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.

<u>Proposed Action</u>

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.

<u>Purpose</u>

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 four aerial surveys would be conducted during each humpback whale season. The Marine Mammal Monitoring Studies would have four components:

- 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).)

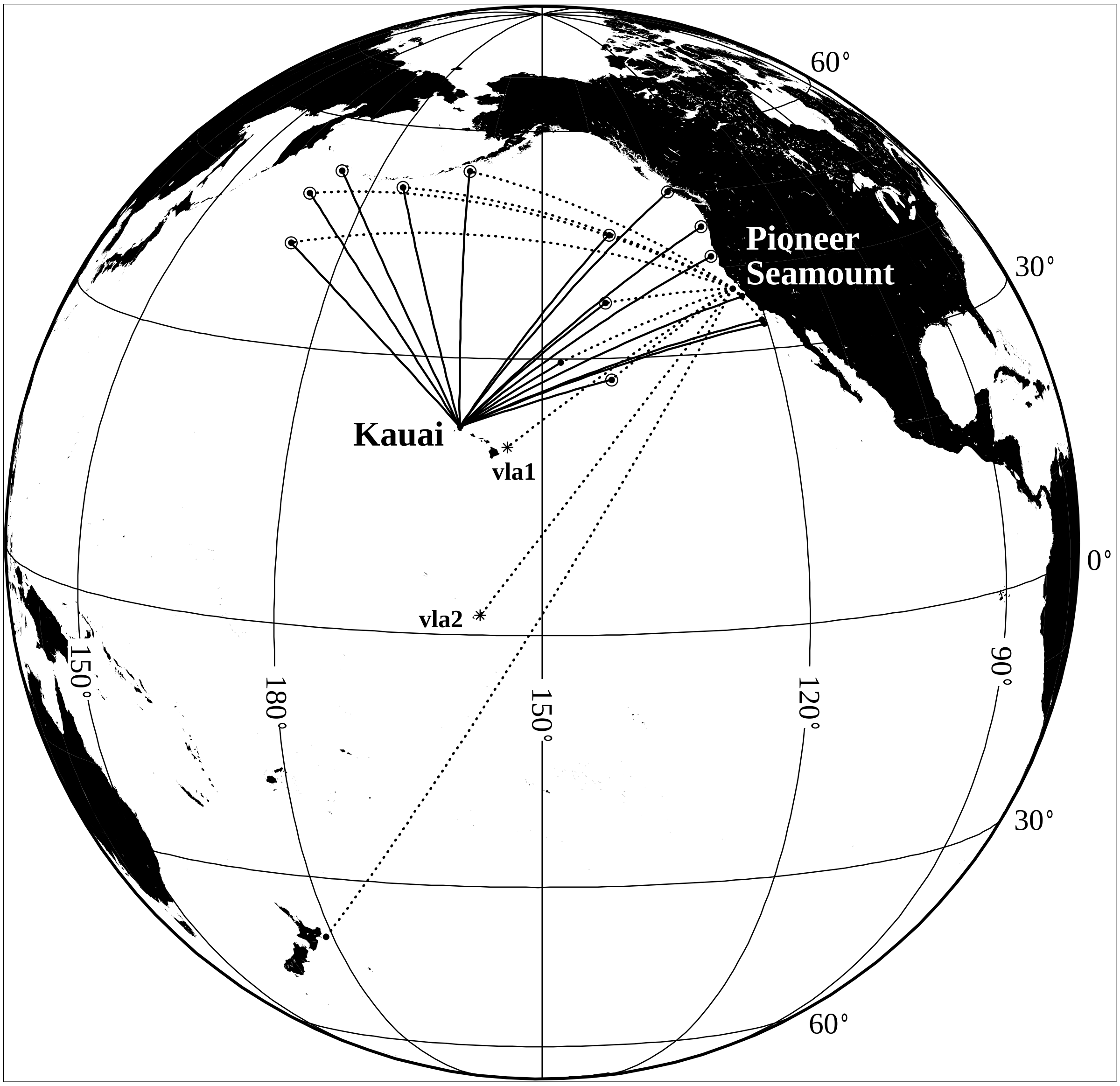

Figure 1-1 Location of the ATOC Sound Sources and Receivers

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 or elephant seals in response to the playback of ATOC-like sounds or 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, 1999). 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.

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, 1999).

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 33, 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) will be published in the *Federal Register*, signaling the start of a 45-day period for review and comment upon this DEIS. The final EIS will incorporate and include responses to comments submitted within the review period, as well as any other appropriate modifications to the DEIS.

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 the ATOC-like sounds and transmissions of the ATOC Kauai source, the suggested effects do not support a request for a LOA. None-the-less, ONR/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 publications of the DEIS, Scripps will commence the process of applying for a LOA.

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.

The project will require a permit for incidental taking of listed species, under § 1539(a)(2)(B) of the Act. Such permits are issued subject to requirements that the activity will not appreciably reduce the likelihood of the species' survival and recovery, that impacts are minimized and mitigated, and other standards are met. This permit process is administered by NMFS in conjunction with the MMPA authorization discussed above.

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 will initiate interagency consultation by submitting to NMFS a Biological Assessment of the proposed action's potential effects on listed species and their designated critical habitat. Consultation will conclude with NMFS' issuance of a Biological Opinion 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.

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 the 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.

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 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 into this DEIS in Section 1.4. Following issuance of this Draft EIS, a 45-day public comment period will be provided, after which the Final EIS will be prepared.

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.