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.

Under these authorities, ONR and Scripps must ensure that the potential environmental effects of the proposed project have been adequately addressed and analyzed. In addition, other agencies will review and consider the information presented in this EIS prior to deciding whether to approve aspects of the project under their specific jurisdiction. These required approvals include incidental harassment/taking authorization from the National Marine Fisheries Service (NMFS), a Conservation District Use Permit (CDUP) from Hawaii Department of Land and Natural Resources (DLNR), and various other reviews and consultations described more fully in Chapters 1 and 6.

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.

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.

Though several potential effects due to source transmissions are discussed, including the potential for physical auditory effects, behavioral disruption, habituation, masking, long-term effects, and indirect effects, only the potential for physical auditory effects and behavioral disruption are believed to be of any significance. 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, 1999a).

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 risk for disturbance of a biologically important behavior if an animal received one 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 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 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.

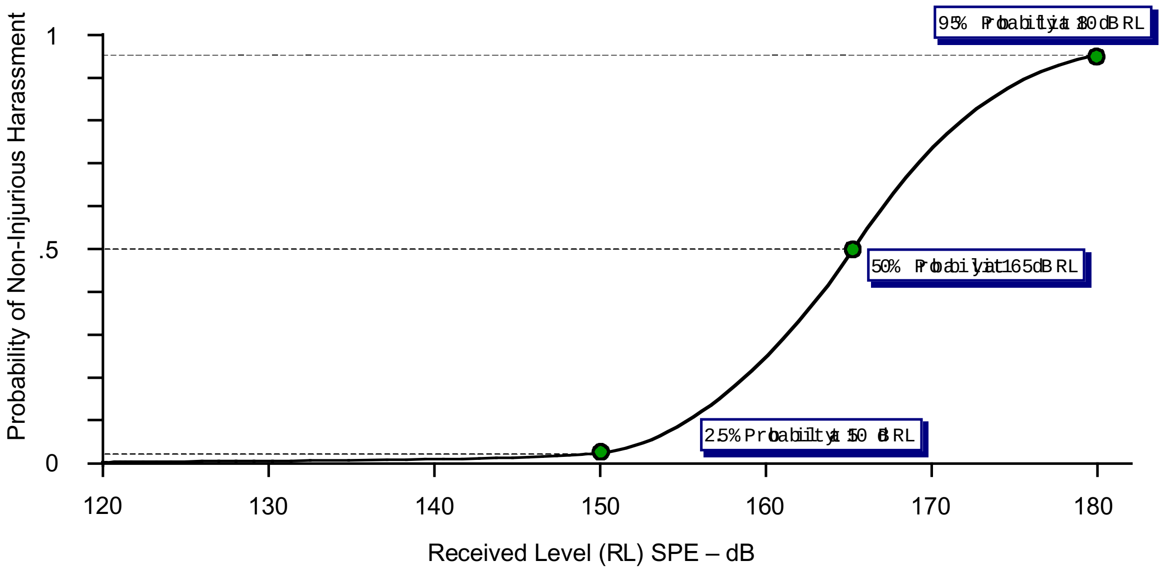

Figure ES-1, Single Ping Equivalent Probability Function

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). 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 demonstrate 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.

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

Marine Mammals	One Transmission		One Day of Transmissions	
	Disturbance of Biologically Important Behavior (120-180 dB)	TTS (≥ 180 dB)	Disturbance of Biologically Important Behavior (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

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

Marine Mammals	One Transmission		One Day of Transmissions	
	Disturbance of Biologically Important Behavior (120-180 dB)	TTS (≥ 180 dB)	Disturbance of Biologically Important Behavior (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.

Little information on hearing exists for marine fish species in the vicinity of the proposed sites. However, fish species can be grouped into two categories: “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.

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.