rock, a statement from Abbotsford, and two observations from Calgary convinced me that *hearers* cannot escape the *sound*.

There is a strong movement in the U.S.A. to prevent the military, a possible source of the *sound*, from using its low frequency sound comunication systems. You wish to know more? Read, ***Angels Don't Play This Haarp*** (Munro's) or call up *Taoshum* on the internet.

In summary, the ***Sound Dragon*** is afflicting many. We have not discovered the dragon's lair. However, there are enough ***hearers*** who can provide help to one another, upon discovering they are not alone and are not ***hearing things***.



Email Address:

BERNARD_McCarron@bc.sympatico.ca

UNIVERSITY OF CALIFORNIA, SAN DIEGO

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

CECIL H. AND IDA M. GREEN
INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS
SCRIPPS INSTITUTION OF OCEANOGRAPHY (0225)

LA JOLLA, CALIFORNIA 92093-0225

June 16, 2000

Aubrey Cooke
A 30 Dallas Road
Victoria, British Columbia

Dear Ms. Cooke,

We have received your letter regarding your concerns about the harmful effects of Navy LFAS. Your comment was received by the North Pacific Acoustic Laboratory (NPAL) project, which is not affiliated with the Navy Low Frequency Active (LFA) Program.

Comments regarding the LFA program should be directed to:
Mr. J.S. Johnson
Attn: SURTASS LFA Sonar OEIS/EIS Program Manager
901 North Stuart Street, Suite 708
Arlington, VA 22203

NPAL, formerly known as the Acoustic Thermometry of Ocean Climate (ATOC) Project Phase II, is a basic scientific research program that proposes to retain in place and reuse the power cable and sound source installed north of Kauai for an additional five years in order to 1) perform the second phase of research on the feasibility and value of large-scale acoustic thermometry; 2) study the behavior of sound transmissions in the ocean over long distances; and 3) conduct studies on the possible long-term effects from the sound transmissions on marine life. The source is located on the seafloor at a depth of 807 meters (2648 ft.), approximately 8 nautical miles (14.8 km) north of Kauai at 22°20.94'N, 159° 34.18'W.

The NPAL project is funded by the Office of Naval Research (ONR) and will be carried out by Scripps Institution of Oceanography, University of California San Diego, in conjunction with the Applied Physics Laboratory of the University of Washington.

By now, you should have received your copy of the NPAL Draft Environmental Impact Statement (DEIS). The results of the Marine Mammal Research Program (MMRP) conducted in conjunction with the ATOC project are included in the NPAL DEIS Chapter 1.2.2 and the potential environmental consequences of the action analyzed in Chapter 4.

If you have further questions or comments regarding NPAL, feel free to contact Susie Pike or myself at (858) 534-8031.

Sincerely,

Dr. Peter Worcester
Research Oceanographer

8/17/99

Kathleen Vigness
Office of Naval Research
901 Stuart St. Suite 708
Arlington, VA 22203

Dear Ms. Vigness:

This is to ask, beg and plead with your department for more time in studying the effects of the LFA system. The oceans have been assaulted with all sorts of pollution and lack of care by the humans on this earth. I wonder if it can withstand another attack.

From what I can gather, the studies that have been done have not bought back positive results for the whales. But, even if the whales could withstand this invasion and manage to survive with damaged eardrums, etc., who is studying the effects on the plankton, the coral, the fish and squid?

This is not something in which one can rely on the "Oops factor". You can't just destroy the ocean habitat and then say "Oh, that wasn't a good idea, sorry 'bout that" and expect it to recover. Not in YOUR lifetime. Do you have children?? I do and I would like to see them and my grandchildren have a living, loving planet.

Have you ever had to sit at a stop light with a kid, (determined to go deaf by age 25), playing his version of music with the base turned way up? If not, you should try it sometime. It will easily help you to understand road rage. I am a peace loving old lady, but after a few minutes of that I am ready to strangle the kid.

Can we afford to run the risk of creating "road rage" in the oceans? I think not. If the oceans die, we die -- and I am not ready to go yet!

Sincerely,

P.D. Draper

Rev. P.D. Draper
254 Garden Lane
Sarasota, FL 34242

UNIVERSITY OF CALIFORNIA, SAN DIEGO

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO   SANTA BARBARA • SANTA CRUZ

CECIL H. AND IDA M. GREEN
INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS
SCRIPPS INSTITUTION OF OCEANOGRAPHY (0225)

LA JOLLA, CALIFORNIA 92093-0225

June 19, 2000

Rev. P.D. Draper
254 Garden Lane
Sarasota, FL 34242

Dear Rev. Draper,

We have received your letter regarding your concerns about the LFA system. Your comment was received by the North Pacific Acoustic Laboratory (NPAL) project, which is not affiliated with the Navy Low Frequency Active (LFA) Program.

Comments regarding the LFA program should be directed to:
Mr. J.S. Johnson
Attn: SURTASS LFA Sonar OEIS/EIS Program Manager
901 North Stuart Street, Suite 708
Arlington, VA 22203

NPAL, formerly known as the Acoustic Thermometry of Ocean Climate (ATOC) Project Phase II, is a basic scientific research program that proposes to retain in place and reuse the power cable and sound source installed north of Kauai for an additional five years in order to 1) perform the second phase of research on the feasibility and value of large-scale acoustic thermometry; 2) study the behavior of sound transmissions in the ocean over long distances; and 3) conduct studies on the possible long-term effects from the sound transmissions on marine life. The source is located on the seafloor at a depth of 807 meters (2648 ft.), approximately 8 nautical miles (14.8 km) north of Kauai at 22°20.94'N, 159° 34.18'W.

The NPAL project is funded by the Office of Naval Research (ONR) and will be carried out by Scripps Institution of Oceanography, University of California San Diego, in conjunction with the Applied Physics Laboratory of the University of Washington.

By now, you should have received your copy of the NPAL Draft Environmental Impact Statement (DEIS). The results of the Marine Mammal Research Program (MMRP) conducted in conjunction with the ATOC project are included in the NPAL DEIS Chapter 1.2.2 and the potential environmental consequences of the action evaluated in Chapter 4.

If you have further questions or comments regarding NPAL, feel free to contact Susie Pike or myself at (858) 534-8031.

Sincerely,

Dr. Peter Worcester
Research Oceanographer

August 24, 1999

Office of Naval Research
C/O Kathleen Vigness
Marine Acoustics, Inc.
901 Stuart St., Suite 708
Arlington, Virginia 22203

Dear Ms. Vigness,

I recently with alarm the CNN report on the LFAS system being tested and implemented by the Navy. The evidence is overwhelming that LFAS disrupts the health and behavior of marine mammals. Saying that the evidence is inconclusive or other such nonsense is like the cigarette industry's denial of the bad effects of smoking.

Please know, that as a US citizen, a taxpayer, a business owner and a registered voter, I am strongly opposed to the continuation of the LFAS project. I'm sure that the US Navy, with so much money invested in this project, and the National Security at stake, will have to encounter significant opposition to the LFAS project to consider cancellation. Unfortunately, we have yet to learn how to communicate with our earth mates in the oceans. Until that time, we should err on the side of their safety and not continue the project.

Thank you for taking the time to read this letter.

Sincerely,

Guy G. Jones
2000 S. Melrose Dr. #112
Vista, CA 92083
(760) 727-8315

UNIVERSITY OF CALIFORNIA, SAN DIEGO

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO   SANTA BARBARA • SANTA CRUZ

CECIL H. AND IDA M. GREEN
INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS
SCRIPPS INSTITUTION OF OCEANOGRAPHY (0225)

LA JOLLA, CALIFORNIA 92093-0225

June 19, 2000

Mr. Guy G. Jones
2000 S. Melrose Dr. #112
Vista, CA 92083

Dear Mr. Jones,

We have received your letter regarding your concerns about the Navy LFAS program. Your comment was received by the North Pacific Acoustic Laboratory (NPAL) project, which is not affiliated with the Navy Low Frequency Active (LFA) Program.

Comments regarding the LFA program should be directed to:
Mr. J.S. Johnson
Attn: SURTASS LFA Sonar OEIS/EIS Program Manager
901 North Stuart Street, Suite 708
Arlington, VA 22203

NPAL, formerly known as the Acoustic Thermometry of Ocean Climate (ATOC) Project Phase II, is a basic scientific research program that proposes to retain in place and reuse the power cable and sound source installed north of Kauai for an additional five years in order to 1) perform the second phase of research on the feasibility and value of large-scale acoustic thermometry; 2) study the behavior of sound transmissions in the ocean over long distances; and 3) conduct studies on the possible long-term effects from the sound transmissions on marine life. The source is located on the seafloor at a depth of 807 meters (2648 ft.), approximately 8 nautical miles (14.8 km) north of Kauai at 22°20.94'N, 159° 34.18'W.

