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2A-1995 Vol. I

DOCUMENT IDENTIFICATION

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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])

Volume I

Prepared by

Advanced Research Projects Agency
3701 North Fairfax Drive
Arlington, VA 22203-1714

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

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108 Administrative Complex
La Jolla, CA 92093

April 1995

Printed on Recycled Paper

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 074-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	April 1995	Final EIS, April 1995

4. TITLE AND SUBTITLE
Final Environmental Impact Statement/Environmental Impact Report for the California Acoustic Thermometry of Ocean Climate Project and its associated Marine Mammal Research Program Volume I

5. FUNDING NUMBERS
N/A

6. AUTHOR(S)
Advanced Research Projects Agency

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Advanced Research Projects Agency
3701 N. Fairfax Dr.
Arlington, VA 22203-1714

NOAA National Marine Fisheries Service
Office of Protected Resources
1335 East-West Highway
Silver Spring, MD 20910

Univ. of California, San Diego
Campus Planning Office
108 Administrative Complex
La Jolla, CA 92093

8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

SERDP
901 North Stuart St. Suite 303
Arlington, VA 22203

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
N/A

11. SUPPLEMENTARY NOTES
Prepared by the Advanced Research Projects Agency in cooperation with the National Oceanic and Atmospheric Administration National Marine Fisheries Service and the University of California, San Diego. April 1995. This work was supported in part by SERDP. The United States Government has a royalty-free license throughout the world in all copyrightable material contained herein. All other rights are reserved by the copyright owner.

12a. DISTRIBUTION / AVAILABILITY STATEMENT	12b. DISTRIBUTION CODE
Approved for public release: distribution is unlimited.	A

13. ABSTRACT ***(Maximum 200 Words)***

This EIS/EIR presents a detailed description of the proposed project, in addition to other information required by the National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA).

The overall Acoustic Thermometry of Ocean Climate (ATOC) project is an international research effort to observe the ocean on the large space scales (3,000 to 10,000 km) which characterize climate, which will enable climate models to be tested against the average ocean temperature changes seen by ATOC over a few years and if, and when, the models prove adequate, use those same observations to "initialize" the models to make meaningful predictions. The basic principle behind ATOC is simple. Sounds travels faster in warm water than in cold water. The travel time is a direct measure of the large-scale average temperature between the source and receiver. Measuring average ocean temperatures is necessary to validate global climate computer models being used and developed to answer the question of whether our earth is warming as a result of the "greenhouse" effect.

14. SUBJECT TERMS	15. NUMBER OF PAGES
ATOC, NEPA, CEQA, SERDP, Ocean temperatures, global warming	469
	16. PRICE CODE
	N/A

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclass.	Unclass.	Unclass.	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

LIST OF TABLES

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Preface

The original, preferred alternative to conduct the proposed acoustic thermometry measurements and the associated Marine Mammal Research Program was at Sur Ridge, offshore Pt. Sur, CA. In response to concerns raised and comments received during the public comment period on the Draft EIS/EIR about conducting the proposed research within the Monterey Bay National Marine Sanctuary (MBNMS), the proposed project site was changed to Pioneer Seamount (Alternative 3-1 in the DEIS/EIR). This site is 88 km (48 nm) offshore Pillar Point, CA and 28 km (15 nm) outside of the MBNMS. The source would be placed at a depth of approximately 980 m (3215 ft), which is 130 m (427 ft) deeper than the preferred site at Sur Ridge. The area that would be within the 120 dB sound field contour at the Pioneer Seamount site is smaller than that for Sur Ridge (735 km^2 vs. 1200 km^2), due primarily to the extreme bathymetry that causes more rapid sound attenuation. No vertical line array (with associated data cable) is planned for the Pioneer Seamount alternative, and the power cable termination would be at the Pillar Point Air Force Station, where the onshore portion would be located entirely underground, in conjunction with previously planned bluff restoration activities of the Air Force.

Because the Pioneer Seamount alternative was already analysed in detail in the Draft EIS/EIR, only minor textual clarifications and elaborations are included in this Final EIS/EIR. As required by the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA), Responses to Comments Raised by the Draft EIS/EIR are included as Appendix F. In accordance with CEQA requirements, a Mitigation Monitoring Program has also been developed and is provided as Appendix G.

In response to several requests by the public for an opportunity for additional participation in the EIS/EIR review and approval process, comments from the public are being solicited during the 30-day period ending June 5, 1995, following official publication of the Final EIS/EIR via the Federal Register. Written comments should be submitted to:

Advanced Research Projects Agency
c/o Clayton H. Spikes
Marine Acoustics, Inc.
Four Crystal Park, Suite 901
2345 Crystal Drive
Arlington, VA 22202

Title

Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR) for the California Acoustic Thermometry of Ocean Climate (ATOC) Project and its associated Marine Mammal Research Program (MMRP) (Scientific Research Permit Application [P557A]).

Abstract

ATOC is proposed as a proof-of-concept study funded by the Strategic Environmental Research and Development Program (SERDP). The primary purpose of ATOC is to make a contribution toward meaningful climate predictions. All viable climate models show that the ocean plays a profound role in climate change. The ocean provides much of the memory which defines climate. No climate forecast, with all its consequences, will have any skill greater than that imbedded in the oceanic component. One will not get the atmosphere right unless one gets the ocean right.

The question is whether these forecasts have any skill; i.e., whether they provide a reasonable basis for policy decisions. We know from experience with weather forecasting that meaningful forecasts are impossible unless the system is correctly described by the equations being used, and then "initialized" properly; i.e., the calculations must be started from a realistic oceanic state--otherwise, the forecast diverges rapidly from reality.

Perhaps the greatest obstacle to making useful forecasts of the ocean climate lies with the difficulty in measuring the ocean state today so as to test the models against present-day reality, and in determining the extent to which the ocean is already changing. Appropriate ocean measurements are then an essential part of any climate prediction. ATOC is intended to observe the ocean on the large space scales that characterize climate--3000 to 10,000 km--so that modelers will be able to: 1) test their models against the changes seen by ATOC over a few years, and 2) if, and when, the models prove adequate, use those same observations to "initialize" the models to make climate predictions.

Acoustic thermometry would provide important tests of seasonal and year-to-year ambient variability. Interplay of the observational and modeling efforts should lead to model improvements and, ultimately, to model credibility. By testing and improving the models now, we can make progress toward greenhouse prediction later.

Virtually all climate models suggest that there will be major shifts in climate over the next several decades ("global warming"), with enormous consequences to the world's economic and social structures (as well as to life within the seas). Acoustic thermometry can make a contribution toward credible climate predictions.

The 1991 Heard Island Feasibility Test proved the principle of using low frequency acoustic signals of moderate intensity over global deep ocean transmission paths to measure propagation time and spatial variability of temperature.

Available information from the limited research carried out to date on the potential effects of low frequency sound on marine animals, including marine mammals and sea turtles, either indicates minimal impact should be expected from the proposed ATOC sound transmissions, or the measured data are so sparse that the possible effects must be stated as uncertain. Consequently, a Marine Mammal Research Program (MMRP) has been designed to assess the potential effects of the proposed low frequency sound transmissions on marine mammals and sea turtles. MMRP research efforts would be an integral part of the entire proposed two-year project, including ATOC feasibility operations that would be dedicated to climate-based studies. An approximate six-month MMRP Pilot Study (although MMRP refers to the Marine Mammal Research Program, all marine animals fall within its purview) would be undertaken, which would allow marine biologists to utilize the source for research studies into the potential effects of low frequency sound on marine animals, prior to approval of feasibility operations. Baseline marine animal population and behavioral data collection efforts have been ongoing in the central California offshore area since mid-1994.

In accordance with Marine Mammal Protection Act and Endangered Species Act guidelines, an Application for Permit for Scientific Research has been submitted to the National Marine Fisheries Service. Because of potential environmental concerns, this EIS/EIR has also been prepared.

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Cooperating Agency:	National Oceanic and Atmospheric Administration National Marine Fisheries Service Office of Protected Resources 1335 East-West Highway Silver Spring, MD 20910
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CALIFORNIA ATOC MMRP FINAL EIS/EIR

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EXECUTIVE SUMMARY

This Executive Summary describes the proposed action and alternatives analyzed in this Environmental Impact Statement/Environmental Impact Report (EIS/EIR) for the California Acoustic Thermometry of Ocean Climate (ATOC) Project and its associated Marine Mammal Research Program (MMRP). This EIS/EIR presents a detailed description of the proposed project, its facilities, environmental setting, alternatives, environmental impacts, and mitigation measures, in addition to other information required by the National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA).

As the lead agencies under NEPA and CEQA, respectively, the Advanced Research Projects Agency (ARPA), and the University of California, San Diego (UCSD) must ensure that the potential environmental impacts of the proposed project have been adequately addressed and analyzed. In addition, other agencies will review and consider the information presented in this EIS/EIR prior to deciding whether to approve aspects of the project under their specific jurisdiction. These required approvals include: a Scientific Research Permit (SRP) from the National Marine Fisheries Service (NMFS), permit to install ATOC facilities from the Monterey Bay National Marine Sanctuary (MBNMS), a coastal development permit from the California Coastal Commission, a permit under Section 10 of the Rivers and Harbors Act under nationwide authorizations of the Army Corps of Engineers, a permit from the California State Lands Commission to install ATOC facilities on state tidelands, and various other reviews and consultations described more fully in Section 5.

PROPOSED ACTION

Introduction

The overall ATOC project is an international research effort to observe the ocean on the large space scales (3000 to 10,000 km) which characterize climate, which will enable climate models to be tested against the average ocean temperature changes seen by ATOC over a few years and if, and when, the models prove adequate, use those same observations to "initialize" the models to make meaningful predictions.

The basic principle behind ATOC is simple. Sound travels faster in warm water than in cold water. The travel time of a sound pulse from a source near California to a receiver near Guam, for example, will decrease if the ocean in between warms up and will increase if the ocean cools down. The travel time is a direct measure of the large-scale average temperature between the source and receiver. Measuring average ocean temperatures is necessary to validate global climate computer models being used and developed to answer the question of whether our earth is warming as a result of the "greenhouse" effect.

The proposed ATOC system takes advantage of an acoustic "waveguide" deep within the ocean that carries subsea sounds over very long distances. This feature, known as the "sound channel" or sound fixing and ranging (SOFAR) channel, is at the ocean depth where the speed of sound is at a minimum. Above the sound channel, sound travels faster because the water is warmer. Below the sound channel, sound travels faster because the pressures are greater. Sounds that would otherwise spread to higher or lower depths are refracted (bent) back toward the sound channel axis by this difference in speeds. The net effect is that the sound channel very efficiently transmits sounds for long distances. This effect also tends to limit sounds that are trapped in the channel from being detectable at depths outside of the channel.

The sounds to be produced by the ATOC sources are digitally coded, low frequency rumbles at a pitch comparable to the low notes of a cello. The same digital sequences are repeated a number of times and combined at the receivers. This allows a signal to be detected beneath the ambient background noise which, in turn, permits use of a less intense sound source. The receiving stations use advanced digital processing techniques similar to those used to retrieve data from deep space probes, to detect the signals after traveling great distances through the sound channel.

The ATOC Feasibility Demonstration

The proposed ATOC project is a 2-year demonstration or "proof of concept," with the goal of testing the acoustic thermometry concept, led by Dr. Walter Munk (Principal Investigator), Dr. Peter Worcester and Dr. Andrew Forbes, all of Scripps Institution of Oceanography, UCSD, and Dr. Robert Spindel at the Applied Physics Laboratory, University of Washington. A previous test in 1991, called the Heard Island Feasibility Test, also led by Dr. Munk, confirmed that low frequency sounds broadcast in the deep sound channel can be detected over great distances. Yet, whether the ATOC technique will provide useful climatic information depends on surmounting a number of technical and other potential barriers. For example, ocean movements from tides, currents, internal waves, eddies, and other oceanographic features also affect acoustic transmissions. While traveling long distances, sounds could be scattered, distorted or otherwise rendered unusable. The project analyzed in this EIS/EIR is of necessity limited to this next step--testing the ATOC concept to determine whether it should be pursued further.

Two sound sources are currently proposed for this 2 year demonstration project. One would be located offshore of central California on Pioneer Seamount, as described in detail in this EIS/EIR, and the other would be located off the north shore of Kauai, Hawaii, and is the subject of a companion EIS that will be released soon after this EIS/EIR. It is proposed to operate these sound sources from 2% to 8% of the time (they will be silent from 92% to 98% of the time), with the current project scope being limited to approximately two years.

Each source would be used to transmit low frequency, digitally coded sounds across the North Pacific ocean basin (at sound levels below ambient conditions along most of the path) to receiving stations around the North Pacific rim, most of which are existing facilities. Two new hydrophone receiver arrays are planned along the radial from Pioneer Seamount to Rarotonga (New Zealand territory), at approximately 3000 km and 6000 km range from Pioneer Seamount. This network would be complemented by up to ten drifting receivers deployed along selected transmission paths.

The proposed Pioneer Seamount facilities would include a 260 Watt output acoustic sound source to be located 88 km (48 nm) offshore at a depth of approximately 980 m (3218 ft). This source would be powered by a cable connected to a signal source and power amplifier in an existing building at the Pillar Point Air Force Station.

Following this initial 2 year demonstration period, any future facilities or operations would be subject to additional environmental review and authorization. The lessons learned from the demonstration phase will support all facets of future global climate change research planning: whether the program will proceed; if so, where facilities will be located, equipment design, sound levels, mitigation measures, etc. Since it is not presently known what would be learned from the demonstration phase, the particulars of any future activities can only be speculated on at this time.

The Marine Mammal Research Program

An integral part of the proposed feasibility demonstration is an extensive marine mammal research program (MMRP) to evaluate the potential effects of the proposed low frequency acoustic transmissions on sea life, in particular marine mammals but also including sea turtles, fish and invertebrates. It is known, for example, that large whales vocalize (and presumably can hear well) in the low frequency range, similar to that used by the ATOC system. Yet very little is known about the effects of low frequency noise on marine mammals.

The 2-year MMRP is directed by Dr. Christopher W. Clark, Director of Cornell University's Bioacoustic Research Program; the California effort is led by Dr. Daniel P. Costa of the Department of Biology and Institute of Marine Sciences, University of California, Santa Cruz. The sound source would initially be controlled by the MMRP Research Team, manipulating the signal strength (power level) and duty cycle (repetition rate) of the source for a period of several months. Climate-related transmissions would only begin if the system is determined to have no acute or short-term effects (Table C-1) on marine animals. The Pilot Study, if successful, would determine whether and, if so, how best to continue the project. A detailed description of the MMRP protocol is included in Appendix C of this EIS/EIR.

In addition to providing information on marine mammals, the MMRP would serve a protective function by monitoring for any adverse impacts of the source transmissions. This function would continue throughout the approximate two year experimental period. During the Pilot Study, source transmissions would stop if the marine biologists observe adverse effects meeting the source termination guidelines of Appendix C. Assuming the experiment proceeds, MMRP research would continue, with the source termination protocols in effect (subject to any modifications resulting from the Pilot Study) throughout the remainder of the experiment.

AREAS OF CONCERN

The ATOC proposal has generated an extraordinary level of public attention. Concerns have centered on three principal areas:

- Potential effects of low frequency sounds on marine mammals, sea turtles and other marine life.
- Alternative technologies to conduct climate change studies.
- Whether the ATOC project is an appropriate activity in the Monterey Bay National Marine Sanctuary.

Attention has been focused on the potential effects of subsea noise on marine animals, and on the lack of available information in the scientific community. The debate also led to the reevaluation of the project and the incorporation of a number of changes:

- A nearly four-fold reduction in the proposed transmission schedule (from the original proposal to broadcast 8% of the time to the current proposal to broadcast 2% of the time for most of the experimental period).
- A reemphasis of the program structure; i.e., the MMRP Pilot Study would be conducted prior to any ATOC climate-related sound transmissions, and its results used to determine whether the study should go forward.
- The change in source location from the preferred action site (Sur Ridge in the MBNMS) to the proposed action site (Pioneer Seamount outside the MBNMS).

POTENTIAL IMPACTS ON MARINE LIFE

The ATOC sound source would transmit a 260 Watt acoustic output, digitally coded sound with a center frequency of 75 Hertz (Hz, or cycles per sec) and a bandwidth of approximately 35 Hz (i.e., sound transmissions will be in the frequency band of 57.5-92.5 Hz).

At 1 m (slightly more than 3 ft) from the source, the sound intensity level would be approximately 195 decibels (dB) referenced to one microPascal (μPa) on a "water standard" basis. At a distance of 30 m (about 100 ft), the level is 30 dB less, or 165 dB. At 1000 m (0.5 nm), the level is down to 135 dB. Unless otherwise noted, all sound levels in this EIS/EIR are referenced to water standard.

The decibel value for sound in water is 61.5 dB higher than for sound with equivalent power levels in air (which are referenced to 20 μPa), a relationship that is explained in greater detail in Section 1.1.4. A 260 Watt acoustic output produces a 133.5 dB sound level (air standard) at 1 m distance, a 103.5 dB sound level (air standard) 30 m away, and a 73.5 dB sound level (air standard) 1000 m away. An air standard level of 58.5 dB is equivalent to the 120 dB water standard level which has produced some detectable changes in the behaviors of certain marine mammals.

By comparison, the noise from an ambulance siren at 30 m is approximately 100 dB (air standard); a rock concert at 30 m is about 110 dB (air standard). At this 30 m range, the ATOC source (103.5 dB air standard at 30 m) could be compared to these two sounds which, on land, are classified as "very loud." Just below the ocean's surface (down to approximately 20 m), the 73.5 dB (air standard) ATOC sound level is somewhat less than freeway noise at 34 m distance, and also is a beluga whale's hearing threshold at 1000 Hz--levels classified as "moderately loud" from the perspective of humans on land. This level is well below the 84 dB (over 8 hrs) workplace exposure standard for humans. The 58.5 dB (air standard) level found to produce a change in behavior in some marine mammals, which would occur in an area 12-18 km (7-10 nm) around the source, is comparable to normal speech at 1 m. While such comparisons should not be overemphasized, given the differences in species (terrestrial [land] mammals [including humans] vs. marine mammals), and media (air vs. water), they do provide some background for considering the issues presented in this EIS/EIR. Table ES-1 summarizes these relationships.

Average ambient noise levels in the 60-90 Hz band offshore central California are estimated to be in the 74-91 dB range for sea state 3-5, and are expected to be higher (≥120 dB) when vessels are present (Buck and Chalfant, 1972; Ross, 1976; Brown, 1982b). Transmissions from the proposed sound source at the water's surface are expected to be 135 dB at a radius of 1000 m (received level is not expected to exceed 135 dB at the water's surface anywhere in the vicinity of the source); 130 dB to a radius of 5 km; 120 dB at 18 km shoreward and 12 km seaward; and 110 dB to 50-60 km shoreward and 55 km seaward. Underwater sound levels are expected to be: 140 dB at 418 m depth (562 m range around source); 145 dB at 664 m depth (316 m range around source); 150 dB at 802 m depth (178 m range around source); 165 dB at 950 m depth (30 m range around source); and 195 dB at 980 m depth (1 m range around source) (see Section 2, Figure 2.2.1-6).

Within the study area, there are no applicable undersea noise standards. Most land-based community noise standards use average measurements that weigh various time periods throughout the day differently (e.g., nighttime hours), due to the greater relative sensitivity of the human population that may be exposed to the noise at those times. However, for determining the significance of the sound from the ATOC source, a long-term average, or level-equivalent (Leq) is considered the most appropriate by some acoustic researchers. The ATOC source operation would transmit on a 2% duty cycle for most of the time and would not emphasize any time of day or

Range from ATOC Source	dB (water standard)	dB (air standard)	Comparable Sounds
1 m (approximately 3 ft)	195	133.5	Container ship at comparable distance. Very high powered loudspeaker system at comparable distance. Ambulance siren at comparable distance.
30 m (approximately 100 ft)	165	103.5	Large ship at comparable distance. Rock concert (comparable to sounds 200-400 ft from ATOC source). Jet airliner (10 m) Ambulance siren (somewhat closer than 34 m). "Very loud"
1000 m (sea surface above ATOC source)	135	73.5	Small power boat. Freeway 34 m away. Beluga whale threshold (1000 Hz). "Moderately loud"
12-18 km (7-10 nm)	120	58.5	Sea sounds (wind and wave action) during storm. Normal speech (1 m)
50-60 km (27-32 nm)	110	48.5	Symphony orchestra at 6 m (20 ft) Heavy surf on beach at 1 m (3 ft) Heavy truck (64 km/hr) at 15 m (50 ft)

Table ES-1. Relationship of sound level of common sounds in air and water (20-1000 Hz) night and, although some marine animals exhibit diurnal activity patterns, in general there are no particular hours of the day that should be of greater concern in the marine environment. Using the scientifically accepted formula for determining Leq, the net value for exposure to the 120 dB sound field is calculated in Section 4. For a 2% duty cycle (20-min signal transmissions six times per day, every fourth day), Leq = 103 dB, which falls within the range of high ambient noise levels expected in the study area.

The significance of the subsea sounds from the ATOC source also depends upon the species that may be exposed, their population density, their diving behavior or likelihood of exposure, and their hearing sensitivity. Table ES-2 compares available marine animal species distribution and abundance data between the preferred action site (Sur Ridge) and the proposed action site (Pioneer Seamount). As can be seen, of the large whales, only the humpback whale is estimated to have somewhat greater stock at Pioneer Seamount vs. Sur Ridge.

For some species, the most important variable may be the types and functions of the sounds produced by the animals, and how production and use of those sounds may potentially be affected by ATOC sound transmissions. Most of this EIS/EIR is devoted to detailed discussions of these questions for the range of species that might be affected. Section 4 presents a detailed analysis of these impacts, and summarizes the results for each category of marine animals at the end of each subsection. Therefore, only a broad summary of conclusions will be presented here.

Mysticetes are believed to have good low frequency (<90 Hz) hearing, but no species are known to dive as deep as 700 m. Therefore, encounters with high intensities of the source transmissions would be expected to be rare inasmuch as the received sound level would be ≤ 135 dB at the water's surface anywhere in the vicinity of the source. Although behavioral changes could occur within the 120 dB sound field (12-18 km radius), it is expected that the use of the 5 min ramp-up procedure and limited duty cycle would mitigate potential impacts. All whale vocalizations detected by passive acoustic arrays would be recorded and analysed.

The most common large whale along the central California coast--the gray whale--rarely ventures into deep water and is not believed to dive deeply (Castro and Huber, 1992). As a result, relatively few encounters with sound that might produce a detectable change in behavior are anticipated for this species. Among the other large whales, blue whales have population densities on the order of one per every 500 sq km (Barlow, 1993c); humpback whales have population densities on the order of one per every 4500 sq km (Dohl et al., 1983).

Sperm whales and some beaked whales are capable of diving to 800 m depth; the former may have some low frequency hearing capability. Thus these species could be affected by passage through the sound fields, although encounters with high intensities would be expected to be rare. It is expected that the use of the 5 min sound ramp-up procedure and limited duty cycle would mitigate potential impacts.

Table ES-2. Comparison of marine animal stock estimates between Pioneer Seamount and Sur Ridge.

SPECIES	STOCK ESTIMATE (Pioneer Seamount vs. Sur Ridge)[1]	REMARKS
Mysticetes		
minke whale	0–	Uncommon, but may be found year-round in shelf waters of central California (to approx 35 km offshore)
blue whale	0	Seasonal, feed mainly between 90-370 km offshore central (and southern) Calif.; found closer to shore at only a few points (e.g., GOF, Monterey Bay)
fin whale	0–	Feeding areas overlap with blue whales, but not as close to shore
sei whale	0	Once common, but now very rare in central California waters
humpback whale	0+	Seasonal, feed mainly between 20-90 km offshore central California
gray whale	–	Seasonal, feed in near-shore waters during migrations
right whale	0–	Rare migration through area; usually in continental shelf waters; no feeding
Odontocetes		
Risso's dolphin	–	Found uniformly in central Calif. waters between shelf break (approx. 35 km offshore) and 370 km offshore
Pacific white-sided dolphin	0+	Found in cold coastal waters offshore central Calif., mostly inside the shelf break (approx 35 km offshore)
northern right whale dolphin	0–	Found in cold coastal waters offshore central Calif., mostly inside the shelf break (approx 35 km offshore)
Dall's porpoise	0+	Found in cold waters (<15 deg C) regardless of depth or distance offshore
killer whale	0	Low numbers; expected concentrations closer to Farallon Islands
sperm whale	0	Deep water species; none observed within GOFNMS during 1991-92 surveys
beaked whales	0–	Offshore foragers; mostly in deep waters

References:
(a) NMFS/SWFSC status of populations of odontocetes along the coast of California, 1992 (Forney, 1993).
(b) NMFS/SWFSC winter abundance estimates for cetaceans along the California coast based on 1991-92 aerial surveys (Forney et al., 1995).
(c) NMFS/SWFSC ship surveys for cetacean abundance estimates in California waters, 1991 (Barlow, 1993a).
(d) NMFS/SWFSC recent information on status of whales in California coastal waters (Barlow, 1993c).
(e) MMS cetacean surveys of central and northern California, 1980-83 (Dohl et al., 1983).
(f) MMS pinniped and sea otter surveys of central and northern California, 1980-83 (Bonnell et al., 1983).
(g) Comparison of marine mammal sightings in the Sur Ridge and Pioneer Seamount areas based on 1980-82 MMS aerial surveys (Calambokidis, pers. comm., 1995).
(h) PRBO report to EPA on abundance and distribution of seabirds and marine mammals in the Gulf of the Farallones (Ainley and Allen, 1992).

[1]Legend: + = greater stock estimated at Pioneer Seamount; - = less stock estimated at Pioneer Seamount; 0 = same; 0- = somewhat less; 0+ = somewhat greater; PSM = Pioneer Seamount; GOFNMS = Gulf of the Farallons National Marine Sanctuary.

Table ES-2. Comparison of marine animal stock estimates between Pioneer Seamount and Sur Ridge.

SPECIES	STOCK ESTIMATE (Pioneer Seamount vs. Sur Ridge)[1]	REMARKS
Pinnipeds		
California sea lion	0	Feed primarily in coastal waters inside shelf break (approx 35 km offshore); also found over Pioneer Canyon
northern elephant seal	0	Abundant in Farallon Islands; feed primarily in slope waters 20-40 km east of PSM
harbor seal	–	Rarely seen in waters >180 m
northern fur seal	0+	Greatest concentrations approx 30 km north of PSM in GOFNMS; have been observed along the 2500 m depth contour approx 7 km from PSM
Steller sea lion	0	Rookery in Farallon Islands, but closest observations to PSM have been 28 km to east and north.
Fissiped		
southern sea otter	–	Never seen near PSM, rarely seen in Farallon Islands
Sea Turtles		
loggerhead	–	
green	–	
olive ridley	–	
leatherback	–	Primary sea turtle of concern, but lower potential occurrence in vicinity of PSM 85 km offshore.

[1]Legend: + = greater stock estimated at Pioneer Seamount; - = less stock estimated at Pioneer Seamount; 0 = same; 0- = somewhat less; 0+ = somewhat greater; PSM = Pioneer Seamount; GOFNMS = Gulf of the Farallons National Marine Sanctuary.

Statistical analysis based on conservative assumptions and a random distribution gives the estimate that, with a 2% duty cycle, one sperm whale might be exposed to greater than 150 dB levels once during a two-year period. Sperm whales are the focus of MMRP research and, as noted above, all whale vocalizations detected by passive acoustic arrays would be recorded and analysed.

Other odontocetes are not known to dive to sound field depths and/or to have low frequency hearing. Therefore, potential impacts from the sound source are expected to be minimal for these species.

With respect to pinnipeds, northern elephant seals are capable of diving to 1200 m (Steward and DeLong, 1993) and could possibly have low frequency hearing. Thus, these species could be affected by passage through the sound fields, but close encounters would be expected to be rare. As with cetaceans, it is expected that the use of the 5-min sound ramp-up procedure and limited duty cycle would mitigate potential impacts.

Other pinnipeds are not known to dive to sound field depths and/or to have low frequency hearing. Therefore, potential impacts from the sound source are expected to be minimal for these species.

Southern sea otters are not believed to hear low frequency sounds well and are coastal dwellers that do not dive deeply. No sea otters are anticipated to hear the ATOC source transmissions.

Concerning sea turtles, maximum diving depths for leatherbacks are >1000 m. No other species of sea turtle are known to dive >500 m. Leatherbacks may be sensitive to low frequency sound. However, densities are presumed low in the Pioneer Seamount area, and it is expected that the 5-min ramp-up and limited duty cycle would mitigate potential effects.

There is potential for auditory injury for individuals of any species of fish located where received sound levels are at or above 180 dB (Hastings, 1991), which equates to a radius of about 8 m around the source. However, given that the 5-min ramp-up period may allow sufficient time for fish to depart the area prior to onset of the main transmission, and the small volume involved for the 180-195 dB level, potential impacts on fish populations would be expected to be minimal. Most pelagic fish species should be far enough away from the proposed source site to experience no impacts from the source transmissions. Similarly, those species inhabiting the areas below the depth of the source (i.e., >980 m) should receive less exposure.

Sharks likely are the species of fish most vulnerable to potential effects from low frequency sound transmissions. Sharks hear best in low frequencies below 300 Hz and, in fact, seem to be attracted to low frequency sounds, which they may use as a means of locating prey.

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 auditory (i.e., TTS) and/or behavioral disruption due to the ATOC 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 ATOC source emanations would wane over a period of time, given its more constant transmission characteristics, at duty cycles (transmission periods) of 2-8%.

The greatest potential impact would be anticipated among those animals that have exhibited the capability to dive as deep as the ATOC source and that do, or might possibly, hear low frequency sounds well. As indicated above, this group includes the sperm whale, the elephant seal, and the leatherback sea turtle. At deep sound channel depths (800-1000 m off the central California coast) the ocean is somewhat quieter, with average ambient noise levels 2-3 dB below those at the surface. When animals capable of detecting low frequency sound are at these depths during the 2% of the time that the source is transmitting, it could be audible to an estimated range of up to 500 km.

Effects of low frequency sound on other species of marine animals, including seabirds, plankton, and invertebrates, are expected to range from uncertain to nonexistent. Effects on growth rates of one species of shrimp have been observed in laboratory experiments (where the sound was continuous and the shrimp were contained within physical boundaries). However, the zone within which this impact might occur as a result of source transmissions would be expected to be very small, and would not be expected to affect a significant portion of the shrimp population or, indirectly, the species (including baleen whales) that prey on shrimp.

In sum, the potential effects of ATOC sounds on marine animals are an important concern, and an accurate assessment of the scale of the possible impacts is required. Based on the data currently available, the greatest concern appears to be presented by elephant seals, and possibly sperm whales, leatherback sea turtles and sharks. However, significant impacts as defined by CEQA (see below) are not anticipated.

OTHER POTENTIAL EFFECTS; CEQA CONCLUSIONS

Apart from potential acoustic effects on marine organisms, the environmental impacts of the proposed project are very minor, as summarized below.

Physical Effects

The ATOC project's physical facilities are relatively small in scope and generally minimal, including a sound source comparable in size to a large water heater, mounted in a tripod frame 3.7 m (11 ft) high, coupled to shore with a 3 cm (1.25 in) diameter power cable; 6.4 cm (2.5 in) for the first 4.6 km (2.5 nm). Trenching would occur onshore and through the surf zone, and all of the facilities would be removable. The direct physical impacts of the project are, therefore, negligible.

Minimal visual effects would be anticipated where the cables are brought onshore, and these would be mitigated further during final design and construction. The source sounds would add to the ambient noise levels in the vicinity of the sound source during the 2-8% of the time it would be operating.

Socioeconomic Effects

Socioeconomic effects are likewise considered to range from minor to nonexistent. No significant impacts are anticipated in the areas of commercial, recreational or potential fisheries, mariculture activities, shipping, military usage, mineral or energy development, cultural and historical areas, recreational activities and tourism, or other socioeconomic areas.

Consistency with Plans and Policies; Other Impacts

The ATOC project and its physical facilities, and the MMRP, are analyzed in relation to applicable plans and policies in Section 6 of this EIS/EIR. It is believed that ATOC and the MMRP are consistent with all such plans and policies, including the California Coastal Act, the California Coastal Management Program, the Monterey Bay National Marine Sanctuary Management Plan, the Sea Otter Game Refuge, the Gray Whale Monitoring Plan, and recovery plans for the humpback whale, Steller sea lion, and northern right whale.

No other potential impacts of the project are of significant concern.

CEQA Conclusions Regarding the Significance of Potential Impacts

As stated above, this EIS/EIR is intended to comply with both NEPA and CEQA. A key difference between the two is the greater emphasis under CEQA on presenting formal conclusions regarding the significance of potential impacts. Guidelines adopted by the Regents of the University of California direct that University EIR writers articulate a standard of significance for each potential environmental impact of a project, and then rate each impact in relation to that standard for each of the alternatives selected for detailed analysis.

For CEQA purposes, this EIS/EIR cites twenty potential impacts that are deemed less than significant based on the application of 25 mitigation measures. With regard to biological resources, the commonly accepted standard (CEQA Guidelines, Title 14, California Code of Regulations, Appendix G; University of California, 1991) for a significant impact is one that would:

- substantially reduce the number or restrict the range of a rare, endangered or threatened plant or animal,
- cause a fish or wildlife population to drop below self-sustaining levels, or
- adversely affect significant wildlife habitats.

Measured by these criteria, potential impacts from the proposed ATOC source are deemed less than significant. No other potential impacts are significant, based on commonly-applied standards articulated in Section 4.

The conclusions in this EIS/EIR regarding the significance of potential impacts for CEQA purposes are not intended to constrain decisions under other regulatory programs, although those conclusions may provide information relevant to other programs. For example, a "taking" by "harassment" of marine mammals requiring a permit from NMFS can still occur despite "less than significant" impacts of that harassment for CEQA purposes. Also, the designation of a potential impact as less than significant is not intended to imply that it is of no significance, or not worthy of concern. This is demonstrated by the adoption of mitigation measures for several less than significant impacts, even though CEQA does not require mitigation of such impacts.

ALTERNATIVES TO THE PROPOSED ACTION

A number of alternatives were evaluated in the development of the ATOC project proposal. The alternatives presented in this EIS/EIR include several different scientific approaches to the global warming problem, alternative technologies for acoustic thermometry, and alternate acoustic source sites. Some of the alternatives identified by the preparers or requested by the public are, in fact, elements of the proposed project and are not analyzed separately. Several other alternatives were found not to meet project objectives and were eliminated from detailed analysis.

The alternatives considered include: 1) the action as currently modified; 2) no action; 3) alternate project sites (six such sites are screened; including sites off the coast of Pacific Beach, Washington; Coos Bay, Oregon; and San Nicolas Island, Pioneer Seamount (proposed action site), Sur Ridge, and Sur Slope, California); 4) moored autonomous sources; 5) restricted source transmission times; 6) modified source operational characteristics; 7) global climate models; 8) satellite sensors for sea surface temperature measurements; 9) satellite sensors for sea level measurements; 10) oceanographic point sensors (measurements using conventional thermometers); 11) autonomous polar hydrophones; and 12) dual site experiment (alternative MMRP techniques--mobile playback experiments).

Of the twelve alternatives considered, the preferred action (Sur Ridge), no action, two alternate sites (Pioneer Seamount [proposed action] and Sur Slope), and moored autonomous sources were selected for detailed consideration.

Generally speaking, all of the alternative scientific methods for addressing the global warming problem are either included in the project as proposed, or would not meet project objectives. For example, the use of global climate models is an integral part of the project. Satellite measurements of sea surface temperature and sea level are also important sources of information regarding global warming, but do not provide information comparable to that expected from ATOC. Oceanographic point sensors are also useful, but are limited due to the relatively small number of measurements that are practicable. Similarly, alternative acoustic thermometry techniques are included in the project proposal to the extent feasible. For example, this project already has source operational characteristics optimized for low transmission intensities and impacts; restricted (seasonal) source transmission times would not be expected to reduce impacts to marine animals given the low aggregate seasonality of the species of concern in the area.

Several constraints are faced in siting an acoustic source for ATOC purposes. A suitable source site must, among other factors: 1) be at or near the deep sound channel depth; 2) have downward slopes in the direction of receiving stations; 3) lack acoustic obstructions (seamounts, shoals, etc.) in the direction of those receivers; and 4) be reasonably close to shore (to minimize cable lengths and other logistical problems). Also, since a goal of these experiments is to evaluate the potential impacts of low frequency sound on marine animals, sufficient populations should be present close enough to shore so that they can be studied. Very few sites meet all of these criteria and none nearly as well as the preferred Sur Ridge site.

NOAA's Sanctuaries and Reserves Division (SRD) responded to the DEIS/EIR by commenting that locating the ATOC sound source within the MBNMS did not appear to meet the permitting criteria for research under MBNMS Regulations. As a result, the preferred Sur Ridge alternative was eliminated from consideration, and the Pioneer Seamount alternative was chosen as the proposed source site.

The ATOC project's screening of potential source sites was comprehensive. First, an ocean basin was selected for the proposal. In making this selection, the northern hemisphere was preferred due to the relatively large number of subsea listening systems already in place; these were installed during the cold war at a cost of approximately $20 billion, and could not practicably be replicated elsewhere. The Pacific was preferred over the Atlantic because the mid-Atlantic ridge is a potential acoustic barrier (and possibly an acoustic mirror) at sound channel depths. Central and eastern Pacific locations were preferred given the proximity to U.S. research institutions and the relative abundance of U.S. possessions, including the mainland U.S. From that point the proposal evolved to locate a source along the Pacific coast of Washington, Oregon, or California. Generally, a number of subsea features at the northern and southern ends of this range (east-west ridges and shoals to the north, and the Channel Islands to the south) would tend to block transmission paths from locations other than the central California region.

Off the coast of central California, only a few subsea locations have the right combination of depth and topography to serve as appropriate source sites. At most U.S. west coast locations, the 800-1000 m depth contours generally parallel the coast, with the best downslope transmission directions being southward, rather than northward, toward the receiving locations in Alaska. Only those sites that either ridge or mount at the sound channel depths present downward slopes toward the receivers, and only some of those sites have additional favorable features. In the central

California area, two of the most suitable sites are at Sur Ridge and Pioneer Seamount. Pioneer Seamount is found some 155 km to the northwest of Sur Ridge, 88 km offshore from Pillar Point, on the San Francisco peninsula. Both of these sites are analyzed in detail in this EIS/EIR.

A third alternate site, Sur Slope, is also analyzed in detail. This site is located just outside the MBNMS, approximately 60 km from shore and 20 km to the southwest of the preferred Sur Ridge site. Because the seafloor at this location is well below sound channel depth, a source would need to be buoyed up from the bottom. Thus, the Sur Slope alternative represents a combination of an alternate site and an alternative technology. As an alternative technology, it shares many of the problems of the moored autonomous source alternative, discussed below.

A moored autonomous source is one which is not attached to shore-based power by cables but is free-standing, powered by large battery assemblies, moored to the ocean bottom with weights, and buoyed up by floats at the correct ocean depth. The principal advantage of moored autonomous sources is the increased flexibility in siting opportunities that they present. On the other hand, most moored autonomous source locations would probably be some distance from shore, and would create severe logistical problems for any marine mammal research program. To date, there have been no sources designed for autonomous operation that efficiently operate at frequencies as low as 75 Hz, or have been proven to function at pressures found at 750-1000 m deep in the ocean. In addition, since a moored source would sway in the horizontal plane (due to current motion), and accurate location is critical for acoustic thermometry, equipment would have to be included for real-time tracking of the source's position within a few feet. Such equipment is available for other applications, but has not yet been adapted for this use. In addition, the power requirements of a moored autonomous source are greater than other oceanographic applications and large battery packs (probably lithium) would be required. As a result, this alternative cannot be considered the optimum choice at this time. Nonetheless, due to its potential future applicability, this alternative is analyzed in detail in this EIS/EIR.

Comparison of Alternatives

The Sur Ridge site best meets the project objectives for both the ATOC feasibility demonstration and the MMRP. The Sur Slope site would be a relatively poor location for the MMRP due to its distance from shore. Installation of an ATOC source at the Sur Slope site and/or the installation of moored autonomous sources would also require the development of new technology and resolution of a number of engineering problems.

The comparative biological impacts of the alternate source sites would depend upon the relative abundance of sensitive animals at the respective locations. For the most part, these differences would be a matter of degree, with no site offering clear advantages from the standpoint of all species. The no action alternative would have no impacts on marine animals, but would not achieve the project objectives.

The Sur Slope site would be expected to have somewhat higher abundance of marine animals that prefer deeper water (such as the sperm whale) than the Sur Ridge site. It would likely have lower abundances of coastal or nearshore species, such as the gray whale, sea otter, humpback, etc., than would the Sur Ridge site. Pioneer Seamount tops out at about the depth of Sur Ridge, but is surrounded by deeper water and is expected to compare more closely to Sur Slope in the relative abundance of deep-water species. Pioneer Seamount is also closer to the Farallon Islands and Cordell Bank, which are biologically productive. It is also believed to have a somewhat greater abundance of humpback whales, and the gray whale migration route is further from shore in this vicinity. On balance, however, none of the alternate sites would have clear benefits from a biological standpoint. A moored autonomous source would offer siting flexibility, so that significant habitats could be avoided.

All of the alternatives would have comparable physical impacts, with the exception of the no action alternative that would have no physical impacts, and the moored autonomous source alternative that would not involve a cable installation, but which would have minor potential impacts from the use, disposal, and potential leakage of toxic battery fluids. Similarly, all of the alternatives would have comparable socioeconomic effects, except for the no action alternative that would have none of the potential beneficial or adverse impacts of the proposed project.

CEQA IMPACTS AND MITIGATION MEASURES

This EIS/EIR has identified CEQA mitigation measures that would be applied to the proposed project in two ways. First, beneficial features of several alternatives, that would mitigate the potential effects of ATOC subsea sounds on marine animals, have been identified and incorporated into the project as proposed. These mitigation measures derived from the alternatives are numbered in sequence with an "A" prefix, as follows:

CEQA Mitigation Measure A-1: A dedicated MMRP Pilot Study would precede ATOC feasibility operations as described in detail in Section 2.2.1.1 and Appendix C.

CEQA Mitigation Measure A-2: ATOC sound sources would utilize frequencies anticipated to have minimal adverse impacts on species that may be exposed to their acoustic output (i.e., based on available information, either a higher or lower frequency might be expected to result in increased potential adverse impacts).

CEQA Mitigation Measure A-3: ATOC sound sources would operate at the minimum power level necessary to support MMRP objectives and feasibility operations.

CEQA Mitigation Measure A-4: The ATOC project would continue to study source waveforms and transmission lengths that may facilitate long-range detection of the source sounds which, in turn, may permit lower source intensities than would otherwise be required.

CEQA Mitigation Measure A-5: ATOC sound sources would operate at the minimum duty cycle necessary to support MMRP and feasibility objectives.

Second, other mitigation measures, with their associated potential impacts, are identified as follows:

CEQA Impact 1: Installation of the ATOC cable and source would have less than significant impacts on the physical environment.

CEQA Mitigation Measure 1-1: The portions of the ATOC cable and any protective casing in the nearshore area, surf zone, and bluff area are designed to minimize the potential for adverse impacts, including the potential for bluff erosion.

CEQA Mitigation Measure 1-2: ATOC facilities would be removed at the end of the experiment, to the extent economically and practicably feasible.

CEQA Impact 2: Leq calculations indicate that less than significant increases in average ambient noise levels would occur in the immediate vicinity of the ATOC source (i.e., within 12-18 km).

CEQA Mitigation Measure 2-1: The duty cycle and power levels of the ATOC source would be adjusted to the minimum necessary to support research objectives, and the source would be shut down if any of the acute or short-term responses in Table C-1 are observed in relation to source transmissions.

CEQA Mitigation Measure 2-2: The ATOC project would coordinate with other oceanographic and acoustic research efforts, U.S. Navy activities, and the commercial fishing industry, to ensure that scheduling and operational conflicts are avoided.

CEQA Impact 3: Physical auditory impacts on mysticetes, potentially consisting of occasional temporary threshold shifts in hearing for deep-diving animals, is presumed to be less than significant.

CEQA Mitigation Measure 3-1: A Marine Mammal Research Program (MMRP) will be carried out in connection with the ATOC project in accordance with the protocols set forth in Appendix C to this EIS/EIR. With regard to potential physical auditory impacts on mysticetes, a goal of the MMRP will be to validate the assumptions regarding population distribution and diving behavior, which form the basis for predicting the potential for effects from the ATOC sound source.

CEQA Impact 4: Although it appears that low numbers of mysticete whales would be exposed to ATOC sounds louder than 120 dB, a level that has been shown to result in detectable changes in behavior in some mysticete species, the lack of additional reliable information justifies the assumption of an impact for purposes of this EIS/EIR. Since the proposed site (i.e., 120 dB sound field 12-18 km around the source) has not been identified as an important habitat (i.e., feeding, breeding, migration route, or comparable area) (EPA, 1993[1]), this potential impact is believed less than significant.

CEQA Mitigation Measure 4-1: As provided in mitigation measure 2-1, the duty cycle and power levels of the ATOC source would be adjusted to the minimum necessary to support research objectives, so that potential impacts to mysticetes would be minimized.

CEQA Mitigation Measure 4-2: As provided in mitigation measure 3-1, a MMRP will be carried out in connection with the ATOC project in accordance with the protocols set forth in Appendix C to this EIS/EIR. With regard to potential impacts on mysticetes, a goal of the MMRP will be to identify the nature, frequency, and significance of any responses to ATOC source transmissions.

CEQA Impact 5: Although any potential long-term impacts to mysticetes are speculative, the evidence of long-term displacement of mysticetes by boat traffic in some instances, coupled with the lack of additional reliable information, justifies the assumption of an impact for purposes of this EIS/EIR. Since the proposed site has not been identified as an important habitat (i.e., feeding, breeding, migration route or comparable area) (EPA, 1993), and considering the minor portion of the range affected, this potential impact is deemed less than significant.

CEQA Mitigation Measure 5-1: As provided in mitigation measure 2-1, the duty cycle and power levels of the ATOC source would be adjusted to the minimum necessary to support research objectives, so that potential long-term impacts to mysticetes would be minimized.

CEQA Mitigation Measure 5-2: As provided in mitigation measure 3-1, a MMRP will be carried out in connection with the ATOC project in accordance with the protocols set forth in Appendix C to this EIS/EIR. With regard to potential long-term impacts on

[1]Table 2.2-1; Criteria: Location in relation to breeding, spawning, nursery, feeding or passage areas of living resources in adult or juvenile stages: 1) low numbers of demersal fish species and abundances, 2) moderate numbers of megafaunal invertebrate species and abundances, 3) moderate apparent use by marine birds and mammals, 4) moderate abundances of midwater fish species, including juvenile rockfishes, 5) infauna community very diverse and abundant.

mysticetes, a goal of the MMRP will be to identify the nature, frequency, and significance of any long-term changes due to ATOC source transmissions (via comparison of animal distribution data before, during, and after source transmission periods over a two-year period).

CEQA Impact 6: The potential for physical auditory impacts on odontocetes, principally consisting of a small potential for occasional temporary threshold shift in sperm or beaked whales; and the potential for behavioral impacts on odontocetes, principally consisting of a temporary cessation of vocalizations in sperm or beaked whales, is uncertain, but presumed to be less than significant.

CEQA Mitigation Measure 6-1: ***A MMRP will be carried out in connection with the ATOC project in accordance with the protocols set forth in Appendix C to this EIS/EIR. With regard to potential physical auditory and behavioral impacts on odontocetes, a goal of the MMRP will be to validate the assumptions regarding population distribution, abundance and diving behavior of sperm whales, which form the basis for predicting the potential for effects from the ATOC sound source.***

CEQA Impact 7: Physical auditory impacts on pinnipeds, principally consisting of the potential for occasional temporary threshold shifts in elephant seals; and potential behavioral impacts on pinnipeds, principally consisting of change in elephant seal swim pattern/direction, would be less than significant (i.e., would not substantially reduce the number or restrict the range of pinnipeds, cause the population to drop below self-sustaining levels, or adversely affect their significant habitats).

CEQA Mitigation Measure 7-1: A MMRP will be carried out in connection with the ATOC project in accordance with the protocols set forth in Appendix C to this EIS/EIR. With regard to potential physical auditory and behavioral impacts on pinnipeds, particularly northern elephant seals, a goal of the MMRP will be to validate the assumptions regarding population distribution, abundance and diving behavior of northern elephant seals, which form the basis for predicting the likelihood of potential impacts due to the ATOC source transmissions.

CEQA Impact 8: It is assumed, given the lack of direct audiometric data, that individual leatherback sea turtles could possibly incur a temporary threshold shift, which is assumed to be an impact at a less than significant level given the anticipated low rate of such occurrences.

CEQA Mitigation Measure 8-1: The MMRP would support field research to attempt the collection of auditory and/or behavioral observations on leatherback sea turtles.

CEQA Impact 9: It is assumed, given the lack of direct information, that sea turtles (particularly leatherbacks) could possibly incur behavioral changes due to ATOC source transmissions, including potential avoidance of the area. However, given the relatively small portion of the range that could be affected, this is assumed to be a less than significant impact.

CEQA Mitigation Measure 9-1: The MMRP would incorporate into its research protocol the goal of assessing whether acoustic transmissions could potentially cause sea turtles to spend more time than normal at the sea surface.

CEQA Mitigation Measure 9-2: The MMRP would incorporate into its research protocol, the goal of assessing whether acoustic transmissions could potentially cause leatherbacks to avoid the ATOC source area.

CEQA Impact 10: Given the lack of direct data, it is assumed that fish could possibly die if exposed to sound levels ≥ 180 dB (8 m radius around source); or could possibly incur TTSs at levels > 150 dB (178 m radius) which, in turn, could result in increased vulnerability to predation; however, given the minor portion of any population that may be affected, this is deemed to be a less than significant impact.

CEQA Mitigation Measure 10-1: The MMRP would monitor fish stock assessments (via CDFG catch-block landing data; LTPY, CPY, and RAY data from NMFS; and interaction with the PCFFA) to attempt evaluation of the potential for increased mortality and predation on fish, in relation to ATOC source sounds.

CEQA Impact 11: Impacts to the behavior of fish are deemed possible, but are considered less than significant due to the comparatively small proportion of any species' range which potentially would be affected.

CEQA Mitigation Measure 11-1: The MMRP would monitor fish stock assessments (via CDFG catch-block landing data; LTPY, CPY, and RAY data from NMFS; and interaction with the PCFFA, PRBO, Bodega Marine Laboratory and Steinhart Aquarium) to attempt evaluation of the potential for impacts to fish, particularly sharks, in relation to ATOC source sounds.

CEQA Impact 12: Minor increases in vessel and aircraft traffic would occur in the project vicinity.

CEQA Mitigation Measure 12-1: Vessel and aircraft traffic would be kept to a minimum, consistent with the requirements of the MMRP protocols and ATOC program requirements. Where possible, trips would be consolidated or other measures taken to reduce the aircraft and vessel traffic levels resulting from the project.

CEQA Impact 13: Although there are no recorded archaeological sites along the onshore cable route, previously unidentified cultural resources could be impacted by the construction required for the ATOC source power cable.

CEQA Mitigation Measure 13-1: A qualified archaeologist would be retained to visit the ATOC activity site and determine whether monitoring of the cable installation is required. If required, he/she would monitor installation activities and specific measures recommended would be implemented to avoid any significant impacts to cultural resource materials.

CEQA Impact 14: Unidentified shipwrecks could possibly be encountered along the proposed cable route for the ATOC source cable.

CEQA Mitigation Measure 14-1: If shipwrecks or other resources are identified, they would be avoided during installation of ATOC facilities.

CEQA Impact 15: ATOC and MMRP vessels and aircraft would create minor amounts of air pollution.

CEQA Mitigation Measure 15-1: All ATOC/MMRP vessels and aircraft would be equipped with required air pollution controls.

All identified and numbered mitigation measures will be the subject of a mitigation monitoring program, to be implemented by the University of California, San Diego, Campus Planning Office.

LIST OF FIGURES

LIST OF FIGURES (cont.)

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1 INTRODUCTION, PURPOSE AND NEED FOR ACTION

This Environmental Impact Statement/Environmental Impact Report (EIS/EIR) evaluates the potential impact of a low frequency sound source and associated facilities proposed to be installed by the University of California, San Diego, Scripps Institution of Oceanography (Scripps) off Pt. Sur, California, as a part of the Acoustic Thermometry of Ocean Climate (ATOC) project. It also evaluates the potential impacts of marine mammal observation activities proposed to be carried out as part of the ATOC program.

Under the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA), permits are required for activities that would "harass" marine mammals, defined further under the MMPA as "any act of pursuit, torment, or annoyance which; 1) has the potential to injure a marine mammal or marine mammal stock in the wild; or 2) 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." Activities falling under the first definition are termed Level A harassment, while those encompassed by the second are called Level B harassment. Since previous studies on marine mammals have observed changes in behavior, such as approach to or avoidance of the sound source or change in habitat utilization, in response to nearby subsea sounds at intensities comparable to the proposed sound source, the ATOC project has been determined to be subject to this permitting program.

Three permit options are potentially available in this situation. First, permits can be issued for *bona fide* research, defined under the 1994 MMPA Amendments as "scientific research on marine mammals, the results of which -- 1) likely would be accepted for publication in a referred scientific journal; 2) are likely to contribute to the basic knowledge of marine mammal biology or ecology; or 3) are likely to identify, evaluate, or resolve conservation problems." Second, authorizations can be issued for the harassment of "small numbers" of marine mammals "incidental" to any other lawful activity. Third, the activity can proceed under a general authorization of minor "Level A" harassment under the MMPA.

In 1993, Scripps was informed by the National Marine Fisheries Service (NMFS), Office of Protected Resources that a scientific research permit (SRP), rather than an incidental take permit or application of a general authorization, would be the preferred approach. This choice was guided, in part, by NMFS's concern that available information was insufficient to make the findings necessary (e.g., potential species/numbers that could potentially be harassed by the proposed sound transmissions) to issue a small take exemption, and that additional scientific research to evaluate the potential impacts of low frequency source transmissions on marine mammals was needed.

The original, preferred, project site was Sur Ridge, offshore Pt. Sur, CA. In response to concerns raised and comments received during the public comment period on the Draft EIS/EIR about conducting the proposed research within the Monterey Bay National Marine Sanctuary (MBNMS), the proposed project location was changed to Pioneer Seamount, offshore Pillar Point, CA (Alternative 3-1). This EIS/EIR concludes that all potential environmental impacts presented by the proposed project would either be reduced or be unaffected by the change in the proposed location of the ATOC sound source to Pioneer Seamount.

As a result, and in compliance with MMPA and ESA guidelines, Scripps submitted an application for a SRP to NMFS to evaluate any potential effects on marine mammals of the ATOC low frequency sound transmissions off Pt. Sur, California, via a Marine Mammal Research Program (MMRP) starting in the spring of 1995.

The purpose of this EIS/EIR is to identify any potentially significant environmental effects associated with the proposed project, to identify alternatives to the proposed project, and to discuss measures which can be incorporated into the project to mitigate or avoid potentially significant impacts. This EIS/EIR has been prepared to facilitate NMFS's consideration of Scripps' SRP application and to provide a public forum for disclosure and discussion of the potential environmental impacts of that proposal. It also is intended to augment other environmental reviews required for the project, including consultation under Section 7 of the ESA and review of the project by the University of California, San Diego, the California Coastal Commission, and the California State Lands Commission, among other regulatory programs. It is also intended to be used by the University of California to evaluate the potential impact of the proposed siting of the source.

This project is proposed to be carried out using two separate acoustic sources; the one discussed in this document, to be located at Pioneer Seamount (proposed action site), and a second source to be located off the north shore of Kauai, Hawaii. Because of the differences between the two sites, in terms of research programs as well as the environmental settings, NMFS determined early in the permitting process that separate environmental documentation should be prepared.

A joint federal/state Environmental Impact Statement (EIS) is being prepared for the Hawaii project pursuant to the requirements of both the National Environmental Policy Act (NEPA) and Chapter 343 of the Hawaii Revised Statutes. This document, known as Kauai ATOC/MMRP Draft Environmental Impact Statement was released for public review in late 1994, and was incorporated by reference into the California ATOC/MMRP Draft Environmental Impact Statement/Environmental Impact Report (EIS/EIR). In addition, the onshore portion of the ATOC cable installation is proposed to be undertaken as part of a bluff restoration project evaluated in a September, 1994 Final Environmental Assessment for Erosion Repair at Pillar Point Air Force Station (Air Force EA), which also is incorporated by reference in this EIS/EIR. Copies of the California Final EIS/EIR, the Hawaii Final EIS, and the Air Force EA will be available for public review at the following locations:

1. University of California, San Diego
University Library
9500 Gilman Drive
La Jolla, CA 92093

2. University of California, Santa Cruz
McHenry Library
Santa Cruz, CA 95060

3. Santa Cruz City/County Library System
224 Church Street
Santa Cruz, CA 95060

4. National Marine Fisheries Service
Office of Protected Resources
1330 East-West Highway
Silver Spring, Maryland 20910

5. Los Angeles Public Library
Central Library
630 West 5th Street
Los Angeles, CA 90071

6. San Francisco Public Library
Civic Center
San Francisco, CA 94102

7. Monterey Public Library
625 Pacific Street
Monterey, CA 93940

The organization of this EIS/EIR is as follows: Section 1 contains a description of the proposed MMRP and ATOC feasibility project, also briefly describing applicable regulatory requirements and the scoping process that supported the development of this EIS/EIR. Section 2 describes eleven potential alternatives to the project on an initial screening level, selecting five of those alternatives for detailed environmental analysis -- the preferred action source location (on Sur Ridge west of Pt. Sur California), no action, two alternative source locations (the proposed action on the Pioneer Seamount west of Pillar Point, California and Sur Slope, to the west of Sur Ridge outside the Monterey Bay National Marine Sanctuary), and an alternative technology (moored autonomous sources). Section 3 describes the environmental setting, focusing on habitat values important to marine mammals, sea turtles, sea birds, fishes and invertebrates, but also discussing other areas of concern expressed by the public during the scoping process. Section 4 evaluates the potential environmental impacts of the proposed action and alternatives, again focusing on habitat questions but also evaluating the full range of potential impacts. Section 5 reviews project consistency with applicable requirements. Section 6 includes analysis of a number of additional issues to be considered under the National Environmental Policy Act, the California Environmental Quality Act (CEQA), and other regulatory programs. Section 7 lists the individuals involved in preparing this document and Section 8 includes the draft EIS/EIR Circulation List.

In response to several requests by the public for an opportunity for additional public participation, comments on this Final EIS/EIR will be received during the 30-day period following official publication via the Federal Register, for NEPA purposes only, as described in the Preface. Any significant comments will be addressed in the decision document of the federal lead agency (ARPA's record of decision).

1.1 THE ATOC PROJECT

This subsection presents background on the global climate change question that ATOC seeks to address, a description of how the ATOC system is expected to work, an evaluation of the rationale and approach proposed for the MMRP, and a description of the specific facilities and activities proposed for Pt. Sur (preferred action site) and Pillar Point (proposed action site).

1.1.1 INTRODUCTION TO THE GLOBAL CLIMATE CHANGE PROBLEM AND ATOC'S ROLE IN ADDRESSING THAT PROBLEM

During the last few decades the problem of global climate change has received intense international attention. It is now known that atmospheric concentrations of a number of gases, particularly carbon dioxide, methane, and freons, are steadily increasing due to human activities. For example, carbon dioxide is produced by the burning of fossil and other fuels. The clearing of tropical rainforests also has been identified as a contributor to carbon dioxide buildup in the atmosphere. Farming activities increase methane production. Freons are widely used in air conditioning equipment and manufacturing processes and, until recently, had been routinely released into the atmosphere during the maintenance and disposal of these systems.

It is also known that these gases tend to trap heat within the atmosphere -- the "greenhouse effect." Whether or not the increasing concentrations of greenhouse gases will lead to global warming is a complex and controversial question. It has been argued that increasing levels of carbon dioxide will simply stimulate plant growth which, in turn, will remove the carbon from the atmosphere. Similarly, it is suggested that temperatures will be moderated by the ocean serving as a "heat sink" or that short-term increases in temperature will result in increased cloud cover which will reflect sunlight, reduce temperatures, and thereby counteract the effect of these emissions.

Those discussions are based on projections primarily derived by complex computer models. In part, these models attempt to reflect the fact that the atmosphere and ocean form a combined system, interacting to determine the earth's weather and climate. The oceans play a pivotal role in moderating or otherwise affecting global climate change. The oceans are the earth's major reservoir of heat, as well as an important depository of carbon dioxide.

Computer models of global climate change due to increasing greenhouse gases predict complicated large-scale patterns of warming and, in some regions, cooling of the atmosphere and ocean. Some predicted changes are very severe; one model predicts that the ventilation of the deep ocean will cease, with severe consequences to marine life.

However, the time scales and the specific global consequences on climate predicted by these models have been criticized as inaccurate and oversimplified. Therefore, they have had limited impact on governmental decisions to take action to curb emissions of greenhouse gases. A principal shortcoming of these models results from the fact that, in several critical areas, they must rely upon assumptions about rather than actual measurements of ocean "weather." Global atmospheric climate changes cannot be predicted without fully understanding global ocean processes. Yet, to date, there are no large-scale observations of ocean temperatures to compare with and verify the predictions of existing climate models. There is important need for model predictions to be tested against observations, if the models are to serve as a persuasive basis for policy formulation.

The proposed ATOC project is a demonstration or "proof of concept" phase, with the goal of testing the acoustic thermometry concept. Following this initial demonstration period, any future facilities or operations would be subject to additional environmental review and authorization. The lessons learned from the demonstration phase would support facets of future global climate change research planning such as whether the program will proceed; and if so, would address where facilities would be located, equipment design, sound levels, mitigation measures, etc. Since it is not presently known what will be learned from the demonstration phase, the particulars of any future activities can only be speculated on at this time.

1.1.2 THE MARINE MAMMAL RESEARCH PROGRAM

The ATOC program recognizes a need to evaluate the potential effects of the proposed source transmissions on marine animals, in particular marine mammals and sea turtles. It is known, for example, that some large whales vocalize (and presumably can hear well) in frequency ranges similar to those to be used by the ATOC system. However, very little is known about the effects of low frequency sound on marine animals, particularly marine mammals and sea turtles.

In response to the question of potential effects, a Marine Mammal Research Program (MMRP), led by Dr. Christopher W. Clark of Cornell University's Bioacoustic Research Program, has been established. The MMRP would investigate the potential impact of the low frequency sound sources on marine mammals and sea turtles at both the California and Hawaii source sites. Dr. Clark leads the research in Hawaii and Dr. Daniel P. Costa of the University of California, Santa Cruz Long Marine Laboratory, leads the California research. The MMRP recognizes that the available data on this question are sparse and has designed a research protocol to broaden the information base.

Initially, the MMRP would conduct a Pilot Study to evaluate potential significant effects on marine mammals and sea turtles before initiating ATOC climate-related operations. This would entail manipulating the signal strength (power levels) and duty cycle (repetition rate) of the source for a period of about six months. Results would be evaluated on a near real-time basis throughout the Pilot Study such that modifications to the sound usage based on initial duty cycles could be implemented and tested during the Pilot Study. A quicklook evaluation available 30 days after conclusion of the Pilot Study would be reviewed by ARPA, NMFS, the Marine Mammal Commission (MMC), the MMRP Advisory Board (MMRP AB), PRSRG, and interested public parties. The quicklook would verify whether or not any acute or short-term responses (Table C-1) could be attributed to ATOC sound transmissions. Research would continue (after the MMRP Pilot Study) only if no such adverse effects were observed. NMFS has the ultimate authority for allowing the research to proceed.

Following successful completion of the MMRP Pilot Study, regularly scheduled ATOC feasibility operations would commence, during which the MMRP research phase would continue throughout. Transmissions would occur on one out of every four days. Transmissions on that day would last for 20 minutes every 4 hrs, which is necessary to continue to study the potential effects on marine mammals and to collect climate-related data. This equates to a duty cycle of 2% (the source will be silent 98% of the time). About six months after the end of the MMRP Pilot Study, two months of transmissions at an 8% duty cycle (20 min transmissions every 4 hrs on every day) would be conducted to investigate the effects of tides and other high frequency ocean fluctuations on the acoustic transmissions. Following the two month ocean effects investigation, the schedule would resume transmissions at the 2% duty cycle. Table 1.1.2-1 displays in a graphic form this sequencing and interrelationship of the components of the program. Studies of the potential effects of low frequency source transmissions on marine mammals and sea turtles would be conducted throughout all of these sequences.

A detailed description of the MMRP Pilot Study Research Protocol is included in Appendix C.

1.1.3 THE ACOUSTIC THERMOMETRY PROGRAM

The basic idea of ATOC is simple. Sound travels faster in warm water than in cold water. The travel time of a sound signal from a source near California to a receiver near Alaska, for example, will decrease if the intervening ocean warms up, and will increase if the ocean cools down. The velocity of sound in the sea increases with an increase in salinity, but in open ocean deepwater, salinity normally has only a small effect on the velocity (Urick, 1983).The travel time is a direct measure of the large-scale average temperature between the source and receiver. The information obtained is similar to that which would be obtained for the atmosphere by averaging data from the many thousands of land-based weather stations that exist.

The California-based source would be used to transmit low frequency, digitally coded sounds across the North Pacific ocean basin to receiving stations offshore Alaska, Hawaii, Guam and New Zealand. By measuring the travel time of these sounds, it is anticipated that basin-scale measurements of ocean temperatures can be obtained that will provide important information (see Section 1.2.2) for studying global climate questions, particularly global warming due to the "greenhouse effect."

The proposed system takes advantage of an acoustic waveguide deep within the ocean that carries sounds over very 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 to higher or lower depths is refracted (bent) back into the sound channel by this difference in speeds. The net effect is that the sound channel serves as a conduit that transmits sounds very efficiently over long distances. This effect also tends to limit sounds that are trapped in the channel from being heard well at depths outside of the channel.

ACTIVITY	TIME PERIOD (duration)	ACTIVITIES INVOLVED (in accordance with Appendix C)	SL/ DUTY CYCLE
1. MMRP Preliminary Baseline Data Collection (No source transmissions)	June 94-Jul 95 (approx.) (13 months approx.)	• Aerial visual & acoustic surveys/observations. • Shipboard photo ID. • SOSUS-based acoustic detection of mysticetes. • Odontocete audiometrics. • Cetacean playback studies (sperm whales).	0/0
2. MMRP Pilot Study; including near real-time data processing and analysis	Sep 95 - Feb 96 (approx.) (6 months approx.)	• MMRP Research Team (MRT) operates source at varying intensities (≤ 195 dB source level) and duty cycles (≤ 8%) 7 days off, 4 days on to assess the potential for any impacts on marine animals. • Continue activities from baseline data collection phase. • Shipboard visual and acoustic surveys/observations. • VLA-based acoustic detection of mysticetes. • Northern elephant seal tagging. • Cetacean playback studies (sperm and humpback whales). • Sea turtle playback studies.	185-195 dB/ 2-8%
3. MMRP Pilot Study-- Quicklook Report	Mar/Apr 96 (approx.) (30-60 days after end of Pilot Study)	• MRT reports on preliminary results from Pilot Study to all concerned (ARPA, Scripps, NMFS, MMC, MMRP AB, PRSRG, public). • Data used as basis for authorization to start follow-on ATOC feasibility ops and MMRP research.	N/A
4. MMRP Research	Apr/May - Sep 96 (approx.) (6 months approx.)	• MMRP continue activities from baseline data collection phase, as scheduled. • Given positive results from Pilot Study Quicklook Report, ATOC feasibility ops proceed at ≤ 195 dB source level and 2% duty cycle (6 transmissions/day, every 4th day).[1]	195 dB/2%
5. MMRP Pilot Study Final Report	Sep 96 (approx.)	• To be used as a final determination for continuation and configuration of ATOC feasibility ops and MMRP activities.	N/A
6. MMRP Research	Sep 96 - Feb 97 (approx.) (6 months approx.)	• MMRP and ATOC feasibility ops continue in parallel. • Given positive results from Final Pilot Study Report, duty cycle increased to 8% (6 transmissions/day every day) for 2-month study of tidal and ocean high freq. fluctuation effects.[1] • After 2-month investigation, ATOC feasibility ops revert to 2% duty cycle (6 transmissions /day every 4th day) for duration.	195 dB/2-8%

[1]If Pilot study quicklook/final report results are negative, ATOC feasibility operations would not commence until the issues raised by the report had been resolved.

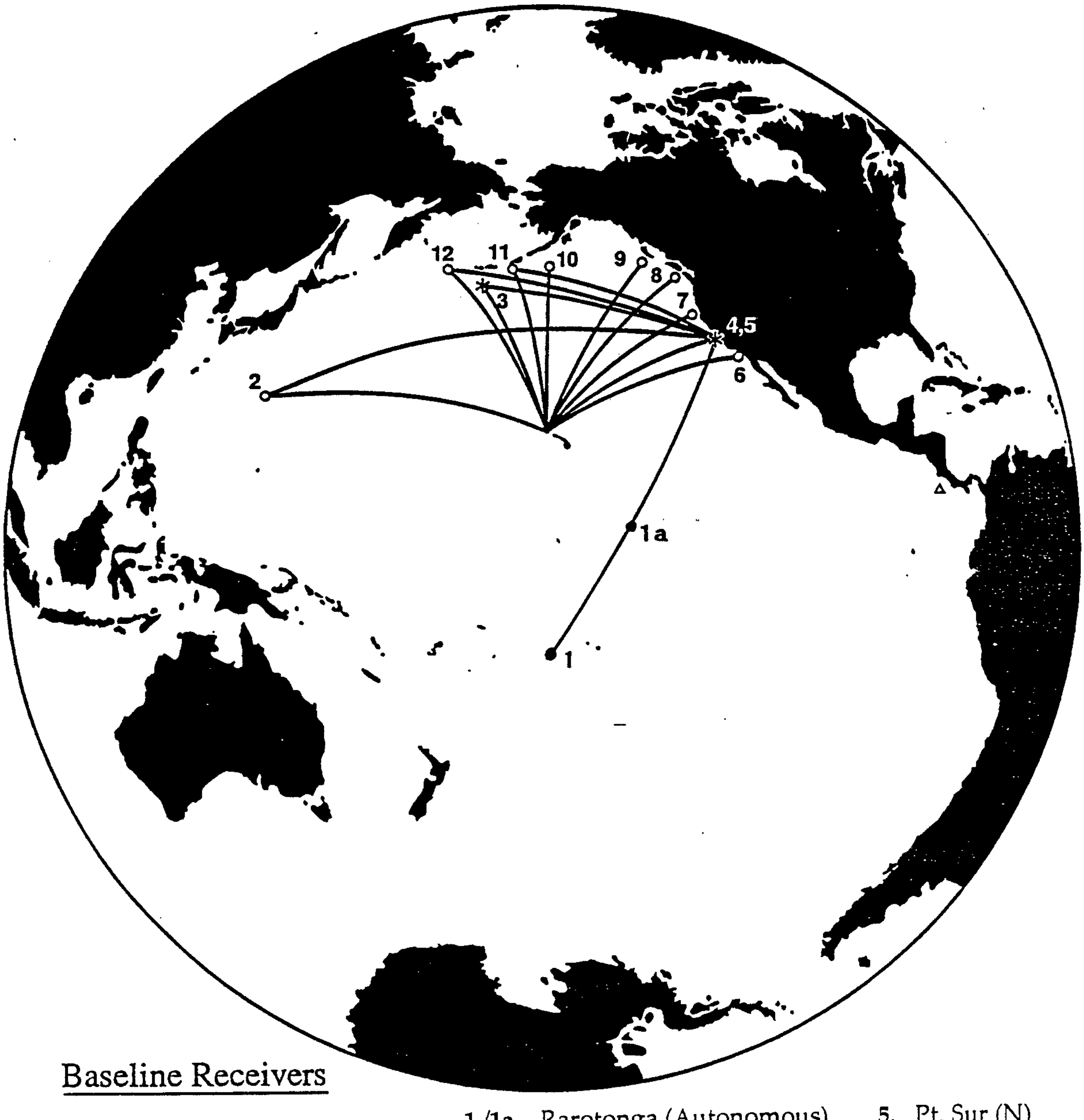
Table 1.1.2-1. MMRP and ATOC program elements and sequencing (proposed Pioneer Seamount site).

The depth of the sound channel depends upon the location of the sound speed minimum, which varies in depth based upon the temperature profile at a given location. Since surface temperatures tend to decrease toward the poles, the sound channel 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 to 200 m, but in warmer areas it is much deeper, on the order of 750 to 1000 m. Off Pt. Sur and in the vicinity of Pioneer Seamount, the sound channel axis is nominally at 800 m, although individual profiles show the channel is broad, extending from about 500 m to 1000 m.

Previous experiments have shown the feasibility of measuring ocean temperature by transmitting signals between sources and receivers separated by 1000-2000 km. ATOC is designed to demonstrate that acoustic thermometry can be used to determine ocean climate variability by extending the range to that needed to monitor ocean temperature over entire ocean basins. The initial phase, involves the development and installation of affordable acoustic hardware, which would extend these ranges to include the entire North Pacific basin. To do so, two low frequency sound sources are planned for the North Pacific, one north of Kauai and one west of central California. Special hydrophone receiver arrays in the South Pacific, near Rarotonga, and in the mid Pacific, approximately halfway between central California and Rarotonga would be used. In addition, existing U.S. Navy seabed receivers in the North Pacific would be used, thereby increasing the network of receiving sites in the most cost-effective and non-invasive way. Special receiving equipment at the U.S. Navy facilities allows the existing Navy receivers to detect and record the sound transmissions. The proposed fixed network of sources and receivers around the Pacific Ocean is illustrated in Figure 1.1.3-1. The network would be complemented by up to ten drifting receivers deployed along selected transmission paths under the Global Acoustic Mapping of Ocean Temperature (GAMOT) program. Together ATOC and GAMOT comprise the Strategic Environmental Research and Development Program's (SERDP) Acoustic Monitoring of Global Ocean Climate Program.

The sounds produced by the acoustic sources are digitally coded, low frequency signals comparable to the lowest notes of a cello. The same digital sequences are repeated a number of times and then combined at the receiving end. The receiving stations would use advanced digital processing techniques, similar to those used in retrieving data from deep space probes, to detect the source signals after they have traveled over long distances. These techniques allow a signal to be detected below the ambient background noise, thereby permitting use of a lower volume at the sound source.

The primary objectives of the California-based MMRP are listed below in Section 1.2. The research project proposes to use two acoustic sources located at a depth of approximately 850 - 980 m (one 88 km west of Pillar Point, California, for which this EIS/EIR is being prepared, and one 14 km off the north coast of Kauai, Hawaii, for which a separate SRP application has been submitted, and a separate EIS is being prepared). Acoustic signals would be transmitted at 75 Hz center frequency (Figure 1.1.3-2), which is near the middle of the spectrum of deep ocean ambient shipping noise, with a nominal bandwidth of 35 Hz. Peak power output of the ATOC source at 75 Hz would be 180 dB; total power, integrated across the entire 35 Hz



Baseline Receivers

o Navy (notional locations)

1./1a. Rarotonga (Autonomous)
2. Guam (N)
3. West Pac (Autonomous)
4. Pioneer Seamount
5. Pt. Sur (N)
6-9. East Pac (N)
10-12. North Pac (N)

Figure 1.1.3-1 ATOC baseline network

bandwidth would be 195 dB, which is equivalent to 260 watts. Table 1.1.3-1 shows how the ATOC source sound level compares with other natural and human-made oceanic noises.

1.1.4 FUNDAMENTALS OF SUBSEA SOUND MEASUREMENTS

An understanding of the conventions of sound measurements is important for evaluating the various decibel values presented in this EIS/EIR. This subsection summarizes the factors most directly pertinent to the analysis in this document.

The decibel scale used for sound measurements is a logarithmic scale of acoustic pressure. 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.

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 1.1.3-2 is an example of such a measurement, showing the power levels within each one Hertz portion of the 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 1.1.3-2, 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.

Comparing sound levels in air and water must also be done carefully. First, due to convention, the reference pressure values are different by 26 dB. Second, due to the relative impedance of air and water (the stiffness or density of the medium), a roughly 5000 times greater power level (35.5 dB) is necessary in air than in water to produce an equivalent pressure level. Combining these two factors, a 61.5 dB difference equivalent or correction factor between the two scales is required -- a conversion factor that produces acoustic intensity values. This is why the 260 watt ATOC source produces 195 dB water-standard sound levels, while a 260 watt acoustic source in air would produce only a 133.5 dB air-standard sound level. Because of these complications, the National Academy of Sciences, National Research Council has noted that "great care must be taken in comparing sound levels in air with sound levels in water." (National Research Council, 1994). Given this potential for confusion, this EIS/EIR generally avoids cross-media comparisons between air and water. All sound values presented in this EIS/EIR are water-standard values unless otherwise specified. Also, all references are broad-spectrum (20-1000 Hz) values standardized at 1 micropascal at 1 m (1 μpa @ 1 m), unless otherwise stated.

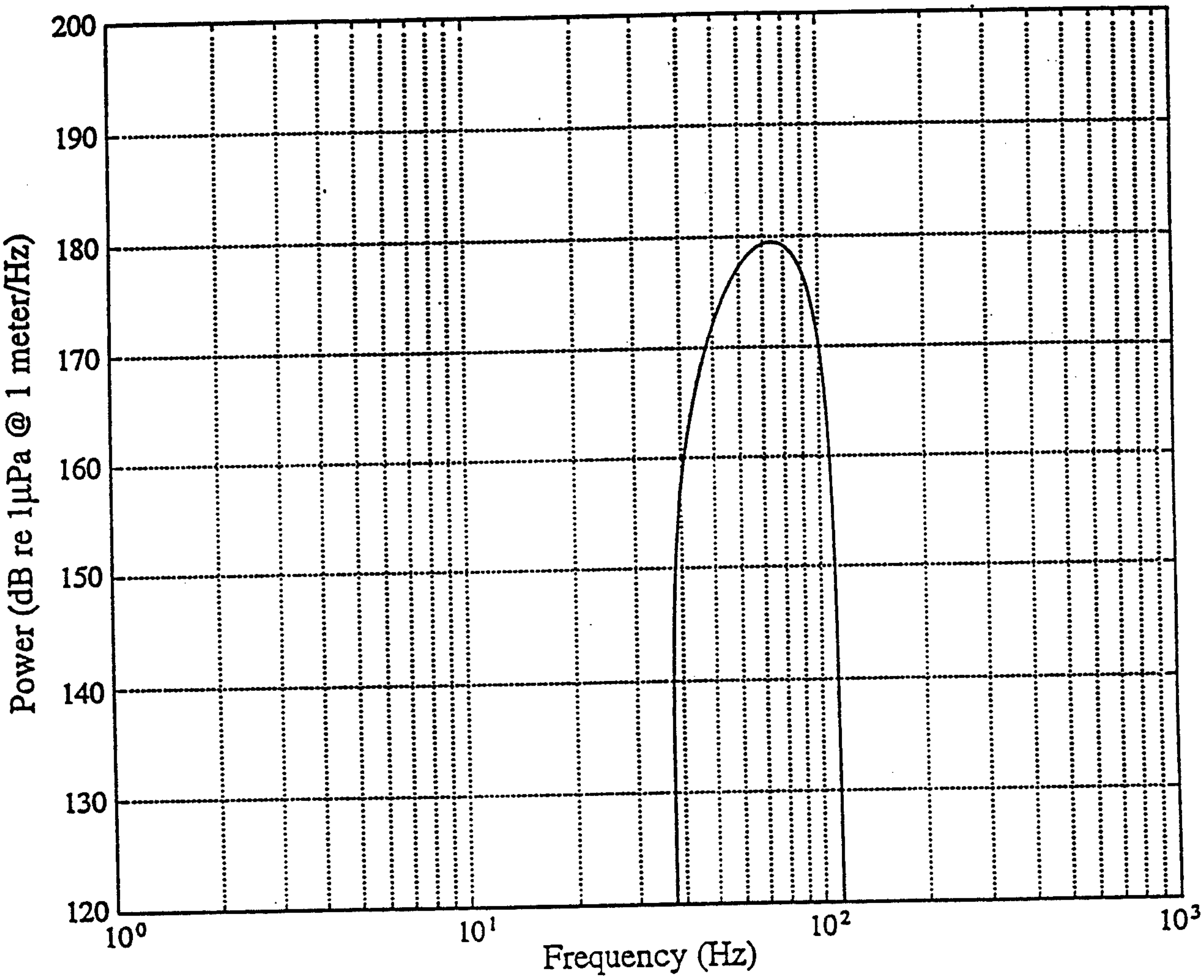


Figure 1.1.3-2 ATOC source power density spectrum

NOISE SOURCE	MAXIMUM SOURCE LEVEL	REMARKS	REFERENCE
UNDERSEA EARTHQUAKE	272 dB	Magnitude 4.0 on Richter scale (energy integrated over 50 Hz bandwidth)	Wenz, 1962.
SEAFLOOR VOLCANO ERUPTION	255+ dB	Massive steam explosions	Dietz and Sheehy, 1954; Kibblewhite, 1965; Northrop, 1974; Shepard and Robson, 1967; Nishimura, NRL-DC, pers. comm., 1995.
AIRGUN ARRAY (SEISMIC)	255 dB	Compressed air discharged into piston assembly	Johnston and Cain, 1981; Barger and Hamblen, 1980; Kramer et al., 1968.
LIGHTNING STRIKE ON WATER SURFACE	250 dB	Random events during storms at sea	Hill, 1985; Nishimura, NRL-DC, pers. com., 1995.
SEISMIC EXPLORATION DEVICES	212-230 dB	Includes vibroseis, sparker, gas sleeve, exploder, water gun and boomer seismic profiling methods.	Johnston and Cain, 1981; Holiday et al., 1984.
FIN WHALE	200 dB (avg. 155-186)	Vocalizations: Pulses, Moans	Watkins, 1981b; Cummings et al., 1986; Edds, 1988.
CONTAINER SHIP	198 dB	Length 274 meters; Speed 23 knots	Buck and Chalfant, 1972; Ross, 1976; Brown, 1982b; Thiele and Ødegaard, 1983.
ATOC SOURCE	**195 dB**	**Depth 980 m; Average duty cycle 2-8%**	**DEIS/EIR for the California ATOC Project and MMRP, 1994.**
HUMPBACK WHALE	192 dB (avg. 175-190)	Fluke and flipper slaps	Thompson et al., 1986.
SUPERTANKER	190 dB	Length 340 meters; Speed 20 knots	Buck and Chalfant, 1972; Ross, 1976; Brown, 1982b; Thiele and Ødegaard, 1983.
BOWHEAD WHALE	189 dB (avg. 152-185)	Vocalizations: Songs	Cummings and Holiday, 1987.
BLUE WHALE	188 dB (avg. 145-172)	Vocalizations: Low frequency moans	Cummings and Thompson, 1971a; Edds, 1982.
RIGHT WHALE	187 dB (avg. 172-185)	Vocalizations: Pulsive signal	Cummings et al., 1972; Clark 1983.
GRAY WHALE	185 dB (avg. 185)	Vocalizations: Moans	Cummings et al., 1968; Fish et al., 1974; Swartz and Cummings, 1978.
OFFSHORE DRILL RIG	185 dB	Motor Vessel KULLUK; oil/gas exploration	Greene, 1987b.
OFFSHORE DREDGE	185 dB	Motor Vessel AQUARIUS	Greene, 1987b.
OPEN OCEAN AMBIENT NOISE	74-100 dB (71-97dB in deep sound channel)	Estimate for offshore central Calif. sea state 3-5; expected to be higher (≥ 120 dB) when vessels present.	Urick, 1983, 1986.

Note: Except where noted, all the above are nominal total broadband power levels in 20-1000 Hz band. These are the levels that would be measured by a single hydrophone (reference 1 μPa @ 1 m) in the water.

Table 1.1.3-1 Natural and human-made source noise comparisons.

1.1.5 SUMMARY OF PREVIOUS OCEAN CLIMATE RESEARCH--DIRECT TEMPERATURE MEASUREMENTS; THE HEARD ISLAND FEASIBILITY TEST

In the past, measurements of ocean temperatures have been taken through direct readings from thermometers lowered from research and other vessels. Oceanographic research ships are used to sample the vertical temperature structure of the ocean, along "sections" across ocean basins. These sections each take many weeks to complete, and are rarely repeated. An exception is the 24°N (latitude) section across the Atlantic, which was first sampled in 1957. Sampling has been repeated twice in thirty-five years, and the changes in deep ocean temperature with time along that section are shown in Figure 1.1.5-1. An analysis of the data from these repeated samples reveals that there is some evidence of warming at depth, on the order of 0.007° C/year. This warming is similar to some modeled estimates of greenhouse-induced warming in the ocean. However, this 24°N section is virtually unique in modern oceanographic history -- very few repeated measurements like this exist, as they are very costly and tedious to repeat. Also, one or two isolated repeat sections are not enough to demonstrate whether the oceans are warming or cooling, overall.

Lowering temperature sensors from slowly moving ships is an inefficient and unreliable way of monitoring large-scale ocean temperature variability. Before large-scale measurements can be completed, the ocean changes, and measurements at each point are "contaminated" by small-scale ocean variability. Acoustic techniques rapidly and directly provide the large-scale averages that are required for global climate modeling purposes. ATOC would allow the measurement of average ocean temperatures along tens of sections, many times each year.

Previous experiments provide the framework for the MMRP and ATOC efforts. One of these experiments was a ten-day exploratory feasibility test conducted in 1991 near Heard Island, a remote site in the southern Indian Ocean. Low frequency acoustic signals were transmitted from underwater acoustic sources suspended from a research ship. Nine nations manned 14 receiver stations, spanning the world oceans. This experiment sent coded, low frequency, acoustic signals through the deep sound channel to receivers as far away as Bermuda and the California coast, 18,000 km away. The Heard Island Feasibility Test (HIFT) demonstrated the feasibility of using coded low frequency sound signals over long distances to measure average ocean temperature. However, HIFT was limited to a duration of just a few days and employed a non-stationary sound source, so long-term climate variability, which is needed for climate model verification and validation, could not be characterized.

A warming in the deep sound channel on the order of 0.05°C per decade (which is the order of magnitude that climate models predict) would cause a decrease in the signal travel time of 1.5 sec per decade for a 10,000 km transmission path. It is expected that the ATOC system would be able to resolve changes of travel time on the order of 0.01-0.1 sec, therefore offering the potential for resolving the emerging patterns of global-scale temperature changes in the oceans.

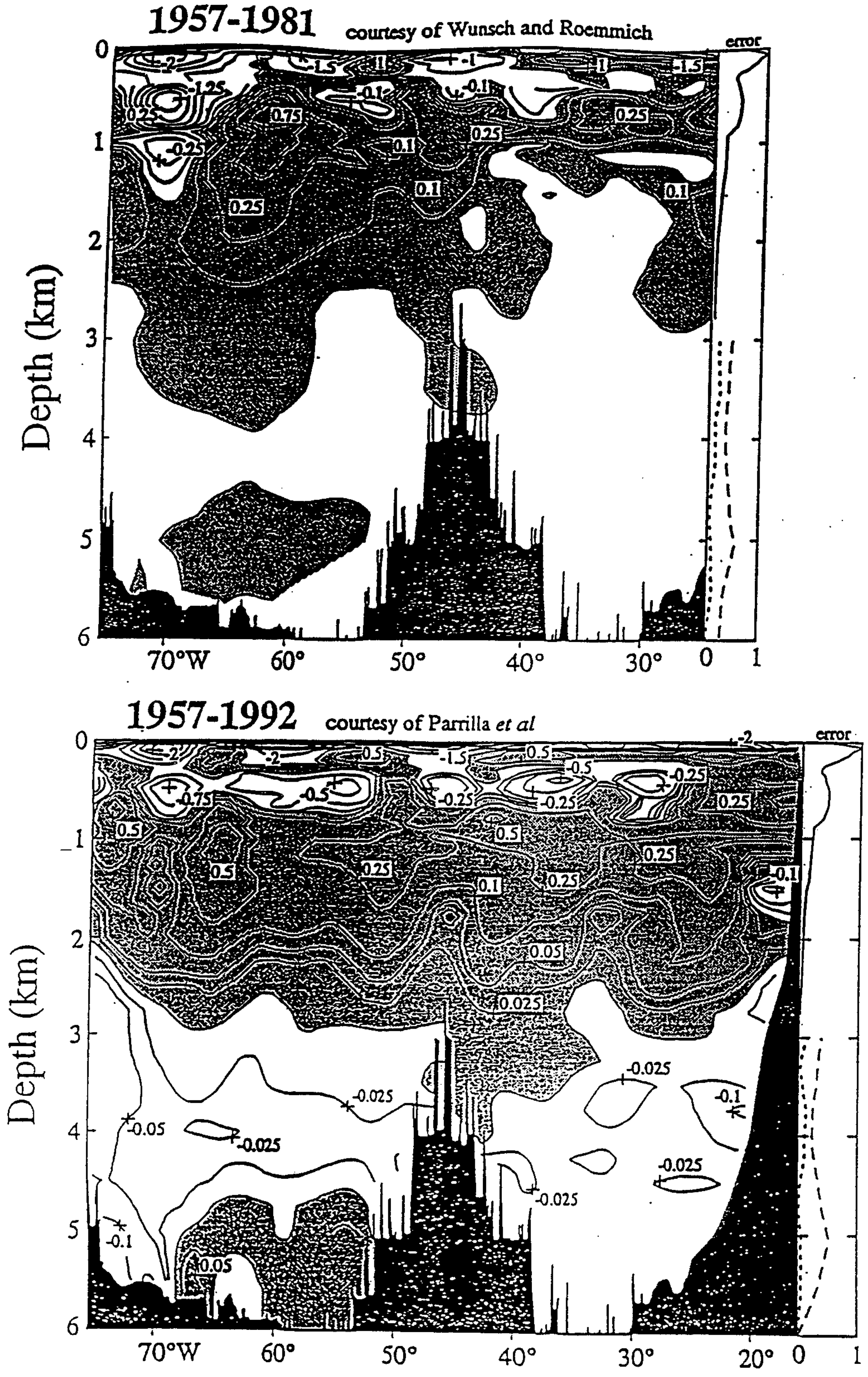


Figure 1.1.5-1 Ocean temperature changes (C) from base year at 24 deg N Atlantic Ocean

In addition to seeking evidence of global-scale ocean warming as a result of the greenhouse effect, ATOC has the potential to detect relatively short-term events such as El Niño, which can change regional ocean temperatures by up to several degrees Celsius; changes of this magnitude are comparable to increases predicted from global warming over periods as long as a century. Also measurable would be the large-scale variability of ocean temperatures due to ocean currents. Some of these natural variations, known as mesoscale variability, are relatively small in scale (100 km). By acoustically measuring average temperatures across distances extending to 5000 km or more, over extended time periods, short-term regional and mesoscale variations would be averaged out, and the predicted global ocean climate warming "signal" would be detectable. Well before global climate change is evident in the data, ATOC would be able to contribute valuable sea-truth data to the climate-research modeling community, to improve their predictive capability. ATOC would be one component of the available techniques used for measuring oceanic thermal variability (see Section 2.2 for discussions of the other techniques).

1.1.6 DESCRIPTION OF THE PROPOSED CALIFORNIA FACILITIES

The preferred action site (Sur Ridge) installation would consist of a sound source connected to shore by a subsea power cable, a vertical line array (VLA) of hydrophone receivers connected to shore by a fiber-optic communications cable, and access to an existing Navy-owned subsea horizontal line array (HLA) of hydrophones with its existing shore cable. The proposed action site (Pioneer Seamount/Pillar Point) installation consists of a sound source connected to shore by a subsea power cable and access to the existing Navy-owned subsea HLA at Pt. Sur.

• Acoustic Source: Produced by Alliant Techsystems, the ceramic bender-bar acoustic source is roughly 2.1 m high by 0.9 m in diameter (comparable in size to a large water heater) and weighs 2268 kg. It is contained in a 3.7 m high, galvanized steel tripod frame, illustrated in Figure 1.1.6-1. Total weight of this unit in air is 5443 kg; in water its weight will be about 4536 kg. The source is isolated with shock mounts from the frame. There are 3 nitrogen gas bottles for pressure compensation, to equalize the internal pressure with the external pressure of the deep ocean. The connector from the sea cable mates with a transmit/receive network which connects either the source or its integral receiver to the sea cable. The source-mounted receiver package has a tilt sensor, temperature and pressure sensors, and 4 hydrophones, all collectively termed the receiver. The hydrophones are on a 100 m line with a phone spacing of 33 m. For deployment, the hydrophone array will be coiled in a plastic container. After 3 days, corrosive links will part and a 60 cm (24 in) syntactic foam float will pull the array up. The tilt sensor on the tripod will transmit its signal acoustically (frequency proportional to tilt), as well as via the source cable. 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. The source mounted hydrophones will be used to provide information on the signal being transmitted and can also be used to detect and monitor marine mammals in the vicinity of the source.

The sound source is a prototype developed for this project. All components have a design life in excess of 10 yrs with a minimum guaranteed design life specification of 3 yrs. Following the initial demonstration experiment, the source can be recovered from the seabed.

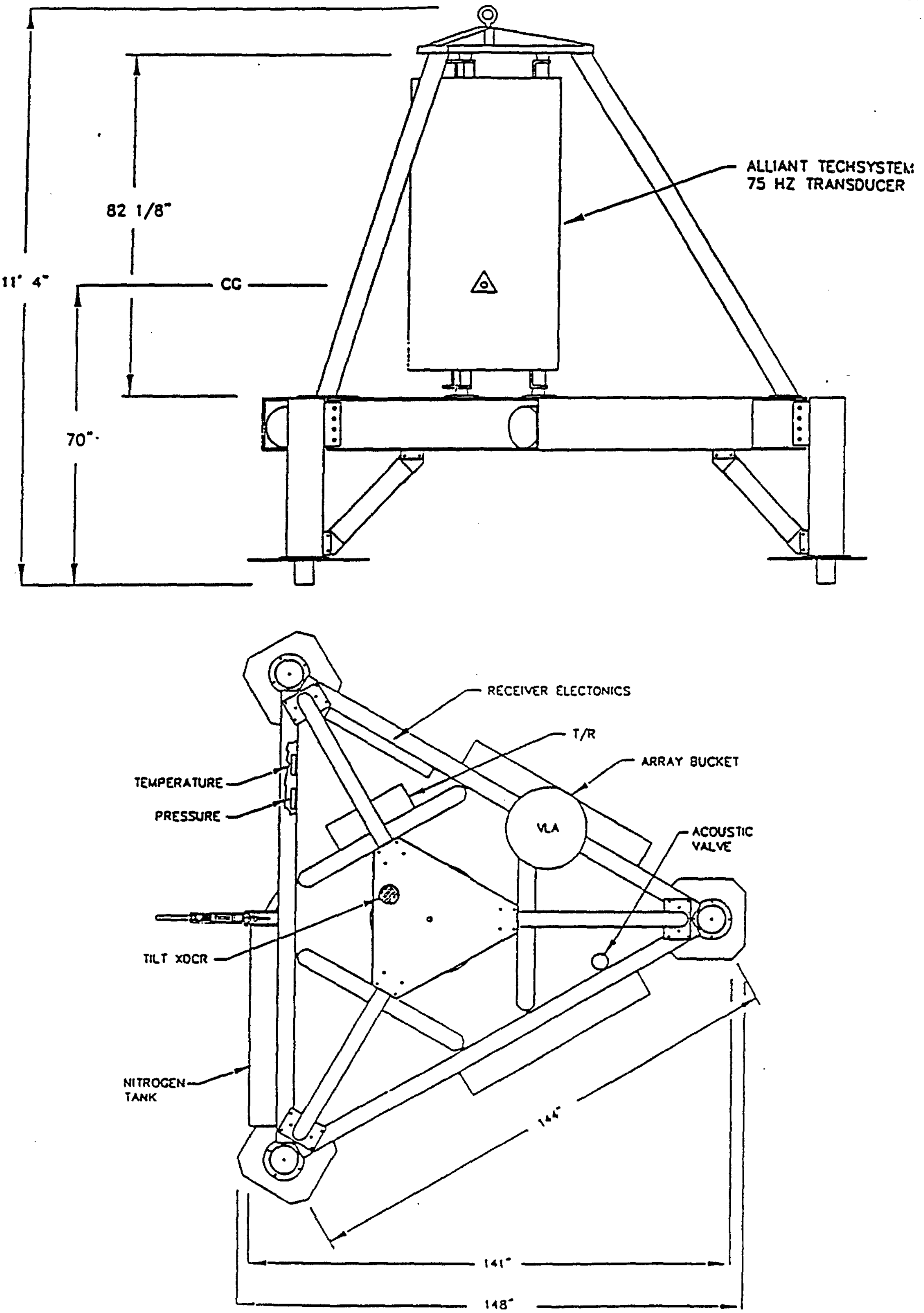


Figure 1.1.6-1 ATOC acoustic source (line drawing)

The acoustic signal has been designed as a digitally coded sequence optimized for decoding at the distant receivers. It is not a pure 75 Hz tone; rather, it is a rapidly phase-switched sound within the nominal 57.5-92.5 Hz band. 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).

• Source Site: The preferred source site is 40 km west of Pt. Sur, California (Figure 1.1.6-2) at 36°18.1' N, 122°19.3' W. Placement of the sound source would be at a depth of approximately 850 m. At this location, the bottom slope is about 4-6 degrees. The proposed source site is 88 km west of Pillar Point, California (Figure 1.1.6-2) at 37°20.6' N, 123°26.7' W. in approximately 980 m of water. At this location, the bottom slope is about 23 degrees.

• Source Sea Cable: The source power/monitoring cable, for the preferred Sur Ridge site, would be approximately 50 km long, laid in two sections. The first section is the nearshore section, a type SD List 3 (nominally 6 cm diameter), coaxial, twin conductor, insulated, armored cable. The cable would originate at a shore-based terminal building (building #114 at the Pt. Sur Naval Facility), buried in a 1 m trench from the terminal building to the bluff, through the surf zone inside a standard 10 cm split pipe. The cable would then be laid through the shallow water to a point approximately 6 km offshore and connected to the second section, a type SD List 1 (nominally 2.5 cm diameter), coaxial, twin conductor, insulated cable. This section extends from the splice with the nearshore cable to the proposed source site. As shown in Figure 1.1.6-3, the cable runs along the seafloor in deep water, closely paralleling the existing Navy cable to its terminus on Sur Ridge.

The source has not yet been installed. The procedure for deploying the source would be first to recover the cable end, attach it to the source on deck, reposition the ship, then lower the source and cable to the seabed. Its final position would be precisely determined using an array of four acoustic transponders, which would be recovered via an acoustic signal after the source's position was determined.

Installation of the source power/monitoring cable for the proposed Pioneer Seamount/ Pillar Point site would be approximately 90 km long, laid in one section (Figure 1.1.6-4). Scripps will first recover the subsea cable that had previously been installed from Sur Ridge to a point approximately 3 nm offshore Pt. Sur, CA. After recovery, the cable would be spliced to an additional length of cable in order to be long enough to reach the proposed Pioneer Seamount source site. The cable would be attached to the source on the ship and lowered to the proposed site via a support line. After the source is positioned the support line would be tied off to the source cable and separated from the ship. The source cable is then laid back towards Pillar Point along a previously surveyed route. The last 6 km, through the shallow water, would be armored as above. The cable would be buried across the beach and up the bluff face inside an existing ravine to the Pillar Point Air Force Station, then buried across the perimeter road and through a trench to the terminal building.

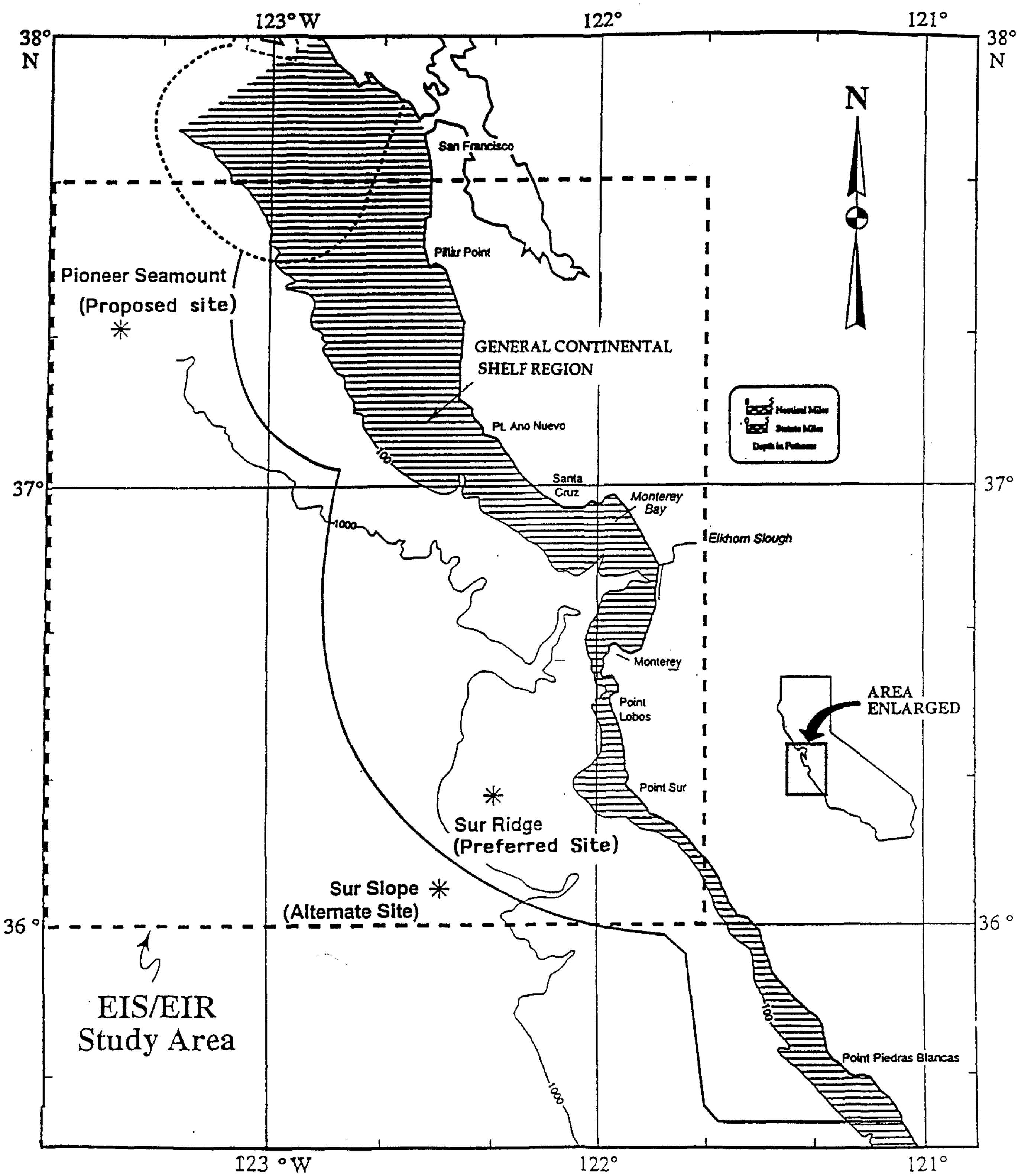


Figure 1.1.6-2 General EIS/EIR study area and ATOC preferred and proposed sites

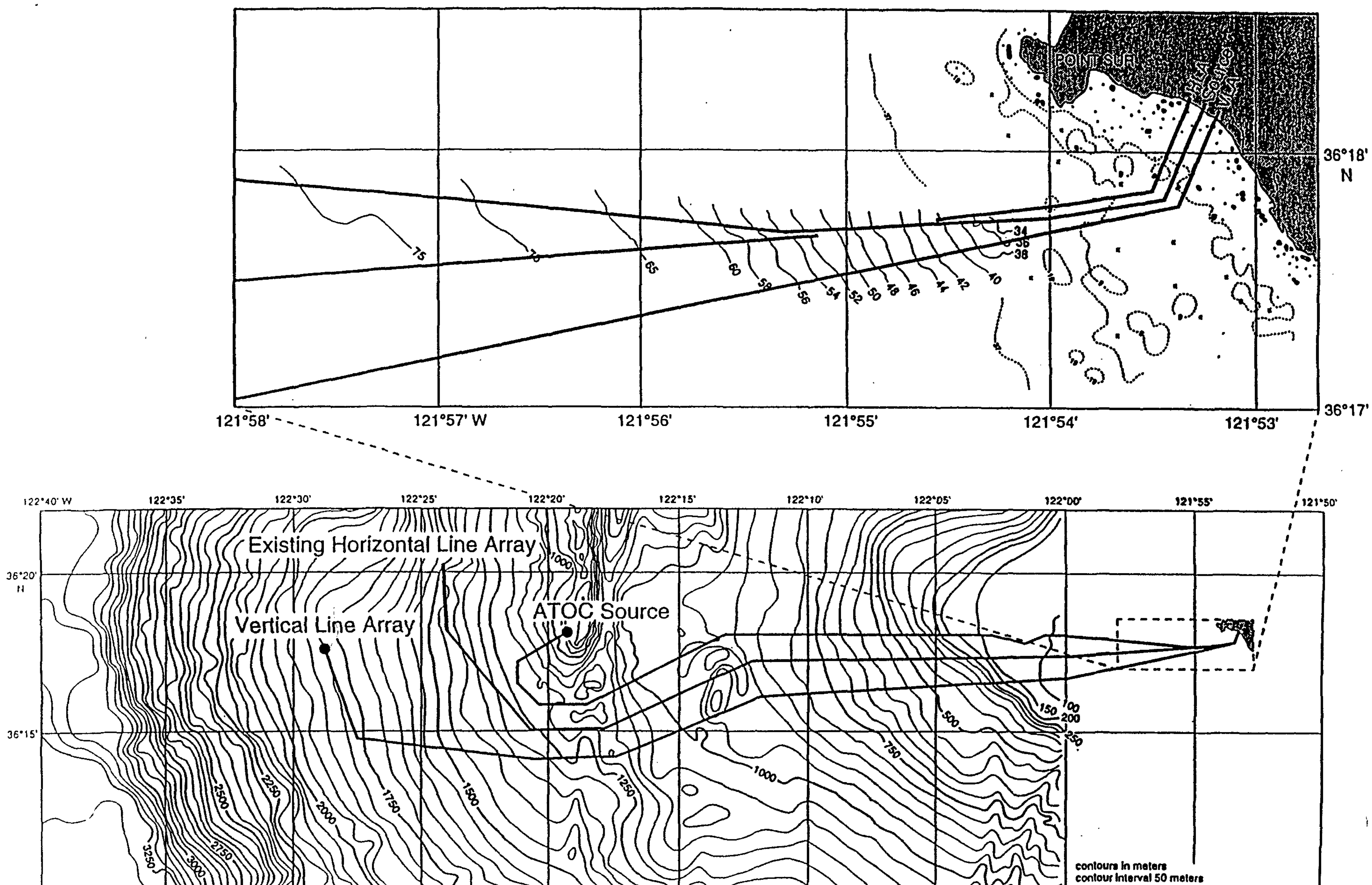


Figure 1.1.6-3 Proposed cable routes at Pt. Sur

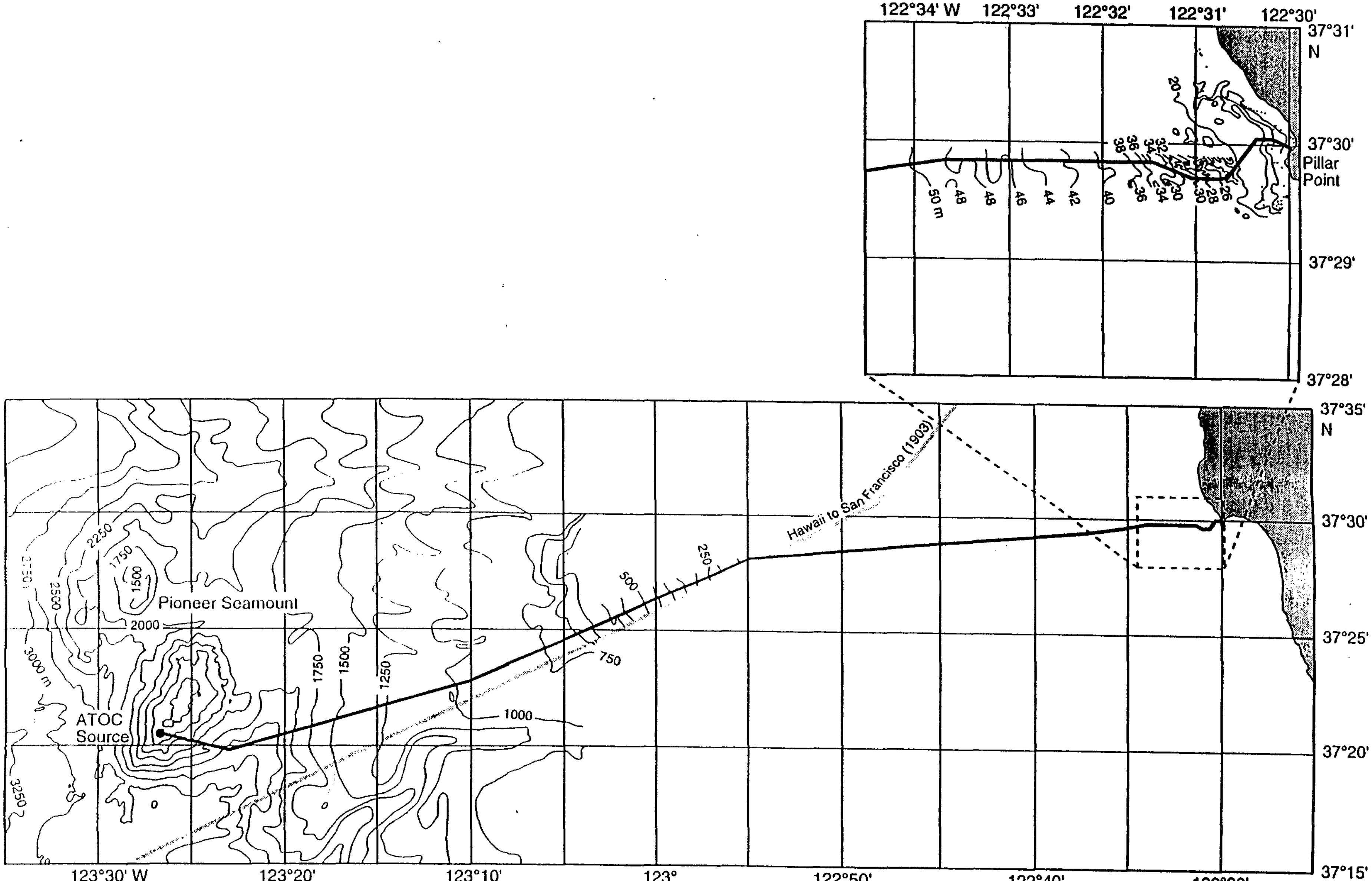


Figure 1.1.6-4 Proposed Pillar Point cable route.

• Subsea Listening System: Two subsea listening systems would be used to collect data in support of both the MMRP and the climate-related studies: 1) an existing Navy-owned, passive horizontal line array (HLA), which was installed in the late 1960s, connected to a seafloor cable extending from the terminal building to the base of Sur Ridge, and 2) the source-mounted VLA (see above).

Data collected from the VLA and the HLA would enable the MMRP to apply passive acoustic array techniques to detect vocalizing whales and dolphins (calls and songs), and other noise sources in the study area (ship, boat, pleasurecraft, aircraft, etc.). These acoustic listening systems would operate on a continuous basis, 24 hr a day, even when visibility conditions were unsuitable for visual surveys (due to fog, high seas, darkness, etc.). Based on experience with arrays in the Beaufort Sea (Clark et al., 1986; Clark and Ellison, 1989) and more recently off Kauai (Frankel, pers comm., 1993 verified the principle that detection range should be approximately equal to 4 times the array baseline length). The HLA (nominal sensitivity 50 Hz - 12 kHz) can provide reliable acoustic location coverage for vocalizing whales out to 40 km and beyond, from the array. The HLA provides the capacity to determine the arrival angle of the signal, which is used in determining the path that the signal takes between source and receiver. See Appendix C for more details on the use of the VLA.

Over the course of one to two field seasons, the arrays should help provide critical data to help determine any potential effect the source may have on whales that vocalize, particular those great whales that are suspected to rely on low frequency acoustics for communication and echolocation.

1.1.7 LONG-TERM ATOC PROGRAM PLANS

During the scoping process for this EIS/EIR, several commenters requested that the document be prepared as a programmatic EIS for a complete long-term global monitoring system. However, at this time, the ATOC project is experimental and is subject to fundamental uncertainties about the extent to which acoustic means can detect ocean climate changes. Without the analysis of experimental results from ATOC's near-term program, the details of any long-term network are too speculative to allow meaningful analysis.

The proposed project described herein should serve as the foundation for designing a system to measure long-term global ocean climate change trends. It should be long enough to assess any potential short-term impacts on marine animals, particularly marine mammals and sea turtles, demonstrate the source technology, and evaluate localized and mesoscale ocean temperature variability. This initial phase should demonstrate that it is possible to construct and operate an affordable international network capable of detecting and characterizing ocean climate change. In this sense, the ATOC project described in this EIS/EIR is a demonstration experiment for the possible long-term program, beyond the proposed project, and is a unique foundation and resource for long-term marine animal research.

There are several key uncertainties that make the design of a long-term system impossible without knowing the results of the proposed project. Obstacles to ATOC's evolution to a long term, global network include the following issues which must be resolved:

- Signal stability (coherence) - Can the signals be decoded at ATOC's receivers with the full, predicted processing gain and time resolution and, if so, over which ocean paths?

- Internal wave field limits - Do the ocean's ambient internal waves limit signal stability at long ranges, and if so at what ranges, and what is their relationship to the frequency band of the signal?

- Acoustic propagation limits - What limits does the incoherent energy among deep ocean acoustic paths (modes) have on signal power levels -- that is, over what paths can signals be sent at less than 195 dB levels?

- Ocean boundary scattering - What deleterious effects to sound reflections/ propagation do the ocean bottom and surface have in the vicinity of the source sites?

- Sound intensity related disturbance of marine animals - To what extent do local sound fields of the 260 watt sources disturb or affect the habitats and critical behaviors of nearby marine animals? Are habitats being denied and, if so, over what areas of the ocean?

This initial experimental ATOC effort should furnish the information to help answer these questions which, in turn, would help verify and validate climate models, and determine the design of an optimal global source and receiver network needed for a long-term program.

In summary, the data necessary to support a programmatic EIS do not exist at this time, and without these data no basis exists for the proposal/approval of a long-term program. It is not possible to predict the features of a long-term research program at a level of detail necessary to support a programmatic EIS. If additional long-term research is proposed, beyond that included in the current project, the additional research activities would be subject to appropriate environmental review and applicable permitting processes.

1.2. OBJECTIVES OF THE PROGRAM

A statement of project objectives serves as the basis for the screening and evaluation of alternatives and discussion of mitigation measures. This subsection summarizes the objectives of both the MMRP and the ATOC feasibility effort.

1.2.1 MARINE MAMMAL RESEARCH PROGRAM OBJECTIVES:

- Assess the potential effects of ATOC sound transmissions on the relative distribution and abundance of marine animals (particularly marine mammals and sea turtles) within the 120 dB sound field (modeled at 100 m depth), so as to minimize uncertainties associated with determination of the significance of any effects.

- Obtain information to help evaluate what effects the ATOC sound transmissions could potentially have on the relative distribution, abundance and diving behavior of marine mammals and sea turtles.

- Identify mitigation measures to avoid the potential disruption of behavioral patterns of local marine animals, particularly marine mammals and sea turtles.

- Assess the level of any responses of indicator species to ATOC sound signals, particularly whether any marine mammal or sea turtle demonstrates an acute or short-term response (Table C-1) to low frequency sound transmissions with ATOC source characteristics.

1.2.2 ACOUSTIC THERMOMETRY PROGRAM OBJECTIVES:

- Observe the ocean on the large space scales (3000 to 10,000 km) which characterize climate, so that modelers will be able to: 1) test their models against the average ocean temperature changes seen by ATOC over a few years, and 2) if, and when, the models prove adequate, use those same observations to "initialize" the models to make meaningful predictions.

- Develop and demonstrate the equipment necessary to undertake acoustic thermometry experiments; in particular, reliable low frequency sound sources.

- Prove the concept of using acoustic thermometry to measure ocean climate variability for global applications by establishing multiple acoustic pathways in the North Pacific.

- Obtain early baseline data on transmission times in Pacific pathways to compare with data that may be obtained in a follow-on global program, if such a program is approved.

- Determine the minimum source level and duty cycle necessary for obtaining valid climatic data.

- Characterize oceanographic factors that could affect the global climate "signal," such as tidal cycles, internal wave fields, and mesoscale variations, and determine the constraints they impose on the design of a future (conceptual) ocean monitoring system.

- Utilize existing U.S. Navy seafloor hydrophones to the maximum extent feasible to increase the number of acoustic pathways and, hence, the quantity of data, at a relatively small cost.

1.3 PURPOSES OF THIS DOCUMENT

This EIS/EIR is intended to serve several purposes. Most immediately, it will support the consideration by NMFS of a scientific research permit for the MMRP. The EIS/EIR is also intended to provide the information necessary for other regulatory approvals of ATOC including, but not limited to, consultation under Section 7 of the Endangered Species Act, consideration of state permits for portions of the project in state waters, and other regulatory requirements. A listing of federal and state agency approvals for which this EIS/EIR will be used is shown in Table 1.3-1.

AGENCY	ACTION
National Marine Fisheries Service	MMPA/ESA Research Permit Federal ESA Section 7 Consultation
Monterey Bay National Marine Sanctuary	Sanctuary Permit
U.S. Army Corps of Engineers	Nationwide Permits
California Coastal Commission	Coastal Development Permit
California Coastal Commission	OCRM Applicability Determination or State of California Coastal Management Plan Federal Consistency Review
California State Lands Commission	State Lands General Lease - Public Agency Lease
California State Historic Preservation Office	Historic Preservation Consultation
Federal Historic Preservation Consultation	Historic Preservation Consultation
California Department of Fish and Game	California ESA Consultation
University of California	Project Approval
ARPA	Decision to Proceed

Table 1.3-1 Federal and state agency approvals for which this EIS/EIR will be used.

1.3.1 MARINE MAMMAL PROTECTION ACT/ENDANGERED SPECIES ACT RESEARCH PERMIT

Scripps currently has pending before NMFS an application for a scientific research permit (SRP) to conduct marine mammal and sea turtle research using the ATOC source. The decision to be made by NMFS is directly connected to the scope of the actions, the alternatives, and potential effects, which are detailed in this EIS/EIR. The following comprise the decision options for NMFS:

- To approve the permit as submitted (without modifications)
- To approve the permit with modifications such as specific management constraints and/or mitigation measures

- To deny the permit (No Action)

1.3.2 PROJECT FUNDING BY SERDP

The ATOC program is funded by the Strategic Environmental Research and Development Program (SERDP), which was established by Congress, who directed the Department of Defense (DoD) to expend a portion of its budget on environmentally-related issues. The goal of SERDP is to use some of the resources from the downsizing of the defense establishment to address environmental problems. The impetus has been to convert some of the assets of the DoD for dual, or non-military, uses. In the case of ATOC, these funds ($35M) are being administered through the Advanced Research Projects Agency (ARPA), the central research arm of DoD.

1.3.3 OTHER PERMITTING REQUIREMENTS

As discussed in Section 5, a number of additional regulatory reviews apply to the MMRP and ATOC Program. This EIS/EIR is intended to support those reviews as well.

1.4 SCOPING SUMMARY

The following discussion summarizes the NEPA and CEQA process to date, future activities under NEPA and CEQA, issues identified during the scoping process, alternatives identified during scoping, and major issues to be evaluated in this EIS/EIR. (Refer to Appendix D).

1.4.1 NEPA REVIEW PROCESS

ARPA is the federal lead agency for the purposes of this EIS/EIR, which has been prepared jointly with NMFS. The environmental review process conducted by ARPA under NEPA for the proposed project was initiated by the issuance of a Notice of Intent (NOI) to prepare an EIS on April 29, 1994 and published in the Federal Register on May 3, 1994.

In addition to the written scoping comments received by ARPA and NMFS, a public scoping hearing was held on May 16, 1994, in Santa Cruz, CA to solicit public comment on the range of issues to be addressed in the federal environmental review process. A public hearing was held on January 6, 1995, in Santa Cruz, CA to solicit public comment on the Draft EIS/EIR.

A 60-day Draft EIS/EIR review and comment period followed the filing of the Draft EIS/EIR with the Environmental Protection Agency (EPA). ARPA, NMFS, and UCSD have considered and responded to comments received and have prepared this Final EIS. In response to several requests by the public, comments on this Final EIS/EIR will be received during the 30-day period following official publication via the Federal Register, for NEPA purposes only, as described in the Preface. Significant comments will be addressed in the decision document of the federal lead agency (ARPA's record of decision).

1.4.2 CEQA REVIEW PROCESS

This document is a combined Environmental Impact Statement/Environmental Impact Report, intended to comply with both NEPA and CEQA. Both NEPA and CEQA strongly encourage federal and state agencies to avoid duplication of efforts in preparing environmental documents pursuant to their respective statutes (See 42 USC 4332; 40 CFR 1506.2 (c) and CA. Pub. Res. Code Sec. 21083.7; Guidelines Sec. 15220-15228). To this end, both statues authorize their respective agencies to prepare joint documents combining the requirements of both the federal and state statutes. The review processes of NEPA and CEQA are similar and have and will occur in parallel with regard to this document. Through this coordinated implementation of federal and state environmental review procedures, unnecessary duplication of effort is avoided.

The University of California, San Diego (UCSD) is the lead agency under CEQA for the project evaluated in this EIS/EIR. The principal purposes of this EIS/EIR under CEQA are: 1) to identify the potential significant effects of the proposed project on the environment and to indicate the manner in which these significant effects can be mitigated or avoided; 2) to identify any unavoidable adverse impacts that cannot be mitigated; and 3) to evaluate alternatives to the project.

UCSD initiated the environmental review process under CEQA by distributing a Notice of Preparation to the State Clearinghouse on June 3, 1994. A public scoping meeting was then held on June 23, 1994, in La Jolla, CA, at the UCSD campus, to discuss the proposed project, and to solicit public comment as to the scope and content of the proposed EIS/EIR. Although the official scoping period closed on July 5, 1994, scoping comments were received from the public through July 20, 1994. This EIS/EIR has been prepared to respond to public concerns identified through both the federal and state public scoping processes, in addition to issues identified by the federal and state lead agencies.

Following issuance of the Draft EIS/EIR, a 60-day public comment period was provided after which the Final EIS/EIR was prepared. No distinction will be drawn between comments submitted under NEPA and comments submitted under CEQA. Commenters therefore needed to only submit a single set of comments. As with the Draft EIS/EIR, this Final EIS/EIR is a joint federal/state document fulfilling the requirements of both NEPA and CEQA.

Upon review and consideration of the Final EIS/EIR, UCSD may approve or disapprove the project under CEQA. If approved, the University would also approve written findings for any significant environmental effects identified in the EIS/EIR. Findings would be accompanied by a brief explanation of the rationale for each finding and would indicate either: 1) that mitigation measures or project alternatives to reduce adverse impacts to less-than-significant levels have been adopted; 2) that measures to mitigate specific effects are not within the jurisdiction of UCSD and that such measures have been or can be adopted by an agency with such jurisdiction; or 3) that specific effects are unavoidable and substantially unmitigatable but are considered acceptable because overriding considerations indicate that the benefits of the proposed project outweigh potential adverse effects. When making these findings, the University would also adopt a monitoring and reporting program for mitigation measures (Appendix G) that have been incorporated into the approved project to reduce or avoid significant effects on the environment. This monitoring program would be designed to ensure compliance with adopted mitigation measures during project implementation.

The Regents of the University of California have adopted guidelines for the preparation of EIRs applicable to University projects. In those areas where the Regents' CEQA guidelines and the NEPA guidelines differ, this document generally follows the NEPA guidelines. For example, while the Regents' guidelines generally recommend organizing sections of EIRs impact-by-impact (i.e., presenting the entire discussion of biological resources in a separate section) with each section combining the discussion of environmental setting and environmental impacts, NEPA documents generally present the environmental setting for all impacts in one section and the environmental impacts in another section. This document follows the NEPA format, while including all of the content required for EIRs under CEQA. For general reference the locations of all CEQA-mandated discussions within this EIS/EIR are indicated in Table 1.4.2-1.

CEQA-MANDATED DISCUSSION	SECTION
1. The Significant Environmental Effects of the Proposed Project	4
2. Unavoidable Significant Effects	4 & 6
3. Mitigation Measures Proposed to Minimize the Significant Effects	2 & 4
4. Alternatives to the Proposed Action	2
5. The Relationship Between Local Short-Term Uses of the Environment and the Maintenance and Enhancement of Long-Term Productivity	4 & 6
6. Significant Irreversible Environmental Changes Which Would be Involved in the Proposed Action Should it be Implemented	4 & 6
7. The Growth-Inducing Impact of the Proposed Action	4 & 6

Table 1.4.2-1 Locations of CEQA-mandated discussions within this EIS/EIR.

1.4.3. ISSUES IDENTIFIED DURING SCOPING

The scoping process resulted in requests that several environmental issues be analyzed in the EIS/EIR. All potentially significant issues have been evaluated in this EIS/EIR. A chronology of scoping activities associated with the preparation of this EIS/EIR is presented in Appendix D. A summary of significant issues identified during scoping follows:

• Scope of Project Analyzed: A variety of comments were received on the necessary scope of the project to be evaluated. Several commenters requested that this EIS/EIR not be restricted to the MMRP alone, but that it also evaluate the ATOC project. The project scope to be evaluated in this EIS/EIR encompasses the MMRP Pilot Study and the continuing MMRP in conjunction with the follow-on ATOC feasibility experiment.

Other commenters requested that a single EIS be prepared for the Kauai and California ATOC installations. A number of distinct differences between these program elements would make this type of combined analysis awkward. First, the number and genera of animal and benthic life in each site is greatly different; second, the opportunities (and therefore information value) for marine mammal research (particularly boat and visual observations) are significantly different; third, the cable to the proposed site location in California, but not Kauai, is proposed to be within a national marine sanctuary; fourth, both the California and the Hawaii documents are joint Federal/state documents. All these factors, plus differing state requirements, militate against development of a single EIS for the two sites. Nevertheless, in an attempt to respond to this request, both the Kauai and California environmental documents were processed on similar schedules. Those commenters interested in the Kauai project were able to review and comment on the EIS for that project. In order to provide for a combined review, and even though public review schedules were not precisely concurrent, the Draft EIS for the Kauai project incorporated by reference the Draft EIS/EIR for the California project. (As indicated previously, the Draft EIS for the Kauai ATOC program has been incorporated by reference into the California Final EIS/EIR.)

A few commenters also requested that a single programmatic EIS be prepared on both the short-term and future long-term ATOC programs. However, any long-term ATOC program is highly speculative at this time, and cannot reasonably or feasibly be evaluated now in a programmatic EIS (see Section 1.1.7). Any future ATOC program will be subject to further permitting and environmental review processes.

• Alternatives to be Considered: During the scoping process, a number of alternatives to the proposed action were suggested and evaluated. Commenters requested that the alternatives analysis include alternate source sites, alternative technologies for measuring global climate change, and alternative protocols for operation of the ATOC source. The range of alternatives considered in Section 2 responds to this request.

• Biological Resources: Nearly all commenters requested that all biological resources that may be affected by the ATOC project proposal be evaluated, focusing on marine mammals, but also assessing impacts on sea turtles, seabirds, fish, and invertebrates. The overall organization and principal focus of this EIS/EIR responds to this scoping comment.

• Scientific Uncertainty: Many commenters highlighted the scientific uncertainty that surrounds the general question of marine mammal response to low frequency noise. The MMRP has been designed to address this uncertainty for purposes of determining whether the program is safe, and this EIS/EIR presents the current state of scientific knowledge regarding those impacts.

• Justification for the MMRP: A number of scientists and other interested individuals and organizations requested that the EIS/EIR present the rationale, procedures, protocol, and anticipated results of the MMRP, focusing on the degree to which the MMRP is appropriately designed to determine whether adverse impacts to biological resources will result from source transmissions. This EIS/EIR responds to this request as a principal task.

• Source Suspension Guidelines: Several commenters requested that the EIS/EIR articulate a standard of harm that will guide whether source transmissions continue. They also requested that the EIS/EIR identify who will implement the standard and make decisions whether to proceed with longer term transmissions. The MMRP Research Protocol included in Appendix C, and discussions elsewhere in this EIS/EIR, respond to this request.

• Effects on Tourism and Fishing: Many local commenters were concerned that adverse impacts on biological resources could have an indirect impact on tourism and fishing. These potential impacts are addressed in Section 4.

• Consistency with Monterey Bay Sanctuary and Land Use Plans, Policies and Requirements: A few commenters requested that the EIS/EIR discuss the consistency of the ATOC program in California with the Monterey Bay National Marine Sanctuary Management Plan. Several commenters requested that the EIS/EIR evaluate the consistency of the ATOC project with land use plans, policies, and requirements. These issues are addressed in Section 5.

2 ALTERNATIVES INCLUDING THE PROPOSED ACTION

2.1 INTRODUCTION

This section describes a range of alternatives to the proposed project and briefly summarizes the environmental consequences of the alternatives. Both secondary and primary alternatives are considered. Secondary alternatives are those alternatives to the proposed action that would accomplish the action in another manner, such as through using a different technology. From the perspective of the acoustic thermometry element of the project, secondary alternatives include such technologies as moored autonomous sound sources, or direct measurements of ocean temperatures with conventional thermometers. Primary alternatives generally are considered to be variations of the proposed action, such as the installation of project facilities at alternative sites, and/or variations of the proposal through implementation of one or more mitigation measures. Some alternatives that are evaluated separately, but are expected to be complementary to ATOC research efforts, do not come under the aegis of the ARPA program and, as such, are not evaluated as part of the ATOC project.

Twelve alternatives, representing a range of options, are described, including the preferred action (Sur Ridge), the proposed action (Pioneer Seamount), and the "no action" alternative. This section describes in detail the eleven alternatives (including six alternate project sites) that were considered. The descriptions focus on the effectiveness of each alternative and its potential to meet the project objectives described in Section 1. Based on this analysis, five alternatives (two of which are alternate project sites) are selected for further study. Evaluation of these five alternatives against the project criteria are included at the end of this section (Table 2.4-1). Potential environmental impacts of the five alternatives are described and compared in Section 4.

2.2 ALTERNATIVES CONSIDERED AND RATIONALE

The alternatives considered in this section include: 1) the preferred action (Sur Ridge site), 2) no action, 3) alternate project sites (five such sites are screened, including sites off the coast of Pacific Beach, Washington; Coos Bay, Oregon; San Nicolas Island, California; Pioneer Seamount, California [proposed action site]; and Sur Slope, California), 4) moored autonomous sources, 5) restricted source transmission times, 6) modified source operational characteristics, 7) global climate models, 8) satellite sensors for sea surface temperature measurements, 9) satellite sensors for sea level measurements, 10) oceanographic point sensors (measurements using conventional thermometers), 11) autonomous polar hydrophones, and 12) separating the MMRP and ATOC experimental sites using mobile sound sources..

Of the twelve alternatives considered, the preferred action, no action, two alternate sites (Pioneer Seamount [proposed action site], Sur Slope), and moored autonomous sources have been selected for detailed consideration in Sections 3 and 4.

With the exception of Global Climate Modeling which is an integral part of the ATOC program, qualitative comparison of ATOC with other oceanic temperature measuring efforts, (e.g., Autonomous Lagrangian Circulation Explorer/Profiling Autonomous Lagrangian Circulation Explorer [ALACE/PALACE][see Section 2.2.10)]) is limited by differing objectives and products and are not directly comparable.

2.2.1 PREFERRED ACTION (ALTERNATIVE 1), PROPOSED ACTION (ALTERNATIVE 3-1) AND MITIGATION MEASURES

This section describes the proposed action by Scripps, as stated in the Scientific Research Permit application now pending before NMFS, and compares it to other suggested alternatives.

Section 1 of this EIS/EIR generally describes the overall ATOC program, the physical facilities, and the MMRP. The description of the proposed action here does not repeat this information, but instead incorporates and relies on the discussion in Section 1. The presentation here focuses on operational protocols for the proposed 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.

2.2.1.1 Proposed Action

The preferred action would have involved the installation and operation of an ATOC sound source at the Sur Ridge site, which is located approximately 40 km west of Pt. Sur, CA, within the Monterey Bay National Marine Sanctuary. The proposed action now involves the installation and operation of an ATOC sound source at the Pioneer Seamount, which is located 88 km west of Pillar Point, California.

Originally, it was proposed that the source be operated six times every day for twenty minutes over a two-year period. Each source transmission would begin with a five-minute "ramp up", a slow increase in the sound volume, to the full 260 watt, or 195 dB source level. Marine mammal research would have occurred against the backdrop of this operational protocol.

In response to comments received during the scoping process, the proposed MMRP research protocol (Appendix C) was revised to now include an initial Pilot Study involving operation of the source at a variety of levels and duty cycles to allow more rigorous examination of the potential effects of the source on marine animals. Specifically, the following features are included:

- ATOC feasibility operations would not commence until after a Marine Mammal Research Program Pilot Study has been performed and reported on by marine biologists (approximately 180 days).

- The source operational protocol would include a variety of levels and duty cycles (source levels ranging from 185-195 dB, duty cycles ranging from 0%-8%), with a 4(±3) day on/7(±3) day off pattern, during which observations would be made of marine animals, offering experienced marine animal observers the opportunity to recognize any acute or short-term effects on marine animals (particularly marine mammals and sea turtles) (Table C-1), as well as any disruption in behavioral patterns.

- Marine animal habitat utilization observations would be conducted from the air (visual and acoustic surveys/observations), from a vessel (visual surveys/observations and acoustic measurements), from underwater (bottom-mounted horizontal and vertical line (array acoustic monitoring), remotely via satellite-tracked position and time-depth-recorder (TDR) tags on northern elephant seals, and vessel-based photo-identification efforts.

- Acoustic surveys would be carried out from a boat with calibrated hydrophones to record received signal levels at various ranges in a systematic pattern around the source.

- Acoustic observations would include the area between the source and the coast, and would also encompass part of the Monterey Bay National Marine Sanctuary and the Gulf of the Farallones National Marine Sanctuary.

- Acoustic sampling would include comparative sound level measurements of existing natural and human noise-producing sources (storms, merchant vessels, recreational power boats, fishing boats, low flying aircraft, etc.).

- Source operations would be suspended at any time that an acute or short-term effect (as described in Table C-1) is observed in association with the operation of the source. The protocols for suspending operations are described more fully in Appendix C.

- Field observational data would be processed and analysed periodically during the MMRP Pilot Study and reported to all concerned (see Appendix C).

- After completion of the MMRP Pilot Study, a report of the preliminary results would be jointly reviewed by the MMRP Advisory Board, NMFS, the Marine Mammal Commission (MMC), The Marine Mammal Center (TMMC), and the Pacific Regional Scientific Review Group (PRSRG), established under MMPA-94. It would be the goal of the project to complete this preliminary review within one month after the completion of the Pilot Study. [Note: The MMRP Advisory Board is an independent panel of scientists, marine biologists, and marine mammal specialists assembled to provide advice and guidance to the MMRP; see Appendix C].

- Results of this review would be used as part of the process to determine the optimum acoustic source parameters for ATOC feasibility operations.

- MMRP surveys and observations would continue throughout any follow-on ATOC operations, with data reviews and reports in accordance with SRP requirements (Table 2.2.1.1-1).

In response to concerns and comments received during the public comment period on the Draft EIS/EIR about conducting research within the MBNMS, the proposed project location was changed to Pioneer Seamount, offshore Pillar Point, CA (Alternative 3-1). This EIS/EIR concludes that all potential environmental impacts presented by the proposed project would either be reduced or be unaffected by the change in the proposed location of the ATOC sound source to Pioneer Seamount.

Several mitigation measures have been included in the proposed action, and are presented below (in italics). These have been developed to generally mitigate the effects of ATOC subsea sounds on marine animals.

CEQA Mitigation Measure A-1: A dedicated MMRP Pilot Study would precede ATOC feasibility operations as described in detail in subsection 2.2.1.1.

Contingent upon findings of no acute or short-term impacts (Table C-1) to marine animals during the MMRP Pilot Study, ATOC feasibility operations would be initiated. Transmissions would be for 20 min every four hours, every fourth day, with each transmission preceded by a 5 min ramp-up period (2% duty cycle). Following issuance of the final MMRP Pilot Study Report; i.e., about six months after the Pilot Study ends, approximately two months of transmissions at an 8% duty cycle (daily every four hours for 20 min) would be required to adequately sample the ocean paths for the possible effects of ocean tides and other high frequency fluctuations. The 2% duty cycle would be re-instituted following the 8% duty cycle tidal observations. Source levels would also be reduced to the minimum necessary to provide sufficiently strong signals at the receivers. The ability to reduce source power below the initial 195 dB source level (260 watts) would depend upon the efficiency of the actual sound transmission paths, ambient noise levels, and other factors, such as vertical mode structure relative to sound channel axis position, and potential amplitude and phase coherence degradation due to oceanographic features, such as internal waves.

Once ATOC feasibility operations commence, the MMRP protocol defined in the Scientific Research Permit application would be followed. That is, marine animals would be observed throughout the study period to identify any significant adverse disruptions to their behavior. The California MMRP Research Team (MRT) would quantify possible effects by comparing results obtained before the installation of the source, during periods when the source is on, and during periods when the source is off.

The effects of the proposed sound source on marine animals (including sea turtles), and particularly cetaceans and pinnipeds, would be monitored by passive underwater acoustic detection, vessel-based visual surveys/observations and acoustic measurements, aerial visual and acoustic surveys/observations, satellite and TDR tagging of northern elephant seals, and photo-identification efforts. In addition, playback studies are planned for sperm and humpback whales, and for leatherback sea turtles, and audiometric measurements are scheduled for three species of odontocetes (see Appendix C). These tasks are part of an integrated experimental approach designed to measure any effects of low frequency sound transmissions on marine animal distribution, behavior, and sound production. A proposed timeline of MMRP and ATOC climate research is summarized in Table 2.2.1.1-1. This is dependent upon a number of assumed criteria, such as the date by which required permits are received and the periods when species of interest are present in the study area. The schedule is therefore subject to change once these criteria are known.

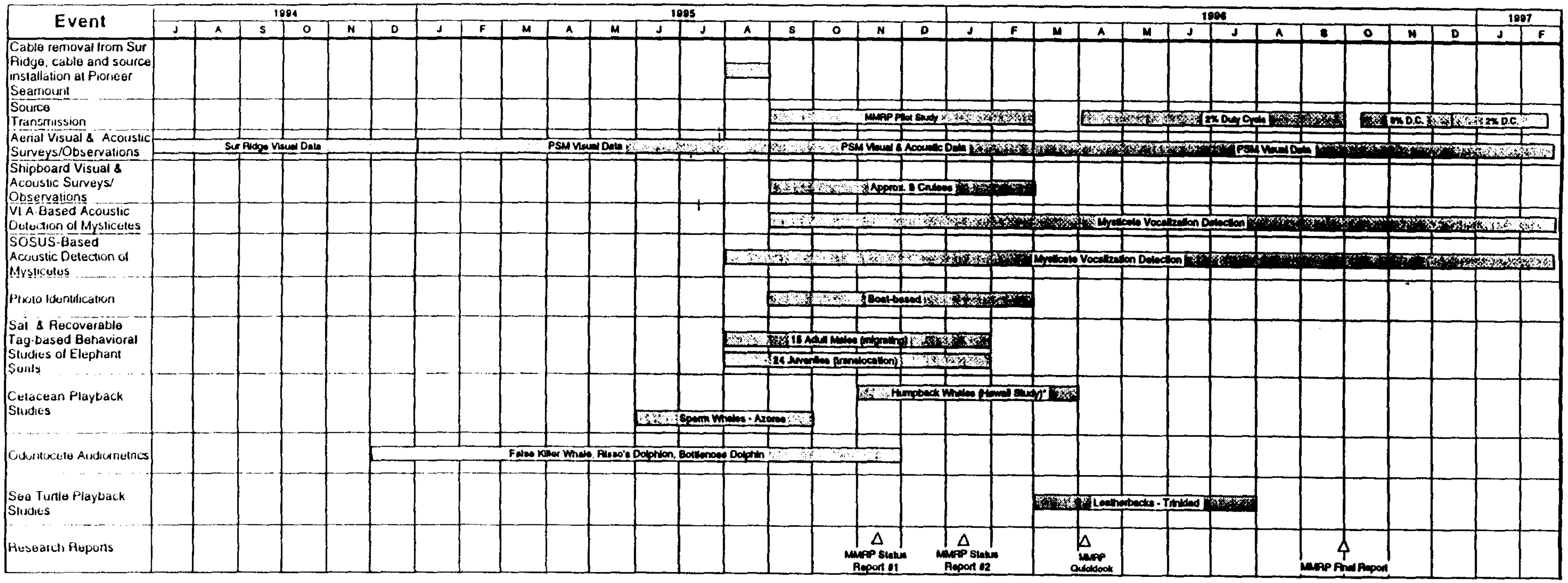
Sound Fields

The potential impacts 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? Section 4 analyses the second and third factors--what animals might be exposed to the source and how do those exposures compare to what is known about the sensitivity of those animals to the signals produced?

As discussed above, when it is operating at full intensity the source will produce approximately 260 watts of acoustic power, resulting in a sound level of 195 dB at one meter from the source. Relatively few animals likely would be exposed to the source at this full intensity, since they would need to be immediately adjacent to the source, 980 m below the surface, in order to receive a 195 dB sound level. In consideration of the potential impacts of this sound source on marine animals, it is therefore necessary to estimate the **received** sound levels (i.e., the sound levels at the marine animal's actual location) 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 spreading is the most appropriate in the three dimensional space immediately surrounding the source. At ranges from the source greater than the ATOC source depth, a two-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 received sound levels at a particular site distant from the source. Parabolic equation models address these attenuating and enhancing effects to produce a more realistic estimate of actual received levels. Parabolic equation model results for the preferred Sur Ridge ATOC source installation are depicted in Figures 2.2.1.2-1 and 2.2.1.2-2 (results for the proposed action site at Pioneer Seamount are depicted in Figures 2.2.1.2-7 and 2.2.1.2-8). Calculations of ranges of the sound fields around the preferred action site (Sur Ridge) source are depicted in Figures 2.2.1.2-3 and 2.2.1.2-4 (results for the proposed action site at Pioneer Seamount are depicted in Figures 2.2.1.2-9 and 2.2.1.2-10). All calculations use spherical spreading to 1000 m, then the parabolic equation model results.



* To be conducted under proposed Kauai MMRP protocol.

Table 2.2.1.1-1 Pioneer Seamount MMRP Schedule of Events

The original SRP application presented a number of theoretical "zones of influence" (ZOI), which were based upon spherical and cylindrical spreading models, and which applied a number of "worst-case" or "bounding" assumptions to predict a maximum potential impact on marine animals. Due to the conservatism of the assumptions made in the ZOI analysis, and the fact that their effects were added together, the ZOI analysis did not accurately state the potential effect of the sound source on marine animals. Since this EIS/EIR is required to analyse anticipated environmental impacts, and because the parabolic equation model provides the most accurate estimates of received sound levels, Finite Element Parabolic Equation (FEPE) acoustic performance prediction model values are used throughout this document.

The sound field contours included in the original SRP application are depicted in Figure 2.2.1.2-5 (sound field rings are depicted as: 5 km = 130 dB, <500 m animal dive depth; 10 km = 130 dB, ≥500 m animal dive depth; 25 km = 120 dB, <500 m animal dive depth; 40 km = 120 dB, ≥500 m animal dive depth. By comparing this with the revised sound field estimates (Figure 2.2.1.2-6 for the preferred action site [Sur Ridge], Figure 2.2.1.2-11 for the proposed action site [Pioneer Seamount]), it can be seen that the original sound field contours significantly overstated the area where received sound intensities would exceed 120 dB, largely due to the fact that the sound field calculations did not account for any attenuating factors other than distance. Figures 2.2.1.2-6 and 2.2.1.2-11 portray parabolic equation model calculations for 100 m depth, which represents sound levels most likely to be encountered by the majority of marine animals offshore central California. At this depth, the 120 dB sound field encompasses approximately 1200 km^2 around the preferred Sur Ridge site, and approximately 735 km^2 around the proposed Pioneer Seamount site. For both sites, the 120 dB and 130 dB sound fields are of smaller area at the 30 m and 500 m depths, and somewhat larger deeper than 850 m.

2.2.2 NO ACTION (ALTERNATIVE 2)

Both NEPA and CEQA require that the proposed project be compared with a "No Action" or "No Project" Alternative. This alternative would consist of not conducting the ATOC study, nor the associated MMRP. Under this alternative, no SRP would be issued by NMFS for the MMRP, the ATOC facilities would not be installed, and neither the MMRP nor ATOC feasibility operations could commence. Results of an evaluation of this alternative are given in Table 2.4-1 at the end of this section. The environmental consequences of the No Action Alternative are further analyzed in Section 4.

Although the No Action Alternative would prevent any potential impacts from the ATOC source on marine animals, it would also delay or preclude both marine mammal research and ATOC feasibility efforts. Because this program offers the opportunity to collect important scientific data on the effects of low frequency sound from other human-related ocean activities, and global climate change, taking no action at this time is not the preferred alternative. Safeguards have been built into the project design--25 mitigation measures (see Executive Summary) and source shut-down guidelines (see Appendix C).

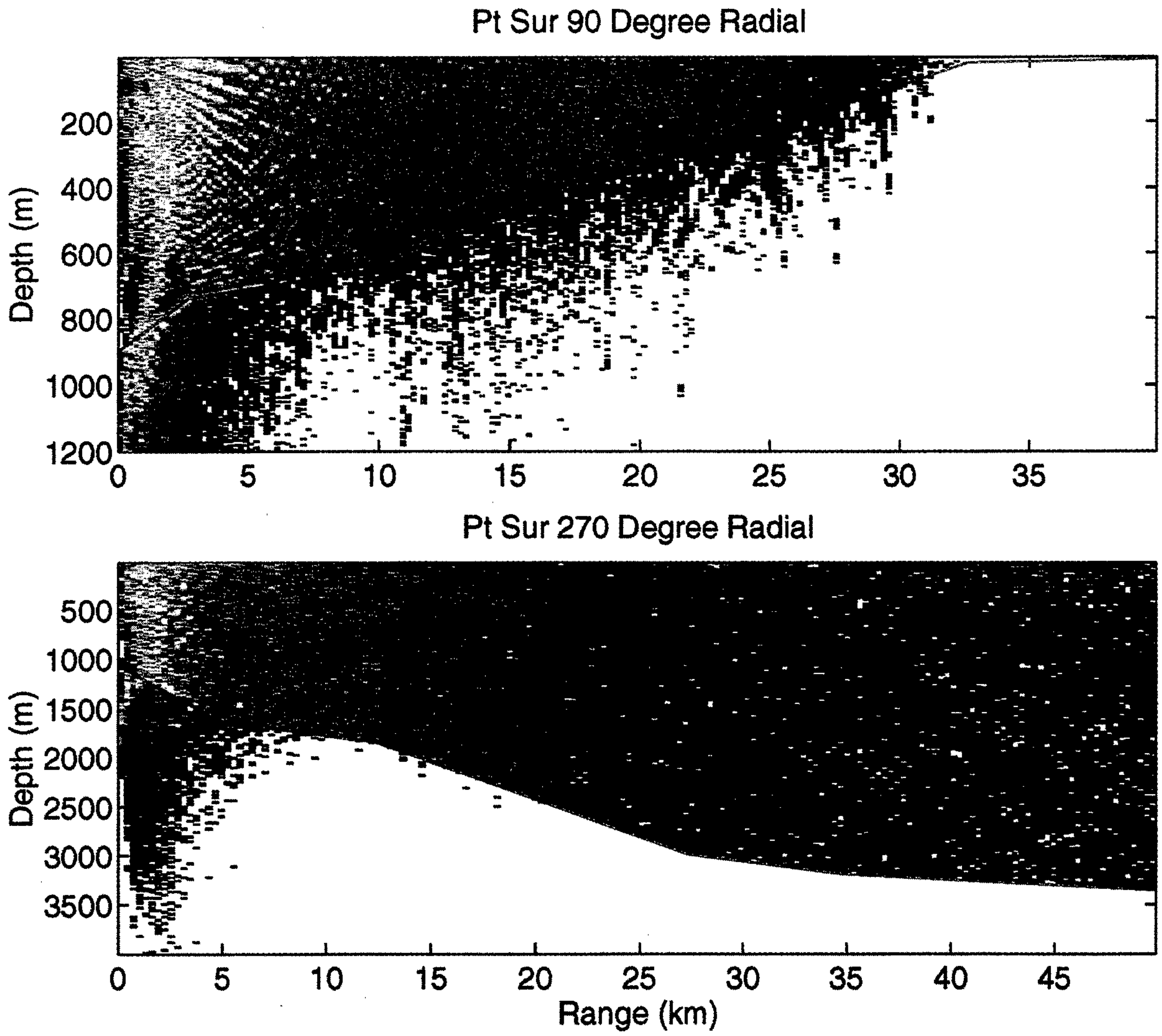


Figure 2.2.1.2-1 **Sur Ridge FEPE acoustic performance prediction model results (cross-section)**

(light green represents 120 dB sound field; i.e., transmission loss of 75 dB)

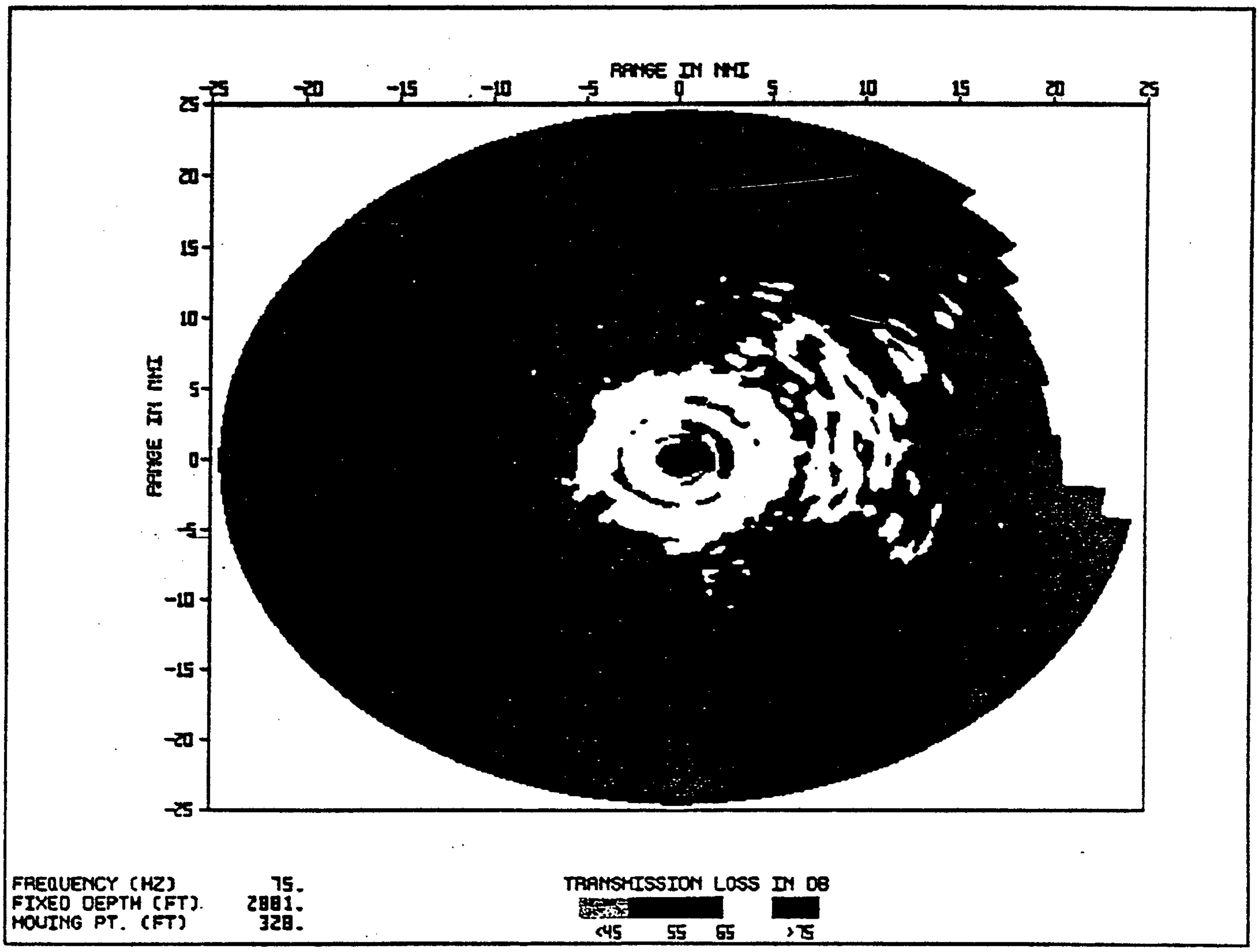
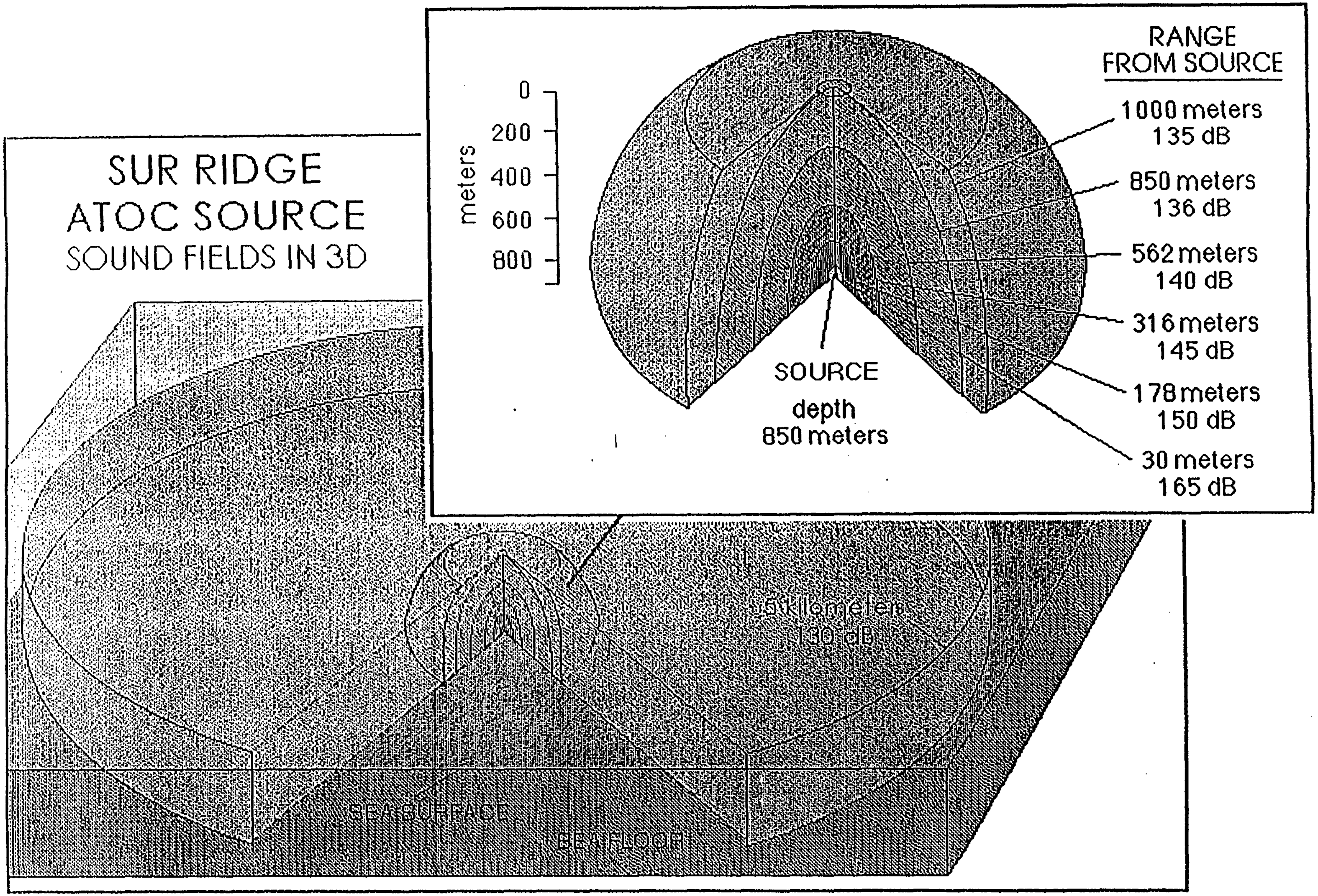
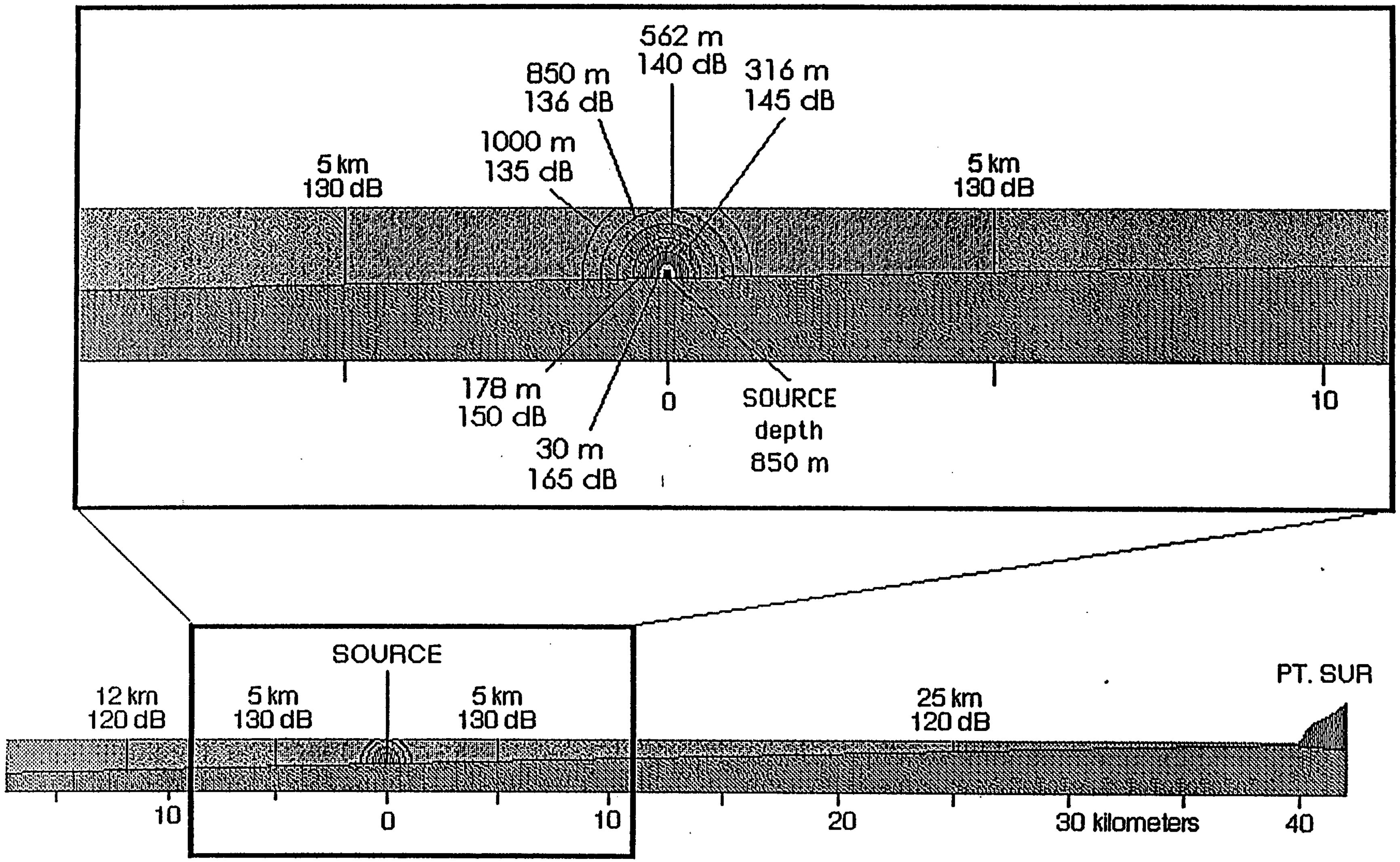


Figure 2.2.1.2-2 FEPE acoustic performance prediction model results for Sur Ridge (plan view)
(white area represents the 120 dB sound field)



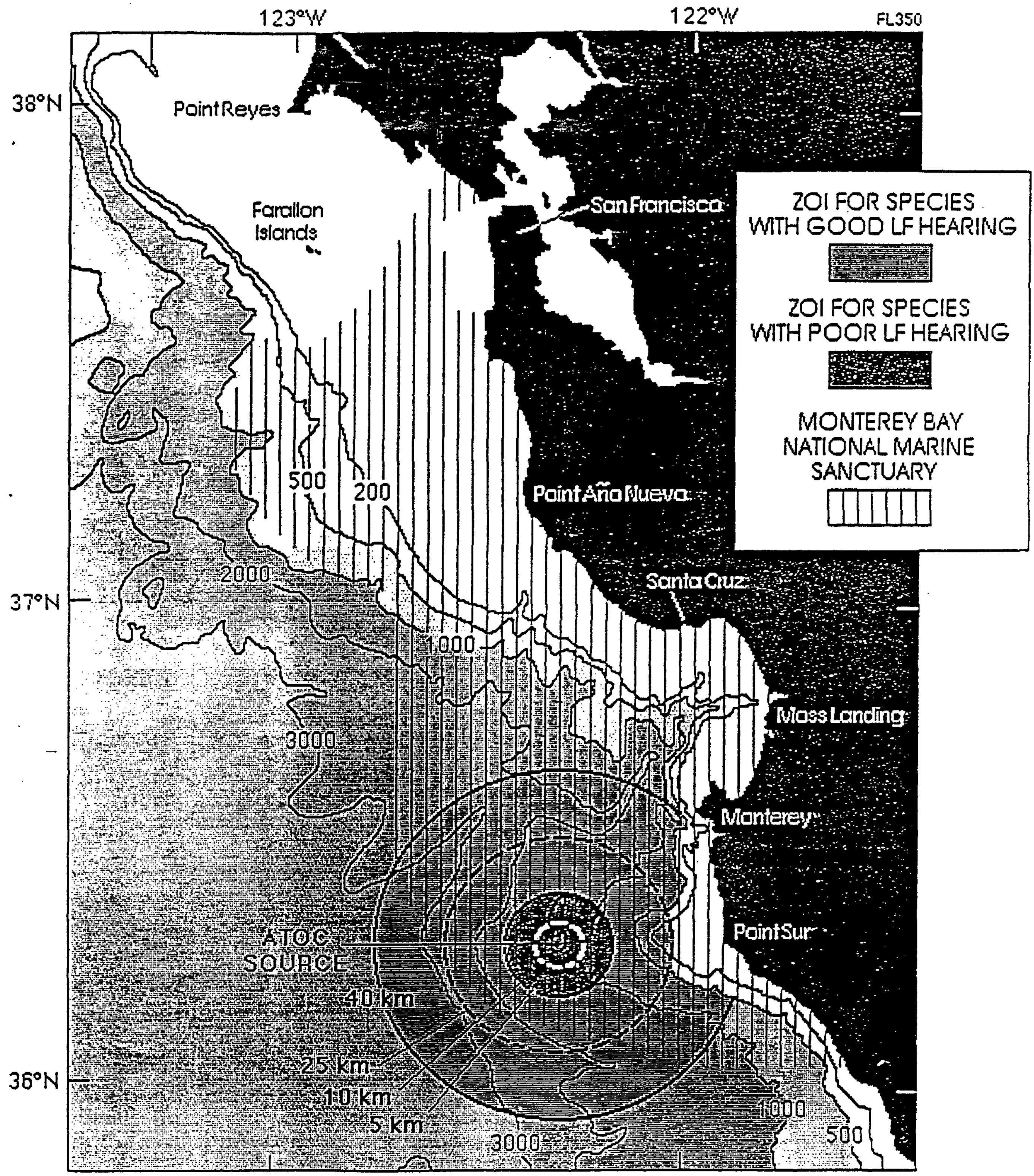
Note: **Sound fields based on sphercal spreading to 1000 m range. PE model data beyond 1000 m.**

Figure 2.2.1.2-3 Sur Ridge ATOC source sound fields in 3D



Note: Sound fields based on spherical spreading to 1000 m range, PE model data beyond 1000 m.

Figure 2.2.1.2-4 Sur Ridge ATOC source sound fields - cross section (to scale)



PT. SUR ATOC PROGRAM STUDY AREA (depths in meters)

Figure 2.2.1.2-5 Original SRP application sound fields (12/8/93)

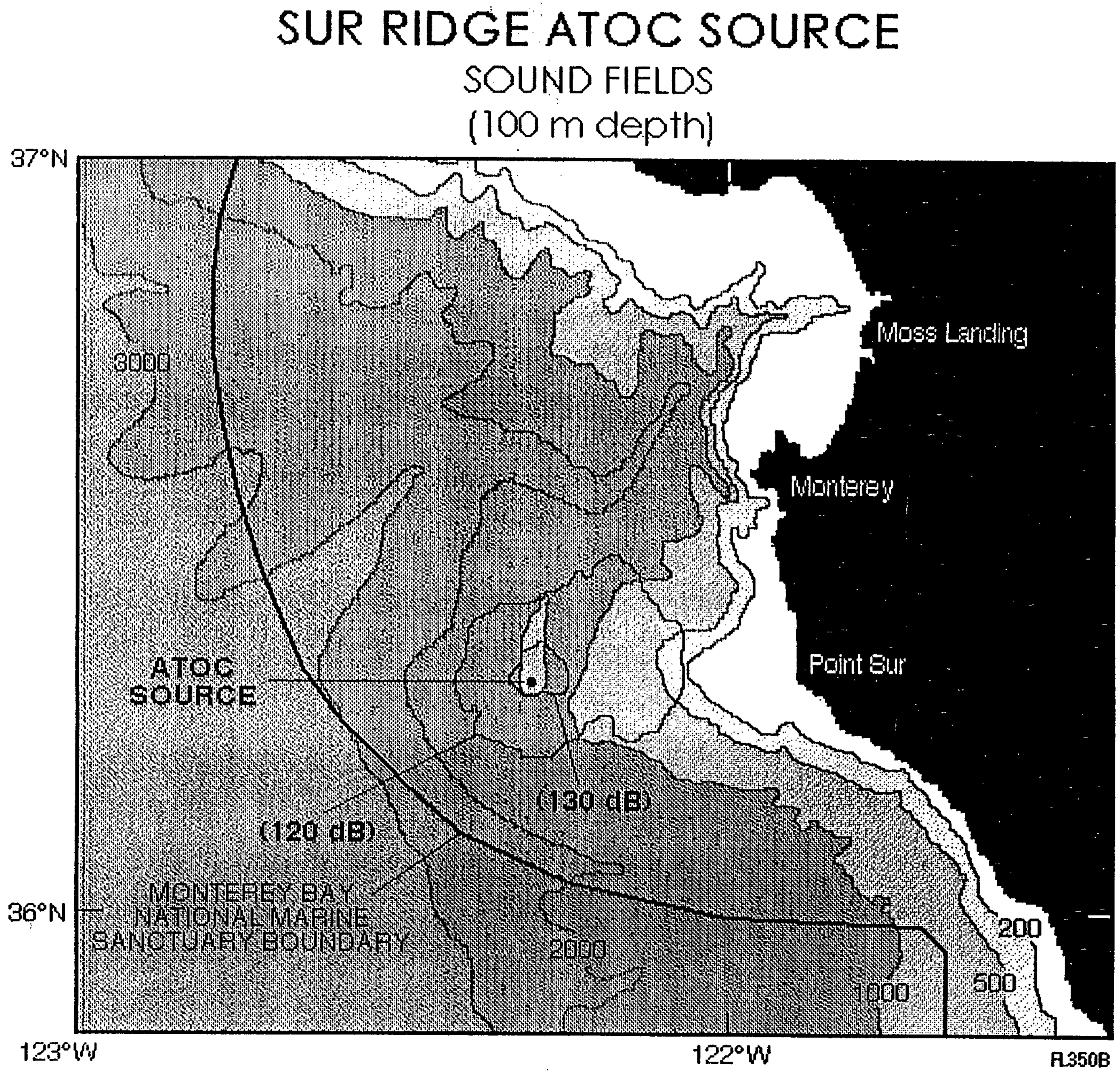


Figure 2.2.1.2-6 Sur Ridge ATOC source sound fields (plan view)

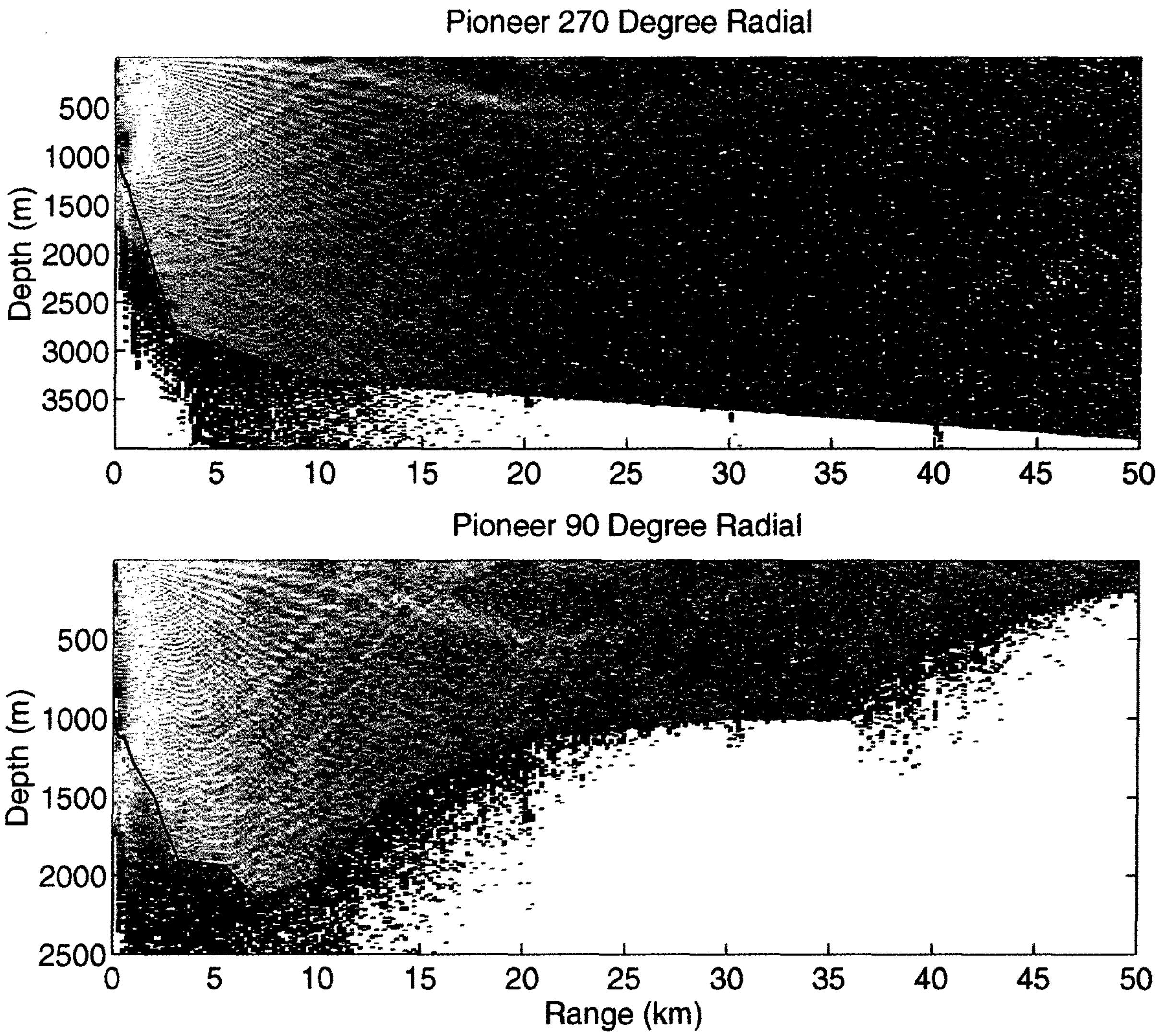


Figure 2.2.1.2-7 **FEPE acoustic performance prediction model results (cross-section) for Pioneer Seamount.**

(light blue represents 120 dB sound field; i.e., transmission loss of 75 dB)

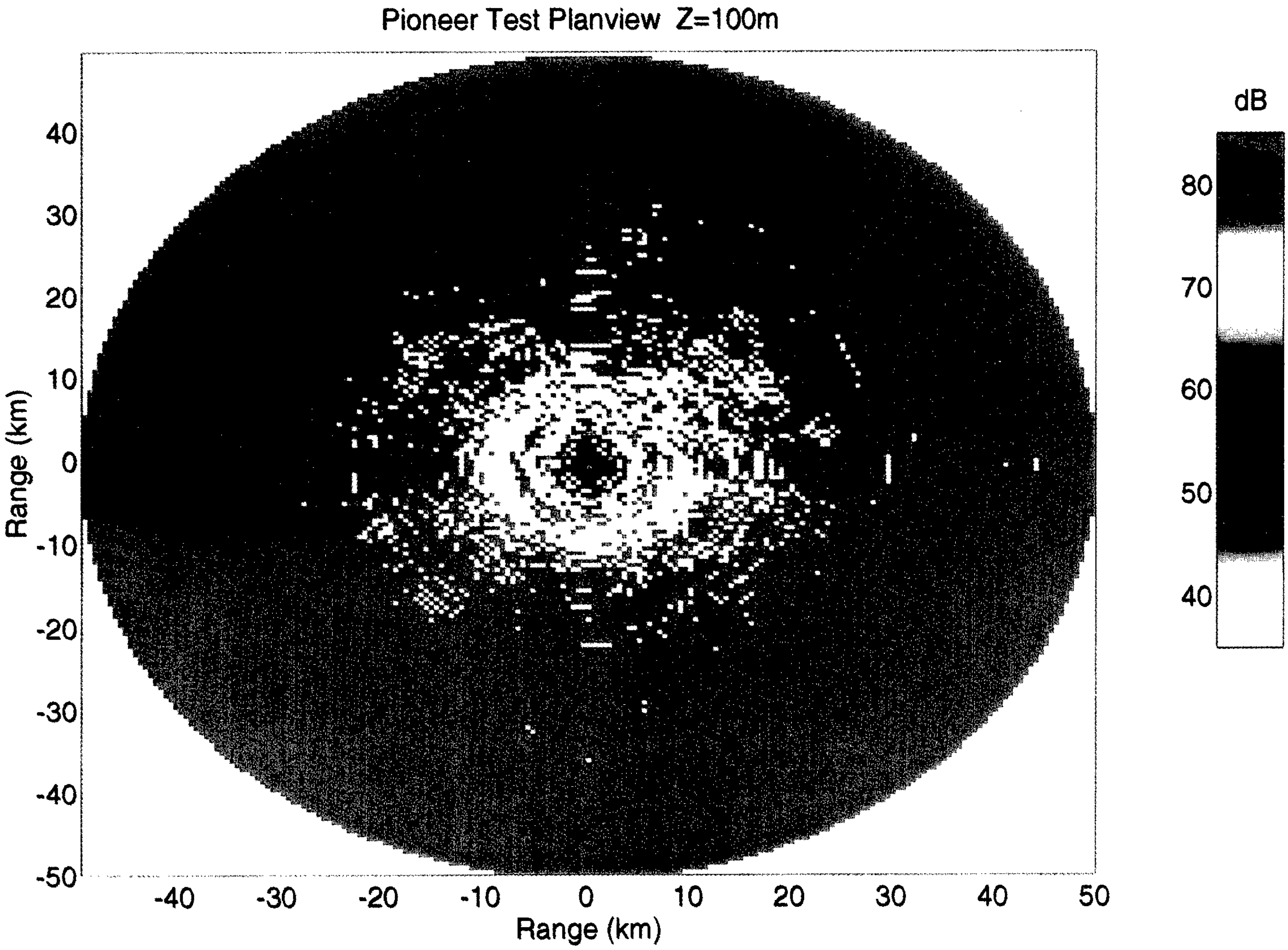
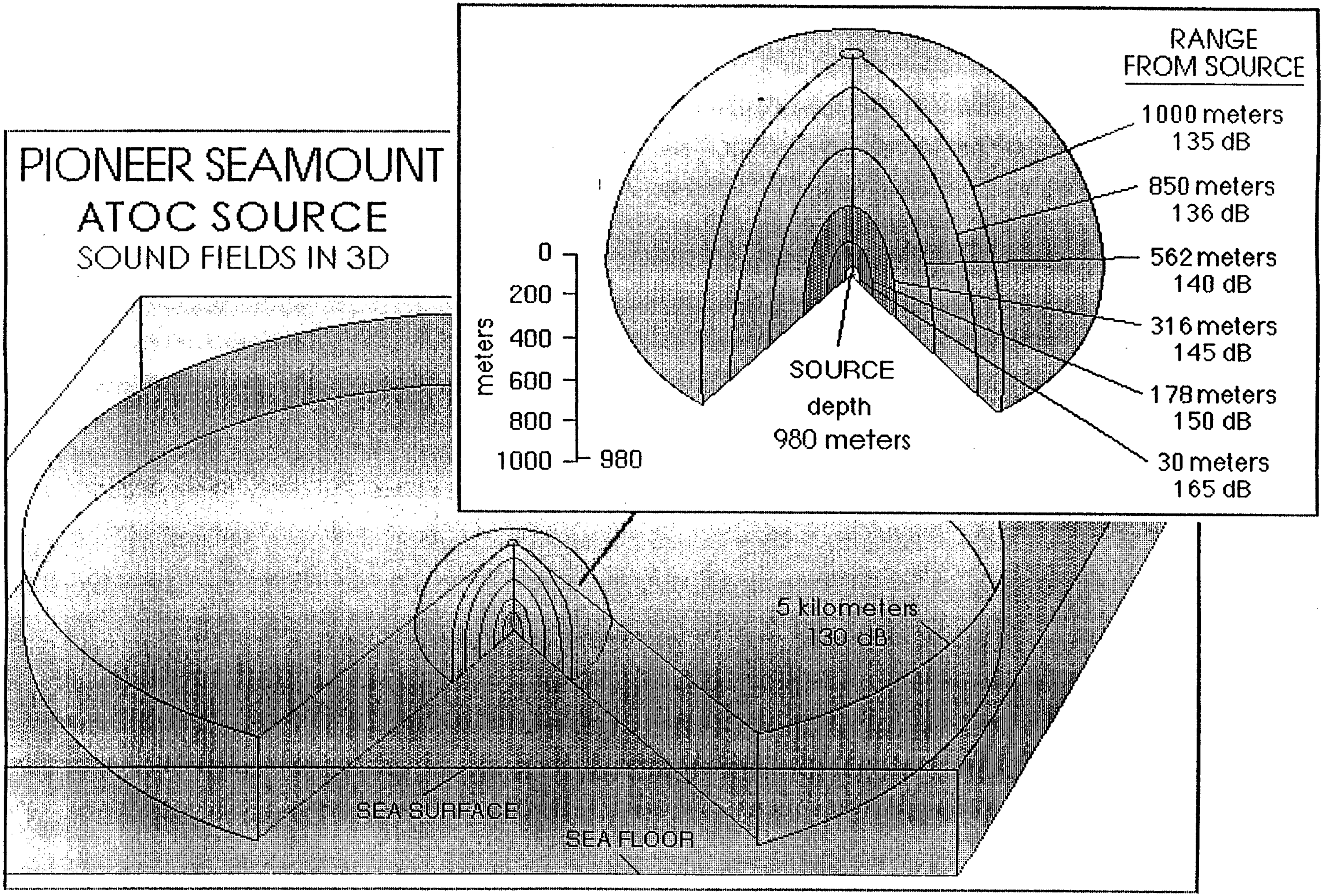


Figure 2.2.1.2–8 **FEPE acoustic performance prediction model results (plan view) for Pioneer Seamount**

(yellow colored area represents the 120 dB sound field; i.e., transmission loss of 75 dB)



Note: Sound fields based on spherical spreading to 1000 m range, PE model data beyond 1000 m.