The NPAL project is funded by the Office of Naval Research (ONR) and will be carried out by Scripps Institution of Oceanography, University of California San Diego, in conjunction with the Applied Physics Laboratory of the University of Washington.

By now, you should have received your copy of the NPAL Draft Environmental Impact Statement (DEIS).. The results of the Marine Mammal Research Program (MMRP) conducted in conjunction with the ATOC project are included in the NPAL DEIS Chapter 1.2.2 and the potential environmental consequences of the action are evaluated in Chapter 4.

If you have further questions or comments regarding NPAL, feel free to contact Susie Pike or myself at (858) 534-8031.

Sincerely,

Dr. Peter Worcester
Research Oceanographer

Subj: **Re: scoping comments**
Date: 9/15/1999 00:38:28 Eastern Daylight Time
From: rwbaird@is.dal.ca (Robin W. Baird)
Reply-to: rwbaird@is.dal.ca
To: KVigness@aol.com

Thanks very much!

Robin

> Dr. Baird:
>
> I got your message inquiring about scoping comments. Actually, there are two
> parallel processes occurring - the National Environmental Policy Act (NEPA)
> requirements and the Hawaiian Environmental Policy Act (HEPA) requirements.
> The date published in the Federal Register referred to the NEPA scoping
> process. What Peter Worcester spoke of was the HEPA scoping process.
> Information regarding the HEPA process was published in the Office of
> Environmental Quality (OEQC) Bulletin on August 8, 1999. For the drafting of
> the document and the work that we are doing, there is no distinction made
> between comments received. Therefore, feel free to send any comments you may
> have through the date given by Peter.
>
> If you have any additional questions, please contact me.
> Sincerely, Kathy Vigness
>
> ____________________
> Kathleen J. Vigness
> Marine Acoustics, Inc.
> 901 N. Stuart St., Suite 708
> Arlington, VA 22203
> phone: (703)465-8404
> fax: (703)465-8420
>
>

Robin Baird Fri. 10 Sep 99 8:37 p.m.
(808) 879-8811
rwbaird@ is.dal.ca

? about scoping process:
date published in Fed. Register of mid-Aug vs. late Sept. deadline which Peter Worcester spoke of at Sanctuary Mtg.
- sent email to explain NEPA/HEPA.

===
Robin W. Baird, Ph.D.
Post-doctoral fellow, Biology Dept., Dalhousie University
Research Director, Pacific Whale Foundation, 101 N. Kihei Road,
Kihei, HI 96753 USA.
Phone (808) 879-8860 (work), 879-7061 (home). Fax 879-2615
e-mail: rwbaird@is.dal.ca
http://is.dal.ca/~whitelab/rwb/robin.htm
http://www.pacificwhale.org/learn/index.html

------------- Headers -------------
Return-Path: <rwbaird@is.dal.ca>
Received: from rly-yh04.mx.aol.com (rly-yh04.mail.aol.com [172.18.147.36]) by air-yh05.mail.aol.com (v60.28) with ESMTP;

Wed, 15 Sep 1999 00:38:28 -0400
Received: from www.mauigateway.com (www.mauigateway.com [205.166.249.5]) by rly-yh04.mx.aol.com (v60.28) with ESMTP; Wed, 15 Sep 1999 00:38:18 -0400
Received: from hook2760.dal.ca (mg2-101.mauigateway.com [208.142.181.101])
by www.mauigateway.com (8.9.3/8.9.3) with SMTP id SAA10681
for <KVigness@aol.com>; Tue, 14 Sep 1999 18:38:16 -1000 (HST)
(envelope-from rwbaird@is.dal.ca)
Message-Id: <199909150438.SAA10681@www.mauigateway.com>
Comments: Authenticated sender is <rwbaird@is.dal.ca>
From: "Robin W. Baird" <rwbaird@is.dal.ca>
To: KVigness@aol.com
Date: Tue, 14 Sep 1999 18:37:10 -1000
MIME-Version: 1.0
Content-type: text/plain; charset=US-ASCII
Content-transfer-encoding: 7BIT
Subject: Re: scoping comments
Reply-to: rwbaird@is.dal.ca
Priority: normal
In-reply-to: <c9f8f78a.250e4e11@aol.com>
X-mailer: Pegasus Mail for Win32 (v2.54)

BY FAX – (703) 465-8420

August 13, 1999

ATTN: Office of Naval Research
c/o Kathleen J. Vigness
Marine Acoustics, Inc.
901 N. Stuart St., Suite 708
Arlington, VA 22203
(703) 465-8404

Re: Environmental Impact Statement Scoping Comments for Continued Operation of the Sound Source Installed by the Acoustic Thermometry of Ocean Climate (ATOC) Project North of Kauai

Dear Ms. Vigness:

On behalf of the Natural Resources Defense Council ("NRDC"), the League for Coastal Protection, and their over 400,000 members and constituents, we submit these scoping comments with regard to preparation of an environmental impact statement for the Acoustic Thermometry of Ocean Climate program ("ATOC") and its continued use of a sound source off the island of Kauai.[1] Proposed by research scientists at the Scripps Institution of Oceanography of the University of California ("Scripps") with assistance from the Office of Naval Research of the U.S. Navy, the program involves the transmission of low-frequency, high-intensity sound waves off Kauai's north coast to receivers distributed across the North Pacific Ocean. Transmissions would take place every four days over a period of five years, after which the program's value, and the value of (oceanic) acoustic thermometry in general, would be assessed and evaluated.

[1] The filing of these comments is in no way intended to waive our rights to challenge or oppose the ATOC program off Kauai or to challenge any future activities conducted under the ATOC program off the coasts of Hawaii, California, or elsewhere.

At the outset, we wish to convey our deep concern regarding the ATOC program, because we believe that long-term operation of its sound source in such biologically rich waters as those off Kauai may present a substantial risk of significant harm to the marine environment, including the "take" of a wide range of marine mammal and other species protected by federal law. The degree of sound produced by the ATOC transmitter, 195 dB re 1 μPa at a frequency of 75 Hz., has been shown or is believed to impact the behavior and physiology of many species of sea life, such as the endangered humpback whale, which is seasonally numerous in Hawaii. And the relatively long term of operation proposed by Scripps for its stationary source only increases the possibility that long-term effects in distribution, abundance, reproductive rate, or other vital factors or processes may result. Indeed, the far-reaching ambitions of the ATOC program, which require time scales long enough to measure interannual, interdecadal, and even broader trends, would seem to extend beyond the requested five years. The current proposal opens the door to an indefinite, intrusive series of operations, and perhaps a permanent siting of the system, in a marine environment of manifest biological significance.

I. BACKGROUND

ATOC has been under development since the early 1990s, when researchers at the Scripps Institution first proposed using sound to measure the changing temperature of the North Pacific Ocean. Since sound travels faster in warm water than in cold, it might be possible (they hypothesized) to gage fluctuations in temperature by the number of seconds, or fractions of seconds, a signal takes to cross from end of the ocean to the other. The signal would be preserved by positioning its source in the SOFAR, or Deep Sound Channel, one of the sea's natural conduits of sound. In 1991, a broadcast was made off Heard Island, a remote spot in the Indian Ocean, to test the program's feasibility; by 1995, researchers were prepared to station two transmitters in U.S. waters, one off California and one off Hawaii, and broadcast sound waves across the Pacific, from the Aleutian Islands to New Zealand to Guam.[2] But the sites Scripps chose for its transmitters happened to occur in areas of high biological significance.

[2] The early history of the ATOC program is summarized in Advanced Research Projects Agency, Final Environmental Impact Statement/Environmental Impact Report for the California Acoustic Thermometry of Ocean Climate Project and Its Associated Marine Mammal Research Program, Vol. I (Apr. 1995) at 1-13.

In response to public opposition, and after months of negotiation with NRDC and other environmental representatives, the researchers agreed to move their California source outside the Monterey Bay National Marine Sanctuary, where it had originally been sited, and to conduct a Marine Mammal Research Program (MMRP) that would investigate the impact of transmissions on the distribution and abundance (and, to a still more limited degree, on certain other biological functions) of selected species.[3] The study entailed over two years of broadcasts from both the California and Hawaii sites, with source levels at or approaching 195 dB re 1 µPa (at 75 Hz.) during experimental blocks of twenty minutes' duration. Preliminary data suggests that, while species under observation did not permanently abandon the ATOC area in response to transmissions, the distribution of some species, including the endangered sperm and humpback whales, appears to have been significantly affected. (Other behavior, such as diving patterns in humpback whales, seems to have been impacted as well.) Owing to the limited nature of the research, however, as well as the low statistical power of some of the data sets that were collected, significant uncertainty remains with regard to the physiological, auditory, and behavioral effects of ATOC on nearly all of the species in the Hawaii region. In particular, it should be noted that the evidence does not support any conclusion about the system's long-term impacts.

The project currently proposed by Scripps would continue operation of the sound source off Kauai for five years, retaining the duty cycle, source level, and transmission schedule of the earlier study.

II. COMPLIANCE WITH NATIONAL ENVIRONMENTAL POLICY ACT

A. General Requirements

Enacted by Congress in 1969, the National Environmental Policy Act ("NEPA") commits the federal government to "encourage productive and enjoyable harmony between man and his environment" and "promote efforts which will prevent or eliminate damage to the environment

[3] See University of California, Natural Resources Defense Council, et al., Settlement Agreement and Release (June 2, 1995).

and biosphere and stimulate the health and welfare of man." 42 U.S.C. § 4321. To realize these goals, NEPA demands that the "policies, regulations, and public laws of the United States [be] interpreted and administered" in accordance with its principles, "to the fullest extent possible." 42 U.S.C. § 4332. This strong mandate was intended to guide agencies in preparing environmental impact statements (EIS), which are required of all projects that "may significantly degrade some human environmental factor." Steamboaters v. F.E.R.C., 759 F.2d 1382, 1392 (9th Cir. 1985) (emphasis in original). As the Supreme Court explained:

> NEPA's instruction that all federal agencies comply with the impact statement requirement—and with all the other requirements of § 102—"to the fullest extent possible," 42 U.S.C. § 4332, is neither accidental nor hyperbolic. Rather the phrase is a deliberate command that the duty NEPA imposes upon the agencies to consider environmental factors not be shunted aside in the bureaucratic shuffle.

Flint Ridge Development Co. v. Scenic Rivers Ass'n, 426 U.S. 776, 787 (1976).[4]

The fundamental purpose of an EIS is to force the decision-maker to take a "hard look" at the environmental consequences of her proposal, before a decision to proceed is made. See 40 C.F.R. § 1502.1 ("Purpose of EIS"); Baltimore Gas & Electric v. Natural Resources Defense Council, 462 U.S. 87, 97 (1983). The EIS must be an objective, neutral document, not a work of advocacy to justify a predetermined result. 40 C.F.R. § 1502.2(g). To help achieve this goal, NEPA sets forth a list of factors that the responsible official must consider "to the fullest extent possible" and include in a "detailed statement":

(i) the environmental impact of the proposed action,
(ii) any adverse environmental effects which cannot be avoided should the project be implemented,
(iii) alternatives to the proposed action,

[4] The Ninth Circuit has recognized that the congressional mandate to apply NEPA "to the fullest extent possible" is "a direction to 'make as liberal an interpretation as we can to accommodate the application of NEPA.'" LaFlamme v. F.E.R.C., 852 F.2d 389, 398 (9th Cir. 1988) (quoting Jones v. Gordon, 792 F.2d 821, 826 (9th Cir. 1981)).

(iv) the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

42 U.S.C. § 4332(2)(C).

The duty to consider "alternatives to the proposed action"—to "rigorously explore and objectively evaluate all reasonable alternatives"—lies, in the words of the regulators, at "the heart" of the entire assessment process. 40 C.F.R. § 1502.14. Agencies must "devote substantial treatment to each alternative" and provide support for their decisions to accept or reject. 40 C.F.R. § 1502.14(b); Natural Resources Defense Council v. Callaway, 524 F.2d 79, 93 n.12 (2nd Cir. 1975). Finally, they must discuss means of mitigating the impacts of their projects, even when those means are not included among the proposed alternatives. 40 C.F.R. § 1502.14(f).

In addition to requiring an environmental impact statement, NEPA directs all federal agencies to "study, develop, and describe appropriate alternatives" to any project involving unresolved conflicts in "alternative uses of available resources." 42 U.S.C. § 4332(2)(E). This alternatives requirement has been repeatedly discussed by the courts; each has found it to be "both independent of, and broader than, the EIS requirement." Bob Marshall Alliance v. Hodel, 852 F.2d 1223, 1229 (9th Cir. 1988), cert. denied, 109 S.Ct. 1340 (1989). The requirement is mandatory "even where a proposed action does not trigger the EIS process." Id.[5]

B. Specific Requirements

In addition to these general requirements, a number of points specific to the ATOC program deserve some brief notice here:

[5] Accord City of Aurora v. Hunt, 749 F.2d 1457, 1466 (10th Cir. 1984); City of New York v. The United States Department of Transportation, 715 F.2d 732, 742-43 (2d Cir. 1983), cert. denied, 465 U.S. 1055 (1984); Aertsen v. Landrieu, 637 F.2d 12, 20 (1st Cir. 1980); Nucleus of Chicago Homeowners Ass'n v. Lynn, 524 F.2d 225, 232 (7th Cir. 1975), cert. denied, 424 U.S. 967 (1976).

(1) Need for Project—The EIS must contain an informative discussion of why the project is necessary. Although Scripps, in its application to the Hawaii Department of Natural Resources, has given some indication of what five more years of research might accomplish, making reference to the study of such seasonal and interannual phenomena as El Niño and the Pacific Decadal Oscillation,[6] its language there is imprecise and inadequate to the decision-making process. It affords neither officials nor the public the means to understand why acoustic thermometry, among all the new and established technologies used to measure ocean variability (e.g., satellite altimeter data, bathythermographic data), is likely to be effective in addressing the asserted need. Furthermore, its reference to longer "time scales" of research, exceeding the five years sought in the current application, suggests that the new study is but the "second phase" in a larger project, whose purposes (and impacts) are left unstated.[7] The EIS must identify both the need for the project and the project's purpose in clear, precise terms.

(2) Range of Species and Impacts—The EIS must carefully investigate, describe, and analyze potential impacts to the affected environment and to all species that may be affected, including marine mammals, sea turtles, fish, invertebrates, sea birds, and human divers.[8] The range of species must include any potentially affected by the system, not just those whose sensitivity to low-frequency sound is well known. Special attention must be paid to the region's endangered and threatened species, including the humpback whale, whose distribution and diving patterns appear to be affected by the ATOC signal, and the Hawaiian monk seal, about whose reactions very little data have been collected. For a representative number of species, observation regimes should be developed to track

[6] Scripps Institution of Oceanography, Conservation District Use Application: Section VI, Environmental Assessment (June 1999) at § 4(a) ("General Project Description: Technical").

[7] Id.

[8] Marine mammals cannot be the sole focus of analysis. It is worth noting, for example, that "[s]ound is important for normal behavior of many species of bony and cartilaginous fishes.... Fish use sound for a variety of reasons, including but not limited to prey detection, intraspecific communication, maintenance of schools, and predator avoidance." Committee on Low-Frequency Sound and Marine Mammals, Low Frequency Sound and Marine Mammals: Current Knowledge and Research Needs at 53 (1994). Negative impacts on fish and invertebrate populations could produce secondary effects on species further up the marine food chain.

long-term changes in abundance, distribution, reproductive rates, and other biological functions and factors.

(3) Cumulative and Indirect Impacts—In analyzing potential impacts, the EIS must consider not just the effects of ATOC in isolation, but its cumulative and indirect effects as well.[9] An adequate discussion of impacts in this instance would have to consider other sources of noise in the affected environment, such as shipping, fishing, and recreational uses, and their combined impact on resident species. It would also have to consider a range of indirect impacts that the Marine Mammal Research Program, with its focus on overt reactions, did not address, such as changes in stress levels, energy expenditures, and reproductive rates. That an effect may be "subtle" does not render it biologically insignificant. Given the duration and magnitude of the ATOC program, and its invasiveness into the marine environment north of Kauai, a careful assessment must be made of these less obvious impacts.