Figure 2.2.1.2-9 Pioneer Seamount source sound fields in 3D

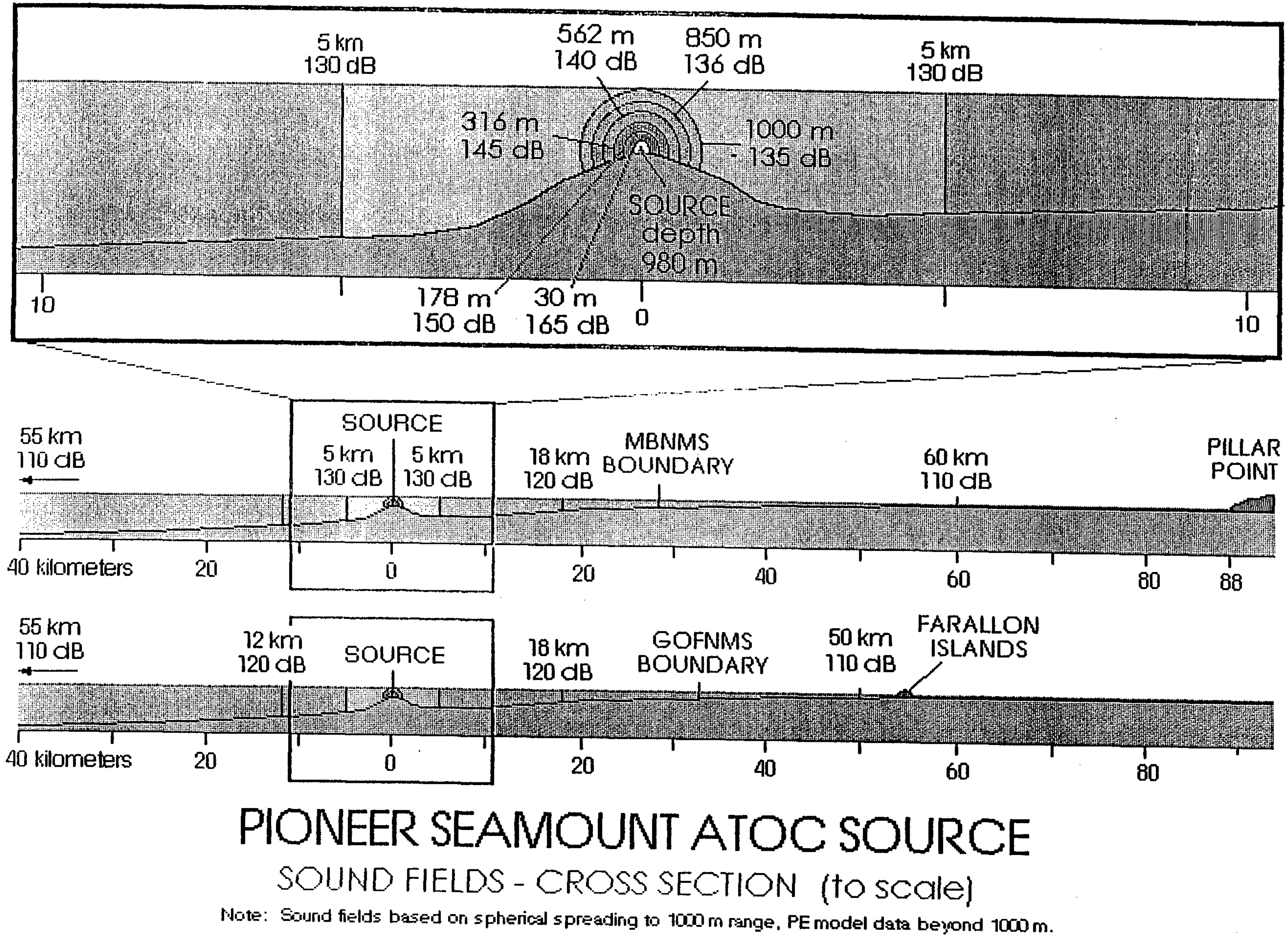


Figure 2.2.1.2-10 Pioneer Seamount source sound fields-cross-section (to scale)

PIONEER SEAMOUNT ATOC SOURCE

SOUND FIELDS
(100 m depth)

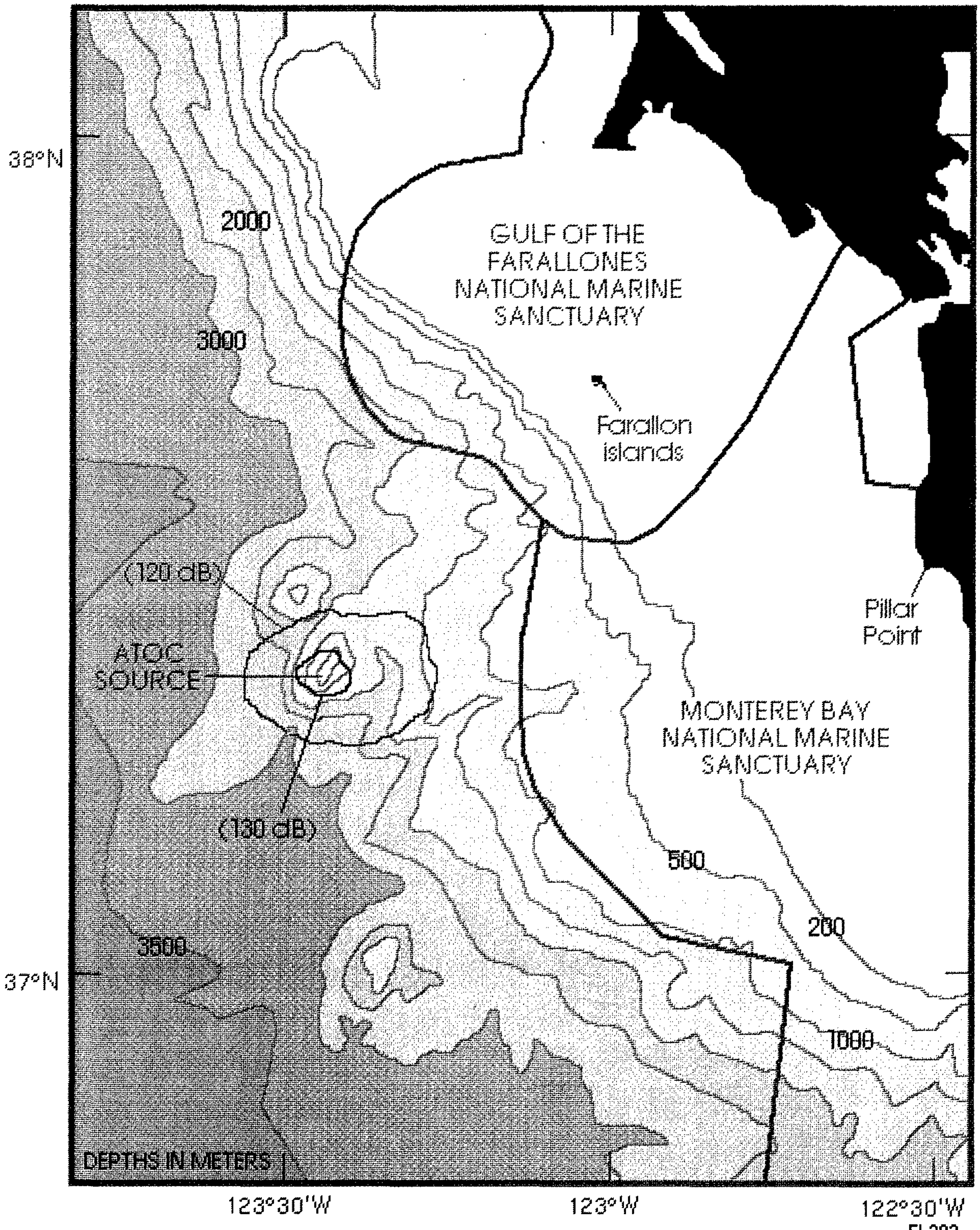


Figure 2.2.1.2-11 Pioneer Seamount ATOC source sound fields (plan view)

2.2.3 ALTERNATE PROJECT SITE (ALTERNATIVE 3)

Under the Alternate Project Site alternative, the MMRP and ATOC projects would be undertaken with the source located at a site other than the preferred Sur Ridge site. 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/EIR.

An initial task in screening alternate sites for the MMRP and ATOC feasibility phase (climate research phase) sources was the selection of an ocean basin and general source site areas that would best serve project objectives. Five factors proved to be particularly important in this regard.

First, an area is needed with a relatively large number of existing subsea listening arrays, in order to obtain the greatest number of acoustic pathways from each source, and 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 was preferable.

Second, in comparing the Atlantic and Pacific Oceans, it was determined that the mid-Atlantic ridge, which acoustically tends to divide the North Atlantic basin, would complicate the ATOC feasibility investigations and limit the ranges over which the ATOC concept could be tested (due to acoustic blockage). A North Pacific study area was therefore preferred to avoid these problems.

Third, the sound channel tends to be deeper at lower latitudes (nearer the Equator), and deeper sound channel source locations are expected to enhance long distance propagation. Deeper source locations also reduce the received sound levels for marine animals in the upper part of the water column. This suggested use of lower latitude, temperate or tropical locations for the sources. Since many of the receiving arrays are in Arctic/Sub-Arctic waters, the combination of low latitude sources and high latitude receivers also results in the most efficient long distance pathways.

Fourth, two source locations were desired to provide a sufficient number of acoustic pathways to cover the greatest ocean volume, preferably some of which would sample overlapping areas. In order to avoid redundancy, provide the greatest number of distinct pathways for each source and minimize the potential for traversing oceanic frontal systems (e.g., the Sub-Arctic front, where volumetric scattering and internal waves occur) and ocean mesoscale gyres (e.g., the California Current), broad areas were evaluated in the western Pacific, mid-Pacific and eastern Pacific for potential source sites.

Finally, since the ATOC project is led by investigators in the United States, source locations in the western Pacific were considered less feasible due to the long distances from the United States and the relative lack of United States possessions in that area. As a result, detailed site selection focused on identifying one source location in the mid-Pacific and one in the eastern

Pacific. The site screening for the mid-Pacific source location is discussed in the EIS for the Kauai ATOC installation. Site screening for source sites off the west coast of the United States is discussed below.

2.2.3.1 Site Survey

In developing the ATOC project proposal, potential locations in the Pacific Ocean were comprehensively surveyed. In the eastern Pacific, a number of potential source sites were initially assessed for their ability to provide long-range acoustic path geometries needed for the viable study of ocean basin-scale circulation variability. This is a necessary step in understanding the sampling required to monitor ocean climate variability. This constituted the first cut of the possible sites and narrowed the field down to the six discussed below.

The following criteria were used to identify source sites that would achieve the Marine Mammal Research Program objectives:

- Location at a site with sufficient populations of marine animal species of interest to ensure that researchers can obtain adequate data to produce statistically meaningful results.
- Location where there are baseline estimates of marine animal populations, preferably derived from calibrated field observation data.
- Location close enough to land to allow aerial visual and acoustic surveys/observations from small aircraft, vessel-based visual surveys/observations and acoustic data collection, and to facilitate tagging of animals.
- Location within the vicinity of other noise sources that can be studied (particularly ship/boat traffic), to allow researchers to compare the effects of various sources of noise on marine animals.
- Location where meteorological (weather) and oceanographic (waves, swell, currents) conditions are conducive to the conduct of at-sea measurement and data collection operations.
- Availability of a SOSUS HLA for passive acoustic detection of vocalizing mysticetes and other noise source monitoring.

The following criteria were used to identify source sites that would achieve the ATOC feasibility objectives:

- Location at or near the deep sound channel axis, to provide the most efficient coupling of sound energy into this long distance sound duct, thereby reducing source power requirements (and nearby surface received levels).

- Location at a site with a clear acoustic "view" to existing and planned receiver locations (islands or shoals between sources and receivers block acoustic paths), preferably at a site that combines transmission pathways with large seasonal variation (e.g., to North Pacific receivers), and pathways with small seasonal variations (e.g., to New Zealand).

- Location at a site that is locally flat (for secure placement), with a steep slope (18° optimum) in the direction of the receivers (to minimize bottom interactions with the transmitted signal that cause acoustic reflections and signal distortions).

- Location at a site with bottom surface features and opportunities for cable connections to shore that do not require extensive cable armoring or cable trenching.

- 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 deployment problems and the potential for source displacement once on the bottom).

- Location at a site that requires the minimum length of power cable to shore, to minimize cable costs and voltage requirements (most cables are voltage-limited).

- Location close to logistic support facilities, shore-based power, and communications nodes.

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

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

Siting criteria that increase the efficiency of the source sound transmissions (location in the sound channel, avoidance of adverse bottom conditions, etc.) permit use of a less intense sound transmission which, in turn, reduces the exposure of marine animals to sound. Source locations with views to a relatively large number of receiving locations (e.g., off Kauai and central California) permit the use of fewer sources (total 2) for a given number of pathways (up to 15). Locations that are logistically convenient reduce energy use, vessel engine noise, air pollution, and other effects of vessel trips to remote sites, and reduce the direct physical impacts of source facility installation. MMRP-related siting criteria are designed to increase the effectiveness of the research program, with corresponding environmental benefits that result from increased knowledge about marine animals.

The possibility of deploying the source off of a ship (by suspending it over the side) in a remote area of the ocean was also studied initially. However, this potential alternative was eliminated because it is essential that the source be sited on a stable platform to ensure experimental accuracy and precision, and the long-term power and logistical requirements would be prohibitive. This scheme would also make it almost impossible to conduct a valid marine animal research program, since most such sites would be in locations where the logistics of long-term marine animal observations would be extremely challenging.

From an acoustic standpoint, ideally, the source would be located at the depth of the sound channel on a mooring in deep water far removed from sea bottom effects. However, this approach presents a number of engineering difficulties, discussed below in connection with the moored autonomous source alternative. The next best option would be to locate the source on the peak of a seamount, with the top at the depth of the sound channel axis. Unfortunately, most seamount configurations do not meet this criterion, and the tops of seamounts are not sharp peaks, but usually rounded. Thus, it is difficult to obtain a wide acoustic view. In addition, some seamounts are associated with upwelling that could relate to abundances of organisms.

A wide horizontal field of acoustic view is important because it defines how large a geographical area can be studied. Relatively steep slopes are required to obtain clean, downward-transmitted energy. Bottom interaction with the transmitted signal path is undesirable for two reasons: 1) useful energy for sampling different parts of the ocean is lost in the sediment, and 2) bottom-interacting energy could contribute to signal distortion at the receivers. The goal is to site the source so that upward-transmitted energy clears the bottom at its first lower refraction (turning) point, and downward-transmitted energy paths are free from bottom interaction.

Because of the depth of the Sur Slope site (approximately 2200 m), the source would have to be buoyed off the bottom by cable to place it near the deep sound channel axis (800-1000 m depth). Although not an infeasible option, this would require additional engineering development efforts. The source would be powered via cable back to shore, but in other respects would be subject to similar drawbacks cited for the autonomous moored source alternative.

Although a full range of potential eastern Pacific source locations was evaluated during the initial site screening process, only six of those sites were sufficiently promising to receive detailed consideration. Specifically, applying the criteria described above, six potential project sites were selected for more detailed analysis as follows:

- Off the coast of Pacific Beach, WA (70 km west)
- Off the coast of Coos Bay, OR (46 km west)
- Pioneer Seamount (off the coast of Pillar Point, CA [88 km west])
- Sur Ridge (off the coast of Pt. Sur, CA [40 km west])
- Sur Slope (off the coast of Pt. Sur, CA [60 km southwest])
- Off the coast of San Nicolas Island, CA (93 km southwest)

Within each of these six general alternate locations, a specific site was identified as the most promising for both marine mammal and ATOC purposes. Charts showing the ocean bottom contours for the Pacific Beach, Coos Bay, Pioneer Seamount, Sur Slope and San Nicolas sites are presented in Figures 2.2.3.1-1 through 2.2.3.1-5. Charts showing the ocean bottom contours for the preferred action (Sur Ridge) location and the proposed action (Pioneer Seamount) location are presented in Section 1.

Of the six possible source sites, Sur Ridge proved to best meet the stated criteria, followed by Pioneer Seamount, and Sur Slope sites. The other three sites were eliminated from detailed analysis as being unsuitable for both the marine mammal research and ATOC feasibility components of the project. The Sur Ridge site is further analyzed as Alternative 1, and the Pioneer Seamount and Sur Slope sites are carried forward as Alternatives 3-1 and 3-2, respectively.

The following discussion evaluates each of these six alternate project sites in relation to the MMRP and ATOC project siting criteria identified above.

2.2.3.2 Evaluation of MMRP Source Site Selection Criteria

Table 2.2.3.2-1 summarizes the MMRP source site selection criteria for the six potential project sites and is discussed in more detail in the following paragraphs.

Pacific Beach, WA

In order to attain the depth required, this potential site would be 70 km west of the Washington coast and can be considered a deep-water site that is located in a region of known adverse weather conditions ("roaring 40's") (Huschke, 1959). Thus, marine biologists would have minimal opportunity to collect data on which to base quantifiable statistical analyses. Further, because few dedicated marine animal resource projects have been undertaken in this area, there are few good baseline animal behavioral studies on which to assess any potential behavioral modifications from ATOC source transmissions.

Because the site would be greater than 50, yet less than 75 km from shoreside aircraft and vessel staging, it has been given a relative criteria fulfillment rating of "M". Although this site would lie almost equidistant between the busy shipping regions of the Strait of Juan de Fuca and the mouth of the Columbia River (downstream Portland, Oregon), the major shipping lanes do not come within 50 km. The closest one would be the Juan de Fuca (Seattle) to Yokohama alternate route for November to March (DMAHTC Pub. 152, Sailing Directions (Planning Guide) for the North Pacific Ocean, 1993). It is also far enough offshore that coastal shipping would remain approximately 35-45 km distant. It is so far offshore that only the incidental pleasurecraft or fishing boats traverse the area. Likewise, the potential for low-flying aircraft in the vicinity of the site would be negligible. Thus, there is a low opportunity to collect data on other noise sources in the area.

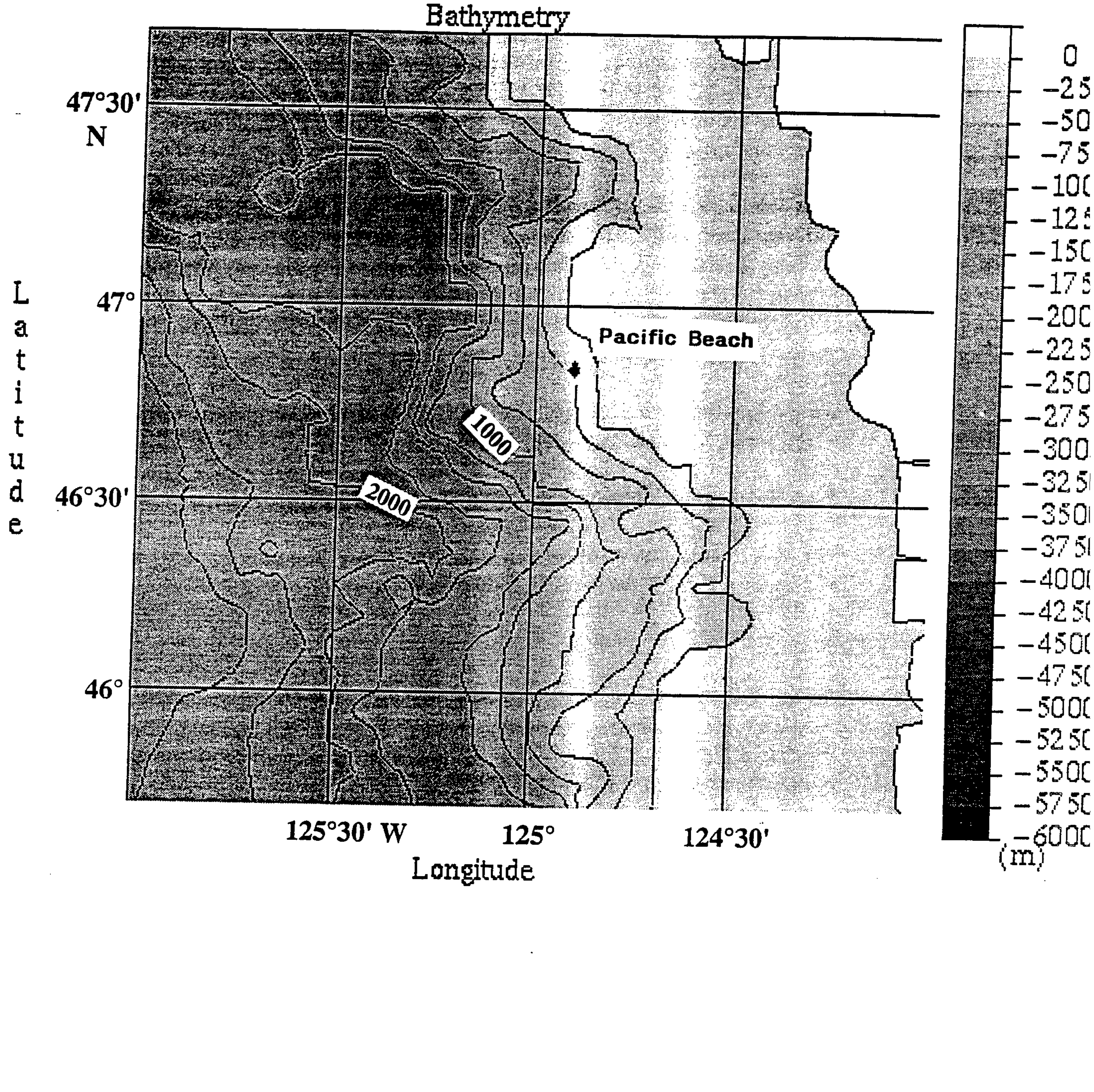


Figure 2.2.3.1-1 Pacific Beach, CA alternate site seafloor contours

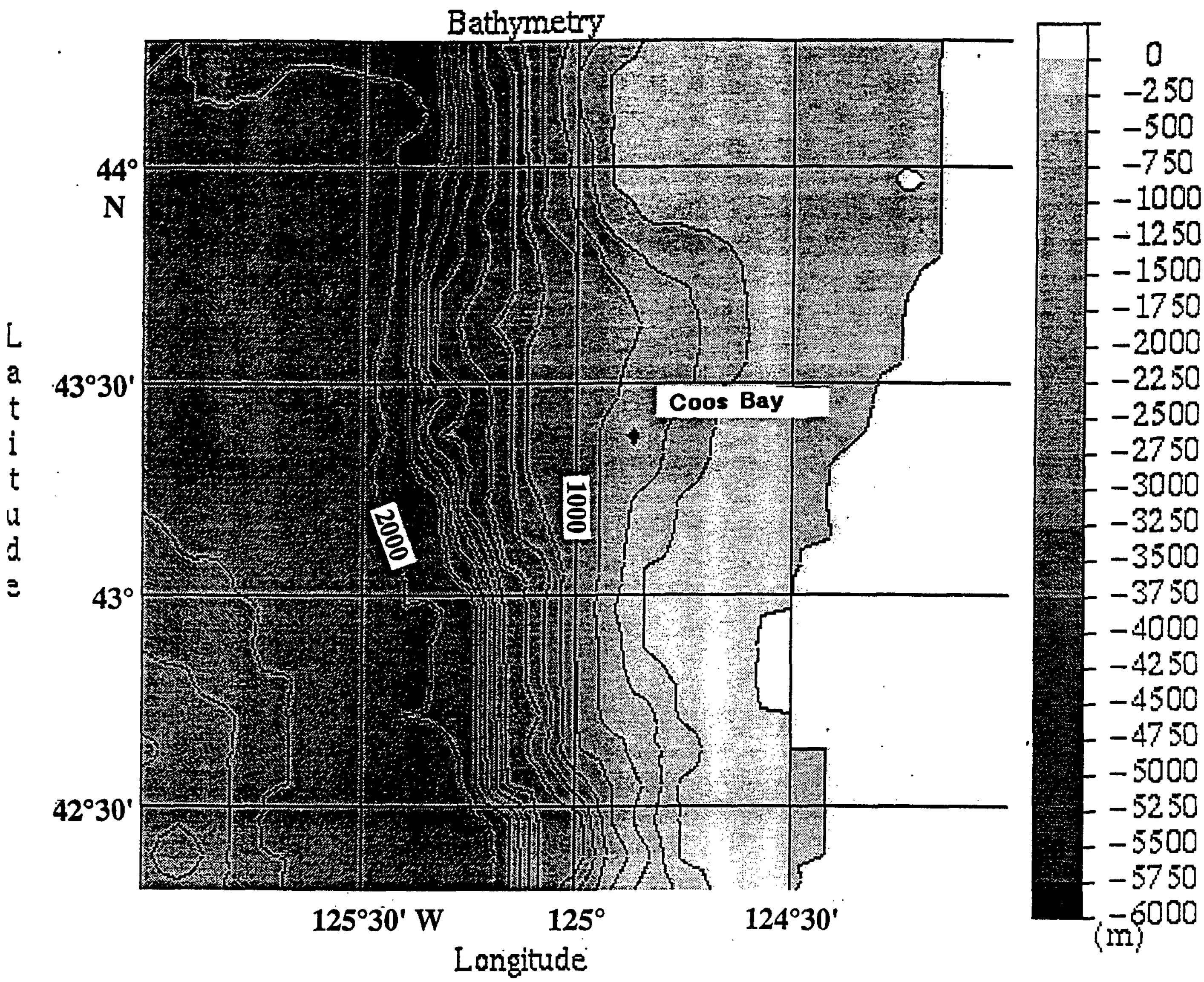


Figure 2.2.3.1-2 Coos Bay, CA alternate site seafloor contours

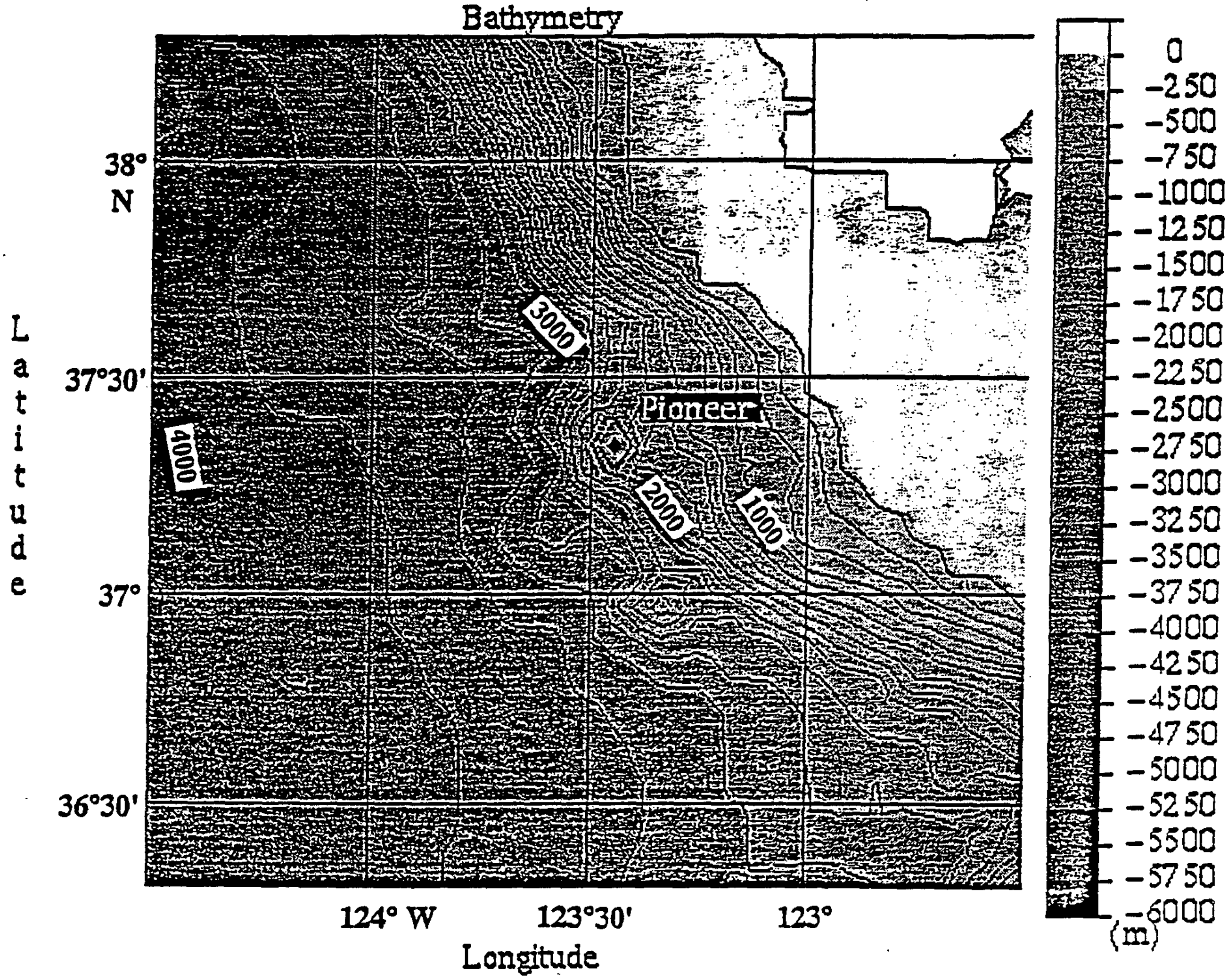


Figure 2.2.3.1-3 Pioneer Seamount, CA alternate site seafloor contours

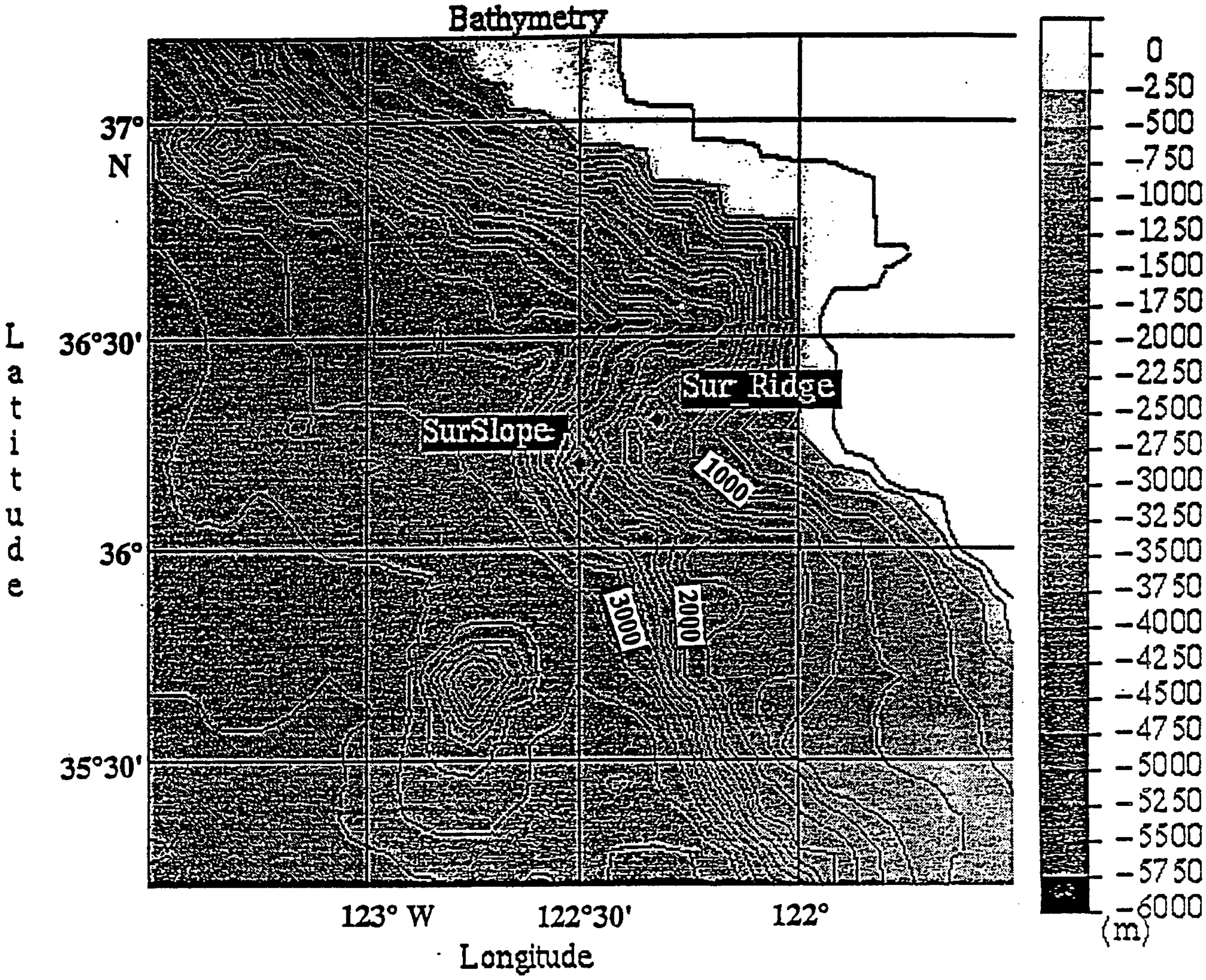


Figure 2.2.3.1-4 Sur Ridge and Sur Slope, CA alternate site seafloor contours

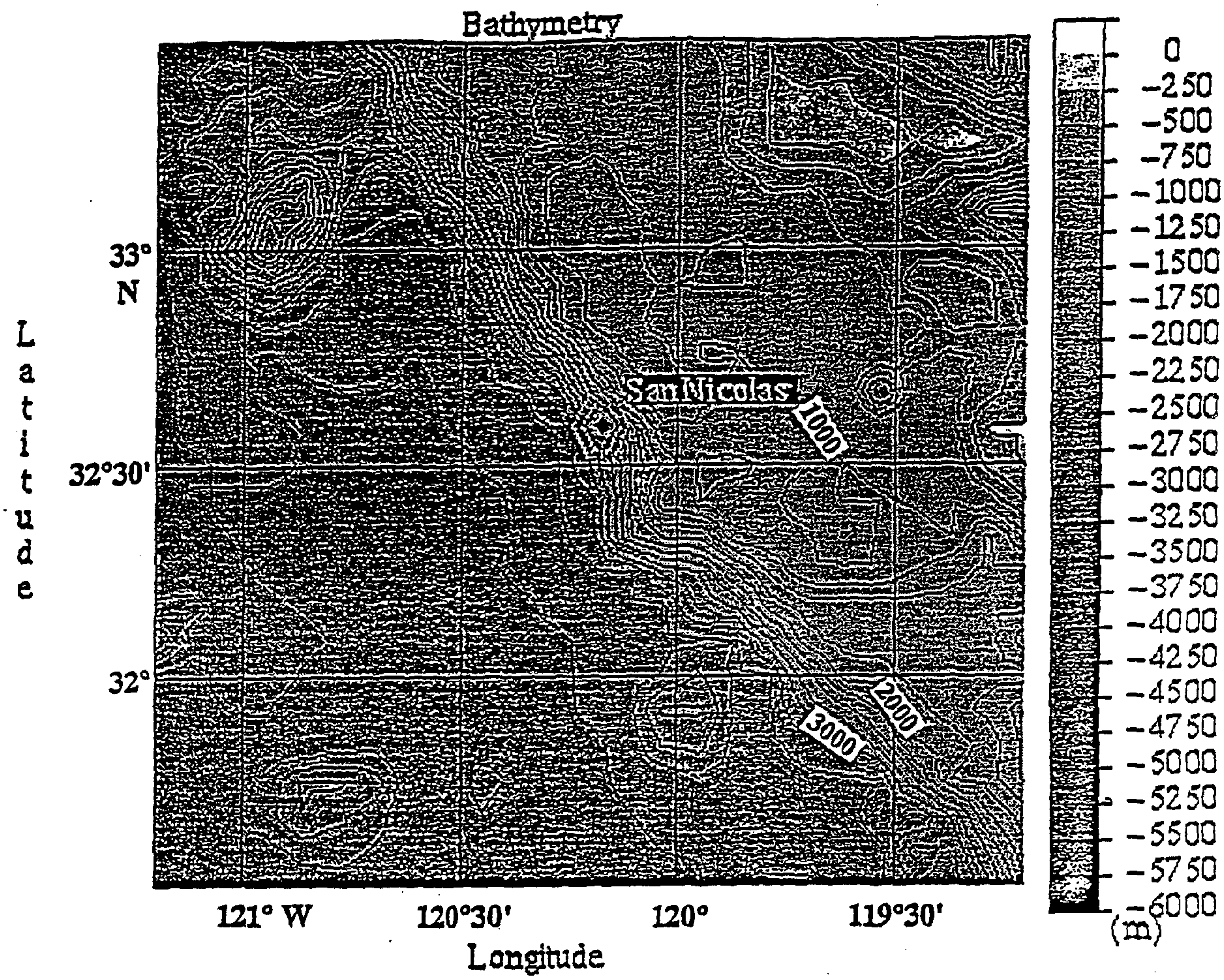


Figure 2.2.3.1-5 San Nicolas, CA alternate site seafloor contours

SITES EVALUATED	Sufficient Marine Animal Populations to Aquire Adequate Data for Meaningful Statistics weighting factor (4)	Baseline Marine Animal Population Estimates Available for Area (3)	Close to Land for Aerial Surveys, Vessel-Based Visual Obs and Acoustic Msmts, & Facilitate Animal Tagging (4)	Close to Other Noise Sources to Allow Comparative Analyses of Effects on Animals (2)	Meteorological/ Oceanographic Conditions Conducive to At-Sea Data Collection (3)	Availability of SOSUS HLA for Passive Acoustic Detection of Mysticetes and Noise Source Monitoring (3)	REL-ATIVE SCORE
Pacific Beach, WA (38 nmi/70 km	L	L	M (>70 km to airport)	L	L	M	47
Coos Bay, OR (25 nmi/46 km	M	L	M (>50 km to airport)	M	L	M	71
Pioneer Seamount, CA	H	M	L (>90 km to airport)	M	M	L	87
Sur Ridge, CA	H	M	H (<50 km to airport)	M	M	H	150
Sur Slope, CA	M	M	M (>50 km to airport)	M	M	H	110
San Nicolas, CA (50 nmi/93 km	L	L	L (>200 km to major airport)	L	H	M	58

Relative Criteria Fulfillment: H = Fulfills Criteria >90%
M = Fulfills Criteria 50%-90%
L = Fulfills Criteria <50%

Note 1: Relative Score Criteria: H = 10; M = 5; L = 1
Note 2: Weighting factor based on relative importance to achieving program objectives.
Note 3: Relative Score determined by multiplying relative score criteria values by weighting factor, then adding the six results for each site.

Table 2.2.3.2-1. MMRP source site selection criteria.

Coos Bay, OR

In order to attain the depth required, this potential site would lie approximately 46 km west of the Oregon coast. It would be about 24 km closer to shore than the Pacific Beach alternative. This, coupled with the fact that a national recreational area is located approximately 15 km north of Coos Bay, results in a higher mark. However, few marine animal abundance estimates have been made in this region; thus, there are few good baseline animal populations on which to assess any potential impact of the acoustic signals on local species. Further, this site is also located in an area of known inclement weather patterns.

This site would be greater than 50 km (but less than 75 km) from an airport that could be used by research aircraft. It also received a rating of "M". Vessel maintenance and operations support is located approximately 48-60 km away. Although this site would be far from any significant shipping lane activity (closest route same as Pacific Beach site), it would be closer to coastal traffic (air and vessel-related), and could also be affected by the boat traffic to and from the national recreation area to the northeast. Therefore, for this criteria an "M" is assigned.

Pioneer Seamount, CA

Based on marine animal species research to date in the vicinity of the Pioneer Seamount and the Farallon Islands (Bonnell et al., 1983; Dohl et al., 1983; Calambokidis et al., 1990a, b; Ainley and Allen, 1992; Jones and Szczepaniak, 1992), this site can be considered to be moderately rich in marine fauna. It fulfills the criteria for sufficient animal population densities to allow the MMRP Research Team to acquire adequate data for meaningful statistical analyses; therefore, the "H" rating. Data from the above mentioned publications would provide good baseline data of population estimates for the site.

Because the site is greater than 75 km from adequate aircraft or vessel staging facilities onshore, it receives an "L" rating. This site lies in relatively close proximity to two major shipping lanes: 1) San Francisco/Oakland to Honolulu and return, 2) Panama to Vladivostok and return. Also, some fish species are harvested in the upwelling waters near Pioneer Seamount. These factors would contribute to the local ambient noise field. However, the site is too far offshore to expect much noise from pleasurecraft or airplanes. The criteria for assessing the potential for comparative analyses of other noise sources on marine animals at this site could be fulfilled at least 75%, but less than 90%; hence, the rating of "M" is applied.

Sur Ridge, CA

The details pertaining to this site alternative are covered in subsection 2.2.1 as the proposed action alternative. This site is known to have sufficient marine animal species available to conduct a viable MMRP. Data on marine resource population estimates can be extracted from publications (e.g., Harville, 1971, Environmental Studies of Monterey Bay and the Central California Coastal Zone; California Department of Fish and Game, 1979, Living Marine Resources of the Proposed Monterey Bay National Marine Sanctuary; University of

California-Santa Cruz, 1983, Marine Mammals and Seabirds of Central and Northern California 1980-1983; Heimlich-Boran, 1988, Marine Resources and Human Activities in the Monterey Bay Area; NOAA, 1992, Monterey Bay National Marine Sanctuary, Final Environmental Impact Statement/Management Plan). Also, there is a great deal of interest in understanding the status of marine species that inhabit the sanctuary. The results of this effort would respond to the MBNMS' long-term requirements for management of living sanctuary resources.

The site would be less than 50 km from an active airport and boat docking and loading installations; therefore, the site receives an "H" rating. This site is not in the path of any major designated shipping lanes (the closest is the sparsely used Panama to Vladivostok and return route), although it is near well-used coastal shipping routes and its location within the Monterey Bay Sanctuary should provide enough small- and medium-sized boat traffic to permit some comparative analyses of effects of other noise sources on marine animals. Hence, this site receives an "M" criteria fulfillment rating.

Sur Slope, CA

This site is approximately 24 km west of Sur Ridge, and thus should be similar to Sur Ridge relative to the criteria. However, since it is further from shore, most criteria fulfillment values are reduced by a factor of one. Nevertheless, this still puts Sur Slope in second place in overall relative score.

San Nicolas Island, CA

This potential site is located so far from shore (93 km from San Nicolas Island proper; approximately 200 km to the California coast) that it does not qualify as a realistic option. It therefore receives the lowest overall score of the six alternate sites.

In summary, Table 2.2.3.2-1 indicates Sur Ridge would be the preferred alternative from a marine animal research viewpoint, with Sur Slope second, and Pioneer Seamount third. All three of these sites are carried forward into Section 3 and 4 of this EIS/EIR for detailed evaluation of alternatives.

2.2.3.3 Evaluation of ATOC Source Site Selection Criteria

This section discusses source site selection criteria for the six potential project sites with respect to proposed ATOC feasibility actions. Table 2.2.3.3-1 summarizes the results; amplifying information is provided in the following paragraphs.

Pacific Beach, WA

This is the northernmost alternate site; therefore, the deep sound channel axis is shallowest (500 m or less) compared with the other five alternate sites. One of the key siting criteria for ATOC purposes is the number of receiving stations that can be "viewed" acoustically from the source location. These acoustic views are presented in the form of computer-generated

SITES EVAL-UATED	Deep Sound Channel Axis weight-ing fac-tor (5)	Clear Acoustic View (4)	Seasonal Vari-ation (1)	Site Locally Flat (2)	Site Steeply Sloped (3)	Minimal Cable Armor & Trench. Reqmts. (2)	Good Bottom Prop-erties (2)	Minimum Bottom Currents (2)	Minimum Cable Run to Shore (5)	Close Logistic Support (5)	Use of Existing Tech-nology (no major eng) (4)	Minimal Risk to Cable from Bottom Fishing (3)	Poten-tial for Low Env. Conse-quence (5)	RELAT-IVE SCORE
Pacific Beach, WA (38 nmi/70 km west)	L	L	M	H	M	M	H	M	M	M	H	M	H	245
Coos Bay, OR (25 nmi/46 km west)	M	L	M	H	L	M	H	M	M	M	H	M	M	227
Pioneer Seamount, CA	H	H	M	M	H	L	M	M	L	L	H	M	M	254
Sur Ridge, CA	H	H	M	H	M	M	M	H	H	H	H	M	M	355
Sur Slope, CA	H	H	M	H	L	M	H	H	M	M	L	M	M	262
San Nic-olas, CA (50 nmi/93 km swest)	H	L	M	H	M	M	H	M	L	L	H	M	H	249

Relative Criteria Fulfillment: H = Fulfills Criteria >90%
M = Fulfills Criteria 50%-90%
L = Fulfills Criteria <50%

Note 1: Relative Score Criteria: H = 10; M = 5; L = 1
Note 2: Weighting factor based on relative importance to achieving program objectives.
Note 3: Relative Score determined by multiplying relative score criteria values by weighting factor, then adding the 13 results for each site.
Note 4: "Potential for Low Environmental Consequences" added since the DEIS/EIR in response to comments.

Table 2.2.3.3-1. ATOC source site selection criteria.

"shadow plots" that depict the acoustic shadows caused by topographical blockages, such as islands, seamounts, shoal areas, and other features of the intervening sea bottom. Features as deep as 1000-2000 m below the axis of the sound channel can be significant, since critical acoustic modes (sound ray paths) reach these depths and temperature measurements there are expected to be important. Figure 2.2.3.3-1 is the 2000 m-depth shadow plot for this site alternative. It can be seen that the location is less than optimal due to the unfavorable path geometry with respect to most of the long-range receivers, where the path is blocked by bottom features near the source site and just north of the equator.

In general, north of Cape Mendocino (40°N latitude) there are a number of significant bathymetric features offshore that would limit the steeper acoustic paths north of the Mendocino Fracture Zone. The Gorda and Juan de Fuca Ridges and the Blanco Fracture Zone, and various seamounts rise up to 2500 m depth. The Cascadia Basin west of the mouth of the Columbia River is about 2800 m deep. Even though the sound channel becomes shallower traveling from south to north, these bottom topographical features would strip off the steeper acoustic rays. Further, as the sound channel shoals, more of the transmitted energy interacts with the ocean surface, with attendant reflective energy losses.

Because of the topographical blockage for some westward paths and the path into the southern hemisphere, only about 50%-70% of the seasonal variation criteria would be fulfilled. The site is locally flat, but not as steeply sloped (about 5°) as would be desired (> 8°). Since the shore infrastructure that would be used is the old Pacific Beach Naval Facility, the acoustic data link/power cable would probably utilize an old Sound Surveillance System (SOSUS) cable track. Thus, there would probably be some cable armor and trenching requirements, but the process would be relatively straightforward. Good bottom sediment and basement properties are expected at this site. Bottom currents should be dominated by either of two poleward flows, the Coastal Countercurrent or the California Undercurrent, both of which are beneath the equatorward-flowing California Current. This California Current influences the water column to a maximum depth of 100 m, outward from the coast to 100-1000 km. Maximum bottom current velocities would be expected to be approximately 30 cm/sec.

The cable run length to shore, and proximity to logistical support facilities, would be greater than 50 km, but less than 75 km, equating to an "M" score. Relative to the other sites, it is expected that there would be a similar risk of possible cable damage from bottom fishing/trawling here.

Coos Bay, OR

Relative to the Pacific Beach site, the sound channel axis here would be deeper, resulting in the "M" rating vs. only an "L" for Pacific Beach. Figure 2.2.3.3-2 is the shadow plot for this site, showing that because this location lies north of Cape Mendocino, like Pacific Beach, the location is associated with unfavorable path geometry to the western and southern receivers.

The site is locally flat, but its slope would be only about 3°. Like Pacific Beach, the shore termination point would be an old Naval Facility (Coos Head), and the acoustic

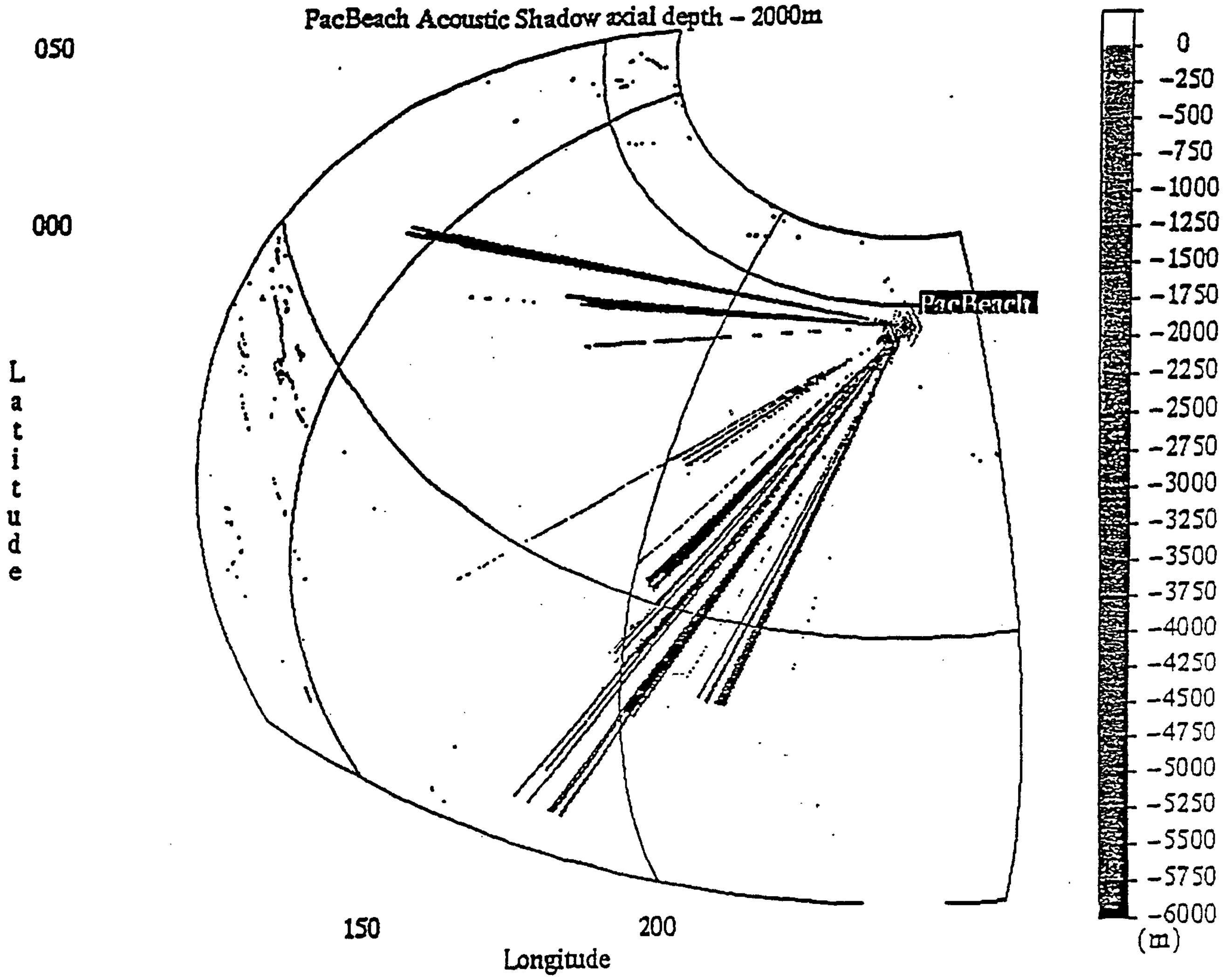


Figure 2.2.3.3-1 **Pacific Beach, WA alternate site shadow plot**

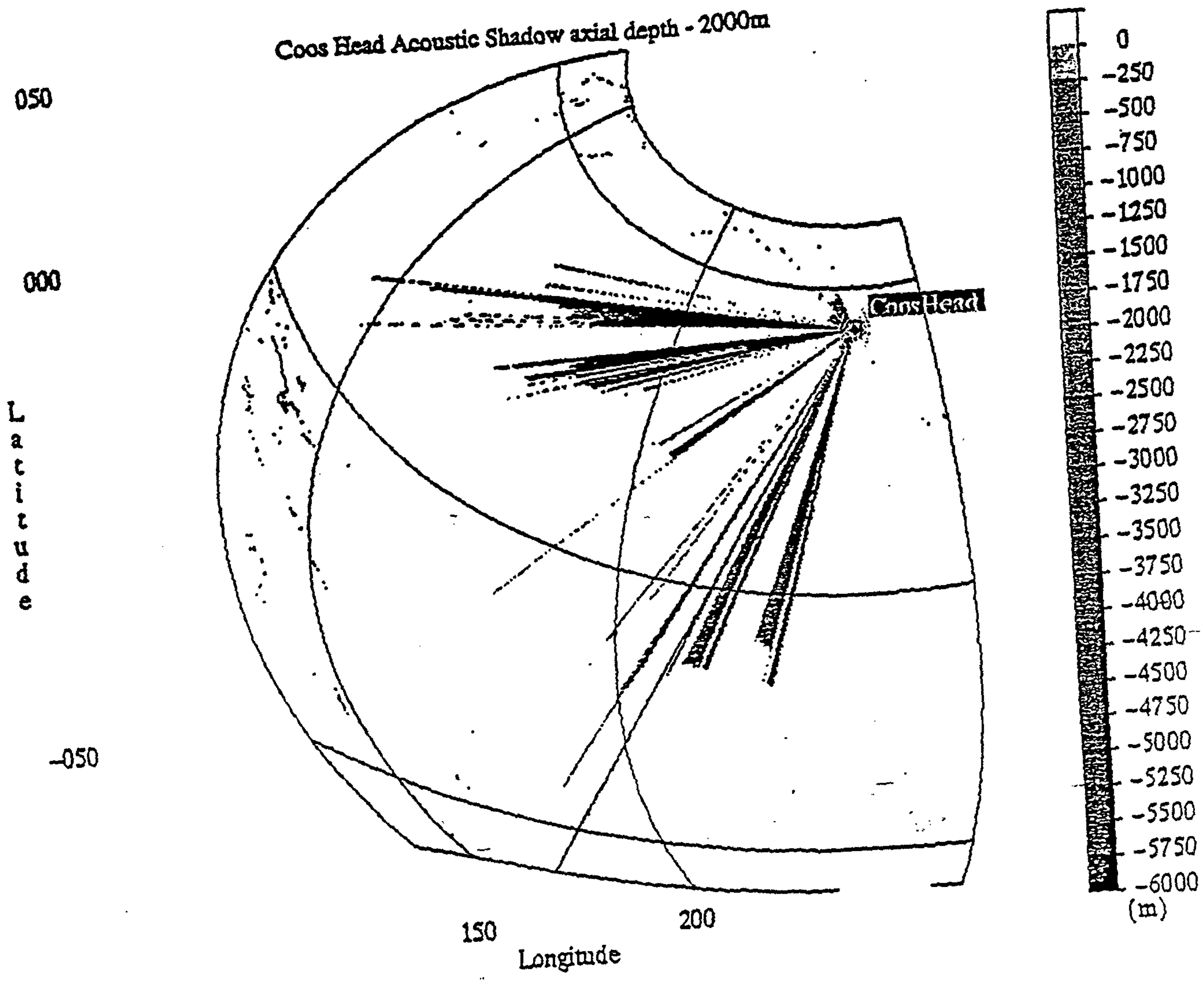


Figure 2.2.3.3-2 Coos Bay, CA alternate site shadow plot

telemetry/power cable would probably utilize part of an old SOSUS cable path. Even though some armoring of the cable and trenching would most likely be required, the work should not be difficult, based on historical information on the SOSUS cable. Good sediment and basement properties would also be expected at this site.

The cable run length to shore and proximity to logistic support would be greater than 50 km, but less than 75 km, equating to an "M" score. The criteria fulfillment value of "M" is applied to potential risk from bottom fishing or trawling, as for Pacific Beach.

Pioneer Seamount. CA

The deep sound channel axis varies in this area from about 800 m to 1000 m depth. The depth of the source at this site would be approximately 980 m, likely resulting in excellent coupling of the source energy into the channel. Ray traces show that the +8° rays graze the surface and the +12° rays are limited by the bottom depth (3500 m) 10 to 20 km from the source. Pioneer Seamount is probably as close to an ideal cone as possible, with 23° slopes. Figure 2.2.3.3-3 depicts the shadow plot for this site, indicating excellent acoustic coverage to all planned receivers.

This site scores the lowest for local flatness ("M" vs. "H") although, for a seamount, the site is relatively flat. The problem would be in deploying the source system exactly on the desired position--a shift of a few hundred meters could place it in a position where the seafloor was not so flat. As stated above, this site has the steepest slopes (up to 23°) of all six alternatives. The score for cable armor and trenching requirements is the lowest of the six alternatives ("L" vs. "M") because this would be the only site that would not have a previous SOSUS cable run to use as a guide. The cable termination point for this site would be an Air Force facility at Pillar Point.

Pioneer Seamount is an old (>20 million years) volcano on a fragment of tectonic plate. Hence, its top is relatively smooth, with only a veneer of pelagic sediment 1-2 m thick, with some rocky outcrops. Maximum bottom current velocities would be expected to be 30-40 cm/sec (Noble, U.S. Geological Survey, pers. comm., 1993). The cable run to shore would be comparable to that for San Nicolas Island (approximately 93 km); hence, an "L" value is applied. Likewise, logistic support facilities would be at least 95-100 km away.

The cable run to shore would traverse some primary bottom fishing areas. Boats fish parallel to the bottom contours, in 400-1000 m depths for Dover sole, and 1000-1200 m depths for sablefish.

Sur Ridge, CA

The source location at this site would be at approximately 850 m depth, which would afford good excitation of the acoustic normal modes propagating within the sound channel. Figure 2.2.3.3-4 shows the shadow plot for this site, displaying coverage comparable to Pioneer Seamount, except for the Gulf of Alaska. Nevertheless, it would satisfy greater than 90% of the

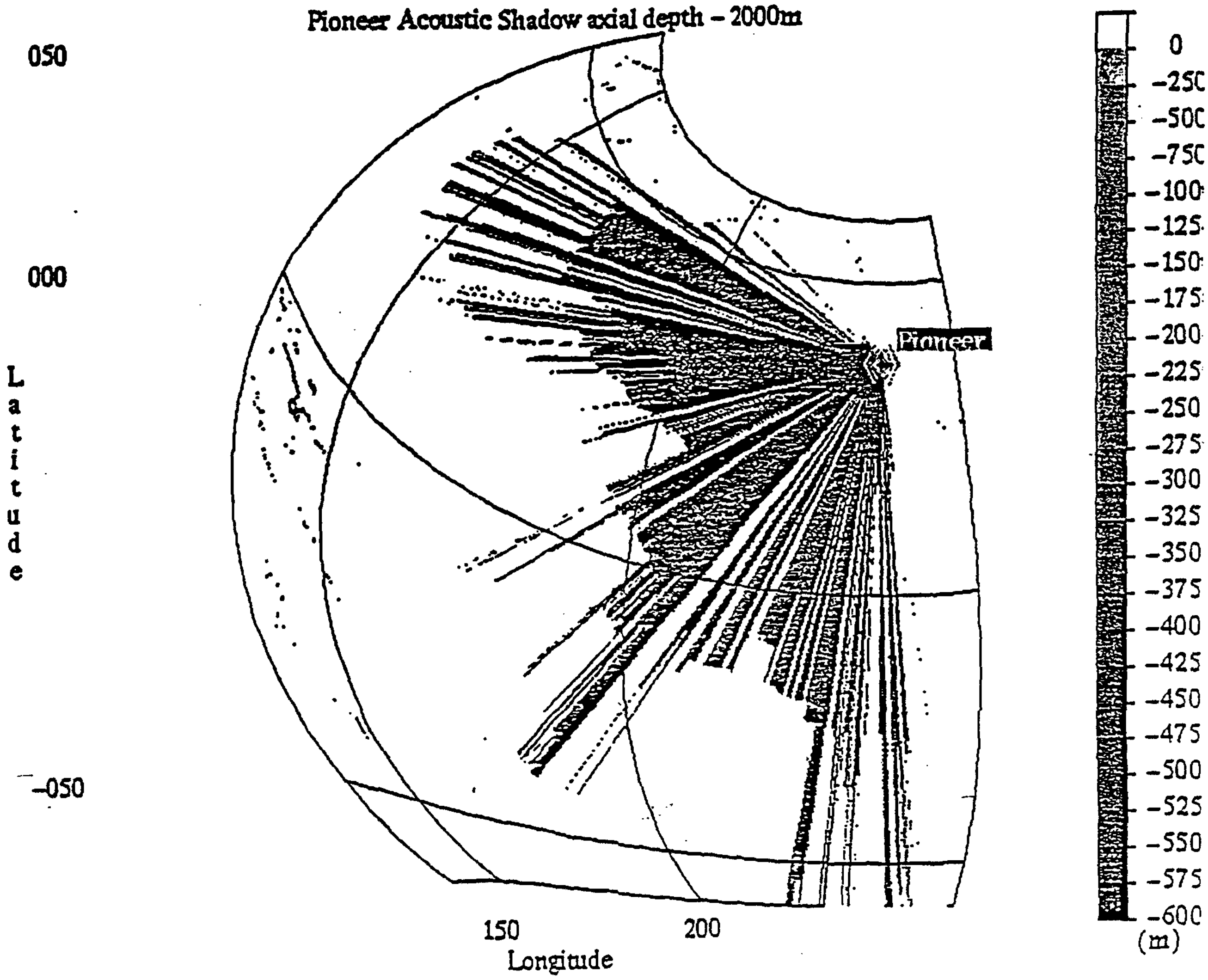


Figure 2.2.3.3-3 Pioneer Seamount, CA alternate site shadow plot

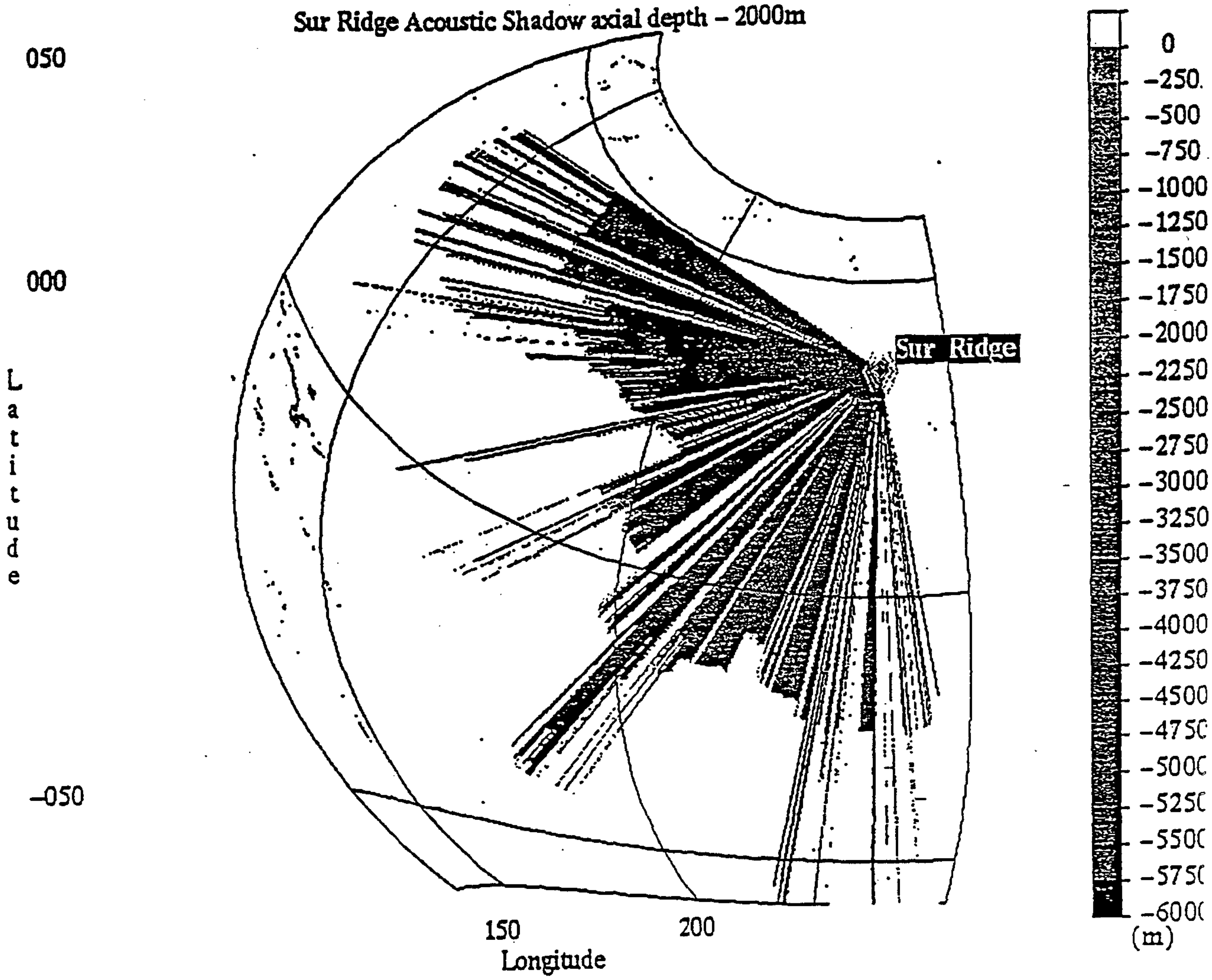


Figure 2.2.3.3-4 Sur Ridge, CA alternate site shadow plot

seasonal variation criteria. The site is locally flat, with slopes on the order of 6°. Cable armor and trenching requirements would be similar to the other sites that would use existing military facilities as the cable terminus.

Sur Ridge is made up mostly of sedimentary rock that has been uplifted on the eastern side, then sheared off. Sediment on the ridge itself is relatively thin, around 1 m thick, with some small rocky outcroppings. Hence, this site is ranked the same as Pioneer Seamount ("M"). Maximum bottom current velocities are expected to be approximately 20 cm/sec (as compared to 30-40 cm/sec for Pioneer Seamount). Because the cable run to shore would be less than 50 km long, this factor receives an "H" value as would the ranking for logistic support installations. The cable for this site would be subjected to similar bottom fishing hazards as the other sites.

Sur Slope, CA

Because this site is so close to the Sur Ridge site alternative, the first four factors (sound channel axis, acoustic view, seasonal variation and local flatness) should be similar. Figure 2.2.3.3-5 represents the shadow plot for Sur Slope. The slope would be only about 4° (vs. 6° for Sur Ridge), but the significance of this factor is degraded because the source would necessarily have to be off the bottom, tethered to a mooring. This results in an "L" value. Cable armor and trenching requirements would be the same as Sur Ridge, as the same termination point would be used for both alternatives. Bottom sediment properties are expected to be more uniform than those that would be encountered at Sur Ridge; i.e., sediment thicknesses on the order of 5 m and greater.

Calibrated current meter data are available for this area (Ramp et al., 1992). The maximum bottom current measured was about 20 cm/sec, the same as the Sur Ridge site. An additional 20 km of cable run beyond the proposed Sur Ridge alternative reduces the final ranking for two factors (cable run to shore and closeness of logistic support) by one value, as compared to Sur Ridge.

San Nicolas Island, CA

For this site, there would be no problem siting the source at the optimum depth to take advantage of deep sound channel propagation paths. However, the shadow plot (Figure 2.2.3.3-6) illustrates the lack of acoustic coverage to the ATOC receivers. There are several seamounts nearby that would result in large azimuthal (horizontal segment) blockage (San Juan Seamount to the northwest comes to within 600 m of the surface). Further, many of the long-range acoustic paths going to the North Pacific must be launched to the northwest in an along-slope direction, resulting in increased bottom interaction and signal losses. This equates to less than 50% fulfillment of the criteria for acoustic view. The site is locally flat with a relatively favorable bottom slope (approximately 8°). Cable armor and trenching requirements would be comparable to those for the other site alternatives that would utilize existing military facilities for the cable terminus.

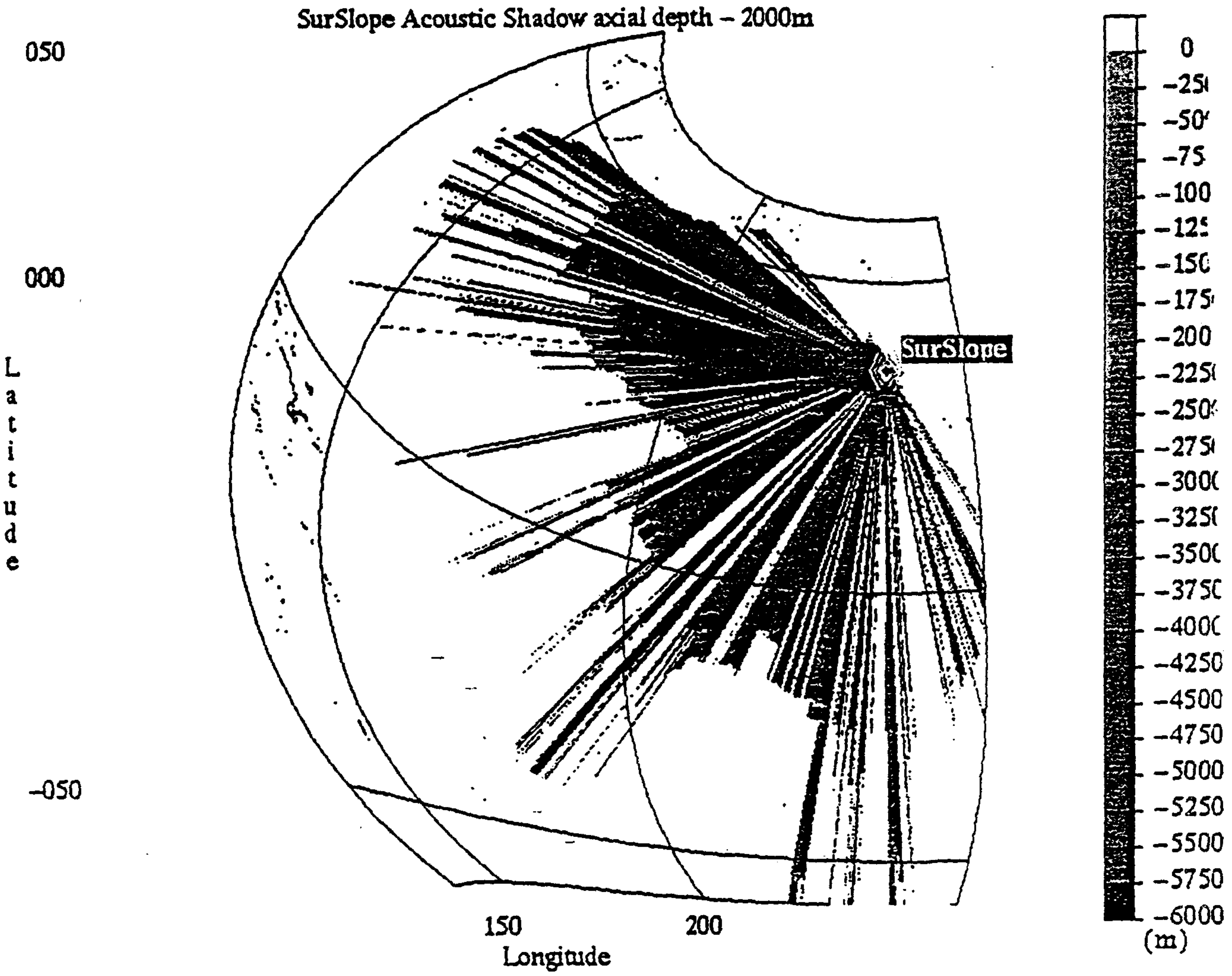


Figure 2.2.3.3-5 Sur Slope, CA alternate site shadow plot

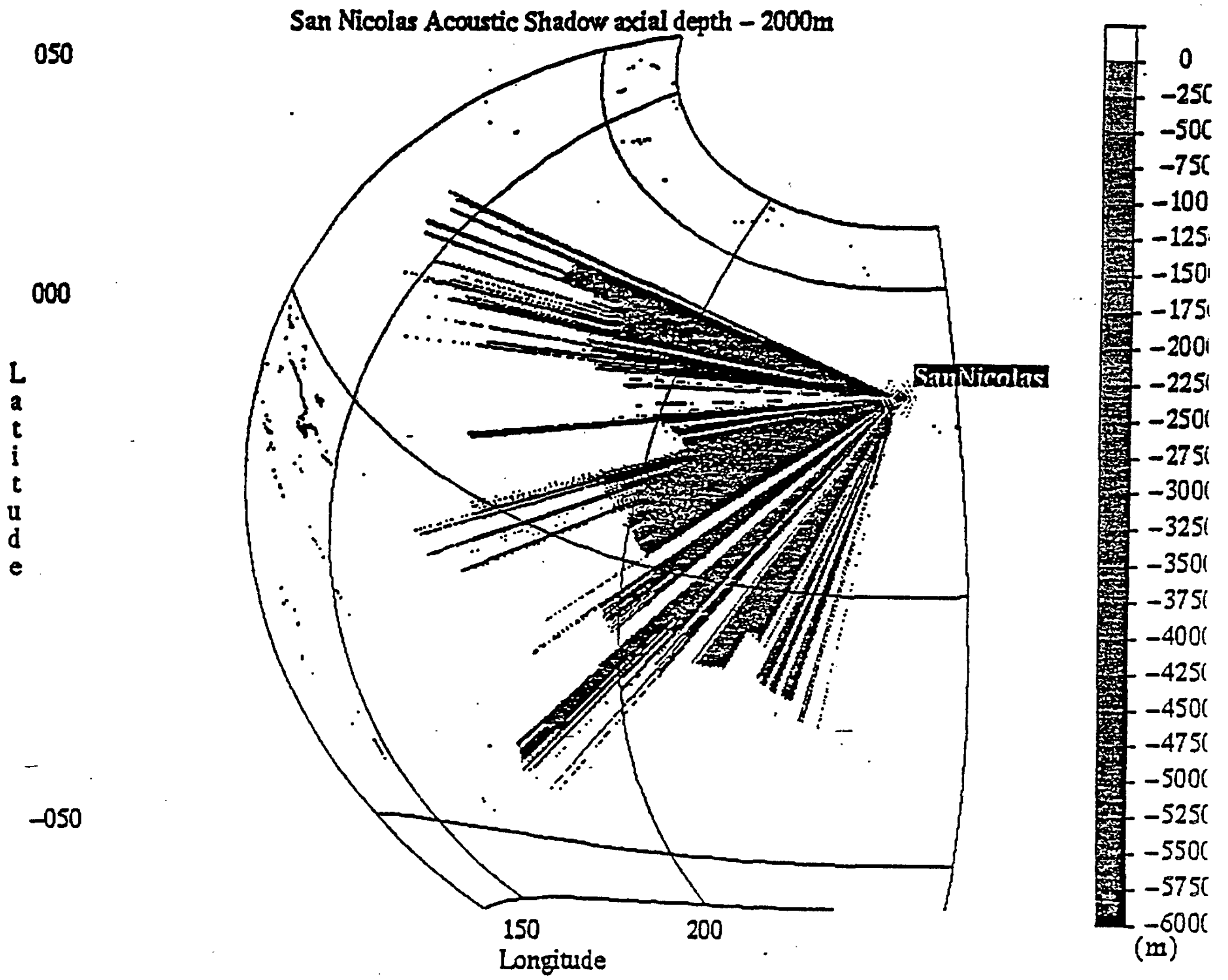


Figure 2.2.3.3-6 San Nicolas, CA alternate site shadow plot

Bottom properties would be expected to be good, with sediment thicknesses of at least 10 m. Extrapolation of the limited present knowledge of bottom currents off the west coast of North America, particularly the potential influence of the California Current system this far offshore, suggest bottom current speeds may be greater than 20 cm/sec at this site.

Because the cable run to the shore terminal on San Nicolas Island would be greater than 75 km long, an "L" value is applied. Logistic support would have to come from even farther away, approximately 200 km. The potential risk from bottom fishing is judged to be similar to the other alternatives. Although the cable run would necessarily have to be extremely long, it would not traverse any predominant near-shore fishing areas.

In summary, table 2.2.3.3-1 indicates that the Sur Ridge site is the most desirable of the six alternate locations from the perspective of ATOC operations, with Sur Slope scoring second, and Pioneer Seamount third. However, if criteria relating to the difficulties faced in implementing each alternative (such as cable length, close logistic support) are removed, Pioneer Seamount ranks slightly higher than Sur Ridge. All three of these alternatives are carried forward to Sections 3 and 4 for detailed assessment of alternatives. However, the Pacific Beach, Coos Bay, and the San Nicholas Island sites have been determined not to possesses the physical and locational characteristics required to adequately meet the project objectives and, therefore, are not considered further.

2.2.4 MOORED AUTONOMOUS SOURCE (ALTERNATIVE 4)

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 correct ocean depth.

2.2.4.1 Moored Autonomous Source

The principal areas of discussion of the moored autonomous source alternative are technical. Two technical aspects necessary to the development and use of such autonomous sources are discussed in this section: 1) development of the sound source itself, and 2) the engineering necessary to integrate the source and the mooring, and to place and use the source for an extended period of time.

Two different kinds of sources are proposed as ATOC options. The first would be a commercial low frequency projector (HX-556) using bender-bar technology that could 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 second source option would be one under development by the Russian Institute of Applied Physics (IAP). The IAP source operates by forcing two opposing faceplates with an interior electromagnet. It is reported to be able to deliver source levels up to 197 dB integrated across a 40 Hz bandwidth from 177 Hz to 217 Hz (center frequency 197 Hz). The source would require pressure compensation equipment at depths below 200 m. However, the IAP states that before it can authenticate the autonomous capability of its sound source, it would require additional development of source-driving electronics and amplifiers.

A conceptual moored autonomous source is depicted in Figure 2.2.4-1. There are two deployment problems to solve with the moored autonomous source alternative: 1) high pressure found in the ocean down to 5 km depth; and 2) movement, or wandering, of the source in a circle of up to a 300 m radius around the anchor on the ocean floor. The solution to the first problem would require the design of a robust pressure compensation system in the integration of the source and the mooring hardware. Cornuelle (1983, 1985) has suggested that a solution to the second problem would be to estimate the exact location of the source by analyzing changes in the travel times of sound transmissions from the source to receivers, or transponders, located around the mooring at different inclination angles to the source itself. This solution would require a mooring electronics package which would include a transponder navigation system, time-shift processing unit, transmitter and acoustic transponder command unit. It is not yet known how well this method may work for ATOC project purposes, where measurement accuracy on the order of 1-2 m is required routinely.

Although techniques of tracking underwater moored device motion are relatively mature, they have yet to be applied to large, heavy autonomous sources that would be deployed in the deep ocean.

Several of the different source types potentially available for this alternative operate at frequencies higher than the currently proposed cabled source. By transmitting at a higher frequency, potentially increased impacts on toothed whale (odontocete) species could occur, since those species' hearing sensitivity increases with increasing frequency. This concern would need to be addressed in the selection of any moored autonomous source. To date, there have been no sources designed for autonomous operation that operate at 70 Hz or have been demonstrated to operate at pressures found at 750-900 m depth in the ocean. While battery-powered capability is theoretically available, the power levels required to support 20-min transmissions at least a 2% duty cycle for one year are significant. At a transmitter efficiency of 10%, the battery pack would consist of a 2.8 m^3 (100 ft^3) box filled with Lithium cells and would weigh over 2722 kg (6000 lbs). This is 34 times the size of "standard" battery packs used routinely for long-range ocean acoustic experiments.

Because the source would most likely be moored at a considerable distance from the seafloor, the instruments would undergo considerable excursions as the moorings respond to tidal and other deep ocean currents (up to 300 m has been measured). This motion complicates interpretation of the received acoustic signal, even if the motion is known exactly, since both distance and path geometry are key determinants in thermometry.

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. They are not constrained by the logistics of shore-based power cable connections.

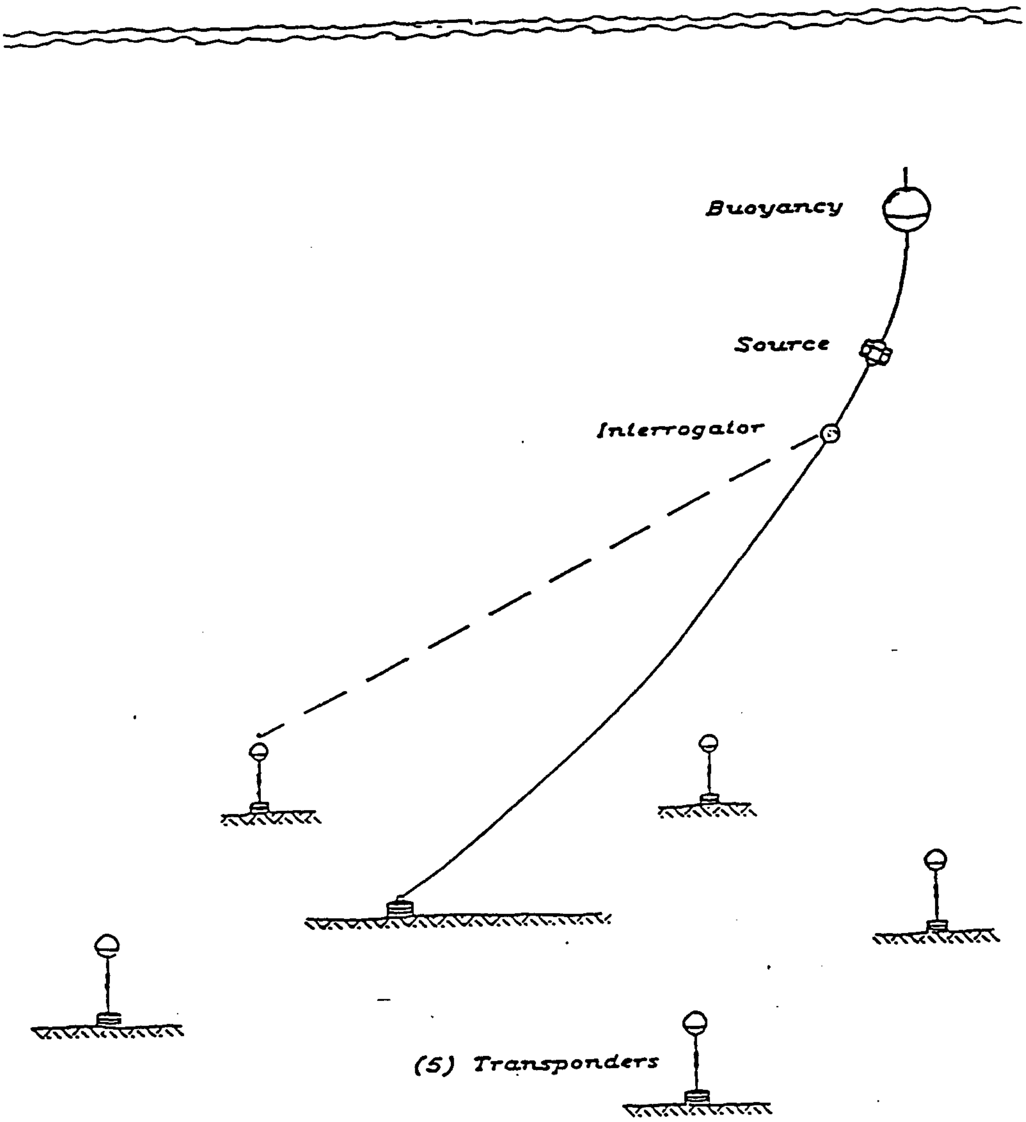


Figure 2.2.4.1-1 Conceptual moored autonomous source

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 research program (e.g., staging facilities for shipboard and 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.

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. Data provided above on the size of a required battery pack are based on an actual transmitter efficiency of 10%. Achievement of better efficiencies would reduce those requirements.

Due to this potential future applicability, this alternative will be carried forward to be further analyzed and included in the summary of consequences of alternatives.

Table 2.2.4-1 summarizes the advantages and disadvantages of a moored autonomous source.

2.2.5 RESTRICTED SOURCE TRANSMISSION TIMES (ALTERNATIVE 5)

Another alternative considered is to limit sound transmissions to times when vulnerable marine species are not present in the vicinity of the source. This subsection analyzes the feasibility and desirability of this alternative, specifically, in relation to sea turtles, mysticetes, and a single pinniped.

Based on available information, it appears that some mysticetes and possibly elephant seals and sperm 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 central California offshore area, the most reliable baseline data available are on mysticetes (particularly the migrating gray whale). Their movements through the area and in the eastern Pacific in general are fairly well understood, and are relatively easily observed from aircraft and by whale-watching vessels. Their vocalizations facilitate underwater acoustic locating and tracking. Some information on the distribution and abundance of sea turtles (particularly deep-diving leatherbacks) and elephant seals in the study area is available and will be useful in the development of a monitoring program for these species.

Since the purpose of the proposed MMRP is to evaluate the potential effects of the ATOC sound source on all marine mammals and sea turtles, and there is no low season where central California waters lack marine animals, there is no scientific basis for restricting sound transmission times by season.

Advantages	Disadvantages
• Would avoid problem of acoustic interaction with the bottom which could influence propagation. • Could potentially be placed in areas of low marine animal activity. • Basic source and battery technology is fairly mature. • Basic mooring and transponder hardware is fairly reliable. • If successful, cost savings over cabled bottom sources could be realized in some situations.	• Frequency of proposed sources is as much as 122 Hz higher than desired: - Transmission loss issue (higher TL). - Marine animal issue (higher frequencies are closer to odontocetes' hearing). • New pressure compensation equipment must be designed, developed and field tested. • New source driving electronics and amplifiers must be designed, developed and field tested. • New mooring electronics package (including time-shift processor) must be designed developed and field tested. • Source wander (up to 300 m) compensation scheme is unproven and would require design, development and field testing. If not fully successful, this would be disqualifying. • Breakdown of large batteries over time could introduce harmful chemicals into marine animals' habitat. • 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 • 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 activity as possible), it would render any viable research on low frequency sound effects on marine animals infeasible.

Table 2.2.4-1 Moored autonomous source advantages and disadvantages

Instead of restricting source transmissions by season, the potential impacts of source sounds on marine animals would be mitigated first through the MMRP Pilot Study, and second by the reduction of source power levels and transmission schedules to the minimum duty cycle necessary to meet the objectives of the feasibility experiment (at the outset, the duty cycle would be only 2%). These mitigation measures are discussed in connection with the following alternative, which discusses Modified Source Operational Characteristics. Section 4 lists the specific mitigation measures proposed to be incorporated into the project.

At some stage during the first year of operations, transmissions must be every day, for two months (8% duty cycle), rather than every fourth day (2%). This period would coincide with the occurrence of the smallest number of marine mammals in the area of the source site. This brief series of transmissions would enable tidal corrections to be made to all subsequent acoustic travel times.

Based on the above, the alternative of restricting source transmissions relative to individual species was eliminated from further analysis and will not be carried forward to the detailed analysis of alternatives.

2.2.6 MODIFIED SOURCE OPERATIONAL CHARACTERISTICS (ALTERNATIVE 6)

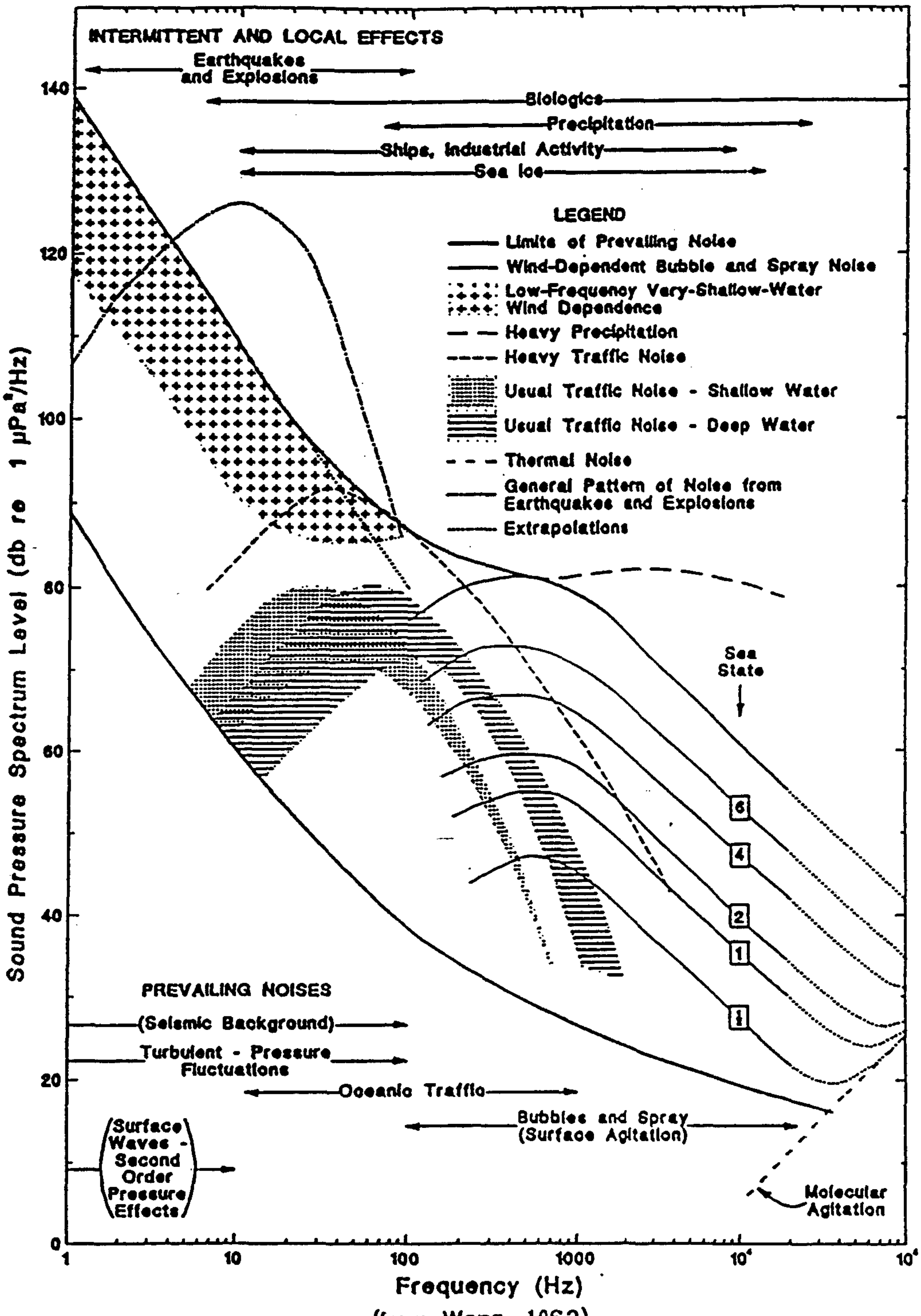
A number of scoping comments requested that alternative ATOC source characteristics be considered that could reduce effects on marine mammals. Source characteristics important to potential habitat effects include source frequency (frequencies outside marine animals' communication bands should be preferred), source level (lower power levels are preferred), waveform and pulse length (optimum waveform and coding can reduce the required source levels), and duty cycle (shorter 'on' periods are assumed to have lower potential impacts). Each of these characteristics is discussed below. Generally speaking, the ATOC source has already been designed to optimize these factors, based on present knowledge. Increased understanding resulting from experimental source operations will provide the basis for further optimization.

2.2.6.1 Modified Source Alternatives

The following section explains the critical acoustic parameters and mitigating actions selected for each preferred source characteristic.

2.2.6.1.1 Frequency

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 mid-frequencies (100-1000 Hz) where surface wave noise dominates the acoustic background (Figure 2.2.6.1.1-1). Based on known dominant frequencies of the great whales (Table 4.3.1.1.1-1), it appears that some species produce sound and can hear in this band. Baleen whales also use frequencies below and above the proposed source frequency, and toothed whales (odontocetes) use



(from Wenz, 1962)

Figure 2.2.6.1.1-1 Ambient noise spectra frequencies above the proposed source frequency (Table 4.3.1.2.1-1)/. The only large whale (sperm) known to be capable of diving to the depth of the source (980 m) produces sounds predominately in the 2-16 kHz range. Thus, there would be no real benefit relative to potential impacts on marine animal populations by changing the source frequency characteristics, particularly to a higher frequency. Based on available information, either a higher or lower frequency might be expected to result in increased potential impacts.

CEQA Mitigation Measure A-2: ATOC sound sources would utilize frequencies anticipated to have minimal adverse impacts on species that may be exposed to their acoustic output (i.e., based on available information, either a higher or lower frequency might be expected to result in increased potential adverse impacts).

2.2.6.1.2 Source Level

Figure 1.1.3-2 portrays the source power density spectrum, indicating 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 measured at 1 m from the source. This specification of maximum source level was derived by combining the results of the Heard Island Feasibility Test (HIFT) and numerous PE acoustic propagation loss model calculations. It is believed that 195 dB represents the upper limit and optimum source level requirements may end up being lower. The maximum source level would be used during the MMRP Pilot Study only if no significant impacts on marine mammals are observed during its early low-power stages. Further, after the start of ATOC operations, the source level would be adjusted to provide the minimum signal levels required at the receivers.

CEQA Mitigation Measure A-3: ATOC sound sources would operate at the minimum power level necessary to support MMRP objectives and feasibility operations.

2.2.6.1.3 Waveform and Pulse Length

The source waveform has been designed as a digitally coded "M-sequence" and has been optimized for decoding at the receivers. An initial 5 min stepped ramp-up period will help reduce the potential for startling animals and provide them an opportunity to move away from the source. The transmission length of 20 min 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. While the sounds cannot be "heard" over most of the transmission path distance or at the receivers, they will be 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. The signal processing technique used at the receivers "stacks" the transmitted energy in order to attain the necessary signal-to-noise ratio for proper data analysis. As a result, the current waveform and repetition protocols are designed to optimize reception, thereby reducing required source power levels to which marine animals would be exposed. Further, studies of migrating gray whales and other marine mammal species (Malme et al., 1983, 1984) indicated reduced sensitivity to intermittent (like ATOC) vs. continuous sounds.

CEQA Mitigation Measure A-4: The ATOC project will continue to study source waveforms and transmission lengths that may facilitate long-range detection of the source sounds, which in turn may permit lower source intensities than would otherwise be required.

2.2.6.1.4 Duty Cycle

The desired ATOC duty cycle would be one transmission every 4 hours (6 per day), for one out of every four days (2% duty cycle). After approximately six months, this duty cycle would be modified for a short period to allow efficient study of the effects of the ocean's daily tidal cycles (8% duty cycle). After about 1-2 months of operation at 8% duty cycle, it would be reduced to the original 2% to permit required sampling of data received from along the acoustic paths.

CEQA Mitigation Measure A-5: ATOC sound sources would operate at the minimum duty cycle necessary to support MMRP objectives and feasibility objectives.

Each source characteristic of the proposed action has been selected for least impact and maximum utility. However, mitigation measures have been incorporated into the proposed action to allow source characteristics to change in response to any observed impacts during the MMRP phase. Additionally, source characteristics will be reduced to the minimum required based on the test period results. Since the ATOC feasibility effort includes all feasible elements of this Modified Source Operational Characteristics alternative, the alternative will not be analyzed separately in the detailed consideration of environmental consequences, but instead should be considered part of the project as proposed.

2.2.7 GLOBAL CLIMATE MODELS (ALTERNATIVE 7)

The alternative of using existing computer models alone to predict long-term changes in the global climate was also evaluated. This section describes global climate models (GCMs) 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 ATOC project data would be coordinated with these models to verify their assumptions and projections, and to improve their reliability. Since the use of GCMs 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 global ocean climate is at a level of development similar to that of weather prediction several decades ago. Modeling of ocean climate presents a greater challenge than numerical weather prediction for two primary reasons. First, significant changes within the ocean occur on a much smaller or localized 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, 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 is very little pertinent oceanographic data collected for ground-truthing or validating the models. This lack of information has been alleviated somewhat with data from the Geosat-Exact Repeat Mission (Geosat-ERM) altimetric satellite, the European Space Agency's ERS-l satellite (using an altimeter, which measures altitude, and scatterometers, which measure wind speed, and direction, and thus sea state), and the NASA/CNES TOPEX/Poseidon precise altimetric satellite. Sea surface height (SSH) measurements from these satellites help benchmark ocean circulation models. However, direct temperature measurements, in addition to measurement of sea surface height, are critically needed before existing models can gain additional credibility.

The only climatic variation for which there has been some verifiable forecasting capability is the El Niño phenomenon in the Pacific Ocean. There is no such corresponding skill for the Atlantic or Indian Oceans.

Taken individually, observed or modeled data sets could yield inconclusive results. For example, satellite altimetry data are subject to many environmental corrections and errors. The effects of these errors may be magnified by sensor parameter differences between satellites such as Geosat-ERM and ERS-l. The model results alone are not conclusive because they are low resolution simulations that use simplifications of the ocean with respect to physical processes and atmospheric forcing functions. From a practical standpoint, these simplifying assumptions make it possible to run the model on existing super-computers, but if the assumptions are wrong the results likely will be wrong as well or, coincidentally, right for the wrong reason.

The ATOC scientific methodology measures the temperature structure throughout the vertical extent of the sound channel in the water column. The upper and lower limits of the sound channel are defined by the two depths of equal maximum velocity on the profile, between which a velocity minimum (sound channel axis) exists (Urick, 1983). These ocean temperature data collected by ATOC operations in the Pacific will lead to assimilation of that data into Pacific GCMs. In addition, ATOC scientists would work on the interpretation of the best available climate models (Hamburg, Princeton, O'Brien/Hurlburt of Florida State University, Wunsch/Marshall of MIT) under development, in terms of their acoustic signatures, to ascertain how well the GCMs describe the ocean acoustically.

The measurements collected from a Pacific ATOC network would need to be infused into GCM development and validation efforts. If the agreement between real data and a model is poor, the goal would be to improve the physics of the models themselves.

The use of GCMs alone to predict global climate change does not address the project objectives. However, the use of GCMs would be an integral part of the overall project. Additionally, ATOC measurements could serve as an essential element of GCM development. Therefore, this alternative has already been incorporated into the preferred alternative and is not analyzed further as a separate alternative.

2.2.8 SATELLITE SENSORS (SEA SURFACE TEMPERATURE MEASUREMENTS) (ALTERNATIVE 8)

Another alternative to acoustic methods of global climate measurements considered is the use of satellite measurements of sea surface temperatures. The discussion below concludes that, while these measurements are fairly accurate for the sea surface, they alone cannot measure global climate changes and, therefore, would not meet the project objectives. However, ATOC research would be coordinated with satellite measurements. Satellite measurement of sea surface temperatures is not a substitute for ATOC, but rather an important adjunct to it.

Satellite sensors offer a number of methods for determining sea surface temperature (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.

The best sea surface temperature measurements are accurate to approximately $\pm 0.6°C$, if all available infrared channels are used. Current investigations are concentrating on examining remotely sensed global water vapor data and atmospheric sounder information in order to improve the atmospheric correction factors.

Unfortunately, this wealth of SST information does not reflect thermal properties below the sea surface. Satellite measurements give surface boundary conditions, but due to the impenetrability of sea water to electromagnetic waves (microwaves, infrared), they do not measure temperatures at depth. As a result, there is also a need to monitor the ocean's interior by other means.

ATOC scientists would work closely with ongoing and future satellite data collection programs to extend satellites' ability to measure temperature at the sea surface, into the ocean's interior, by acoustic thermometry. Therefore, this alternative has been incorporated into the preferred alternative, and is not analyzed further as an independent alternative.

2.2.9 SATELLITE SENSORS (SEA LEVEL MEASUREMENTS) (ALTERNATIVE 9)

An additional technology for measuring ocean climate changes is the use of satellite-based measurements of sea level. This section explains the accuracy and limitations of this alternative. It concludes that sea level measurements alone, no matter how accurate, are not an effective measure of ocean temperatures. However, satellite sea level measurements are one component, along with ATOC project data, that will be assimilated into the computer predictions of global climate change, which is the ultimate objective of this project. Satellite sea level measurements are not a substitute for ATOC, but instead represent one method of augmenting larger ATOC project objectives.

There are two main reasons why mean sea level rises or falls on long time scales (≥5 yrs). 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. 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.

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. 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. However, the underlying enigma is the problem of understanding the extremely complex relationships among atmospheric warming or cooling, oceanic warming or cooling, polar ice cover area and thickness, and sea level rise or fall. Further, in modeling ocean temperatures from sea surface levels, it would be necessary to compensate for the fact that earth crustal movements also change apparent sea levels by comparable amounts.

In order for this alternative to offer any level of viability, concurrent, well-calibrated measurements of polar ice cover and thickness would be needed on the one hand, and sea level rise or fall on the other hand. At this stage, the former is not yet resolved and the latter still an area of active research.

Precise measurements of sea level heights from satellite altimetry sensors would be appropriately incorporated into ATOC oceanographic and acoustic modeling efforts, that would feed into the global climate model prediction efforts. Therefore, this alternative has been incorporated into the preferred alternative, and is not analyzed further as a separate alternative.

2.2.10 OCEANOGRAPHIC POINT SENSORS (ALTERNATIVE 10)

All measurements that have been made of ocean temperatures to date have used either remote satellite sensing or conventional thermometers placed directly in the ocean, referred to in this section as oceanographic point sensors.

A number of oceanographic point sensor technologies are in use, the most pertinent of which are expendable bathythermographs (XBTs) and conductivity-temperature-depth (CTD) profiling systems. The ATOC project would use XBTs and CTD/XCTDs in order to validate its own temperature measurements; therefore, this alternative is an element of the ATOC project proposal. However, oceanographic point sensors are not a substitute for acoustic thermometry, due to the extremely large number of such sensors that would be required to provide a comparable level of data.

A component of the ALACE and PALACE systems is capable of ocean point measurements. These are free-floating devices which flow with the current at a specified depth.

At programmed intervals they surface, report their position and data, then return to their depth. They provide precise track information and furnish point measurements along a track following ocean currents at depth, but do not provide repeatable path temperature averages, which is the core concept of the ATOC technique.

XBTs are a combined temperature and depth sensing unit with a copper wire connecting them to the surface. They are launched from all sizes of vessels, out of aircraft, and from submarines at depth. As the units sink, they transmit depth and temperature data to the surface. They enable mapping of the temperature pattern of the upper ocean to the standard depth of the T-4 model (460 m), which is most commonly used, or the more expensive models, the T-7 (760 m) or T-5 model, which go to 1830 m. There are several volunteer ocean observation programs in which XBTs are launched from ships of opportunity along major (and some minor) commercial shipping routes.

XCTDs operate on a similar principle, but add conductivity measurements to determine salinity levels. They are more expensive than XBTs.

XBTs and XCTDs have environmental impacts of their own. Since they are expendable, hundreds of thousands of miles of fine copper wire and tons of zinc and plastic waste have been introduced into the oceans in the form of XBTs and XCTDs. In addition, a program that would expand use of XBTs to the degree required could no longer rely primarily on ships of opportunity.

Furthermore, XBTs are not adequate tools with which to measure climate change in the oceans. XBTs have a temperature accuracy of ±0.15°C and a depth accuracy of ±2%. Climatological researchers expect that the climate "signal," which is swamped by local variability near the sea surface, would be about 0.005°C per year at 1000 m. Thus, the XBTs of today do not meet the requirements of long-term climatological research aimed at addressing questions of global warming. Moreover, merely improving XBT accuracy could not replace acoustic thermometry measurements, since point source measurements are inherently limited in time and space. It is not economically feasible to overcome this limitation by increasing the numbers of launching platforms.

For a dedicated, cost-effective oceanographic program, specialized ships would be required to handle CTD profiling systems. These ships would stop at each sampling station and lower a CTD to obtain salinity and temperature profiles. Each profile typically takes 3-4 hr to complete, thus a single line of point samples across the ocean takes several weeks. The combined resources of tens of nations, each with dedicated oceanographic ships, have not been sufficient to map the global ocean's temperature structure in any detail, and certainly not repeatedly.

XBTs, along with the other oceanographic research tools available, provide complementary forms of data, but cannot be used alone to resolve global climate questions. ATOC is expected to provide instantaneous temperature data averaged on ocean basin scales and would complement, not compete, with the other data collection research technologies. The puzzle of global climate change is sufficiently complex and important to demand the proper integration of all available useful measurement tools. No single technique can answer the outstanding questions of how the oceans are responding to changes in the atmosphere resulting from human activities and natural events (e.g., seismic).

In any event, point source measurements would be taken as part of the ATOC project in order to compare measurements obtained through direct physical measurements with acoustic results.

2.2.11 AUTONOMOUS POLAR HYDROPHONES (ICE NOISE MEASUREMENTS) (ALTERNATIVE 11)

At least one scoping commenter suggested that atmospheric temperature changes could be predicted by listening with hydrophone(s) to Arctic ice noise (J. Lewis, 1994). Lewis suggests that noise levels could be related to the quantity of ice melting, which could then be translated into changing temperatures in the atmosphere.

Correlation between ice noise and air temperature is limited to short-term local changes that are basically unrelated to climate change. It would be extremely difficult to calibrate or quantify any ice noise measurements over a reasonable time period.

In addition, it was suggested that ATOC measure the transmission times of existing noises in the ocean, such as polar ice noises, rather than adding new sources of subsea noise. However, the unpredictable timing, source location and intensity of such noises, and the fact that they are not specially coded for long distance reception nor inserted directly into the sound channel, make their use as a sound source to support acoustic thermometry infeasible.

Listening to Arctic ice noise was not selected as an alternative for further analysis, as it does not address the issue of ocean climate change or present an opportunity for ocean temperature measurements in a scientifically viable manner, and does not meet project objectives.

2.2.12 DUAL SITE EXPERIMENT; ALTERNATIVE MMRP TECHNIQUES -- MOBILE PLAYBACK EXPERIMENTS (ALTERNATIVE 12)

Several commenters suggested that the ATOC/MMRP experiments should be located at two separate sites, with the MMRP being performed using a mobile sound source at a location with relatively large numbers of marine mammals, and the ATOC experiment being performed at a remote location with lower densities of marine animals, without any attempts at associated marine mammal research.

In response to this comment, mobile sound source (playback) experiments have been added to the MMRP at several locations chosen for marine mammal and sea turtle abundances (Hawaii for humpback whales, Azores or Dominica for sperm whales, and Trinidad for leatherback sea turtles). However, playback experiments have only limited relevance to evaluating the potential impacts of an ATOC-like sound source, since they use much lower power levels, they have more pronounced distance/received level relationships (the received sound level from a lower output source closer to an animal varies more quickly as an animal moves in relation to the source), they include the confounding influence of the boat from which the source is deployed, and unless the boat can remain stationary for a long period of time prior to commencement of the experiment (to allow the area return to steady state), the boat motion diminishes the utility of the data (because the animal could be responding to the motion of the boat; plus the fact that the ATOC source is not mobile). As a result, MMRP experiments utilizing an ATOC-like source are still required, and reasonable abundances of marine mammals are needed to support those experiments.

Moreover, offshore central California, there are a limited number of good acoustic thermometry sites that feasibly could be utilized at this time, since current technology requires a cabled source for long-term operations. There is no feasible cabled source site that has lower marine mammal and sea turtle abundances than Pioneer Seamount. As a result, this alternative, to the extent that it is feasible, has already been adopted; it therefore, will not be analysed further.

2.3 RANGE OF ALTERNATIVES AND ALTERNATIVES ELIMINATED FROM DETAILED STUDY

The evaluation of possible alternatives to the proposed project was conducted based on a list of criteria needed to meet project objectives. The suggestions were narrowed to a list of eleven possibilities, including the preferred action, proposed action, and a no action alternative. After further analysis, some of the alternatives were eliminated outright, and some of the features of the suggested alternatives were incorporated into the proposed action. Five alternatives--the preferred action, no action, Sur Slope source site, Pioneer Seamount source site (proposed action) and the use of moored autonomous sources--were carried over for further analysis and evaluation. Table 2.4-1 at the end of this section summarizes the analysis of these five alternatives, while Section 4 evaluates their potential environmental impacts. The following is a summary of the alternatives eliminated from further analysis.

2.3.1 ALTERNATIVE 5 (RESTRICTED SOURCE TRANSMISSION TIMES)

Species that may be affected by source transmissions, and which exhibit seasonal presence in eastern Pacific waters are primarily mysticetes (including the gray whale), a pinniped (northern elephant seal), and at least one sea turtle (leatherback). However, as discussed below in Section 4, it is not anticipated that gray whales would be affected by the source transmissions since they migrate close to shore and the Farallon Islands in the proposed site area (Pioneer Seamount), and would not be exposed to sound levels anticipated to affect their behavior (i.e., 120 dB sound field would be $\geq$30 km to the southwest) (Malme et al., 1983, 1984). Four of the large cetaceans do not exhibit seasonality or have different seasons in the area (fin, sei, right and sperm whales). Thus, adopting this alternative would be ineffective in minimizing potential affects of sound on marine mammals.

However, even though this alternative is not analyzed further as a potential alternative, its mitigating effect has been incorporated into the preferred alternative, which includes the reduction of source transmission times.

2.3.2 ALTERNATIVE 6 (MODIFIED SOURCE OPERATIONAL CHARACTERISTICS)

The proposed action calls for source operational characteristics which would minimize potential adverse impacts and optimize project goals. There would be no known decrease to any potential impact on marine animal populations by changing the source frequency characteristics. After initial climate studies, the source level and duty cycle would be decreased to the minimum required. Since the mitigating effects of this alternative have already been incorporated into the proposed action, modified source characteristics have not been analyzed as a separate alternative.

2.3.3 ALTERNATIVE 7 (GLOBAL CLIMATE MODELS)

Computer model results alone would be inconclusive because they are a simplification of the ocean with respect to physical processes and atmospheric forcing functions. ATOC temperature measurements would be incorporated into GCMs as benchmarks for verification and validation, with the goal to improve the models' reliability.

2.3.4 ALTERNATIVE 8 (SATELLITE SENSORS--SEA SURFACE TEMPERATURE MEASUREMENTS)

Satellite sea surface temperature measurements would be used in conjunction with ATOC project data to predict global climate changes. SST data do not reflect oceanic thermal properties below the surface. Global warming relies on high latitude convective interchange between the surface and the ocean interior. Satellite SST measurements would be used in conjunction with ATOC project data to provide GCM modelers with data to better predict global climate changes.

2.3.5 ALTERNATIVE 9 (SATELLITE SENSORS--SEA LEVEL MEASUREMENTS)

There is an inherent inter-relationship among atmospheric warming, ocean warming, polar ice cover and sea level change. For this alternative to be viable, coincidental, calibrated measurements of polar ice cover and thicknesses and sea level changes would have to occur on a global scale, which is not currently feasible. However, though this alternative by itself does not meet project objectives, it could be used in conjunction with ATOC data and is included in the preferred alternative.

2.3.6 ALTERNATIVE 10 (OCEANOGRAPHIC POINT SENSORS)

XBTs (and XCTDs) alone are not the proper tool to measure global climate change in the oceans and therefore do not meet project objectives. This is primarily due to the difficulty of implementing a high-resolution, global sampling plan that would need literally millions of XBTs at a prohibitive cost, but also because of the lack of required measurement accuracy of XBTs.

XBT data would be integrated with ATOC measurements, and are therefore incorporated into the preferred alternative and not analyzed further as a separate, independent alternative. Likewise, ALACE and PALACE floats are not considered an alternative to ATOC because they are not able to provide large-scale seasonal and year-to-year temperature variabilities amenable to input to climate prediction model algorithims.

2.3.7 ALTERNATIVE 11 (AUTONOMOUS POLAR HYDROPHONES--ICE NOISE MEASUREMENTS)

Correlation between ice noise and air temperature would be limited to short-term local changes that are basically unrelated to global climate changes. It would also be infeasible to calibrate or quantify ice noise measurements over a long time. Therefore, this alternative would not meet project objectives.

2.3.8 ALTERNATIVE 12 (DUAL SITE EXPERIMENT; ALTERNATIVE MMRP TECHNIQUES -- MOBILE PLAYBACK EXPERIMENTS)

Mobile playback experiments alone cannot adequately study potential marine mammal and sea turtle responses to ATOC-like sound transmissions which, unlike the equipment used in those experiments, use a fixed, high intensity source that is not associated with boats or other human activities. No currently feasible acoustic thermometry sites exist offshore California that would further reduce potential exposures of marine mammals and sea turtles to low frequency sounds. To the extent that this alternative is feasible, it has been added to the proposed project by including playback experiments in the MMRP; and by shifting the sound source location to Pioneer Seamount; it therefore will not be analysed as a separate alternative.

2.4 SUMMARY OF RELATIVE RESPONSE OF ALTERNATIVES TO OBJECTIVES

The relative response of the alternatives to the marine animal research and acoustic thermometry research criteria are key elements in distinguishing among the alternatives. The information in Table 2.4-l supplies the relative response of the alternatives to the marine animal research criteria and the acoustic thermometry program criteria. Table 2.4-1 assumes that the MMRP described in Appendix C would be carried out in support of Alternative 3-1; if Alternative 1, 3-2, or 4 were selected, the table assumes a MMRP research protocol of comparable adequacy would be executed at that site. The percentage values are based upon criteria fulfillment requirements deemed necessary by both marine mammal biologists and acoustic oceanographers associated with the program.

2.5 PREFERRED ALTERNATIVE

The preferred alternative is Alternative 1; however, the proposed action with identified mitigation measures is Alternative 3-1. The MMRP described in Appendix C is tailored for Alternative 3-1; however, it would be restructured to become an integral part of any other alternative except Alternative 2 (No Action).

CRITERIA	Alternative 1 (Preferred Action) (Sur Ridge)	Alternative 2 (No Action)	Alternative 3-1 (Alt. Site-Pioneer Seamount)	Alternative 3-2 (Alt. Site-Sur Slope)	Alternative 4 (Moored Autonomous Source)
Marine Mammal Research Program					
• Assess the potential effects of low frequency sound (ATOC, natural, or other human-produced) on the relative distribution and abundance of marine animals (particularly marine mammals and sea turtles) within the 120 dB sound field (modeled at 100 m depth), so as to minimize uncertainties associated with determination of the significance of any effects.	H	N	M	M	L
• Obtain sufficient information to confirm that ATOC sound transmissions will have no effects, or negligible effects, on the relative distribution, survival, and productivity of marine mammals and sea turtles.	H	N	M	M	L
• Identify mitigation measures to avoid the potential disruption of behavioral patterns of local marine animals, particularly marine mammals and sea turtles.	H	N	M	M	L
• Assess the level of any responses of indicator species to low frequency sound signals, particularly whether any marine mammal or sea turtle demonstrates an acute or short-term response (Table C-1) to low frequency sound transmissions with ATOC source characteristics.	M	N	M	M	UNK (presume L)
Acoustic Thermometry Program					
• Observe the ocean on the large space scales (3000-10,000 km) which characterize climate, so that modelers will be able to: 1) test their models against the average ocean temperature changes seen by ATOC over a few years, and 2) if, and when, the models prove adequate, use those same observations to "initialize" the models to make meaningful predictions.	H	N	H	H[1]	H[1]
• Develop and demonstrate the equipment necessary to undertake acoustic thermometry experiments; in particular, reliable low frequency sound sources.	H	N	H	UNK (presume L)	UNK
• Prove the concept of using acoustic thetmometry to measure ocean climate variability for global applications by establishing multiple acoustic pathways in the North Pacific.	H	N	H	H[1]	H[1]
• Obtain early baseline data on transmission times in Pacific pathways to compare with data that may be obtained in a follow-on program, if such a program is approved.	H	N	H	M[1]	M[1]
• Determine the minimum source level and duty cycle necessary for obtaining valid climatic data.	H	N	H	H[1]	H[1]
• Characterize oceanographic factors that could affect the global climate "signal," such as tidal cycles, internal wave fields, and mesoscale variations, and determine the constraints they impose on the design of a future (conceptual) ocean monitoring system.	H	N	H	H[1]	H[1]
• Utilize existing U.S. Navy seafloor hydrophones to the maximum feasible to increase the number of acoustic pathways and, hence, the quantity of data, at a relatively small cost.	H	N	H	H[1]	H[1]

[1]Assumes that reliable, efficient, safe systems can be developed, tested and deployed successfully.

Relative response criteria:
H = Fulfills criteria >90%
M = Fulfills criteria 50%-90%
L = Fulfills criteria <50%
N = Fulfills criteria 0%

Table 2.4-1. Relative response of the alternatives to the marine animal research and acoustic thermometry program criteria.

3 AFFECTED ENVIRONMENT

3.1 INTRODUCTION

This section presents background information on the physical, biological, and socioeconomic environments of the alternative sites potentially impacted by the proposed action. Where feasible, this information is related to the habitats and depth ranges that may be affected by the sound field so that potential environmental impacts, discussed in Section 4, can be evaluated for each site.

Considerable information for the region encompassing the Sur Ridge (hereinafter preferred action), Sur Slope, and Pioneer Seamount (hereinafter proposed action) alternative sites is available from recently completed environmental impact statements for the Monterey Bay National Marine Sanctuary (NOAA, 1992) and the deep-water dredged material disposal site off San Francisco (EPA, 1993). Other key environmental information was available from published literature, particularly on the Monterey Bay and Pt. Sur areas; recent bathymetric and side-scan sonar surveys of the Sur Ridge and Pioneer Seamount sites (SSI, 1993); agency studies by Minerals Management Service, NOAA, and EPA; and personal communications on socioeconomic data from local and county sources.

3.2 PHYSICAL ENVIRONMENT

This section addresses the physical characteristics of the alternative site environments that may affect or be affected by the proposed action. A site description is presented first (Section 3.2.1), followed by an overview of meteorology (Section 3.2.2), physical oceanography (Section 3.2.3), water column characteristics including the existing noise setting (Section 3.2.4), and geography/geology (Section 3.2.5). Due to the large-scale influence of many environmental features such as currents and winds off the central California coast, much of the following discussion applies to all the alternative sites.

3.2.1 SITE DESCRIPTION

The preferred action site (Sur Ridge) is approximately 48 km (26 nm) from shore and within the Monterey Bay National Marine Sanctuary (Figure 3.2.1-1). The Sur Slope alternate site is approximately 20 km west of Sur Ridge (Figure 3.2.1-1). The Pioneer Seamount alternate site (proposed action site) is north of Pioneer submarine canyon, 88 km (46 nm) from shore, and approximately 37 km (20 nm) and 28 km (15 nm) from the boundaries of the Gulf of the Farallones National Marine Sanctuary (GOFNMS) and Monterey Bay National Marine Sanctuary (MBNMS), respectively (Figure 3.2.1-1).

3.2.2 METEOROLOGY

The coastal environment off the central California coast has a maritime climate characterized by a general lack of weather extremes (Williams et al., 1980), with cool summers and mild, wet winters.

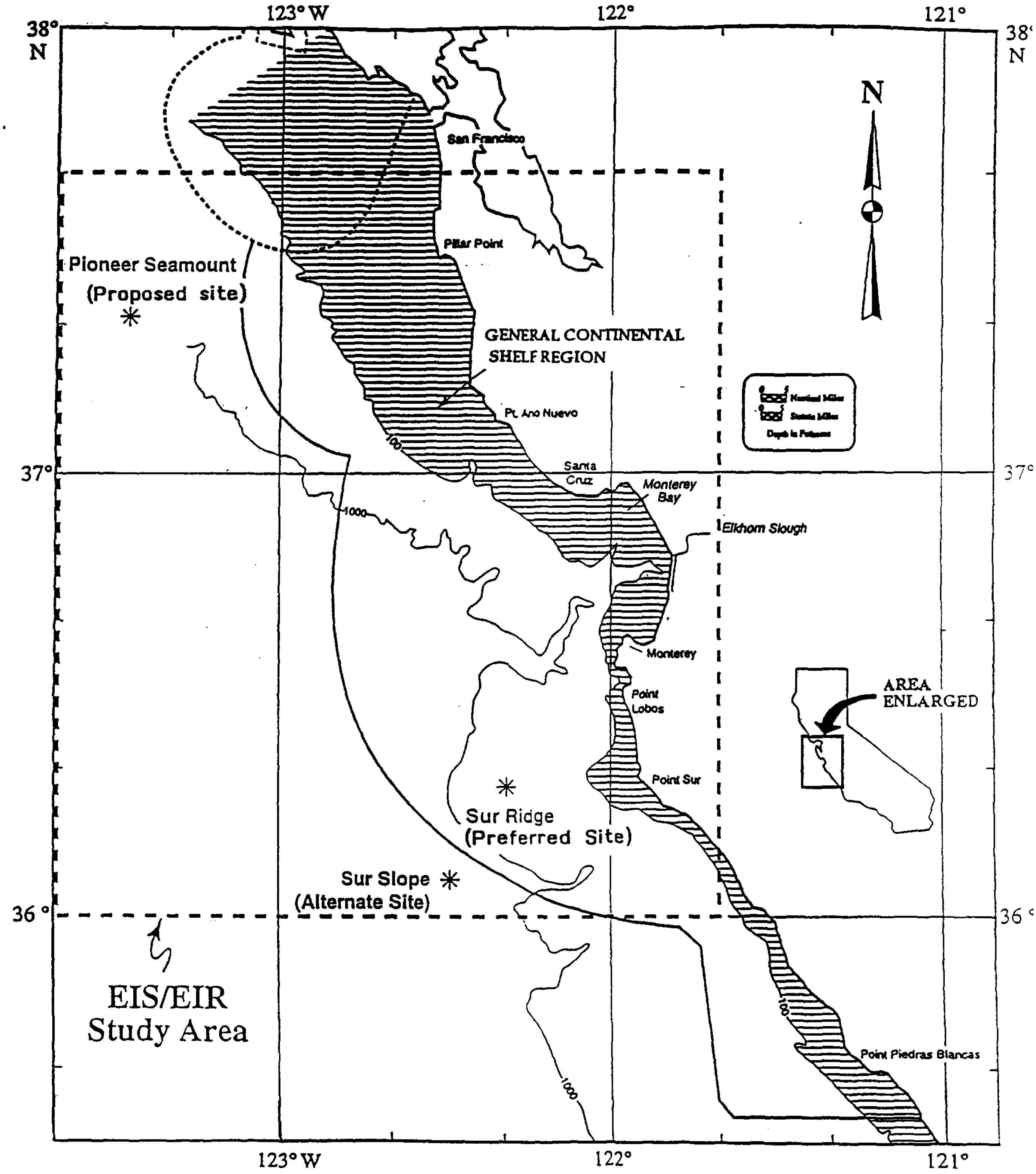


Figure 3.2.1-1 General EIS/EIR study area and ATOC preferred and proposed sites

Weather conditions are most stable in summer and autumn, with moderate but persistent winds diminishing to calmer conditions through mid-autumn. Variable weather conditions occur during winter when series of storms produce strong winds and high seas. Spring has fewer frontal rainstorms and less extreme conditions, but is usually the windiest period of the year. Fog occurs off the coast throughout the year, but is most persistent during summer. Upwelling tends to cool the relatively warm, moist air masses moving eastward and results in the formation of fog off the coast.

Winds are an important influence on water column characteristics and currents over the continental shelf and upper continental slope (i.e., bottom depths up to 500 m; Winant et al., 1987). Strong north to northwest winds in spring and early summer promote offshore-directed flows of surface waters, resulting in upwelling of cool, saline, nutrient-rich waters along the coast. Relaxation periods of weak or calm winds can result in reversals in the surface currents (Halliwell and Allen, 1987). The wind field in the region exhibits a seasonal cycle. Summer winds are driven by the pressure gradients of the North Pacific subtropical high pressure and southwestern U.S. thermal low pressure systems (Halliwell and Allen, 1987). Mean summer winds have an equatorward alongshore component that is relatively strong (approximately 20 kts or 10 m/sec) along the California coast (Halliwell and Allen, 1987). The strongest equatorward winds occur in April and May (Chelton et al., 1987). Winds exhibit greater spatial and temporal variability in the winter than in the summer (Halliwell and Allen, 1987). This is due to the passage of atmospheric cyclones (counterclockwise winds) and anticyclones (clockwise winds) moving onshore from over the Pacific Ocean. Storm-driven winds occur approximately 2% of the time.

3.2.3 PHYSICAL OCEANOGRAPHY

The study area is located within the California Current system. The California Current is a broad surface flow approximately 100 to 1,000 km from shore. This current is driven primarily by wind stress over the North Pacific Ocean, and it transports cold, low salinity, subarctic waters. The typical mean flow in the upper few hundred meters is equatorward (i.e., towards the southeast) at speeds less than 0.1 m/sec (0.2 knots).

Within the California Current system are two poleward flows: the Coastal Countercurrent and the California Undercurrent (Hickey, 1979; Chelton, 1984; Neshyba et al., 1989). The Coastal Countercurrent flows northward over the continental shelf, inshore from the California Current, and typically is only 10 to 20 km wide, with velocities less than 0.3 m/sec (0.6 knots) (Kosro, 1987). It is broader and stronger in the winter (October through early March), when it occasionally covers the entire continental shelf and is referred to as the Davidson Current; however, it remains strongest nearshore (Huyer et al., 1978). The Coastal Countercurrent has been observed both north and south of the region. The California Undercurrent is a strong poleward flow over the slope (i.e., bottom depths of 200-5,000 m). The position, strength, and core velocity of the undercurrent vary spatially and at different times of the year, although a maximum poleward velocity of around 0.3 m/sec (0.6 knots) typically occurs between 150 to 300-m depth in slope waters 500 to 1,000 m deep.

Characteristics of currents within 20 m of the seabed cannot be predicted reliably from measurements made in the overlying water column. This is because near-bed currents are more strongly controlled by topographic features than currents higher in the water column. One of the most notable features of the tidal currents over the slope is the increase in amplitude of both the diurnal and semidiurnal tidal constituents towards the bottom at some locations (Kinoshita et al., 1992). Amplification can result in tidal currents which are two to three times stronger at the bottom than in overlying waters. This difference may promote resuspension and transport of larger grain-sized sediment than would otherwise occur in the absence of "bottom trapping." Enhancement of tides by topographic features also can cause unusually strong mean flows which can result in unidirectional sediment transport. Bottom trapping of the tidal currents has been observed previously over the continental shelf off Pt. Sur (Sielbeck, 1991).

3.2.4 WATER COLUMN CHARACTERISTICS

Water column characteristics of greatest importance to the proposed project are temperature, salinity, and ambient noise. Temperature and salinity are important because they affect the properties of the deep sound channel, representing a key consideration for the proposed ATOC program. Ambient noise levels are important because they establish the background settings for ATOC sound transmissions. Dissolved oxygen (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 Sur Ridge, Sur Slope, and Pioneer Seamount sites are located within the OMZ depth range (500-900 m). Data for other water quality parameters, including light transmittance, pH, concentrations of trace contaminants (metals, chlorinated and petroleum hydrocarbons, and radionuclides), for the region of the alternative sites exist from a variety of sources. However, it is unlikely that the proposed action will have any demonstrable effect on, or be affected by, these parameters (see Chapter 4). EPA (1993) provides a discussion of these other parameters for the general project region.

3.2.4.1 Temperature-Salinity Properties

Recent hydrographic and current measurements indicate that the outer shelf and slope regions off central California are dynamic areas (Ramp et al., 1992). Current and water mass variability occurs on time scales from days to months, corresponding to current and wind events and seasonal patterns. Surface waters show a great deal of variability in temperature-salinity (T-S) properties.

In the study area, a typical temperature-versus-depth profile during summer consists of a surface layer of nearly constant temperature that is tens of meters 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 varies depending on the characteristics and extent of mixing of the various water masses.

3.2.4.2 Dissolved Oxygen

Dissolved oxygen (DO) concentrations are important because they can affect the diversity and abundance of marine organisms. In upwelling areas, such as off the central California coast, organic material associated with high primary production settles through the water column and consumes oxygen via microbial respiration as it sinks. The depletion of dissolved oxygen at depths of about 500 to 900 m produces an OMZ (DO values as low as 0.5 mg/l) (Broenkow and Green, 1981). Intersection of the OMZ with the sea floor potentially can affect the distribution of oxygen-sensitive organisms.

DO concentrations in surface waters are approximately 8 mg/l. DO concentrations averaged over a period of 18 years at a location offshore from Pt. Reyes and north of the Farallon Islands ranged from 8.7-10.1 mg/l at the surface to 5.3-7.3 mg/l at 50 m. The higher concentrations typically were measured in January and lower concentrations occurred in October. Concentrations near all alternative sites are expected to decline through the mixed layer, and reach minimum values of about 0.5 mg/l at a depth of 800 m. Below 800 m, DO concentrations increase to over 3 mg/l at depths greater than 2,000 m (Figure 3.2.4.2-1). This DO concentration/depth pattern is similar to those reported for other portions of the central California continental margin (Thompson et al., 1985).

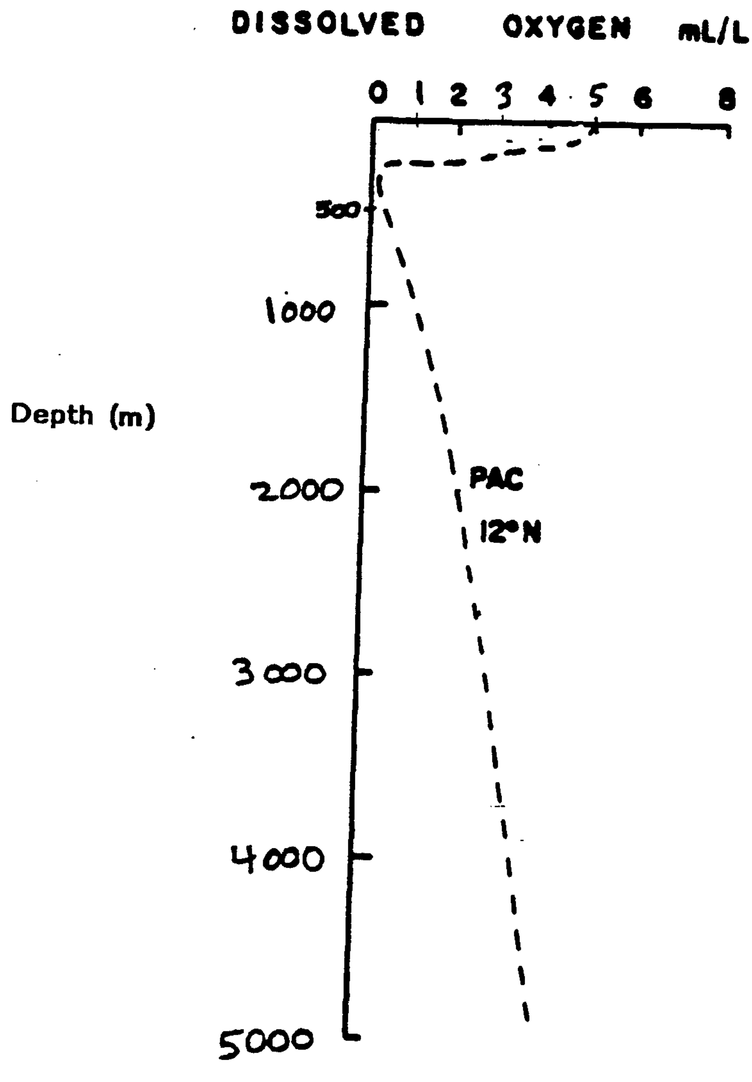
3.2.4.3 Existing Noise Setting

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

- Tidal currents and waves
- Wind and rain over the water surface
- Water turbulence and infrasonic noise
- Biological sources
- 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 ATOC source frequency band can reach 107 dB (re:1μpa at 1m) from natural sounds alone (Heindsman et al., 1955), and up to 120 dB in major storms.

Noise associated with human sources varies with the characteristics of the specific noise source as well as the distance between the source and the alternative sites. The primary man-made noise source within the study area is expected to be associated with ship and vessel traffic. This source may include commercial tankers and container ships transiting to and from ports within San Francisco Bay, commercial fishing boats and research vessels (see Section 3.4.3), and military surface vessels, submarines, and aircraft which utilize designated operating areas along the central California coast (see Section 3.4.4). Vessel noise is primarily associated with the propeller and propulsion machinery. In general, noise levels increase with vessel size, speed, and load. Levels



(data from Reid, 1965)

Figure 3.2.4.2-1 Profiles of dissolved oxygen for Pacific Ocean within the ATOC source frequency band from large merchant ships can reach 198 dB (Table 1.1.3-1), whereas levels associated with smaller fishing vessels range from approximately 140-160 dB.

Noise associated with the passage of vessels and low-flying aircraft is expected to be transient because the source typically is moving through the study area. Based on review of information contained in the Historical Temporal Shipping (HiTS) database, major eastern Pacific tanker shipping lanes have been defined (Figure 3.2.4.3-1). The average densities (ships per 1000 nm^2) of vessels at anytime in the vicinities of the Sur Ridge/Slope and Pioneer Seamount sites are as follows: merchant-0.5 to 2 and 0.2; tankers-0.1 to 0.15 and 0.1 to 0.2; large tankers-0.005 to 0.008 and 0.007 to 0.012; supertankers-0.001 and 0.013 to 0.015; and fishing vessels-0.03 and 0.025, respectively. These densities are based on data from the months of April and August over several recent years. Figure 3.2.4.3-2 is an example of estimated tanker traffic for the month of April. The monthly variability in ship densities along the coast does not change appreciably (i.e., 20% to 30%).

In 1988, an estimated 4,500 commercial vessels (excluding fishing boats) transited through the general study area. The majority of these were passenger and dry cargo vessels, although an estimated 25% were considered medium size tankers (NOAA, 1992). Thus, averaged over a one-year period, one commercial vessel would be expected to pass through the study area every two hours. This frequency is generally consistent with the average HiTS data and expected vessel speeds. The inclusion of military, commercial fishing, and other medium size vessels would increase the number of transient noise sources (having levels similar to the ATOC source frequency, ranging from approximately 140-175 dB), occurred in the study area. Vessel movements near the alternative sites follow generalized transit routes, although designated shipping lanes occur near the entrance to San Francisco Bay. Nevertheless, approximately 63% of the north-south vessel traffic occurs within 10 nm (18 km) of the coast. Therefore, distances between vessel routes and the alternative sites, and consequently the associated vessel noise levels at the sites, are expected to vary.

At least one scientist (Ross, 1993) suggests that, although low frequency noise levels in the world's oceans increased as much as 10 dB between 1950 and 1975, this trend has probably not continued to the same degree, since ocean trade in the last decade has been hampered by high oil prices and depressed economic conditions.

The magnitude of ambient noise was measured in 1991 at a location approximately 450 km north of the proposed action site (Pioneer Seamount) and input to the Surveillance Towed Array Sensor System (SURTASS) beam noise database. An ambient noise polar plot, showing noise levels collected from a highly sensitive SURTASS towed HLA for specific frequencies, at a depth of 146 m, is presented in Figure 3.2.4.3-3. According to these measurements, noise levels for several frequencies, including 75 Hz, exceeded 90 dB, particularly in directions east and northeast (i.e., shoreward) of the sampling location. This may be related to vessel passage within coastal shipping routes. Other measurements of noise, e.g., the 1990-94 Integrated Rainform Analysis System (IRAS) database of noise (frequencies <100 Hz) within the area bounded by 34° N-38° N and 120°W-124°W, and mostly at a depth of 120 m, indicated a mean ambient noise level at 75 Hz of 82 dB (range: 74-91 dB).

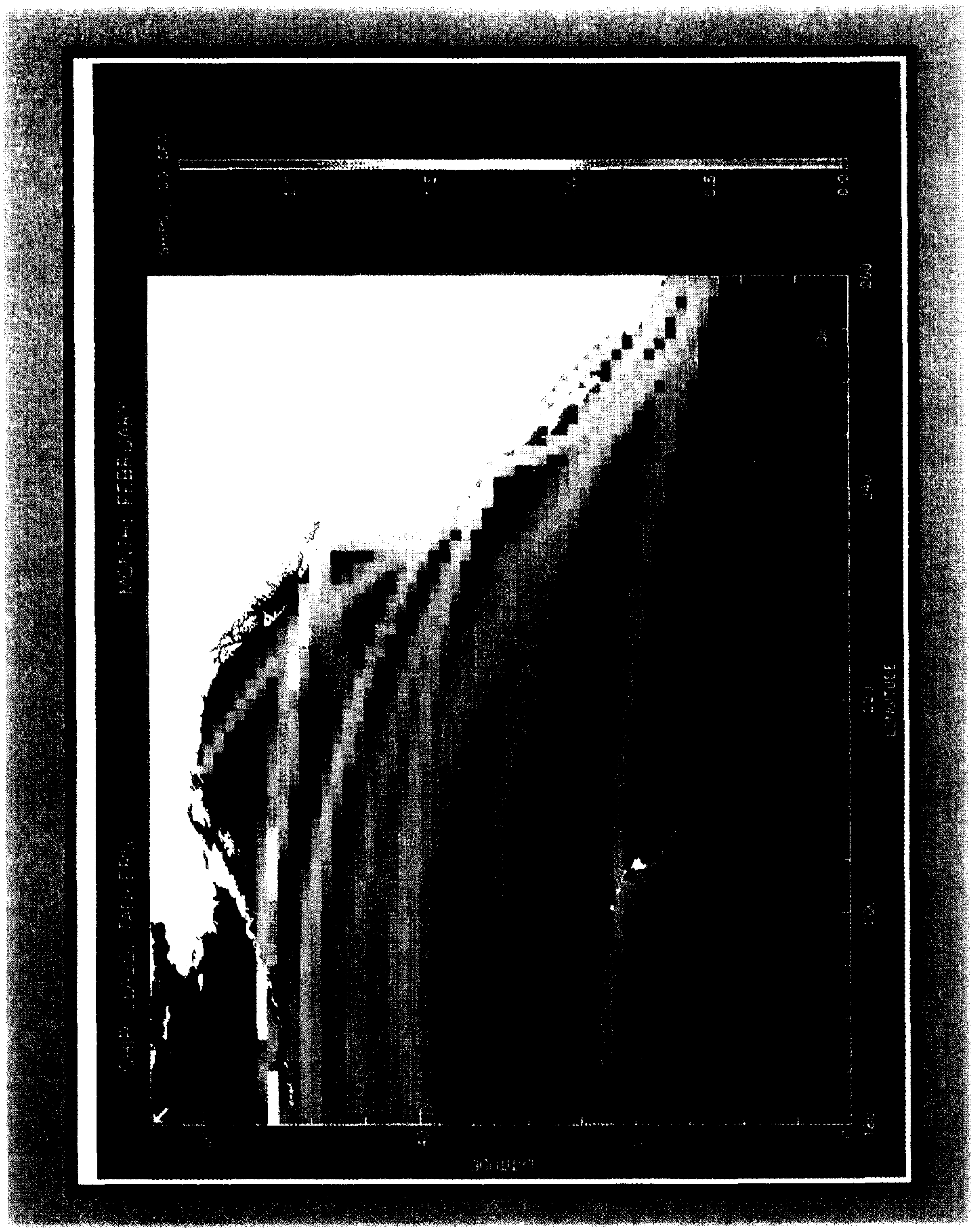


Figure 3.2.4.3-1 East Pacifc major tanker shipping lanes (from HITS model, 1994)

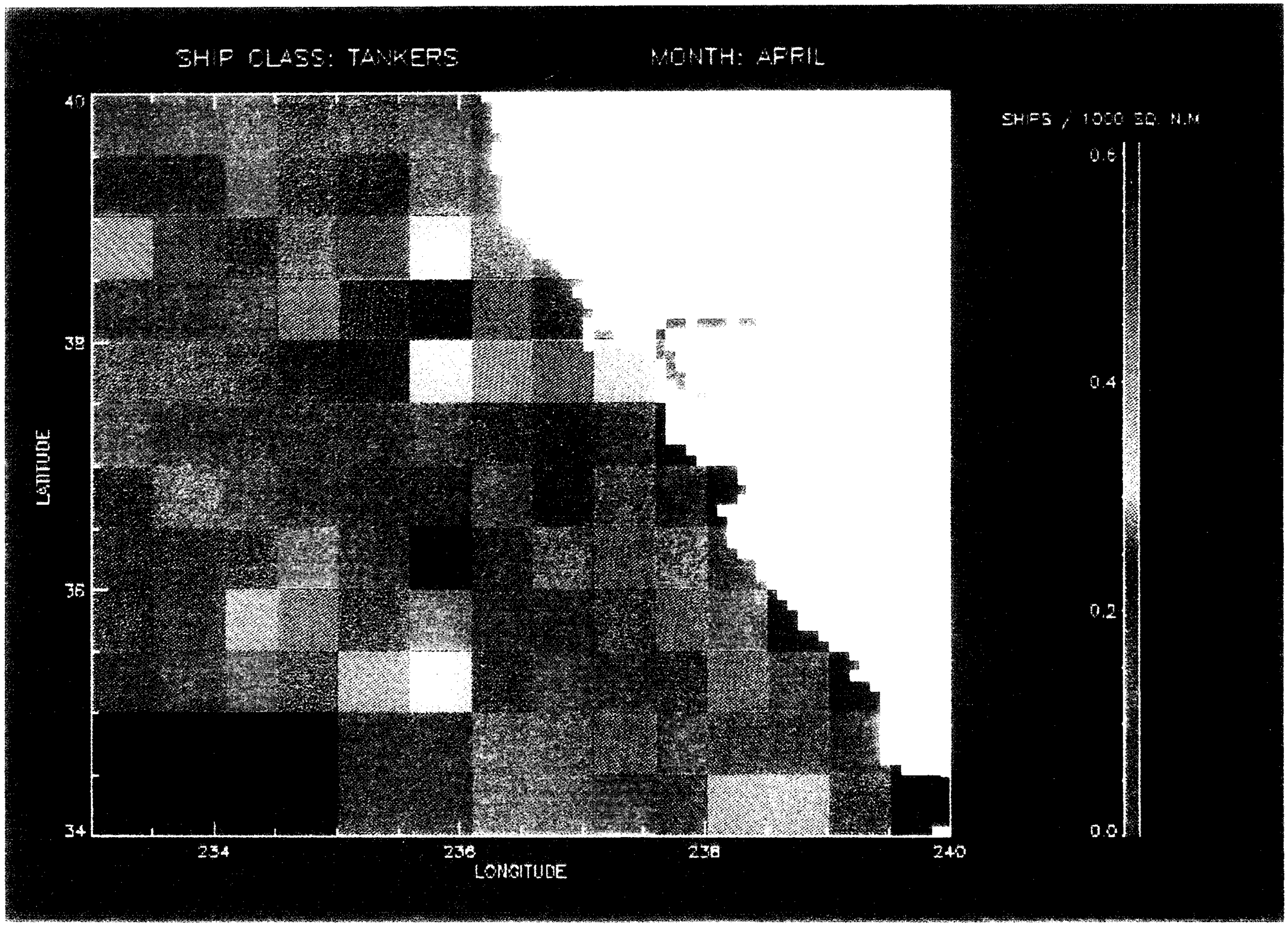


Figure 3.2.4.3-2 Central California offshore area tanker shipping density (from HITS model 1994)

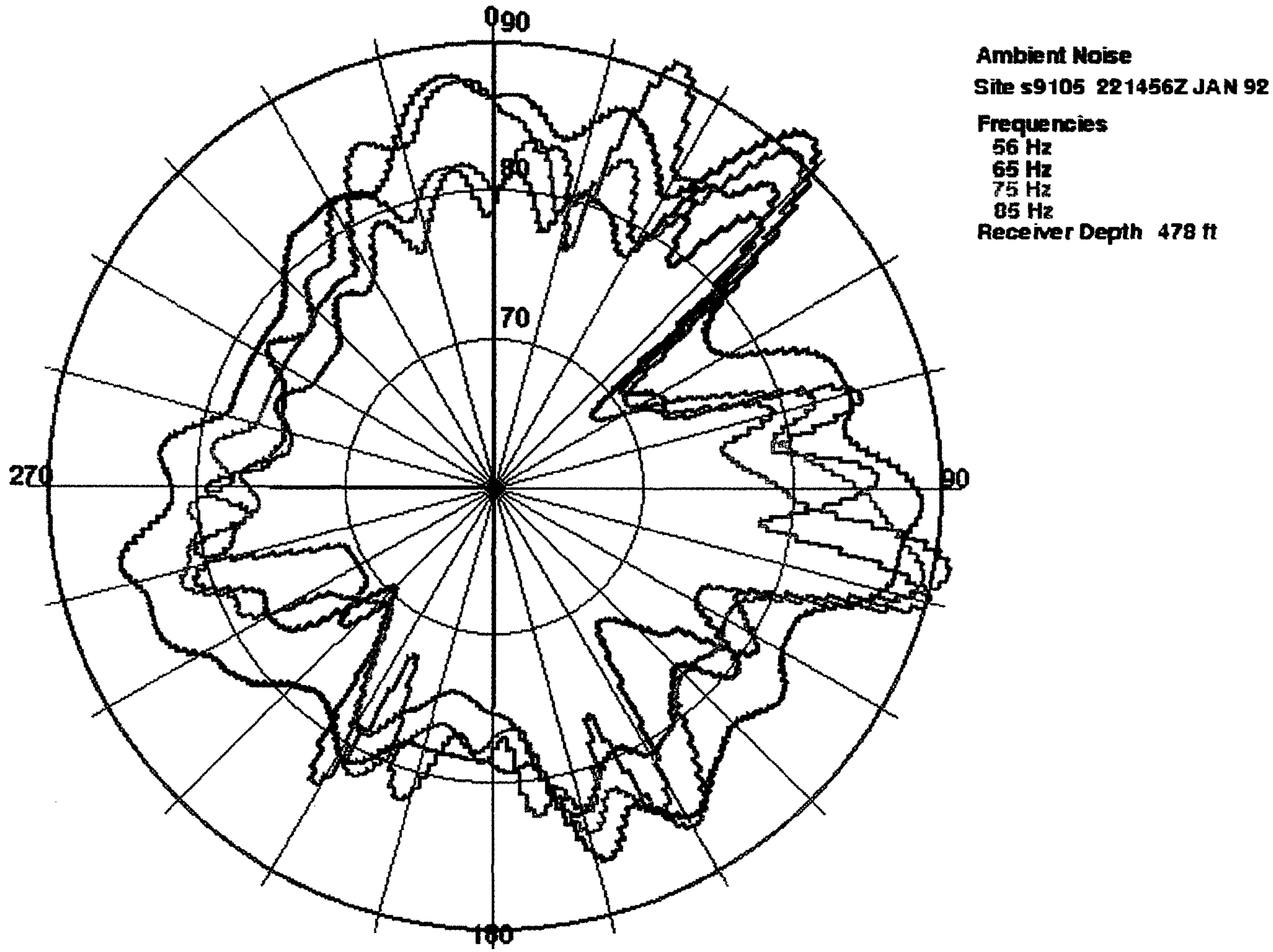


Figure 3.2.4.3–3 Ambient noise levels at a depth of 146m, 180-550 km from preferred action site (Sur Ridge)

The sound fixing and ranging (SOFAR) channel (deep sound channel) corresponds to a depth range in which the speed of sound is minimal. At depths shallower and deeper than the SOFAR channel, the speed of sound is relatively greater than in the channel due to higher water 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 alternate sites, the SOFAR channel occurs within an approximate depth range of 500-1000 m. Ambient sound levels in the SOFAR channel are generally somewhat lower than those at the surface but only by about 3 dB (Morris, 1978).

3.2.5 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. Data exist from a variety of sources on other sediment quality parameters, including concentrations of major and trace constituents, for the region of the alternative sites. However, the proposed action is not expected to affect or be affected by these sediment conditions (see Section 4). EPA (1993) provides a discussion of these parameters for the general project region. A discussion of the geographic and geologic characteristics of the proposed cable route is presented in Section 3.3.9 and in Section 1.1.6.

3.2.5.1 Regional Subsea Geography

The main divisions of the seafloor are the shore, continental shelf, continental slope and rise, and deep-sea bottom. The continental shelf extends seaward from the shore to approximately 200 m depth (Figure 3.2.1-1). Because of the variability of coastline and offshore topography in the study region, the distance that the shelf extends from shore varies from approximately 2 to 45 km (1 to 25 nm). The continental slope extends from approximately 200 m depth to an average depth of a few thousand meters (Figure 3.2.1-1). The continental slope can be further divided into upper, middle, and lower slope areas. The upper slope areas off California occur between 200 and 500 m, the middle slope between 500 and 1200 m, and the lower slope areas between 1200 and approximately 3200 m. The preferred action site (Sur Ridge), Sur Slope, and Pioneer Seamount sites are located in areas that extend from the continental shelf to the lower continental slope, with the Sur Ridge site located adjacent to a much narrower shelf region than occurs inshore from Pioneer Seamount (Figure 3.2.1-1). The southwestern side of Sur Ridge, which encompasses both Sur Ridge and Sur Slope sites, has a bottom depth below 850 m. The topography of the site is flatter than that of Pioneer Seamount. Sur Ridge is composed of sedimentary rock that has been uplifted on the eastern side and sheared (Howe, 1993). The ridge rises from a depth of about 1200 m at the base to 800 m at the crest. The eastern slope of the ridge is steep; whereas, the slope of the western side is relatively flat (4-6°; Howe, 1993).

Pioneer Seamount is located within the Farallones Escarpment. The major topographic features of the escarpment consist of Pioneer Canyon and Pioneer, Guide, and Mulburry Seamounts at the base of the slope. Pioneer Seamount rises from a depth of 2700 m at the base, to a depth of about 900 m at the summit, corresponding to apparent volcanic cones that form the ridge of the seamount (Karl, 1992). The western side has steeper slopes (23°) than the shallower, east-facing slope of the proposed action site vicinity.

3.2.5.2 Seismicity

The continental margin within the California Coast Range province is tectonically active, and the distribution of present day seismic activity reflects interactions of the Pacific and North American plates (SSI, 1993). Within the Monterey Bay region, faults lie primarily within two zones -- the Palo Colorado-San Gregorio Fault, extending between Pt. Año Nuevo and Pt. Sur, and the Monterey Bay Fault zone between Santa Cruz and Monterey (NOAA, 1992). The area near Pioneer Seamount is also expected to be tectonically active; however, little evidence of recent mass sediment movement was apparent from geophysical surveys of the area (Karl, 1992).

3.2.5.3 Bottom Conditions

Sediment grain size generally decreases with increasing depth off the central California coast, from predominantly sand-sized sediments on the continental shelf to fine-grained muds on the continental slope. The sand-to-sandy mud transition occurs at depths of 600 to 800 m (SAIC, 1992c). Above this transition depth, waves and the California Undercurrent can scour the bottom, preferentially removing the finer-grained sediments. At depths below this range the scouring effects are attenuated and fine-grained sediments have longer residence times on the bottom (Vercoutere et al., 1987).

Within the depth range of 600 to 800 m, where the slope flattens from 8 to 4%, the mud (silt and clay) content of the sediment increases from 12 to 55%. This is called the "mud line" or the mud transition (Vercoutere et al., 1987) that generally separates non-depositional or erosional bottoms above this depth range from more depositional regimes below this depth range.

Sediments near Sur Ridge are characterized as predominantly muds (silt and clays; NOAA, 1992). Sediments near the base of Pioneer Seamount consist primarily of silt and clay with little or no sand component. No information exists on sediment grain size on the summit of Pioneer Seamount, although on the top of the seamount basalts are exposed or covered with a thin layer of sediment, predominantly from oceanic or planktonic origins with little land-derived material (Karl, 1992).

3.3 BIOLOGICAL ENVIRONMENT

This section describes the biological environment within or in the general region of the alternative sites, depending on data availability. Separate sections are presented on marine mammals (3.3.1), sea turtles (3.3.2), fish (3.3.3), invertebrates (3.3.4), plankton (3.3.5), seabirds (3.3.6), threatened, endangered, and special status species (3.3.7), marine sanctuaries and special biological resource areas (3.3.8), and nearshore and landfall biota along the cable route (3.3.9).

3.3.1 MARINE MAMMALS

This section provides information on marine mammals residing in, or passing through, the general EIS/EIR study area (Figure 3.2.1-1). Thirty-four marine mammal species including seven baleen whales, twenty toothed whales, six pinnipeds, and one fissiped may reside permanently or occur seasonally to rarely within the region.

All marine mammals are protected by the Marine Mammal Protection Act (MMPA 1972, amended 1988 and 1994), administered by NOAA/NMFS and the United States Fish and Wildlife Service (USFWS). In addition, humpback, blue, fin, sei, right, and sperm whales are federally listed as endangered species and thereby protected by the Endangered Species Act (ESA, 1973, amended 1978). Gray whales have recently been de-listed from federally endangered status due to increased population numbers (NMFS, 1993). The Steller sea lion, Guadalupe fur seal, and the southern sea otter are designated as threatened species under federal law and are fully protected under California law. Northern fur seals are designated as a depleted species by NMFS and have special status under the MMPA. Because marine mammals are protected, evaluation of the alternative sites includes consideration of the extent to which the areas may be used by marine mammals for breeding, weaning, feeding, or migration.

The general Pt. Sur region, including the Sur Ridge and Sur Slope sites, is characterized by a diverse and abundant marine mammal fauna, with many species occurring seasonally. Table 3.3.1-1 provides a review of current marine mammal stocks offshore central California derived by NMFS/SWFSC (Forney and Barlow, 1993; Forney, 1993; Barlow, 1993a; Barlow, 1993c). Additional marine mammal census data for the entire California offshore area (to 556 km offshore) is available from the NOAA Ship McARTHUR Cruise No. AR-93-02 (29° N-40° N). These data have been studied and incorporated, where appropriate, in Table 3.3.1-1. To maintain conservative estimates of pinniped species, which were not the focus of the offshore surveys cited, it was assumed that all species breeding in the Southern California Bight (SCB; encompassing the body of water between Pt. Conception and a point just south of the US-Mexico border) could potentially migrate through some part of the central California coastal region. Density estimates of the one fissiped species are based on counts made by the USFWS for the Pt. Sur coast.

Pioneer Seamount lies in the southwest portion of the Gulf of the Farallones, off the continental slope. Twenty-three marine mammal species, of the 34 in the general EIS/EIR study area (seven mysticetes, eleven odontocetes, and five pinnipeds) have been observed in the Gulf of the Farallones region (Ainley and Allen, 1992). One fissiped species has been recorded occasionally in the general area.

Broad-scale surveys of marine mammals off central and northern California, including the Gulf of the Farallones and the Farallon Islands, were conducted by Dohl et al. (1983) and Bonnell et al. (1983). Dohl et al. focused on the seasonal occurrence of cetaceans while Bonnell et al. studied pinnipeds and sea otters during a three-year (1980-1983) research program. Both of

SPECIES	WINTER/ SPRING (Note 1)		SUMMER/ FALL (Note 2)	
	N	CV	N	CV
Mysticetes:				
Minke whale (*B. acutorostrata*)	71	0.61	569	1.10
blue whale (*Balaenoptera musculus*)	28	1.03	2,198	0.36
fin whale (*B. physalus*)	78	0.80	913	0.59
sei whale (*B. borealis*)	n/c	n/c	n/c	n/c
humpback whale (*Megaptera novaeangliae*)	375	0.36	609	0.41
gray whale (*Eschrichtius robustus*)	20,869	0.34	n/c	n/c
right whale (*Eubalaena glacialis*)	16	1.08	n/c	n/c
Odontocetes:				
common dolphin (*Delphinus delphis*)	270,983 (Note 3)	0.31	249,712 (Note 4)	0.28
striped dolphin (*Stenella coeruleoalba*)	n/c	n/c	20,715	0.43
Risso's dolphin (*Grampus griseus*)	28,809	0.45	9,433	0.40
Pac. white-sided dolphin (*Lagenorhynchus obliq.*)	110,398	0.44	13,060	0.58
north. right whale dolphin (*Lissodelphis borealis*)	19,835	0.43	9,390	0.58
Dall's porpoise (*Phocoenoides dalli*)	8,489	0.23	82,876	0.35
bottlenose dolphin (*Tursiops truncatus*)	2,959	0.50	1,606	0.47
killer whale (*Orcinus orca*)	62	0.75	431	1.21
sperm whale (*Physeter macrocephalus*)	857(1286)*	1.05	725(1088)*	0.47
beaked whales (*Ziphius cavirostris, Berardius bairdi, Mesoplodon* spp.)	426(852)*	0.38	1430(2860)* (Note 5)	0.91
harbor porpoise (*Phocoena phocoena*)	1,532	0.33	3,810	0.24

pygmy sperm whale (*Kogia breviceps*)	Abundance Unknown	Note 6
dwarf sperm whale (*Kogia simus*)	Abundance Unknown	Note 6
short-finned pilot whale (*Globicephala macrorhyn.*)	Abundance Unknown	Note 7

Pinnipeds (SCB unless otherwise noted):	ANNUAL	
California sea lion (*Zalophus californianus*)	122,000	
northern elephant seal (*Mirounga angustirostris*)	87,000	
harbor seal (*Phoca vitulina richardsi*)	32,325	
northern fur seal (*Callorhinus ursinus*)	30,000	Note 8
Guadalupe fur seal (*Arctocephalus townsendi*)	1-5	Note 9
Steller sea lion (*Eumetopias jubatus*)	100	Note 9
Fissiped (Pt. Sur coast):		
southern sea otter (*Enhydra lutris*)	114	Note 10

Table 3.3.1-1 Estimates of the stock of marine mammal and sea turtle species offshore central California

SPECIES	ABUNDANCE	REMARKS
Sea Turtles:		
loggerhead (*Caretta caretta*)	Unknown	Note 11
green (*Chelonia mydas*)	Unknown	Note 11, 12
olive ridley (*Lepidochelys olivacea*)	Unknown	Note 11
leatherback (*Dermochelys coriacea*)	Unknown	Note 13

***Numbers in ( ) indicate estimates accounting for whales submerged during entire survey evolution; correction factors: x 1.5 for sperm whales, x 2 for beaked whales (Barlow, pers. comm., 1995)**

Note 1: Corrected estimates from Forney et al. (1995); Buckland et al. (1992) for gray whales.
Note 2: Corrected estimates from Barlow (1993a); Forney et al. (1995) for harbor porpoises.
Note 3: Short and long beaked..
Note 4: Short-beaked only.
Note 5: Unidentified beaked whales.
Note 6: "No real estimates of abundance available" (Handbook of Marine Mammals, Vol. 4, D.K. and M.C. Caldwell, 1989)
Note 7: Dept. of Navy Report on Continuing Action (NAVFACENGCOM, SW Div., San Diego, CA, Sep 1993)
Note 8: From Bonnell et al., 1983. Majority of animals are migratory--present in central Calif. waters only in winter and early spring. Small pupping colony resides on San Miguel Island year-round
Note 9: Do not breed in SCB; therefore no incidental take is anticipated (56 FR 1608, July 30, 1990).
Note 10: Stock estimate for Pt Sur area; however, sea otters are coastal (<2 km offshore) never diving >100 m; therefore no incidental take is anticipated.
Note 11: NOAA-TM-NMFS-F/SPO-2, Dec 1992 (for eastern tropical Pacific [ETP])
Note 12: "Green turtles are the most commonly observed hard-shelled sea turtle on the western coast of the USA" (NOAA-TM-NMFS-SWFSC-186, Sep 1993)
Note 13: Predominant sea turtle species in central California coastal area (Eckert, pers. comm., 1994)

N=corrected abundance estimates.
CV=coefficient of variation calculated by Forney et al. (1995).
n/c = not calculated
SCB = Southern California Bight

Table 3.3.1-1 Estimates of the stock of marine mammal and sea turtle species offshore central California these historical studies provide seasonal estimates of the relative abundance of marine mammals within the region. In addition, a three-year (1986-88) photo-identification study on humpback and blue whales within and near the Gulf of the Farallones provides information on movements and site fidelity for these two endangered whale species common to the region (Calambokidis et al., 1990a,b). More recent marine mammal surveys by the Pt. Reyes Bird Observatory (PRBO) (Ainley and Allen, 1992) and EPA (Jones and Szczepaniak, 1992) have focused on deeper waters south and west of the Gulf of the Farallones National Marine Sanctuary (GOFNMS). Ainley and Allen (1992) provide information on regional use by marine mammals; this information was collected during seven cruises conducted each June from 1985-91. Thus, seasonal events within the study region, such as the spring and fall migrations of gray whales and the late summer concentrations of humpback whales, are not represented in these survey results. In contrast, Jones and Szczepaniak (1992) conducted five cruises between August 1990 and November 1991 on marine mammal use of the region. Although coverage of the region was not uniform, these surveys supply incidental information on seasonal occurrence. Therefore, site-specific data (historical and recent) exist for marine mammals of the region and may be used to determine relative marine mammal use.

During the 1980-83 surveys, Dohl et al. (1983) counted 116,800 cetaceans comprising 18 species. The most abundant odontocetes were the Pacific white-sided dolphin, followed by the northern right whale dolphin, Risso's dolphin, Dall's porpoise, and the harbor porpoise. The most common baleen whales were the California gray whale followed by the humpback whale. Sperm, blue, minke, and killer whales also were sighted, although their abundances were lower. Overall, the highest densities of cetaceans occurred in autumn and winter.

Results from the northern and central California regions surveyed by Dohl et al. (1983) indicate that for all cetaceans combined, abundance estimates were highest near the Gulf of the Farallones. According to this study, all slope and deep-water areas contained cetaceans during March through May with moderate to high densities (0.3-1.2/km^2) in waters west of the GOFNMS and approximately 22 km (12 nm) north of Pioneer Seamount; moderate densities (0.3-0.6/km^2) in waters 9-28 km (5-15 nm) east of Pioneer Seamount; and low densities (0.01-0.15/km^2) over continental shelf waters east of Pioneer Seamount and slope waters approximately 19 km (10 nm) southeast of Pioneer Seamount.

Recent censuses indicated similar marine mammal occurrences and species within the Gulf of the Farallones region (Ainley and Allen, 1992; Jones and Szczepaniak, 1992). During the June 1985-91 surveys, Ainley and Allen (1992) reported a higher incidence of cetaceans over slope and deep waters. Deeper waters north of Pioneer Seamount had the highest counts for a single species (22 Pacific white-sided dolphins) (Ainley and Allen, 1992). However, the highest number of cetacean species and the highest counts for some species, including 15 Pacific white-sided dolphins, 7 humpback whales, 2 Risso's dolphins, and 1 minke whale, were reported for slope waters southeast of Pioneer Seamount. Cetaceans observed within slope waters east of Pioneer Seamount included 12 Risso's dolphins, 3 Pacific white-sided dolphins, and 1 Dall's porpoise. In contrast, only three cetaceans (2 harbor porpoises and 1 humpback whale) were observed in shelf waters.

During June surveys from 1985-91, Dall's porpoise, Pacific white-sided dolphin, and harbor porpoise were the most abundant odontocetes near Pioneer Seamount (Ainley and Allen, 1992). Of the larger cetaceans, humpback whales were the most abundant, followed by minke and gray whales. Seasonal surveys conducted by the EPA (Jones and Szczepaniak, 1992) also reported Dall's porpoise and Pacific white-sided dolphin as the most frequently observed cetaceans, although only two harbor porpoise were observed during the entire study. In contrast to the findings of Dohl et al. (1983), no gray whales were observed during EPA surveys; instead, humpback whales were the most frequently sighted baleen whale (Jones and Szczepaniak, 1992).

The seven species of large whales that occur within the Pioneer Seamount study region are classified as seasonal visitors or migrants (Table 3.3.1-1). Gray, humpback, and blue whales are listed as seasonal visitors because they likely feed opportunistically in, as well as migrate through, the Gulf of the Farallones region. Conversely, fin, sei, and right whales are listed as migrants or incidentals because they appear to pass through the area during seasonal migrations, rarely stopping to feed. Sperm whales are known to inhabit the central California coastal area, particularly during the May-September timeframe, but researchers are not in agreement as to indications of true migration patterns through the area. The following paragraphs provide information on the distribution, abundance, and general life history of mysticetes, odontocetes, pinnipeds, and the fissiped within the study area corresponding to the alternative sites.

3.3.1.1 Mysticetes

Baleen whales, or mysticetes, include minke whales (*Balaenoptera acutorostrata*), blue whales (*B. musculus*), fin whales (*B. physalus*), sei whales (*B. borealis*), humpback whales (*Megaptera novaeangliae*), gray whales (*Eschrichtius robustus*), and right whales (*Eubalaena glacialis*) (Table 3.3.1-1). Overall comparisons of mysticete abundances indicate that populations have increased in numbers offshore California over the 12-year period from 1979/80 to 1991 (Barlow, 1993b). Barlow (1993c) summarized current population demographic information for baleen whales that occur seasonally in California coastal waters. Forney et al. (1995) and Barlow (1993a) provided population estimates for mysticetes offshore California from winter/spring 1991-92 aerial surveys (to 278 km/150 nm offshore), and summer/fall 1991 ship surveys (to 556 km/300 nm offshore). Mysticete population estimates for the Pt. Sur region summarized in Table 3.3.1-1 are based on these surveys.

The summer range of the minke whale population in the eastern North Pacific extends from northern Baja California to the Chukchi Sea. In winter they can be found from central California to the equator, with most of them below the latitude of Pt. Conception (35°N latitude). These whales dive to depths of less than 500 m and are not known to make prolonged dives. More minke sightings have been reported in the SCB in spring/summer than fall/winter, but this may be due to sighting conditions rather than actual seasonal movements of whales (Leatherwood et al., 1987). Forney et al. (1995) estimated 71 animals during winter 1991 aerial surveys; no minke whales were sighted during the 1992 surveys. Only one minke was seen in the NMFS/SWFSC survey of the central California region (offshore between 34° 30'N and 40° N latitude) that includes Pt. Sur and Pioneer Seamount.

There is evidence that minke whales are year-round residents in the Gulf of the Farallones (PRBO, unpubl. data) and in Monterey Bay (Stern, 1990). The sexes of resident populations in the gulf and off Monterey migrate separately (Stern, 1990). Dohl et al. (1983) sighted 16 minke whales over 3 years, with only one animal seen near the Farallon Islands in 1981. A single minke whale was observed over slope waters south of Pioneer Seamount during the June PRBO (1992) surveys. The majority of minke whales observed during these surveys were along the northern coastline of the study region (Ainley and Allen, 1992). EPA surveys observed only two minke whales shoreward of the 100 m depth contour (Jones and Szczepaniak, 1992).

Blue whales winter from central California to about 20° N latitude, and summer from central California to the Gulf of Alaska. They are seen relatively often off southern California from June to December, with sightings most frequent from July to October (Leatherwood et al., 1987). Similar to minke whales, these animals are not known to make prolonged deep dives, but may possibly dive to depths of approximately 200 m, remaining submerged for up to 18 min (Mate et al., 1992). Blue whale abundance estimated from the 1991 spring/summer ship survey was between 2198 (Barlow, 1993a) and 2364 (Barlow, 1993b). Forney et al. (1995) estimated 28 animals offshore California during winter/spring 1991-92 aerial surveys; however, this estimate was based on only a single whale sighting offshore of the SCB. In contrast, a separate study, based on photo-identification of animals, suggested at least 1000 blue whales, with over 600 individuals specifically identified (Calambokidis et al., 1993). However, only seven individuals were observed in the Pt. Sur region.

Blue whales use the Farallon Basin for feeding in summer and early fall, but occur in lower numbers (Dohl et al., 1983). A total of 179 blue whales were identified photographically in the Gulf of the Farallones over three years (1986-88), with some movement of individual whales between the Farallones and feeding aggregations in Monterey Bay documented in 1987 and 1988 (Calambokidis et al., 1990b). In 1986, a single sighting of 41 blue whales was recorded near Southeast Farallon Island (PRBO, unpubl. data), the same year that unusually large aggregations of blue whales were observed feeding on euphausiids in Monterey Bay (Schoenherr, 1991). During the EPA (1992) surveys, blue whales were seen in slope waters east of Pioneer Seamount and shelf waters in August, with most seen along the continental shelf break. No blue whales were observed along survey transects during the June 1985-91 surveys (Ainley and Allen, 1992).

Recent surveys suggested aggregations of fin whales remain year-round in southern and central California offshore waters (Barlow, 1993a). Barlow estimated 913 animals occurring in California coastal waters during summer/fall 1991. In contrast, Forney et al. (1995) estimated 78 fin whales offshore California during winter 1991-92 aerial surveys. All sightings during the 1991 surveys were made within the inshore region of the SCB. Fin whales may potentially dive to 335 m depths, remaining submerged for up to 20 min (Scholander, 1940). They feed on small fish, crustaceans, and squid (Caldwell and Caldwell, 1983).

Sei whales are distributed offshore in deeper waters and do not appear to be associated with coastal bottom features (Barlow, 1993c). They winter from Pt. Piedras Blancas (35° 30'N latitude) south to the Revillagigedo Islands (18° 30'N latitude) (Leatherwood et al., 1982). In summer, most sei whales are found west of the Channel Islands (offshore southern California) and north throughout the Gulf of Alaska (Leatherwood et al., 1982). None were seen offshore California during winter/spring 1991 ship surveys (Barlow, 1993a; Table 3.3.1-1). Based on these results, Barlow (1993) concluded that sei whales are rare in California coastal waters. The maximum diving depth for sei whales is believed to be less than 200 m (Castro and Huber, 1992); prey items include surface plankton, krill, small schooling fish, and squid (Caldwell and Caldwell, 1983).

Endangered fin and sei whales rarely occur in the Farallones study region (Dohl et al., 1983), and none were observed during the PRBO (Ainley and Allen, 1992) and EPA (Jones and Szczepaniak, 1992) surveys. Thirty sightings of a total of 56 fin whales were recorded from 1980-83 (Dohl et al., 1983), with 70% of the sightings occurring in continental shelf and slope waters. One fin whale was seen about 11 nm (20 km) west of Pt. Reyes, and a group of 5 to 8 whales was observed just south of the Farallon Islands in 1981. Although the Gulf of the Farallones lies within the distributional range of sei whales (Caldwell and Caldwell, 1983), none were recorded during recent (Ainley and Allen, 1992; Jones and Szczepaniak, 1992) or historical (Dohl et al., 1983) surveys.

The summer distribution of humpback whales off California appears to be centered near the Farallon Islands. The waters off southern California apparently are migration corridors. Humpbacks are seen seasonally in the SCB in fall and spring as they travel to and from wintering grounds off Mexico. Over a three-year survey period (1980-82) during August-November, an estimated 338 (±199) humpbacks resided in California coastal waters between Pt. Conception and the California-Oregon border (Dohl et al., 1983). However, this estimate did not include a correction factor for submerged whales (Barlow, 1993a). The abundance of humpback whales in the fall of 1991 was estimated by Calambokidis et al. (1992) as ranging from 551 to 719 individuals. These latter estimates are very close to more recent estimates of 609 (Table 3.3.1-1) and are well within 95% confidence intervals. In contrast, Forney et al. (1995) estimated 375 humpbacks offshore California during winter/spring 1991-92 aerial surveys. This was based on a total of 13 individuals sighted, of which only 3 were in the central California region. Maximum diving depths for humpback whales are approximately 150 m; they may remain submerged for up to 21 min (Dolphin, 1987). They feed on krill and small schooling fish (Caldwell and Caldwell, 1983).

Annual local populations have been estimated at roughly 150-200 whales in the region for the years 1986-88 (Calambokidis et al., 1990a). During more recent surveys, highest abundances were observed in August between shelf and slope waters east of Pioneer Seamount (EPA, 1992), while data from the multi-year June surveys (Ainley and Allen, 1992) suggested higher relative abundances in deeper waters south of Pioneer Seamount. Calambokidis et al. (1990a) described movements of humpbacks between feeding aggregations in the Gulf of the Farallones and along the California coast, particularly in Monterey Bay. Differences in sighting distributions from the PRBO and EPA surveys could result from differences in survey timing, or movement of the whales between Monterey Bay and Gulf of the Farallones feeding areas.

The eastern Pacific population of gray whales ("California stock") is currently estimated at 21,113 individuals and is considered to be essentially recovered from historical reductions attributable to commercial whaling (IWC, 1990; Marine Mammal Commission, 1993). Migrations occur twice annually between winter breeding lagoons in Baja California and summer feeding grounds in the Bering and Chukchi seas (Moore et al., 1986; Swartz, 1986; Clarke et al., 1989). Ninety-four percent of all migrating gray whales pass within 1.6 km (0.9 nm) of the Monterey-Pt. Sur coast (Rice et al., 1984). The most recent absolute population size estimate for 1987-88 is 20,869 animals (Buckland et al., 1993). The main corridor of migration for this species, especially during northward migrations lies close to shore, following coastal contours (Poole, 1984). Gray whales are believed to dive to depths less than 200 m (Castro and Huber, 1992), and feed on burrowing crustaceans, primarily amphipods. There are incidental reports of gray whales associated with sediment trails (which indicate feeding) near the Farallon Islands and off Pt. Reyes (Nerini, 1984; PRBO, unpubl. data) and there is evidence that gray whales feed opportunistically near the Farallon Islands as well (P. Jones, EPA, pers. comm., 1992).

There is recent evidence of year-round residency of some gray whales in the Gulf of the Farallones (PRBO, unpubl. data). Southbound gray whales may appear as early as October, with the majority of animals occurring in late December-early January (Dohl et al., 1983). Individuals usually pass west of the Farallon Islands on their way south from Pt. Reyes (Dohl et al., 1983). The year-round residency of some gray whales in the Gulf of the Farallones indicates that some breeding/calving of gray whales may occur in the study region. For the proposed action site (Pioneer Seamount), this would place the 120 dB sound field at least 30 km to the southwest of most of the migrating gray whales. The northward gray whale migration period is less well defined, but generally occurs from mid-January through June (Dohl et al., 1983; Herzing and Mate, 1984). Northbound animals tend to stay closer to shore, especially cow/calf pairs.

Few gray whale sightings were recorded during the PRBO surveys, although moderately high counts were made near the northwest boundary of the GOFNMS (Ainley and Allen, 1992). This overall scarcity of sightings could be due to limitation of the field effort (May/June surveys only). However, gray whales also were not observed during the EPA seasonal surveys (Jones and Szczepaniak, 1992). In recent years, 3 to 8 gray whales summered in the vicinity of the Farallon Islands (Dohl et al., 1983; Huber et al., 1986).

Right whales are slow swimmers that are usually seen near shore in continental shelf waters. However, there have been only 13 sightings in California waters during this century (Scarff, 1986; Carretta et al., 1994), with only 5 sightings in the SCB since 1955. The most recent right whale sighting was in March 1992 during the NMFS/SWFSC surveys, from which Forney et al. (1995) estimated a population size of 16 whales (Table 3.3.1-1). These whales are not thought to be deep divers, with maximum diving depths believed to be less than 200 m (Castro and Huber, 1992).

The Gulf of the Farallones lies within the distributional range of right whales (Caldwell and Caldwell, 1983); however, none were recorded during recent (Ainley and Allen, 1992; Jones and Szczepaniak, 1992) or historical (Dohl et al., 1983) surveys.

3.3.1.2 Odontocetes

Toothed whales or odontocetes are represented by twenty species in the Pt. Sur study area, including common dolphin (*Delphinus delphis*), striped dolphin (*Stenella coeuruleoalba*), Risso's dolphin (*Grampus griseus*), Pacific white-sided dolphin (*Lagenorhyncus obliquidens*), northern right whale dolphin (*Lissodelphis borealis*), Dall's porpoise (*Phocoenoides dalli*), bottlenose dolphin (*Tursiops truncatus*), killer whales (*Orcinus orca*), sperm whales (*Physeter macrocephalus*), pygmy sperm whale (*Kogia breviceps*), dwarf sperm whale (*K. simus*), short-finned pilot whale (*Globicephala macrorhyncus*), seven species of beaked whales (*Ziphius cavirostris, Berardius bairdi,* and *Mesoplodon* spp.), and harbor porpoise (*Phocoena phocoena*). Estimates of toothed whale abundances presented in Table 3.3.1-1 are drawn from the winter/spring 1991-92 aerial surveys conducted offshore California (Forney and Barlow, 1993) and the summer/fall ship surveys (Barlow, 1993a). Absent from this discussion are false killer whales (*Pseudorca crassidens*). False killer whales are seen occasionally in the area, but were not sighted in either of the recent aerial or ship surveys.

Odontocetes occurring within the Gulf of the Farallones region include Risso's dolphin, Pacific white-sided dolphin, northern right whale dolphin, Dall's porpoise, killer whales, sperm whales, beaked whales, and harbor porpoises. In contrast to the preferred action site (Sur Ridge), common dolphins, striped dolphins, and bottlenose dolphins do not typically occur within the Pioneer Seamount study area.

Common dolphins occur more frequently over areas of steep topographic relief than flat areas (Hui, 1985), an association that may be related to the availability of prey. Maximum diving depths for common dolphins are 260 m with a maximum submergence time of 5 min (Evans, 1971). During 1991-92 aerial surveys, 94% of the animals sighted were in southern California waters.

In the eastern North Pacific, striped dolphins are most common from 20° N latitude southward to the equator. Barlow (1993a) estimates a population abundance of 20,715 based on the summer/fall ship survey covering the entire California coastal area out to 556 km (300 nm). No striped dolphins were sighted less than approximately 185 km (100 nm) from shore during the summer/fall ship survey, and none were seen during the winter/spring aerial surveys that extended to 278 km/150 nm offshore (probably because of their more offshore, warm water distribution; Forney and Barlow, 1993). Similar to common dolphins, maximum diving depths for striped dolphins are less than 400 m (Ross and Bass, 1984). They feed at mid-depths on fish, squid, and crustaceans (Caldwell and Caldwell, 1983).

Risso's dolphins inhabit offshore waters and are likely part of a population that extends both north and south of California's latitudinal boundaries. Forney et al. (1995) estimated 28,809 animals offshore California during winter/spring 1991-92, with most individuals (49%) in central California waters. Risso's dolphins are believed to be able to dive to approximately 610 m depth, based on their frequent association with pilot whales (Leatherwood and Reeves, 1983). Squid are preferred prey items, although some fish species are consumed (Caldwell and Caldwell, 1983).

Risso's dolphins comprised 18% of the cetaceans sighted by Dohl et al. (1983). The few Risso's dolphins that were seen within the study region during PRBO surveys were along slope waters east of Pioneer Seamount (Ainley and Allen, 1992). Although Risso's dolphins occur regularly in the Gulf of the Farallones, the population reportedly is concentrated in southern

California waters (Dohl et al., 1983). Jones and Szczepaniak (1992) recorded a single sighting of a Risso's dolphin in slope waters south of Pioneer Seamount.

Dohl et al. (1983) found the largest numbers of Pacific white-sided dolphins in California waters in the fall north of Pt. Conception. However, seasonal movements off southern California are not well understood, and there appear to be resident pods that increase in size from fall through spring due to arrivals of animals from other areas (Leatherwood et al., 1987). Forney et al (1995) estimated 110,398 animals offshore California during the 1991-92 winter/spring season. Most of the sightings (52%) were off central California. Pacific white-sided dolphins may dive to 215 m depths, remaining submerged for up to 6 min (Hall, 1970). They feed on a variety of fish (northern anchovy, whiting, saury) and squid species (Caldwell and Caldwell, 1983).

Within the Gulf of the Farallones, Pacific white-sided juveniles were observed from July through October with the highest number of sightings between Pt. Conception and Pt. Reyes, including heavy use of the Gulf of the Farallones region (Dohl et al., 1983). Counts of this species over five years indicated moderate numbers (11-100 individuals) observed over slope waters in and around Pioneer Seamount, although greatest abundances were observed within the GOFNMS (Ainley and Allen, 1992). During EPA surveys, this species was seen in low to moderate abundances over slope waters in the Pioneer Seamount vicinity during August 1990 and 1991 (Jones and Szczepaniak, 1992). These results indicate that slope and deep-water habitats (depths greater than 200 m) are used more often than shelf waters (depths between 50 and 200 m), as reported by Dohl et al. (1983).

Northern right whale dolphins use nearshore waters between Pt. Piedras Blancas and Pt. Piños as a breeding ground in winter (Dohl et al., 1983). They comprised 35% of all animals sighted by Dohl et al. (1983), and usually were observed over deep waters. Diving depths are relatively shallow (usually less than 300 m; Clark, 1993). Forney et al. (1995) estimated 19,835 animals offshore California, with only 11.5% of the sightings in central California waters. Leatherwood et al. (1987) reported that their distribution appears to shift south and inshore between October and June, then north and offshore from summer through fall. Northern right whale dolphins feed primarily on squid, lanternfish, and other mesopelagic fish at depths less than 300 m (Leatherwood and Reeves, 1983; Dohl et al., 1983; Castro and Huber, 1992).

During the PRBO surveys (Ainley and Allen, 1992), most northern right whale dolphins were seen within the GOFNMS, with fewer sighted over upper slope waters east of Pioneer Seamount. EPA sightings of this species were over slope waters southeast of Pioneer Seamount (Jones and Szczepaniak, 1992). All EPA sightings occurred during August and October surveys, confirming the observation by Dohl et al. (1983) that this species tends to be found over slope waters during autumn. Thus, like Pacific white-sided dolphins, with which they commonly co-occur, northern right whale dolphins prefer slope and deep-water habitats rather than continental shelf waters.

Throughout most of the eastern North Pacific, Dall's porpoises are present during all months of the year, although there may be seasonal onshore-offshore movements along the west coast of the U.S. (Leatherwood and Fielding, 1974; Loeb, 1972). Dall's porpoises were the most frequently encountered species during 1980-83 surveys (Dohl et al., 1983), occurring in small aggregations, which accounted for only 2% of the overall number of cetaceans observed (Dohl et al., 1983). Forney et al. (1995) estimated 8,489 animals from the 1991-92 winter aerial surveys, with most sightings (42%) off the central California coast. The maximum diving depth for Dall's porpoise is estimated to be approximately 610 m, based on their frequent association with pilot whales, from about 40°N latitude southward (Leatherwood and Reeves, 1983). They are nocturnal feeders, primarily consuming anchovies, squid, crustaceans, and deep-water fish (Morejohn, 1979; Jones, 1981; Ainley and Allen, 1992).

Dall's porpoise were the most frequently observed cetaceans within the study region during PRBO (1992) surveys, primarily within GOFNMS boundaries. During EPA (1992) surveys, this species occurred most often in summer in the study region (Jones and Szczepaniak, 1992) with greatest numbers occurring along the seaward edge of the continental shelf and slope (Ainley and Allen, 1992; Jones and Szczepaniak, 1992). Preferred prey abundance may significantly affect the foraging range of the species. For example, the highest densities of Dall's porpoise were observed around the Farallon Islands, coincident with unusually high numbers of anchovies (Ainley and Allen, 1992).

Three stocks of bottlenose dolphins have been recognized in the eastern North Pacific (Hansen, 1990). Two of these stocks, the coastal form and the northern temperate offshore form, are believed to occur along the coast of California (Hansen, 1990). The coastal form appears to occur only near shore (< 18.5 km [10 nm]), inhabiting shallow water just beyond the surf and in bays and estuaries (Hansen, 1990). The northern temperate offshore form inhabits offshore waters from within a few kilometers of the coast to at least 556 km (300 nm) offshore. Forney et al. (1995) estimated 2959 bottlenose dolphins offshore California, with all but one sighted within waters of the SCB. Bottlenose dolphins may dive to maximum depths of 535 m, remaining submerged for 8 min (Kanwisher and Ridgway, 1983). They feed on a variety of fish, squid, shrimp, and crabs (Caldwell and Caldwell, 1983).

Killer whales occur from the Gulf of California more or less continuously along the Pacific coast from 35° N to just below 5°S latitude (NMFS, 1991). Dohl et al. (1983) reported that killer whales ranged along the entire California coastline, occurring most frequently over the continental slope north of Monterey Bay. Forney et al. (1995) estimated the California population at 62 based on only 2 sightings of single whales, neither of which was in central California waters, during the 1991-92 aerial surveys. Based on recent information from the Vancouver Aquarium, killer whales commonly dive as deep as 100 m and may, on occasion, dive as deep as 500 m (Ford, pers. comm., 1995). Prey items include pinnipeds, fish, squid, sea turtles, seabirds, and other marine mammals (Caldwell and Caldwell, 1983).

A group of 5 to 8 killer whales was seen west of the Farallon Islands in 1981 (Dohl et al., 1983). However, none were observed during long-term (Ainley and Allen, 1992) or seasonal surveys (Jones and Szczepaniak, 1992) of the Gulf of the Farallones region.

Sperm whales are commonly found off central California, with peaks of abundance in mid-May and mid-September, suggesting a northward migration in the spring and a southward migration in fall. From November to April, breeding groups are sighted over the continental slope off California between 33° to 38°N latitude (Gosho et al., 1984). There were 66 sightings of a total of 218 sperm whales from 1980-83 (Dohl et al., 1983), with 68% of the sightings in water depths greater than 1700 m (leading to the assumption that approximately 30% occur in water depths of 1000-1700 m). Forney et al. (1995) estimated 857 sperm whales offshore California during the winter/spring period. However, only 3 sightings were made, one of which was in waters off the central California coast. Sperm whales show a strong preference for deep waters, usually along the 1000 m contour and seaward of the continental slope (Whitehead and Weilgart, pers. comm., 1993). They can dive to depths of 2000 m and more, and may remain submerged for an hour or more (Watkins, et al., 1993). Sperm whales feed primarily on giant squid, but may also eat a variety of fish (Caldwell and Caldwell, 1983), and other cephalopods (Fiscus et al., 1989).

Pygmy sperm whales appear to be cosmopolitan, with sightings recorded for nearly all temperate, subtropical, and tropical waters. Along the west coast they are found from Gray's Harbor, Washington, to Baja California. There are no reliable abundance estimates for this species because distributional data are based almost exclusively on stranding records, and even these are suspect due to the failure of many observers to distinguish pygmy sperm whales from the smaller, dwarf sperm whale. Maximum diving depths for pygmy sperm whales are unknown, but believed to be deeper than the smaller dwarf sperm whale (i.e., 300-600 m). Preliminary analysis of stomach contents indicate that pygmy sperm whales are primarily pelagic, feeding on squid, crabs, shrimp, and some fish, usually staying seaward of the continental shelf. None were observed during recent surveys of the Gulf of the Farallones region (Ainley and Allen, 1992; Jones and Szczepaniak, 1992).

Dwarf sperm whales have only recently been recognized as a distinct species from pygmy sperm whales. Most historical records of species abundance and distribution have been lumped together with those of the larger pygmy sperm whale. As a result, the limits and extent of its range are not well-defined. In the eastern Pacific, it has been recorded from central California to the southern coast of Baja, California. It is also seen off Hawaii. Analysis of stomach contents indicate that they dive to depths of at least 300 m, and that their distribution may be somewhat more inshore than that of the pygmy sperm whale, perhaps centered along the edge of the continental shelf. Similar to pygmy sperm whales, they are known to feed on squid, crustaceans, and fish. No dwarf sperm whales were observed during recent surveys within the Gulf of the Farallones (Ainley and Allen, 1992; Jones and Szczepaniak, 1992).

Short-finned pilot whales were previously common in southern California, but have not been seen during recent survey efforts. The El Niño event of 1983 may have disrupted their distribution pattern. Since that time, they have not reestablished their populations in offshore southern California waters (Forney, 1993). Radiotelemetric studies have shown that these whales can dive to depths of at least 610 m (Leatherwood and Reeves, 1983) feeding on squid and fish (Caldwell and Caldwell, 1983). None were observed during recent surveys of the Gulf of the Farallones region (Ainley and Allen, 1992); however, Jones and Szczepaniak (1992) cite the observation of one group of 25 in October, 1991.

Seven species of beaked whales occur offshore California: Baird's beaked whale, Hubb's beaked whale (*Mesoplodon carlhubbsi*), Ginkgo-toothed beaked whale (*M. ginkgodens*), Stejneger's beaked whale (*M. stejnegeri*), Cuvier's beaked whale, Blainville's beaked whale (*M. densirostris*), and Hector's beaked whale (*M. hectori*). Cuvier's beaked whales are the most widely distributed and frequently sighted in the northeastern Pacific (Mead, 1984; Leatherwood et al., 1987). Overall, there is much uncertainty about the number and seasonal distribution of beaked whales. Most beaked whales are thought to forage offshore in relatively deep water (Leatherwood et al., 1987; Mead, 1989), diving as deep as 1000 m (Matsuura, 1943; Pike, 1953; Tomilin, 1957; Balcomb, 1987). Beaked whales generally feed on squid and fish (Caldwell and Caldwell, 1983).