(4) Data Gaps and Incomplete Information—Despite over two years of research on the biological impacts of the ATOC signal, the record is mostly incomplete. The focus of the Marine Mammal Research Program was initially limited to certain overt, short-term behavioral reactions in certain species, and even in these instances the data that the teams managed to collect are often limited by low statistical power. NEPA requires, however, that all data gaps be filled during the EIS process; if they cannot be filled, or if the costs of doing so are exorbitant, they must at least be disclosed and explained, with the existing evidence summarized and the impacts assessed using theoretical approaches or research methods that are generally accepted in the scientific community. 40 C.F.R. § 1502.22. For example, it would not be reasonable to conclude, because the total acoustic output of humpback whales in the vicinity of the ATOC source did not change during transmissions, that ATOC has had no effect on whale vocalization; rather, the EIS would have to disclose that individual animals may have altered their singing (as preliminary data from other studies suggest), even if their total output

[9] The regulations define "indirect effects" to include impacts that occur "later in time or further removed in distance," such as changes in population density, migration patterns, feeding or breeding rates, or growth rate. 40 C.F.R. §1508.8(b).

remained the same, and would then have to work over the available data, if possible, to address this uncertainty. Given the undeniable need for more information about the impacts of low-frequency sound on marine species, particularly over the long term, it is essential that the EIS treat data gaps and scientific uncertainty with the analytical rigor that the law requires.

(5) Alternatives to the Proposed Project—The analysis of alternatives must be objective, unbiased, and searching—unprejudiced by the prior commitment of resources to the Kauai site. In addition to the "no action" alternative, in which other methods of analysis are used in lieu of acoustic thermometry to accomplish the stated goals, the EIS should consider alternate sites for the ATOC transmitter. Setting the source away from coastal waters and endangered species and in biologically less productive habitat, as a mid-ocean site might provide, could reduce its impact considerably. The prior commitment of resources to Kauai cannot be used to prejudice a careful weighing of prospective sites.

(6) Mitigation and Monitoring—An extensive discussion of mitigation measures is essential where, as here, the potential impacts of the system are substantial and not well understood. Such measures might include visual and acoustic monitoring, aerial surveillance, reductions in source levels or duty cycle, emergency shut-down procedures, continued involvement of an independent advisory board, additional scientific research on impacts, etc. In any case, a thorough and well-planned monitoring program is essential to assess the ongoing impacts on marine biota and alter or cease transmissions if unforeseen impacts are observed. Details of the monitoring program, including funding provisions, should be provided in the EIS.

(7) Funding and Completion of Needed Research—In order to understand the potential impacts of the ATOC system on the marine environment of Kauai, particularly over the period of years contemplated in the proposal, additional research will be necessary if the EIS is to be meaningful. Such research should be identified and funding obtained promptly from the Office of Naval Research, the University of California, or elsewhere to allow progress to be made within the EIS timeframe. The EIS must disclose

not only this work, but explain why other data gaps cannot reasonably be eliminated before a decision on the program is made.

(8) Compliance with Other Federal Laws—A number of federal laws are implicated by the ATOC program. Among those that must be disclosed and addressed in the EIS are the following:

First, the Marine Mammal Protection Act, 16 U.S.C. §§ 1361 et seq., requires the issuance by the National Marine Fisheries Service or U.S. Fish and Wildlife Service of a permit or other authorization prior to any "take" of marine mammals by any U.S. citizen or agency of the U.S. government. Natural Resources Defense Council v. U.S. Department of the Navy, 857 F. Supp. 834 (C.D. Ca. 1994). The moratorium on taking includes "harassment": any act of pursuit, torment, or annoyance that (a) has the potential to injure a marine mammal or marine mammal stock in the wild; or (b) has the potential to 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, feeding, or sheltering. 16 U.S.C. § 1362(18)(A).

Second, the federal Endangered Species Act, 16 U.S.C. §§ 1531 et seq., requires the issuance by the National Marine Fisheries Service or U.S. Fish and Wildlife Service of permits or a legally valid Biological Opinion prior to the "take" of any endangered or threatened marine mammals or other threatened or endangered species, including fish, sea turtles, or birds. 16 U.S.C. § 1536(a)(2).

Third, other statutes may also apply, including the Coastal Zone Management Act, 16 U.S.C. § 1456(c)(1)(A) (see below).

Each of these statutes is applicable to the ATOC project, and each imposes permitting or other administrative review requirements. Operation of the ATOC system cannot legally be undertaken without compliance with these laws.

(9) Conflicts with Federal, State, and Local Land Use Planning—The EIS must assess the possibility of conflict between ATOC transmissions and federal, regional, state, and local land-use policies, plans, and controls. 40 C.F.R. § 1502.16(c). For example, by operating its source off the north shore of Kauai, Scripps may enter into

conflict with several components of Hawaii's coastal management program, such as the mandate to preserve valuable coastal ecosystems of significant biological or economic importance. Because the program stands to affect the Hawaiian coastal zone, it is subject to the federal consistency requirements of the Coastal Zone Management Act. 16 U.S.C. § 1456(c)(3). The consistency of ATOC with Hawaii's management program should be discussed in the EIS.

(10) Breadth of Analysis—The EIS must address the ATOC program as a whole and not simply focus on individual segments, or "phases," of the program. Only in this manner can the full impacts of the program be understood.[10] Thus, if the goals and purposes of ATOC contemplate a foreseeable sequel to the current project in the same geographical region, or a longer term of operations than the five years discussed in the proposal, the EIS must evaluate the cumulative impacts of the whole. To do so later, when still more resources have been committed to the project, would frustrate the purpose of NEPA.

(11) Timing of ATOC Operations—NEPA prohibits an agency or citizen from proceeding with an action before the EIS process has been completed. We oppose any further operation of the ATOC source in violation of this requirement.

CONCLUSION

We believe the ATOC program as currently conceived may present a significant risk to the marine environment off Kauai and particularly to the humpback whales, sperm whales, Hawaiian monk seals, and other species that make their habitat there. We are filing these comments, despite our deep reservations, in order that the Office of Naval Research might undertake a thorough investigation of the matters outlined above, identify the project's

[10] The courts have required that complex proposals be analyzed in their entirety through a programmatic EIS. For example, according to the Ninth Circuit Court of Appeals, "[w]here foreseeable similar projects in a geographical region have a cumulative impact, they should be evaluated in a single EIS." City of Tenakee Springs v. Clough, 915 F.2d 1308, 1313 (9th Cir. 1990) (citing LaFlamme v. F.E.R.C., 852 F.2d 389, 401-02 (9th Cir. 1988); accord National Wildlife Fed. V. Appalachian Reg. Com., 677 F.2d 883, 888 (D.C. Cir. 1981); Conservation Law Foundation v. Harper, 587 F. Supp. 357, 364-65 (D. Mass. 1984)).

environmental impacts, explore alternative plans of action, and produce the objective, rigorous, and detailed evaluation that the law requires.

Very truly yours,

Joel R. Reynolds
Senior Attorney
Natural Resources Defense Council

Susan Jordan
Board Member, League for Coastal Protection
Observer, ATOC Marine Mammal Research Advisory Board

CORRECTION

THE PRECEDING DOCUMENT(S) HAS
BEEN REPHOTOGRAPHED TO ASSURE
LEGIBILITY
SEE FRAME(S)
IMMEDIATELY FOLLOWING

environmental impacts, explore alternative plans of action, and produce the objective, rigorous, and detailed evaluation that the law requires.

Very truly yours,

Joel R. Reynolds
Senior Attorney
Natural Resources Defense Council

Susan Jordan
Board Member, League for Coastal Protection
Observer, ATOC Marine Mammal Research Advisory Board

UNIVERSITY OF CALIFORNIA, SAN DIEGO

BERKELEY • DAVIS • IRVINE • LOS ANGELES • MERCED • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

CECIL H. AND IDA M. GREEN
INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS
SCRIPPS INSTITUTION OF OCEANOGRAPHY (0225)

LA JOLLA, CALIFORNIA 92093-0225

June 22, 2000

Joel R. Reynolds, Senior Attorney
Natural Resources Defense Council
6310 San Vicente Boulevard, Suite 250
Los Angeles, CA 90048

Susan Jordan, Board Member
League for Coastal Protection
805 23rd Street
Manhattan Beach, CA 90266

Dear ~~Mr. Reynolds~~ Joel and ~~Ms. Jordan~~ Susan:

Scripps Institution of Oceanography (Scripps) provides these comments in response to the letter submitted by you to the Office of Naval Research during the scoping period for the North Pacific Acoustic Laboratory (NPAL) project environmental impact statement (EIS). The NPAL project, formerly known as the Acoustic Thermometry of Ocean Climate (ATOC) Project Phase II, is a basic scientific research program that proposes to retain in place and reuse the power cable and sound source installed north of Kauai for an additional five years in order to 1) perform the second phase of research on the feasibility and value of large-scale acoustic thermometry; 2) study the behavior of sound transmissions in the ocean over long distances; and 3) conduct studies on the possible long-term effects from the sound transmissions on marine life.