Harbor porpoises are the most common nearshore cetaceans in the central California region (Leatherwood et al., 1982; Dohl et al., 1983). Dohl et al. (1983) estimated a peak central California population of 3000 porpoises in the fall season, although recent observations suggest the species is present year-round in the Gulf of the Farallones (Szczepaniak and Webber, 1985). Harbor porpoises rarely are seen in waters deeper than 180 m, and usually occur within the 18 m depth contour (Caldwell and Caldwell, 1983). Sightings during the PRBO and EPA (1992) surveys support this observation; all animals were observed in continental shelf waters (Ainley and Allen, 1992; Jones and Szczepaniak, 1992). Harbor porpoises dive to depths less than 200 m (Evans, 1987). They feed on juvenile rockfish, herring, mackerel, sardines, pollack, and whiting (Leatherwood and Reeves, 1982).

3.3.1.3 Pinnipeds

Six pinniped species may be found in the study area. These include California sea lions (*Zalophus californianus*), northern elephant seals (*Mirounga angustirostris*), harbor seals (*Phoca vitulina richardsi*), northern fur seals (*Callorhinus ursinus*), Guadalupe fur seals (*Arctocephalus townsendi*), and Steller sea lions (*Eumotopias jubatus*). Because pinnipeds are difficult to census at sea, population estimates (Table 3.3.1-1) and trends in abundance are generally derived from pup counts at rookeries (California sea lions, northern elephant seals, northern fur seals), or from shore counts during molting season (harbor seals) (Stewart et al., in press). The status of pinniped stocks was reviewed by NMFS/SWFSC in 1992 using all available data, and resultant population estimates were published in the Federal Register (30 July 1993).

The most recent pinniped data available were derived from a 1991 SWFSC marine mammal survey of the California coast aboard the NOAA Ship RV McARTHUR (Hill and Barlow, 1992). This study recorded all sightings of pinnipeds encountered more than 18.5 km (10 nm) from the coast. The survey included a grid of predetermined tracklines that uniformly covered California coastal waters seaward to approximately 555 km (300 nm). Because estimates of pinniped populations are not documented separately for the central California offshore region, Table 3.3.1-1 values are conservative estimates for this area based on all available abundance and population information, coupled with known migration corridors.

Bonnell et al. (1983) censused pinnipeds and southern sea otters of central and northern California by means of monthly aerial transects and quarterly coastal censuses. They estimated that the five predominant pinniped species, the California sea lion, harbor seal, northern elephant seal, northern fur seal, and Steller sea lion, had combined populations of approximately 50,000 animals. Peak numbers at sea occurred in winter and spring with the arrival of migrant northern fur seals from the Bering Sea. Steller sea lions, northern elephant seals, and harbor seals had large populations of approximately 3000, 4000, and 12,000 individuals, respectively.

The Farallon Islands are among the most important pinniped haul-out grounds in central California (Bonnell et al., 1983). The primary pinniped foraging grounds are the shallow shelf waters from Pt. Reyes south in summer and fall, and deeper continental slope waters in winter and spring. California sea lions and northern fur seals are present seasonally either along the coast or offshore, and the northern elephant seal, harbor seal, and northern sea lion breed in the area (Table 3.3.1-1).

The three subspecies of California sea lion have exhibited a steady population increase over the last two decades. From 1970-1989, total numbers increased from approximately 10,000 to 87,000 in the SCB alone. A projection of the population growth based on these figures indicates that mid-1990 populations could be as high as 122,000 (NOAA/NMFS, 1993). Most dives by this species are relatively brief (average 3-9 min) and feeding usually takes place at depths from 100-350 m (maximum diving depth approximately 485 m) (DeLong, 1993, unpub. data). Crabs, squid, herring, hake, and mackerel are primary prey items (Ainley and Allen, 1992).

A few California sea lion pups have been born on Southeast Farallon Island (Pierotti et al., 1977; Huber et al., in prep.) and on Año Nuevo Island (Keith et al., 1984), but viable rookeries have not been established at either site. At sea, the relative abundance of California sea lions is characterized by two peaks (May-June and September-October) which correspond to peaks in abundance in haul-out areas. These peaks are due to the arrival and subsequent departure of transient northern populations, with the highest at-sea mean seasonal density (0.18/km^2) recorded in fall (Bonnell et al., 1983). During this period, California sea lions feed over Pioneer Canyon (east of Pioneer Seamount) and Cordell Bank. During EPA surveys (Jones and Szczepaniak, 1992), California sea lions were the most abundant pinniped in all seasons; the greatest number of individuals were observed during August in slope waters near Pioneer Canyon. PRBO (Ainley and Allen, 1992) reported California sea lions as the second most common pinniped of the region (following northern fur seals), occurring primarily along the continental shelf.

The northern elephant seal, found from central Baja to Pt. Reyes, has also made a remarkable recovery in population numbers. Estimates in the SCB have increased from 28,000 in 1975-78, to 50,789 in 1989-1990, to a projected 87,000 by 1994 (Stewart et al., in press). Both sexes dive extensively while at sea; females are submerged about 91% of the time and males about 88% (Stewart and DeLong, 1993). On average, female dives are to approximately 400-600 m (maximum 1200 m) and last about 24 min, with 2-min interdive surface intervals; males dive to approximately 200-600 m (maximum 1565 m) for about 23 min, with 3-min interdive surface intervals. Northern elephant seals typically feed on squid, octopus, hagfish, anchovies, and rockfish (Ainley and Allen, 1992).

Northern elephant seals are present year-round in the Gulf of the Farallones study region and reach peak numbers in haul-out areas during the spring (Bonnell et al., 1983). A breeding colony is located on Southeast Farallon Island. The greatest numbers of elephant seals near the study area were sighted near the Año Nuevo and Farallon rookeries and in areas over the continental slope from Pt. Reyes to Monterey Bay (Bonnell et al., 1983). The few northern elephant seals seen during PRBO (Ainley and Allen, 1992) and EPA (Jones and Szczepaniak, 1992) surveys were primarily over slope waters east of Pioneer Seamount.

Harbor seals do not migrate seasonally, remaining in the general vicinity of haul-out areas, and usually prefer to remain close to the coastline. They are year-round residents of the central California coast, and haul out at islands, secluded beaches, estuaries, and offshore rocks between Año Nuevo and Pt. Reyes (Allen and Huber, 1983, 1984; Bonnell et al., 1983; Allen et al., 1987; Hanan et al., 1986). They are widely dispersed from Baja California to the eastern Aleutian Islands, and are considered abundant throughout most of their range. Populations have increased substantially in the last 10-15 years (approximately 317,000 in the North Pacific). California population estimates range from 23,089 to 46,178 (Hanan et al., 1993). Their maximum diving depths have been calculated at 500 m for males and 365 m for females (Stewart et al., 1989). Harbor seals forage close to shore, feeding on crabs, squid, smelt, mackerel, and rockfish (Ainley and Allen, 1992), and rarely are seen in waters deeper than 180 m (KLI, 1991).

Northern fur seals tend to concentrate along the continental shelf and slope where nutrient-rich waters support a variety of prey species. They are the predominant pinnipeds in waters seaward of the continental shelf (greater than 200 m depth) in winter and spring, with an estimated 25,000-30,000 animals present off central and northern California (Bonnell et al., 1983). The general distribution of animals at sea is described in Kajimura (1984). Females and juveniles from Bering Sea rookeries are highly migratory and range all the way down to the SCB. These animals are present in northern and central California waters only in the winter and early spring. Northern fur seal sightings in the late 1970s were mostly in relatively deep, offshore waters over the continental slope (Bonnell et al., 1981). Almost 80% were west of 120°W longitude. The limited information regarding animal movements during foraging periods indicates some may remain in SCB waters year-round. Maximum diving depths are relatively shallow (less than 200 m; Clark, 1993). Northern fur seals consume a variety of prey including crabs, squid, sablefish, anchovies, and rockfish (Ainley and Allen, 1992).

A few individual northern fur seals haul out on Año Nuevo Island and the Farallon Islands (Le Boeuf and Bonnell, 1980; Huber et al., in prep.). Although a pupping colony resides on San Miguel Island year-round, northern fur seals are considered primarily winter-spring pelagic visitors to the area (Bonnell et al., 1983; KLI, 1991). Within the study region, northern fur seals were the second most frequently observed pinniped during seasonal surveys (Jones and Szczepaniak, 1992) and the most common pinniped during June 1985-91 surveys (Ainley and Allen, 1992). Northern fur seals were observed along the 2500 m depth contour near Pioneer Seamount during EPA (Jones and Szczepaniak, 1992) surveys. During June 1985-91, northern fur seals were seen in low numbers throughout slope waters, although the greatest concentrations were found north of Pioneer Seamount, within or near the GOFNMS.

Guadalupe fur seals have been sighted north of Santa Barbara Channel annually over recent years (The Marine Mammal Center [TMMC], pers comm., 1995). A total of 43, mostly adult and juvenile males, were seen during summer months between 1969 and 1986 (Stewart et al., in press). Because of extremely low population estimates in the SCB and the fact that this species breeds only on Isla de Guadalupe offshore Baja California, Mexico, few animals are expected in the study area.

The southern-most rookery for Steller sea lions is now Año Nuevo Island off central California (37° 06'N latitude). The SCB was once the southern-most rookery; however, no Steller sea lion pups have been born there since 1981, and there have been no sightings at all since 1984 (Stewart et al., in press). Steller sea lions typically feed on smelt, flatfish, rockfish, squid, and octopus (Ainley and Allen, 1992).

A rookery of about 200 Steller sea lions exists on Southeast Farallon Island; however, fewer than 30 pups are reported born per year (Huber et al., in prep.). There is a minor haul-out area for this species at Pt. Reyes Headland. Steller sea lions were observed twice during seasonal studies: once approximately 28 km (15 nm) east of Pioneer Seamount in water depths of 500 m, and once 28 km (15 nm) north of Pioneer Seamount in water depths over 2500 m (Jones and Szczepaniak, 1992). Two individuals were observed during the PRBO surveys, one over Cordell Bank and one along the coast south of Pt. Reyes (Ainley and Allen, 1992).

3.3.1.4 Fissipeds

Abundance of the only Pacific fissiped population, the southern sea otter (*Enhydra lutris*), is estimated to be 2100 individuals off California (Orr and Helm, 1989). Southern sea otters are common to the general study region, but occur primarily along the coast south of Pt. Año Nuevo to Pt. Conception (Bonnell et al., 1983). Counts of sea otters in the vicinity of Pt. Sur are made regularly by the USFWS. In the 40 km segment of coast adjacent to Pt. Sur, there are an estimated 114 sea otters (Jameson, pers. comm., 1993), and their habitat is confined to areas within 2 km of shore. Southern sea otters can dive for only 4-5 min, to depths of perhaps 55 m (Castro and Huber, 1992). They feed primarily on fish and shellfish (Siniff and Ralls, 1988).

Although sea otters are considered common visitors to the Gulf of the Farallones (Ainley and Allen, 1992), recent area sightings have been rare. In October 1986, a single sea otter was observed over a four-day span at Southeast Farallon Island (PRBO, unpubl. data). Incidental sightings also occur annually along the Pt. Reyes peninsula (PRBO, unpubl. data). Typical sea otter habitats include rocky intertidal and kelp bed areas (Ainley and Allen, 1992) which suggests that their presence is unlikely within any of the deep, slope waters surrounding Pioneer Seamount.

3.3.2 SEA TURTLES

Leatherback sea turtles are federally listed as endangered, while green, olive ridley and loggerhead sea turtles are threatened species and, thereby, protected by the ESA (1973).

Information regarding sea turtle distributions in California waters is limited. Eckert (1993) concluded that knowledge of the pelagic distribution and ecology of sea turtles in the North Pacific and throughout the world is fragmentary, and that there is little information regarding temporal and spatial patterns of distribution and abundance, migration corridors, and geographically specific developmental habitats. Sea turtle stock estimates are presented in Table 3.3.1-1.

In general, it is thought that the California coast offers good habitat for leatherback turtles (*Dermochelys coriacea*) and that there are resident populations of green *(Chelonia mydas)*, olive ridley (*Lepidochelys olivacea*), and loggerhead *(Caretta caretta)* turtles (Eckert, pers. comm., 1990). These species are known to occur in proximity to the MBNMS, with leatherbacks being the most common, followed by greens, loggerheads, and an occasional olive ridley. There are no documented sea turtle nesting sites within the MBNMS (NOAA, 1992). All four species generally have been observed foraging in the summer and early fall, corresponding to periods of the warmest sea temperatures (NOAA, 1992). Hardshell (green, olive ridley, and loggerhead) turtles tend to prefer the 18° C isotherm (i.e., those waters maintaining a relatively constant temperature, in this case 18° C) and exhibit northward movement as the northern waters warm to this temperature (Eckert, pers. comm., 1994). Because these turtles are expected to occur throughout the central California coast, the discussion provided below applies to the Sur Ridge, Sur Slope, and Pioneer Seamount regions. All four species have worldwide extensive ranges; however, this discussion of their movements focuses on activities in the eastern Pacific. 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.

The leatherback turtle is the most frequently sighted marine turtle off northern and central California (Dohl et al., 1983). Leatherbacks have the most extensive range of any extant reptile (Eckert, 1993). They are known to undertake extensive migrations (Pritchard, 1976) following bathymetric (depth) contours (Morreale et al., 1993) for more than 10,000 km. However, specific distribution and life history data are not available for adult leatherbacks in the Pacific (Eckert, 1993). They have been sighted from Alaska and the Aleutian Islands (Hodge 1979; Stinson 1984) to California (Dohl et al., 1983; Stinson, 1984; Jones and Szczepaniak, 1992) and Baja California, Mexico (Smith and Smith, 1980; Clifton et al., 1982). Available data indicate that leatherbacks occur north of central California during the summer and fall when sea surface temperatures are highest (Dohl et al., 1983; Brueggman, 1991).

Stinson (1984) suggests that leatherback arrivals in southern California coincide with the summer arrival of the 18-20 ° C isotherms. July through September sightings north of Pt. Conception likely include individuals originating in offshore portions of 13-15° C isotherms pushed inshore in late summer. Leatherbacks have been reported to dive (two occasions) to depths exceeding 1000 m; however, average diving depth and duration of dives were 61.6 m and 9.9 min/dive, respectively (Eckert et al., 1986).

Leatherback distribution is most significant in the Pt. Sur region, extending north into waters offshore from San Francisco as water temperatures increase. From 1986 to 1991, 96 leatherbacks were sighted within 50 km of Monterey Bay; the majority of sightings occurred during August (Starbird et al., 1993). It has been suggested that leatherbacks arrive in the Monterey Bay area during July and August, moving up toward the Farallones and toward Washington in the fall; however, Eckert (pers. comm., 1994) postulates instead that they head south during fall months to reach nesting grounds in Mexico by November. Two sightings of leatherbacks in northern California (Jones and Szczepaniak, 1992) identified one in shallow (approximately 54 m) water south of the Farallon Islands and another within waters of approximately 1000-m depth around

Pioneer Canyon. Both sightings occurred in August, consistent with Dohl et al.'s (1983) findings of highest leatherback abundances during summer and fall months (EPA, 1992).

Some of the major nesting colonies of leatherbacks in the world border the Pacific Ocean, with the largest known colony breeding on the Pacific coast of Mexico, where approximately 30,000 leatherbacks may nest each year (Pritchard, 1982). Leatherback reproduction is seasonal, with nesting activities in Mexico generally extending from November to February, although some females have been recorded to arrive as early as August (Sarti et al., 1989). It is thought that migratory corridors most likely exist along the western seaboard of the Americas (Stinson, 1984; Marquez and Villanueva, 1993). There has been an alarming decline in the number of nesting females in Maylasia (1950: 1800 females; 1987: 100 females) (Marquez, 1990).

Adults are assumed to inhabit primarily open waters (Eckert, 1993) where their distribution may reflect the distribution and abundance of planktonic prey. Adults feed primarily on cnidarians and tunicates (Brongersmka, 1969; Den Hartog and Van Nierop, 1984; Davenport and Balazs, 1991) and they will follow jellyfish into bays (Eckert, pers. comm., 1994). Aerial surveys of California, Oregon, and Washington waters have shown that most leatherbacks occur in slope waters, with fewer occurring over the continental shelf. The principal predators of leatherbacks are sharks and killer whales (Eckert, pers. comm., 1994).

Green sea turtles occur primarily in coastal waters where they forage on algae and seagrasses. Stinson (1984) concluded that green turtles are the most commonly observed hard-shelled sea turtle on the western coast of the U.S., with the majority of sightings reported from northern Baja California and southern California. The northernmost resident green turtles in the eastern Pacific consist of a small population (thought to be 20-30 individuals) that resides in San Diego Bay (Stinson, 1984; Dutton and McDonald, 1990). Although rare, green turtles have been sighted as far north as Alaska (Hodge, 1981) and British Columbia (Carl, 1955) and regularly strand due to the cold on the Washington and Oregon coasts in mid-winter (Eckert, unpubl. data, 1994).

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; Balazs et al., 1992). In the open sea, hatchlings are associated with *Sargassum* seaweed rafts, remaining epipelagic (i.e., within the upper 100 m of the water column) for an undetermined number of years before taking up residence in continental shelf habitats (Eckert, 1993). Juveniles are subject to predation by groupers (Serranidae) (Witzell, 1981) as well as other predatory fish, including sharks (Hirth, 1971; Balazs, 1980). Average age at first reproduction in the Hawaiian Islands has been estimated to be 25 yrs (Balazs et al., 1992). 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 m) surrounding island and continents. However, they are highly mobile and juveniles inhabit a number of developmental habitats potentially encompassing vast regions of the Pacific, with adults undertaking extensive long-distance migrations between foraging and nesting grounds. The non-breeding range typically is tropical and can extend some 926-1481 km (500-800 nm) from shore. Because green 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 (beyond the photic zone).

Loggerheads are circumglobal, inhabiting continental shelves, bays, estuaries, and lagoons in temperate, subtropical, and tropical waters of the Atlantic, Pacific, and Indian Oceans (Dodd, 1990). In the eastern Pacific, loggerheads are reported as far north as Alaska (Bane, 1992) and as far south as Chile (Frazier and Salas, 1982). Occasional sightings have been reported off Washington, with most records of juveniles off California and Mexico (Guess, 1981a,b; Stinson, 1984). Evidence that they inhabit open ocean areas of the Pacific is indicated by their relatively common occurrence (several hundred per year) in pelagic north Pacific driftnets (Gjernes et al., 1990; Wetherall et al., 1993).

Females typically migrate at multiple year intervals to nesting beaches, with individuals returning to the same nesting area over many years. There is no documented nesting activity along the Pacific coast of Canada, the U.S., or Mexico (Eckert, 1993). No comprehensive data concerning the distribution, abundance, habitat use, or general ecology of juveniles in the north Pacific are available, although it is thought that the transition from hatchling to juvenile occurs in the open sea (Eckert, 1993). Juveniles are relatively abundant off the southwestern coast of Baja California, Mexico. Little is known of survivorship, foraging range, migration or other ecological parameters of adults, and virtually nothing is known about the behavior or movements of adult males, particularly during the non-breeding season (Eckert, 1993). Juvenile and subadult loggerheads are omnivorous, foraging on pelagic crabs, molluscs, jellyfish, and vegetation captured at or near the surface. Adult loggerheads are generalist carnivores that forage on nearshore benthic invertebrates (Mortimer, 1982; Dodd, 1988; Plotkin, 1993). The maximum recorded diving depth for loggerhead turtles is 233 m (Sakamoto et al., 1990).

Olive ridleys are nomadic, swimming hundreds to thousands of kilometers during migrations (Marquez, 1990). They are the most abundant of the north Pacific sea turtles, although little is known about their oceanic distribution (Eckert, 1993). Pitman (1990) reported their range as bounded to the north by the cold California Current that veers southwest of the southern tip of Baja California (although individuals occasionally venture further north) and to the south by the cold Humboldt current that veers northwest off the coast of northern Peru. Stinson (1984) reported ridleys throughout the year in 15-20° C waters south of Pt. Conception, California, as well as predominantly October-December sightings north of Pt. Conception in 12-14° C waters. Strandings, one each off Oregon and Washington, have been reported, and Marquez (1990) suggests that fisherman have identified ridleys in the Gulf of Alaska.

Olive ridleys are migratory in the Pacific, with movement recorded from nesting grounds in Mexico and Central America southward to feeding grounds off Ecuador (Groombridge, 1982). Post-nesting females can travel over 9000 km in 16 months (Plotkin, 1993). The reproductive cycle is nearly annual with greater than 60% of the turtles nesting every year (Eckert, 1993). No information is available on the dispersal of hatchlings from natal beaches, their survivorship, or ecological requirements. Juveniles have been reported from several locations in the Pacific ranging from Micronesia, China, Hawaii, Mexico, and Washington, although their Pacific distribution is generally unknown. They are commonly associated with floating objects (e.g., logs) and oceanographic discontinuities (e.g., fronts and driftlines; Arenas and Hall, 1992). During non-breeding periods, olive ridleys have a wide distribution in the Pacific, both coastal and pelagic, with the majority of adult females present in tropical waters. Very little is known about the behavior and movements of males (Eckert, 1993).

This species is known to forage on salps, tunicates, pelagic crustaceans, and other invertebrates (Fritts, 1981; Mortimer, 1982). They spend a large proportion of their time at the water surface (Byles and Plotkin, 1992; Pitman, 1993) although they have been captured in prawn trawls at depths of 80-110 m and have been observed feeding on crabs at 300 m in the Sea of Cortez (Eckert, 1994).

3.3.3 FISH

Site-specific information on the distribution of fish communities is not available for the study area. However, substantial information exists from surveys in the vicinity of Pt. Sur (Wakefield, 1990), Pioneer Seamount (SAIC, 1992b), and north of Pioneer Seamount (Cailliet et al., 1992). Fish communities are comprised of demersal species (those that live on or near the bottom) and pelagic species (those that spend most or part of their life in the water column). Details on species composition, abundance, distribution, and biomass of demersal and pelagic fish communities near the alternative sites are presented below. Although some information on commercially and recreationally important invertebrates and fish is included in the previous sections, a more detailed discussion of potential fisheries is presented in Section 3.4.1.

3.3.3.1 Demersal Species

Trawl studies were conducted by Wakefield (1990) off Pt. Sur, and extensive trawl and remotely operated vehicle (ROV) biological surveys were completed in the vicinity of Pioneer Canyon, including areas adjacent to Pioneer Seamount (SAIC, 1992b) and north of Pioneer Seamount (Cailliet et al., 1992). Additional information from midwater and bottom trawls off central and northern California is summarized in Bence et al. (1992).

Demersal fish species collected near the alternative sites by Wakefield (1990), SAIC (1992b), and Cailliet et al. (1992) are differentiated based on depth or depth-related factors. All depths discussed in this section relate to bottom depths. The shelf community (from depths of at least 50 to approximately 200 m) is characterized by sanddabs (*Citharichthys sordidus*), English sole (*Pleuronectes vetulus*), rex sole (*Errex zachirus*), rockfish (not including thornyheads), pink surfperch (*Zalembius rosaceus*), plainfin midshipman (*Porichthys notatus*), and white croakers (*Genyonemus lineatus*) (Table 3.3.3-1). Of these, all except pink surfperch and plainfin midshipman have important commercial value. Upper and middle slope communities from approximately 200 to 500 m and 500 to 1200 m depth, respectively, are characterized by fish species such as rockfish (including thornyheads), flatfish, sablefish (*Anoplopoma fimbria*), hake (*Merluccius productus*), slickheads (*Alepocephalus tenebrosus*), and eelpouts (e.g., *Lycenchelys jordani*), with thornyheads (*Sebastolobus* spp.), hake, slickheads, and rattails (e.g., *Coryphaenoides filifer*) being collected primarily from the middle slope. Common taxa collected on the lower slope (from depths of approximately 1200 m to at least 3200 m) include rattails, thornyheads, finescale codling (*Antimora microlepis*), and eelpouts.

Fish communities on the continental shelf near Pt. Sur are expected to be similar in species composition, abundance, and biomass to other shelf locations along the central California coast. Common taxa collected by SAIC (1992b) on the continental shelf off San Francisco included flatfish (such as Pacific sanddab, English sole, and rex sole), rockfish (*Sebastes* spp.), and pink surfperch (Table 3.3.3.1-1). Wakefield (1990) noted that flatfish, including Dover sole (*Microstomus pacificus*) and rex sole, were dominant on the shelf and upper slope off Pt. Sur at depths between 100 and 500 m. In comparison, flatfish, rockfish, and eelpouts were abundant between 600 to 1600 m off Pt. Sur. Bence et al. (1992) indicated that thornyheads were most abundant at depths between 700 to 900 m. On the lower slope, thornyheads, rattails, eelpouts, and finescale codling dominated the catches (Wakefield, 1990; SAIC, 1992b).

Overall fish densities on the shelf (at depths between 50 and 200 m) are expected to be high, with flatfish densities being highest for species such as Pacific sanddabs and English sole. SAIC (1992b) found biomass (kilograms per km^2; kg/km^2) at depths less than 200 m on the continental shelf was relatively low (less than approximately 25,000 kg/km^2) due to the presence of numerous small flatfish such as Pacific sanddabs and rex sole (Table 3.3.3.1-1). Rockfish as a group are extremely abundant on the shelf and at depths between approximately 180 and 270 m (Bence et al., 1992).

Fish densities and biomass on the upper and middle slope are relatively high, with rockfish such as thornyheads, sablefish, and flatfish such as Dover sole predominating (SAIC, 1992b). At depths greater than approximately 1500 m, the numbers of fish species, densities, and biomass typically are very low. The highest biomass contribution at these deeper depths will be from rattails and slickheads (SAIC, 1992b; Bence et al., 1992).

Fish communities in the vicinity of Pioneer Seamount are expected to be similar to those surveyed by Wakefield (1990) off Pt. Sur, SAIC (1992b) in the Gulf of the Farallones, Cailliet et al. (1992) north of Pioneer Seamount, and Bence et al. (1992) off central California.

3.3.3.2 Pelagic Species

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

Epipelagic fish can be distinguished based on two ecological types. Oceanic forms are those that spend all or part of their life in the open ocean away from the continental shelf, while neritic forms spend all or part of their life in water above the continental shelf (Moyle and Cech, 1988). Typical epipelagic fish include fast-moving species such as tunas (e.g., *Thunnus alalunga*),

Survey Location	Depth Range (m)	Total Species	Density (individuals per km^2)	Biomass (kg per km^2)	Predominant Species	Commercially Important Species
Continental Shelf	72-85	29	150,000-250,000	10,000-25,000	Sanddabs Rex Sole English Sole Pink Surfperch	yes yes yes no
Shelf/Slope	128-504	19	50,000-1,400,000	22,000-120,000	Shortbelly Rockfish Flatfishes Sablefish Skates	yes yes yes no
Near Pioneer Canyon	495-1170	19	150,000-250,000	55,000-115,000	Flatfishes Rockfishes Sablefish	yes yes yes
Continental Slope	1008-1656	16	50,000-150,000	8000-40,000	Rattails Thornyheads Dover Sole Finescale Codlings	potential yes yes no
Continental Slope	1278-1764	14	< 10,000-50,000	2000-40,000	Rattails Thornyheads Eelpouts	potential yes no
North of Pioneer Seamount[1]	2300-3065	15	~ 1400	Data not collected	Rattails Finescale Codlings Eelpouts Snailfishes	potential no no no

Source: SAIC 1992b, except for footnote[1].

[1] Cailliet et al., 1992; Data are not directly comparable to SAIC (1992b) since different trawl methods were used (beam and small otter trawl versus large otter trawl for SAIC 1992b).

Table 3.3.3.1-1 Summary of demersal fish community characteristics in the general vicinity of the study area mackerels (e.g., *Scomber japonicus*), and salmon (*Onchorhyncus* spp.), as well as schooling baitfish such as Pacific herring (*Clupea pallasii*), northern anchovy (*Engraulis mordax*), and juvenile rockfish. Considerable information exists for epipelagic fish over the continental shelf; however, little information exists for epipelagic species collected over depths greater than 1500 m. Bence et al. (1992) reported approximately 140 epipelagic species in midwater trawls off central California, including juvenile rockfish, Pacific herring and northern anchovy. Epipelagic species likely to occur in the study area include Pacific herring, northern anchovy, medusafish (*Icichthys lockingtoni*), Pacific sardine (*Sardinops sagax*), Pacific mackerel, Pacific saury (*Cololabis saira*), Pacific argentines (*Argentina sialis*), salmon, tunas, and juvenile rockfish. Some albacore tuna and salmon are commercially important species likely to migrate through the area. Pelagic shark species such as blue sharks (*Prionace glauca*) also could occur within the study area. Juvenile rockfish represent an important component of both commercial and recreational fisheries along the entire Pacific coast (Bence et al., 1992), as well as an important prey item for many seabirds (Ainley and Boekelheide, 1990), and for fish such as chinook salmon, lingcod (*Ophiodon elongatus*), and other rockfish species (Chess et al., 1988).

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). Typical mesopelagic species occurring at depths between 200 to 1000 m include deep-sea smelt (Bathylagidae), lanternfish (Myctophidae), and viperfish (Chauliodontidae). Some of these species comprise the deep scattering layer (DSL). In addition to various mesopelagic invertebrates such as krill and copepods, the major mesopelagic fish species forming the DSL include lanternfish and bristlemouths (Gonostomatidae). These fish species migrate vertically. North of Pioneer Seamount, Cailliet et al. (1992) collected six species of mesopelagic fish, most of which were from the families Bathylagidae, Myctophidae, Chauliodontidae, and Sternoptychidae.

In contrast to mesopelagic fish, bathypelagic species are largely adapted for a sedentary existence in a habitat with 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 vertical migrations. At depths greater than 1000 m, common bathypelagic fish include blackdragons (Idiacanthidae), dragonfish (Melanostomiidae), and tubeshoulders (Searsiidae).

Pelagic species (e.g., epipelagic, mesopelagic, and bathypelagic) in the vicinity of Pioneer Seamount likely include species similar to those expected at Sur Ridge and Sur Slope sites. Common epipelagic fish species may include northern anchovy, medusafish, Pacific sardine, Pacific mackerel, Pacific saury, Pacific argentines, and juvenile rockfish. Epipelagic species such as tunas and salmon migrate through/to San Francisco Bay in nearshore coastal environments. Thus, these species probably do not occur in substantial numbers near the Pioneer Seamount. Common mesopelagic species near Pioneer Seamount likely include deep-sea smelt, lanternfish, and viperfish. Cailliet et al. (1992) collected similar mesopelagic species north of Pioneer Seamount. At depths greater than approximately 1700 m, Cailliet et al. (1992) and Bence et al. (1992) collected bathypelagic fish such as deep-sea smelt and lanternfish.

Site-specific information on the abundances of sharks and rays is not available. However, some information exists on the distribution of sharks off Monterey (Ferguson and Cailliet, 1990).

For example, approximately 20 shark species occur in the Monterey Bay area. Common species likely to occur in the vicinity of the alternative sites include blue sharks (*Prionace glauca*), sevengill shark (*Notorhynchus cepedianus*), sixgill shark (*Hexanchus griseus*), and white shark (*Carcharodon carcharias*) (Ferguson and Cailliet, 1990). The environment of the study area consists of nearshore continental shelf habitats extending offshore to the upper and middle continental slope. Species such as the blue shark typically occupy and utilize all of these habitats. Blue sharks are found worldwide in temperate and subtropical seas. In the eastern Pacific they occur from the Gulf of Alaska to Chile, and are the most abundant pelagic shark off the west coast of North America (Love, 1991). The blue shark likely will occur in the study area in greater abundances than other shark species. Prey species of the blue shark may include various fish species such as slender sole (*Lyopsetta exilis*), cuskeels (e.g., *Chilara taylori*), and sanddabs, as well as some invertebrate species such as squid (Love, 1991). Other shark species, such as white sharks, are likely to be found within the study region, including the proposed action site (Pioneer Seamount), the preferred action site (Sur Ridge), and Sur Slope. While whites mainly occur close to shore, they have been collected in water depths to nearly 1300 m (4200 ft), and are particularly abundant near seal and sea lion haul-out and rookery areas (Love, 1991). Thus, white sharks in the study region are most likely to occur near the Farallon Islands, northeast of Pioneer Seamount.

3.3.4 INVERTEBRATES

Site-specific information on the distribution and abundance of infauna (those organisms living within the sediments), demersal epifauna (those organisms living in contact with the sea floor), and pelagic invertebrates is not specifically available for the alternate sites. However, substantial information is available from recent surveys (e.g., SAIC, 1992a,c) in the general vicinity of the sites, as presented in Sections 3.3.4.1 through 3.3.4.3.

3.3.4.1 Benthic Infauna

Benthic infaunal communities, defined generally as small invertebrates such as polychaetes (marine worms) and amphipods (small crustaceans) living within sediments, are described by a number of parameters, such as faunal composition (which species are present), dominant taxa (which species are most abundant), density (number of individuals/1.0 m^2), diversity (number of different species relative to the total number of individuals), species richness (number of species), and community assemblage patterns (which species are usually found together in a sample, or how similar the samples are to each other). The following sections describe community parameters for regions near the study area. Descriptions of the areas near Pt. Sur are based on information from the MBNMS EIS (NOAA, 1992) and various studies within and outside of Monterey Bay, while Pioneer Seamount information is based primarily on recent EPA and Navy sponsored surveys in the Gulf of the Farallones (SAIC, 1992a,c).

Continental shelf habitats (e.g., depths to 200 m) off central California are very rich in the number of species and abundances of infauna (EPA, 1993). This trend is influenced strongly by upwelling and high productivity in the GOF and the Monterey through Pt. Sur areas. Continental shelf communities are dominated by polychaetes of several families including Paraonidae, Spionidae, Cossuridae, and Cirratulidae, although the polychaete species and other common taxa such as amphipods exhibit distinct zonation patterns by depth. Continental slope communities (200 m to a few thousand meters) also are very rich, with even higher numbers of species at some depths than noted for the continental shelf sites (EPA, 1993). For example, species richness ranged from 95 to 131 species collected per 0.1 m^2 grab on the shelf, and from 59 to 165 species per 0.1 m^2 grab on the slope at depths between 800 and 1780 m. From approximately 75 to 125 m depth on the continental shelf off San Francisco, infaunal densities at some stations exceeded 20,000 individuals/1.0 m^2 (SAIC, 1992a,c). Similar densities were found on the continental slope at depths similar to those described above.

Other key features of the slope communities include the following: 1) a marked decrease in infaunal densities between approximately 800 to 1000 m depth, corresponding to the OMZ, followed by 2) sharp density increases to approximately 1800 m depth, and finally 3) a gradual decrease with further increases in depth.

The infaunal communities on the continental shelf near Pt. Sur are expected to be similar to other shelf locations along the central California coast. Common taxa may include polychaete worms such as *Prionospio* and *Spiophanes*, which represented nearly 50% of the total species and 76% of all individuals collected by SAIC (1992c) on the continental shelf off San Francisco. Other common taxa include amphipod crustaceans, gastropod snails, decapods, mysids, ostracods, and phoronids, with gastropods being more diverse in shallow areas of the shelf than in any of the deep offshore areas surveyed. SAIC (1989) collected similar infauna on the continental shelf north of Santa Cruz, California. Dominant species during these surveys included amphipods (*Metopa* spp.), polychaete worms (*Spiophanes berkeleyorum*), and brittle stars (*Amphiodia urtica*). On the upper slope and middle slope, SAIC (1992c) collected nearly 475 species from 18 box core samples (Table 3.3.4-1). Dominant taxa included subsurface deposit-feeding polychaete worms of the families Paraonidae, Cossuridae, and Cirratulidae, as well as some small, detrital-feeding or scavenging crustaceans (e.g., tanaids and isopods).

Densities and biomass of infaunal species off Pt. Sur also are expected to be similar to those off other areas of central California. Infaunal densities were highest on the continental shelf off San Francisco, ranging between 12,920 and 42,490. In contrast, densities on the upper slope were approximately 3300/1.0 m^2 and on the lower slope were approximately 19,560/1.0 m^2 (SAIC, 1992c). Infaunal densities at depths greater than 2000 m are expected to be substantially lower than shallower slope areas. Densities off San Francisco at depths greater than approximately 2500 m ranged between 5000 and 9800 individuals/1.0 m^2 (SAIC, 1992c).

Infaunal communities near Pioneer Seamount are expected to be similar to those surveyed in the general region (SAIC, 1992c). This study identified a total of 475 species over a depth range from 610 to 2005 m (Table 3.3.4-1). Subsurface deposit-feeding polychaete worms of the families Paraonidae, Cossuridae, and Cirratulidae each contributed between 9% and 11% of the entire infauna, and represented 49% of the total species collected. Detrital-feeding or scavenging tanaidacean and isopod crustaceans were the next most dominant taxa, each representing 9% of the total number of species. The subsurface deposit-feeding polychaetes *Tharyx* spp., *Cossura pygodactylata, Cossura rostrata,* and *Aricidea ramosa* were the most common species of the taxa that predominated.

Taxon (Number of Samples)	Continental Shelf (50-200 m)	Continental Slope (610-2005 m)	Continental Slope (800-1900 m)	North of Pioneer Seamount (> 2400 m)
Porifera	-	-	-	1
Coelenterata				
Anthozoa	3	2	2	4
Platyhelminthes	1	1	1	3
Nemertinea	1	8	6	14
Annelida				
Hirudinea	1	1	-	-
Oligochaeta	1	1	1	1
Polychaeta	125	232	234	184
Pogonophora	-	1	1	2
Sipuncula	2	5	3	3
Echiura	1	-	-	0
Mollusca				
Aplacophora	1	13	13	11
Bivalvia	18	25	23	19
Gastropoda	27	9	15	3
Scaphopoda	2	2	-	1
Arthropoda				
Amphipoda	33	33	31	39
Cumacea	13	30	32	21
Decapoda	3	-	-	-
Isopoda	5	45	41	39
Leptostraca	1	1	-	-
Mysidacea	1	-	-	-
Ostracoda	4	-	-	-
Tanaidacea	1	47	43	23
Phoronida	1	-	-	-
Echinodermata				
Asteroidea	-	1	-	1
Echinoidea	1	2	-	1
Holothuroidea	4	2	3	6
Ophiuroidea	10	12	12	8
Hemichordata				
Enteropneusta	-	2	1	1
Urochordata	1	-	-	-
TOTAL	261	475	462	385

Table 3.3.4.1-1 Total number of species belonging to each major taxonomic group collected from the continental shelf and slope and areas north of Pioneers Seamount

SAIC (1992c) found densities in the region near Pioneer Seamount ranging from 3300 to 19,560 at 800 m to 1780 m depth. The highest densities there were due to dense populations of the amphipod *Photis* and several polychaete families. The lowest densities were observed at stations between 800 and 985 m depth, located within the OMZ. These stations were dominated by oligochaetes, which are frequently associated with low dissolved oxygen conditions, and cossurid or paranoid polychaetes.

3.3.4.2 Demersal Epifauna

This section describes demersal epifaunal communities (such as seastars that live on the seafloor) found in the general vicinity of Pt. Sur and Monterey Bay (NOAA, 1992), and Pioneer Seamount (SAIC, 1992b). Extensive trawl and remotely operated vehicle (ROV) studies were conducted in areas adjacent to and within Pioneer Canyon (SAIC, 1992b), and also in the region north of Pioneer Seamount using beam trawls, otter trawls and camera sled tows (Nybakken et al., 1992; SAIC, 1992a).

Similar to general distributional patterns observed for infaunal communities (Section 3.3.4.1), epifaunal communities in the region also are differentiated based on depth or depth-related factors. Types of depth-related factors that influence community structure near the alternate sites include differences in the sedimentary environment (i.e., sand vs. mud), the OMZ, and regional current patterns (Wakefield, 1990).

The distribution, species composition, and abundance of epifaunal communities in various habitats throughout the Monterey Bay area (generally from the bay south to Pt. Sur) are determined by a number of factors including submarine geology, substrate type, and various oceanographic features such as current flow and upwelling (NOAA, 1992). Wakefield's (1990) trawl data off Pt. Sur indicated invertebrates accounted for about 35% to 75% of the total catch, based on individual abundances, for each 200 m depth stratum from 400 to 1400 m. The shelf epifauna near Pt. Sur are expected to be similar to other continental shelf communities in central California. Representative taxa include sponges, brittlestars, seastars, sea pens, and octopus (SAIC, 1992b; NOAA, 1992). SAIC (1989) documented numerous species typical of hard-bottom communities throughout the region such as sea anemones, gorgonians, vase sponges, and cup corals in a study area north of Santa Cruz, California, at depths of approximately 100 m. Common epifaunal taxa likely to occur in the Pt. Sur region at upper slope depths include Tanner crabs, seastars, brittlestars, snails, and sea cucumbers. Similar taxonomic groups are expected to occur at middle slope depths. Epifauna likely to occur on the lower slope include sea cucumbers, brittlestars, and seastars. Because of the proximity of this alternative site to the Monterey Bay Submarine Canyon, some epifaunal species may be found at deeper slope depths off Pt. Sur than in other slope areas.

Dominant epifaunal groups on the middle continental slope near Pioneer Seamount are expected to include echinoderms (particularly seastars such as *Pteraster tessalatus* and brittlestars such as *Asteronyx loveni*), cnidarians (sea pens), and molluscs (octopus) (EPA, 1993). Echinoderm, sea pen, and crustacean densities are highest on the slope at depths between 1200 and 1800 m. SAIC (1992b) observed a deep middle slope (>1200 m) community in the Gulf of the Farallones that was characterized by a relatively high number of species including sea cucumbers, brittlestars, seastars, and sea pens. Densities and biomass in these areas also were relatively high and represented primarily by sea cucumbers, brittlestars, and seastars. A lower continental slope community (from depths of approximately 2000 m to almost 4000 m) in an area north of Pioneer Seamount was characterized by Nybakken et al. (1992) as containing low numbers of megafaunal taxa, densities, and biomass. Predominant species in this area included sea cucumbers (*Molpadia intermedia* and *Paelopadites confundeus*), brittlestars (*Amphiura carchara*), seastars, and cnidarians. Biomass at these depths most likely will be low based on the low densities and small sizes of the organisms.

The presence of gradients such as those produced by the OMZ may be responsible for the depth-related patterns of many species on the California continental slope between approximately 600 and 800 m depths (Wakefield, 1990). Compared to most fish species, the number of epifaunal invertebrate species tended to increase through the OMZ, perhaps due to reduced movement and activity (and lesser sensitivity to low oxygen conditions) of these invertebrates (SAIC, 1992b).

3.3.4.3 Pelagic Invertebrates

Pelagic invertebrates include those species capable of movement throughout the water column and/or just above the bottom. Examples include euphausiids, squid, pteropods, heteropods, and octopuses. Documentation of pelagic invertebrate populations and abundances near the alternative sites is limited. Most of the available information focuses on euphausiids and cephalopods that are either of commercial importance or are prey items for fish, seabirds, and marine mammals.

Many species of pelagic invertebrates are components of the deep scattering layer (DSL). Ingmanson and Wallace (1973) described the DSL as a layer of living organisms, ranging from almost microscopic zooplankton to copepods, shrimp, and squid. This layer is present at different depth ranges during the day (between 230 and 800 m) and night (sometimes near the surface). Many species occupying the DSL are "vertical migrators" such as zooplankton and certain fish species that utilize this dense layer as a food source.

Midwater surveys by NMFS (Bence et al., 1992) and analysis of commercial fisheries data (MMS/CDFG Commercial Fisheries Database, 1992) indicated that cephalopods are a predominant pelagic invertebrate group off central California. Market squid (*Loligo opalescens*) collected in midwater trawls at depths of approximately 30 m tended to be most abundant in areas less than 180 m in bottom depth, similar to continental shelf areas near Pt. Sur, while squid abundances in areas near Pioneer Seamount were uniformly low (Bence et al., 1992). In contrast, other squids (not including market squid) had low abundances on the shelf and higher abundances at depths greater than 1200 m (Bence et al., 1992). Euphausiids were patchily abundant.

A combination of deep-water sampling and monitoring of local commercial fisheries in Monterey Bay resulted in the collection of ten species of previously unreported cephalopods including *Gonatus* spp., *Berryteuthis anonychus*, *Chiroteuthis calyx*, *Octopoteuthis deletron*, *Valbyteuthis danae*, *Japetella heathi*, and *Graneledone* spp. (Anderson, 1978). Pelagic invertebrates from large midwater trawls and commercial anchovy purse-seine hauls were dominated by the common market squid (Cailliet et al., 1979). SAIC (1992b) collected seven species of cephalopods, including market squid, *Moroteuthis robusta*, *Vampiroteuthis infernalis*, *Benthoctopus* spp., *Octopus dofleini*, *O. rubescens*, and *Opisthoteuthis californiana*. Cephalopods are also a primary prey item for many marine mammals foraging over the continental shelf (Fiscus, 1982; Roper et al., 1984), including toothed whales which commonly feed on squid off the central California coast (Fiscus et al., 1989).

3.3.5 PLANKTON

This section presents information on plankton distribution and abundances off central California, including the study area.

Plankton are free-floating organisms that typically drift with ocean currents, in contrast to actively swimming species such as fish. In general, plankton can be divided into two broad categories: 1) phytoplankton, representing single-celled plants that are capable of photosynthesis and which form an important base for many marine systems; and 2) zooplankton, which include animals that are a primary link in many food webs between phytoplankton and larger marine organisms such as fish, seabirds, and marine mammals. Zooplankton includes animals that remain planktonic throughout their life (holoplankton) as well as larval stages of benthic invertebrates (meroplankton) and fish (ichthyoplankton). Plankton distributions are characterized by high spatial patchiness, strong seasonal and interannual variation, and direct responses to oceanic circulation, including the California Current system (McGowan and Miller, 1980). General patterns of coastal circulation are influenced by local topography and wind fields, and can change considerably on time scales of a few days (Breaker and Mooers, 1986), thereby contributing to the high variability in plankton communities.

In coastal and offshore environments, phytoplankton will be limited in distribution from the sea surface to approximately 100 m depth, corresponding to the effective range of light penetration for photosynthesis. In contrast, zooplankton can occur throughout the depth range from surface to bottom.

Site-specific information on the production, abundance, and species composition of plankton communities is not available for the study area; however, a general description of the plankton communities along the central California coast is summarized in the following sections.

3.3.5.1 Phytoplankton

The predominant members of the phytoplankton community are diatoms, silicoflagellates, coccolithophores, and dinoflagellates. Three parameters commonly used to describe phytoplankton communities are the following: 1) productivity, reflecting the amount of new plant material formed per unit of time; 2) standing crop, representing the amount of plant material present, usually expressed as concentrations of chlorophyll or cell numbers; and 3) species composition. Interannual variation and seasonal cycles of productivity and standing crop reflect variations in the upwelling regime along the central coast of California.

The most frequently used method for estimating the standing crop (e.g., total abundance) of phytoplankton is to extract and measure the amount of photosynthetic pigments such as chlorophyll *a* and other phaeopigments in seawater samples (Valiela, 1984). Concentrations of chlorophyll *a* and phaeopigments are highest in continental shelf waters, indicating higher standing stocks of phytoplankton in nearshore areas (water depths to 100 m) than in offshore regions along the central California coast (Bence et al., 1992). The highest productivity levels between Pt. Sur and the Gulf of the Farallones occur within approximately 50 km of the coast (Owen, 1974). Average productivity values in the latter study ranged from 342 to 586 mg carbon/m^2/day over the course of a year. Maximum productivity of 1300 mg carbon/m^2/day was reported during August-September. The minimum productivity (256 mg carbon/m^2/day) was observed during a May-June cruise (Bence et al., 1992). Thus, more phytoplankton and higher production levels occur within the study region between August and September. The combination of seasonal coastal upwelling events and nutrient inputs from San Francisco Bay may help promote high primary productivity throughout the Farallon Islands region (KLI, 1991) and potentially including offshore areas such as Pioneer Seamount. Similar nutrient inputs may occur near Pt. Sur, based on inputs from Monterey Bay and adjacent Monterey Submarine Canyon.

Surface chlorophyll concentrations in the offshore San Francisco region ranged from less than 0.5 mg/m^3 during July-September to 2-8 mg/m^3 during October-December (Owen, 1974). Garrison (1976) reported similar values from waters near the mouth of Monterey Bay; however, Ambler et al. (1985) measured chlorophyll concentrations ranging from less than 1 mg/m^3 between October and January to nearly 5 mg/m^3 in April and June. Differences in chlorophyll concentrations among studies may be related to the time lag required for phytoplankton growth (Abbott and Zion, 1985). Phytoplankton initially respond to nutrient input with increased primary production, leading to increased population size after a time lag, and resulting in a dynamic biological structure (Denman and Abbott, 1988).

Species composition of phytoplankton communities also varies seasonally. The spring/summer phytoplankton bloom, coincident with upwelling events, is dominated by diatoms, including species of *Chaetoceros* and *Rhizosolenia*. During non-upwelling periods, dinoflagellates of the genera *Ceratium* and *Peridinium* dominate (Bolin and Abbott, 1963; Welch, 1967).

In summary, studies on phytoplankton along the central California coast indicate strong seasonal cycles of productivity, standing crop, and species composition. However, the communities often are characterized by high variability in their distribution and abundance. It is anticipated that phytoplankton in the study area will exhibit these same general cycles, and will be affected in similar ways by factors such as upwelling and nutrient inputs from nearby bays. In general, higher abundances are expected in nearshore as compared to further offshore regions of the study area.

3.3.5.2 Zooplankton

In contrast to phytoplankton, which are limited to approximately the upper 100 m of the water column, zooplankton can occur in dense concentrations over a wide range of depths from surface waters to over 400 m (Schoenherr, 1991). Many zooplankton species are able to vertically migrate up to several hundred meters. An estimated 546 invertebrate zooplankton species occur in the California Current system (Kramer and Smith, 1972). Copepods and euphausiids, an important food source for many organisms, including juvenile fish and mysticete whales, dominate the holoplankton in terms of numbers and biomass, although thalacians (salps), chaetognaths (arrow worms), and pelagic molluscs also are abundant. Common species in the California Current which are expected to be found at the alternative sites include the euphausiid *Euphausia pacifica*, copepods of genera *Calanus*, *Neocalanus*, *Eucalanus*, and *Acartia*, and salps. Bence et al. (1992) classified holoplankton and meroplankton species, noted by California Cooperative Fisheries Investigations (CalCOFI), Hatfield (1983), and Tasto et al. (1981) as common to the California Current, into nearshore or offshore distribution categories. Various species of copepods, euphausiids, and chaetognaths were found in both nearshore and offshore waters, whereas thaliaceans and pelagic molluscs occurred primarily offshore.

Hatfield (1983) noted substantial differences in spatial distributions and abundances of a number of zooplankton species associated with upwelling and seasonal and localized current patterns. For example, plankton species that are characteristic of more northerly latitudes were rare in the Gulf of the Farallones including the vicinity of Pioneer Seamount. Additionally, in the winter of 1977 when the Davidson Current dominated the area, species typically seen nearshore were found farther offshore and mixed with offshore forms. Examples of peak densities of some species of zooplankton include the following: 15,000/100 m^3 for the copepod *Acartia clausi*, 2500/100 m^3 *for Cancer* spp. larvae, and 1200/100 m^3 for developing larvae (e.g., zoeae) of *Cancer antennarius.*

There were few holoplankton species common to the CalCOFI, Hatfield, and Tasto et al. reports. For example, adult euphausiids were present in low abundances in samples from 1975-1977 (Tasto et al., 1981), but three species (*Euphausia pacifica*, *Nematoscelis difficilis*, and *Thysanoessa gregaria*) were more abundant in the March 1979 samples taken on two transects off San Francisco Bay (Hatfield, 1983). Using differences in species compositions and distributions that could be identified from CalCOFI atlases, Hatfield (1983) and Tasto et al. (1981) noted the following characteristics of zooplankton distributions: 1) the distribution of zooplankton is dynamic in nature due to the complex hydrography of the California Current system; and 2) much of the variance between data sets likely results from differences in sampling schedules, designs, and collection equipment. In addition, taxonomic uncertainties remain for some taxa, such as the genus *Acartia.*

3.3.5.3 Ichthyoplankton

Ichthyoplankton (larval fish) are an important component of the zooplankton and have been the focus of numerous CalCOFI surveys. This is due to the importance of this group to commercial fishing, with approximately 1000 ichthyoplankton species occurring in the California Current system (Kramer and Smith, 1972). Bence et al. (1992) summarized data from CalCOFI surveys by season and depth. Dominant species in terms of abundance included rockfish species such as shortbelly rockfish (*Sebastes jordani*) and Pacific hake. The highest ichthyoplankton abundances occurred in nearshore areas in winter, with lowest abundances in offshore areas in fall. Seasonal differences in total fish larvae showed some variation among sampling stations, with highest overall values in winter and spring and lowest values in summer and fall. CalCOFI data suggest that Pacific hake larvae were relatively more abundant south of the Farallon Islands at depths greater than 600 m (depths similar to Pioneer Seamount). In contrast, the relative abundance of shortbelly rockfish was greatest at depths just beyond the shelf break (approximately 200 m) and at depths greater than 1800 m (Figure 23 in Bence et al., 1992).

3.3.6 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 acoustic sources would be located at approximately 800-900 m depths, 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 2.2.1.2-4), seabird species most likely to be affected are those that dive frequently to deep (greater than 20 m) depths. This section provides a focus on the distribution, abundance, and ecology of representative deep diving seabird species.

Most of the seabird studies along the central coast region have focused on Monterey Bay; these data are expected to be representative of the Pt. Sur region (including the Sur Ridge and Sur Slope sites) as well. Monterey Bay and associated Monterey Submarine Canyon, located approximately 40 to 50 km (22-27 nm) north of Pt. Sur, are recognized as important regions for seabird populations due to 1) location along the Pacific Flyway migratory route; 2) prevalence of nutrient-rich, upwelled waters that support and concentrate an abundance of seabird prey items; 3) sheltering capacity related to landward protection on three sides; and 4) diversity of shoreline habitats (NOAA, 1992). Ninety-four seabird species are known to occur within the Monterey Bay region (Briggs and Chu, 1987), thirteen of which are resident breeding (or formerly breeding) species (NOAA, 1992). Several resident breeding species, including double-crested cormorant (*Phalacrocorax auritus*), Brandt's cormorant (P. *penicillatus*), pelagic cormorant (*P. pelagicus*), common murre (*Uria aalge*), tufted puffin (*Fratercula cirrhata*), pigeon guillemot (*Cepphus columba*), marbled murrelet (*Brachyramphus marmoratus*), and rhinocerus auklet (*Cerorhinca monocerata*), are capable of diving to depths ranging from 50 to 190 m (Table 3.3.6-1) (Ainley and Allen, 1992). In addition, winter resident or visitor species, such as the common loon (*Gavia immer*), Arctic loon (*G. pacifica*), western grebe (*Aechmophorus occidentalis*), surf scoter (*Melanitta perspicillata*), and migrant species such as horned puffin (*Fratercula corniculata*), frequent Monterey Bay (NOAA, 1992) and also are capable of diving to depths ranging from 25 to 100 m (Ainley and Allen, 1992; Baird, 1993). Density estimates for several of these species, including Brandt's cormorant and common murre, over central California shelf and slope waters are relatively constant across seasons (Figure 3.3.6-1). However, some species, such as rhinocerus auklets and Arctic loons, show peak densities during winter or fall/spring months. Significant concentrations of jaegers, gulls, and terns also occur in the Pt. Sur region during winter months, although these species are generally surface feeders.

The Gulf of the Farallones is the most important seabird breeding area on the west coast of the United States (Sowls et al., 1980). Many of the 74 species of birds recorded by Briggs

Species	Abundances Within California (Abundances in Central California)	Primary Population Sites	Primary Foraging Habitat	Common Prey Items	Maximum Diving Depth (m)	Sites at Which Present
Double-crested cormorant *(Phalacrocorax auritus)*	1900[1] (500)[1]	Channel Islands, Farallon Islands, nearshore rocks and islands north of San Francisco[1]	Shelf	Primarily fish, including juvenile sanddabs and surfperch[2]	20[3]	Preferred Action Site Pioneer Seamount Site (found regionally, but not observed during site-specific surveys)[4]
Brandt's cormorant *(Phalacrocorax penicillatus)*	64,200[1] (47,000)[1]	Farallon Islands, Santa Barbara Channel Islands, Bird Rock at Pt. Lobos (30 km south of Monterey Bay), and Castle Rock near Crescent City[5]	Shelf	Demersal fish (rockfish, flatfish, tomcod, midship-man, and cusk eels)[6]	190[4]	Preferred Action Site Pioneer Seamount Site (found regionally, but not observed during site-specific surveys)[4]
Pelagic cormorant *(Phalacrocorax pelagicus)*	16,000[1] (6000)[1]	Primarily Farallon Islands and coastal areas north of San Francisco[1]	Shelf	Primarily fish and shrimp species[1]	190[4]	Preferred Action Site Pioneer Seamount Site (found regionally, but not observed during site-specific surveys)[4]
Common murre *(Uria aalge)*	363,000[1] (109,000)[1]	Largest colonies north of Trinidad Head and in the Gulf of the Farallones; no nesting further south than Hurricane Pt. near Pt. Sur[5]	Shelf, slope	Rockfish, northern anchovy, market squid, and euphausiids[6]	180[7]	Preferred Action Site Sur Slope Site Pioneer Seamount Site (found regionally, but not observed during site-specific surveys)[4]
Tufted puffin *(Fratercula cirrhata)*	10,000-20,000[5] (ne)	Castle Rock, near Crescent City, and the Farallon Islands[5]	Shelf, slope	Sablefish[4]	100[4]	Preferred Action Site Sur Slope Site Pioneer Seamount Site (found regionally, but not observed during site-specific surveys)[4]

[1]Sowls et al. (1980)
[2]Ainley and Sanger (19790
[3]Baird (1993)
[4]Ainley and Allen (1992)
[5]Briggs et al. (1987)
[6]Ainley and Boekelheide (1990)
[7]Piatt and Nettleship (1985)
[8]Peterson (1961)

Table 3.3.6-1 Abundances, primary population sites, foraging habitat, prey items, and maximum diving depths (> 20 m) of deep-diving seabird species found along the central California coast.

Species	Abundances Within California (Abundances in Central California)	Primary Population Sites	Primary Foraging Habitat	Common Prey Items	Maximum Diving Depth (m)	Sites at Which Present
Pigeon Guillemot *(Cepphus columba)*	14,700[1] (9700)[1]	Farallon Islands, coastline between Davenport and Pt. Santa Cruz, and Pt. Arguello	Shelf	Rockfish and sculpin[2]	100[4]	Preferred Action Site Sur Slope Site Pioneer Seamount Site (found regionally, but not observed during site-specific surveys)[4]
Marbled murrelet *(Brachyramphus marmoratus)*	2000[1] (ne)	Coastline from Eureka to the California-Oregon Border and from Santa Cruz to Half Moon Bay[1]	Shelf	Fish and crustaceans[1]	50[4]	Preferred Action Site Pioneer Seamount Site (found regionally, but not observed during site-specific surveys)[4]
Rhinocerus auklet *(Cerorhinca monocerata)*	200,000-300,000[3] (ne)	Farallon Islands, Castle Rock, near Crescent City, and Pt. Arguello[5]	Shelf, slope, pelagic	Juvenile sablefish and other midwater schooling species[4]	50[4]	Preferred Action Site Sur Slope Site Pioneer Seamount Site (found regionally, but not observed during site-specific surveys)[4]
Common loon *(Gavia immer)*	5000-10,000[3] (ne)	Coasts of Morro Bay, Monterey Bay, the Farallon Islands, Tomales Bay, and north of Trinidad Head[5]	Shelf	Fish[2]	60[8]	Preferred Action Site Pioneer Seamount Site (found regionally, but not observed during site-specific surveys)[4]
Arctic loon *(Gavia pacifica)*	115,000-347,000[3] (ne)	Bodega Bay, Tomales Bay, Gulf of the Farallones, Monterey Bay, and the eastern Santa Barbara Channel[5]	Shelf, slope	Fish[2]	100[4]	Preferred Action Site Sur Slope Site Pioneer Seamount Site (found regionally, but not observed during site-specific surveys)[4]

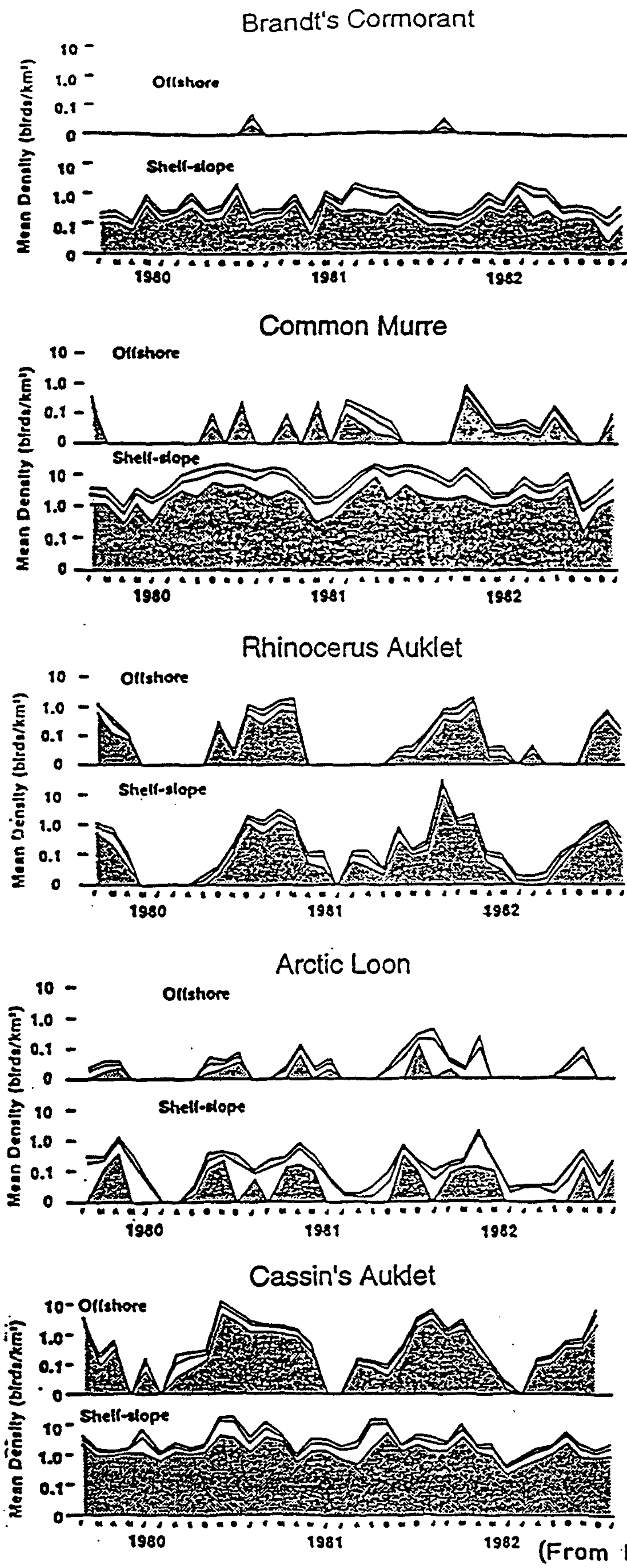
[1]Sowls et al. (1980)
[2]Ainley and Sanger (1979)
[3]Baird (1993)
[4]Ainley and Allen (1992)
[5]Briggs et al. (1987)
[6]Ainley and Boekelheide (1990)
[7]Piatt and Nettleship (1985)
[8]Peterson (1961)

Table 3.3.6-1 Abundances, primary population sites, foraging habitat, prey items, and maximum diving depths (> 20 m) of deep-diving seabird species found along the central California coast.

Species	Abundances Within California (Abundances in Central California)	Primary Population Sites	Primary Foraging Habitat	Common Prey Items	Maximum Diving Depth (m)	Sites at Which Present
Western grebe *(Aechmophorus occidentalis)*	52,000[3] (ne)	Coastline between Trinidad Head and Pt. St. George; waters from Bodega Bay to Monterey Bay; and the eastern end of Santa Barbara Channel[5]	Shelf	Topsmelt, herring, and sculpin[2]	25[4]	Preferred Action Site Pioneer Seamount Site (found regionally, but not observed during site-specific surveys)[4]
Surf scoter *(Melanitta perspicillata)*	30,000[3] (ne)	Nearshore waters of Eureka, Bodega, and Tomales bays; the Gulf of the Farallones; Monterey Bay; Morro Bay; Santa Barbara Channel; Santa Monica Bay; and 75 km of coastline north of San Diego[5]	Shelf	Molluscs[2]	25[4]	Preferred Action Site Pioneer Seamount Site (found regionally, but not observed during site-specific surveys)[4]
Horned puffin *(Fratercula corniculata)*	5000-10,000[3] (ne)	Near San Miguel Island; from Pt. Sur to the Farallones; and from Cape Mendocino to the Oregon Border[5]	Slope, pelagic	Flatfish[2]	50[4]	Preferred Action Site Sur Slope Site Pioneer Seamount Site (found regionally, but not observed during site-specific surveys)[4]
Sooty shearwater *(Puffinus griseus)*	2.7-4.7 million[3] (ne)	Outer shelf waters off Pt. Conception, Pt. Montara, and Pt. Reyes[5]	Shelf, slope	Anchovies, squid, euphausiids, and juvenile rockfish[4]	20[4]	Preferred Action Site Sur Slope Site Pioneer Seamount Site
Cassin's auklet *(Ptychoramphus aleuticus)*	131,000[1] (127,000)[1]	Channel Islands, Farallon Islands, and Castle Rock near Crescent City[1]	Slope	Euphausiids and larval fish[6]	50[4]	Sur Slope Site Pioneer Seamount Site

[1]Sowls et al. (1980)
[2]Ainley and Sanger (1979)
[3]Baird (1993)
[4]Ainley and Allen (1992)
[5]Briggs et al. (1987)
[6]Ainley and Boekelheide (1990)
[7]Piatt and Nettleship (1985)
[8]Peterson (1961)

Table 3.3.6-1 Abundances, primary population sites, foraging habitat, prey items, and maximum diving depths (> 20 m) of deep-diving seabird species found along the central California coast.



(From Briggs et al., 1987)

Figure 3.3.6-1 Monthly mean densities of selected deep-diving seabird species along the central California coast et al. (1987b) off the California coast occur in the Gulf of the Farallones during their migration and/or breeding seasons. Pioneer Seamount is located to the southwest of the Farallon Islands and generally is characterized by much lower abundances of seabirds than sites closer to the islands (EPA, 1993). The Farallon Islands and vicinity are used throughout the year by some 350,000 seabirds representing 122 species (Ainley and Boekelheide, 1990). The islands support the world's largest breeding colonies of ashy storm petrels (*Oceanodroma homochroa*, 85% of the world population), Brandt's cormorants (10% of the world population), and western gulls (*Larus occidentalis*, 50% of the world population) (DeSante and Ainley, 1980; Ainley and Boekelheide, 1990). Additionally, an estimated one million sooty shearwaters (*Puffinus griseus*) use the Gulf of the Farallones, especially during their breeding season from March to July (DeSante and Ainley, 1980; Ainley et al., 1987).

Studies of seabirds near the Farallon Islands have been conducted for over a century. More recent studies emphasize the biology of twelve species that nest on the Farallon Islands (Ainley and Boekelheide, 1990) and the distributions of birds that forage in the Gulf of the Farallones (Briggs et al., 1987). Each June from 1985 through 1991, the Pt. Reyes Bird Observatory (PRBO) conducted surveys within the Gulf of the Farallones, including a few stations in the Pioneer Seamount region (Ainley and Allen, 1992). Data from these surveys provide a long-term record of the distribution of seabirds during the breeding season, when overall abundances are highest, although no comparable studies were conducted during other seasons.

Ainley and Allen (1992) list a total of 63 seabird species which occur regularly (i.e., are present each year, either year-round or seasonally) or have special status (i.e., species that are threatened, endangered, or of special concern in the gulf). Of these species, 14 are breeding species, 37 are seasonal visitors, and 12 are passage migrants.

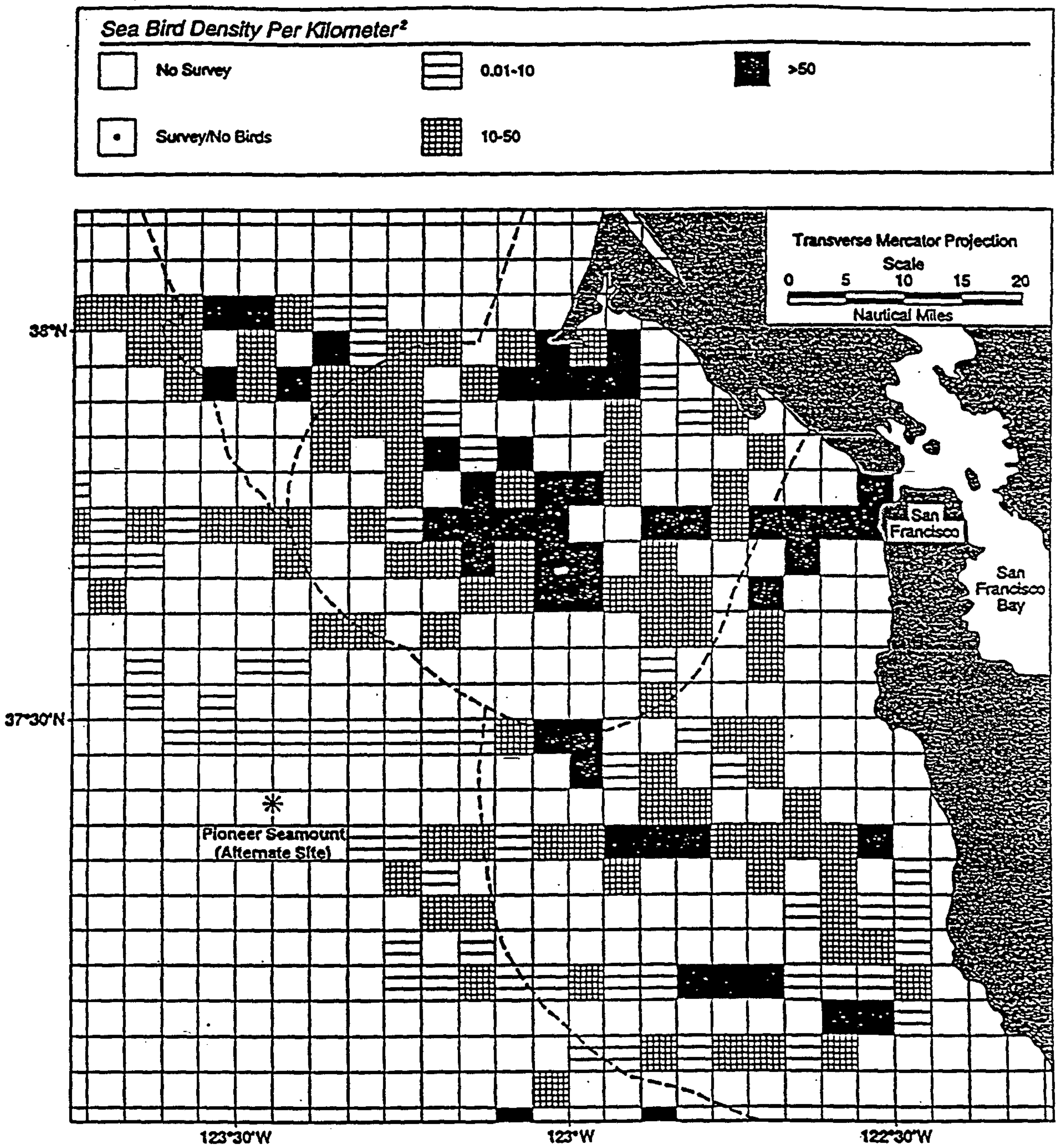
Results from long-term survey data indicated that only eight seabird species were found in proximity to Pioneer Seamount. These species were northern fulmar (*Fulmarus glacialis*), sooty shearwater, red phalarope (*Phalaropus fulicarius*), western gull, rhinocerus auklet (*Cerorhinca monocerata*), Cassin's auklet (*Ptychoramphus aleuticus*), black-footed albatross (*Diomedea nigripes*), and ashy storm-petrel (Ainley and Allen, 1992). Of these eight, only the sooty shearwater, rhinocerus auklet, and Cassin's auklet are capable of diving to depths greater than 20 m (Table 3.3.6-1) (Ainley and Allen, 1992). The other five species are primarily surface feeders or surface plungers, only capable of diving to relatively shallow depths (< 20 m) (Ainley and Allen, 1992; Baird, 1993).

Density estimates of the three diving species sighted in the general region of Pioneer Seamount generally indicated that, except for the rhinocerus auklet, overall abundances were low (i.e., 0.01-10 birds/km^2). In contrast, rhinoceros auklet densities were 10-50 birds/km^2 (Ainley and Allen, 1992). The majority of birds surveyed occurred in proximity to or over waters west of the Farallon Islands (Figure 3.3.6-2). In general, survey results suggested that coastal regions, including shelf waters and areas closest to nesting sites on the Farallon Islands, supported the largest number of seabirds (Ainley and Allen, 1992). Shelf waters are typically more productive and thus serve as more viable fishing grounds for many seabirds (Ainley and Allen, 1992; Jones and Szczepaniak, 1992). Further, regions located closest to nesting sites of breeding species were likely to be a more convenient feeding ground for breeding individuals. Ainley and Allen (1992) suggested that due to limited prey availability and prevailing northerly winds, seabirds forage less often to the south than to the north, west, or east of the Farallon Islands. This is most likely due to the fact that an upwind return flight for an adult bird with prey is estimated to be a costly expenditure of energy.

In addition to the above-mentioned diving species, one migratory bird, the brown pelican (*Pelecanus occidentalis*), occurs in significant numbers in the study area. Brown pelicans are a federally and state endangered species, occurring over coastal waters throughout the central California coast. The nesting range for brown pelicans extends from the Santa Barbara Channel to Mexico. Two major roosting sites are Año Nuevo Island and Southeast Farallon Island (Briggs et al., 1983). Daytime surveys of these areas recorded 500 animals, whereas nocturnal censuses recorded several thousand individuals (Briggs et al., 1983). Surveys conducted from 1985 to 1991 indicated that California brown pelican populations were centered along the coastline and over shelf waters (Ainley and Allen, 1992). EPA surveys (Jones and Szczepaniak, 1992) also recorded the highest numbers of brown pelicans over the continental shelf. Brown pelicans typically forage in shallow waters, and feed primarily on northern anchovy (Anderson et al., 1980; Anderson et al., 1982), but they can be found during calm weather in waters over the continental slope (Briggs et al., 1983; Jones and Szczepaniak, 1992). Although they are not true divers, brown pelicans are surface plungers, capable of reaching depths up to 5 m (Ainley and Allen, 1992).

Other representative seabird species in the Monterey Bay area, including breeding species, winter residents or visitors, spring and autumn migrants, nonbreeding residents or visitors, and rare species, are shown in Table 3.3.6-2. Of the 59 species listed, only 10 are deep divers (i.e., capable of diving to depths ranging from 20-190 m) (Table 3.3.6-1). The remaining species are generally surface feeders or shallow (<20 m) divers that feed primarily on squid, euphausiids, anchovies, and rockfish (Baird, 1993). Other seabird species recorded in the Gulf of the Farallones, including breeding seasonal visitors and passage migrants, are listed with their estimated densities in Jones and Szczepaniak (1992) and Ainley and Allen (1992). Most of these species, including gulls, phalaropes, and storm-petrels, are surface feeders or are generally limited to shallow depths (< 20 m).

Figure 3.3.6-2 represents density estimates of all seabird species combined for the year 1991. This year is representative of intermediate foraging conditions, based on pelagic juvenile rockfish abundance. Ainley and Boekelheide (1990) concluded that the feeding range of pigeon guillemots, Cassin's and rhinocerus auklets, tufted puffins, sooty shearwaters, and many other resident species primarily is a response to food availability as opposed to nesting activities. Further, at least in the summertime, the natural history of breeding seabirds of the Gulf of the Farallones, including visitors such as the sooty shearwater, is based on a "juvenile rockfish economy." When juvenile rockfish are available, foraging habits, behaviors, and diets of many species overlap extensively. The dominant juvenile rockfishes used as prey are yellowtail rockfish and shortbelly rockfish. When rockfish are unavailable or are in lower abundance (e.g., during warm-water years), they are replaced in the diet of many species by anchovies and a variety of other prey including cephalopods and zooplankton. Additional prey species include hake, smelt, and squid, all of which are considered either midwater-schooling species or species that avoid the



(From Ainley and Allen (1992)

Figure 3.3.6-2 Density estimates for all seabird species during June 1992, an "intermediate" rockfish year

Breeding Species	
•Double-crested cormorant	Forster's tern
•Brandt's cormorant	•Common murre
•Pelagic cormorant	•Pigeon guillemot
Western gull	•Marbled murrelet (State endangered, federally threatened)
Snowy plover (Federally threatened)	•Rhinoceros auklet
Caspian tern	Brown pelican (State and federally endangered)
•Tufted puffin	
Winter residents/visitors	
•Common loon	Black scoter
•Arctic loon	•Surf scoter
•Western grebe	Harlequin duck
Red-necked grebe	Herring gull
Laysan albatross	Glaucous gull
Northern fulmar	Black-legged kittiwake
Spring/autumn migrants	
Flesh footed shearwater	Long-tailed jaeger
Mottled petrel	South Polar skua
Brant	Laughing gull
Red phalarope	Sabine's gull
•Horned puffin	Arctic tern
Pomarine jaeger	Common tern
Summer/autumn (nonbreeding) residents/visitors	
Buller's shearwater	Black storm petrel
Black-footed albatross	Royal tern
Pink-footed shearwater	Elegant tern
•Sooty shearwater	Xantus' murrelet
Black-vented shearwater	Ashy storm-petrel
Rarities	
Yellow-billed loon	Brown booby
Short-tailed albatross	King eider
Cape petrel	Black tern
Greater shearwater	Thick-billed murre
Least storm-petrel	Black skimmer
Red-billed tropicbird	Little gull

• indicates deep diving species (capable of diving to depths > 20 m)

Source: Briggs et al. 1983; Ainley and Allen, 1992

Table 3.3.6-2 Representative seabirds and their seasonal status in the Monterey Bay area surface. Figure 3.3.6-2 indicates that seabird densities for an intermediate rockfish year (1991) are scattered over the region, with highest densities occurring within the GOFNMS.

3.3.7 THREATENED, ENDANGERED, AND SPECIAL STATUS SPECIES

This section presents information on threatened, endangered, and special status species that may occur in the study area. Information on species status, abundance, and general life history is also included.

Twenty threatened, endangered, or special status marine species occur offshore from the central California coast. These include five mysticetes (blue, fin, sei, humpback, and right whales), one odontocete (sperm whale), three pinnipeds (northern fur seal, Guadalupe fur seal, and Steller sea lion), one fissiped (southern sea otter), five bird species (peregrine falcon, California brown pelican, short-tailed albatross, marbled murrelet, and western snowy plover), four sea turtles (leatherback, green, olive ridley, and loggerhead turtles) and one fish species (winter-run chinook salmon). The current status of these species under the Federal Endangered Species Act (ESA) and the State of California endangered or protected species list is summarized in Table 3.3.7-1.

Details on the biology and distributions of the twenty species observed within the study regions are provided in Sections 3.3.1 (Marine Mammals), 3.3.2 (Sea Turtles), 3.3.6 (Seabirds), and 3.4.1. (Commercial, Recreational, and Potential Fisheries). A brief summary of species occurrence based on historic surveys and recent annual and seasonal censuses within the study area is presented below.

Mysticetes

Blue whales are most common off the California coast during summer and fall seasons. Estimates of central California populations, presumed to pass through the Pt. Sur region, included almost 2200 individuals (Barlow, 1993a) as compared to only 28 during the winter and spring (Forney and Barlow, 1993). The greatest abundances of blue whales within the Farallon Basin also occur in summer and early fall (Dohl et al., 1983), although overall counts are generally lower than those cited for the Pt. Sur region. Studies conducted from 1986-1989 identified a total of 179 blue whales within the Gulf of the Farallones (Calambokidis 1990b). In 1986, an aggregation of 41 blue whales was sighted near Southeast Farallon Island (National Marine Sanctuary Program 1987). Recent seasonal studies (Jones and Szczepaniak, 1992) recorded the greatest abundances of blue whales along the continental shelf break, east of Pioneer Seamount.

Recent surveys by Barlow (1993a) suggest that fin whales may remain year-round off the central and southern California. Conservative estimates for the study area include 913 animals during the summer/fall seasons (Barlow, 1993a) and 78 during winter/spring seasons (Forney and Barlow, 1993), although a major portion of the sightings was within the SCB. In comparison, during broad-scale surveys of central and northern California marine mammal populations (including the Pioneer Seamount study region), recorded 30 sightings for a total of 56 fin whales, primarily over continental shelf and slope waters (Dohl et al., 1983). In addition, this survey observed a group of five to eight fin whales just south of the Farallon Islands, and a single

Common Name	Scientific Name	Status
Mysticetes		
Blue Whale	*Balaenoptera musculus*	FE
Fin Whale	*B. physalus*	FE
Sei Whale	*B. borealis*	FE
Humpback Whale	*Megaptera novaeangliae*	FE
Right Whale	*Eubalaena glacialis*	FE
Odontocetes		
Sperm Whale	*Physeter macrocephalus*	FE
Pinnipeds		
Northern Fur Seal	*Callorhinus ursinus*	D (Special Status)
Guadalupe Fur Seal	*Arctocephalus townsendi*	ST, FT
Steller Sea Lion	*Eumetopias jubatus*	FT
Fissipeds		
Southern Sea Otter	*Enhydra lutris*	FT
Birds		
Peregrine Falcon	*Falco peregrinus*	FE
California Brown Pelican	*Pelecanus occidentalis californicus*	SE, FE
Short-Tailed Albatross	*Diomedea albatrus*	FE
Marbled Murrelet	*Brachyramphus marmoratus*	SE, FT
Western Snowy Plover	*Charadrius alexandrinus nivosus*	FT
Sea Turtles		
Leatherback Turtle	*Dermochelys coriacea*	FE
Green Turtle	*Chelonia mydas*	FT
Olive Ridley Turtle	*Lepidochelys olivacea*	FT
Loggerhead Turtle	*Caretta caretta*	FT
Fish		
Winter-Run Chinook Salmon	*Oncorhyncus tshawytscha*	SE, FE

FE = Federally listed endangered
ST = State listed threatened
FT = Federally listed threatened
SE = State listed endangered
D = Depleted (under the Marine Mammal Protection Act) (Special Status)

Table 3.3.7-1 Threatened, endangered, or special status species individual approximately 20 km west of Point Reyes. However, no fin whales were sighted within the region during later annual (Ainley and Allen, 1992) and seasonal surveys (Jones and Szczepaniak, 1992).

Sei whales typically are distributed offshore in deeper waters and are not associated with coastal bottom features (Barlow, 1993). Population estimates for the Pt. Sur region include 61 animals during the summer/fall seasons (Barlow, 1993a), although none were observed during winter/spring surveys (Forney and Barlow, 1993). Similarly, sei whales rarely occur in the Gulf of the Farallones (Dohl et al., 1983), with none observed during recent survey efforts (Ainley and Allen, 1992; Jones and Szczepaniak, 1992).

Humpback whales in the eastern north Pacific migrate between winter breeding grounds in Hawaii and Mexico and summer feeding grounds in Alaska. Therefore, central California offshore waters may serve as migration corridors between breeding and feeding grounds. A total of 609 humpback whales are estimated to cross through the Pt. Sur region during the summer and fall season (Barlow, 1993a). Winter/spring population estimates for the region include approximately 375 individuals (Forney and Barlow, 1993). Humpback whales typically are found in the Pioneer Seamount region from March through January with the greatest concentrations occurring from mid-August through October (Dohl et al., 1983; Baker et. al., 1986; Calambokidis et al., 1990a). Annual surveys conducted during June from 1985-1991 (Ainley and Allen, 1992) and seasonal surveys in August (Jones and Szczepaniak, 1992) recorded the greatest abundances (2-10 individuals) over the continental shelf and deeper slope waters east of Pioneer Seamount.

The distributional range for right whales extends from the Gulf of Alaska to central Baja California (Caldwell and Caldwell, 1983). Although sightings in California waters are rare (see Section 3.3.1.1), they are usually seen nearshore in shelf waters. Forney et al. (1995) estimated that only 16 individuals (based on a single sighting) were likely to pass through the Pt. Sur region during the winter and spring seasons. Sightings of right whales within the Gulf of the Farallones also are uncommon. None were observed in the vicinity of Pioneer Seamount during long-term (Ainley and Allen, 1992) or seasonal (Jones and Szczepaniak, 1992) surveys.

Odontocetes

Sperm whales exhibit a strong preference for deep waters, usually occurring along the 1000 m contour and seaward (Whitehead and Weilgart, pers. comm., 1993). An estimated 857 and 725 individuals for winter/spring and summer/fall, respectively, occur offshore of California, including waters within and surrounding the Pt. Sur and Pioneer Seamount regions. Dohl et al. (1983) characterized sperm whales as regular visitors to the Gulf of the Farallones; however, actual counts were somewhat lower than those cited for the Pt. Sur region. Historical surveys from 1980-83 recorded 66 sperm whale sightings for a total estimate of 218 individuals (Dohl et al., 1983). Most of the sightings occurred in deeper waters (greater than 1700 m) but in some areas (e.g., off Nova Scotia) they are found in waters <1700 m depth (Whitehead, pers. comm., 1995). Although sperm whales historically were listed as the sixth most common cetacean in the region, recent surveys recorded no sightings of this species (Ainley and Allen, 1992; Jones and Szczepaniak, 1992).

Pinnipeds

Although currently not listed as endangered or threatened, the northern fur seal is considered depleted under the Marine Mammal Protection Act. It is found primarily over the continental shelf and slope where potential prey items are most abundant. Estimates of northern fur seal populations in the Pt. Sur region are approximately 4000 individuals (see Section 3.3.1). Northern fur seals were the most abundant pinniped species in the Gulf of the Farallones study region during June surveys (Ainley and Allen, 1992). During these surveys, low densities of these seals (0.01-10/km^2) were observed in slope waters, with slightly higher densities observed along the western edge of the GOFNMS. Jones and Szczepaniak (1992) listed northern fur seals as the second most frequently sighted pinniped. Similar to Ainley and Allen (1992), most sightings occurred over the continental slope, although almost half of the sightings occurred over deeper water in close proximity to Pioneer Seamount (Jones and Szczepaniak, 1992).

The Guadalupe fur seal is considered a threatened species by Federal and State agencies. Currently, this species is known to breed only at Guadalupe Island, Baja, Mexico, and sightings have been restricted to waters south of the Channel Islands (Bonnell et al., 1981). Because their breeding range is so far south of the study area, and species sightings have been restricted to waters south of the Santa Barbara Channel, no Guadalupe fur seals are expected to occur within the study area.

Steller sea lions were listed as threatened under the ESA due to recent reductions in their numbers. Their southernmost rookery is Año Nuevo Island, north of Pt. Sur. A rookery of approximately 200 animals exists on Southeast Farallon Island (Huber et al., in prep.), approximately 30 nm (56 km) from Pioneer Seamount. Although this species is one of three pinniped species that breed in the region, few sightings were made during recent surveys (Ainley and Allen, 1992; Jones and Szczepaniak, 1992). Ainley and Allen (1992) recorded two sightings of single individuals, one near Cordell Bank and one nearshore within the eastern boundary of the GOFNMS. Similarly, Jones and Szczepaniak (1992) sighted only two individuals over slope waters east and north of Pioneer Seamount.

Fissipeds

The southern sea otter was federally listed as threatened in 1977. Its distribution ranges from Pt. Año Nuevo south to Pismo Beach (Jameson, 1989) within coastal regions extending from the shore to approximately 2 km offshore. There are an estimated 114 sea otters located along the coast near Pt. Sur. In contrast, no sightings of these sea otters were made during recent surveys of the Gulf of the Farallones (Ainley and Allen, 1992; Jones and Szczepaniak, 1992). Southern sea otters typically inhabit rocky intertidal and kelp bed areas (Reidman and Estes, 1990). Thus, it is very unlikely that any would be present within deeper, slope waters of the study area.

Sea Turtles

Leatherback, green, olive ridley, and loggerhead turtles do not nest in the study area. These species are most often observed foraging within central California waters, especially during summer and fall months when water temperatures are warmest. The leatherback is the most frequently sighted sea turtle within northern and central California (Dohl et al., 1983), followed by greens, loggerheads, and an occasional olive ridley. Leatherbacks currently are federally listed as endangered while the other three species are federally listed as threatened. Although all four species are known to occur in the Pt. Sur region, only two leatherbacks were sighted during recent seasonal surveys of the Pioneer Seamount region (Jones and Szczepaniak, 1992). The first sighting occurred in shallow water (54 m depth) east of Pioneer Seamount, while the second observation was over waters approximately 1000 m deep, southeast of Pioneer Seamount. Both sightings occurred in August, consistent with Dohl et al. (1983) findings of highest leatherback abundances during summer and fall months.

Fish

A dramatic reduction in winter-run chinook populations over the past two decades has led to its listing as a federally threatened and state endangered species. Based on CDFG data, these salmon pass through the Delta region, San Pablo Bay, and San Francisco Bay during upstream and downstream migrations (J. Turner, pers. comm., 1991). Their natural range extends from Japan to the Bering Sea and southward to San Diego, California. Chinook salmon are common from Pt. Conception northward (Love, 1991). Although this species is the least abundant Pacific salmon, it has the highest value per pound and is fished commercially in North America from Kotzebue Sound, Alaska, to Santa Barbara, California (Emmett et al., 1991). Ocean-dwelling juveniles occur primarily over continental shelf waters (Fredin et al., 1977). Commercial fish block data for the Gulf or the Farallones study region (MMS/CDFG Commercial Fisheries Database, 1992) indicate highest abundances of salmon, including winter-run chinook, within shelf regions. The coho (silver) salmon (*Oncorhynchus kisutch*) population in Scott and Waddell Creeks, Santa Cruz County, have been listed by the State of California as a candidate species for threatened status. The steelhead (rainbow trout) has also been petitioned for listing as an endangered species.

Birds

Peregrine falcons are federal- and state-listed as endangered species. Although this species is not a seabird and does not dive, it preys on other seabird species, and thus is usually found in proximity to seabird roosting and nesting sites. Peregrine falcons are considered rare in the Gulf of the Farallones region, but historically have bred on the Farallon Islands (DeSante and Ainley, 1980). Currently, a relatively high number of individuals (5-8) continue to winter on the Islands (PRBO, unpubl. data). During 1987 and 1991 winter/spring NMFS cruises, two peregrine falcons were observed foraging over waters north and west of the Farallon Islands (PRBO, unpubl. data). No peregrine falcons were observed during annual or seasonal surveys by Ainley and Allen (1992) and Jones and Szczepaniak (1992), respectively.

California brown pelicans currently are listed by federal and state agencies as endangered; however, they appear to be recovering (Ainley and Allen, 1992). The MBNMS, including the Pt. Sur region, has been identified as an important area for visiting autumn and winter populations of California brown pelicans (NOAA, 1992). Similarly, large numbers of pelicans roost at various sites on the Farallon Islands (Pyle and Henderson, 1991) and coastal mainland sites (Shuford et al., 1989). Recent annual surveys (Ainley and Allen, 1992) suggest that pelican populations are concentrated nearshore, over waters shallower than 180 m. Seasonal surveys (Jones and Szczepaniak, 1992) also concluded that abundances were greatest over continental shelf and upper slope waters.

The short-tailed albatross (*Diomedea albatrus*) is also a federally endangered species. One individual was sighted within Monterey Bay in 1990 (PRBO, unpubl. data). Although the short-tailed albatross historically was a common species in offshore waters of the North American west coast (Ainley and Allen, 1992), only one individual has been sighted (circa 1985) over Cordell Bank, in proximity to the Pioneer Seamount region (PRBO, unpubl. data).

The marbled murrelet is a federally threatened and state endangered species. This species rarely forages farther than 3-5 km (1.6-2.7 nm) offshore (Ainley and Allen, 1992) and is known to occupy several isolated sites in the Santa Cruz mountains (NOAA, 1992). Marbled murrelets were not observed in the Pioneer Seamount region during annual or seasonal surveys (Ainley and Allen, 1992; Jones and Szczepaniak, 1992, respectively).

Western snowy plovers are federally threatened shorebird species known to occur on sandy ocean beaches. Although they are not a true seabird, they inhabit coastal regions in the study area. Snowy plovers forage on beaches and flats and nest in sand depressions above the high tide line.

3.3.8 MARINE SANCTUARIES AND SPECIAL BIOLOGICAL RESOURCE AREAS

A number of protected areas occur within the general region of the study area. The preferred action site (Sur Ridge) is located within the MBNMS. In addition, this site is within 37 km of coastal or island ecological reserves, wildlife refuges, and/or areas of special biological significance (ASBS) (Figure 3.3.8-1). The proposed action site (Pioneer Seamount) is approximately 37 km (20 nm) from the MBNMS and the GOFNMS.

The National Marine Sanctuaries Act (NMSA; also known as Title III of the Marine Protection, Research and Sanctuaries Act of 1972) was established for the protection and management of discrete areas having special ecological, recreational, historical, or aesthetic resources. These areas are administered by NOAA's Sanctuaries and Reserves Division (SRD) (NOAA, 1992). The MBNMS is one of fourteen designated national marine sanctuaries, encompasses approximately 13,780 km^2 (4,020 nm^2) (NOAA, 1992), and supports a high diversity of marine resources. A complete list of species known to occur in the sanctuary is presented in the Final Environmental Impact Statement/Management Plan for the MBNMS (NOAA, 1992). Important nearshore and/or offshore resources within the sanctuary include commercial fisheries, aquaculture operations, kelp harvesting, estuaries, sloughs, sandy beaches, rocky intertidal habitats, and nearshore littoral habitats (NOAA, 1992).

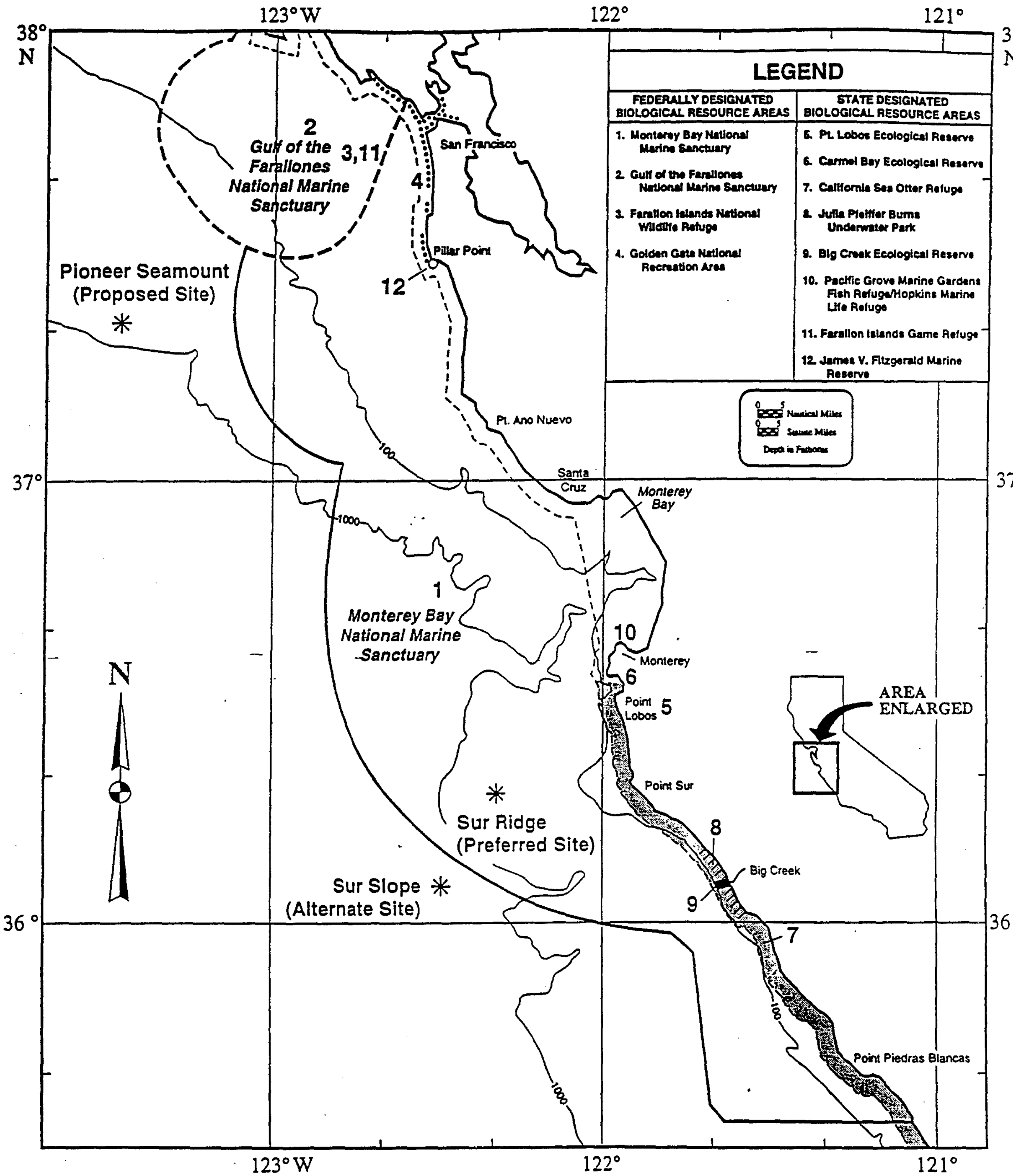


Figure 3.3.8-1. Federal and state designated biological resource areas near the proposed ATOC source site location.

In addition to the federally-designated MBNMS, several state refuges and reserves are located in the Pt. Sur region (Figure 3.3.8-1). The Pt. Lobos and Carmel Bay Ecological Reserves represent extensive areas of rocky tidepools and are used extensively by marine mammals and birds. The California Sea Otter Game Refuge covers portions of Monterey and San Luis Obispo Counties between the Carmel River on the north and the Santa Rosa Creek on the south. It is the largest refuge in the state, covering 160 km (86 nm) of coastline in Monterey County and 56 km (30 nm) in San Luis Obispo County. Within its boundaries are several state parks and reserves, including Pt. Lobos Ecological Reserve (see above), Julia Pfeiffer Burns State Park, and the entire Big Sur coastline.

Hopkins Marine Life Refuge includes ocean waters extending 305 m (1000 ft) from shore at the southern end of Monterey Bay. The Pacific Grove Marine Gardens Fish Refuge includes ocean waters of Monterey Bay adjacent to the City of Pacific Grove to a depth of 18 m.

The GOFNMS encompasses approximately 3250 km^2 (948 $nm^{2)}$ of nearshore and offshore waters, most of which lie in the Gulf of the Farallones (GOFNMS; Figure 3.3.8-1). The GOFNMS, including the Farallon Island National Wildlife Refuge and the Farallon Island Game Refuge and ASBS, is considered the most important seabird breeding site on the west coast of the continental U.S. (Sowles et al., 1980; Briggs et al., 1987b).

The Golden Gate National Recreation Area (GGNRA) includes designated lands and offshore water seaward to 0.25 mile (0.40 km) from the mean-high tide line at Pillar Point. The GGNRA is managed by the U.S. Parks Service. The ATOC cable would pass through approximately 0.40 km of the GGNRA offshore of the western edge of Pillar Point.

The James V. Fitzgerald Marine Reserve extends from the mean high tide line, 1000 ft (305 m) into the ocean off San Mateo County. The Reserve, like other fish and game refuges throughout California, is managed by the CDFG. Regular California fishing and hunting regulations do not apply within the Reserve. Instead, taking or possessing fish, shellfish, abalone, invertebrates or marine plant life is prohibited or severely restricted within the Reserve.

3.3.9 NEARSHORE AND LANDFALL BIOTA ALONG CABLE ROUTE

The cable routes from the Sur Ridge, Sur Slope, and Pioneer Seamount sites would extend over continental slope and shelf habitats from a few thousand to tens of meters bottom depths, as described in Sections 3.3.3 and 3.3.4 (Fish and Invertebrates, respectively), and finally through shallow subtidal, intertidal, and terrestrial (landfall) areas. This section describes these latter habitats.

Shallow subtidal (i.e., 15-20 m and less) areas adjacent to the Pt. Sur and Pillar Point landfalls are expected to include typical central California kelp bed habitats characterized by numerous species of brown, red, and green algae such as bull kelp (*Nereocystis luetkeana*), feather boa (*Egregia menziesii*), *Codium* spp., *Laminaria, Alaria*, and *Gigartina* (Brusca and Brusca, 1978). Erect coral-like algae, such as *Calliarthron* and *Corallina* also are present. Invertebrate communities include seastars such as *Pisaster, Henricia, Dermasterias,* and *Asterina*, red abalone (*Haliotis rufescens*), and *Cancer* crabs. The fish community is characterized by rockfish (*Sebastes* spp.), lingcod (*Ophiodon elongatus*), cabezon (*Scorpaenichthys marmoratus*), kelp greenling (*Hexagrammos decagrammus*), surfperch (e.g., *Hyperprosopon*), salmon (*Oncorhynchus* spp.), halibut (*Paralichthys californicus*), and starry flounder (*Platichtys stellatus*) (California Coastal Commission, 1987; Brusca and Brusca, 1978). The southern sea otter also may occur in the study area. The nearshore Pt. Sur cable route would cross through the California Sea Otter Refuge. The nearshore Pillar Point cable route would cross through the James V. Fitzgerald Marine Reserve, where California sea lions (maximum 200) and breeding and molting harbor seals (maximum 200) exist (also around Pillar Point).

Algal communities of rocky intertidal habitats in the study area are dominated (percent cover) by *Endocladia muricata* and *Mastocarpus papillatus* (Foster et. al, 1992), but also are characterized by sea palm (*Postelsia palmaeformis*), coralline algae (e.g., *Corallina* and *Bossiella*), surfgrass (*Phyllospadix*), *Fucus*, sea lettuce (*Ulva* spp.), *Gigartina, Cystoseira,* and *Pelvetiopsis* (Brusca and Brusca, 1978). Intertidal invertebrates are characterized primarily by mussels (*Mytilus californianus*), snails (*Littorina* and *Tegula* spp.), barnacles (*Balanus glandula*), hermit crabs (*Pagurus* spp.) and various limpet species (Foster et. al, 1992), with sea anemones (*Anthopleura elegantissima* and *A. xanthogrammica*) common in many areas (Brusca and Brusca, 1978). Intertidal fish include various species of sculpins (*Clinocottus* and *Leptocottus* spp.), kelpfish (*Gibbonsia*), and blennies (*Hypsoblennius*).

At the Pt. Sur landfall near the Naval Facility, seabird potential roosting sites occur for Brandt's and pelagic cormorant, and western gulls. The threatened western snowy plover and rare black swift have been sighted in the Pt. Sur region (CDFG Natural Diversity Database, 1993). Cormorants, brown pelicans, and gulls also are common in the Pillar Point area (California Coastal Commission, 1987). Monarch butterflies have been observed roosting in trees near Pt. Sur (CDFG Natural Diversity Database, 1993). Approximately 35 species of terrestrial birds and mammals were observed on bluffs and grasslands adjacent to the Pillar Point landfall (SFBO, 1993), including vultures, red-tailed hawks, black-shouldered kites, Steller's jay, canyon wrens, dark-eyed juncos, coyotes, bush rabbits, deer mice, long-tailed weasels, and pocket gophers. Vegetation in the vicinity of the Pillar Point cable landfall route consists of typical low, soft-woody coastal shrubs and herbaceous perennials. Several introduced "nuisance" species are present, including two types of iceplant (*Carpobrotus* spp.), german ivy (*Senecio mikanioides*), and pampas grass (*Cortaderia jubata*) (Air Force, 1994). The top of adjacent bluffs are characterized by grasses and scattered shrubs. The Air Force (1994) study was conducted in the same erosion gully as the proposed ATOC cable route. A recent search of the CDFG Natural Diversity Database revealed no endangered or threatened species in the vicinity of Pillar Point. Similar bird and mammal species found near Pt. Sur are also likely to occur near Pillar Point.

3.4 SOCIOECONOMIC ENVIRONMENT

This section describes the socioeconomic environment within the general study area, depending on data availability. Separate sections are presented on commercial, recreational, and potential fisheries (3.4.1), mariculture (3.4.2), shipping (3.4.3), military usage (3.4.4), mineral or energy development (3.4.5), cultural and historical areas (3.4.6), recreational activities and tourism (3.4.7), research and education (3.4.8), and water contact sports (3.4.9).

3.4.1 COMMERCIAL, RECREATIONAL, AND POTENTIAL FISHERIES

This section describes the commercially and recreationally important invertebrates and fish near the study area, including those collected by trawls from EPA- (SAIC 1992b) and Navy-sponsored studies (Cailliet et al. 1992), as well as information summarized in NOAA (1992), Bence et al. (1992), and Jow (1992). Information also is presented on potential fisheries likely to occur in the study area.

The continental shelf and slope areas off central California support an economically valuable range of commercial fisheries utilizing a variety of methods, including purse seine, dip net, trawl, trap, gill net, troll, and hook and line (Battelle, 1989). In 1987, a combined total of over 74 million kg (34 million pounds) of fish with an ex-vessel value of almost $15 million was landed at the ports of Moss Landing, Monterey, Santa Cruz, and Princeton. The retail value of the fish to the local economy is worth two to three times that of the ex-vessel value (NOAA, 1992).

The principal market species in this region include Dungeness crab, market squid, salmon, tuna, flatfish species including Dover sole, rex sole, English sole, and petrale sole, a variety of rockfish (including shortbelly, widow, boccacio, chilipepper, splitnose, canary, and yellowtail), thornyheads, and sablefish (Bence et al., 1992; Jow, 1992; SAIC, 1992b; Batelle, 1989; MBC, 1989; Tetra Tech, 1987). In addition to primary market species, a number of other species including albacore tuna, mackerel, anchovy, Pacific herring, lingcod, and several species of sharks have commercial value.

In the Pt. Sur and Monterey Bay regions, the most substantial commercial invertebrate fisheries include both pelagic and demersal invertebrates such as spot prawn, *Cancer* crabs, and market squid. In contrast, Dungeness crab, a significant bottom fishery resource in shallow inshore depths along much of the west coast of North America (Botsford et al., 1989), was collected infrequently on the continental shelf off San Francisco by SAIC (1992b) and Parr et al. (1987).

In contrast to fisheries resources on the continental shelf, shallower inshore areas, and upper and middle slope depths, little information exists regarding commercial invertebrate fisheries in deeper areas (> 2000 m). This likely is due to lower fishing effort for invertebrates and fish at these deeper locations, particularly for far offshore areas such as Sur Slope and Pioneer Seamount. For example, a total of less than 0.5 million pounds/fisheries catch block of fish and invertebrates were commercially collected from the Pt. Sur area between 1978 and 1986 (MMS/CDFG Commercial Fisheries Database, unpublished) (Figure 3.4.1-1). Moreover, no depth-related trends in total landings were evident in this area. This is likely due to relatively low fishing effort south of Monterey and a much narrower shelf, compared to other areas off San Francisco. Similarly, a total of less than 0.5 million pounds/catch block of invertebrates and fish were collected between 1978 and 1986 from an area near Pioneer Seamount (at depths of approximately 2000 m), while more productive inshore areas, generally associated with the shelf break, typically yielded total catches over 2.5 million pounds/catch block during the same time period (MMS/CDFG Commercial Fisheries Database, unpublished) (Figure 3.4.1-1).

Dungeness Crab

Because of its economic importance to commercial fisheries in central and northern California (as well as Oregon, Washington, British Columbia, and Alaska), the population dynamics of the Dungeness crab have been studied extensively (summarized in MBC, 1987). They typically occur in depths from low tide to approximately 180 m, although they are most abundant in inshore coastal waters (MBC, 1987). Pollution stress to juvenile stages has been suggested as a possible cause for substantial declines in crab abundances (Wainwright et al., 1992). Other causes for population fluctuations may include oceanographic factors (temperature and currents), overfishing, parasitism, predation, and environmental degradation (Wild and Tasto, 1983).

Market Squid

Market squid are fished commercially from Baja California to British Columbia, with major fishing grounds located off central California (MBC, 1989, 1987). Market squid typically are collected using small purse-seines and dip nets. Historically, they have been an important commercial fishery, representing one of the top five in California in terms of weight harvested (MBC, 1987). Market squid represent a limited fishery in the Monterey Bay area, primarily occurring at continental shelf depths. Similarly, Bence et al. (1992) suggest that market squid abundances are highest close to shore, at depths less than 180 m.

Pelagic Fish

The predominant pelagic fish (defined as those species which spend all or part of their life in the water column Moyle and Cech, 1988), of commercial importance off central California are anchovies, herring, juvenile rockfish, and hake. Some species, such as salmon and tuna, may occur seasonally while migrating through the study area.

Northern anchovy are distributed from British Columbia to the tip of Baja California, occurring from the surface to depths greater than 300 m (Love, 1991), and are a major component of the commercial and baitfish fisheries in California. Bence et al. (1992) indicated that juvenile northern anchovy were most abundant in the shallow inshore areas over the continental shelf.

Pacific hake range in distribution from the Bering Sea to Baja California, and can occur in dense midwater schools at depths between 10 to 1000 m (Love, 1991). However, this species is not normally targeted by recreational fishermen because of its deep distribution, and is a smaller component of commercial fisheries in the San Francisco region. SAIC (1992b) collected some Pacific hake using bottom trawls on the continental shelf off San Francisco and in adjacent mid-depth areas near Pioneer Canyon. Bence et al. (1992) concluded that Pacific hake had their highest abundances at intermediate depths (500-1000 m). Although this species is not currently taken in high numbers, it represents a potentially valuable fishery.

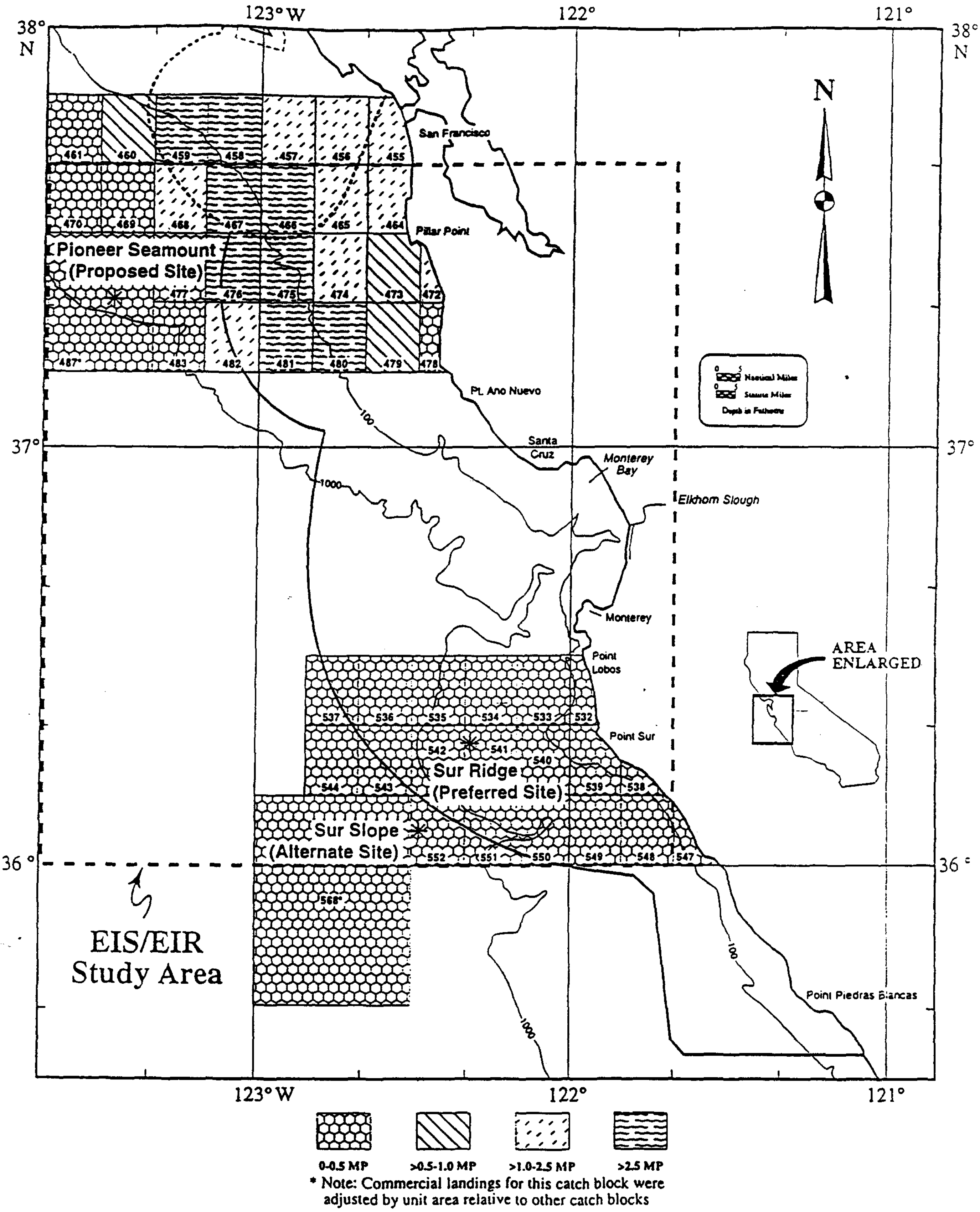


Figure 3.4.1-1 Total commercial fishing landings by catch block between 1978-1986 (data from MMS-CDFG).

Flatfish

Commercially important species of flatfish collected by SAIC (1992b), Bence et al. (1992), and KLI (1991) on the continental shelf off central California included Dover sole, rex sole, Pacific sanddabs, English sole, petrale sole, and California halibut (see Table 3.3.4-1). Similarly, the weight of flatfish landed by trawlers between 1985 and 1987 was highest for species such as Dover sole, English sole, Pacific sanddabs, petrale sole, and rex sole (Jow, 1992). Bence et al. (1992) indicate that slender sole were most abundant between 270 and 360 m depth. SAIC (1992b) collected two species of flatfish (Dover sole and deep-sea sole) at middle slope depths within the Gulf of the Farallones. Of these two species, only Dover sole represents a commercially important flatfish species. No flatfish were collected by SAIC (1992b) in waters deeper than approximately 1500 m. Dover sole that are collected commercially at depths greater than 800 m typically have a high water content which makes them less valuable to commercial fishermen under current market conditions (Bence et al., 1992).

Rockfish

Rockfish, such as splitnose, shortbelly, boccacio, chilipepper, stripetail, and thornyheads, are commercially and/or recreationally important. Rockfish (not including thornyheads), found primarily on the continental shelf by SAIC (1992b) and Bence et al. (1992), were one of the most abundant and species-rich groups. Juvenile rockfish abundances vary seasonally over most areas. Analysis of the California Department of Fish and Game Trawler Database by Jow (1992) indicated rockfish, not including thornyheads, were the predominant species collected commercially on the continental shelf off San Francisco, while rockfish, including thornyheads, were targeted in deeper slope depths from approximately 500 to 1000 m. Of the 16 species of rockfish collected by SAIC (1992b), only two species, the thornyheads *Sebastolobus altivelis* and *S. alascanus*, were abundant on the middle and lower continental slope. However, thornyheads accounted for approximately 25% to 50% or more of the total abundance and biomass of the upper to middle slope fish collected by SAIC (1992b) and Wakefield (1990).

Sablefish

Sablefish commonly rank third in biomass of the trawl-collected fish along the California coast (SAIC, 1992b; Wakefield, 1990; Butler et al., 1989). Sablefish adults and juveniles occur on the continental shelf, but adults tend to be highest in abundance and biomass on the upper to middle slope depths from approximately 200 to 1200 m. Their abundance is somewhat lower (10% to 25% of the total fish biomass) at middle slope depths (SAIC, 1992b; Wakefield, 1990; Butler et al., 1989). The commercial trawl catch of sablefish primarily occurs in depths ranging between 110 and 183 m on the continental shelf and between 457 and 1372 m on the upper and middle slope (Jow, 1992). SAIC (1992b) found that sablefish densities were highest at depths between 200 and 500 m.

Potential Fisheries

In general, limited fisheries currently exist in depths greater than 900 to 1440 m (R. Lea, CDFG, pers. comm., 1991). However, data on deep demersal fish with fisheries potential are available from studies conducted in other areas at similar depths (Pearcy et al., 1982; Stein, 1985; Wakefield, 1990). Currently, the only deep demersal species being targeted are various grenadiers (rattails). The Pacific grenadier (*Coryphaenoides acrolepis*) and the giant grenadier (*Albatrossia pectoralis*), dominated sampling depths greater than approximately 1200 m (SAIC, 1992b; Cailliet et al., 1992; Bence et al., 1992; Eschmeyer and Herald, 1983). Rattails are commercially important in many parts of the world; however, these fish have been lightly exploited along the Pacific Coast due to the difficulties of deep-water trawling in the region (Matsui et al., 1990). Some rattails are landed in California as part of the deep-water Dover sole fishery (Oliphant et al., 1990).

Several other fish species represent a potential future fishery resource. Potential or currently underutilized species include shortbelly rockfish, Pacific sanddab, jack mackerel, ocean sunfish, Tanner crab, king crab, rock crabs, krill, giant Pacific octopus, spiny dogfish, sea cucumber, sheep crab, hagfish, sharks, and skates (NMFS, 1983; S. Kato, NMFS, pers. comm., 1991). Shortbelly rockfish have been identified by NMFS Tiburon as an unexploited fishery with major potential (Chess et al., 1988; Lenarz, 1980). Bence et al. (1992) indicated high abundances of certain species of juvenile rockfish are an extremely important potential component to the commercial rockfish fishery. Other less heavily fished species include hagfish (*Eptatretus* spp.), for which a substantial trap fishery exists for their skins. Wakefield (1990) found black hagfish (*E. deani*) to be predominant along camera sled transects off Pt. Sur at depths between 400 and 1200 m, with a strong peak in abundance within the 600 m zone. Wakefield (1990) estimated that 82% of the total population of black hagfish resided in this zone. Hagfish were collected infrequently by SAIC (1992b) on the continental slope off San Francisco at approximately 1000 m depth.

3.4.2 MARICULTURE

Mariculture operations along the central California coast are located nearshore or within embayments. Present operations shoreward of the study area are listed below, as summarized primarily from NOAA (1992) and EPA (1993).

Mariculture operations in the Pt. Sur region include Silverking Oceanic Farms in Davenport, north of Santa Cruz, which operates a silver and king salmon hatchery, and Pacific Mariculture, which conducts abalone research and production in Santa Cruz at the Long Marine Laboratory. Pacific Mariculture operates the only bivalve mollusc hatchery in California and produces oyster and clam seed for grow-out to other operators (NOAA, 1992).

Several aquaculture operations are located in the Elkhorn Slough area, in Monterey Bay north of Moss Landing. These operations cultivate sea hares, algae, and oysters. There also is a plan to release fry in the Elkhorn Slough area to enhance sport and commercial catches of chinook salmon in the Monterey Bay area.

Another aquaculture facility is the Granite Canyon Marine Laboratory, located north of Pt. Sur and operated by the California Department of Fish and Game. Research at the laboratory focuses on abalone and marine finfish.

Several mariculture operations exist in nearshore embayments of the San Francisco Bay region (EPA, 1993). These consist primarily of oyster culturing operations in Tomales Bay and Drakes Estero at sites leased from the California Department of Fish and Game.

3.4.3 SHIPPING

Types of shipping in the study area include commercial ships, commercial fishing vessels, research vessels, and recreational boating (NOAA, 1992). Most of the commercial shipping along the coast south of San Francisco Bay follows customary north-south shipping lanes. Within these shipping lanes, approximately 27% of commercial vessel traffic travels within 0-9 km (0-5 nm) of the coast; 36% within 9-18.5 km (5-10 nm); 17% within 18.5-28 km (10-15 nm) and 20% over 28 km (15 nm) off the coast. In 1988, approximately 4500 commercial vessels (excluding domestic fishing craft) either entered or exited the San Francisco Bay entrance and transited through the waters south of the bay. Some commercial shipping vessels enter Monterey Bay; five vessels offloaded at Monterey Harbor or Moss Landing Harbor in 1986. Additionally, Pacific Gas and Electric uses a marine terminal for offloading oil for its power generating plant in Moss Landing.

Southbound tankers loaded with oil from Alaska pass by Pt. Sur approximately 157 km (85 nm) offshore. Those bound for the Los Angeles area turn to the east at a point about 185 km southwest of Pt. Sur and then gradually approach the entrance to the Santa Barbara Channel. Northbound vessels following the customary shipping lanes would travel within 18.5-28 km of Pt. Sur.

Other types of vessels include commercial fishing vessels and recreational boating from Monterey Harbor, Santa Cruz Harbor, Moss Landing Harbor, and Pillar Point (Princeton) Harbor. (For a discussion of fisheries, see Section 3.4.1, Commercial, Recreational, and Potential Fisheries; for recreational boating, see Section 3.4.7, Recreational Activities and Tourism.) Research vessels also may operate in the area conducting biological and seismic surveys, and research on submarine communications and remotely operated vehicle guidance technology.

Annual movements in 1991 of all types of vessels transiting in, out, and solely within San Francisco Bay exceeded 86,000, of which approximately 56,000 were ferries, 13,000 tugs with tows, and 6000 were commercial vessels (EPA, 1993). The remainder (11,000) was split between tankers, military vessels, dredges and several smaller categories. However, over 80 percent of these movements are by small vessels such as ferries, tugs, and dredge barges and primarily involve transits within the bay. Movements through the Golden Gate account for less than 10 percent (8600) of all vessel traffic, although they represent a large percentage of the commercial cargo, Coast Guard, Navy, tanker, and other large vessel movements. Approximately 38% of vessels arriving and departing San Francisco Bay use the northern traffic lane, 20% the western lane (the extension of which traverses the Pioneer Seamount region), and 42% the southern lane. These lanes have been established by the Coast Guard as a safety measure to regulate vessel traffic.

The volume of recreational and small vessel traffic, including fishing vessels, in the San Francisco Bay area is not monitored, but is estimated by the Coast Guard at 25 to 50 times the number of large commercial and military movements. Most recreational boating takes place within the protected waters of the San Francisco Bay; however, the GOFNMS and Farallon Islands attract recreational and nature expeditions as well (see Section 3.4.7).

3.4.4 MILITARY USAGE

There are four areas of military activity located within the Monterey Bay region (NOAA, 1992). The U.S. Navy has historically utilized a zone extending 8000 yd (7.2 km) offshore for Navy mine warfare operations between February and July each year. Additionally, the U.S. Navy has an operating area in the northeast section of Monterey Bay that has been used for mine sweeping practice maneuvers. However, presently these areas are not being used for any military operations (P. Cotter, MBNMS, pers. comm., 1994). The military operations portion of the U.S. Coast Guard Special Notice to Mariners (USCG, 1994) identifies Danger Zone 334.1150 in Monterey Bay (Lt. J.G. Grudzinski, USCG, pers. comm., 1994). However, this zone was discontinued associated with base closure of Ft. Ord (1994).

The San Francisco Warning Area (W-285), used for both air and surface training, is located approximately 37 km west of Pt. Sur (NOAA, 1992). It is approximately 74 km (40 nm) in width, and extends north to an area offshore of Davenport and south to an area offshore and south of Cambria. Air activities can include aircraft carrier takeoffs and landings, and low-level air combat maneuvering, with expenditure of smoke markers, sonobuoys, and non-explosive ordnance.

The San Francisco Bay region and adjacent Gulf of Farallones represent a major area of military usage, primarily by the U. S. Navy. The U. S. Coast Guard Special Notice to Mariners indicates that the Navy may conduct continuous, day and night countermeasure training operations in the Gulf of the Farallones. The operations include low flying (below 61 m/200 ft) naval helicopters towing mine sweeping equipment extending 120-240 m (400-800 ft) behind them. A towed hydrofoil platform trails an additional 180 m of submerged cable.

The Navy's Third Fleet utilizes the Gulf of the Farallones region for offshore air, surface, and submarine operations. In the third quarter of 1994, 90 Navy vessels transited in or out of San Francisco Bay (Lt. Cmdr. S. Krammes, USCG, pers. comm., 1994). The Navy maintains five submarine operating areas (U1-U5) located 45-56 km from the Golden Gate (EPA, 1993). Use of submarine operating areas is typically associated with trial diving exercises and equipment checkouts. The Navy also conducts aircraft and surface vessel exercises, often in conjunction with submarine operations, in an area that encompasses North Farallon Island and Noonday Rock along its southern boundary. Activities include antisubmarine warfare training, air intercepts, surface vessel coordination, and dropping of inert ordnance. These exercises typically represent 15 use-days per quarter.

In 1993, there were 78 Navy submarine transits of the San Francisco Bay Region (Lt. Cmdr. S. Krammes, USCG, pers. comm., 1994) as compared to 69 transits in 1991 (EPA, 1993).

The U. S. Coast Guard supports infrequent aerial overflight missions throughout the area and conducts approximately five helicopter sorties per week around the Farallon Islands for offshore enforcement purposes. Event-specific search and rescue missions also are conducted (EPA, 1993).

3.4.5 MINERAL OR ENERGY DEVELOPMENT

The MBNMS lies within the Central California Planning Area of the Minerals Management Service (MMS). Exploring for, developing, or producing oil, gas, or minerals is prohibited within the sanctuary. Further, all State waters off central California have been designated as an oil and gas sanctuary (Sections 6871.1 and 6871.2 of the California Public Resources Code); no oil and gas leasing is permitted within 3 nm (5.6 km) of the coast. The only significant mineral development in the region is sand, which is mined in Marina and Sand City by Monterey Sand Company and Lone Star Industries (NOAA, 1992).

There are no oil and gas development activities or structures within the Pioneer Seamount region (EPA, 1993) and all potential lease areas are over 370 km (200 nm) from the site. The GOFNMS and the Cordell Bank National Marine Sanctuary consist of more than 1852 km^2 (1000 nm^2) of ocean area, primarily north of San Francisco. The coastal boundaries of these sanctuaries follow the seaward limit of Pt. Reyes National Seashore and the mean high tide line between Bodega Head (Sonoma County) and Rocky Point (Marin County). The seaward boundaries extend 22 km (12 nm) offshore and encompass all the waters encircling the Farallon Islands within 22 km. No new oil or gas development activities are permitted within the sanctuaries.

3.4.6 CULTURAL AND HISTORICAL AREAS

Historical and cultural resources are defined as those areas of the marine environment possessing historical, cultural, archaeological, or paleontological significance, including sites, structures, and objects significantly associated with or representative of earlier people, cultures, and human activities and events. Historical and cultural resources in the marine environment may generally be categorized into prehistoric remains; inundated cities, harbors, and shore installations; and ship and aircraft wrecks.

Literature reviews and site record searches for the Pt. Sur area have been initiated by Geoarch consulting marine archaeologists. Information was obtained from the Northwest Information Center of the California Archaeological Inventory at California State University-Sonoma, Scripps Institution of Oceanography, MMS, National Maritime Museum, and the California State Lands Commission shipwreck database. Results of this literature review and records search indicate that there are approximately fifteen recorded shipwrecks within about a 16 km (10 mi) radius of Pt. Sur, and at least six recorded shipwreck sites with position locations listed as "Point Sur" (38° 18' 24" N Latitude, and 121° 53' 48" W Longitude). The oldest of these ships is W.T. WHEATON, sank in 1854. The others are LOS ANGELES, sunk in 1894; MAJESTIC, sunk in 1909; CATANIA, sunk in 1915; G.C. LINDAUER, sunk in 1921; and RHINE MARY, sunk in 1930. Two other shipwreck sites are listed in the general vicinity: FALLMOUTH, sunk in 1874; and FRANK

LAWRENCE, sunk in 1946. All of these shipwreck sites may be potentially historically significant and are potentially eligible for listing on the National Register of Historic Places.

The Geoarch progress information indicates that governmental baseline studies have assessed the cultural (historical) sensitivity of the Pt. Sur area as moderate to high; however, the potential for preservation of submerged historic cultural resources in the project vicinity is assessed as fair to poor depending on the type and age of the vessel. Preservation potential of older wooden vessels in the proposed project area is considered poor. Vessel remains could possibly exist within the cable corridor for the preferred action site (Sur Ridge), but expected site integrity has been assessed by Geoarch as low. After a ship is holed or capsized, it may sink to the seafloor intact or in fragments. In either case, over the years, waves, currents, marine organisms, and other factors may break up, scatter, and degrade vessel remains. Potentially significant remnants of a vessel (e.g. ballast piles, fasteners and structure) often remain, however, and can add important information to the historic record. For more recent vessels, fair preservation potential can be expected due to the use of more durable construction materials such as composite, steel or ferro-cement.

On land, a number of historic and prehistoric cultural resource sites are recorded within the general project area, primarily in the vicinity of the Pt. Sur Lighthouse. However, there are no known archaeological sites within the onshore cable route for the preferred action site.

A literature review and site records search was conducted at the State Lands Commission to identify any known ship or aircraft wreck sites in the Pioneer Seamount study area. Results (P. Pelkofer, pers. comm., 1994) indicate that there are no recorded ship or aircraft wreck sites on the topographic landform known as Pioneer Seamount. In addition, a sidescan sonar survey of the Pioneer Seamount-to-Pillar Point cable route identified no shipwrecks or similar cultural/historical resources along the proposed route. Onshore, a cultural/historical resources survey undertaken by the U.S. Air Force in conjunction with their proposed bluff restoration project concluded that there are no such resources in the onshore project area (Air Force, 1994).

3.4.7 RECREATIONAL ACTIVITIES AND TOURISM

Recreational activities and tourism in the study area are discussed in the following sections. In-water sports such as surfing and diving are discussed in Section 3.4.9, Water Contact Sports.

There are approximately nine operators of commercial whale-watching boats in the general Pt. Sur region. Four are located in Santa Cruz Harbor, four in Monterey Harbor, and one in Moss Landing Harbor. The whale-watching season generally starts in late December and ends in early April. Monterey Harbor is located over two hours by boat from Pt. Sur. Most whale-watching trips, other than special charters, last only two to three hours and do not travel as far south as Pt. Sur.

Most of the whale-watching businesses operate trips in the winter months and sport fishing trips the remainder of the year. Based on trip estimates for the 1994 season reported by eight whale-watching businesses in Santa Cruz and Monterey, whale-watching boats in Santa Cruz Harbor served approximately 13,000 passengers in the 1994 season, and those based in Monterey

Harbor served approximately 50,000 passengers. Santa Cruz Harbor operators include Chardonnay, Santa Cruz Sport Fishing, Shamrock Charters, and Stagneros Fishing Trips. Monterey Harbor whale-watching operations include Chris' Fishing Trips, Randy's Fishing Trips, Monterey Sports, and Sam's. These estimates exclude commercial boat operators that indicated they do not specifically provide whale-watching trips. There is one whale-watching operation, Tom's Fishing, in Moss Landing Harbor. It carried approximately 100 passengers in the 1994 season.

Other opportunities for nature observations include seabird nesting and roosting sites, and marine mammal pupping and haul-out areas. Shearwater Journeys, which offers natural history boat trips, takes over 3000 people each year throughout Monterey Bay to view seabirds and marine mammals.

From the Big Sur area north to the San Mateo County line, there are 13 state beaches, state parks, and state reserves located on the coast (Rand McNally and Co., 1990). Three of these are located south of Monterey, including the Pt. Lobos State Reserve, Pt. Sur State Historical Park (lighthouse), and Andrew Molera State Park. Eight state beaches are located between Monterey and Santa Cruz.

Offshore tours of the GOFNMS are operated by Oceanic Society Expeditions on weekends from approximately June to September (EPA, 1993). Nature organizations visit the Farallon Islands somewhat infrequently, or conduct commercial ventures such as whale-watching trips during the winter and spring migrations. On average, over 10,000 people per year have participated in these tours between 1984 and 1992. Large numbers (greater than 2500 people per year) of bird watchers also made boat trips to the sanctuary and adjacent areas to observe the rookeries. The majority of recreational traffic occurs on weekends.

An average of five sailboats per month, mostly originating from San Francisco Bay, are observed in the vicinity of the Farallon Islands. In addition, several motor boat and sailing clubs use the Farallon Islands as a turning point during sponsored races that can occur throughout the year (EPA, 1993).

Four state beaches and one state park are located on the California coast from the San Mateo County line north to the entrance to San Francisco Bay. James V. Fitzgerald Marine Reserve is located 7 nm (13 km) north of Half Moon Bay. Approximately 200,000 visitors per year, including approximately 26,000 students, use the park for self-guided and docent-guided tours to observe the 6.5 km (3.5 nm) long intertidal reef area (E. Gartside, pers. comm., 1994).

Public access would be relatively open near the proposed Pillar Point cable route landfall (associated with use of the Pioneer Seamount site) due to nearby access roads and gentle topography. In contrast, public access to the Pt. Sur cable route landfall would be limited since the nearest public beach access is located approximately 3.2 km (2 mi) south and the intervening property is privately owned. Both areas are characterized by open coastal views typical of large areas of the shoreline.

3.4.8 RESEARCH AND EDUCATION

Numerous marine research and education facilities are located along the coastal region of Santa Cruz and Monterey counties (NOAA, 1992):

- Hopkins Marine Station of Stanford University is located in Pacific Grove, and focuses on research using intertidal organisms to study cellular and developmental biology, immunology, and neurobiology. Research is also conducted on the ecology of the rocky intertidal zone of the Hopkins Marine Life Refuge, located offshore of the laboratory.

- The Naval Postgraduate School is operated in Monterey by the U.S. Navy. Marine research at the school focuses predominantly on physical oceanography.

- NOAA's Center for Ocean Analysis and Prediction is located in Monterey and distributes oceanic and atmospheric data.

- Moss Landing Marine Laboratories of San Jose State University conducts research in many marine science fields including ecology and oceanography, and has an active field studies program.

- The Elkhorn Slough National Estuarine Research Reserve, managed by NOAA and the California Department of Fish and Game, provides a natural outdoor laboratory setting utilized by researchers from all fields of oceanography and limnology. Data are used to assist other agencies with coastal zone management, and interpretive walks are provided to the public.

- The Long Marine Laboratory of the Institute of Marine Sciences of the University of California at Santa Cruz specializes in research on cetaceans, pinnipeds, sea otters, invertebrates, and plankton.

- Granite Canyon Marine Laboratory of the California Department of Fish and Game, located on the Big Sur coast, conducts mariculture research, including marine toxicology studies.

- The Monterey Bay Aquarium Research Institute (MBARI) was incorporated in 1987. Their research focus includes nearshore habitats of the Monterey Bay to deeper water studies in Monterey Canyon.

- The University of California Landels-Hill Big Creek Reserve in Big Sur, south of Julia Pfeiffer Burns State Park, protects and manages the lower portion of the 25 mi^2 (7.3 km^2) Big Creek watershed and conducts limited research and education programs.

In addition to the many research activities conducted in the project area, extensive education and interpretive programs exist, especially in the Monterey Bay area (NOAA, 1992). Over 70,000 school children participate in education programs at the Monterey Bay Aquarium each year. Examples of other institutions that provide interpretive programs include Pt. Lobos Ecological

Reserve, Elkhorn Slough National Estuarine Research Reserve, Long Marine Laboratory, and Año Nuevo State Reserve. Marine-related postsecondary or postgraduate education in the project area is available through the University of California-Santa Cruz, Moss Landing Marine Laboratories, and the Naval Postgraduate School located in Monterey.

Marine research and education programs in the Pioneer Seamount region include those associated with the GOFNMS, the Pt. Reyes Bird Observatory-Farallon Island Program, TMMC, and the NMFS.

The GOFNMS office, based in San Francisco, conducts marine studies and convenes a biennial, multidisciplinary workshop on research in the Gulf of the Farallones (J. Roletto, pers. comm., 1994).

The Pt. Reyes Bird Observatory, a non-profit institution located in Stinson Beach, operates the Farallon Islands Program, representing marine bird and marine mammal research in the Gulf of the Farallones, including the Farallon Islands (K. Merriman, pers comm., 1994).

TMMC, located in Sausalito, recovers, rehabilitates, and releases stranded marine mammals along the central and northern California coast, and conducts related research. Also in the San Francisco Bay area, the NMFS office located in Tiburon conducts offshore research primarily related to fisheries (EPA, 1993).

North of the study area, the University of California at Davis, operates the Bodega Marine Laboratory, located in Bodega Bay, specializing in marine research on population biology/ecology, cellular and developmental biology, aquaculture, and fisheries (K. Brown, pers. comm., 1994). The University of California at Berkeley, University of California at Davis, Stanford University, and San Francisco State University offer studies related to marine biology and oceanography, and conduct related research. Offices of the Pt. Reyes National Seashore and Cordell Bank National Marine Sanctuary also are located in this area.

3.4.9 WATER CONTACT SPORTS

Surfing, diving, and snorkeling activities potentially occurring within the study region are discussed below.

The area from Cannery Row on the Monterey Peninsula to Pt. Lobos State Underwater Reserve is the most popular diving area in all of central and northern California (NOAA, 1992). The most popular dive spots in the project area are in Monterey and Carmel Bays (C. Raisbeck, pers. comm., 1994). Diving in the Monterey Bay area is estimated at 65,000 dives per year, mostly associated with shore-entry diving. Underwater parks popular with divers include Carmel Bay State Underwater Park and Julia Pfeiffer Burns State Underwater Park. Coastal access south of Pt. Lobos to Big Sur is limited; therefore, diving in this area primarily is from dive boats. Two commercial dive boats that operate out of the Monterey Bay area offer trips south of Pt. Lobos (J. Loomis, pers. comm., 1994). If it is assumed that the majority of all scuba diving activities occur at depths of 60 m or less, then the maximum distance from shore for these activities is approximately

1-2 nm (1.9-3.8 km). The closest dive boat operators to Pioneer Seamount are located in Fort Bragg to the north and Monterey Bay to the south.

There are at least 32 primary surfing sites in Santa Cruz County, 10 sites around the Monterey peninsula and 6 sites in Big Sur. The main surfing season runs from late summer through early spring, although surfing continues year round. Most surfing activities occur at maximum distances of a few hundred feet to a few hundred yards (60-200 m) from shore. Wind surfing is popular at Pt. Año Nuevo (NOAA, 1992), generally within a few kilometers of shore.

Diving and other water sports at the alternative sites would be unlikely due to typically rough weather and sea conditions, and the deep water depths (> 850 m).

4 ENVIRONMENTAL CONSEQUENCES

4.1 INTRODUCTION

This Section forms the scientific and analytical basis for comparison of alternatives in Section 2 and the affected environment descriptions presented in Section 3. It describes the potential consequences of the five alternatives on a range of environmental resources. Unless otherwise indicated, the effects on marine animals of the "no action" alternative are presumed to be inconsequential. The Section is organized first by resources (i.e., physical environment, biological environment, and socio-economic environment), followed by a discussion of minor and secondary effects in a Section on "other impacts."

Each Section analyzes the potential effects of the five alternatives, both individually and cumulatively. Cumulative impacts are those impacts on the environment which result from the combined impact of the action when added to other past, present, and reasonably foreseeable future actions. Mitigation measures for each impact are identified, where applicable.

For purposes of CEQA, and as directed by CEQA Guidelines adopted by the Regents of the University of California, this Section also describes standards of significance for identifying impacts. Under CEQA a significant effect is defined as "a substantial, or potentially substantial, adverse change in the environment" (California Public Resources Code 21068). The guidelines implementing CEQA direct that this determination be based on scientific and factual data. The specific criteria for determining the significance of a particular impact are identified prior to the impact discussion in each issue Section, and are consistent with significance criteria set forth in the guidelines implementing CEQA. This articulation of standards of significance, identification of impacts and conclusions as to significance of impacts are strictly CEQA-related and are not intended for any broader purpose, such as NEPA standards or requirements.

Under CEQA guidelines, three types of environmental impact are identified: 1) beneficial impacts, 2) significantly adverse impacts, and 3) less than significant impacts. The last type has been divided into two categories: 3a) less than significant impacts for which mitigation measures, although not required by CEQA, are identified to reduce potential effects, and 3b) less than significant impacts for which no additional mitigation measures are identified or necessary.

Relative to Table C-1, the MMRP research protocol methodology matrix, most of the potential responses listed pertain to reactions in individual animals and not potential effects on the species as a whole and, therefore, would not necessarily result in a significant impact under CEQA as defined below. However, even some of these less than significant impacts (acute or short-term effects, as defined) would trigger source shut-down guidelines, ensuring that no significant impacts would occur.

These latter (less than significant impacts) are underlined in the text of this document. All other identified impacts are numbered and in bold type, and the corresponding mitigation measures are in italics. Table 4.1-1 summarizes the environmental consequences on the physical,

biological, economic and social environments for the alternatives presented. These results are supported by the discussion and data presented in Section 3 and the following Subsections.

4.2 POTENTIAL EFFECTS ON THE PHYSICAL ENVIRONMENT

This section considers the potential effects of the five alternatives (Alternative 1, Preferred Action; Alternative 2, No Action; Alternative 3-1, Alternate Project Site - Pioneer Seamount (Proposed Action); Alternative 3-2, Alternate Project Site - Sur Slope; Alternative 4, Moored Autonomous Sources) on the physical environment. Such effects include potential disturbance of the seafloor through installation of MMRP or ATOC source facilities, and the increase in noise levels that would occur during source operations. The potential impacts of ATOC transmissions on biological resources are discussed below in Section 4.3.

4.2.1 POTENTIAL DIRECT AND INDIRECT EFFECTS ON THE PHYSICAL ENVIRONMENT

4.2.1.1 Construction of Facilities

Direct physical impacts of the ATOC facilities installation would be considered significant if they could lead to significant 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 project are relatively minor and generally are benign from an environmental standpoint. Alternatives 1, 3-1, and 3-2: the proposed installation on Sur Ridge, Pioneer Seamount, and Sur Slope, respectively, involve the placement of a small sound source with a footprint of 4.7 m^2 on the seafloor, with negligible alteration of the bottom. Likewise, the cable connection to the source, except for those portions in the surf zone, would lay on the seafloor with extremely minor physical alterations of the sea bottom. For each site, the cable would be laid through the shoreline band, with associated trenching (nominally 1 m deep) that would protect the cable from wave action and prevent movement. This installation, however, would be comparatively minor and would not result in significant physical effects on the environment. Existing U.S. Navy cable installations at Pt. Sur have resulted in some erosion to the bluff where the pipe containing the cable transitions from the top of the bluff to the surf zone. Proper design of the ATOC facilities in this area would minimize the potential for impacts from bluff erosion.

At Pillar Point, the cable installation would be undertaken as part of a bluff restoration project of the U.S. Air Force. Specifically, late in the spring of 1995, the Air Force will be correcting problems that have occurred in an eroded gully on the west side of the Pillar Point Air Force Station by filling, contouring and installing drainage facilities. The ATOC cable would be installed in coordination with these activities and covered by fill material during this restoration project. The Air Force project was analysed in a September, 1994, Environmental Assessment,

DESCRIPTION	IMPACT LEVEL BY SITE/ALTERNATIVE				COMMENTS (apply to each site/alternative, except where noted)
	Sur Ridge (Preferred Alt.)	Sur Slope	Pioneer Seamount (Proposed Alt.)	Moored Autonomous Source	
PHYSICAL ENVIRONMENT					
Meteorology	N	N	N	N	Project would not cause impacts
Physical Oceanography	N	N	N	N	Project would not cause impacts
Water Column					
Temperature	N	N	N	N	Project would not cause impacts
Salinity	N	N	N	N	Project would not cause impacts
Dissolved Oxygen	N	N	N	N	Project would not cause impacts
Ambient Noise	LSM	LSM	LSM	LSM	Sound source would contribute to ambient noise, but is not expected to result in adverse impacts given proposed frequencies and duty cycles.
Geography and Geology					
Subsea Geography	N	N	N	N	Project would not cause impacts
Seismicity	N	N	N	N	Project would not cause impacts
Sediments	N	N	N	N	Project would not cause impacts
BIOLOGICAL ENVIRONMENT					
Marine Mammals					
Mysticetes	Uncertain*	Uncertain*	Uncertain*	Uncertain*	Mysticetes are believed to have good LF (<90 Hz) hearing capability, but no species are believed capable of diving >700 m. Thus, mysticetes could be affected by passage through sound fields; although encounters with high intensities would be unlikely. Use of 5-min sound ramp-up and low duty cycle should mitigate potential impacts. Potential for long-term effects (e.g., stress) unknown.

N = No Significant Impact; S = Significant Impact; B = Beneficial Impact; LSM = Less Than Significant Impact--Mitigation measures identified; LSNM = Less Than Sig. Impact--No Mitigation measures required

*Presumed LSM[1] under CEQA Criteria.

[1]Precise level of impact is uncertain given the general lack of available measured data on the potential effects of LFS on marine animals. Findings of "no significant impact" and "less than significant impact" are criteria under CEQA standards of significance.

Note: No Action alternative not shown; impact level in all cases = N.
Impact level by site/alternative applies CEQA criteria.

Table 4.1-1 Summary of potential environmental impacts and mitigation measures

DESCRIPTION	IMPACT LEVEL BY SITE/ALTERNATIVE				COMMENTS (apply to each site/alternative, except where noted)
	Sur Ridge (Preferred Alt.)	Sur Slope	Pioneer Seamount (Proposed Alt.)	Moored Autonomous Source	
Odontocetes (deep divers with possible LF hearing capability)	Uncertain*	Uncertain*	Uncertain*	Uncertain*	Sperm whales and some beaked whales are capable of diving >800 m; sperm whales may have some LF hearing capability. Thus, they could be affected by passage through the sound fields; although encounters with high intensities would be rare. Use of 5-min sound ramp-up and low duty cycle should mitigate potential impacts. Sperm and beaked whales stopped vocalizing during HIFT LF sound transmissions, and started again within 48 hr of end of test--fundamental acoustic differences exist between HIFT source and ATOC source. Moored autonomous source could possibly be placed in area devoid of sperm and beaked whales.
Others	LSNM[1]	LSNM[1]	LSNM[1]	LSNM[1]	Other odontocetes are not known to dive deep enough to reach 150 dB sound field and/or to have good LF hearing. Therefore, potential impacts are expected to be minimal.
Pinnipeds (deep divers with possible LF hearing capability)	Uncertain*	Uncertain*	Uncertain*	Uncertain*	Northern elephant seals are capable of diving to 1200 m and may have LF hearing capability. Thus, these species could be affected by passage through the sound fields, but close encounters would be rare. Use of 5-min sound ramp-up and low duty cycle should mitigate potential impacts.
Others	LSNM[1]	LSNM[1]	LSNM[1]	LSNM[1]	Other pinnipeds are not known to dive deep enough to reach 150 dB sound field and/or to have good LF hearing capability. Therefore, potential impacts are expected to be minimal.
Fissiped	N	N	N	N	Southern sea otters primarily occur near shore and are not known to dive >55 m, and do not have good LF hearing. Therefore, potential impacts are expected to be negligible.

N = No Significant Impact; S = Significant Impact; B = Beneficial Impact; LSM = Less Than Significant Impact--Mitigation measures identified; LSNM = Less Than Sig. Impact--No Mitigation measures required

*Presumed LSM[1] under CEQA Criteria.

[1]Precise level of impact is uncertain given the general lack of available measured data on the potential effects of LFS on marine animals. Findings of "no significant impact" and "less than significant impact" are criteria under CEQA standards of significance.

Note: No Action alternative not shown; impact level in all cases = N.
Impact level by site/alternative applies CEQA criteria.

Table 4.1-1 Continued

Table 4.1-1 Summary of potential environmental impacts and mitigation measures.

DESCRIPTION	IMPACT LEVEL BY SITE/ALTERNATIVE				COMMENTS (apply to each site/alternative, except where noted)
	Sur Ridge (Preferred Alt.)	Sur Slope	Pioneer Seamount (Proposed Alt.)	Moored Autonomous Source	
Other Marine Species					
Sea Turtles Leatherback	LSM[1] Uncertain*	LSM[1] Uncertain*	LSM[1] Uncertain*	LSM[1] Uncertain*	Maximum diving depth for leatherbacks >1000 m. No other species are known to dive >500 m. Leatherbacks may be sensitive to LF sound; however, densities are presumed low in central Calif. area. This, plus the 5-min ramp-up and low duty cycle should mitigate potential impacts.
Fish (demersel [bottom] species)	LSM[1]	LSM[1]	LSM[1]	LSM[1]	Auditory injury and/or deafness are potential close to the source (within 15 m). However, this volume of water represents a small portion of the range for any demersal species. This, plus the 5-min ramp-up and low duty cycle should mitigate potential impacts.
Fish (pelagic [water column] species) Shark	LSM[1] Uncertain*	LSM[1] Uncertain*	LSM[1] Uncertain*	LSM[1] Uncertain*	Behavioral impacts and TTS are possible close to the source (within 178 m). However, this volume of water represents a small portion of the range for any pelagic species. Further, because these species are broadly distributed and are expected to be transient occupants in the study area, minimal impacts on the pelagic fish populations are expected. Sharks may be attracted to LF sound. ATOC source transmissions could possibly cause some temporary disturbance (e.g., attraction and/or masking) in shark species.
Invertebrates	LSNM[1]	LSNM[1]	LSNM[1]	LSNM[1]	Little information is available on the potential for LF sound impacts on invertebrates. No known species of significant distribution occur at the proposed source site. No direct auditory injury or deafness are anticipated for any species of invertebrate. Two cephalopod species exhibited low sensitivity to 75 Hz sound transmissions. Thus, potential impacts on invertebrates are unlikely.

N = No Significant Impact; S = Significant Impact; B = Beneficial Impact; LSM = Less Than Significant Impact--Mitigation measures identified; LSNM = Less Than Sig. Impact--No Mitigation measures required

*Presumed LSM[1] under CEQA Criteria.

[1]Precise level of impact is uncertain given the general lack of available measured data on the potential effects of LFS on marine animals. Findings of "no significant impact" and "less than significant impact" are criteria under CEQA standards of significance.

Note: *No Action alternative not shown; impact level in all cases* = N.
Impact level by site/alternative applies CEQA criteria.

Table 4.1-1 (cont.)

Table 4.1-1 Summary of potential environmental impacts and mitigation measures.

DESCRIPTION	IMPACT LEVEL BY SITE/ALTERNATIVE				COMMENTS (apply to each site/alternative, except where noted)
	Sur Ridge (Preferred Alt.)	Sur Slope	Pioneer Seamount (Proposed Alt.)	Moored Autonomous Source	
Plankton	N	N	N	N	Due to broad distribution and variable nature of zooplankton communities, and the relatively small portion of a species' range that could possibly be affected, the potential for impacts is expected to be negligible.
Seabirds (deep divers)	N	N	N	N	Maximum diving depths <190 m (to 137 dB sound field) and highest in-air auditory sensitivity for most birds lies between 1 and 3 kHz. Because 150 dB sound field is located at much greater depths and bird hearing is primarily HF, the potential for impacts is expected to be negligible.
Others	N	N	N	N	Other seabird species are not capable of diving >20 m. Thus no impacts are expected.
Threatened/Endangered/Special Status Species					
Mysticetes	Uncertain*	Uncertain*	Uncertain*	Uncertain*	Same as identified for mysticetes above.
Odontocetes	Uncertain*/ LSNM[1]	Uncertain*/ LSNM[1]	Uncertain*/ LSNM[1]	Uncertain*/ LSNM[1]	Same as identified for odontocetes above.
Pinnipeds	Uncert.*/ LSNM[1]	Uncert.*/ LSNM[1]	Uncert.*/ LSNM[1]	Uncert.*/ LSNM[1]	Same as identified for pinnipeds above.
Fissiped	N	N	N	N	Same as identified for fissiped above.
Sea Turtles	LSM[1]/ Uncertain*	LSM[1]/ Uncertain*	LSM[1]/ Uncertain*	LSM[1]/ Uncertain*	Same as identified for sea turtles above.
Fish	LSM[1]/ Uncertain*	LSM[1]/ Uncertain*	LSM[1]/ Uncertain*	LSM[1]/ Uncertain*	Minimal information exists on potential for LF sound impacts on winter-run chinook salmon. However, because of their rare and temporary (migratory) occurrence in the study area and estimated low hearing sensitivity at 75 Hz, minimal, if any impacts are expected.
Seabirds (and Peregrine falcon)	N	N	N	N	Same as identified for seabirds above (see Section 4.3.2.6 for discussion on Peregrine falcon).

N = No Significant Impact; S = Significant Impact; B = Beneficial Impact; LSM = Less Than Significant Impact--Mitigation measures identified; LSNM = Less Than Sig. Impact--No Mitigation measures required

*Presumed LSM[1] under CEQA Criteria.
[1]Precise level of impact is uncertain given the general lack of available measured data on the potential effects of LFS on marine animals. Findings of "no significant impact" and "less than significant impact" are criteria under CEQA standards of significance.
Note: No Action alternative not shown; impact level in all cases = N.
Impact level by site/alternative applies CEQA criteria.

Table 4.1-1 (cont.)

DESCRIPTION	IMPACT LEVEL BY SITE/ALTERNATIVE				COMMENTS (apply to each site/alternative, except where noted)
	Sur Ridge (Preferred Alt.)	Sur Slope	Pioneer Seamount (Proposed Alt.)	Moored Autonomous Source	
Marine Sanctuaries/Areas of Special Biological Significance	N	N	N	N	No conflicts with applicable sanctuary plans, policies, or resources. All ASBS are located in nearshore or coastal areas, beyond the influence of the source sound fields (<110 dB). Impacts are expected tobe minimal, if any.
Cable Route	N	N	N	N	Due to small diameter cable and careful installation procedures, potential for impacts is expected to be negligible.
ECONOMIC ENVIRONMENT					
Commercial/Recreational/Potential Fisheries	LSM[1]	LSM[1]	LSM[1]	LSM[1]	Same as identified for fish above.
Mariculture	N	N	N	N	Mariculture/aquaculture activities occur in nearshore areas beyond the influence of the source sound fields. No impacts are expected.
Shipping	N	N	N	N	Project would not cause impacts.
Military Usage	N	N	N	N	Project would not cause impacts.
Mineral/Energy Development	N	N	N	N	Project would not cause impacts.
SOCIAL ENVIRONMENT					
Human Environment					
Population Dynamics	N	N	N	N	Project would not cause impacts.
Educational Institutions	B	B	B	B	Interaction between ATOC and MMRP research scientists, and educational communities (teachers, students, public) in central Calif. area would stimulate interest and knowledge in oceanography, underwater acoustics, marine biology and environmental monitoring techniques.
Recreational and leisure activities (water contact sports: diving, board/wind surfing)	N	N	N	N	Activities occur in areas and depths outside of the influence of the source sound fields (<110 dB). No impacts likely.
OTHER IMPACTS					
Cultural/Historical Resources	N	N	N	N	Cultural/historical areas would be avoided during ATOC facilities (e.g., cable) installation.

N = No Significant Impact; S = Significant Impact; B = Beneficial Impact; LSM = Less Than Significant Impact--Mitigation measures identified; LSNM = Less Than Sig. Impact--No Mitigation measures required

*Presumed LSM[1] under CEQA Criteria.

[1]Precise level of impact is uncertain given the general lack of available measured data on the potential effects of LFS on marine animals. Findings of "no significant impact" and "less than significant impact" are criteria under CEQA standards of significance.

Note: No Action alternative not shown; impact level in all cases = N.
Impact level by site/alternative applies CEQA criteria.

Table 4.1-1 Continued

which concluded that no significant impacts would result from those activities. The ATOC cable would be entirely underground throughout this onshore area. Since the ATOC cable would be installed in connection with the Air Force's previously planned restoration project, the potential incremental impacts from the onshore cable installation would be negligible. It is also intended to bury the cable across the beach and through the shallow intertidal zone to further reduce any potential impacts. Installation through the beach area would be scheduled for mid-week to minimize any potential disruption to public access in this area.

Likewise, the moored autonomous source alternative (Alternative 4) would have a low impact on the physical environment, since it would have a small seafloor footprint, would involve no alteration to the bottom, and would not have an associated cable installation. There would be a minor risk that the batteries necessary to support such a source would leak over time, particularly if recovery of the source were not possible at the end of its life. This could introduce small quantities of potentially toxic chemical components into the ocean; however, they should be neutralized quickly in seawater.

None of the fixed or drifting receiving arrays associated with ATOC project operations, including those located in non-U.S. waters (e.g., Guam, near Rarotonga) are expected to have significant environmental impacts.

CEQA Impact 1: Installation of the ATOC cable and source would have less than significant impacts on the physical environment.

CEQA Mitigation Measure 1-1: The portions of the ATOC cable and any protective casing in the nearshore area, surf zone and bluff area are designed to minimize the potential for adverse impacts, including the potential for bluff erosion.

CEQA Mitigation Measure 1-2: ATOC facilities would be removed at the end of the experiment, to the extent economically and practicably feasible.

4.2.1.2 Noise

Generally CEQA identifies significant noise impacts as those that result in a substantial increase in the ambient noise levels for adjoining areas. Marine biologists consider some negative effects due to present-day ocean noise pollution may already be occurring to marine mammals. The potential for significant impacts also exists where land use compatibility standards, such as those defined by the State of California, are exceeded.

Within the study area, there are no applicable subsea noise standards. Most community noise standards are based upon average measurements that may weigh various time periods differently (such as nighttime hours) due to the relatively greater sensitivity of the human population exposed to the noise at those times. For determining the significance of the noise from the ATOC source, a long-term average (Leq) measurement could be considered the most appropriate, since the ATOC source operation will not emphasize any time of day or night, and there is no indication that particular hours are of relatively greater concern in the marine environment (although many animals exhibit diurnal activity patterns). This approach is based on long-term average measurements, and is commonly applied to human occupational noise exposure situations (Kryter, 1985).

An estimate of the net Leq of a given sound source can be derived from the following formula:

$$Leq(T) = RL + 10Log_{10}(t/T)$$

where: T = Leq measurement period
RL = Received Level of sound field at animal
t = duration of signal during the time period T

For example, using the 120 dB sound field (at 2% duty cycle) elicits the following result:

$$Leq(4\ days) = 120 + 10Log_{10}(120\ min/5760\ min) = 120 - 17 = 103\ dB.$$

Thus, exposure to the 120 dB sound field over a 4-day period (the signal being transmitted 120 min out of the total 5760 min) equates to continuous exposure to a 103 dB sound field over the same 4 day period. As is shown in Section 3, this value is relatable to high ambient noise levels that could be expected in the study area. During the 2-8% of the time the source is transmitting, received levels in the 57.5-92.5 Hz frequency band should decrease to below average ambient noise levels within 500 km.

The MMRP includes components in both Hawaii and California to evaluate the validity of this assumption. This work includes the attempted development of low frequency audiograms for species of concern and additional measurement of subsea noise on an Leq basis to allow comparisons to ATOC source operations (see Appendix C). Section 3 of this EIS/EIR provides available noise data for the study area.

Habitat uses by marine organisms and oceanographic acoustic research are the primary noise-sensitive uses in the project vicinity. Other oceanographic research efforts and U.S. Navy activities would be coordinated through Scripps to avoid interference. No human land use incompatibilities or corresponding noise impacts are presented.

CEQA Impact 2: Leq calculations indicate that less than significant increases in average ambient noise levels would occur in the vicinity of the ATOC source (i.e., within 500 km).

CEQA Mitigation Measure 2-1: The duty cycle and power levels of the ATOC source would be adjusted to the minimum necessary to support research objectives, and the source would be shut down if any of the acute or short-term responses listed in Table C-1 are observed in relation to source transmissions.

CEQA Mitigation Measure 2-2: The ATOC project would coordinate with other oceanographic and acoustic research efforts, U.S. Navy activities, and the commercial fishing industry to ensure that scheduling and operational conflicts are avoided.

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. MMRP vessels and aircraft would also add somewhat (on an intermittent basis) to ambient noise levels. See Potential Cumulative Effects Sections 4.3.1.1.2, 4.3.1.2.2, 4.3.1.3.2, 4.3.2.1.2, 4.3.2.2.2, and 4.3.2.3.2, and responses to comments in Appendix F.

4.2.1.3 Other Potential Physical Impacts

Source installation and operation at any 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).

4.2.2 POTENTIAL CUMULATIVE EFFECTS ON THE PHYSICAL ENVIRONMENT

The National Environmental Policy Act (NEPA) defines a cumulative impact 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."

Other than general increases in vessel traffic through the project vicinity, and onshore development of various kinds, no other human activities (existing or future), or natural sounds are anticipated to cumulate with the ATOC source transmissions and MMRP activities. Specifically, a single ATOC source should provide adequate coverage from the eastern Pacific to receivers in the north Pacific, and additional sources should not be required at any eastern Pacific location. No other new sound sources or similar facilities currently are proposed for the project area. Similarly, the central California area is not a likely site for new commercial or other subsea cable installations, or substantial onshore development. As a result, no significant development of facilities comparable to the ATOC cable and onshore equipment installations are anticipated.

As discussed above, the effects of the proposed cable installation on the physical environment 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. Noise from the source would be expected to add to the ambient noise levels in the vicinity of the source. 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, recreation boats, aircraft, and onshore and nearshore construction). The potential cumulative effect of noise produced by MMRP aircraft and vessels during the course of research conduct would be negligible, constituting less than 0.01% of the total overall ambient noise in the study area throughout the Pilot Study. While human-related sources of noise may increase over time with increases in population, economic activities and resulting traffic levels, any such increase is unknown.

Table 4.1-1 summarizes the potential effects on the physical environment.

4.3 POTENTIAL EFFECTS ON THE BIOLOGICAL ENVIRONMENT

This Section discusses the potential impacts of the five alternatives (including the proposed action) on marine mammals and sea turtles, as well as on fish, invertebrates, plankton, and seabirds.

The effects of noise on marine animals have not been studied extensively. The lack of information is particularly acute regarding large whales, which are difficult to study in the wild, and on invertebrates. In many areas, potential impacts must be inferred from incomplete data. The following Sections must be reviewed with this caveat in mind. Furthermore, because data concerning marine animal stock structure and population delineation are incomplete for many of the protected species addressed in this EIS/EIR, most of the discussions in this section on the potential effects of low frequency sound transmissions deal with the possibility of impact on a particular species, based on that species' pertinent biological and spatial characteristics (i.e., low frequency hearing sensitivity, dive depth profile, distribution and abundance, and known behavioral patterns). The null hypotheses presented in Appendix C would be tested by conducting the MMRP, which includes the study of both individual animals (e.g., playback studies and audiometric measurements) and groups of animals (e.g., pods of cetaceans via aerial, vessel or acoustic detection).

There is a difference between effects that might occur on a single animal of a large population (e.g., fish) and an individual within a very small population (e.g., minke whale). Thus, the low total number of individuals would make for a lower potential for encounter and possible impact; however, if that impact were to occur to one or more individuals of a relatively rare species (due to unpredicted clumping, age/sex class groupings, etc.), this could be construed as a significant impact. Based on the findings herein, the only documented evidence of good low frequency hearing capability is for baleen whales, none of which apparently dive deep enough to approach the source close enough to incur TTS. Sperm whales, some beaked whales, elephant seals and leatherback sea turtles can dive close to the source depth, but any evidence of low frequency hearing capability among these species is anecdotal to date. Among these, the sperm whale and leatherback sea turtle are federally listed as endangered. However, based on the data presented herein, the proposed action site (Pioneer Seamount) has not been identified as an important marine mammal habitat (i.e., feeding, breeding, migration route or comparable area).

If the MMRP goes forward, by virtue of its designated focused study area around the proposed source site, population sub-units or stocks local to California (or at least the eastern Pacific) would necessarily be the focal animals/sub-units used in assessing the potential for adverse impacts on protected animals. The best available estimates of the stock of marine mammal and sea turtle species that would be expected to reside or pass through the general EIS/EIR study area during the course of the proposed two-year MMRP are listed in Section 3.3.1. MMRP population distribution and abundance data collected would supplement these estimates and support future research efforts that could use population sub-units or stocks as indicator groups for determining the potential for low frequency sound impacts on marine species.

Generally speaking, a range of potential impacts can be summarized as follows:

Death or Injury: The potential for death to any marine mammal or sea turtle as a result of the proposed research is considered nonexistent. The potential for death or injury with respect to other animals (e.g., fish) is unlikely, but injury is possible at sound levels ≥180 dB (8 m range from source) (Hastings, 1991). However, even in fish, any lethal impacts would be indirect and result from the potential increase in predation on fish in the immediate vicinity (i.e., <8 m range) of the source where TTS/PTS could occur. There would be no direct lethal effects on any marine animals.

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 (Section 4), no direct damage to hearing structures of marine mammals or sea turtles is expected from this project (see Section 4.3.1.1.1).

Permanent Threshold Shift: A permanent threshold shift or PTS is, as the name suggests, an increase in the threshold of hearing that is permanent, not temporary. It is an unrecoverable deafening that does not diminish with time. PTSs generally occur 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)-level stimuli can induce PTS, as well. Based on analysis of available data (Section 4), no PTSs to marine mammals or sea turtles are expected from this project (see Section 4.3.1.1.1).

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. TTSs generally occur 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. Based on analysis of available data (Section 4), TTSs are only anticipated for animals venturing very close (within approximately 100-200 m) to the ATOC source.

Behavioral Disruption and Habituation: Sounds can result in behavioral changes in movement patterns that may 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 detected at sound intensities higher than the levels at which the sounds would be 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 alternative areas that meet their requirements (Brodie, 1981b).

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 sound 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, predators, 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 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 impact 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., pelicans or resting sea lions with their heads out of the water) because the maximum possible received level would be only 74.5 dB directly over the source, 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.

CEQA Standard of Significance

CEQA indicates that a project has a significant adverse impact on biological resources if it:

- Substantially affects a rare or endangered species of animal or plant or the habitat of the species;
- Interferes substantially with the movement of any resident or migratory fish or wildlife species; or
- Substantially diminishes habitat for fish, wildlife, or plants.

For purposes of this EIS/EIR, a significant impact on biological resources is considered to be one that has one or more of these identified effects.

Generally, any reasonably anticipated direct auditory injury or permanent threshold shift in any individual of a rare or endangered species or any significant population of another species should be considered a significant impact. Temporary threshold shifts, behavioral, and masking effects will be considered significant if they qualify under one or more of the standards set forth above.

Scientific Uncertainty

As stressed in this EIS/EIR, available information on subsea noise and its biological impact in many cases is incomplete to nonexistent, depending on the species being considered. The NEPA Guidelines (40 C.F.R. § 1502.22) state that if there is incomplete or unavailable information regarding "reasonably foreseeable significant adverse effects" and that information is essential to a reasoned choice among alternatives and the overall costs of obtaining it are not exorbitant, the information is to be obtained and included in the EIS/EIR. If relevant information concerning significant adverse impacts cannot be obtained because the overall costs of obtaining it are exorbitant or the means to obtain it are not known, the agency is to include in the EIS/EIR: 1) a statement that such information is incomplete or unavailable; 2) a statement of the relevance of the incomplete or unavailable information to evaluating reasonably foreseeable significant adverse impacts on the human environment; 3) a summary of existing credible scientific evidence which is relevant to evaluating the reasonably foreseeable significant adverse impacts on the human environment; and 4) the agency's evaluation of such impacts based upon theoretical approaches or research methods generally accepted in the scientific community. All of the above are included in this EIS/EIR.

As set forth below, the ATOC project and MMRP are not anticipated, in most cases, to result in acute or short-term effects (Table C-1) on biological resources. This conclusion is based on available information regarding the species potentially affected, which is analyzed in this

Section. In some cases, the lack of available data necessitate a finding of uncertain, as to whether impacts are expected.

Potential impacts on biological resources also are limited by the relative temporary nature of the initial ATOC and MMRP experimental activities, which will span at most a two-year period of transmissions, and the limited duty cycle of the ATOC source (on 2% of the time, off the remaining 98%, for most of the experimental period). It also is 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 potentially harmful sound fields.

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. At the other end of the spectrum, many of the animals are small, or even microscopic, and include invertebrates and other animals that often provide no measurable indication of hearing perception or acoustic impacts. The sheer number of species also would render a comprehensive survey exorbitantly expensive and unwieldy. The MMRP has been designed to obtain much-needed information (Appendix C).

This EIS/EIR contains an expansive analysis and implements the directives of the NEPA guidelines listed above, acknowledging the lack of information, stating its relevance to the analysis, summarizing existing evidence, and evaluating the impacts based on available information. As an integral part of the MMRP, an attempt will be made to fill several of the gaps in available information concerning a number of species of concern, so that future decisions concerning any long-term ATOC activities can be made based on an improved information base.

In addressing the ATOC project and MMRP, one of the costs/benefits that must be weighed in the EIS/EIR is the cost of uncertainty--the costs of proceeding without more and better information. The ATOC project itself is intended to fill information gaps and reduce uncertainty concerning the global warming question. The associated MMRP, while designed to assess and evaluate potential efects of ATOC low frequency sound transmissions, it is expected to result in greater knowledge of low frequency sound impacts in general.

4.3.1 MARINE MAMMAL SPECIES

This Section pertains to marine mammals in the central California coastal region: mysticetes (7 species of baleen whales), odontocetes (20 species of toothed whales and dolphins), and pinnipeds/fissipeds (6 species of seals and sea lions and the sea otter). It presents information on: the ability of mysticetes, odontocetes, and pinnipeds/fissipeds to hear and produce low frequency sounds; the potential behavioral and physical auditory effects of low frequency noise on various species; and the potential cumulative impacts of noise from the proposed alternatives in combination with other human-related noise and activities. Conclusions are provided on the potential effects of the five alternatives based on the currently available data.

This Section proceeds with an analysis of the potential impacts on mysticete whales, odontocetes, and pinnipeds/fissipeds.

4.3.1.1 Mysticetes

As discussed in Section 3, the gray whale is the most common mysticete (in terms of numbers of individuals) that annually passes through the central California offshore region. It migrates between winter breeding lagoons in Baja, California and summer feeding grounds in the Bering and Chukchi Seas (Moore et al., 1986; Swartz, 1986; Clarke et al., 1989). However, gray whale northward and southward migration routes are close to shore and the Farallon Islands, and few animals are expected to be found in the vicinity of the proposed ATOC source. Northward-bound whales remain inside the 183 m depth contour (Leatherwood and Reeves, 1983), often staying within 2 km of shore (Evans, 1987); 94% of southward-bound whales pass within 1.6 km offshore and 96% within 4.8 km (Sund and O'Conner, 1974). The remaining 4% most likely travel within 5-8 km of shore. Blue and humpback whales are the next highest in numbers in the general vicinity, and are highest in numbers anticipated to pass through the ATOC sound fields.

4.3.1.1.1 Potential Direct and Indirect Effects on Mysticetes

Direct and indirect effects of low frequency noise on mysticetes, including the potential for temporary threshold shifts, auditory interference by masking, behavioral disruption and habituation, long-term effects, and adverse impacts on the food chain (indirect effects), are discussed below.

Based on mysticete density estimates from NOAA NMFS's Southwest Fisheries Science Center ship and aerial survey data for 1991, 1992 and 1993 and an average mysticete swim speed of 9 km/hr (Ray et al., 1978), it is believed that few individuals traveling through the study area would remain within the 120 dB source sound field (derived from FEPE acoustic model analysis) for more than 3 hrs at a time. This is further supported by the belief that Pioneer Seamount has not been identified as an important habitat (i.e., feeding, breeding, migration route or comparable area) (EPA, 1993).

Ambient noise levels in the 60-90 Hz band offshore central California can be 74-91 dB (for sea state 3-5) (see Section 3.2.4.3) and are expected to be higher (≥120 dB) when vessels are present. Based on information provided in Section 2, transmissions from the proposed sound source at the water's surface are expected to be 135 dB at a radius of 1000 m (received level is not expected to exceed 135 dB at the water's surface anywhere in the vicinity of the source); 130 dB to a radius of 5 km; 120 dB at 18 km shoreward and 12 km seaward from the source; 110 dB to 50-60 km shoreward and 55 km seaward. Underwater sound levels are expected to be: 140 dB at 418 m depth (562 m range around source); 145 dB at 664 m depth (316 m range around source); 150 dB at 802 m depth (178 m range around source); 165 dB at 950 m depth (30 m range around source); and 195 dB at 980 m depth (1 m range around source). See Figure 2.2.1-6.

• Hearing Capabilities and Sound Production of Mysticetes: There are no direct measurements of auditory thresholds in mysticetes. It generally is believed that they are adapted for hearing at low frequencies (below 1 kHz) (Fleischer, 1976, 1978; Ketten, 1994), and likely hear best in the frequency range of their calls (Evans, 1973; Myrberg, 1978; Turl, 1980). Baleen whale vocalizations range from below 10 Hz, to 25 kHz, with principal energy below 1 kHz (Table 4.3.1.1.1-1). At least 10 of the 11 extant species of mysticetes produce some form of low frequency sound below 400 Hz (Thompson et al., 1979; Watkins and Wartzok, 1985; Clark, 1990). Most of the low frequency sounds of coastal species, including fin and blue whales which can sometimes be found in coastal waters, are usually in the 100-400 Hz band, while those of pelagic (deep ocean) species are usually in the 10-100 Hz band. Fin whale sounds generally consist of 20 Hz pulses (Watkins, 1981b) and blue whales have been recorded producing loud (188 dB), long (>35 sec) triplets of infrasonic (<20 Hz) moans (Cummings and Thompson, 1971; Edds, 1982).

Table 4.3.1.1.1-1 lists the characteristics of underwater sounds produced by baleen whales found off the coasts of the United States.

Gray whale sounds are predominantly knocks and pulses in the frequency range from <100 Hz to 2 kHz, with the highest rate of calls in the 327-824 Hz range (Richardson et al., 1991). Knocks, the most common sounds recorded during their feeding activities, have source levels estimated at about 142 dB. Reliable associations between sounds and surface behaviors could not be made (Cummings et al., 1968).

The rate of sound production in gray whales may be related to social activities (Dahlheim, 1987). In general, they are relatively silent when dispersed across summer feeding grounds, slightly more vocal when migrating, and vocalize the most (seven distinct types of sounds) when on their winter breeding/calving grounds (Dahlheim, 1987).

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).

Blue whale moans within the low frequency range of 12.5-200 Hz, with pulse duration up to 36 seconds, have been recorded off Chile (Cummings and Thompson, 1971a). A short, 390 Hz pulse also is produced during the moan. Overall source level was estimated to be as high as 188

Species	Signal Type	Frequency Range (Hz)	Dominant Frequencies (Hz)	Source Level (dB re 1 μPa at 1 m)	References
Fin Whale	moans, downsweeps	14-118	20	160-186	Watkins 1981b; Watkins et al. 1987; Edds 1988
	constant call	20-40	-	-	Edds 1988
	moans, tones, upsweeps	30-750	-	155-165	Watkins 1981b; Cummings et al. 1986; Edds 1988
	rumble	10-30	-	-	Watkins 1981b; Edds 1988
	whistles?, chirps?	1500-5000	1500-2500	-	Thompson et al. 1979
	clicks?	16,000-28,000	-	-	Thompson et al. 1979
Blue Whale	moans	12-390	10-30, 50-60	188	Cummings and Thompson 1971a; Edds 1982
	clicks?	6,000-8,000	6,000-8,000	130, 159	Beamish and Mitchell 1971; Beamish 1979
		21,000-31,000	25,000		
Bryde's whale	moans	70-245	124-132	152-174	Cummings et al. 1986
	growl	400-800	-	-	Edds and Odell 1989
Minke whale	down sweeps	60-130	-	165	Schevill and Watkins 1972
	moans, grunts	60-140	60-140	151-175	Schevill and Watkins 1972; Winn and Perkins 1976
	ratchet	850-6,000	850	-	Winn and Perkins 1976
	clicks	3,300-20,000	<12,000	151	Beamish and Mitchell 1973; Winn and Perkins 1976
	thump trains	100-2,000	100-200	-	Winn and Perkins 1976
Sei whale	two phrases of 10-20 FM sweeps each; 30-40 msec/ sweep	1500-3500	3000	-	Cummings 1989 Thompson et al. 1979 Knowlton et al. 1991
Gray whale	moans	20-1,200	20-200, 700-1,200	185	Cummings et al. 1968; Fish et al. 1974; Swartz and Cummings 1978
	pulse modulated	80-1,800	225-600	-	Dahlheim et al. 1984
	FM up-down sweep	100-350	300	-	Dahlheim et al. 1984
	pulses	100-2,000	300-825	-	Dahlheim et al. 1984
	clicks (calves only)	100-20,000	3,400-4,000	-	Fish et al. 1974; Norris et al. 1977
Humpback whale	song components	40-8,000	100-4,000	144-174	Thompson et al. 1979
	shrieks	-	750-1,800	179-181	Thompson et al. 1986
	horn blasts	-	410-420	181-185	Thompson et al. 1986
	moans	10-1,900	25-360	175	Thompson et al. 1986
	grunts	25-1,900+	-	190	Thompson et al. 1986
	pulse trains	25-1,250	25-80	179-181	Thompson et al. 1986
	underwater blows	100-2,000	-	158	Beamish 1979
	fluke & flipper slap	30-1,200	-	183-192	Thompson et al. 1986
	clicks	2,000-8,200	-	-	Winn et al. 1979b; Beamish 1979
Bowhead whale	tonal moans	25-900	100-400	129-178	Ljungblad et al. 1982a; Cummings and Holliday 1987; Clark et al. 1986
	pulsive	25-3,500	-	152-185	Würsig et al. 1985; Clark and Johnson 1984; Cummings and Holliday 1987
	song	20-500	<4,000	158-189	Cummings and Holiday 1987
Right whale	tonal	30-1,250	160-500	-	Cummings et al. 1972; Clark 1983
	pulsive	30-2,200	50-500	172-187	Cummings et al. 1972; Clark 1983
				181-186	C. Clark (in Würsig et al. 1982)

? Infrequently recorded, and/or questionable correlation of sound with species.

(from Richardson et al., 1991)

Note: Not all found in Hawaiian waters.

Table 4.3.1.1.1-1 Characteristics of baleen whale sounds off U.S. coasts

dB, with most energy in the 1/3-octave bands centered at 20, 25, and 31.5 Hz, as well as secondary components near 50 and 63 Hz (Cummings and Thompson, 1971a). Each sound was uttered as a 3-part sequence.

Low frequency sounds (<110 Hz) have been recorded from at least six blue whales spread over 6 km^2 of the Gulf of Mexico (Thompson et al., 1987). Four of the animals, possibly subadults, were traveling in pairs, and almost half of the recorded sounds were stereotyped doublets, unlike the sounds recorded by Cummings and Thompson in the southern hemisphere, and others recorded off California and Oregon (Cummings, pers. comm., 1991).

U.S. Navy Sound Surveillance System (SOSUS) underwater hydrophones in the western North Atlantic tracked a solitary blue whale for 41 straight days during February-March 1993. The distinct downward sweep of the "commas" on the spectrograms identifying the animal were typically between 15-20 Hz and approximately 60 sec apart (Gagnon, pers. comm., 1993).

- Potential for physical auditory effects: With respect to physical auditory effects, exposure of humans to high sound levels can accelerate the normal process of gradual hearing deterioration with increasing age (Kryter, 1985), resulting in a permanent threshold shift (PTS). This could presumably apply to marine mammals, as well. Ketten (1994) melds current knowledge about acoustic trauma with marine mammal ear data as a framework for an informed, albeit theoretical, discussion of what auditory impacts to marine mammals, if any, are likely. The following are excerpts from her findings (impact estimates are based on extrapolations from available data):

> Marine mammals are acoustically diverse with wide variations in ear anatomy, range, and sensitivity. Like land mammals, dolphins, whales, and seals have ears that are essentially a fluid-filled bony spiral containing a resonating membrane and a series of frequency-pressure-energy detectors. With this basic device, some animals (e.g., dolphins) hear well into the ultrasonic range (>20 kHz), while others (baleen whales) hear well into the infrasonic range (<50 Hz). Frequency ranges (hearing capacity) differ for each species based largely on differences in stiffness and mass of middle and inner structures. There are also important differences among species in their sensitivity in any frequency band.
>
> Marine mammals have both large hearing ranges and specialized ear structures adapted to the acoustic characteristics of water rather than air-borne sound. Their middle and inner ears are heavily modified from terrestrial mammal ears to accommodate rapidly changing pressures encountered in deep dives, and acoustic power relationships several magnitudes greater than in air. These adaptations may coincidentally lessen the risk of injury from high intensity noise to some extent.
>
> A key component of whether or not a hearing loss occurs is an animal's ability to hear the frequencies of that sound source. Virtually all studies show that the extent of a hearing loss depends on the frequency sensitivity of the animal, and that losses center around the peak spectra of the source. For pure tones and

narrow band sound sources of short duration (<1 hr), threshold shifts occur at the frequency of the stimulus. Any hearing impairment that may occur at frequencies beyond those of the sound source would be expected to be much less pronounced, unless the stimulus continues for very long time periods (e.g., a hydroelectric power plant generator) or rapidly reaches an exceptionally high broadband intensity (e.g., a seismic air gun).

Any damage is proportional to an animal's sensitivity. For most terrestrial species, a signal must have an intensity 80 dB over the hearing threshold of the animal, at that particular frequency, to produce a significant temporary threshold shift. [Data to substantiate this with respect to marine mammals are unavailable at this time] Therefore, a moderately intense sound source near an animal's best frequency could possibly affect its hearing in that range, but would probably have little effect in other parts of its hearing range.

The duration of a threshold shift is generally correlated with both the length of time and the intensity of exposure. If the exposure is short (<1 hr), hearing is usually recoverable (i.e., temporary threshold shift (TTS) occurs); if great (>8 hr/day), hearing is more prone to permanent degradation (PTS). With short duration, narrow band stimuli, recovery periods can vary from hours to days. TTSs have been produced in humans with underwater sound sources at levels of 150-180 dB for frequencies between 700-5600 Hz (most sensitive range of human hearing). [Hollien (1993) suggests that the dynamic range of human hearing underwater is less than in air. For frequencies between 50 Hz and 16 kHz, his model delineates the dynamic range for human underwater hearing to be 55-65 dB wide, ranging from about 60-65 dB, up to about 120-130 dB. In air, comparable values are a dynamic range 144 dB wide, going from approximately 1 dB, up to 145 dB. However, there is no information as to whether the human range, or some lower (or higher) range, applies to marine mammals (Hollein, 1993). If a lower value is appropriate, then the received level that would cause a mysticete to incur TTS could be less than the assumed 150 dB (≤15 dB difference); if higher, 150 dB would be too conservative (≤15 dB difference).]

Given the similarities of whale and seal ears to land mammal ears, it is certainly possible that a relatively intense sound source, like the proposed ATOC signal, could produce acoustic impacts in some--but not all--species in that sound field. Because the ATOC signal has a narrow frequency band with slow onset, losses in any one animal are likely to be restricted to frequencies in or near the broadcast band. Assuming TTS and PTS in marine mammals occur at intensity-duration limits similar to those in land mammals, and therefore that such noise trauma requires a signal 80 dB over threshold, this means only those species capable of detecting signals lower than 90 Hz with sensitivity level below (better than) 115 dB threshold (+80 = 195 dB, maximum ATOC source level at 1 m range from the source) could possibly be adversely impacted.

> As an example, audiograms and anatomical data on marine mammal hearing ranges imply that the humpback whale is likely to have adequately sensitive low frequency hearing to be a candidate for temporary threshold shift from the ATOC source. For the humpback, a 150 dB or greater signal could represent a significant hazard with repeat exposures. Any hearing impairment would likely be limited to the lower limit of their hearing range. Given that transmission loss estimates stated elsewhere in this EIS/EIR are correct, intersecting a 150 dB level requires a dive depth >800 m, which is beyond the limit for humpbacks for even a single dive, let alone the many dives necessary to incur PTS due to sound levels >80 dB above assumed threshold level. It is unlikely that the hearing of any humpback whale would be adversely affected physiologically outside the 150 dB sound field.

Based on Ketten's analysis, it appears possible that mysticetes could experience discomfort or a temporary elevation of their hearing threshold if exposed to the source in the high intensity zone (i.e., ≥150 dB). A temporary elevation in threshold levels would most likely last from a few minutes to hours (TTS can be experienced for days in some cases, depending on the level and duration of noise exposure, among other factors). If TTS occurred, it could temporarily reduce an animal's ability to hear calls, echolocation sounds, and other ambient sounds. Based on Ketten's findings and assuming that the calculated sound field levels are correct, to suffer TTS, the animal must be:

- capable of hearing signals below 90 Hz and have hearing sensitivity below (better than) 70 dB (150 dB-80 dB=70 dB) for frequencies below 90 Hz (assuming that TTS would occur for received levels >80-100 dB above the absolute threshold, as for humans listening in air, and that sound field levels are correct).