We appreciate the extensive set of comments you prepared at this early stage of review. All have been taken into consideration in the preparation of the draft EIS, and most are addressed directly in the document. A copy of the document has been provided to you under separate cover. As you know, many of the issues raised by the NPAL proposal were explored in the EIS prepared for the Acoustic Thermometry of Ocean Climate (ATOC) project. New information obtained through the ATOC Marine Mammal Research Program (MMRP) studies and from other sources has been used in preparation of the present DEIS. However, much of the information and analysis in the ATOC EIS remains valid and relevant. That document has been incorporated in the NPAL DEIS, and the two should be considered together.

Your letter reviews the general requirements of NEPA, including requirements to prepare an EIS for a project that may affect the environment, to take a hard look at environmental consequences, to explore and evaluate reasonable alternatives, and to include mitigation measures. These requirements have guided the sponsoring agency's decision to prepare an EIS for the NPAL project as well as preparation of the document. Specific points covered in your letter are discussed below.

Need for the project. You have called for more specificity in discussion of the need for the proposed action. Chapter 1 of the DEIS includes a detailed discussion of the need for each of the three components of the NPAL project: (i) a second phase of research on the feasibility and value of large-scale acoustic thermometry, (ii) long-range underwater sound transmission studies, and (iii) marine mammal monitoring and studies. Chapter 1.1 in particular discusses the NPAL objectives at some length.

Range of species and impacts. Your proposals for scope of impact analysis have been carefully considered. Chapter 3 provides background information for assessing the potential effects of the proposed action on the physical, biological, social, and economic environments of the proposed Kauai site and the alternate Midway Atoll site. Chapter 3.2 in particular describes the biological environment, including invertebrates, baleen whales (Mysticetes), toothed whales (Odontocetes), pinnipeds, sea turtles, fishes, and seabirds. Chapter 4 then analyzes the potential effects, both individually and cumulatively. Chapter 4.4.1 in particular discusses the potential for impact on human divers. Chapters 1.1.3 and 5.2 describe the marine mammal monitoring studies designed to advance the understanding of the potential for long-term effects of man-made sound on marine mammals by monitoring the distribution and abundance of marine mammals in the vicinity of the sound source.

Cumulative and indirect impacts. The potential for both direct and indirect effects on the biological environment is discussed in Chapter 4.2.1. Information and analysis of cumulative effects on potentially affected species is covered in Chapter 4.2.2, including impacts from the various sources you note and others as well.

Data gaps and incomplete information. Chapters 1.2.2 and 4.2.1.2.1 discuss the findings of the California and Hawaii ATOC Marine Mammal Research Programs. Chapter 4 also presents results of other relevant research. It is recognized that data and information on potential biological impacts of underwater sound are not complete. The draft EIS discloses this fact where appropriate. The analysis reflects and explicitly discusses the limitations of knowledge, and fully complies with the requirements of 40 C.F.R. section 1502.22 on these issues.

Alternatives. The range of alternatives considered, including a site away from the existing Kauai sound source, is in keeping with principles cited in your scoping comments. However, consideration of alternatives need not include those which are incapable of achieving the purposes of the proposed action.

Mitigation and monitoring. Chapter 5 of the DEIS summarizes the proposed mitigation and monitoring measures in keeping with the information on potential impacts and the requirements of NEPA, including some of the ideas suggested in your comments.

Funding and completion of needed research. The proposed action addresses the issue of long-term effects through a program of monitoring and study. The program was designed based upon results of the MMRP and input from marine scientists with direct knowledge of the Kauai location. Additional research and funding, such as you suggest, would be desirable, but they are beyond the scope of this project. As previously noted, data gaps and incomplete information are acknowledged and discussed as appropriate in the DEIS.

Compliance with other federal laws. Chapter 6 addresses the federal, state, and local environmental review programs that do, or may, apply to the proposed action (Preferred Alternative). The project sponsors have consulted with state and federal agencies involved in implementation of each of the federal authorities noted in your comment letter: the Marine Mammal Protection Act, the Endangered Species Act, and the Coastal Zone Management Act. On-going compliance activities are discussed in detail in the DEIS.

Conflicts with federal, state, and local land use planning. This issue also is covered in the DEIS. In particular, you note the applicability of federal consistency provisions of the federal Coastal Zone Management Act. As applicant for incidental take authorization under the Marine Mammal Protection Act, Scripps has prepared a certification of consistency with Hawaii's federally certified Coastal Zone Management Program. The certification analyzes the relationship of the proposed action to each of the relevant policies of the state's program.

Breadth of analysis. Your comments raise the issue of whether the EIS must address what you term the "ATOC program as a whole," including possible future phases of acoustic thermometry research. This issue of the scope of the EIS has been given particularly close consideration in preparation of this document, and an extended discussion appears at Chapter 1.3.1.2. In summary, currently there are no plans, proposals, or recommendations for future projects using ATOC-type sound transmissions. There is no "ATOC program as a whole." The mere contemplation of a long-term project involving deployment of low frequency sound sources at unknown locations is not sufficient to trigger impact analysis requirements. Such "analysis" would necessarily be speculative and of little value. These conclusions are consistent with well established principles of NEPA. However, the DEIS does address the potential cumulative effects of the NPAL project in combination with the ATOC project and, as previously noted, with other sources of underwater sound in the region north of Kauai.

Timing of ATOC Operations. Transmissions from the ATOC Kauai source ceased on October 2, 1999, in accord with the various permits governing its operation. No further operations are planned unless and until all necessary permits have been obtained.

Once again, thank you for your participation in submitting comments to help guide the preparation of this EIS. If you have further questions or comments regarding NPAL, feel free to contact Susie Pike or myself at (858) 534-8031.

Sincerely yours,

Peter Worcester
Research Oceanographer

BENJAMIN J. CAYETANO
GOVERNOR OF HAWAII

TIMOTHY E. JOHNS
CHAIRPERSON
BOARD OF LAND AND NATURAL RESOURCES

DEPUTY DIRECTOR
JANET E. KAWELO

AQUATIC RESOURCES
BOATING AND OCEAN RECREATION
COMMISSION ON WATER RESOURCES
MANAGEMENT
CONSERVATION AND
RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
HISTORIC PRESERVATION
LAND
STATE PARKS

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
P. O. BOX 621
HONOLULU, HAWAII 96809

September 21, 1999

Office of Naval Research
c/o Kathleen Vigness
Marine Acoustics, Inc.
901 Stuart Street, Suite 708
Arlington, VA 22203

Dear Ms. Vigness:

In response to the June 15, 1999, Federal Registry notice, the State of Hawaii, Department of Land and Natural Resources (DLNR) offers for your consideration the following comments regarding the preparation of a draft Environmental Impact Statement (EIS) for continuation of the Acoustic Thermometry of Ocean Climate (ATOC) project. These comments focus primarily on aspects of the project that are directly related to DLNR's mandate to manage marine resources located within Hawaii's State waters, as well as DLNR's responsibility to co-manage the Hawaiian Islands Humpback Whale National Marine Sanctuary (Sanctuary) in partnership with the National Oceanic and Atmospheric Administration.

The proposed project involves continued use of the sound source previously installed for the ATOC project on the sea floor north of the island of Kauai. The sound source would remain in its present location, and transmissions would resume with the same signal parameters and approximately the same transmission schedule (six 20-minute transmission every fourth day). The purpose of the project is to determine the precision with which acoustic methods could be used to measure large-scale changes in ocean temperature and heat content.

DLNR recommends that the draft EIS describe and analyze at least one alternative that entails no operation of the ATOC sound source during the humpback whale breeding season in Hawaii. This recommendation arises from our concerns that the sound emitted by the ATOC sound source may have long-term adverse impacts on humpback whales frequenting Hawaiian waters.

The original ATOC project was accompanied by a marine mammal research program, which was designed to assess any short-term impacts on humpback whales and other marine organisms. Should the draft EIS consider an alternative that entails use of the sound source during humpback whale breeding season in Hawaii, DLNR strongly recommends that such an alternative include continuation or expansion of the marine mammal research program to assist in assessing any long-term impacts on humpback whales and other marine organisms.

We appreciate the opportunity to provide these comments. If there are any questions, please contact Jeffrey Walters, Sanctuary Co-Manager, at (808) 587-0100.

Yours Truly,

TIMOTHY E. JOHNS

UNIVERSITY OF CALIFORNIA, SAN DIEGO

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

CECIL H. AND IDA M. GREEN
INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS
SCRIPPS INSTITUTION OF OCEANOGRAPHY (0225)

LA JOLLA, CALIFORNIA 92093-0225

June 21, 2000

Mr. Timothy Johns
P.O. Box 621
Honolulu, HI 96809

Dear Mr. Johns,

Thank you for your September 21, 1999 letter offering comments to be considered in the preparation of the Draft Environmental Impact Statement (DEIS) for the proposed North Pacific Acoustic Laboratory (NPAL), formerly known as the Acoustic Thermometry of Ocean Climate (ATOC) Project Phase II. By now, you should have received your copy of the NPAL DEIS. The following information responds to points raised in your letter.