- capable of diving > 800 m (2625 ft) (making the same assumption as above).

- within the 150 dB isopleth (at 800 m depth, 178 m radius from the source); choose not to depart or be unable to depart the area; and/or be subjected to repeated exposures. In this regard, it is assumed that if an animal considered the sound to be annoying, it would depart the area during the 5-min source ramp-up period. All marine mammals have adequate swim speed to accomplish this.

Provided that the above assumptions/criteria are correct and, as available research data indicate, and none of the seven mysticete species are expected to dive to depths greater than 800 m, it appears unlikely that any of these animals would experience direct effects, such as TTS or PTS. EPA (1993) states that the Pioneer Seamount area has not been identified as an important habitat (i.e., feeding, breeding, migration route or comparable area).

Another concern which has been raised with respect to physical auditory effects is that marine mammals exposed to the source could be injured or killed as a result of sound-induced physiological damage, similar to that experienced by two humpback whales that died apparently as a result of being exposed to two 5000 kg underwater explosive charges off the coast of

Newfoundland. Ketten notes, however, that there is a great difference between simple acoustic trauma and blast injury, and that the humpback whales that died had experienced extensive ear damage not simply as a result of the intensity of the sound source, but as a result of an extreme, sharp onset pressure source (Ketten, Lien, and Todd, 1993). In this respect, it is instructive to compare the acoustic energy level originating from a single underwater explosion to the acoustic energy level in a single ATOC transmission. Using the aforementioned example of a 5000 kg charge of TNT as an example, and applying the basic formula provided by Urick (1967), elicits the following results:

Peak Explosive Overpressure, $p_o(\mu Pa) = 1.49X10^{14}(W^{1/3}/r)^{1.13}$
where,

W = Charge weight in lbs (note that 5000 kg = 11,000 lbs)
r = range in ft

and the related time constant, $t_o(sec) = 58X10^{-6}\ W^{1/3}(W^{1/3}/r)^{-0.22}$

The total acoustic energy, E, in this shock wave is given by:

$$E = p_o^2 t_o/(2\rho c)$$

where ρc is the characteristic impedance of sea water.

To illustrate, at a range of 100 yds (91.4 m) from a 5000 kg charge:

$p_o(\mu Pa) = 7.8X10^{12}\ \mu Pa$ at 91.4 m
$t_o(sec) = 2.28X10^{-3}$ sec

Similarly, the relative acoustic energy from a 20 min ATOC source transmission at a range of 91.4 m can be calculated as follows (assuming a source level of 195 dB re 1 µPa-m, and spherical spreading losses to 91.4 m):

$p_o(\mu Pa) = 5.6X10^{7}\ \mu Pa$ at 91.4 m
$t_o(sec) = 1.2X10^{3}$ sec

On a logarithmic basis, the ratio of the two source energies is given by:

$$10Log_{10}[E(20\text{ min ATOC}/E(5000\text{ kg TNT})]_{@91.4\,m} = -45.7\text{ dB}$$

Thus, at a nearby range of 91.4 m, the ATOC source produces 45.7 dB (45,700 times) less acoustic energy over a full 20 min transmission than a single 5000 kg explosive charge. The ATOC source, of course, does not produce an explosive shock wave, the peak pressures from the two sources being different by a factor of more than 100,000 in magnitude.

CEQA Impact 3: Physical auditory impacts on mysticetes, potentially consisting of occasional temporary threshold shifts in hearing for deep diving animals, is presumed to be less than significant.

CEQA Mitigation Measure 3-1: A Marine Mammal Research Program (MMRP) will be carried out in connection with the ATOC project in accordance with the protocols set forth in Appendix C to this EIS/EIR. With regard to potential physical auditory impacts on mysticetes, a goal of the MMRP will be to validate the assumptions regarding population distribution and abundance and diving behavior, which form the basis for predicting the potential for effects from the ATOC sound source.

- Potential for behavioral disruption: Previous studies of mysticete responses to human-made noise have examined short-term behavioral responses to broadband industrial and recreational vessel noise extending from below 75 Hz to 1000 Hz. There are no data on potential auditory effects of a sound with specific ATOC source characteristics. To estimate how the available data relate, or scale, to ATOC source transmission characteristics, the following must be accounted for: 1) ATOC source bandwidth is 35 Hz, whereas noise produced by industrial and recreational vessel sources usually have wider bandwidths (e.g., a semi-submersible drillrig's broadband signals can cover as much as 3200 Hz [80-4000 Hz] [Greene, 1986], and a 70 hp outboard motor's bandwidth is on the order of 3600 Hz [400-4000 Hz] [Stewart et al., 1982]); 2) maximum duty cycle for the ATOC source would be 8%, whereas available data from industrial sources usually is based on duty cycles >50%; 3) peak power output of the ATOC source would be 180 dB/Hz at 75 Hz; total power, integrated across the entire 35 Hz bandwidth (57.5-92.5 Hz) would be 195 dB. Although most available data are not directly relatable to projected ATOC source transmission parameters, basic physical acoustic phenomenology can be applied. In so doing, estimates of potential impacts based on analysis of available data can, for the most part, be considered relatively conservative.

Based on available studies and reported observations, the possible short-term reactions of mysticetes disturbed by human-made noise include interruption of feeding, resting, or social activities, abrupt diving, swimming away, and change in vocalization patterns (Finley, 1982; Calkins, 1983). There are few data available concerning the potential effects of various types of sound and other disturbance on cetacean vocalization patterns (e.g., call type, rate and intensity). Temporary cessation of vocal behavior in response to anthropogenic noise is not well documented in baleen whales, but does occur (Bowles et al., 1994). In the 1991 Heard Island Feasibility Test (HIFT), minke whales may have altered their distribution in the immediate vicinity of the low frequency transmissions, but they returned or were replaced by new individuals quickly when transmissions stopped. During the same experiment, one blue whale tracked before, during and after a transmission, changed respiration and reorientation rates, but did not avoid the source detectably. During this test, sperm whales and pilot whales were heard in 23% of 1181 min of baseline acoustic surveys, but in none of the 1939 min during transmissions (57 Hz at 209-220 dB source level). Both species were heard within 48 min after the end of the test (Bowles et al., 1994).

There is also a great deal of variability in animal responses, even among individuals of the same species. Reasons for this variation can be physical (e.g., varying/increasing as opposed to steady sound levels; sound propagation conditions; and background noise levels) and/or biological (e.g., the animals' activity; age and sex class; habitat; habituation, and individual variation) (Richardson et al., 1991).

Studies of the effects of simulated and actual oil industry noise on bowhead whales *(Balaena mysticetus)* conducted in the Beaufort Sea from 1980 to 1991, showed a wide variation in behavioral reactions to received levels of noise depending, in part, on the source and characteristics of noise, the whales' activities when exposed, and the physical situation, as well as individual variation among animals exposed. Reactions to increasing noise levels from approaching boats occurred at received levels as low as 90 dB. In both spring and summer, approximately half of the whales exhibited avoidance when the received level of steady drillship or dredge noise was about 115 dB, or 20 dB above ambient. However, in the spring some whales tolerated the levels of drilling sound up to 135+ dB if the only available migration route through ice required close approach to a sound projector. Whales exhibited avoidance behavior to repetitive pulses from airgun arrays only at received levels exceeding 150-180 dB (as well as more subtle behavioral changes to weaker pulses) (Richardson et al., 1991).

Acoustic disturbance studies conducted by Malme et al. (1984) showed a 50% avoidance by gray whales to continuous sound levels of >120 dB. For impulsive airgun sounds of <0.5 sec duration, effective pulse levels 30 to 50 dB higher are required to produce 50% avoidance for the same species. The 120 dB value appears to be roughly constant among the mysticetes tested, including gray whales (Malme et al., 1984; Tyack et al., 1991); bowhead whales (Richardson et al., 1991); and humpback whales (Malme et al., 1985), but is qualified by species, social context, and source characteristics. In general, observations indicate that marine mammals show fewer and less pronounced short-term behavioral responses to sources with constant and predictable acoustic characteristics, than to sources with variable and unpredictable acoustic characteristics (Malme et al., 1984; Richardson et al., 1985), but this has not been quantified.

Studies were conducted by Frankel, Herman, and Mobley in 1985-86 (reported by Mobley et al., 1988) of humpback whales in Hawaiian waters exposed to the playback of humpback songs (50 Hz-10 kHz), social sounds (200 Hz-3 kHz), Alaskan feeding calls (450-550 Hz), artificially synthesized sounds (10 Hz-1.4 kHz), and blank tape control. Results showed that the minimum received level that produced a strong reaction (rapid approach to the boat) was probably 110-115 dB, for transmission loss models using spherical spreading ($20\log_{10}R$) and mode stripping ($15\log_{10}R$) to estimate received levels based on source levels.

According to Maybaum (1989), humpback whales in Hawaiian waters exhibited avoidance behaviors (i.e., increased their distance from the sound source) when presented with sounds of a 3.3 kHz sonar pulse, a sonar frequency sweep from 3.1 to 3.6 kHz, or a control (blank) tape. While the two types of sonar signals differed in their effects on the whales, both elicited avoidance behaviors (the animals increased their distance from the sound source). The strength of this effect varied directly with time. Responses to the frequency sweep primarily consisted of increased swimming speeds and track linearity. The latter was a direct function of increasing sound intensity. Overall, the sounds did not strongly or consistently affect the whales' dive cycles or vocalizations. Observed avoidance reactions may have resulted from possible resemblance between the sonar signals and natural sounds in the humpback's environment that are associated with biological threats or warnings.

During gray whale migration, Wyrick (1954) noted that the animals changed course at a distance of 200-300 m to move around a vessel in their paths. Sumich (1983) recorded that the fastest moving grays near a boat breathed and used energy more rapidly than slower whales. Hubbs and Hubbs (1967) suggested that migrating gray whales disturbed by ship/boat traffic tend to exhale more underwater and expose their blowholes only to inhale. Cummings and Thompson (1971b) noticed the same behavior in response to playbacks of killer whale sounds (one of their only predators). Bursk (in Atkins and Swartz, 1989) reported that the rate of course change by migrating grays can be correlated with the number of vessels in the vicinity, particularly whale-watching boats. In the presence of boats or playbacks of outboard noise, gray whale call rate increased, call structure changed, and average received levels of calls increased. The higher received levels were interpreted to mean that source levels of the calls had also increased in the presence of boat noise, not because the whales were seriously disturbed, rather to reduce masking of the calls by the boat noise (Dahlheim et al., 1984).

Cowles et al. (1981) noted that the eastern Pacific gray whale population continues to migrate along the west coast of North America, despite the growing number of ships, boats, low-flying aircraft and thrillcraft.

In summary, variations in sensitivity to human-made noise between and within marine mammal species and lack of information about the consequences of short-term disruptions on marine mammals, make it difficult to define the criteria of their-responsiveness and to assess the consequences of a disruption in their natural activities. Disruption of marine mammals as a result of human-made noise can be expected to result in interruption (at least briefly) of normal behavioral and social interactions with other animals of their species, an increase in energy cost (whether or not feeding was disrupted), and displacement to a habitat that may be less suitable. Displacement also can have the benefit of removing the animal from a location where, had the animal remained, there might be more serious consequences (e.g., by reducing the masking effect of the human-made noise or the physiological stress that might continue if the animal remained close to the noise source).

Social disruption is a potentially important disturbance factor. Animals that are aggregated may flee in different directions upon the approach of a fast, noisy vessel or thrillcraft, or low-flying aircraft. The duration of this social disruption rarely has been measured, but is sometimes several hours (e.g., cetaceans engaged in cooperative feeding or sexual activity) (Richardson et al., 1991). The possible consequences of this intrusion on marine mammals are poorly understood. It could possibly result in changes to social order, sexual behavior, parental care, or cooperative activities. It only can be assumed that repeated social disruption is a disadvantage because it could decrease or disrupt activities that would have occurred naturally and, in turn, could adversely affect the social ordering that probably took some measure of time and energy to establish.

The possibility of separation of dependent young from their mothers is a potentially severe consequence of disturbance-induced social disruption. Although, in baleen whales, older nursing calves occasionally are separated from their mothers by a few hundred meters, with apparently no ill effects detected.

Richardson et al. (1991) suggested that these isolated disturbance incidents usually have minimal or no lasting effects, as marine mammals around the globe continuously cope with occasional disruption of their activities by predators, poor weather conditions, unusual ice conditions at high latitudes, and other unpredictable natural phenomena.

Richardson et al. (1991) also speculated that although there is little definite information about the long-term effects of short-term disturbance reactions, isolated disturbance incidents usually have minimal or no lasting effects and that the energetic consequences of most single disturbance incidents probably are insignificant. They noted, however, that recurrent incidents of interrupted feeding and rapid swimming, if sufficiently frequent, can have negative effects on the well-being of individuals. The frequency and duration of disturbance that might initiate negative effects are unknown, and would undoubtedly depend on the species, area, feeding requirements, and reproductive status of the marine mammals involved (e.g., animals in regions with abundant and widely distributed food resources would likely be less severely affected than in areas where feeding is necessary but suitable food is less readily available). Animals most severely affected would likely be pregnant or lactating females and other animals subject to heavy natural energy drain.

Richardson et al. (1991) also noted that the long-term implications of prolonged disturbance, as might occur if a stationary and continuously noisy human activity were established near a marine mammal concentration area, would depend, in part, on the degree to which the marine mammals habituate. If they fail to habituate and, as a consequence, are excluded from an important concentration area or are subject to ongoing stress while in that area, then there could be long-term effects on the individuals and the population. Conversely, when habituation occurs, as it does for some marine mammals exposed to ongoing human activities, then the consequences may be minimal.

As summarized by Richardson, et al. (1991), some marine mammals have been found to tolerate, at least over periods of a few hours, continuous sound received at levels greater than 120 dB. During one study, 50% of migrating gray whales exhibited avoidance reactions at industrial noise levels (drill ship) of 117-123 dB, and 10% reacted to levels $\geq$110 dB. It is doubtful that many marine mammals would remain in areas where received levels of continuous noise remain at or above 140 dB, unless hearing is impaired. Tolerance of mysticetes to an ATOC source transmission sound level of 120 dB, at 2% or 8% duty cycles, is uncertain.

Some general conclusions can be drawn from the relative abundance of various mysticete species in relationship to the ATOC sound fields. The majority of mysticetes in the area are gray whales; and most (96%) gray whales migrate within 4.8 km of shore and the Farallon Islands in the area of the sound source (Rice et al., 1984). At this distance from the ATOC source, the intensity of the sound field would be less than 120 dB. Because only 4% of the gray whales are found farther offshore where they could be exposed to sounds ≥120 dB, behavioral disruptions are anticipated to be minimal. Similarly, because humpback whales usually prefer nearshore locations, few are expected to be exposed to the 120 dB ATOC sound field.

Other mysticetes have hearing frequencies within the range of those produced by the ATOC source, with the blue whale and fin whale being the most abundant. With average annual densities of one animal per 500-1000 sq km, and given the areal extent of the 120 dB sound field (735 sq km), there is a possibility that a small number of blue and/or fin whales (i.e., 1-2, on average) could be present within that sound field during ATOC transmission.

CEQA Impact 4: Although it appears that low numbers of mysticete whales would be exposed to ATOC sounds louder than 120 dB, a level that has been shown to result in detectable changes in behavior in some mysticete species, the lack of additional reliable information justifies the assumption of an impact for purposes of this EIS/EIR. Since the proposed site (i.e., 120 dB sound field 18 km around the source) has not been identified as an important habitat (i.e., feeding, breeding, migration route, or comparable area) (EPA, 1993), this potential impact is believed less than significant.

CEQA Mitigation Measure 4-1: As provided in mitigation measure 2-1, the duty cycle and power levels of the ATOC source would be adjusted to the minimum necessary to support research objectives, so that potential impacts to mysticetes would be minimized.

CEQA Mitigation Measure 4-2: As provided in mitigation measure 3-1, a MMRP will be carried out in connection with the ATOC project in accordance with the protocols set forth in Appendix C to this EIS/EIR. With regard to potential impacts on mysticetes, a goal of the MMRP will be to identify the nature, frequency, and significance of any responses to ATOC source transmissions.

- 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. Many human-made sounds, both waterborne and airborne, fall into this category. While relatively few studies of habituation in marine mammals have been done, several cases of apparent habituation have been reported in baleen whales (Watkins, 1986; Dolphin, 1987; Malme et al., 1985; Richardson et al., 1985c, 1990b) which suggest they tend, over time, to become less sensitive to certain types of repeated noise and disturbance which they perceive as non-threatening. Animals are also more likely to habituate to a sound with relatively steady characteristics than to a highly variable sound.

Richardson et al. (1991) noted that it is not known how often an animal must be exposed to a stimulus to remain habituated (e.g., whether animals exposed and habituated to a disturbance during one year would still be habituated the next year).

Several cases of apparent habituation have been reported in baleen whales. When wintering gray whales first enter the calving lagoons of Baja, California, they are wary of small boats. However, later in the winter they are less cautious, and some individual animals actively seek out motorboats (Swartz and Jones, 1978). Watkins (1986) suggested that, near Cape Cod, reactions of various species of baleen whales changed over the years as whale-watching cruises became popular. Some species, particularly humpback and fin whales, have become less wary of boats in recent years. Dolphin (1987) reported that humpbacks off southeast Alaska initially reacted to an outboard motorboat used in his research, but soon accommodated it. Malme et al. (1985) suggested that reactions of humpbacks to noise pulses from an airgun waned after the first exposure. Richardson et al. (1985, 1990b) found that some bowheads remained near dredges and drillships that were producing continuous noise, even though bowheads exhibited at least weak avoidance reactions at the onset of about the same levels of drillship or dredge noise. These observations suggest that marine mammals, like other animals, tend, over time, to become less sensitive to noise and disturbance to which they are repeatedly exposed. However, this reduction in responsiveness is not likely to occur if the animals are harmed or harassed severely when exposed to the noise or disturbance.

Generally, habituation effects can be considered beneficial, since they limit the direct impact of a stimulus. Habituation can be detrimental, however, if it leads to a lack of response to hazardous situations or, in the case of noise, results in hearing loss. For example, habituation to low frequency sounds, including sounds from large vessels, could lead to decreased avoidance of vessels and increased injury or death from collisions. It can also limit an animal's capability to hear vocalizations from other animals. However, in the ATOC source vicinity, noise from existing vessel traffic would be expected to have a much greater habituating effect than that from the ATOC sound source, yet no such increase in collisions from habituation has been documented. Any such adverse effect from habituation to the ATOC source therefore is speculative and is rated for purposes of this EIS/EIR to be minimal.

- 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, 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. 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 distributional changes of humpback whales around Maui, as a result of human activity, are discussed in Section 4.3.1.1.2 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%/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, 1981b). 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 in marine mammals 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 ATOC sound fields is unknown; however, all marine mammal exposures to subsea sounds would be minimized wherever feasible.

CEQA Impact 5: Although any potential long-term impacts to mysticetes are speculative, the evidence of long-term displacement of mysticetes by boat traffic in some instances, coupled with the lack of additional reliable information, justifies the assumption of an impact for purposes of this EIS/EIR. Since the proposed site has not been identified as an important habitat (i.e., feeding, breeding, migration route or comparable area) (EPA, 1993), and considering the minor portion of the range affected, this potential impact is deemed less than significant.

CEQA Mitigation Measure 5-1: As provided in mitigation measure 2-1, the duty cycle and power levels of the ATOC source would be adjusted to the minimum necessary to support research objectives, so that potential long-term impacts to mysticetes would be minimized.

CEQA Mitigation Measure 5-2: As provided in mitigation measure 3-1, a MMRP will be carried out in connection with the ATOC project in accordance with the protocols set forth in Appendix C to this EIS/EIR. With regard to potential long-term impacts on mysticetes, a goal of the MMRP will be to identify the nature, frequency and significance of any long-term changes due to ATOC source transmissions (via comparison of animal distribution data before, during, and after source transmission periods over a two-year period).

- Potential for masking: 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. More data are needed on: 1) the functional importance to marine mammals of faint signals from other members of their species, predators, prey, and other natural sources; 2) the 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 their call intensities and perhaps frequencies to minimize masking effects.

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 (Watkins, 1981b).

During the proposed sound transmissions (mostly 2% 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 500 km, could be greater than average ambient levels. 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 ATOC source. 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. The few 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.

For species with broad spectrum hearing, presumed to be the case for mysticetes, masking from a narrowband source, such as ATOC, 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).

In light of the number of mysticetes that may be exposed and the relatively brief and intermittent nature of the ATOC source transmissions, masking effects are uncertain, but presumed to be less than significant (i.e., would not substantially reduce the number or restrict the range of mysticetes, cause the population to drop below self-sustaining levels, or adversely affect their significant habitats). Because masking effects on mysticetes are not amenable to further study or mitigation beyond those measures already proposed (see mitigation measures 2-1 and 3-1), no additional mitigation measures are identified.

- 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 mysticetes in the vicinity of the study area. Humpbacks primarily feed on euphausiid prey species (*Thysanoessa spinifera*) during winter months in central California waters (Schoenherr, 1991; Kieckhefer, 1992).

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. This provides a major food source for humpbacks and other mysticetes in the region (e.g., blue, fin, sei). The euphausiids provide these animals an unusually efficient two-step food chain, enabling a much greater biomass of large animals to be supported than would be the case if most of them preyed upon animals of intermediate size (McConnaughey, 1970).

The eastern Pacific gray whale population spends from May through November feeding on benthic (bottom-dwelling) gammarid amphipods (at depths <200 m), which abound in parts of the Bering, Chukchi, and western Beaufort Seas (Leatherwood and Reeves, 1983). Some whale researchers believe that gray whales feed opportunistically year-round, although direct evidence is lacking.

If low frequency sounds were to affect krill, or benthic fauna, depending on the extent to which their availability might be altered, there could be negative consequences to the marine mammals that feed on them. There is laboratory evidence that such sounds can affect egg viability and growth rates of fish and invertebrates (Banner and Hyatt, 1973; Lagardere, 1982). Thus, intense sounds in the open ocean (e.g., ≥150 dB), potentially could affect the availability of organisms in the food chain of marine mammals, even if these organisms do not have auditory receptors.

MMRP activities, and acoustic source transmissions under the proposed action that would be conducted from the seabed off the coast of central California, would have little effect on the primary food species of mysticetes in the North Pacific (high latitude) and no effect in Arctic regions. The potential effect of low frequency sounds on *T. spinifera* is unknown at this time but it would be expected that a very small portion of this species' population could possibly be affected during the 2%-8% of the time the source is transmitting. Nevertheless, this points up the necessity for a coordinated study of the distribution and behavior of the regions marine animals, associated with their prey species. For a more thorough discussion of the potential direct, indirect, and cumulative impacts of the proposed action on krill and other invertebrates which are the prey species of mysticetes, see Section 4.3.2.3.

The proposed ATOC source site is not known to be an essential feeding area for mysticetes (EPA, 1993), and it is expected that any potential effects on prey species would be incremental and affect only a small portion of their range. This presumes that both mysticetes and their prey will not be significantly affected beyond the estimated 120 dB sound field. However, with virtually no data available, the potential for impacts on mysticetes' food chain must be stated as unknown. To further assess the potential for indirect impacts, the MMRP, to the extent feasible and practicable, would include observations of the potential impact of source operations on prey species (see Appendix C).

The potential direct and indirect effects of the alternatives are summarized in Table 4.1-1.

4.3.1.1.2 Potential Cumulative Effects on Mysticetes

The types of actions that might reasonably be considered to have the potential to interact to affect mysticetes 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 research activities that could add cumulative noise stimuli to the marine environment. The discussions below also account for MMRP-related activities that could potentially cumulate with the source transmissions: 1) aerial visual and acoustic surveys/
observations, 2) shipboard visual and acoustic surveys/observations, 3) shipboard photo-identification activities, 4) shipboard translocation of tagged elephant seals.

- 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 baleen whales.

Collisions with ships are an increasing threat to many whale species. As ships get larger and faster and the numbers of vessels and/or whales increase, the incidence of encounters is expected to increase. Large ships, tugboats with barges on long towlines, and recreational vessels are potential collision threats to whales in some offshore regions of the central California coast and in portions of some mysticete migration routes.

According to Glockner-Ferrari et al. (1987), the number of physical injuries to calves, juveniles, and adult humpbacks as a result of collisions with boats has increased in Hawaiian waters. At least 5 humpbacks photographed in southeastern Alaskan waters have exhibited large dents or gashes on the upper body that probably were caused by collisions with vessels. Most of those whales were also noticeably skittish when approached by boats or skiffs for fluke photography (NMFS, 1991).

A hydrofoil struck and killed a gray whale off San Diego in 1975. Seven persons were looking forward from the bridge at the time, and despite calm seas and good visibility, the animal was not spotted (Shallenberger, 1978). During a six-year period, 14 collisions between ships and whales were recorded off southern California, twelve of which involved gray whales. Six of the grays and two other whales died as a result of those collisions (Patten et al., 1980). Similarly, Brownell et al. (1986), and Reeves and Mitchell (1986) mentioned several instances where right whales apparently were killed or injured by collisions with vessels.

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 185-200 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) (Figure 4.3.1.1.2-1 superimposes an idealized supertanker's area of influence over that of the preferred Sur Ridge site's). 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 away, characterized by faster swimming with few long dives; and 2) "vertical avoidance" of vessels from 0-2 km away, during which whales swam more slowly, but spent more time submerged. Other responses observed, such as trumpeting (Watkins, 1967a) 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.

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 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-

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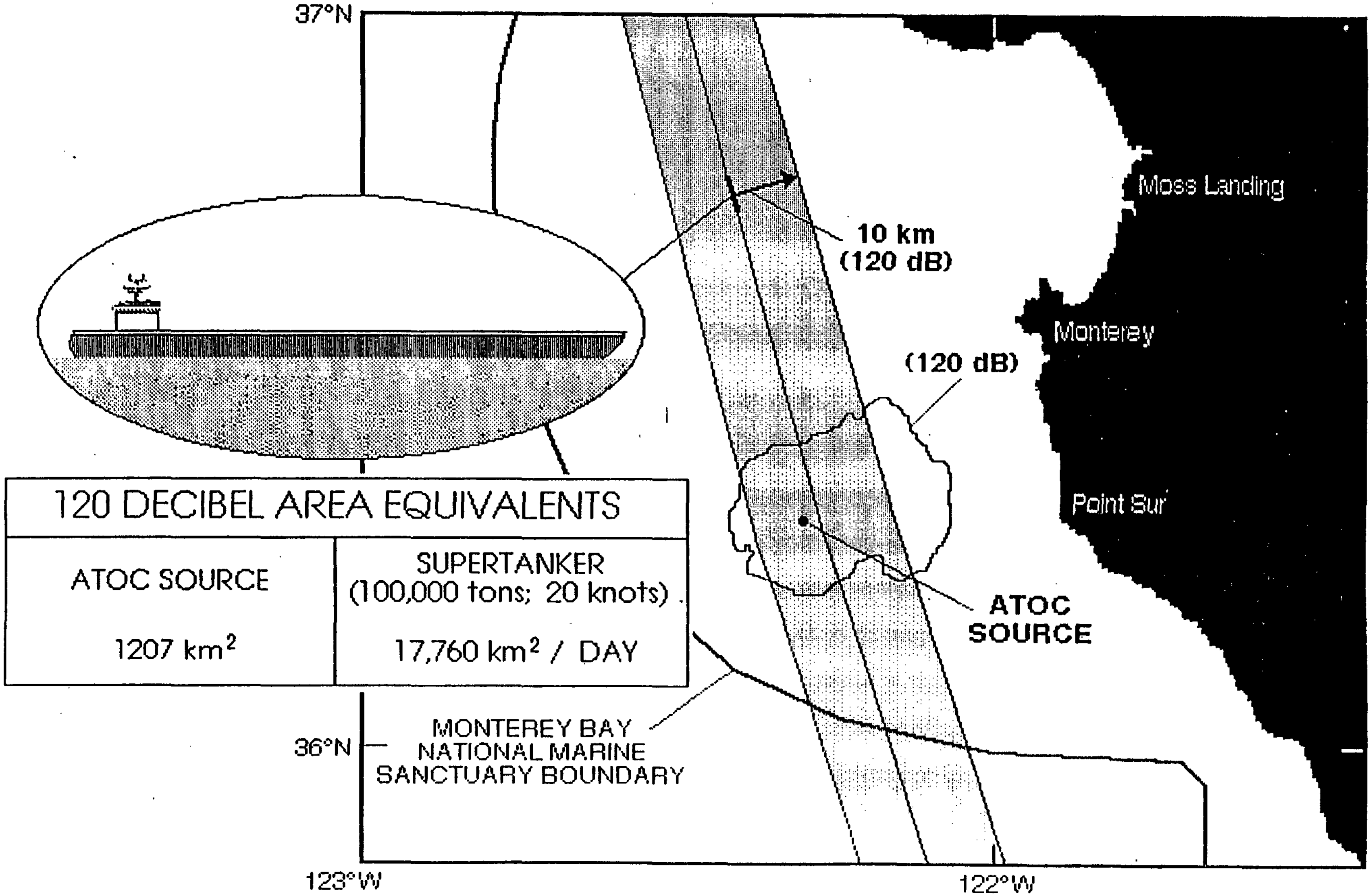
SUR RIDGE SOURCE SOUND FIELD VERSUS SUPERTANKER SOUND FIELD



120 DECIBEL AREA EQUIVALENTS	
ATOC SOURCE	SUPERTANKER (100,000 tons; 20 knots)
1207 km^2	17,760 km^2 / DAY

Figure 4.3.1.1.2-1 Sur Ridge source sound field vs. supertanker sound field

term negative consequences of such short-term stress (e.g., on fertility) could not be assessed (Bauer, 1986; Bauer and Herman, 1986).

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% of the cases, the animal(s) departed the vicinity of the boat/ship noise immediately. About 85% 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.

• Recreational water activities: Over the years there has been increased vessel traffic and a significant increase in human activity off the coast of central California. For example, over 2,350 boat slips now are available in the combined harbors of Santa Cruz, Monterey, Moss Landing, and Pillar Point (Princeton). Also, once per year large speedboats participate in a charity race in the Monterey Bay area, at top speeds exceeding 100 mph.

Although five of the baleen whales that could potentially inhabit the area are listed as endangered (blue, fin, sei, humpback and right), the populations of some have actually increased in the area in recent years. Blue whales have significantly increased in numbers within and adjacent to Monterey Bay (Dohl, pers. comm., 1989). Fins have increased in numbers and length of stay in the area in recent years, using the Monterey, Soquel, and Carmel canyons for feeding (Dohl, pers. comm., 1989). Humpback numbers also have increased dramatically throughout central California offshore waters, beginning in the early 1980s. At first limited to the general area of the Farallon Basin, they are now found in coastal waters from Pt. Sur to Pillar Point from April to December. Protection from commercial whaling by international agreement in 1946 has allowed the gray whale population to grow to its current estimated level of >20,000. Most whaling historians and marine biologists believe the pre-exploitation stock size was between 15,000 and 24,000 (Leatherwood and Reeves, 1983). However, the Pacific right whale is an extremely endangered species--fewer than 200 individuals inhabit the entire North Pacific (Braham and Rice, 1984). No right whales have been seen in Monterey Bay, but some were seen in 1986 and 1987 in the waters off Half Moon Bay (Scarff, 1986).

Based on the above information, albeit limited in detail and geographical scope, there is no direct correlation between increased recreational water activities off the central California coastline and the number of mysticetes in the area.

• 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).

Offshore oil development on the central California outer continental shelf (OCS) south of the MBNMS boundary could occur, if approved in the five-year plan starting in 1998. This would not only generate construction noise, but also additional noise from increased oil tanker traffic. Also, maintenance and supply vessels would lead to increased small boat traffic within the area.

The potential for impacts on mysticete habitat due to nearshore resort operations would most likely be related to small boat (thrillcraft, parasailing [at least one company operates out of

Santa Cruz], 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 assessed to date.

- Aircraft operations: Aircraft are known to affect whales. Shallenberger (1978), Herman et al. (1980), and others found, however, 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, speed of the aircraft, wind speed, wave height, water depth, distance from shore, and the age, sex, number, and activities of the whales.

Off the coast of central California, commuter traffic and small private planes are potential sources of aerial disturbance. These planes regularly fly along the coast, sometimes crossing areas of high whale concentrations at altitudes of approximately 305 m or less. Pilots occasionally divert from their flight path to circle whales so that passengers can view or photograph them. Helicopter tour operators also disturb gray whales by flying low or hovering in their vicinity, and these commercial organizations operate with no permit.

Noise from military airplanes and other government exercises also are potential sources of disturbance. The preferred action site (Sur Ridge) is within San Francisco Warning Area 285 (W-285) (approximately 3400 sq km), and is in frequent use for air training (700 scheduled operations per month [Capt. Larson, pers. comm., 1989], which include aircraft carrier takeoffs and landings, and low-level air combat maneuvering). The latter activity results in the expenditure of smoke markers, sonobuoys, and non-explosive ordnance. The proposed action site (Pioneer Seamount) does not lie within any military training areas and is approximately 30 km to the northwest of the western edge of W-285.

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

- Research activities: There are currently at least ten SRPs authorizing studies of mysticetes off California. Approved SRPs and pending SRP applications have been reviewed and considered non-duplicative with each other, or with the proposed action. There is relatively little geographic overlap in study areas. Scientists are required to coordinate research activities through NMFS's Southwest Region. Boats used strictly for scientific research include outboard motor-powered inflatable boats or runabouts less than 6 m long, sailboats up to approximately 12 m long, and inboard motor-powered boats up to approximately 15 m long.

Multiple noise sources in an area can increase natural ambient levels in the 50-100 Hz frequency band (normally 74-100 dB at sea state 3-5 [wave heights 1-3.6 m] based on analysis of a four-year data set of U.S. Navy sonobuoy measurements) offshore central California to up to 120 dB and higher. Ambient noise levels near ships (within approximately 0.25 km) can increase to 150 dB. The proposed source would contribute only 82 dB (on an Leq basis over a 4-day period) to normal background noise at ranges of approximately 5-25 km from the source (2% duty cycle). During actual transmission times, the contribution to the ambient noise field would be delineated by the sound fields discussed in Section 2. The simultaneous presence of these multiple noise sources in the area could potentially cause more frequent masking, behavioral disruption, and short- or long-term displacement. However, the effects of multiple noise sources on marine mammals have not been studied specifically, nor have there been any systematic studies of the effects of human-related activities on marine animals in the central California coastal waters.

Richardson et al. (1991) noted that the long-term consequences of multiple noise sources are likely to depend, in part, on the degree to which the animals habituate to repeated noise exposure. Based on the meager information that is available, they note that animals habituate more rapidly and completely if: 1) the various noise sources emit similar sounds, rather than sounds with varying acoustic characteristics; and 2) if the sources are stationary (e.g., offshore drillrigs), rather than moving (e.g., ships, boats, thrillcraft), provided that noise levels from the moving vessels are at least as intense as those from the drillrigs.

The presence of multiple noise sources in the study area would have the potential to increase the severity of any deleterious effects that might exist for a single source. For example, if animals are displaced from an area around some or all of these sources, the total amount of habitat affected would be greater than for any one source. Thus, a higher proportion of the population would likely be affected as the number of sources increases. If either animals or the noise sources are moving, an individual animal is likely to encounter a noise source more often as the number of sources increases. Thus, interruption of behavior, and possibly displacement, would be more frequent as the number of sources increases. The consequences of these presumptive situations remain uncertain, but would presumably be negative in nature.

<u>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</u>. 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 Japan, 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.

Table 4.1-1 summarizes the potential cumulative effects of the alternatives on mysticetes.

4.3.1.1.3 Summary and Conclusions Concerning the Effects on Mysticetes

This Section summarizes the information presented in the previous Subsections regarding potential effects of the ATOC source operations and MMRP on mysticetes.

A key factor in the prediction of potential impacts is the distribution and abundance of each species in relation to ATOC sound fields. To focus on key areas of potential risk, Table 4.3.1.1.3-1 below presents, for each species, the maximum exposure anticipated to occur during full power ATOC source operations, given the diving depth and distribution of the species.

there are no mysticetes in the area that are believed to dive >700 m, and no acute or short-term responses (Table C-1) are anticipated from any of the species at maximum exposure levels.

The gray whale is believed to have a maximum diving depth of less than 200 m and generally makes dives deeper than 100 m only for bottom feeding. Since the ocean bottom at the location of the ATOC source is out of diving range for the gray whale, it is not anticipated that gray whales would make deep dives in that vicinity; maximum exposure would therefore be experienced by individuals at or near the surface, where a maximum of 138 dB level would be received at approximately 200 m depth immediately above the source. This level is higher than that believed could possibly result in detectable changes in gray whale travel direction, but is well below the level anticipated to result in threshold shifts. Most (96%) gray whales are found within 4.8 km of shore and the Farallon Islands; at that location (30 km from the source or more) no effects are likely and, indeed, gray whales may be exposed to ATOC sounds below their threshold of hearing at that distance from the source. Only an occasional gray whale can be expected in the vicinity of the ATOC source. Given the fact that the source site offers no significant habitat values for gray whales (it is not within a migration route, a feeding area, or other significant area), any minor diversions of gray whale movements in the source vicinity would not be expected to result in significant (as defined by CEQA) biological effects.

Humpback whales are found mostly in water depths 75-150 m, and have been known to dive as deep as 150 m. Average feeding depth appears to be 41-60 m. Humpbacks migrate through the project vicinity on their way to and from their wintering grounds in Mexico and their summer feeding grounds around the Farallon Islands. Humpbacks, like other baleen whales, are thought to have good low frequency hearing. They produce sounds from 40 Hz to 8 kHz, primarily centered around 100-300 Hz. Therefore, it is possible that some ATOC transmissions could mask their vocalizations. However, due to the small numbers of humpbacks which move through the area, and their shallow diving depths, it is unlikely that they would experience any acute or short-term impacts (Table C-1) from the transmissions. Other potential behavioral responses to the 120 dB sound field are uncertain.

Few blue whales are found off California during the winter, but they are relatively abundant during the summer. Blue whales do not make prolonged deep dives, and are thought capable of diving to 200 m. They are probably sensitive to low frequency sound, and produce

Mysticete Species	Maximum Exposure (dB)	Potential Effects
blue whale	138	Uncertain; however, no acute or short-term responses (Table C-1) expected. Minimal potential for TTS. Notes 1, 2.
fin whale	139	Uncertain; however, no acute or short-term responses (Table C-1) expected. Minimal potential for TTS. Notes 1,2.
sei whale	138	Uncertain; however, low population makes exposure unlikely. No acute or short-term responses (Table C-1) expected. Minimal potential for TTS. Notes 1,2.
minke whale	140	Uncertain; however, no acute or short-term responses (Table C-1) expected. Minimal potential for TTS. Notes 1, 2.
humpback whale	137	Uncertain; however, no acute or short-term responses (Table C-1) expected. Minimal potential for TTS. Notes 1, 2.
gray whale	138	Uncertain; however, no acute or short-term responses (Table C-1) expected. Minimal potential for TTS. Notes 1, 2.
right whale	138	Uncertain; however, very low population and preference for coastal areas makes exposure very unlikely. No acute or short-term responses (Table C-1) expected. Notes 1, 2.

Note 1: Potential for adverse effects from behavioral modification and/or habituation are speculative but expected to be minimal.

Note 2: In light of the number of mysticetes that could potentially be exposed to some transmissions and the relatively brief and intermittent nature of the transmissions, masking effects are uncertain, but presumed to be less than significant.

Table 4.3.1.1.3-1. Summary table of potential effects of ATOC sound on mysticetes

infrasonic moans in the 20-60 Hz range. Given their patterns of short, relatively shallow dives, no acute or short-term effects (Table C-1) are expected. Other potential behavioral responses to the 120 dB sound field are uncertain.

Right whales are so rare that none are expected to be exposed to source transmissions. Only 13 have been sighted off California this century. Further, they are believed to be shallow divers (<200 m), and so would not experience high levels of exposure. Therefore, the potential for any impacts to right whales is remote.

Minke whales are presumed to make shallow dives <500 m. Because they produce moans in the 60-140 Hz range, they are likely to hear low frequency sounds. They may be found off California in summer, and during winter as they migrate back and forth to Alaska. Given their shallow diving behavior, no acute impacts are anticipated.

Fin whales are found year-round off central and southern California. They may dive to 335 m, are thought to hear in low frequencies, and produce moans at 20 Hz. Conclusions for fin whales are similar to those for blue whales, above.

Sei whales are rare in California offshore waters, but apparently pass by the California coast on their yearly north-south migrations. The few sei whale sounds that have been recorded are in the 1.5-3.5 kHz frequency band, but they may hear in the low frequency range like other baleen whales. The fact that they are so rare makes it improbable that any sei whale would pass near the source during the 2-8% of the time that it would be transmitting. Sei whales are believed to dive to depths less than 200 m, and so should not be exposed to transmission levels great enough to cause acute or short-term impacts (Table C-1). Other potential behavioral responses to the 120 dB sound field are uncertain.

The potential for some masking in relation to any of the mysticetes cited must be stated as uncertain due to the lack of available data.

Generally, due to the relative distribution and abundance of species at the alternate sites, the Pioneer Seamount alternative could have slightly increased potential for impacts on humpbacks (see comparison of estimate of species stocks for the preferred action site [Sur Ridge] vs. the proposed action site [Pioneer Seamount] in the Executive Summary). The Sur Slope alternative could have slightly decreased impacts on mysticetes (due to the comparatively lower numbers of animals, particularly gray whales, expected at that distance from shore), and the moored autonomous source (assuming a relatively mysticete-free location) would likely have minimal, if any, impacts, given the relative lack of exposure of mysticetes. The no project alternative would have no impacts.

4.3.1.2 Odontocetes

As with mysticetes, the proposed ATOC sound transmissions may have the potential to adversely affect odontocetes, directly and/or indirectly. It also may have the potential to contribute to cumulative effects, including disturbance as a result of associated aerial surveys or observations. A description of the species of odontocetes expected to be found in the proposed study area is located in Section 3, and is not repeated here.

4.3.1.2.1 Potential Direct and Indirect Effects on Odontocetes

Section 3 discusses the species of odontocetes that have been sighted in or near the proposed study area during ship and/or aerial surveys. Based on odontocete population estimates from NOAA NMFS, and ship and aircraft survey data through 1993-94, known migration patterns, and average swim speeds of 9-30 km/hr (Webb, 1975; Lockyer, 1981a; Au and Perryman, 1982), it is believed that few, if any, individuals traveling through the area would remain within the 120 dB sound field area (derived from FEPE acoustic model analyses) for more than 3 hrs at a time. This is further supported by the belief that Pioneer Seamount has not been identified as an important habitat (i.e., feeding, breeding, migration route or comparable area) (EPA, 1993).

As noted previously, transmissions from the proposed sound source at the water's surface are expected to be 135 dB at a radius of 1000 m (received level is not expected to exceed 135 dB at the water's surface anywhere in the vicinity of the source); 130 dB to a radius of 5 km; 120 dB to 18 km shoreward and 12 km seaward from the source; 110 dB to 60 km shoreward, 55 km seaward. Below the surface, sound levels are expected to be: 140 dB at 418 m depth (562 m range around source); 145 dB at 664 m depth (316 m range around source); 150 dB at 802 m depth (178 m range around source); 165 dB at 950 m depth (30 m range around source); and 195 dB at 980 m depth (1 m range around source).

Direct and indirect effects of low frequency noise on odontocetes include the potential for auditory interference by masking, behavioral disruption and habituation, long-term effects, and adverse impacts on the food chain (indirect effect), as discussed below.

• Hearing capabilities and sound production of odontocetes: Toothed whales, whose hearing has been studied, are most sensitive to sounds above about 10 kHz. This sensitivity of many toothed whales to high frequency sounds is related to their use of very high frequency sound pulses for echolocation and moderately high frequency calls for communication. There are three general categories of odontocete sounds (Watkins and Schevill, 1977a; Watkins et al., 1985a, b):

- Tonal whistles,
- Pulsed sounds of very short duration used in echolocation,
- Less distinct pulsed sounds such as cries, grunts and barks.

Sperm whales produce clicks rather than whistles, which may be used for echolocation (Mullins et al., 1988). Generally it is believed that most odontocetes also use whistle vocalization as "signature calls" to convey information about the specific identity of the sender. Sperm whales, it is believed, use clicks rather than whistles for this purpose and unique stereotyped click sequence "codas" have been recorded from individual whales over periods lasting several hours (Watkins and Schevill, 1977b; Adler-Fenchel, 1980; Watkins et al., 1985b). According to Weilgart and Whitehead (1988), sperm whale clicks also may convey information about the age, sex, and reproductive status of the sender.

Sperm whale clicks range from <100 Hz to 30 kHz, with most energy at 2-4 kHz and 10-16 kHz. Clicks are repeated at rates of 1-90 per second (Backus and Schevill, 1966; Watkins and Schevill, 1977b; Watkins et al., 1985a). Source levels of clicks for sperm whales at sea can be near 180 dB (Watkins, 1980a).

Table 4.3.1.2.1-1 lists the characteristics of underwater sounds produced by odontocetes. It should be noted that none of the dominant frequencies of odontocete vocalizations overlap with the ATOC sound source.

According to Richardson et al. (1991), odontocetes' upper limits of sensitive hearing range from at least 31 kHz in killer whales and near 70 kHz in false killer whales, to well above 100 kHz in some species. Low frequency hearing has not been studied in many species, but the bottlenose dolphin and white whale (beluga) can hear sounds at frequencies as low as 40-125 Hz. However, below about 10 kHz, sensitivity decreases with frequency. Below 1 kHz, sensitivity appears to be poor.

An underwater hearing experiment (Turl, 1993) suggested that an Atlantic bottlenose dolphin *(Tursiops truncatus)* may detect low frequency sound by some mechanism other than conventional hearing. The skin of the dolphin (and presumably other odontocetes) is highly innervated (Palmer and Weddell, 1964; Yablokov et al., 1974) and sensitive to vibrations (Ridgway, 1986) or small pressure changes in the area surrounding the eye, blowhole, and head region (Kolchin and Bel'kovich, 1973; Bryden and Molyneux, 1986). These authors suggest that dolphin skin receptors may detect changes in hydrodynamic and hydrostatic pressure, or perceive low frequency vibrations. It is possible that mechanoreception in cetaceans (Pryor, 1990) is yet another sense that performs its own specific role and, together with audition and echolocation, enables the animal to react to its environment.

• Potential for physical auditory effects: As discussed earlier in subsection 4.3.1.1.1, based on currently available data on acoustic trauma and the structure/mechanics of the marine mammal ear, Ketten (1994) speculated that if the calculated sound field levels are correct, to suffer TTS, the animal must be:

Species	Signal type	Frequency Range (kHz)	Dominant Frequencies (kHz)	Source Level (dB re 1 µPa at 1 m)	References
Physeteridae					
Sperm whale	clicks	0.1-30	2-4, 10-16	160-180	Backus and Schevill 1966; Levenson 1974; Watkins 1980a
Pygmy sperm whale	echolocation	<2	-	-	Caldwell et al. 1966a; Caldwell and Caldwell 1987
	clicks	60-200	120	-	Santoro et al. 1989
Monodontidae					
White whale	whistles	0.26-20	2-5.9	-	Sjare and Smith 1986a,b
	pulsed tones	0.4-12	1-8	-	Sjare and Smith 1986a,b
	noisy vocalizations	0.5-16	4.2-8.3	-	Sjare and Smith 1986a,b
	echolocation	40-120	variable	160-222	Au et al. 1985, 1987
Ziphiidae					
Northern bottle-nose whale	whistles	3-16	-	-	Winn et al. 1970a
	clicks	0.5-26+	-	-	Winn et al. 1970a
Blainville's beaked whale	chirps/short whistles	<1-6	-	-	Caldwell and Caldwell 1971a
Mesoplodon sp.	clicks	to 80+	0.875	-	Buerki et al. 1989; Lynn and Reiss 1989
Delphinidae					
Killer whale	whistles	1.5-18	6-12	-	Steiner et al. 1979; Ford and Fisher 1983;
	pulsed tones	0.5-25	1-6	160	Awbrey et al. 1982; Ford and Fisher 1983; Schevill and Watkins 1966
	echolocation	0.1-35	12-25	180	Diercks et al. 1971, Wood and Evans 1980
False killer whale	echolocation	-	20-65	-	Thomas et al. 1988
	whistles	-	4-9.5	-	Busnel and Dziedzic 1968
Pygmy killer whale	echolocation?	-	-	-	Pryor et al. 1965
	growls, blats	-	-	-	Pryor et al. 1965
Long-finned pilot whale	whistles	1-8	1-5[1]	-	Steiner 1981; Taruski 1979; Busnel and Dziedzic 1966a
	echolocation	1-18	-	-	Busnel and Dziedzic 1966a
Short-finned pilot whale	whistles	0.5-20+	2-14	180	Fish and Turl 1976; Caldwell and Caldwell 1969
	echolocation	0.1-100	-	180	Evans 1973

1 Maximum and minimum frequencies.

? Questionable data

(from Richardson et al., 1991)

Continued. . .

Table 4.3.1.2.1-1 Characteristics of underwater sounds produced by odontocetes

Species	Signal type	Frequency Range (kHz)	Dominant Frequencies (kHz)	Source Level (dB re 1 μPa at 1 m)	References
Bottlenose dolphin	echolocation	10-200	110-130	220	Au et al. 1974; Au and Penner 1981; Au et al. 1982
	whistles	4-18	9-12	-	Lilly and Miller 1961
	rasp, grate, mew, bark, yelp	-	-	-	Wood 1953
Northern right-whale dolphin	clicks	1-40+	40+?	180	Fish and Turl 1976
	whistles	?-16+	-	-	Leatherwood and Walker 1979
	tones	1-4	1.8, 3	-	Leatherwood and Walker 1979
Common dolphin	whistles	-	2-18	-	Caldwell and Caldwell 1968
	chirps	-	8-14	-	Caldwell and Caldwell 1968
	barks	-	<0.5-3	-	Caldwell and Caldwell 1968
	echolocation	0.1-150	20-100	180	Evans 1973; Fish and Turl 1976
Risso's dolphin	whistles	-	3.5-4.5	-	Caldwell et al. 1969
	clicks	<1-8	-	-	Watkins 1967b
	rasp/pulse burst	0.1-8+?	2-5	-	Watkins 1967b
Atlantic spotted dolphin	whistles	-	6-13	-	Caldwell et al. 1973a; Steiner 1981
	clicks	1-8	-	-	Caldwell and Caldwell 1971b
	squealy-squawk	0.1-3	-	-	Caldwell and Caldwell 1971b
	squawk	<1	-	-	Caldwell and Caldwell 1971b
	barks	0.1-3	-	-	Caldwell and Caldwell 1971b
	growls	-	-	-	Caldwell et al. 1973a
	chirps	4-8	-	-	Caldwell et al. 1973a
Striped dolphin	whistles	-	8-12.5	-	Busnel et al. 1968
Spinner dolphin	clicks	-	-	85-95?	Watkins and Schevill 1974
	whistles (= squeals?)	1-20	9-14[1]	109-125?	Watkins and Schevill 1972; Steiner 1981
	pulse bursts	-	2-3	108-115	Watkins and Schevill 1972
Atlantic white-sided dolphin	whistles	-	8-12	-	Steiner 1981
Pacific white-sided dolphin	whistles	2-20+	4-12	-	Caldwell and Caldwell 1970b, 1971c
	echolocation	0.2-150	60-80	170	Evans 1973
Rough-toothed dolphin	clicks	16-100+	-	-	Norris and Evans 1967
	whistles	-	4-7	-	Busnel and Dziedzic 1966b
Phocoenidae					
Dall's porpoise	clicks	0.04-12, 125-135	-	120-148	Evans 1973; Evans and Awbrey 1984
Harbor porpoise	clicks	100-160	130	132-149	Dubrovskii et al. 1971; Mohl and Andersen 1973
	clicks	2	-	100	Busnel and Dziedzic 1966a; Schevill et al. 1969

1 Maximum and minimum frequencies.
? Questionable data.

Table 4.3.1.2.1-1 Continued Characteristics of underwater sounds produced by odontocetes

- capable of hearing signals below 90 Hz and have hearing sensitivity below (better than) 70 dB (150 dB-80 dB=70 dB) for frequencies below 90 Hz (assuming that TTS would occur for received levels >80-100 dB above the absolute threshold, as for humans listening in air);

- capable of diving deeper than 800 m (2625 ft) (making the same assumptions as above). The odontocetes in the area that are believed to be capable of diving below 700 m are the sperm whale and some beaked whales;

- within the 150 dB isopleth (a radius of 178 m from the source at a depth of 800 m); choose not to depart or be unable to depart the area; and/or be subjected to repeated exposures. In this regard, it is assumed that if an animal considered the sound to be annoying, it would depart the area during the 5-min source ramp-up period. All marine mammals have adequate swim speed to accomplish this.

Hollien (1993) suggests that the dynamic range of human hearing underwater is less than in air. However, there is no information as to whether the human range, or some lower (or higher) range, applies to marine mammals (Hollein, 1993). If a lower value is appropriate, then the received level that would cause an odontocete to incur TTS could be less than the assumed 150 dB (≤15 dB difference); if higher, 150 dB would be too conservative (≤15 dB difference).

According to Ketten, no current auditory data support a serious concern for permanent hearing damage to any odontocete, including the sperm whale. As with mysticetes, however, she notes that her conclusions are speculative, depending largely upon anatomical models for an approximation of hearing characteristics of most marine mammal species in question. She notes that such models appear to reliably estimate frequency, but are not yet proven indicators of sensitivity. Potential complications with the assumptions include the possibility that dolphins, which have better intensity discrimination than other mammals, may have hair cells that are more susceptible to acoustic trauma. Alternatively, the dolphin uses a nonconventional sound conduction pathway, surrounding head tissues are large, and there are acoustic isolation mechanisms within its head, all of which may provide significant passive or reflexive attenuation of potentially damaging sounds. She adds that substantially more research is needed on both the hearing mechanisms and audiometry of marine mammals, to develop definitive guidelines for safe limits on underwater signals.

Ketten (1994) stated that although the sperm whale might be expected to have good low frequency hearing, its inner ear resembles that of most dolphins, and is tailored for ultrasonic (>20 kHz) reception. She noted that based on inner ear anatomy, the predicted functional lower hearing limit for sperm whales is near 100 Hz, a prediction consistent with evoked response data from one stranded sperm whale (good sensitivity above 2.5 kHz). There are, however, indications that the sperm whale may have hearing capability at low frequencies (Carder and Ridgway, 1990), and it is known to be sensitive to changes in its acoustic environment (Watkins and Schevill, 1975; Watkins et al., 1985). Sperm whales have been found to react to sounds at frequencies below 28 kHz, including 3.5 kHz submarine sonar signals (Watkins et al., 1993).

The only odontocete species on which underwater audiograms have been published are the killer whale (only down to 500 Hz), false killer whale (only down to 2 kHz), white whale, or beluga (down to 40 Hz), harbor porpoise (only down to 1 kHz), Amazon River dolphin (only down to 1 kHz), bottlenose dolphin (down to 75 Hz) (Johnson 1967; Awbrey et al., 1988; Johnson et al., 1989; Thomas et al., pers. comm., 1994), and the Chinese river dolphin (baiji) (Wang, 1992). The beluga and Amazon River dolphin do not inhabit the proposed study area. The bottlenose dolphin has a hearing threshold of approximately 132 dB at 75 Hz (Johnson, 1986) (Figure 4.3.1.2.1-1). Beluga audiograms suggest poor audiometric and behavioral sensitivity to low frequency sounds, with diminishing sensitivity as frequency decreases from 20 kHz to 40 Hz (White et al., 1978; Awbrey et al., 1988; Johnson et al., 1989). White whale thresholds (which are similar in bottlenose dolphins) are about 102 dB at 1 kHz, 127 dB at 100 Hz, 132 dB at 57 Hz, and 140 dB at 40 Hz (White et al., 1978; Awbrey et al., 1988; Johnson et al., 1989).

White whales that winter in the Davis Strait area (between Greenland and Baffin Island) and summer in the Canadian high arctic show behavioral sensitivity to weak sounds from distant ships and icebreakers. Strong reactions have been seen to ships up to 35-50 km away when received noise levels were 94-105 dB (20 to 1000 Hz band) (LGL and Greeneridge, 1986; Cosens and Dueck, 1988). However, based on the hearing sensitivity profiles of these animals, it is likely that they were responding to that portion of the noise spectrum in mid-frequency ranges.

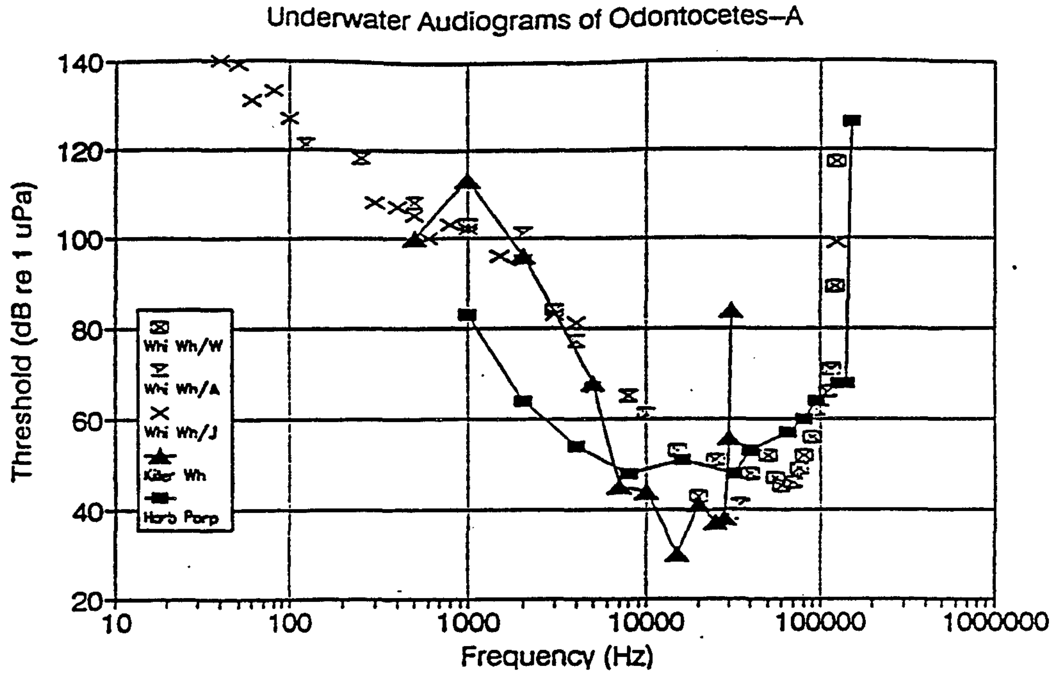
Preliminary data suggest that audiometric sensitivity to low frequency sound of Pacific white-sided dolphins may be slightly better than bottlenose dolphins or white whales, which are the two species previously tested at frequencies near that of the ATOC source (Thomas unpub., 1993). Studies are currently being conducted to obtain low frequency audiograms on bottlenose dolphins, Risso's dolphins, and false killer whales (Nachtigall and Au, pers comm., 1994).

Preliminary audiometric data from Au and Nachtigall (pers. comm., 1995) indicate that the hearing threshold at 75 Hz for false killer whale and Risso's dolphin is no better than 145 dB.

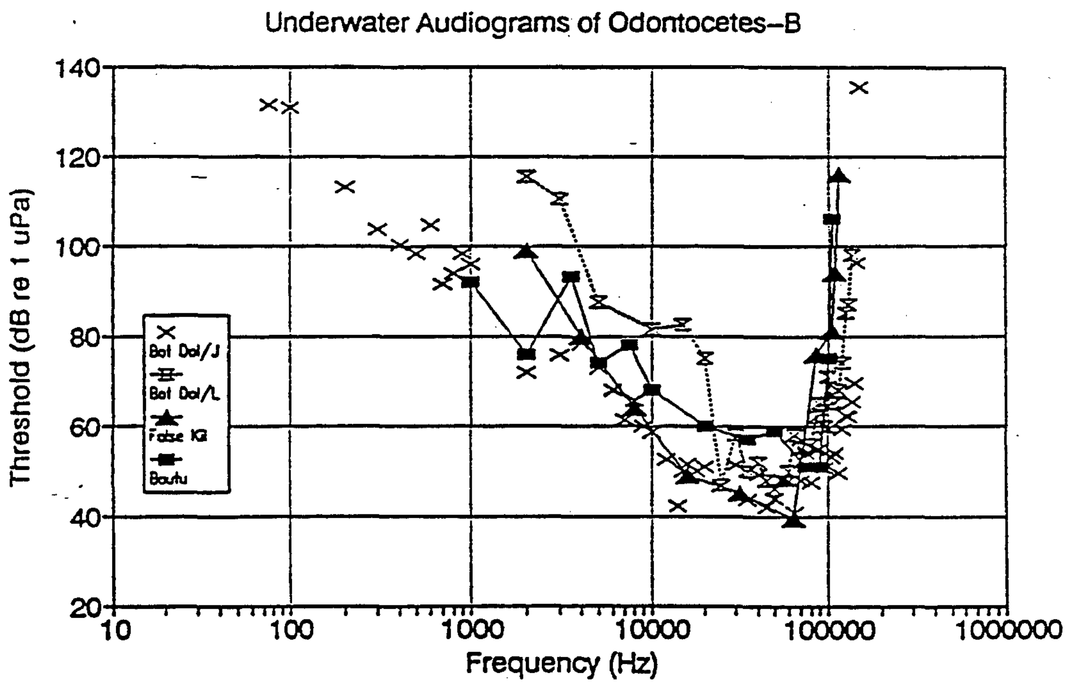
Based on the above, it appears that the potential for physical auditory impact on odontocetes is minimal. At a relatively conservative threshold of 130 dB at ATOC frequencies, odontocetes would only hear the source within 5 km and TTS would not be expected at any location relative to the source. A possible exception may be the sperm whale, for which there appears to be some anecdotal evidence of reaction to low frequency sound, coupled with the fact that they are known to dive to depths exceeding 800 m.

Although it is believed that short-finned pilot whales are capable of diving to 610 m, no data exist on their frequency of making such deep dives, nor how long they would be expected to stay at depths >500 m (presumably for only short time periods).

Beaked whales also are considered to be potentially capable of diving as deep as 1000 m. Most of what is known about all species of beaked whales comes from stranding records; they are rarely seen and difficult to identify at sea. Most animals of this species are thought to forage far



(From LGL OCS Study MMS 90-0093, 1991)



(A) white whale (White et al. 1978, n=2; Awbrey et al. 1988*, n=3; Johnson et al. 1989); killer whale (Hall and Johnson 1972); harbor porpoise (Andersen 1970a);
(B) bottlenose dolphin (Johnson 1968a; Ljungblad et al. 1982c); false killer whale (Thomas et al. 1988); Amazon river dolphin or boutu (Jacobs and Hall 1972). n=1 except where noted. * Awbrey et al. (1986) reported higher-frequency data for these white whales, but these data did not represent sensitivity in the direction of best hearing.

Figure 4.3.1.2.1-1 Underwater audiograms of odontocetes offshore in waters >1000 m deep, feeding on mesopelagic fishes and squid (Leatherwood et al., 1987; Mead, 1989). Cuvier's beaked whales are the most widely distributed and frequently sighted beaked whales in the northeastern Pacific (Mead, 1984; Leatherwood et al., 1987); however, no seasonal movements can be inferred from the infrequent sightings or stranding data (Dohl et al., 1983). Furthermore, there are no data on hearing sensitivity of any beaked whales.

Thus, provided that sound field acoustic performance prediction computer models and the assumptions/criteria regarding TTS discussed previously are correct, it is highly unlikely that any odontocete species, with the possible exception of the sperm whale and other deep-diving odontocetes for which audiometric data do not exist, could experience physical auditory effects.

For sperm whales, only anecdotal evidence suggests they may have low frequency hearing capability. Even assuming that low frequency hearing of sperm whales is comparable to that of mysticetes, the fact that they make dives >800 m (i.e., to within the 150 dB sound field of the ATOC source) in much deeper water (Rice, 1989), means that the potential for sperm whale encounters with the 150 dB sound field would be minimal. However, Watkins et al. (1993) noted that sperm whales off Dominica in the Atlantic Ocean appear to commonly dive almost to the bottom. Given the proposed 2% duty cycle of the ATOC source, with approximately 550 transmissions per year (1100 transmissions total for the two-year study period), and applying conservative assumptions concerning the percentage of time (10 to 20%) spent by sperm whales at depths below the top of the 150 dB zone (>800 m depth), the statistical probability of a sperm whale being exposed to the 150 dB sound field during the initial two-year study period is no more than 1%. The chance of repeated 150 dB or greater exposures to the same animal, expected to be required before significant (as defined by CEQA) hearing impacts result, is extremely small. As a result, any impacts would likely be confined to potential behavioral changes, with the possibility of an occasional temporary threshold shift.

CEQA Impact 6: The potential for physical auditory impacts on odontocetes, principally consisting of a small potential for occasional temporary threshold shift in sperm or beaked whales; and the potential for behavioral impacts on odontocetes, principally consisting of a temporary cessation of vocalizations in sperm or beaked whales, is uncertain, but presumed to be less than significant.

CEQA Mitigation Measure 6-1: A MMRP will be carried out in connection with the ATOC project in accordance with the protocols set forth in Appendix C of this EIS/EIR. With regard to potential physical auditory and behavioral impacts on odontocetes, a goal of the MMRP will be to validate the assumptions regarding population distribution, abundance and diving behavior of sperm whales, which form the basis for predicting the potential for effects from the ATOC sound source.

• Potential for behavioral disruption: Odontocetes, like mysticetes, exhibit disturbance reactions such as cessation of resting, feeding, or social interactions and/or changes in surfacing, respiration, or diving cycles, and avoidance behavior. For example, they have been observed responding with both attraction and avoidance to noisy sources (Wursig, pers. obs., 1990), but they are also relatively unresponsive to noise at low frequency (Awbrey et al., 1983). As noted above, however, sperm whales may have reacted to sounds at low frequencies (unknown source levels) at received levels (100 dB) of submarine sonar signals at 3.5 kHz (Watkins et al., 1993).

Richardson et al. (1990b) used underwater playback techniques to test the effects of drilling sounds on white whales migrating through leads north of Alaska in spring. The test sounds were from a drillrig on a grounded ice platform, and were mainly below 350 Hz (source level 165 dB). Although the sounds were detectable with hydrophones as much as 5 km from the projector, no overt reactions were detected until the white whales were within 200-400 m. Within that distance, some diverted or hesitated for a few minutes, but then continued within 50-200 m of the operating underwater projector. However, white whales swimming along an ice lead in spring changed course when they came within 1 km of a stationary drillship, and exhibited more active avoidance when support vessels were moving near the drillship (Norton et al., 1982). This, together with the aforementioned results suggests that white whales may be especially sensitive when in ice leads during spring.

Stewart et al. (1983) tested reactions of white whales to underwater sounds projected into an Alaskan river. In most tests, the sound level increased rapidly (within 5 sec) from zero to maximum when whales were within 1.5 km. These whales usually swam faster in the same direction as before the playback. In some tests, respiration rates increased during playbacks. During two tests, sounds were projected continuously as whales approached from about 3.5-4.6 km upstream. In one test, there was no detectable reaction until the whales were within 50-75 m; in the second test, whales reacted at 300-500 m. Reactions included rapid swimming and, in one case reversal of direction. However, most whales passed close to the projector where received sound levels must have been high. Received levels in the shallow river were not measured, and were probably quite different than would occur at similar ranges in the ocean. Stewart et al. (1983) concluded that reactions to drillrig noise were less severe than those to motorboat noise.

Just prior to and during the Heard Island Feasibility Test (HIFT) that took place in January, 1991 (discussed in Section 1), experienced marine mammal observers conducted line-transect surveys and monitored marine mammal behavior visually and acoustically in a 70 x 70 km square centered on the transmission site. Bowles et al. (1994) reported that 39 groups of cetaceans were sighted both prior to and during the transmission periods, including sperm whales and other odontocetes (hourglass dolphin [*Lagenorhynchus cruciger*], Commerson's dolphin [*Cephalorhynchus commersoni*], dusky dolphin [*Lagenorhynchus obscurus*], killer whales, long-finned pilot whales [*Globicephala melas*], southern bottlenose whale [*Hyperoodon planifrons*], and Arnoux's beaked whale [*Berardius arnouxii*]). More schools of hourglass dolphins were sighted during transmissions, but fewer groups of pilot whales and southern bottlenose whales. There was no evidence that dolphins may have surfaced to avoid higher sound levels at depth. The density of all cetaceans was 0.0157 groups/sq km before transmissions and 0.0166 groups/sq km during. Sperm whales and pilot whales were heard in 23% of 1181 min of baseline acoustic surveys prior to transmissions, and in none of the 1939 min during. Both species were heard within 48 hr after the test. It should be noted that there were fundamental differences between the acoustic characteristics of the HIFT source and that planned for ATOC research: 57 Hz center frequency (vs. 75 Hz for ATOC); 30 Hz bandwidth (vs. 35 Hz bandwidth for ATOC); 209-220 dB source level (vs. 195 dB for ATOC); 175 m depth (vs. 980 m for ATOC); 33% duty cycle (vs. 2%-8% for ATOC); and location in the upper water column (vs. seafloor-mounted for ATOC).

As with mysticetes, variations in sensitivity to human-made noise between and within odontocete species and the lack of information about the consequences of short-term disruptions on odontocetes make it very difficult to define criteria of responsiveness and to assess the consequences of a disruption in their natural activities.

The potential for short-term behavioral disruption, or displacement, is unlikely, although the sound transmissions of ≥130 dB would likely be audible to some animals within 5 km of the source. Potential effects on sperm whales and other deep-diving odontocetes are more uncertain.

Behavioral changes in odontocetes may occur in deep diving species that have good low frequency hearing. Given the relatively low sensitivity of most odontocetes to low frequency sounds (other than possibly sperm and beaked whales) and the relatively low density of many odontocete species in the study area, potential impacts on these species are anticipated to be minimal. Potential effects on sperm and beaked whales, which for purposes of this EIS/EIR are presumed to have low frequency hearing capabilities, are uncertain but anticipated to be minor (less than significant) given the relatively low density of those animals and resulting rarity of encounters with the ATOC sound fields. Mitigation measures 2-1 (minimizing the ATOC source power level and duty cycle) and 3-1 (MMRP research) serve to mitigate these impacts and no additional mitigation measures are proposed.

• Potential for habituation: As noted previously, relatively few studies of habituation in marine mammals have been done. In toothed whales, one apparent example of habituation is the tolerance by white whales of the many boats that occur in certain estuaries versus the extreme sensitivity of this species to the first icebreaker approach of the year in a remote area of the high arctic. Also, in certain areas, wild dolphins have become unusually tolerant of humans, and may even actively approach them (Lockyer, 1978; Conner and Smolker, 1985; Shane et al., 1986).

As discussed above, habituation generally helps moderate potential impacts, except if the habituation is generalized to include hazardous sources. Since most odontocetes hear well in mid and high frequency ranges, however, it is unlikely that habituation to the low frequency ATOC source would result in decreased avoidance of vessels, etc. As a result, no adverse impacts from habituation are anticipated.

• Potential for long-term effects: The discussion in Section 4.3.1.1.1 on the potential for and ramifications of long-term effects of underwater noise on mysticetes is relevant to odontocetes, as well.

In general, changes in marine mammal usage of an area could be quite slow and difficult to detect, and the causes of any changes may be difficult to discern. There are no documented instances of long-term effects of subsea sounds on odontocetes, but given the difficulties of obtaining such information, the potential for adverse impacts from long-term exposures to the ATOC source sound fields should be considered unknown. Although no such impacts are anticipated, marine mammal exposures to subsea sounds will be minimized whenever feasible. Although there is no evidence of any long-term impacts to odontocetes from sounds comparable to the ATOC source, the lack of reliable information justifies the assumption of an impact for purposes of this EIS/EIR, but at a less than significant level (i.e., would not substantially reduce the number or restrict the range of odontocetes, cause the population to drop below self-sustaining levels, or adversely affect their significant habitats). Mitigation measures 2-1 (minimizing the ATOC source power level and duty cycle) and 3-1 (MMRP research) serve to mitigate these impacts and no additional mitigation measures are proposed.

• Potential for masking: The same general principles concerning masking discussed at the beginning of section 4.3 apply to odontocetes. As noted previously, 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. 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 ATOC sounds or most industrial noises (or ATOC 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).

As discussed by Richardson et al. (1991), the maximum radius of influence of an industrial noise (or ATOC sound transmission) on a marine mammal is the distance from the source at which the noise can barely be heard. This range is determined by either the hearing sensitivity of the animal, or the background noise level.

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, inasmuch as echolocation and communication signals are of higher frequencies, they will not be masked by most industrial or other (e.g., ATOC) 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 HIFT acoustic signals, or if those species simply stopped emitting sounds during the test. 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., 1985a). 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, the potential for increased masking for any odontocete, as a result of the proposed sound transmissions, is expected to be minimal.

There are no documented instances of masking of subsea sounds on odontocetes, and given the fact that odontocetes do not call at frequencies near the ATOC source frequencies, there would be very little, if any, potential for masking of odontocete calls by ATOC (Richardson, pers. comm., 1994). Although no such impacts are anticipated, marine mammal exposures to subsea sounds would be minimized whenever feasible. Given the relatively low sensitivity of most odontocetes to low frequency sounds (other than possibly sperm and beaked whales) and the relatively low density of many odontocete species in the study area, potential masking effects on these species are anticipated to be minimal. Potential masking effects on sperm whales (and possibly beaked whales), which for the purpose of this EIS/EIR are presumed to have low frequency hearing capabilities, are uncertain but anticipated to be minor (less than significant) given the relatively low density of those animals and the resulting rarity of encounters with the ATOC sound fields. Mitigation measures 2-1 (minimizing the ATOC source power level and duty cycle) and 3-1 (MMRP research) serve to mitigate these impacts and not additional mitigation measures are proposed.

• 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 could ultimately affect odontocetes in the vicinity of the study area. 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 potential effects of the MMRP and low frequency sound transmissions on these prey species are addressed in this EIS and, as such, constitute the discussion of indirect effects on odontocetes.

For a discussion of potential direct, indirect, and cumulative impacts on fish which are prey species for most odontocetes, see Section 4.3.2.2. Impacts on squid, the prey species for sperm whales, pygmy sperm whales, dwarf sperm whales, pilot whales, beaked whales, melon-headed whales, false killer whales, pygmy killer whales, and dolphins, are discussed in Section 4.3.2.3. In addition, the impacts of the proposed project on the prey species for killer whales are discussed in the following sections: pinnipeds, Section 4.3.1.3; sea turtles, Section 4.3.2.1; fish, Section 4.3.2.2; and seabirds, Section 4.3.2.4.

The proposed source site is not known to be a significant feeding area for odontocete species (EPA, 1993), and it is believed that any potential effects on prey species would be incremental and affect only a small portion of the range. To further assess the potential for indirect impacts, the MMRP, to the extent feasible and practicable, would include observations of the potential impact of source operations on prey species.

The potential direct and indirect effects of the alternatives are summarized in Table 4.1-1.

4.3.1.2.2 Potential Cumulative Effects on Odontocetes

Activities that might reasonably be considered to have the potential to interact cumulatively to affect odontocete species that inhabit or travel through the proposed study area have been discussed in Section 4.3.1.1.2. They include commercial merchant shipping and other vessel-related activities, recreational water activities (as a result of the potential for ship/boat collisions and noise from ship/boat engines); and noise from aircraft. The discussions below also account for MMRP-related activities that could potentially cumulate with the source transmissions: 1) aerial visual and acoustic surveys/observations, 2) shipboard visual and acoustic surveys/observations, 3) shipboard photo-identification activities, 4) shipboard translocation of tagged elephant seals.

• Merchant shipping and other vessel-related activities: 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 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. (1985a) 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 levels (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).

• Aircraft operations: Few data are available on the reactions of odontocetes to aircraft overflights; however, as with humpback whales, sensitivity to aircraft varies greatly, depending on the animals' activity. Bel'kovich (1960) and Kleinenberg et al. (1964) reported that white whales did not react to an aircraft flying at 500 m. However, when the aircraft descended to 150-200 m, 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. 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 altitudes. However, sperm whales appeared unaware of a Cessna 310 observation aircraft overhead at 152 m altitude (Gambell, 1968).

• Research activities: The discussion in Section 4.3.1.1.2 of the potential for and, consequences of, ongoing and future research activities in the vicinity of the study area on mysticetes is relevant to odontocetes, as well.

As with mysticetes, any cumulative impacts from other sources of subsea sounds or developments that affect the marine environment in the vicinity of the proposed action are speculative. No additional mitigation measures beyond those already identified are proposed to address cumulative impacts.

4.3.1.2.3 Summary and Conclusions Concerning the Potential Effects on Odontocetes

This subsection summarizes the information presented in the previous subsections regarding potential effects of the ATOC source operations and the MMRP on odontocetes.

Table 4.3.1.2.3-1 below presents, for each species, the exposure anticipated given the distribution, range, and diving ability of that species. As can be seen from this table, none of the dolphins dive deep enough to experience physical impacts from the source transmissions, and short-finned pilot whales are unlikely to receive any exposure.

The sperm whale may be the odontocete with the greatest potential to experience any impacts from the source transmissions. Sperm whales dive to depths of more than 2000, remain submerged for an hour or more, and are usually found in the ocean beyond the 1000 m depth contour. Therefore, it is conceivable that sperm whales could be exposed to maximum source transmissions, which could theoretically cause temporary threshold shift. Although, limited data indicate that sperm whales may be able to hear frequencies as low as 100 Hz, the construction of their inner ear indicates best reception of very high frequency, ultrasonic, sounds. Further, the sounds produced by sperm whales center around two frequency bands, 2-4 kHz and 10-16 kHz (see Section 4.3.1.2.1 for a discussion of possible functions of these sounds), well above the frequency of the ATOC source transmissions. Therefore, it is unlikely that the ATOC transmissions would interfere with, or mask, usual sperm whale sounds (Richardson, pers. comm., 1994). In addition, there is no documented evidence of low frequency sound transmissions with the ATOC source characteristics causing sperm whales to stop vocalizing. The low frequency source used during the HIFT apparently caused sperm whales to cease vocalizing (during transmissions--they started back up again within 48 hrs after the end of the test), but that source's characteristics were different from the proposed ATOC source's (see

Odontocete Species	Maximum Exposure (dB)	Potential Effects
sperm whale	195	No acute or short-term behavioral responses (Table C-1) expected; masking very unlikely; low potential for temporary threshold shift.
beaked whale	195	Masking unlikely; low potential for short-term disruption, but probable lack of low frequency hearing capability makes these impacts unlikely.
killer whale	140	No acute or short-term behavioral responses (Table C-1) expected due to lack of low frequency hearing capability and shallow dives.
Risso's dolphin	145	No acute or short-term behavioral responses (Table C-1) expected due to lack of low frequency hearing capability and shallow dives.
common, striped, Pacific white-sided, bottle-nosed, and northern right-whale dolphin	140	Shallow diving and poor low frequency hearing make impacts unlikely.
Dall's, and harbor porpoise	140	No acute or short-term behavioral responses (Table C-1) expected due to lack of low frequency hearing and shallow diving.
short-finned pilot whale	145	Rare in project vicinity; unlikely that any individuals would be exposed.

Table 4.3.1.2.3-1. Summary table of potential effects of ATOC sound on odontocetes

above). Although not anticipated, if ATOC source transmissions did cause sperm whales to modify their vocalizations, it could possibly affect their echolocation clicks, which have also been suggested to convey information about their age, sex and reproductive status.

Research on killer whales indicates that they hear in the mid-frequency range, down to at least 500 Hz. However, if killer whales follow the pattern of most other odontocetes, low frequency hearing capabilities are anticipated to be poor, so even closer proximity to the ATOC source would be required for a TTS, as compared to mysticetes. Moreover, they are not believed to dive deep enough to get close enough to the source to possibly incur TTS (i.e., >800 m). Densities of killer whales along the California coast are low; i.e., less than one animal per 5000-10,000 sq km. As a result of the aforementioned factors, and a 2% duty cycle, the statistical probability of close encounters by killer whales with the ATOC source that could produce a TTS is negligible.

Beaked whales are believed to be able to dive to 1000 m. They are usually found in offshore waters, in depths >1000 m, and are thought to hear primarily in the high frequency band. Beaked whales also are rare (less than one animal per 500 sq km). Although they might be exposed to the maximum source transmissions, their expected inability to hear in low frequencies, and their rarity reduces the probability of potential impacts.

Neither Risso's dolphins, Dall's porpoises, nor harbor porpoises are known to dive below 700 m and so would not be exposed to high levels of transmissions. In addition, these porpoises are thought to only hear well in the high frequencies. Therefore, minimal impacts are anticipated to these species.

Generally, due to the relative distribution and abundance of species at the alternate sites, the Pioneer Seamount alternative could have slightly increased potential for impacts on Pacific white-sided dolphins and Dall's porpoises (see comparison of estimate of species stocks for the preferred action site [Sur Ridge] vs. the proposed action site [Pioneer Seamount] in the Executive Summary). The Sur Slope and moored autonomous source alternatives, which would both use sources buoyed up from the seafloor, could possibly result in more close encounters with sperm and beaked whales due to their diving behavior (although moored autonomous sources possibly could be placed in an area believed devoid of sperm and beaked whales). The no action alternative would have no impacts.

Table 4.1-1 summarizes the potential direct and indirect effects, and potential cumulative effects of the alternatives on odontocetes.

4.3.1.3 Pinnipeds and Fissipeds

This section focuses on the potential impacts of the proposed action on pinnipeds, a suborder of marine mammals which includes seals, sea lions, and walruses; and fissipeds, a suborder that includes the southern sea otter. There are a total of six pinnipeds (California sea lion, northern elephant seal, harbor seal, northern fur seal, Guadalupe fur seal, and Steller sea lion) and one fissiped (southern sea otter) that inhabit the central California coastal area. More information about these animals' habitat and distribution is found in Section 3, and is not repeated here.

Since pinnipeds are the prey of killer whales (an odontocete) the following sections on the potential direct, indirect, and cumulative impacts of the proposed project on pinnipeds are also a discussion of indirect impacts on killer whales. Both pinnipeds and sea otters are also the prey of some sharks, so this section also constitutes a discussion of the indirect effects of the proposed project on sharks.

Section 3 discusses the species of pinnipeds and the one fissiped that have been sighted in or near the proposed study area during ship and/or aerial surveys. The maximum residence time within the area of the proposed action alternative for northern elephant seals, northern fur seals and California sea lions is estimated to be <24 hrs (based on a review of pinniped stocks by NMFS/SWFSC in 1992, using all available data). However, based on average swim speeds, it is believed that few, if any, individuals traveling through the area would remain within the 120 dB source sound field for more than 3 hrs at a time. Because harbor seals and southern sea otters are predominantly coastal dwellers, it is considered unlikely that either of these species would encounter the 120 dB sound field.

As noted previously, transmissions from the proposed sound source at the water's surface are expected to be 135 dB at a radius of 1000 m (received level is not expected to exceed 135 dB at the water's surface anywhere in the vicinity of the source); 130 dB to a radius of 5 km; 120 dB to 18 km shoreward and 12 km seaward from the source; 110 dB to 50-60 km shoreward, 55 km seaward. Below the surface, sound levels are expected to be: 140 dB at 418 m depth (562 m range around source); 145 dB at 664 m depth (316 m range around source); 150 dB at 802 m depth (178 m range around source); 165 dB at 950 m depth (30 m range around source); and 195 dB at 980 m depth (1 m range around source).

As with mysticetes and odontocetes, the proposed action has the potential to adversely affect pinnipeds and/or fissipeds, directly and/or indirectly, as a result of noise disturbance during source sound transmissions. It also has the potential to contribute to cumulative effects, including disturbance as a result of associated aerial surveys or observations.

4.3.1.3.1 Potential Direct and Indirect Effects on Pinnipeds and Fissipeds

Direct and indirect effects of low frequency noise on pinnipeds and fissipeds, including the potential for auditory interference by masking, temporary threshold shifts, behavioral disruption, long-term effects, and adverse impacts on the food chain (indirect effects) are discussed below.

• Hearing capabilities and sound production of pinnipeds: Phocid (hair) seal sounds seem to be associated with mating, mother-pup interactions, and territoriality; thus, underwater calls may not be very important for species such as elephant seals that perform most of these activities on land. Some phocid seals produce intense underwater sounds that may propagate for great distances (Burns, 1967; Ray et al., 1969; Watkins and Ray, 1977); whereas other species produce faint and infrequent sounds (Schevill et al., 1963). Phocids probably hear underwater sounds at frequencies up to approximately 60 kHz. Vocalizations between 90 Hz and 16 kHz have been reported (Table 4.3.1.3.1-1), but it is possible that other high frequency sounds were missed (Richardson et al., 1991), because of recording equipment frequency limitations.

Otariid (eared) seal sounds are used to defend territories and secure mates on traditional terrestrial rookeries. In-air vocalizations are part of the displays used to establish and defend territories, attract females, and form and maintain the mother-pup bond. California sea lions also use underwater calls to establish territory and dominance. The underwater sounds of other otariid species have not been studied extensively.

The most common sound of California sea lions is a bark. When these vocalizations are made while the seal is in the water, with its head above the surface, they are transmitted into the water and have similar acoustic characteristics both in water and air (Schevill et al., 1963). Most of the energy of the in-air barks is at frequencies below 2 kHz. When California sea lions are submerged, vocalizations include barks, whinny and buzzing sounds, and click trains (Schusterman et al., 1967). Sounds produced underwater by this species have most of their energy below 4 kHz, and are associated with social situations (Schusterman et al., 1967).

Sonograms of fur seal and Steller sea lion calls were published by Poulter (1968) (Table 4.3.1.3.1-1). Underwater clicks and bleating sounds have been attributed to northern fur seals (Poulter, 1968; Cummings and Fish, 1971). Schevill et al. (1963) attempted to record sounds from a captive fur seal, but were unable to find purely underwater sounds. However, clicks, growls, snorts and bleats have been heard from the Steller sea lion while underwater (Poulter, 1968).

Although southern sea otters spend most of their time in the water, any vocalizations made while underwater have not been studied to date. Airborne sounds include whines, whistles, deep-throated growls, soft cooing sounds, chuckles and snarls (Kenyon, 1981). Kenyon also noted that, when stressed, they may utter a harsh scream. These in-air calls are important in maintaining contact between mother and pup (Sandegren et al., 1973). The mother leaves her offspring at the surface when she dives to forage for food (to <100 m depth), and the pup usually whines until she reappears. If the mother cannot immediately locate her pup upon surfacing, she vocalizes and the offspring responds immediately. Most energy in mother and pup in-air sounds is in the frequency band of 3-5 kHz, but there are higher harmonics.

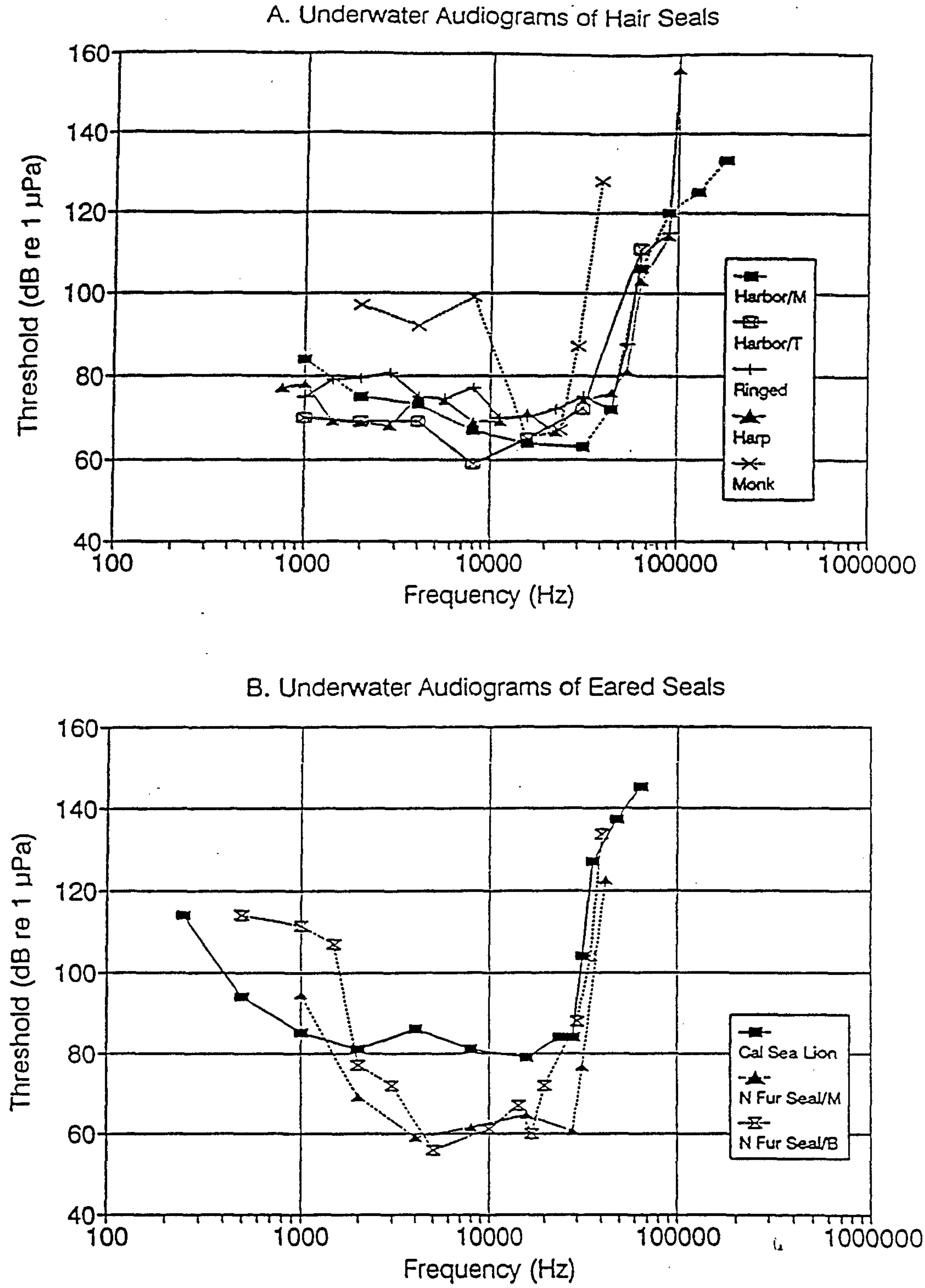
Within the pinniped suborder, none of the species tested to date have exhibited good hearing capabilities at low frequencies, although the northern elephant seal, California sea lion and harbor seal appear to communicate within the upper low frequency band (100-1000 Hz) (Schusterman et al., 1967). Underwater audiograms are available for several species of pinnipeds (phocids - harbor seal [Mohl, 1968; Terhune, 1989]); ringed seal [Terhune and Ronald, 1975]; harp seal [Terhune and Ronald, 1972]; and monk seal [Thomas et al., 1990]; and otariids - California sea lion [Schusterman et al., 1972]; northern fur seal [Moore and Schusterman, 1987]) (Figure 4.3.1.3.1-1).

Species	Signal type	Frequency Range (kHz)	Dominant Frequencies (kHz)	Source Level (dB re 1 μPa at 1 m)	References
Phocids[a]					
Bearded seal	song	0.02-6	1-2	178	Ray et al. 1969; Stirling et al. 1983; Cummings et al. 1983
Ribbon seal	frequency sweeps	0.1-7.1	-	160 (estimated)	Watkins and Ray 1977
Harp seal	15 sound types	<0.1-16+	0.1-2	130-140	Mohl et al. 1975; Watkins and Schevill 1979; Terhune and Ronald 1986
	clicks	-	30	131-164	Mohl et al. 1975
Ringed seal	barks, clicks, yelps	04.-16	<5	95-130	Stirling 1973; Cummings et al. 1984
Harbor seal and Spotted seal	social sounds	0.5-3.5	-	-	Beier and Wartzok 1979
	clicks	8-150+	12-40	-	Schevill et al. 1963; Cummings and Fish 1971; Renouf et al. 1980; Noseworthy et al. 1989
Gray seal	clicks	0-30	-	-	Schevill et al. 1969; Oliver 1978
	hiss	0-40	-	-	Oliver 1978
Otariids[a]					
California sea lion	barks	<3.5	<8	-	Schusterman et al. 1967
	whinny	<1-3	-	-	Schusterman et al. 1967
	clicks		0.5-4	-	Schusterman et al. 1967
	buzzing	<1-4	<1	-	Schusterman et al. 1967
Northern fur seal	clicks, beats	-	-	-	Poulter 1968
Steller sea lion	clicks, growls	-	-	-	Poulter 1968
Walrus	bell tone	0.4-1.2	-	-	Schevill et al. 1966
	clicks	0.4-10	-	-	Ray and Watkins 1975

a Underwater sounds of monk and elephant seals, and of Guadalupe fur seals, have not been described.