You requested that at least one alternative be analyzed that included no operation of the sound source during the humpback breeding season. This alternative is analyzed in Chapter 2.1.3 of the DEIS. In addition, your concerns regarding long-term adverse impacts are addressed in the DEIS Chapter 5.

You also recommended that an alternative that includes operation of the sound source during the humpback season (our preferred alternative) include a continuation of the marine mammal research program to assist in assessing long-term impacts. Chapter 5.2 of the DEIS discusses the project plans for monitoring to prevent adverse changes in distribution and abundance of marine animals.

We appreciate your interest in our project. If you have further questions or comments regarding NPAL, feel free to contact Susie Pike or myself at (858) 534-8031.

Sincerely,

Dr. Peter Worcester
Research Oceanographer

Cc: Jeffrey Walters

Main Office
726 South Kihei Road
Kihei, Maui, HI 96753
(800) 831-4888 - Toll Free
(808) 879-2818 - Voice
(808) 874-3815 - FAX

hihwnms@ocean.nos.noaa.gov
Website: http://www.t-link.net/~whale

Hawaiian Islands Humpback Whale
NATIONAL MARINE SANCTUARY

O'ahu Office
300 Ala Moana Blvd., Rm 5350
Honolulu, HI 96850
(808) 541-3184 - Voice
(808) 541-3450 - FAX

Kaua'i Office
P. O. Box 3390
Lihue, HI 96776
(808) 335-0941 - Voice
(808) 335-0942 - FAX

September 22, 1999

Office of Naval Research
c/o Kathleen Vigness
Marine Acoustics, Inc.
901 Stuart Street, Suite 708
Arlington, VA 22203

Dear Ms. Vigness:

NOAA's Hawaiian Islands Humpback Whale National Marine Sanctuary (Sanctuary) respectfully submits the following scoping comments to the Office of Naval Research in regards to the development and preparation of a draft Environmental Impact Statement (EIS) for the continuation of the Acoustic Thermometry of Ocean Climate (ATOC) project north of the island of Kauai.

Please note that the comments being provided primarily focus on aspects of the project that are directly relevant to NOAA's resource protection and stewardship mandate under the National Marine Sanctuaries Act (NMSA) and the Hawaiian Islands Humpback Whale NMS designation.

The Sanctuary recommends the draft EIS identify an alternative that restricts the operation of ATOC during the humpback whale breeding season in Hawaii. The Sanctuary further recommends that the draft EIS provide a detailed analysis of this alternative.

The draft EIS should also explain how collecting additional ATOC climate data from the project site, north of the island of Kauai, compliments ATOC's future research plans of being able to expand predictions of global climate change across other ocean basins.

The original ATOC project, a "2-year demonstration or proof of concept", was accompanied by a marine mammal research project which was designed to assess any short-term impacts on marine animals. If ATOC proposes an alternative to continue conducting operations during the humpback whale season, the Sanctuary strongly recommends such alternative include a marine mammal research program to assess any potential long term impacts on marine animals. In addition, the draft EIS should provide details on the commitment of funding levels for any associated marine mammal research program.

The Sanctuary also advises the principal investigators to work with the principal investigators of the original marine mammal research program to design an appropriate marine mammal monitoring program that would address the difficulties experienced during the initial phase of ATOC. These principal investigators in a recent presentation on Oahu, seemed to indicate that some inconsistencies regarding data on dive times and surface times

NATIONAL MARINE SANCTUARIES

of humpback whales may have been influenced by small sample size. In addition, the distance from shore to the source site inhibited shore observers from monitoring respiration rates of animals that may have surfaced directly above the ATOC source site.

We thank you for the opportunity to provide these comments and look forward to receiving a copy of the draft EIS for ATOC. Please ensure that my name is on your mailing list to receive a copy of the draft EIS. Please call Naomi McIntosh, Sanctuary Operations Coordinator at (808) 397-2651, if you have any questions regarding this letter.

Sincerely,

Allen T. Tom
Sanctuary Manager

cc: Helen Golde, NOAA/Marine Sanctuaries Division
Ramona Schreiber, NOAA/Policy and Planning
Steve Kokkinakis, NOAA/Polciy and Planning

UNIVERSITY OF CALIFORNIA, SAN DIEGO

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

CECIL H. AND IDA M. GREEN
INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS
SCRIPPS INSTITUTION OF OCEANOGRAPHY (0225)

LA JOLLA, CALIFORNIA 92093-0225

June 21, 2000

Mr. Allen Tom
Sanctuary Manager
Hawaiian Islands Humpback Whale National Marine Sanctuary
726 S. Kihei Road
Kihei, HI 96753

Dear Allen,

Thank you for your September 22, 1999 letter offering comments to be considered in the preparation of the Draft Environmental Impact Statement (DEIS) for the proposed North Pacific Acoustic Laboratory (NPAL), formerly known as the Acoustic Thermometry of Ocean Climate (ATOC) Project Phase II. By now, you should have received your copy of the NPAL DEIS. The following information responds to points raised in your letter.

You requested that at least one alternative be analyzed that included no operation of the sound source during the humpback breeding season. This alternative is analyzed in detail in Chapter 2.1.3 of the DEIS.

You requested that the DEIS explain how collecting additional climate data complements possible plans for expansion projects across other ocean basins. NPAL project objectives, including the thermometry objectives, are described in Chapter 1.1.

You also recommended that an alternative that includes operation of the sound source during the humpback season (our preferred alternative) include a marine mammal research program to assist in assessing long-term impacts. Chapter 5.2 of the DEIS discusses the project plans for monitoring to prevent adverse changes in distribution and abundance of marine animals.

We appreciate your interest in our project. If you have further questions or comments regarding NPAL, feel free to contact Susie Pike or myself at (858) 534-8031.

Sincerely,

Dr. Peter Worcester
Research Oceanographer

Sanctuary Advisory Council

Hawaiian Islands Humpback Whale National Marine Sanctuary

September 22, 1999

Office of Naval Research
c/o Kathleen Vigness
Marine Acoustics, Inc.
901 Stuart Street, Suite 708
Arlington, VA 22203

Dear Ms. Vigness:

I am submitting the following scoping comments regarding the development of the Environmental Impact Statement for the continued operation of the Acoustic Thermometry Ocean Climate (ATOC) Project on the behalf of the Hawaiian Islands Humpback Whale National Marine Sanctuary Advisory Council (SAC).

The SAC's Research Working Group and Conservation Committee have each reviewed this issue and their comments are attached.

Please accept these comments for consideration and review during the development and preparation of the Environmental Impact Statement for the continued operation of ATOC.

Sincerely,

Kellie Araki
SAC Coordinator

Encl: (1) SAC Research Working Group Scoping Comments
(2) SAC Conservation Committee Scoping Comments

6700 Kalanianaʻole Highway, Suite 104 Honolulu, Hawaiʻi 96825 Phone: 397-2651 Fax: 397-2650

Sanctuary Advisory Council Research Working Group Scoping Comments regarding the development of the Environmental Impact Statement for the continued operation of the Acoustic Thermometry Ocean Climate Project

Dr. Paul Nachtigall, SAC Research Chair. Phone: (808) 247-5297

The Advanced Thermometry of Ocean Climates (ATOC) project has projecting a low frequency (78 Hz) signal from a transmitter located of the North side of Kaui. The oceanic 'climate' is relatively unknown as compared to the atmospheric climate and thermometry offers an additional tool to oceanographers to examine macroscale ocean temperature and examine the effects of global warming on the oceans. Concern about the transmission of loud (195dB re 1 mpa) sounds through the habitat of the humpback whales led to the ATOC Marine Mammal Research Program. Although the program is not complete, data to date indicate minor changes in the behavior of humpback whales when the sounds are transmitted as compared to times when no sounds are transmitted. Data from that research program indicate a positive increase in the number of humpback whales migrating to Hawaiian waters during the winter migrations from Alaskan waters.

Although short term deleterious effects are not apparent, long term effects of sound transmission on the behavior and fitness of the population of humpback whales migrating to the Hawaiian Islands remain unknown. Given the importance of gathering knowledge on the effects of global warming on the earth's atmosphere and oceans and the initial success of the project, the Sanctuary Advisory Council takes the position that it is reasonable to continue both research projects. The ATOC study should continue to examine ocean temperatures only as long as the Marine Mammal Research Program associated with ATOC continues to examine the effects of low frequency sound on the behavior and population of migrating humpback whales.

Encl. (1)

Sanctuary Advisory Council Conservation Committee Scoping Comments regarding the development of the Environmental Impact Statement for the continued operation of the Acoustic Thermometry Ocean Climate Project

Dr. Louis Herman, SAC Conservation Committee Chair. Phone: (808) 591-2121

The Sanctuary Advisory Council is charged with considering issues that may affect the well being and recovery of humpback whales or that may affect their habitat in the Hawaiian Sanctuary waters. We cannot resolve the relative importance of further investigation of global warming through the technique of acoustic thermometry of ocean climate versus the need to protect a vital region occupied each winter by humpback whales.

It seems clear, however, that many more years of ATOC emissions will be necessary to more fully validate the technique and that many more years beyond that will be necessary to see whether the technique adds significantly to answering questions about global warming. Hence, ATOC, by its goals and through its techniques, is a very long-term project. To determine its impact, if any, on humpback whales or on other marine mammals and marine life will also require many more years of study. The position of SAC is that if ATOC is to continue in its present location than monitoring of marine life must also continue until there are sufficient data gathered to draw firmer occlusions than those available now about effects, if any, on the whales. To this end, all data gathered by the ATOC MMRP team should be made available for peer review by individuals or agencies not directly connected with ATOC or dependent on support from ATOC or its related projects. "

Encl. (2)

UNIVERSITY OF CALIFORNIA, SAN DIEGO

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

CECIL H. AND IDA M. GREEN
INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS
SCRIPPS INSTITUTION OF OCEANOGRAPHY (0225)

LA JOLLA, CALIFORNIA 92093-0225

June 21, 2000

Ms. Kellie Araki
SAC Coordinator
Hawaiian Islands Humpback Whale National Marine Sanctuary
6700 Kalaniana'ole Highway, Suite 104
Honolulu, HI 96825

Dear Ms. Araki,

Thank you for your September 22, 1999 letter offering Hawaiian Islands Humpback Whale National Marine Sanctuary Advisory Council (SAC) comments to be considered in the preparation of the Draft Environmental Impact Statement (DEIS) for the proposed North Pacific Acoustic Laboratory (NPAL), formerly known as the Acoustic Thermometry of Ocean Climate (ATOC) Project Phase II. The NPAL DEIS has been completed, and is now available for distribution.

In your letter, you submitted separate statements from the Research Working Group and Conservation Committee. Both groups recommended that a marine mammal research and monitoring program continue in conjunction with the sound transmissions. The Research Working Group also recommended that the data gathered by the marine mammal research team be made available for peer review.

We have included a plan for monitoring marine mammals in Chapter 5.2 of the DEIS. The Marine Mammal Monitoring Studies element of the proposed action is designed to advance the understanding of the long-term effects of the sound transmissions on the distribution and abundance of marine life through the conduct of aerial surveys in the vicinity of the sound source. We have also indicated that all reports published by the marine mammal researchers, as well as the annual reports provided to the National Marine Fisheries Service, would be made available in the public domain.

We appreciate your interest in our project. If you have further questions or comments regarding NPAL, feel free to contact Susie Pike or myself at (858) 534-8031.

Sincerely,

Dr. Peter Worcester
Research Oceanographer

Cc: Dr. Paul Nachtigall, SAC Research Chair
Dr. Louis Herman, SAC Conservation Committee Chair

Sanctuary
Advisory
Council

Hawaiian Islands Humpback Whale National Marine Sanctuary

September 7, 1999

Office of Naval Research
c/o Kathleen Vigness
Marine Acoustics, Inc.
901 Stuart Street, Suite 708
Arlington, VA 22203

Dear Ms. Vigness:

The Conservation Committee of the Hawaiian Islands Humpback Whale National Marine Sanctuary Advisory Council is submitting the following comments to the Office of Naval Research regarding the development and preparation of a draft Environmental Impact Statement for the continuation of the Acoustic Thermometry of Ocean Climate (ATOC) project north of the island of Kauai.

The position of the Sanctuary Advisory Council's (SAC) Conservation Committee regarding the ATOC project is to require the applicants to continue and expand the marine mammal research and monitoring program, if ATOC is permitted.

Dr. Peter Worcester, ATOC's Principal Investigator and Research Oceanographer and Dr. Joseph Mobley will be presenting information on ATOC at the next scheduled SAC meeting on September 9, 1999. The SAC and its Conservation Committee may submit additional comments after Dr. Worcester's and Dr. Mobley's presentation on September 9th.

If you have any questions, please do not hesitate to contact me at (808) 591-2121.

Sincerely,

Dr. Louis Herman
Conservation Committee, Chair

cc: Office of Senator Daniel K. Inouye
Office of Senator Daniel K. Akaka
Office of Representative Neil Abercrombie
Office of Representative Patsy Mink
Office of Governor Benjamin Cayetano
Dr. Peter Worcester

6700 Kalaniana'ole Highway, Suite 104 Honolulu, Hawai'i 96825 Phone: 397-2651 Fax: 397-2650

UNIVERSITY OF CALIFORNIA, SAN DIEGO

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO   SANTA BARBARA • SANTA CRUZ

CECIL H. AND IDA M. GREEN
INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS
SCRIPPS INSTITUTION OF OCEANOGRAPHY (0225)

LA JOLLA, CALIFORNIA 92093-0225

June 21, 2000

Dr. Louis Herman
Conservation Committee, Chair
Hawaiian Islands Humpback Whale National Marine Sanctuary
6700 Kalaniana'ole Highway, Suite 104
Honolulu, HI 96825

Dear Dr. Herman,

Thank you for your September 7, 1999 letter offering Conservation Committee comments to be considered in the preparation of the Draft Environmental Impact Statement (DEIS) for the proposed North Pacific Acoustic Laboratory (NPAL), formerly known as the Acoustic Thermometry of Ocean Climate (ATOC) Project Phase II. By now, you should have received your copy of the NPAL DEIS.

In your letter, you recommended that the project be required to continue and expand the marine mammal research and monitoring program. You also recommended that an alternative that includes operation of the sound source during the humpback season (our preferred alternative) include a marine mammal research program to assist in assessing long-term impacts. Chapter 5.2 of the DEIS discusses the project plans for monitoring to prevent adverse changes in distribution and abundance of marine animals.

We appreciate your interest in our project. If you have further questions or comments regarding NPAL, feel free to contact Susie Pike or myself at (858) 534-8031.

Sincerely,

Dr. Peter Worcester
Research Oceanographer

SUMMARY OF COMMENTS FROM SCOPING MEETINGS

GENERAL COMMENTS

1. Why isn't a programmatic EIS being done? Settlement agreement stated MMRP was to be conducted for 24 months in lieu of full ATOC program. Any continuation of ATOC would require programmatic EIS.

2. Would like to have all details of source use, including Navy's interest spelled out in detail in DEIS. Would like DEIS to include all details, not save the controversial material for the FEIS when the public cannot comment and review. Address Navy's interest in long range propagation.

ALTERNATIVES:

1. What are other techniques could achieve same results? i.e., satellite altimetery, XBTs dropped from ships of opportunity, computer models, ARGOS project (subsurface drifters for temperature, salinity profiles)

2. Will alternative locations for the source and cable be considered?

AFFECTED ENVIRONMENT

1. The EIS should address the received levels at which effects on animals occur.

2. Do surface length and duration results imply that the animals were stressed?

3. Not enough long-term data to do chronic studies; not enough short-term studies to estimate acute effects.

4. None to limited studies on fish, sea turtles, sharks, Hawaiian monk seals, dolphins.

5. Date of transmission coincided with date a man's leg was bitten off at Barking Sands by a shark. No research on sharks; may be endangering public, tourist industry with transmissions.

6. Does cable enter into Hawaiian Islands Humpback National Marine Sanctuary? How will that be addressed?

7. Is the cable located on the coral reef?

8. Need to analyze correlation of ATOC transmissions with stranding data. Need to address lack of stranding networks on Hawaii.

9. MMRP results are inconclusive and should not be used to allow ATOC to continue untested. Should broaden MMRP to address additional species, particularly deep divers. Should use more and better survey techniques. Need to continue extensive marine mammal monitoring work. Need to do studies of migration patterns.

CUMULATIVE IMPACTS

1. How long will project occur? If it was possible to apply for an infinite permit, what would be the length of time requested? How many phases could there be? Is this one of 20 phases, how many? What is the lifetime of the equipment? What happens if the equipment fails within the five years? Need to address length of potential project and not segment into 5-year blocks.

2. How many additional sound sources are projected for this project? How many acoustic thermometry projects will there be? (issue of segmentation)

3. Issue of cumulative impacts – other federal agencies could use ATOC to address how to mitigate shipping noise; Navy could mitigate with number of vessels they have traveling through Hawaiian waters. What is the point where the environment becomes unfavorable for marine life?

UNIVERSITY OF CALIFORNIA, SAN DIEGO

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO   SANTA BARBARA • SANTA CRUZ

CECIL H. AND IDA M. GREEN
INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS
SCRIPPS INSTITUTION OF OCEANOGRAPHY (0225)

LA JOLLA, CALIFORNIA 92093-0225

June 21, 2000

To: Scoping Meeting Attendees

From: Dr. Peter Worcester
Research Oceanographer

RE: Draft Environmental Impact Statement (DEIS) for the North Pacific Acoustic Laboratory (NPAL), formerly the Acoustic Thermometry of Ocean Climate (ATOC) Project, Phase II

We would like to thank you for your interest in our project and your attendance at the June 30, July 1 and July 2, 1999 scoping meetings for the NPAL DEIS. By now, you should have received your copy of the DEIS. In it, you will find that we have summarized your comments and included them in the Scoping Summary, Section 1.4. We have also added an Appendix D, entitled Scoping Comments and Responses, to the DEIS Addendums.

If you would like an opportunity to comment on the DEIS, we will be holding public meetings to provide information and allow the public the opportunity to comment. The evening meetings will consist of an informational presentation at 7:00 PM, followed by a public hearing at 8:00 PM. The afternoon meeting in Kilauea will consist of an informational presentation at 1:30 PM, followed by a public hearing at 2:30 PM.

Wednesday, July 5, 2000
7:00 to 9:30 PM
Kauai Community College Dining Rm
3-1901 Kaumualii Highway
Lihue, Kauai

Thursday, July 6, 2000
7:00 to 9:30 PM
Hawaii Imin International Conference Center
East-West Center, 2nd Floor, Pacific Room
1777 East West Road
Honolulu, Hawaii

Saturday, July 8, 2000
1:30 to 4:00 PM
Kilauea Neighborhood Center
2460 Keneke Street
Kilauea, Kauai, Hawaii

You can also submit your comments in writing to:

Office of Naval Research
c/o Kathleen Vigness Raposa
Marine Acoustics, Inc.
809 Aquidneck Avenue
Middletown, RI 02842

If you have further questions or comments regarding NPAL, feel free to contact Susie Pike or myself at (858) 534-8031.

Sincerely,

Peter Worcester
Research Oceanographer

RESPONSES

The scoping process resulted in requests that several enviornmental and procedural issues be analyzed in the EIS. All comments have been evaluated in preparation of this EIS. A summary of the principal issues identified during scoping follows:

- **Scope of Project Analyzed:** See Section 1.3.1.2.

- **Need for Project:** Several commenters requested information on why a second phase of research on large-scale acoustic thermometry is necessary and how the information will be used. This issue is addressed in Chapter 1.

- **Alternatives to be Considered**: During the scoping process the question was raised whether the same results could be achieved using alternate methods. Techniques such as satellite altimetry, XBTs dropped from ships of opportunity, computer models and subsurface drifters were suggested. The range of alternatives considered in Chapter 2 responds to this comment.

- **Address Navy's Interest**: A few commenters requested to have the Navy's interest in long-range underwater acoustic propagation and in this project described in detail. This issue is addressed in Chapter 1.

- **Biological Resource Impacts**: A number of commenters were concerned about the potential impacts on biological resources and habitats, including marine mammals, fish, sharks, sea turtles, Hawaiian monk seal, dolphins, migratory birds, invertebrates and coral reefs. These issues are addressed in Chapters 3 and 4.

- **Hawaiian Islands Humpback Whale National Marine Sanctuary:** The question was raised whether the cable crosses the boundaries of the Sanctuary and how potential effects on the Sanctuary will be addressed. This issue is covered in Chapters 3 and 6.

- **Project Duration**: Several commenters requested information on the potential project length, number of sources and long-term plans. These issues are addressed in Chapter 1.

- **Marine Mammal Research Program (MMRP):** A number of interested individuals and organizations were concerned that the MMRP results-to-date were inconclusive and requested that the MMRP continue and be broadened to include additional species, techniques and studies. This is addressed in Chapter 5.

- **Cumulative Impacts**: Several commenters requested that the EIS evaluate the cumulative and indirect impacts, including the effects of other sources of noise. These potential impacts are discussed in Chapter 4.

• **Mitigation Measures:** Several organizations requested that the EIS propose mitigation and monitoring efforts designed to minimize the potential impacts of the proposed action on surrounding resources. These issues are addressed in Chapter 5.

APPENDIX E

LIST OF PERSONS CONSULTED IN PREPARING THE DEIS

CORRECTION

THE PRECEDING DOCUMENT(S) HAS BEEN REPHOTOGRAPHED TO ASSURE LEGIBILITY
SEE FRAME(S)
IMMEDIATELY FOLLOWING

APPENDIX E

LIST OF PERSONS CONSULTED IN PREPARING THE DEIS

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF PERSONS CONSULTED

FEDERAL

U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service

- Hilda Diaz-Soltero
- Jeannie Drevenak
- Alan Everson
- Roger Gentry
- Ken Hollingshead
- Donald Knowles
- Ann Liu
- Marilyn Luipold
- Gene Nitta
- Donna Weiting

U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Hawaiian Islands Humpback Whale National Marine Sanctuary

- Allen Tom, Sanctuary Manager

U. S. Army Corps of Engineers

- George Young

U.S. Department of the Interior, Fish and Wildlife Service

Office of Naval Research

Commander Navy Region Hawaii

- Rebecca Hommon, Regional Counsel

Department of the Navy

Pacific Missile Range Facility

- David Anderson
- Jim Dawson
- Mike Dick
- Ave Soto

STATE

Department of Land and Natural Resources
Office of the Chair
Timothy Johns

Land Division
Tom Eisen
Dean Uchida

Aquatic Resources Division
Emily Gardner
Don Heacock
Jeff Walters

Division of Historic Resources Preservation
Ross Corty

Department of Business, Economic Development and Tourism
Office of Planning, Hawaii Coastal Zone Management Program (HCZMP)
John Nakagawa

Department of Health, Clean Water Branch
Denis Lau

Hawaii Office of Environmental Quality Control
Jeyan Thirugnanam
Nancy Heinrich

Office of Hawaiian Affairs
Collin Kippen
Lynn Lee

State of Hawaii Attorney General's Office
Linnel Nishioka
Larry Lau

University of Hawaii
Joe Mobley

University of Hawaii Environmental Center
Jackie Miller

STATE (cont.)

University of Hawaii, Hawaii Institute of Marine Biology
Whitlow Au
Paul Nachtigall

University of Hawaii, International Pacific Research Center
Julian McCreary

University of Hawaii Sea Grant Program
Peter Rappa

CITY AND COUNTY

County of Kauai
Dee M. Crowell, Planning Director
George Kalisik

Mayor Maryanne Kusaka
W. Rezentes

Kauai County Council

ORGANIZATIONS

ATOC Marine Mammal Research Program Advisory Board

Cascadia Research
John Calambokidis

Cornell University, Bioacoustic Research Program
Chris Clark

Hawaiian Islands Humpback Whale National Marine Sanctuary
Sanctuary Advisory Council

Natural Resources Defense Council
Joel Reynolds

University of California, Santa Cruz
Dan Costa

INDIVIDUALS

Scoping meeting attendees

- Nicole Adimey
- Carmen Bazua
- Carl Berg
- David Boynton
- Brian Branstetter
- Nancy Bushnell
- Ray Chuan
- Alison Craig
- Dee Crowell
- Mark Deakos
- Michael Dick
- Dr. & Mrs. Walter Haas
- James Hager
- Vivian Hager
- Alanna Hobbs
- Douglas Ing
- Kevin Kelly
- Cindy Knapman
- Donna Lee
- Lynn McCrory
- Naomi McIntosh
- Bobbie Sandoz
- John Sibert
- Jean Souza
- Richard Sugiyama
- Ashley Summers
- Gang Yuan

LIST OF PERSONS CONSULTED THAT HAD NO COMMENT

STATE

Department of Land and Natural Resources
Division of Historic Resources Preservation
Ross Corty

Department of Health, Clean Water Branch
Denis Lau

Office of Hawaiian Affairs
Collin Kippen
Lynn Lee

THIS PAGE INTENTIONALLY LEFT BLANK