(from Richardson et al., 1991)

Table 4.3.1.3.1-1 Characteristics of underwater sounds produced by northern hemisphere pinnipeds



(A) Hair seals - harbor seal (Møhl 1968a; Terhune 1989a); ringed seal (Terhune and Ronald 1975a, n=2); harp seal (Terhune and Ronald 1972); monk seal (Thomas et al. 1990b);
(B) Eared seals (otariids) - California sea lion (Schusterman et al. 1972); northern fur seals (Moore and Schusterman 1987, n=2; Babushina et al. 1991). n=1 except where noted.

Figure 4.3.1.3.1-1 Underwater audiograms of pinnipeds

The northern elephant seal, for which there is currently no published audiometric data, may have mid to low frequency hearing capability (Schusterman, pers. comm., 1993). The southern sea otter's underwater hearing capability has not been studied, but is believed to be only in the high frequency range.

Published literature does not delineate the lower limit of phocid hearing, since frequencies below 760 Hz have not been applied in published test protocols, at least in part due to the acoustical limitation of small observation tanks and pools. However, based on the available audiograms, phocids can hear frequencies at least as low as 1 kHz (Schusterman, 1981), with harbor seals testing as low as 760 Hz (Renouf, 1991). Variation among audiograms of different phocid species may be similar to that among audiograms of individual humans (Terhune, 1981).

With respect to otariids, at 250 Hz, the audiograms show the threshold of a California sea lion to be approximately 115 dB (Schusterman et al., 1972).

Schusterman (in progress) is testing auditory-thresholds of California sea lions, harbor seals, and northern elephant seals. In an in-air study, a TTS at 100 Hz was observed and quantified in a harbor seal after continuous exposure to broadband noise with an average source level of 85-90 dB (air standard) (equating to 147-152 dB in water), peaking at 95 dB (air standard) (157 dB in water).

In comparing data for pinnipeds with those for odontocetes, it appears from the slopes of the audiograms at the lowest frequencies tested that certain pinnipeds (e.g., California sea lion) may have better hearing sensitivity at lower frequencies than the beluga whale and bottlenose dolphin, for which low frequency audiograms are available. Schusterman (unpub. data, 1994) substantiates this.

• Potential for physical auditory effects: As discussed earlier in section 4.3.1.1.1, based on currently available data on acoustic trauma and the structure/mechanics of the marine mammal ear, Ketten (1994) speculated that for TTS to occur with regard to the ATOC sound source (provided sound field calculations are correct) the animal must be :

- capable of hearing signals below 90 Hz and have hearing sensitivity below (better than) 70 dB (150 dB-80dB=70dB) for frequencies below 90 Hz (assuming that TTS would occur for received levels >80 dB above the absolute threshold, as for humans listening in air).
- capable of diving deeper than 800 m (2625 ft) (making the same assumption as above). The only pinniped believed capable of dives ≥700 m is the northern elephant seal. The only fissiped in the general project vicinity, the southern sea otter, is not known to dive deeper than 55 m.

- within the 150 dB isopleth (a radius of 178 m from the source at a depth of 800 m); choose not to depart or be unable to depart the area; and/or be subjected to repeated exposures. In this regard, it is assumed if an animal considered the sound to be annoying, it would depart the area upon onset of the 5 min source ramp-up period. All marine mammals have adequate swim speed to accomplish this.

Hollien (1993) suggests that the dynamic range of human hearing underwater is less than in air. However, there is no information as to whether the human range, or some lower (or higher) range, applies to marine mammals (Hollein, 1993). If a lower value is appropriate, then the received level that would cause an odontocete to incur TTS could be less than the assumed 150 dB (≤15 dB difference); if higher, 150 dB would be too conservative (≤15 dB difference).

Based on extrapolation of the available audiometric data, the potential for physical auditory effects on five of the six pinnipeds that may be found in the central California coastal region (northern fur seal, California sea lion, harbor seal, Guadalupe fur seal and Steller sea lion) would be highly unlikely. Further, Guadalupe fur seals breed only off Baja California, Mexico and rarely are sighted north of the Southern California Bight (SCB); and the southernmost Steller sea lion rookery is Año Nuevo Island.

There are no published audiograms on elephant seals, but they are known to dive deeply and, thus, are of special interest because they may dive deep enough to reach the 150-195 dB sound field of the source (i.e., deeper than 800 m). Both sexes of elephant seals dive continuously while at sea; females are submerged about 91% of the time and males about 88% (Stewart and DeLong, 1993). Costa (pers. comm., 1993) noted that, on average, female dives are to approximately 400-600 m (note: <800 m) (maximum believed to be 1200 m), and last about 24 min, with 2 min inter-dive surface intervals. Males dive to approximately 200-600 m (note: <800 m) (maximum believed to be 1565 m), for about 23 min, with 3 min inter-dive surface intervals.

The harbor seals in the study area do not migrate seasonally, and remain in the general vicinity of their haul-outs, near the coast. This would keep them from entering the 120-135 dB sound fields of the source; their maximum dive depths have been calculated at 500 m for the male and 365 m for the female (Stewart et al., 1989).

For the harbor seal, it can be seen, via extrapolation that its hearing threshold would be approximately 90 dB or higher. Thus, this animal does not come close to the 70 dB hearing threshold needed to have the potential for TTS, and it would not be expected 20-40 km offshore where the 120-135 dB ATOC source sound fields could be encountered.

Although there are no underwater audiometric data for the southern sea otter, based on the fact that their in-air vocalizations are at 3-5 kHz and higher, it is assumed that they have poor underwater low frequency hearing capability. This, coupled with the fact that these animals rarely venture more than 2 km from shore, make the possibility of affecting them negligible.

The only pinniped believed capable of diving deep enough to enter the 150-195 dB sound field, and inhabit the area encompassing Pioneer Seamount, would be the northern elephant seal. At this point, it is instructional to refer back to the criteria believed necessary for TTS to occur in a pinniped, and couple these with the common dive pattern of the elephant seal, and the fact that the ATOC source duty cycle would be only 2-8%. The integration of these elements leads to the conclusion that the number of elephant seals that could possibly be located within the 0.0118 km^3 volume of the hemisphere (above the seafloor) defined by the 150 dB isopleth, at the onset of the 5-min ramp-up period, would be extremely small. Further, if an elephant seal was in the area, it would be assumed that if the sound were annoying, the animal would simply depart the area prior to maximum source level output. However, it cannot be ruled out that some individual seals may forage at depth in spite of an acoustic annoyance because their stimulus to feed might be greater than the avoidance response. Although the determination of this occurrence would be problematical, the elephant seal tagging effort (Appendix C) may provide some meaningful data on which to base some estimates of possible impact.

Thus, provided that sound field predictions and the assumptions/criteria regarding TTS discussed previously are correct and, based on available data that the elephant seal would be the only pinniped that may be at risk if it does in fact possess some low frequency hearing capability, it is highly unlikely that any pinniped species, or the one fissiped species (with the possible exception of the northern elephant seal), could experience any physical auditory effects.

During the 2-year ATOC feasibility study phase, it is estimated statistically that less than one elephant seal would be exposed to the 150 dB sound field even once. Repeat exposures, which are necessary before permanent threshold shifts occur, would be exceedingly unlikely.

CEQA Impact 7: Physical auditory impacts on pinnipeds, principally consisting of the potential for occasional temporary threshold shifts in elephant seals; and potential behavioral impacts on pinnipeds, principally consisting of change in elephant seal swim pattern/direction, would be less than significant (i.e., would not substantially reduce the number or restrict the range of pinnipeds, cause the population to drop below self-sustaining levels, or adversely affect their significant habitats).

CEQA Mitigation Measure 7-1: A MMRP will be carried out in connection with the ATOC project in accordance with the protocols set forth in Appendix C to this EIS/EIR. With regard to potential physical auditory and behavioral impacts on pinnipeds, particularly northern elephant seals, a goal of the MMRP will be to validate the assumptions regarding population distribution and abundance and diving behavior of northern elephant seals which form the basis for predicting the likelihood of potential impact due to the ATOC source transmissions.

• Potential for behavioral disruption and habituation: There has been little study of potential pinniped behavioral disruption due to low frequency underwater sound transmissions. It has been reported that harbor seals continued to haul out in Kachemak Bay, Alaska during construction of hydroelectric facilities 1.6 km away (Roseneau and Trugden in Johnson et al., 1989, and in Malme et al., 1989). Kingsley (1986) found no evidence that numbers of ringed seals were lower adjacent to artificial island oil drilling and production sites. However, Frost and Lowry (1988) reported a reduction in numbers of ringed seals within 3.7 km of artificial islands, on some of which oil drilling operations were underway. Gales (1982) and McCarty (1982) reported that sea lions were common around oil production platforms off California and in Cook Inlet, Alaska. In spring, some ringed and bearded seals approached and dove within 50 m of an underwater sound projector broadcasting steady low frequency (<350 Hz) drilling sound (Richardson et al., 1991a). At that distance, the received sound level at depths greater than a few meters was approximately 130 dB.

With respect to noise from seismic exploration activities, Richardson et al. (1991) noted that there is evidence that some ringed seals abandon areas where on-ice seismic techniques (Vibroseis) are used in winter. However, the effect is very localized, and other species of seals often tolerate intense noises.

No detailed studies of reactions by pinnipeds to noise from seismic exploration in open water have been published. During seismic exploration at Sable Island, Nova Scotia, gray seals exposed to noise from airguns did not react strongly (Parsons in Greene et al., 1985); however, no details were given as to whether the seals that were exposed were in the water or hauled out. "Seal bombs" have been used to prevent harbor seals, sea lions and other mammals from feeding on fish (Mate and Harvey, 1987). These pyrotechnics expose the animals to sharp noise pulses of varying intensities which, in some ways, are analogous to the noise pulses used for seismic explorations. The general consensus is that, when first used, they startle the animals and often induce them to move away from the feeding areas temporarily. However, this avoidance response wanes if the animals perceive that the noises are not harmful and, thereafter, some seals tolerate quite intense underwater sounds to gain access to food (Mate and Harvey, 1987).

No disturbance reactions by southern sea otters were evident when a full-scale seismic ship conducted operations as close as 0.9 km (Riedman, 1984). Feeding otters continued to dive and feed successfully at these times. Also, no apparent reactions were evident among otters that were rafting, grooming, swimming, mating, or interacting with pups (Riedman, 1983). Sea otters also were observed by Riedman (1983, 1984) during underwater playbacks of oil/gas drillship, semi-submersible, and production platform sounds conducted by Malme et al. (1983, 1984). Riedman reported no evidence of any changes in behavior or use of the ensonified area during the playbacks, even though the received sound levels in the 1/3-octave band with the strongest sounds were estimated to be ≥10 dB above the ambient noise level (Malme et al., 1983, 1984).

The aforementioned is inadequate for more than general conclusions, but the available information indicates that seals and sea otters sometimes tolerate intense impulsive sounds with strong low frequency content when they are strongly attracted to an area for feeding, reproduction, or other natural function. They also often tolerate more-or-less steady or transient sounds at lower intensities (Richardson, pers. comm., 1994).

As with mysticetes and odontocetes, variations in sensitivity to human-made noise between and within pinniped/fissiped species and the lack of information about the consequences of short-term disruptions on pinnipeds/fissipeds, make it very difficult to define criteria of responsiveness in them and to assess the consequences of a disruption in their natural activities. In light of available data on pinniped and fissiped low audiometric and behavioral sensitivity to low frequency sound, the potential for short- or long-term effects as a result of the proposed sound transmissions also is believed to be minimal, with the possible exception of elephant seals.

Behavioral changes in pinnipeds would only occur in species that have low frequency hearing capability, primarily harbor seals, elephant seals, and California sea lions. Harbor seals remain close to haul-out areas and, therefore, would not be exposed in significant numbers even to a 120 dB sound field, so no behavioral impacts are anticipated. Elephant seals are found throughout the area of the proposed project and are deep divers. Given the estimated densities of elephant seals in the study area, it is anticipated that several dozen could be exposed to the 120 dB sound field during ATOC transmissions. Since elephant seals are not anticipated to have low frequency hearing abilities better than great whales, this 120 dB level is assumed to set an outer bound for areas within which elephant seals may be subject to behavioral changes (including the unlikely possibility that the animals could be attracted to the source). However, since this area represents only a small portion of the habitat range of elephant seals, and given the fact that the source would operate only 2-8% of the time, the impacts of any behavioral changes should be minimal. Based on current unpublished test results (Schusterman, pers. comm., 1994), it appears that California sea lions may have some hearing capability at 100 Hz, but probably with relatively poor sensitivity.

Of all the species considered in this EIS/EIR, the combination of possible presence, deep diving abilities, and potential low frequency hearing capabilities, makes the elephant seal one of the most likely animals to experience adverse effects from the proposed ATOC source. For that reason, among others, the elephant seal has been proposed as a principal indicator species of the MMRP. If elephant seals are responsive to low frequency sounds, the potential for adverse behavioral impacts is present, but should be low because of the expected relatively low density of this species within the area of the modeled 120 dB sound field for the proposed action site (Pioneer Seamount), based on sighting locations during surveys by Bonnell et al. (1983) and PRBO (Ainley and Allen, 1992) (adjusted for animals missed underwater). Mitigation measures 2-1 (minimizing the ATOC source power level and duty cycle) and 3-1 (MMRP research) would serve to mitigate these impacts and no additional mitigation measures are proposed.

• Potential for long-term effects: The discussion of the potential for and, ramifications of, long-term effects with respect to mysticetes and odontocetes also is relevant to pinnipeds. In general, changes in marine mammal usage of an area may be quite slow and difficult to detect, and the causes of any changes difficult to discern. There are no documented instances of long-term effects of subsea sounds on pinnipeds or fissipeds. Existing information suggests that pinnipeds and fissipeds habituate quite readily to noisy environments. However, given the difficulties of obtaining such information, the potential for adverse impacts from long-term exposures to the ATOC source sound fields should be considered unknown. Although no such impacts are anticipated, marine mammal exposures to subsea sounds will be minimized whenever feasible. Although there is no evidence of any long-term impacts to pinnipeds or fissipeds from sounds comparable to the ATOC source, the lack of reliable information justifies the assumption of an unknown impact for purposes of this EIS/EIR, but at a less than significant level (under CEQA standards) due to the expected relatively low densities of these species (within the area of the modeled 120 dB sound field for the proposed action site [Pioneer Seamount], based on sighting locations during surveys by Bonnell et al. [1983] and PRBO [Ainley and Allen, 1992]) and their lack of deep-diving capabilities (except for elephant seals). Mitigation measures 2-1 (minimizing the ATOC source power level and duty cycle) and 3-1 (MMRP research) would serve to mitigate these impacts and no additional mitigation measures are proposed.

• Potential for masking: The same general principles concerning masking discussed at the beginning of Section 4.3 apply to pinnipeds and fissipeds, as well. As noted, the maximum radius of influence of an industrial (or proposed source transmission) noise on a marine mammal is the distance from the noise source at which the noise can barely be heard. This distance is determined by either the hearing sensitivity of the animal, or the background noise level present. For many pinnipeds (e.g., fur seal, harbor seal), the radius of audibility of higher frequency, human-made sounds (e.g., 5-30 kHz), would normally be limited by the background noise level, since these species are more sensitive to high than to low frequency sounds. For sounds dominated by low frequency components, the maximum radius of audibility for these species may often be determined by their hearing sensitivity, rather than the background noise level.

There are limited data concerning underwater call characteristics of California pinnipeds, but it is believed that most, if not all, calls are in the frequency band above 100 Hz. If so, there is little potential for masking of communication calls, regardless of hearing thresholds; however, if other low frequency environmental sounds are relevant, they might be masked by ATOC sounds.

Provided that the assumptions discussed previously are accurate, it appears that the potential for increased masking for any pinniped or the one fissiped, with the possible exception of the elephant seal, as a result of the proposed sound transmissions, is minimal.

In light of the relatively brief and intermittent nature of the ATOC source transmissions, the fact that the only pinniped or fissiped with the potential to experience masking effects is the elephant seal, and the expectation that low frequency sounds in the ATOC frequency band (57.5-92.5 Hz) are assumed not to be a particularly significant band for elephant seals, any masking effects are expected to be minor. Because masking effects on pinnipeds are expected to be no more than minor, and are not amenable to further study or mitigation beyond those measures already proposed, no additional mitigation measures are identified for this impact.

• 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 the potential impact on the food chain that could ultimately affect any species of pinniped or the one fissiped found in the vicinity of the study area. The following lists the common prey species for the pinnipeds and one fissiped expected in the study area:

- Northern elephant seal: squid, octopus, hagfish, anchovies, and rockfish (Ainley and Allen, 1992).
- Northern fur seal: crabs, squid, sablefish, anchovies, and rockfish (Ainley and Allen, 1992).
- California sea lion: crabs, squid, herring, hake, and mackerel (Ainley and Allen, 1992).
- Harbor seal: crabs, squid, smelt, mackerel, and rockfish (Ainley and Allen, 1992).
- Southern sea otter: shellfish and small fish (e.g., anchovies) (Siniff and Ralls, 1988).

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/fissiped population off the central California coast. However, since at most only a very minor portion of the range (within approximately 5 km [130 dB sound field] of the source site) of these prey species might be affected, indirect impacts would likely be minimal.

The potential direct and indirect effects of the alternatives on pinnipeds and fissipeds are summarized in Table 4 1-1.

4.3.1.3.2 Potential Cumulative Effects on Pinnipeds and Fissipeds:

Activities that might reasonably be considered to have the potential to interact cumulatively to affect pinniped or fissiped species that inhabit or travel through the proposed study area have been discussed in Section 4.3.1.1.2. They include commercial merchant shipping and other vessel-related activities, recreational water activities (as a result of the potential for ship/boat collisions and noise from ship/boat engines); noise from aircraft operations, and research activities. The discussions below also account for MMRP-related activities that could potentially cumulate with the source transmissions: 1) aerial visual and acoustic surveys/observations, 2) shipboard visual and acoustic surveys/observations, 3) shipboard photo-identification activities, 4) shipboard translocation of tagged elephant seals.

- Merchant shipping and other vessel-related activities: Few authors have described responses of pinnipeds or fissipeds 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. 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).

Sea otters commonly allow boats to approach them, but may sometimes tend to avoid groups of boats. However, Roseneau (in Malme et al., 1989) described situations where sea otters occurred in areas of high vessel densities. Garshelis and Garshelis (1984) reported that sea otters avoid southern Alaskan waters with frequent boat traffic, but reoccupy those same areas in seasons when fewer vessels are present. Riedman (1983) noted that some rafting sea otters showed only mild interest in a boat passing a few hundred meters away, and did not exhibit any alarm reaction. Other than these anecdotal reports, the authors know of no specific studies of the behavioral reactions of sea otters to ships or boats.

NMFS and TMMC have documented evidence on collisions between pinnipeds and ships, boats, and thrillcraft in the central California offshore area (TMMC, pers. comm., 1995). It is expected that these incidents occur from time to time, particularly in light of the fact that the primary habitat for all but the elephant seal is close to the coast, where fishing and pleasure boating are most prevalent.

- Aircraft operations: There has been little systematic study of the reactions of pinnipeds or fissipeds to aircraft overflights, but many opportunistic, anecdotal reports are available. 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) 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.

- Research activities: The discussion in Section 4.3.1.1.2 of the potential for and, consequences of, ongoing and future research activities in the vicinity of the study area on mysticetes, is relevant to pinnipeds and the one fissiped, as well.

As with mysticetes and odontocetes, any cumulative impacts on pinnipeds or fissipeds from other sources of subsea sounds or developments that affect the marine environment in the vicinity of the proposed project are speculative. No additional mitigation measures beyond those already identified are proposed to address cumulative impacts.

4.3.1.3.3 Summary and Conclusions Concerning the Potential Effects on Pinnipeds and Fissipeds

This section summarizes the information presented in the previous sections regarding potential effect of the ATOC source operations and MMRP on pinnipeds and fissipeds.

Table 4.3.1.3.3-1 below presents, for each species, the maximum exposure anticipated given the distribution, range, and diving ability of that species.

As can be seen from this table, none of the pinnipeds, except the northern elephant seal, have potential low frequency hearing abilities and dive deep enough to experience any impacts from the source transmissions. Nor is the southern sea otter able to come close enough to the source to receive any exposure. The Steller sea lion is so rare, and stays so close to its haul-out and breeding sites, that it is unlikely that any members of this species would be exposed to transmissions.

Of all the pinnipeds, northern elephant seals have the potential for the greatest exposure to the sound source. When at sea, they are almost continuously under water, surfacing for periods of less than a minute. Females usually dive to depths of 400-600 m and males to 200-600 m. Maximum recorded diving depths are 1200 m for females and 1565 m for males. Populations of elephant seals have been increasing since they almost became extinct in the 1880s. They have reestablished breeding colonies on the Farallon and Año Nuevo Islands, and are found the length of the California coast. Since this area is highly developed, evidence indicates that elephant seals are tolerant to sounds similar to the ATOC transmissions.

Generally, it might be expected that the impacts would be somewhat greater at the Pioneer Seamount site which is close to the Farallon Islands, which are important breeding and haul-out grounds for several pinniped species. However, based on comparison of marine animal stock estimates between the preferred action site (Sur Ridge) and the proposed action site (Pioneer Seamount), only the northern fur seal is expected to be in somewhat greater abundance (see table in the Executive Summary). Impacts might be slightly less at the Sur Slope site because it is farther offshore and most pinnipeds generally stay close-in along the coast. For this reason, the autonomous source alternative is expected to have minimal impacts on pinnipeds (only elephant seals and fur seals could possibly be exposed during their pelagic phase) or fissipeds because none would be exposed to transmissions originating in the open ocean.

Table 4.1-1 summarizes the potential direct and indirect effects, and potential cumulative effects of the alternatives on pinnipeds and fissipeds.

Pinniped/Fissiped Species	Maximum Exposure (dB)	Potential Effects
northern elephant seal	195	Possible low-mid-frequency hearing capacity results in low potential impacts; some minor masking or behavioral disturbance could occur.
northern fur seal	138	Mid-high-frequency hearing and shallow diving capability prevent impacts.
California sea lion	142	Mid-high frequency hearing capability limits impacts.
harbor seal	<120	Mid-high frequency hearing capability, shallow diving and near-shore range prevents impacts.
Guadalupe fur seal	None	Rare in study area.
Steller sea lion	142	Rarely enter study area.
southern sea otter	<110	Assumed mid-high frequency hearing capability, shallow diving and near-shore range prevent impacts.

Table 4.3.1.3.3-1. Summary table of potential effects of ATOC sound on pinnipeds/fissipeds

4.3.2 OTHER MARINE SPECIES

Although potential effects of the ATOC source sounds on marine mammals have been the principal area of concern, other marine species might also be affected by the proposed MMRP and ATOC source transmissions. These include sea turtles (such as green, loggerhead, olive ridley, and leatherback); fish (including demersal, pelagic, and shark); invertebrates (including cephalopod and crustacean); coral and algae; plankton; and seabirds (particularly those that are known to dive deeply). With regard to many of these species, evidence concerning hearing ability and the response to low frequency sound is even less known than is the case for marine mammals. This section of the EIS, however, summarizes the knowledge available about these species and discusses the potential direct, indirect and cumulative impacts of the alternatives.

4.3.2.1 Sea Turtles

As discussed in Section 3, the most frequently sighted sea turtle off central California is the leatherback. Other sea turtles are less common, but some of those species are relatively good divers that could approach, but likely not reach, proximity to the ATOC source. This subsection presents the available scientific information concerning the hearing abilities of these animals, together with a discussion of their diving abilities and resulting potential impacts on sea turtles.

Since sea turtles, especially leatherbacks, are one of the prey species for killer whales, and some sharks, the following discussions of the potential direct, indirect, and cumulative impacts of the proposed project on sea turtles, is also a discussion of the indirect impacts on killer whales and sharks.--

4.3.2.1.1 Potential Direct and Indirect Effects on Sea Turtles

Section 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 northeast Pacific, coupled with the expected average transit speeds for sea turtles (0.65 m/sec for leatherbacks; approximately 1 m/sec for loggerheads and olive ridleys) (Eckert, pers. comm., 1994). These estimates apply primarily to leatherbacks, loggerheads and olive ridleys that would be more likely to pass through the sound fields located relatively far offshore, as green turtles spend most of their time in waters closer to the coast.

As noted previously, transmissions from the proposed sound source at the water's surface are expected to be 135 dB at a radius of 1000 m (received level is not expected to exceed 135 dB at the water's surface anywhere in the vicinity of the source); 130 dB to a radius of 5 km; 120 dB to 18 km shoreward and 12 km seaward from the source; 110 dB to 50-60 km shoreward, 55 km seaward. Below the surface, sound levels are expected to be: 140 dB at 418 m depth (562 m range around source); 145 dB at 664 m depth (316 m range around source); 150 dB at 802 m depth (178 m range around source); 165 dB at 950 m depth (30 m range around source); and 195 dB at 980 m depth (1 m range around source).

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).

The few studies completed on the auditory capabilities of sea turtles suggest that they could be capable of hearing low frequency sounds. These investigations have used adult green, loggerhead, and Kemp's ridley (*Lepidochelys kempii*) in their research protocol. The authors are aware of no studies to date of olive ridley, hawksbill, or leatherback. The MMRP would support field research to obtain auditory and/or behavioral observations on leatherbacks.

Ridgway et al. (1969) used aerial and mechanical stimulation to measure the cochlear 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 ATOC source transmissions if they were located in the sound field corresponding to 132 dB received level (<3 km 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 depth could be a direct cause of injury to green turtles.

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 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 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. There is anecdotal information that a leatherback in the wild appeared to exhibit changes in its behavior in response to the sound of a boat motor, transmitted at an estimated 160 dB, from a distance of 10-15 km from the turtle. This observation suggests that leatherbacks may be sensitive to low frequency sounds, but the response could have been to mid or high frequency components of the sound (Eckert, pers. comm., 1994).

• Potential for physical auditory effects: Of the four species of sea turtle that may occur off the central California coast, only the dive depth capabilities of the leatherback have been investigated. An olive ridley once was observed at a depth of 300 m (Landis, 1965, reported in Eckert et al., 1989), but there are no other published data available on dive depth capabilities of this species, greens, or loggerheads.

The leatherback is the only species known to be capable of diving deep enough to enter the 150 dB sound field around the source (where it is suspected that a temporary threshold shift could possibly occur). The deepest dive recorded for a leatherback was approximately 1300 m (Eckert et al., 1989). However, the average dive depth recorded for six females during their internesting period was only 61.6 m (Eckert et al., 1989). Some sea turtles exhibit a noticeably different diving behavior during the internesting period, as compared to the postnesting period, because they are gravid, and tend to be less active during this time (Plotkin, pers. comm., 1994). If this is also true for leatherbacks, then internesting dive behavior may not accurately reflect their postnesting dive behavior. Eckert (pers. comm., 1994) noted that time-depth-recorder (TDR) satellite tracking data obtained from two leatherbacks indicated that all dives >400 m depth were made subsequent to the nesting season and represented only 0.6% of all dives. The leatherback spends most of his dive time traveling to and from maximum depth; typical times spent at maximum depth are on the order of 2-4 min. This information is based on data from TDRs deployed on six leatherbacks (Eckert et al., 1989). Even though this animal has been known to dive as deep as 1300 m, and these deep dives are probably important evolutions, it is not considered a bottom-feeder, and does not usually forage, nor find refuge on the bottom., but rather it appears to forage in the water column, possibly tracking the deep scattering layer (Eckert, pers. comm., 1994).

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 and loggerhead) 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, or loggerhead 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 shifts, and such an impact will therefore be assumed. Given the presumed low density of leatherbacks in the vicinity of Pioneer Seamount (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 ATOC source, and the fact that the proposed project site is not a particularly important location of leatherback prey species, any impact should be minimal.

CEQA Impact 8: It is assumed, given the lack of direct audiometric data, that individual leatherback sea turtles could possibly incur a temporary threshold shift, which is assumed to be an impact at a less than significant level given the anticipated low rate of such occurrences.

CEQA Mitigation Measure 8-1: The MMRP would support field research to attempt to obtain the collection of auditory and/or behavioral observations on leatherback sea turtles.

• 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. To encounter received levels of 140 dB, a turtle would have to dive to depths greater than 418 m, and be located inside the 140 dB isopleth (equating to 0.372 km^2 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%.

The potential for short-term behavioral disruption or displacement, on sea turtles is also unlikely, although sound transmissions with received levels $\geq$132 dB could possibly be audible to animals within approximately 3 km of the source. Potential effects on the deep-diving leatherback are more uncertain.

CEQA Impact 9: It is assumed, given the lack of direct information, that sea turtles (particularly leatherbacks) could possibly incur behavioral changes due to ATOC source transmissions, including potential avoidance of the area. However, given the relatively small portion of the range that could be affected, this is assumed to be a less than significant impact.

CEQA Mitigation Measure 9-1: The MMRP would incorporate into its research protocol the goal of assessing whether acoustic transmissions could potentially cause sea turtles to spend more time than normal at the sea surface.

CEQA Mitigation Measure 9-2: The MMRP would incorporate into its research protocol the goal of assessing whether acoustic transmissions could potentially cause leatherbacks to avoid the ATOC source area.

• Potential for long-term effects: Discussion of the potential for and, ramifications of, long-term effects with respect to mysticetes, odontocetes and pinnipeds is relevant to sea turtles, as well. In light of the available data (both measured and anecdotal) 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.

• 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, with the possible exception of leatherbacks.

Moreover, any sounds that the ATOC 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 ATOC source means that it will only mask sounds for brief periods; sounds longer than this will 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 ATOC source's narrow bandwidth low frequency transmissions will not completely mask these sounds. If the ATOC 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 ATOC 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 could occur, but it is anticipated any effects would be minor. Mitigation measures 8-1, 9-1, and 9-2 (regarding research on sea turtles as a component of the MMRP) would serve to mitigate these impacts and no additional mitigation measures are proposed.

• 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:

- Leatherback sea turtle: cnidarians (gelatinous zooplankton), tunicates (filter feeders), and jellyfish.
- Green sea turtle: pelagic phase--various invertebrates; neritic phase--coastal algae and seagrasses).
- 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.

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 sea turtle population off the central California coast.

Section 4.3.2.3 contains discussions of the potential direct, indirect, and cumulative impacts of the proposed project on squid, crabs, mollusks, jellyfish and other invertebrates and zooplankton which are the prey species for sea turtles, other than green sea turtles. That section constitutes the discussion of the indirect impacts on sea turtle species, other than green sea turtles, in the project vicinity. The proposed project should have no impact on coastal algae and seagrasses that green turtles feed on (maximum received levels during transmissions would be <110 dB, which is relatable to nearshore ambient noise conditions during storms) and, therefore, there should be no indirect impacts on that species. The proposed ATOC source site is not known to be a significant feeding area for any sea turtle species, and any potential effects on prey species would be incremental and affect only a small portion of the range. To further assess the potential for indirect impacts, the MMRP would include observations of the impact of ATOC source operations on prey species, as discussed and identified as a mitigation measure in the corresponding section below.

Table 4.1-1 describes the potential direct and indirect effects of the alternatives on sea turtles, which are considered to be minor.

4.3.2.1.2 Potential Cumulative Effects on Sea Turtles

Activities that can be considered to have the potential 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 MMRP-related activities that could potentially cumulate with the source transmissions: 1) aerial visual and acoustic surveys/observations, 2) shipboard visual and acoustic surveys/observations, 3) shipboard photo-identification activities, 4) shipboard translocation of tagged elephant seals.

• Merchant shipping and other vessel-related activities: There are virtually no published details on collisions between sea turtles and ships, boats, or thrillcraft in the central California, or other offshore 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 influence 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 <3 km from the source, on the surface. To be exposed to sound levels >138 dB, it would have to be located deeper than 150 m and within 700 m range from the source proper. Added to these positional criteria are the facts that the 'on' period for the source would usually be 2%, and there would always be a 5-min ramp-up period, 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. Nevertheless, 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 MMRP activities and sound transmissions is unknown, although presumed to be very minimal. The potential change in cumulative effect due to the addition of MMRP aerial survey flights (maximum 2 flights per week; usually 1) must be stated as unknown, but is presumed to be minimal.

As with the other marine species, any cumulative impacts on sea turtles from other sources of subsea sounds are speculative. No additional mitigation measures beyond those already identified are proposed to address potential cumulative impacts.

4.3.2.1.3 Summary and Conclusions Concerning the Potential Effects on Sea Turtles

This section summarizes the information presented in the previous sections regarding potential effects of the ATOC source operations and MMRP on sea turtles.

Table 4.3.2.1.3-1 below presents, for each species, the maximum exposure anticipated given the distribution, range, and diving ability of that species.

Leatherbacks represent the only species that are known to have the capability to dive deep and may possess some measure of low frequency hearing capability, the combination of which presents the possibility that a very small number potentially could be at risk due to the ATOC sound transmissions, over the course of a two-year period. Leatherbacks have been known to dive to depths of 1300 m, but most dives are more shallow, following the deep scattering layer, from which they feed on squid and plankton. They make extensive seasonal migrations from their nesting sites in Baja California to Alaska, seeming to follow the water temperature contours (usually the 16°C isotherm). They are found in the study area during the summer months, most frequently in open water over the continental slope. Although little is known about leatherback hearing, they may be sensitive to low frequency sound. It is therefore possible that they might exhibit some behavioral disturbance if they happen to be close enough to the sound source during transmissions. However, given the presumed density of this species for the study area, the infrequency of deep dives, the 5-min source ramp-up period, and their ability to swim to beyond the 150 dB sound field, very few, if any, leatherbacks are expected to be exposed to ATOC sound transmissions at levels high enough to have the potential to cause TTS.

Impacts on leatherback sea turtles might be slightly greater at the Sur Slope site because that species prefers water over the continental slope. Not enough is known about sea turtle migration paths and distribution ranges to analyze any other differences among the alternatives, although the "no action" alternative would have no impacts.

Table 4.1-1 summarizes the potential direct and indirect effects, and potential cumulative effects of the alternatives on sea turtles.

4.3.2.2 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). This EIS/EIR primarily addresses the potential impact on marine fish off the central California coast. 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.

Sea Turtle Species	Maximum Exposure (dB)	Potential Effects
loggerhead sea turtle	136	Low frequency hearing capability uncertain but sensitivity presumed to be relatively poor; significant impacts unlikely
olive ridley sea turtle	136	Low frequency hearing capability uncertain but sensitivity presumed to be relatively poor; significant impacts unlikely.
green sea turtle	136	Low frequency hearing capability uncertain but sensitivity presumed to be relatively poor; significant impacts unlikely
leatherback sea turtle	195	Potential for behavioral changes and temporary threshold shift but low possibility of occurrence.

Table 4.3.2.1.3-1. Summary table of potential effects of ATOC sound on sea turtles

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 (Figure 4.3.2.2-1).

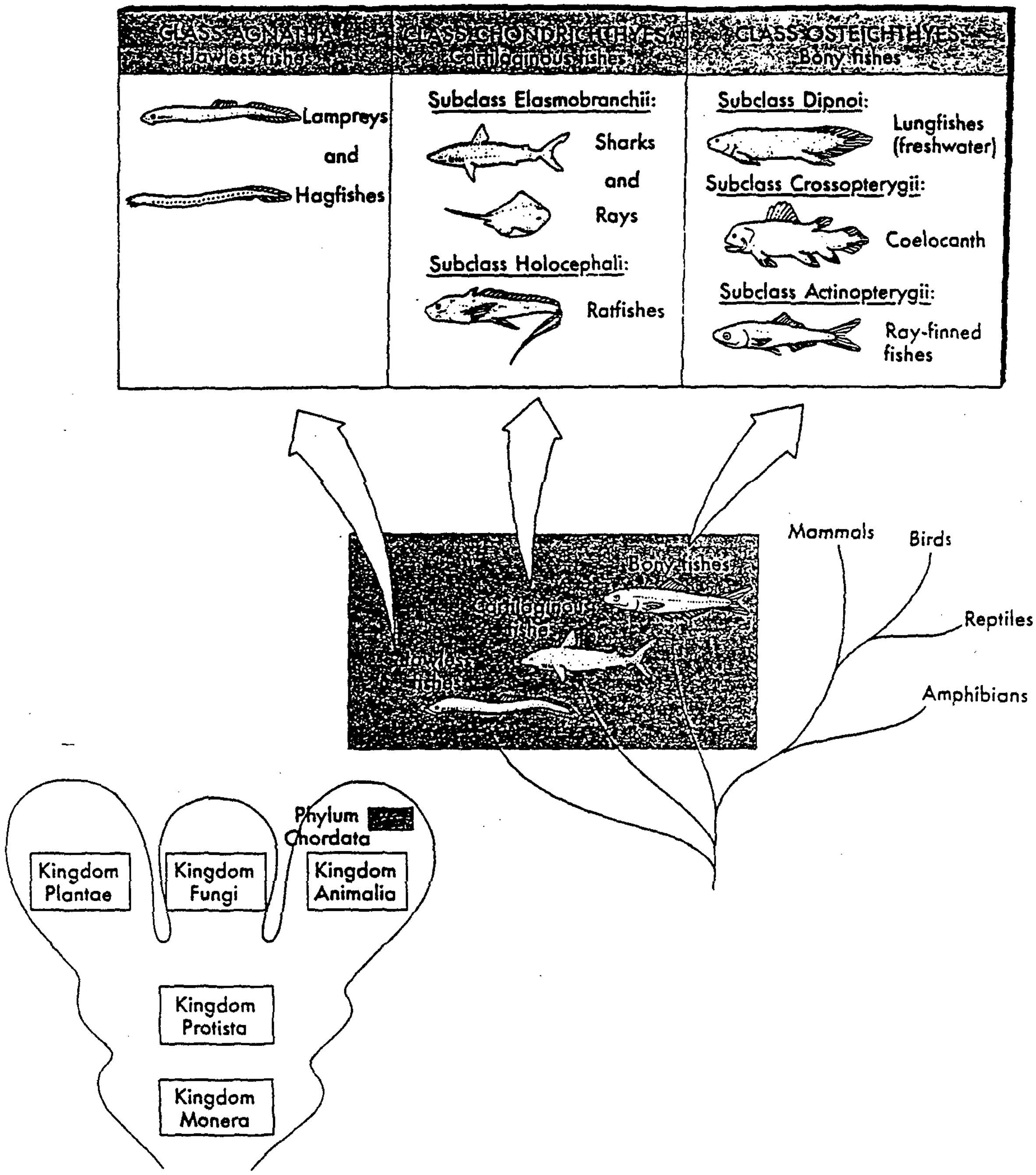
Most species for which hearing has been studied are teleost fish. Among the teleosts, the species with the best hearing capabilities are members of the series Otophysi. Otophysans represent about 6000 species that include goldfish, carp, minnows, catfish and knifefish. In the otophysans, the gas-filled 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). Thus, the study of this series of animals may provide a relatively conservative estimate for any potential impact of the four alternatives on fish in general. All species without Weberian ossicles are referred to as "non-otophysans." 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.

Many species of fish, particularly rockfish, mackerel, and anchovies, are important prey for marine mammals. Smaller fish are also the prey of larger fish and sharks. Therefore, the following paragraphs also constitute a discussion of potential indirect impacts on odontocetes and pinnipeds, as well as a discussion of the indirect impacts on fish and sharks, which prey on other fish.

4.3.2.2.1 Potential Direct and Indirect Effects on Fish

- Hearing capabilities and sound production of fish: 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).

Hastings (1990, 1991) presented a good summary of the issues of fish hearing and noted that almost every species of fish has a different auditory system and a different audiogram. She notes that, in general, fish hear sounds in the 50-2000 Hz range, with best sensitivity in the 200-800 Hz bandwidth. In the 100-200 Hz band and below, their lateral system, consisting of tissue containing sensory hair cells (found on the body, head, and in canals on the head and trunk) detects near-field hydrodynamic disturbances. The only reference in the literature to any potential damage to a fish's lateral line system from underwater sound comes from Denton and



(From Castro and Huber, 1992)

Figure 4.3.2.2-1 Taxonomic classification scheme for fish

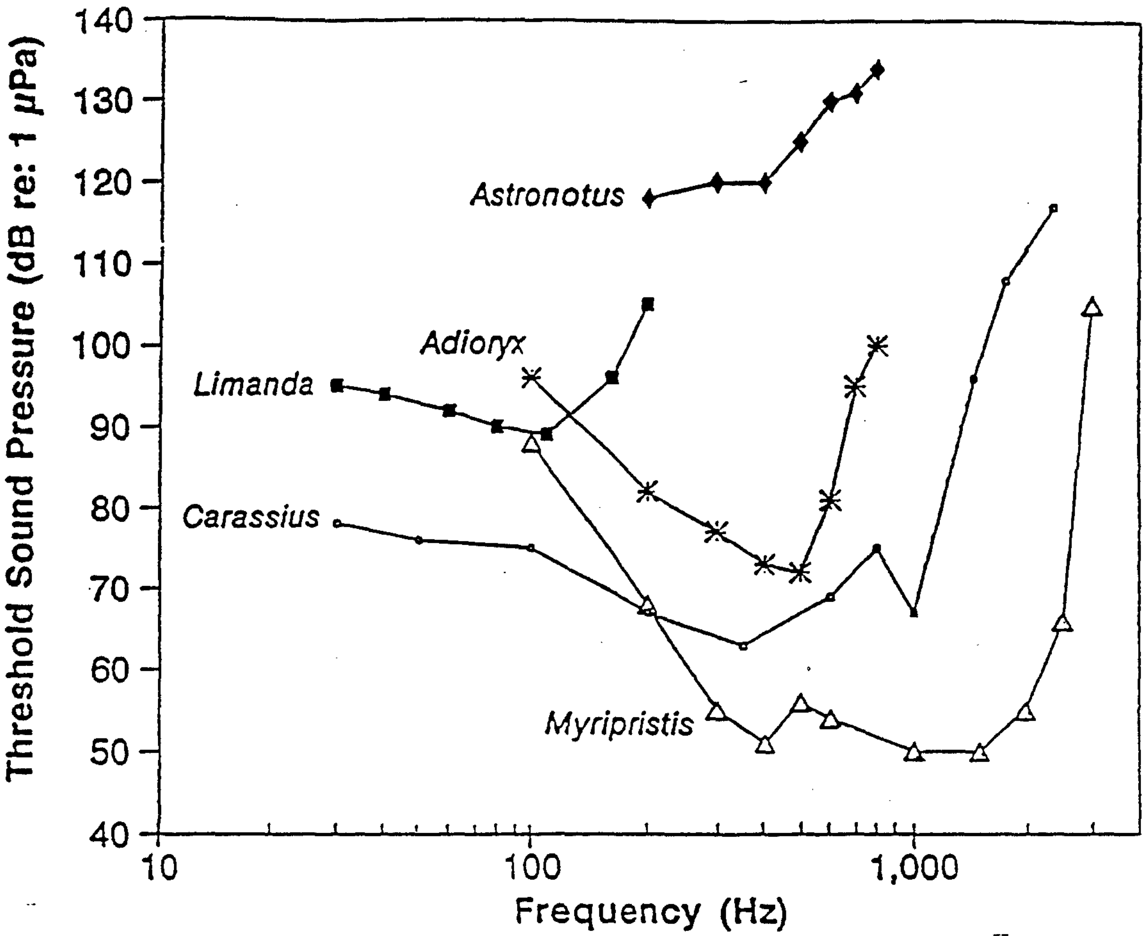
Gray (1993) wherein their study of clupeids (herrings) suggested that very intense sound stimulation (unquantified) can cause damage to the neuromasts (nerve connection at the base of each sensory organ) of the lateral line.

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, whose best hearing sensitivity is believed to rest between 20 and 300 Hz, local fish should have their best hearing sensitivity in the 200-800 Hz frequency bandwidth.

Myrberg (1980) stated that the most important region of sound detection in most fish is between about 40 and 1000 Hz. Additionally, fish whose hearing sensitivity is in the extremely low register (i.e., 10-500 Hz), including cod and its relatives (e.g., haddock, pollack, lingcod) and toadfish, appear keenly adapted to this particular range of frequencies, possibly because they produce sound in this range (Brawn, 1961; Gray and Winn, 1961; Winn, 1967; Fish and Offutt, 1972). Sharks also have been found to be sensitive to low frequency sounds. For sharks, hearing sensitivity is important for the identification of sounds produced by their prey (Nelson and Gruber, 1963; Myrberg et al., 1976; Nelson and Johnson, 1976; Myrberg, 1978).

Audiograms have been determined for over 50 fish (mostly freshwater) and three shark species (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 4.3.2.2-2 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.

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 peaking during the reproductive season. Those benthic fish species that are territorial in



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).

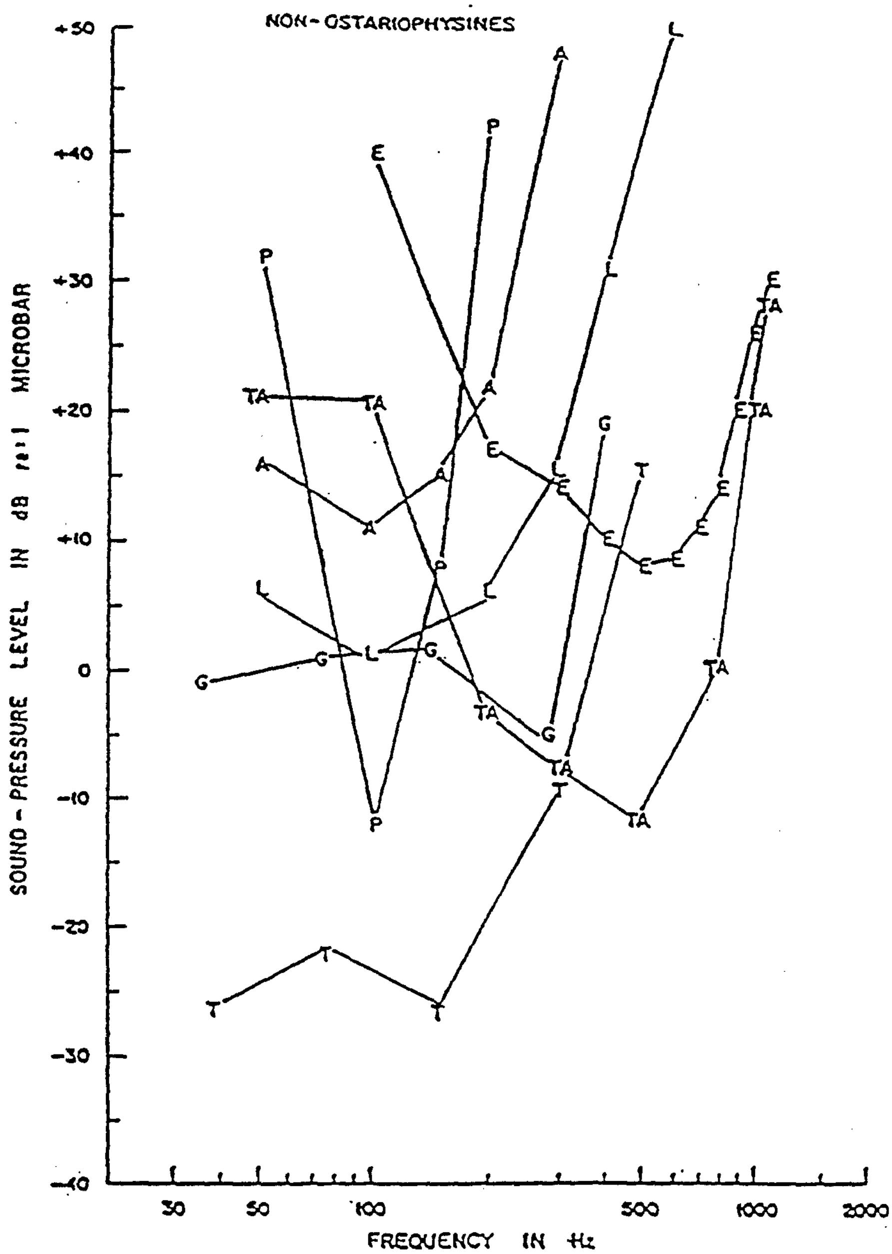
Figure 4.3.2.2-2 Behavioral audiograms for two "hearing specialists"

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.

Myrberg (1983) believed that fish communicate, or at least attempt to communicate, with different types of receivers; however, direct evidence of such activity is not overwhelming. He goes on to state that most fish sounds are composed predominantly of frequencies below 1 kHz and, accordingly, the animals themselves are most likely sensitive to such frequencies. The fish with the best hearing, the goldfish (*Carassius*) (Popper and Clarke, 1976) had a threshold level between 57.5 and 92.5 Hz of about 78 dB. However, this is a freshwater species, the data for which cannot be compared directly with fish in the ATOC study area. Figure 4.3.2.2-3 depicts the auditory threshold for seven non-ostariophysine species. The threshold for one of the migratory pelagic species that would be found in the study area, the yellowfin tuna (*Thunnus albacares*) (a non-specialist) is shown to be approximately 120 dB at 50-100 Hz. The figure also portrays the threshold for the codfish *Gadus* to be at about 100 dB. The labrid *Tautoga onitis* (a bony fish with a swimbladder) appears to have the best sensitivity, with a threshold of approximately 75-80 dB in the 50-100 Hz frequency band. The latter two species also do not occur in the study area.

Figure 4.3.2.2-4 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 ATOC source transmissions. This is because some fish may reside in the immediate vicinity of the ATOC source, and at least a portion have relatively sensitive hearing.

Fish that hear sound at >1000 Hz usually have a special connection between their swimbladder and inner ear, or a swimbladder that is very close to their inner ear. Hastings (1991) made some general conclusions from evidence based on a thorough literature search that, in the 50-2000 Hz frequency band, received levels at or above 180 dB would be harmful to fish, and received levels below 150 dB should not cause physical harm to fish. For the ATOC project,

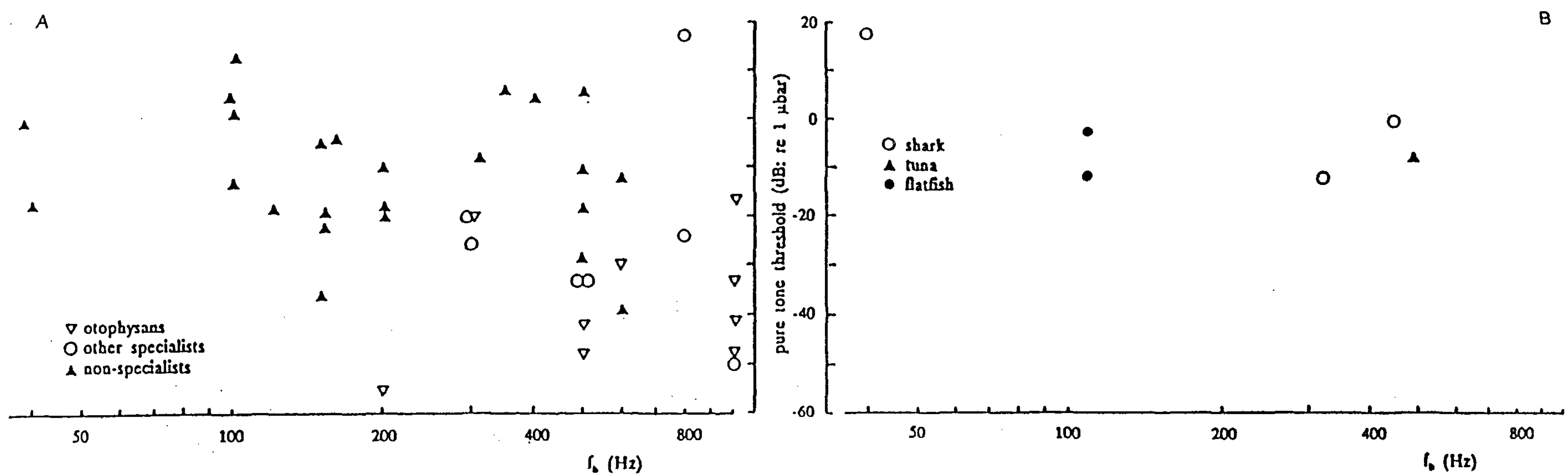


(From Popper and Fay, 1973)

G - *Gadus morhua*, Buerkle; Ta - *Thunnus albacares*, Iversen; E - *Euthynnus affnis*, Iverson; P - *Perca fuviatilis*, Wolff; A - *Acerina cernua*, Wolff; L - *Lucioperca sandra*, Wolff; T - *Tautoga onitis*, Offutt

Note: Add 100 to convert from reference of 1 microbar to 1 microPascal.

Figure 4.3.2.2-3 Auditory thresholds determined for seven non-ostariophysine 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 4.3.2.2-4 Relationships between psychophysical pure tone pressure thresholds and best hearing frequency

proportionally few fish are expected to be exposed to levels >150 dB, which would occur within a radius of 178 m from the source proper, encompassing a volume of approximately 0.0118 km^3.

It is not anticipated that the inducement of threshold shifts in fish would be significant from a habitat standpoint. No known populations of endangered fish reside in the vicinity of Pioneer Seamount. Any possible threshold shifts would likely occur in a small zone around the ATOC source, which could increase vulnerability to predation (a potentially adverse impact on the fish).

The proposed source site is not known to be particularly abundant for fish, compared to similar areas of the continental shelf (see Section 3.3.3), and 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, and the uncertainty surrounding the issue of TTS vs. habitat effects in fish, leads to the conclusion that threshold shifts could occur, but their impact on fish populations should be minimal.

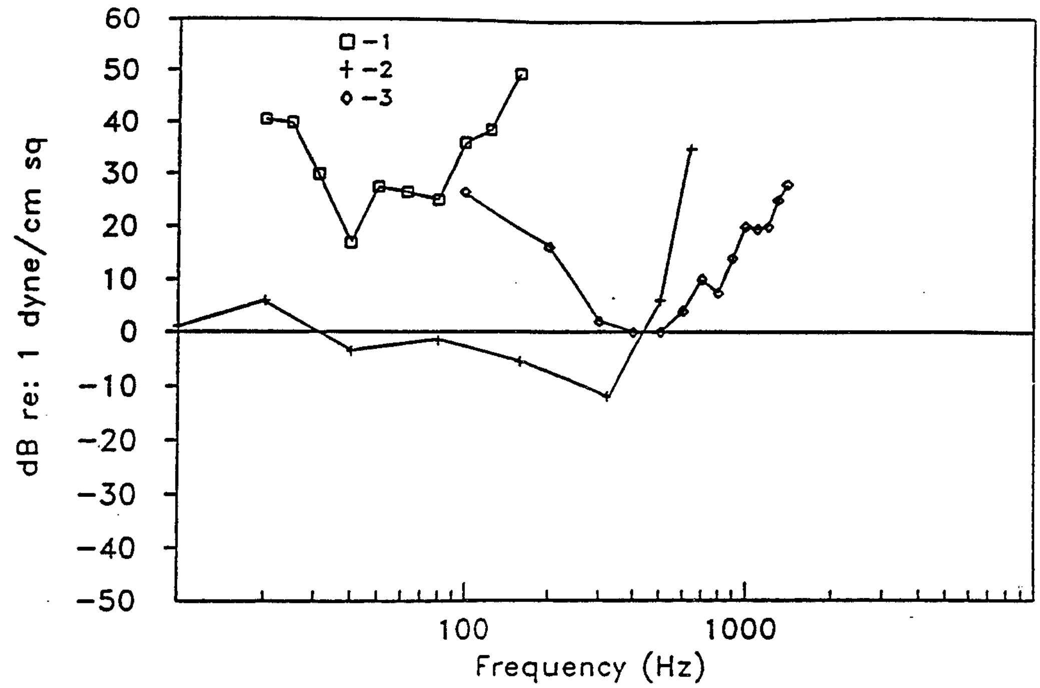
CEQA Impact 10: Given the lack of direct data, it is assumed that fish could possibly die if exposed to sound levels ≥ 180 dB (8 m radius around source); or could possibly incur TTSs at levels > 150 dB (178 m radius) which, in turn, could result in increased vulnerability to predation; however, given the minor proportion of any population that may be affected, this is deemed to be a less than significant impact.

CEQA Mitigation Measure 10-1: The MMRP would monitor fish stock assessments (via CDFG catch-block landing data; LTPY, CPY, and RAY data from NMFS; and interaction with the PCFFA) to attempt evaluation of the potential for increased mortality and predation on fish, in relation to ATOC source sounds.

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 ATOC source.

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 4.3.2.2-5 depicts audiograms for three shark species: horn shark (*Heterodontus francisci*), lemon shark (*Negaprion brevirostris*), and bull shark (*Carcharhinus leucas*)(Fay,



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 4.3.2.2-5 Sound pressure thresholds for 3 shark species

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 (to the authors' knowledge these three sharks are the only ones for which audiometric data have been obtained) have thresholds 120 dB or higher at frequencies comparable to the ATOC source.

Most fish (including sharks) are not anticipated to be adversely affected by low frequency sounds below 150 dB, and harmful effects are not expected until exposures of 180 dB or greater occur. As with the other species in the project area, exposures to sound levels comparable to those created by the ATOC source already occur due to commercial shipping traffic. As a result, while the potential for impacts to sharks is relatively unknown, it is not anticipated that large numbers of sharks could be adversely affected by the ATOC project; therefore, this impact is assumed possible, but is expected to be less than significant.

Another potential impact from a noisy environment could be effects on fish egg mortality, and fry survival and growth rate (Banner and Hyatt, 1973). These authors noted that under controlled testing conditions, the viability of the eggs of one species of estuarine fish (*Cyprinodon variegatus*) was significantly reduced in aquaria when a low frequency (40-1000 Hz) noise source, at 105-120 dB source level, which was approximately 40-50 dB above ambient noise conditions, was maintained over a number of consecutive days. Further, growth rates of fry in that same species, as well as in another species of estuarine fish (*Fundulus similis*), were significantly less than those noted when noise levels were reduced by about 20 dB during the same time period.

Hastings (1991) postulated a safe zone of 150 dB or lower for fish, which would be at 178 m range from the source, and a potential hazard zone of 180 dB or higher, which is at a distance 8 m or less from the source. This should also apply to fish fry (Hastings pers. comm., 1995). There is no reason to believe that viviparous (internally fertilizing and live-bearing) fishes would be affected by the source transmissions, and the chance of premature release of larvae (already fertilized) occurring as a result of the source transmissions is negligible (Cailliet, pers. comm., 1995). Only a few individual fish would be found in the potential hazard zone, and only a very small number (representing an insignificant proportion of any population of a species) would be found closer to the source than the boundaries of the safe zone, during a transmission (2-8% of the time).

• 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. 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.

Behavior of captive rockfish (*Sebastes* spp.) exposed to geophysical exploration airgun sounds was examined by Pearson et al. (1987) to establish parameters in a subsequent fishing experiment to determine the effects of a geophysical survey device on fishing success. Rockfish observed in an enclosed field showed startle and alarm responses during 10-min exposures to sounds from a single 1639-cm^3 airgun. For olive and black rockfish (*S. serranoides* and *S. melanops*), the threshold for startle responses was 200-205 dB within the 20-400 Hz frequency band. At these levels, blue rockfish (*S. mystinus*) exhibited changes in their milling patterns. The general threshold for alarm responses for all rockfish species was approximately 180 dB. Regression analyses of changes in depth distribution and shifts to active behaviors suggested that more subtle behavioral responses may have been evident at received levels of 161 dB. These initial responses were sustained for only a few minutes and undoubtedly differ from those of unconfined fish of this species (Pearson et al., 1987).

Pearson et al. (1987) also cited findings related to fish dispersal behavior in response to acoustic energy. Rockfish located from 1.6-18 km from a single airgun source exhibited some behavioral changes. Their dispersal resulted in a decline in fishing vessel catch-per-unit-effort of 52.4%.

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 from the source) (Konagaya, 1980).

The best sensitivity range of the majority of the fish expected in the central California offshore region should be in the 200-800 Hz frequency band. Thus, it is considered unlikely that ATOC 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 et al. (1978) reported that a silky shark (*Carcharhinus falciformis*) withdrew from a 300 Hz, 155 dB source level sound at 10 m 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 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 and interdaily 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 ATOC low frequency 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 ATOC source emanations would wane over a period of time, given that it would generate more constant transmission characteristics, at duty cycles (transmission periods) of 2%-8%.

CEQA Impact 11: Impacts to the behavior of fish are deemed possible, but are considered less than significant due to the comparatively small proportion of any species' range which potentially would be affected.

CEQA Mitigation Measure 11-1: The MMRP would monitor fish stock assessments (via CDFG catch-block landing data; LTPY, CPY, and RAY data from NMFS; and interaction with the PCFFA, PRBO, Bodega Marine Laboratory and Steinhart Aquarium) to attempt evaluation of the potential for impacts to fish, particularly sharks, in relation to ATOC source sounds.

• 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 often 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 problemmatical 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, 1981d), 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.

There is insufficient information to determine whether any adverse long-term impacts to fish could result from ATOC sound transmissions. However, given factors of population density, portions of the range that might be affected, low duty cycle of the ATOC source, and the deep location of the source, this impact is not expected to be significant.

• Potential for masking: The same general principles concerning masking discussed at the beginning of Section 4.3 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 for sea states 1 vs. 2, and 110 m 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 ATOC 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 to approximately 300 km. However, at a 2% duty cycle, it is anticipated that masking would be minor and temporary (i.e., at least 92% 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 ATOC transmission period, that happened to fall within that 20 min window).

• 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.

One mesopelagic fish species, the lanternfish (Myctophidae), migrates through the water column over a 24-hour cycle, and makes up a significant part of the food chain for many marine animals (particularly baleen whales). While nothing is directly known about the acoustic behavior of myctophids, some of these species may use sound for communication and hear quite well. For example, Marshall (1967) demonstrated that several myctophid species have particular groups of muscles that are likely used for sound production. Popper (1977) published work on the ears of myctophids where, through the use of electron microscopy, it was seen that several species have highly specialized ears, compared to other species, such as tuna, that do not hear well. Based on the study of almost 100 other species, Popper concluded that the ear pattern in myctophids is typical of those species that hear very well.

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. Myctophids make up the bulk of the deepest of three fairly well-defined deep scattering layers, at about 500 m (Castro and Huber, 1992) during the daylight hours. Applying Hastings' (1991) safe received level of ≤150 dB, myctophids would generally have a buffer zone of at least 300 m (500 m depth for the DSL, 800 m depth to the 150 dB sound field). During nighttime periods, the DSL moves toward the surface, expanding the buffer zone to up to 700 m. Therefore, the potential for acute or short-term effects (Table C-1) on myctophids is not anticipated to be significant (CEQA standards).

The potential direct, indirect, and cumulative impacts of the proposed project on these prey species are discussed in the following sections of this EIS/EIR: invertebrates and plankton, Section 4.3.2.3; odontocetes, Section 4.3.1.2, and sea turtles, Section 4.3.2.1. These sections supplement this discussion of the potential indirect impacts of the proposed project on fish.

The potential direct and indirect effects of the alternatives on fish are summarized in Table 4.1-1.

4.3.2.2.2 Potential Cumulative Effects on Fish

Activities that could potentially be considered to interact cumulativly to affect fish species off the central coast of California 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 MMRP-related activities that could potentially cumulate with the source transmissions: 1) aerial visual and acoustic surveys/observations, 2) shipboard visual and acoustic surveys/observations, 3) shipboard photo-identification activities, 4) shipboard translocation of tagged elephant seals.

Since the level of ambient noise produced by endemic activities cannot be changed, any potential cumulative effects caused by the addition of ATOC 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 ATOC sound transmissions. Any potential for increases of commercial fishing in the area are speculative. As discussed in this EIS/EIR, 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.

Table 4.1-1 summarizes the potential cumulative effects of the alternatives on fish.

4.3.2.2.3 Summary and Conclusions Concerning the Potential Effects on Fish

This section summarizes the information presented in the previous sections on potential effects and significance of the ATOC source operations and MMRP on fish. Where there is no potential effect or no likely effect, even from maximum potential exposures, the project is considered not to have impacts.

There is potential for auditory injury for individuals of any species of fish located where received levels are at or above 180 dB (Hastings, 1991), which equates to a radius of about 8 m around the source. However, given the fact that the 5-min ramp-up period may allow sufficient time for fish to depart the area prior to onset of the main transmission, and the small volume involved for the 180-195 dB level, impacts on fish populations should be minimal. The possibility of masking must be stated as uncertain, due to the lack of available data, but is expected to be minimal. In addition, most pelagic species should be far enough away from the proposed source site that they should experience no impacts from the source transmissions. Similarly, those species inhabiting the areas below the depth of the source (i.e., >980 m) should receive less exposure.

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 ATOC low frequency 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 ATOC source emanations would wane over a period of time, given that it would generate more constant transmission characteristics, at duty cycles (transmission periods) of 2%-8%. Based on available data, there is the potential for masking low frequency sound used by sharks; although, at a 2% duty cycle, it is anticipated that such masking would be minor and temporary.

It is likely that some fish inhabiting the continental shelf are able to hear low frequency sounds. They have been observed to move away from fishing boats which generate a high level of low frequency noise, but the effect is short-lived. From the fact that California has a thriving commercial fishing industry, harvesting many of the species in the general study area, it could be speculated that these fish probably do not experience any permanent negative impacts due to low frequency sound from fishing boats.

Generally, the impacts are expected to be about the same at each of the alternate project sites, with the exception of the autonomous source. Open ocean species inhabiting the depth of the sound channel would be expected to receive more exposure in the immediate vicinity of an autonomous moored source than they would from any of the alternate sites closer to shore (although the source could possibly be placed in an area devoid of myctophids). Also, species inhabiting the continental slope would receive slightly higher levels of exposure from the Sur Slope site than from other alternate sites.

It should be noted that despite the small spatial area of potential influence around the ATOC source, there could be a large temporal component; i.e., fish exposed to the ATOC sounds at time "t" may not be the same fish exposed at time "t+1". Thus, although the number of fish affected at any one time may be small, over a long period of time, the proportion of fish in a population exposed to the source could be relatively large.

Table 4.1-1 summarizes the potential direct and indirect effects, and potential cumulative effects of the alternatives on fish species. Given the large number of species, the lack of quantifiable, calibrated information for many species, and the general lack of significant impacts, no species-by-species table of potential impacts is presented for fish.

4.3.2.3 Invertebrates

Hawkins and Myrberg (1983) conclude that some sound-producing invertebrates are capable of communicating with each other; although the significance of such interactions is unclear, and overall little is known about the importance of sound communication in invertebrates. Further, there is minimal experimental evidence of sound reception in invertebrate species. However, some information exists for sound reception in three crustaceans, including the American lobster (*Homarus americanus*), a crayfish (*Cherax destructor*), and brown shrimp (*Crangon crangon*), as discussed below.

Invertebrates are important food sources for many of the other species discussed in this EIS/EIR. For example, many invertebrate and fish species forming the deep scattering layer are the prey of sea turtles, other fish, and mysticetes; crustaceans are preyed upon by sperm whales and olive ridley sea turtles; shellfish are eaten by sea otters and loggerhead sea turtles; crabs are the prey of loggerhead sea turtles and various sea lions and seals; squid is an important food source for many odontocetes, as well as sea lions and seals; and octopi are eaten by pygmy sperm whales, dwarf sperm whales and elephant seals. The following sections on invertebrates also constitute a discussion of the potential indirect impacts on these predator species.

4.3.2.3.1 Potential Direct and Indirect Effects on Invertebrates

• Hearing capabilities and sound production of invertebrates: There is experimental confirmation of a sense of hearing in at least one invertebrate, the American lobster, and its audiogram at the ATOC frequency of 75 Hz indicates a hearing threshold value of 120 dB (meaning extremely low sensitivity) (see below). Despite a general lack of experimental evidence for hearing, Pumphrey (1950), Frings and Frings (1964, 1967), Budelmann (1992) and others have suggested that sound reception may be possible among aquatic invertebrates. The suggested acoustic receptors have been many and varied but predominant among them are the following:

- Flow detectors (superficial hydrodynamic receptors)
- Statocysts (internal receptors)
- Chordotonal organs (associated with joints of flexible body appendages)

Flow detectors include sensory cilia, either naked or embedded within a gelatinous cupula projecting into the water, or situated in pits on the body surface, as well as a great variety of other hair-like and fan-like projections from the cuticle, often articulated at the base and connected to the dendrites of sensory cells. Most are considered prime candidates as receivers of water-borne vibration because they are highly sensitive to mechanical deformation, and are in close contact with the surrounding water. The effectiveness of these cutaneous receptors in detecting purely local water movements is evident. Tautz and Sandeman (1980) have stressed that quite short sensory hairs can be effective flow detectors in water. Pumphrey (1950), Harris and van Bergeijk (1962), and Siler (1969) have all stated that low frequency vibrating objects in water show a near-field effect, and although the magnitude of propagated back-and-forth motion is extremely low at a distance, there is a steep increase in amplitude close to the source, which may serve to stimulate an appropriate detector.

Whether these various water-flow receptors are true sound detectors is difficult to answer. Although the organs concerned can detect oscillatory movements, there is still doubt as to whether they are sufficiently sensitive to detect the exceedingly low amplitude water movements found in the far field of the ATOC sound source. Weise (1976), investigating the telson hairs of the crustacean *Procambarus clarkii*, calculated a particle displacement amplitude at a threshold of 0.1 μm (1 μm or micrometer is equivalent to 0.000001 m) at 100 Hz, while Tautz and Sandemen (1980) have directly measured a threshold of 0.6 μm at 100 Hz for the sensory hairs on the chelae of the crayfish *Cherax destructor*. These thresholds would seem to fall far short of the sensitivity necessary in an auditory receptor. To put these figures in perspective, Offutt (1970) claimed a sensitivity threshold of 8.1×10^{-4} μm at 75 Hz for the American lobster. Moreover, fish responding to underwater sounds show calculated displacement amplitudes at the otolith organs of 0.5×10^{-4} μm at 75 Hz for cod (Chapman and Hawkins, 1973), and 3.0×10^{-4} μm at 75 Hz for salmon (Hawkins and Johnstone, 1978). Based on this differential of more than four orders of magnitude, it can be concluded that the water motion detectors of aquatic invertebrates do not approach the sensitivity of fish.

Another type of organ suggested as an auditory receptor is the statocyst, which may be more suitable for the purpose. A statocyst is an organ consisting of a fluid-filled sac which helps indicate position when the animal moves. Unloaded cilia or sensory hairs are almost certainly acoustically transparent, and though they may respond to bulk movements of water that impinge directly on them, sound waves will tend to propagate through them. However, in the statocyst organ, one end of the sensory cilia is often anchored to a mass of sand or calcareous material which has a much higher impedance than the surrounding water. This dense mass tends to remain stationary, while the body tissues move back and forth deforming or shearing the sensory hairs. This form of statocyst reception would pertain mostly to protozoan species (e.g., ciliates and free-swimming tintinnids), and not invertebrates, and probably only peripherally to cephalapods.

It is by no means apparent that the statocyst serves an acoustical function. Any sensory organ loaded with a dense mass will not only respond to sound but will inevitably also suffer deformation under the action of gravity, and linear and angular accelerations. The statocyst likely serves an equilibrium function, and any auditory function may be secondary (Schone, 1971). Although both Pumphrey (1950) and Horridge (1971) suggest that statocysts evolved from stiff cilia which were originally vibration receptors, and that the response to gravity and acceleration is a by-product of an improvement in hearing, there is little experimental support for this view. Some evidence which may indicate an acoustic function is an early paper by Cohen (1955) on the lobster, in which he reported that the statocyst responded to vibrations of the substrate, but the animal exhibited no response to a tuning fork immersed in the water.

Recent literature (Budelmann, 1992) states that statocysts of cephalopods include angular, as well as equilibrium and gravity receptor systems, and because of the latter's gross morphology as linear accelerometers, they should not be categorically excluded as acoustic particle detectors and thus could be involved in underwater hearing as well. However, experiments conducted by M. Clarke (pers. comm., 1993) involving the detonation of dynamite near living captive squid produced no reaction from the squid, suggesting that cephalopods are deaf. There are apparently no other measurements of noise-induced effects on cephalopods. Pertinent data on other invertebrates are addressed below.

A chordotonal organ with two sets of sensory cells has been described in the basal segment of the antennal flagellum of the hermit crab (*Petrochirus*) (Taylor, 1967) and comparable organs exist on the large and small antenna of spiny lobster (*Panulirus marginatus*) (Laverack, 1964; Hartman and Austin, 1972; Rossi-Durand and Vedel, 1982). An extremely sensitive system that is associated with intersegmental joints of the flagellum of the first and second antenna has been described for a crayfish (*Astacus*) (Tautz et al., 1981; Bender et al., 1984). In water, these appendages easily follow an oscillation of the water column surrounding it, whereby they stimulate the chordotonal sensory cells. To date, no experimental measurements have been carried out to quantify the relationship between underwater acoustic pressure and sound threshold levels of chordotonal organs.

Many aquatic invertebrates can generate sound (Hawkins and Myrberg, 1983). Some of these sound producers have been identified, particularly those that contribute substantially to the level of the ambient noise in the ocean. However, little information is available on the importance of sound communication to invertebrate fauna. Most research emphasis has been on the determination of the various sound sources and their sound-producing mechanisms. Among the crustacean sound producers are the barnacles, Balanidae (Busnel and Dziedzic, 1962; Fish, 1964); decapods like the spiny lobsters, Palinuridae (*Palinurus*) (Dijkgraaf, 1955; Moulton, 1957); prawns of the families Palaemonidae and Penaeidae; snapping shrimps of the family Alpheidae (Johnston et al., 1947; Hazlett and Winn, 1962; Fish, 1964); mantis shrimp, *Gonodactylus* (Hazlett and Winn, 1962); and brachyuran and anomuran crabs. Among the molluscs, the common mussel *Mytilus* produces a crackling sound, while squid emit a popping sound (Iversen et al., 1963). Of the echinoderms, some sea urchins produce a "frying" sound (Fish, 1964).

Some of the invertebrate sound producers have no clearly defined vocal organs, and may well be making noise incidentally while performing other natural activities. However, some crustaceans make sounds by mechanisms that have no obvious alternative function. For example, spiny lobsters have a pair of stridulating organs capable of producing a grating or creaking sound, each composed of a series of fine parallel ridges lining a hollow surface on the base of the second antenna. By raising both antennae, the ridges are rubbed along the edge of the rostrum, producing a loud creak (Hawkins and Myrberg, 1983). The provision of this specialized mechanism provides strong evidence that these sounds may serve a communication function (Moulton, 1957).

The sharp, explosive click, or pop, produced by various species of snapping shrimp is generated by a plunger mechanism on the enlarged claw (Johnston et al., 1947). The shrimps' habit of snapping may be associated with defensive and offensive activities, or serve to frighten away predators. However, occasionally snaps are produced spontaneously by undisturbed animals, and are combined with the snapping of other individuals within a large population.

Hawkins and Myrberg (1983) conclude that at least some of the sound-producing invertebrates are capable of communicating with one another, although the significance of their behavior is unclear at this time. Although the sounds generated are impulsive, and therefore contain a wide spread of frequencies, it is likely that only the lowest frequency components are detected by the animals themselves.

• Potential for Physical Auditory or Behavioral Effects:

Experiments with bivalve molluscs, such as clams and mussels, have shown a wide range of cuticular hair organs which are sensitive to oscillatory motion of the water (Laverack, 1962a,b; Tazaki and Obnishi, 1974; Vedel and Clarac, 1976; Weise, 1976; Tautz and Sandeman, 1980). However, researchers still question whether these various water-flow receptors are true sound detectors, and whether they are sensitive enough to detect low amplitude water movements produced by a sound source. Threshold levels seem to fall short of the sensitivity necessary for auditory reception (Hawkins and Myrberg, 1983). Therefore, no physical auditory or behavioral impacts on bivalves would be expected from ATOC source transmissions.

Branscomb and Rittschof (1984) reported that the cyprid larvae of at least one species of barnacle (*Balanus amphitrite*) were inhibited from settling onto structures "protected" by specific low frequency vibrations. Less than 1% of 0-day cyprids settled in the presence of such vibration. Although settlement on the protected surfaces increased with older and apparently less-discriminating larvae, the percentage of metamorphosis was significantly reduced for up to 13 days. Larvae that were prevented from settling merely attached themselves elsewhere. Most interesting were the frequency discriminations noted: 30 Hz signals evoked far superior protection than 15 or 45 Hz. Branscomb and Rittschof believe that such specificity may be due to the adaptive recognition of vibrations produced by natural predators of these larvae.

Offutt (1970) was able to condition the heartbeat of an American lobster to sounds in the frequency range of 10-150 Hz (Figure 4.3.2.3-1 shows the best frequency reception at about 75 Hz, with threshold levels above 120 dB). However, later studies by Hawkins (unpub.) have failed to demonstrate similar abilities in the European lobster.

The only true lobster species in the study area is the Pacific spiny lobster (*Panulirus interruptus*), which does not inhabit depths below 200 m (the ATOC 120 dB sound field shoreward limitation is well seaward of the 200 m bottom contour). Thus, these animals should

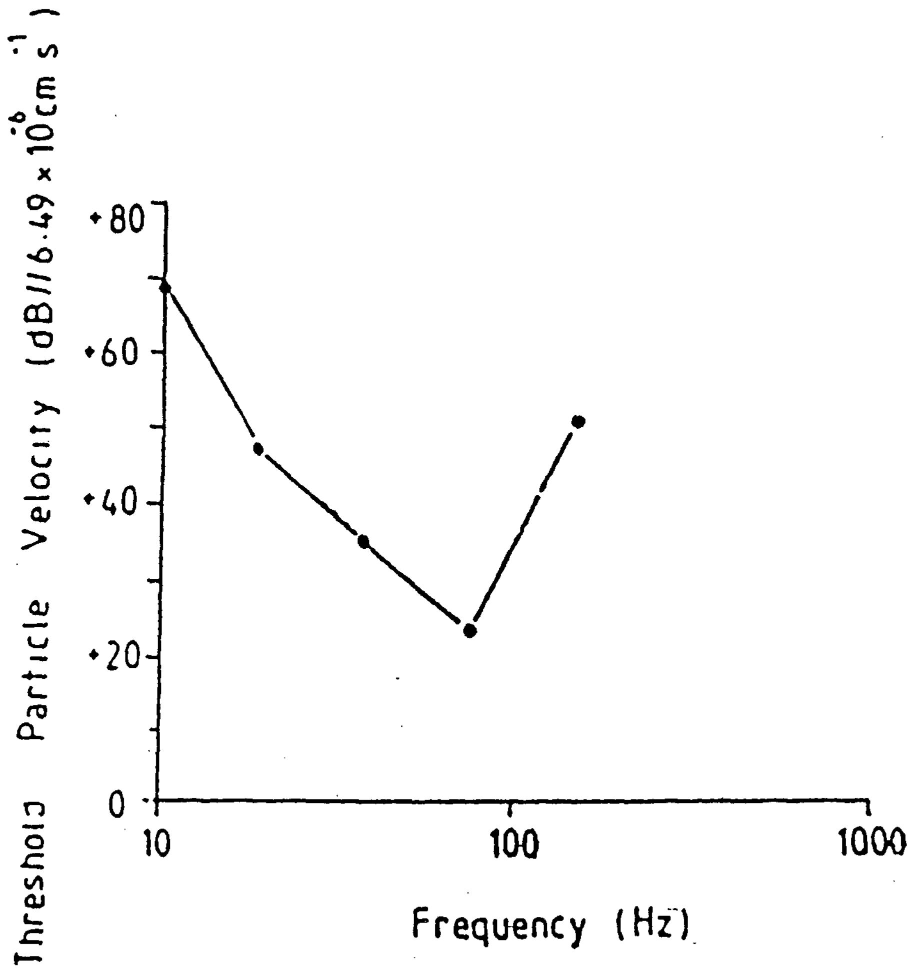


Figure 4.3.2.3-1 Audiogram of the American lobster, Homarus americanus Thresholds are expressed in terms of particle velocity, which corresonds to a sound pressure of 1 microbar in the far field. Add 100 dB to convert to 1 microPascal at 1 m (from Offutt, 1970).

not be subject to sound fields above their threshold and should not be affected by acoustic source transmissions.

Lagardere (1982) reports that several small populations of the brown shrimp (*Crangon crangon*) were reared in sound-proof containers with acoustical noise conditions measured in the 5-1000 Hz band (noise levels of 100 dB on average) similar to those prevailing in their natural environment. Additionally, several similar sized populations were held in non-sound-proofed containers that were acoustically louder by about 30 dB in the 25-400 Hz range (i.e., about 130 dB), and about 20 dB louder in the 400-1000 Hz range. After the experimental period of two months, those shrimp reared under the permanently high sound level were shown to have grown significantly less than those held under the quieter conditions, and their reproductive rate was also significantly reduced from that shown by the animals kept under the quieter conditions. To a lesser degree, the higher noise level also appeared to increase aggression and mortality, while decreasing food intake. Previous work on peneid shrimp has shown that when conditions affect both food intake and metabolic rate, as apparently occurred in the case of the shrimp held under the noisy conditions, lipid reserves are reduced (Myrberg, 1990). This leads to polyunsaturated fatty acid deficiency with subsequent slowing of ovarian maturation.

The above-mentioned studies suggest that noise may impact the production levels of certain shrimp species. Figures of sound field estimates in Section 2 illustrate the relatively small area in which ATOC sound transmissions reach the 130 dB level ($\leq$5 km radius). Furthermore, this level would only be attained a maximum of 8% of the time; whereas, Lagardere's study involved continuous sound transmission for two straight months--and the species tested were confined and unable to depart the area of the noise source. On an Leq basis, the 130 dB sound field is a 300 m radius around the source. Given the numerous differences in the conditions of the brown shrimp tests vs. the conditions expected for the ATOC project, the potential for adverse physical or behavioral impact on shrimps from ATOC source transmissions is considered unlikely, although this cannot be definitively stated.

The best evidence for low frequency sound detection in cephalopods is for octopus, cuttlefish, and squid (Karlsen et al., 1989; Packard et al., 1990). Classical conditioning in a standing-wave acoustic tube showed that cephalopods respond to particle motion rather than to the pressure of sound, and that they can be trained to stimuli below 100 Hz, with best results in the range of 1-3 Hz (Budelmann, 1992). *Octopus vulgaris* displays response to particle acceleration on the order of 0.0014 m/sec^2 at 3 Hz, but only 0.16 m/sec^2 at 75 Hz--a decrease in sensitivity of over two orders of magnitude (Packard et al., 1990). A decapod cephalopod (*Sepia officinalis*) exhibits almost the same thresholds to low frequency sounds, except that its best frequency appears to be about 1 Hz (0.00125 m/sec^2), and at 75 Hz it falls off to 0.16 m/sec^2--again, a decrease in sensitivity of over two orders of magnitude (Packard et al., 1990).

Minor decreases in shrimp productivity are possible, but would would be expected to affect only a small part of the range of the shrimp (within at most 5 km of the source).

• Potential for long-term effects: Virtually no scientific data appear to exist on the possible long-term effects that low frequency sound transmissions could have on invertebrates.

Indeed, very few data are available on the true method of sound reception by individual invertebrate species; limited information is available from such scientific researchers as Sandeman and Okajima, 1973; Tautz and Tautz, 1983; Yoshino et al., 1983; Roye, 1986; and Budelmann, 1992. If invertebrates do react to noise from human activities by reduced use of certain areas, there presently are insufficient reliable and systematic data with which to document any positive or negative trend.

• Potential for indirect effects: Indirect effects include those effects that could potentially 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 could ultimately impact invertebrates as predator or prey in the vicinity of the study area.

Potential indirect effects to pelagic and benthic invertebrates could include changes in the distribution and abundance of species that serve as prey for fish and other invertebrates, or that function as predators of invertebrates. Benthic invertebrates, particularly infauna, serve as a primary food source for many species of bottom-dwelling fish and epifaunal invertebrates. Similarly, many pelagic invertebrates, including numerous species that occur in the DSL (such as euphausiid shrimp), are important prey items for pelagic fish, marine mammals, seabirds, sea turtles, and other invertebrates. However, because there are no known benthic or pelagic invertebrates of significant distribution within the potential ATOC sound field, and because of the planned ramp-up period (expected to be beneficial to some, but not all invertebrates [i.e., those that are non-mobile or move very slowly and are located within 8 m of the source]), and limited duty cycle, it is unlikely that there would be impacts on invertebrates (as predators or as prey for other species) from the proposed action.

The potential direct and indirect effects on invertebrates are summarized in Table 4.1-1

4.3.2.3.2 Potential Cumulative Effects on Invertebrates

Activities that could potentially be considered to interact in a cumulative sense to affect invertebrate species in the study area off the central California coast include noise-generating activities: merchant shipping, commercial fishing, recreational water sports, marine and nearshore construction, and resort operations. The discussions below also account for MMRP-related activities that could potentially cumulate with the source transmissions: 1) aerial visual and acoustic surveys/observations, 2) shipboard visual and acoustic surveys/observations, 3) shipboard photo-identification activities, 4) shipboard translocation of tagged elephant seals.

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 ATOC sound transmissions. As discussed in this EIS/EIR, direct impacts to most marine invertebrate species are considered to be unlikely. No major impacts on invertebrate populations are anticipated when the current project is added to other cumulative effects in the environment.

Table 4.1-1 summarizes the potential cumulative effects of the alternatives on invertebrates.

4.3.2.3.3 Summary and Conclusions Concerning the Potential Effects on Invertebrates

This section summarizes the information presented in the previous sections regarding the potential effects of the ATOC source operations and MMRP on invertebrates. Where there is no potential effect or no likely effect even from maximum potential exposures, the project is considered not to have impacts on that species. It should be reemphasized that there is minimal experimental evidence of sound reception in invertebrate species.

No direct auditory injury or deafness are anticipated for any species of invertebrate. There is minimal evidence that marine invertebrates are capable of hearing or intentionally producing sounds; no hearing organs or vocal organs have been identified for most species. One exception is the lobster which research indicates is able to perceive low frequency sound, but only at very high volumes. Since lobsters are not found in water deeper than 200 m, they would not be exposed to sounds loud enough for them to hear.

Research has found that certain shrimp species are less productive when exposed to continuous high sound levels. Shrimp are found both on the seafloor and in the DSL. They provide an important source of food for many larger species of fish and marine mammals. The DSL moves vertically within the ocean, ranging from about 500 m during the day, and migrating to near the surface at night. A small portion of the DSL which happens to be within 480 m of the source during the 2-8% of the time it is transmitting, could be exposed to relatively high sound levels (about 142 dB). However, given the intermittent nature of the transmissions, and the small part of the range of the shrimp exposed, the impacts on shrimp populations are not expected to be significant.

Generally, there is no difference between any of the alternate sites, except the autonomous source, which would be placed in among somewhat different (open ocean rather than shelf and slope) invertebrate communities. Since direct impacts on most invertebrates are considered to be unlikely, the difference in sites is presumed to be inconsequential.

Table 4.1-1 summarizes the potential direct and indirect effects, and potential cumulative effects of the alternatives on invertebrates. Given the large number of species, the lack of quantifiable, calibrated information for most species, and general lack of major impacts, no species-by-species table of potential impacts is presented for invertebrates. However, commercially-taken invertebrates (e.g., squid and octopus) would be monitored, to the extent practicable and feasible, via stock assessments (with fish species; see Section 4.3.2.2.1) to attempt evaluation of the potential for increased predation on invertebrates or changes in their reproductive output.

4.3.2.4 Plankton

Zoolankton are addressed primarily because some of their species make up the DSL. As night approaches, these layers rise and become more diffuse, forming again at dawn. In the northern latitudes, where the DSLs are most pronounced, three fairly well-defined layers are often formed. The deepest is at about 500 m, composed mostly of small myctophid fishes (see Section 4.3.2.2 for discussion of potential effects on this fish species); the second at 400-500 m, made up mostly of zooplankton, such as copepods (e.g., *Calanus, Neocalanus, Eucalanus, Acartia*) and krill (e.g., *Thysanopoda, Meganyctiphanes*), and euphausiid shrimps (e.g., *Euphausia pacifica/mutica/recurva*); and an upper stratum, at 300-400 m made up primarily of shrimps (e.g., *Sergestes, Gnathophausia*) (McConnaughey, 1970).

The species discussed below are important food sources for many of the other species discussed in this EIS/EIR. For example, many zooplankton species forming the DSL are the prey of sea turtles, fish, and mysticetes. The following sections on the direct, indirect, and cumulative impacts of the proposed action on plankton, therefore, also constitute a discussion of the potential indirect impacts on these predator species.

4.3.2.4.1 Potential Direct and Indirect Effects on Plankton

Copepods comprise the bulk of the zooplankton in the world's oceans. In both numbers of individuals and numbers of species they exceed all the rest of the metazoan plankton combined, and are a key group in the economy of the seas. The free-floating/swimming copepods are usually very small, ranging from 0.2 mm to about 2 cm in length. Copepods of genera *Calanus, Neocalanus, Eucalanus, and Acartia* are widespread in the study area. The greatest swarms of copepods are commonly found in colder waters; however, they do occur in warmer waters, often just as numerous as some of the species characteristic of and limited to warmer regions. No known studies have been completed on the potential impact of low frequency sound transmissions on copepods. Therefore, the reader is referred to the comments made above concerning crustaceans in general.

In summary, no direct short-term impacts to zooplankton are anticipated. Any impact on planktonic abundance in the DSL is likely to be less than comparable effects from indigenous sound sources.

No scientific data are available on the potential for long-term or indirect effects of low frequency sound on zooplankton. However, any change in the status of DSL predators could indirectly affect the planktonic species that make up the DSL. The potential for this occurring is addressed in other sections of this EIS/EIR.

4.3.2.4.2 Potential Cumulative Effects on Plankton

Section 4.3.2.3.2, potential cumulative effects on invertebrates, also pertains to zooplankton (particularly copepods). No cumulative impacts are anticipated.

4.3.2.4.3 Summary and Conclusions Concerning the Potential Effects on Plankton

This section summarizes information on the potential effect of the ATOC source operations and MMRP on zooplankton. Where there is no potential effect or no likely effect, even from maximum potential exposures, the project is considered not to have impacts on that species.

No direct auditory injury or deafness are anticipated for any species of zooplankton. There is no direct evidence that zooplankton are actually capable of sound discrimination or intentionally producing sounds; no hearing organs or vocal organs have been identified for those species studied. Therefore, for most species, it appears that no impacts would occur.

Zooplankton are distributed widely throughout the DSL, which provides an important source of food for many larger species of fish and marine mammals. The DSL moves vertically within the ocean, ranging from 400-500 m during the day, and migrating to near the surface at night. Therefore, during the day there is at least a 300 m buffer zone between the zooplankton in the DSL and the 150 dB sound field (500 m depth for the DSL, 800 m to the 150 dB sound field). During nighttime, when the DSL migrates toward the surface, the buffer zone expands to up to 700 m. This, plus the intermittent nature of the transmissions, and the small portion of zooplankton populations exposed (particularly copepods), leads to the conclusion that any impacts are expected to be negligible.

Generally, there is no difference between any of the alternate sites, except the autonomous source, which would be placed in among somewhat different (open ocean rather than shelf and slope) zooplankton communities. Since impacts on most planktonic species are anticipated to be negligible, this difference is presumed to be inconsequential.

Table 4.1-1 summarizes the potential direct and indirect effects, and potential cumulative effects of the alternatives on zooplankton (particularly copepods). Given the large number of species, the lack of quantifiable, calibrated information for most species, and the general lack of significant impacts anticipated, no species-by-species table of potential impacts is presented for plankton.

4.3.2.5 Seabirds

Section 3 lists the species of seabirds that can be expected to be found off the central California coast. Marine birds are of two types: those that spend most of their time near shore, and those that remain at sea, approaching land only during breeding season. Shore birds and those seabirds that spend most of their time feeding in the coast and nearshore zones, and do not commonly plunge dive, can be considered to be unaffected by any acoustic source transmissions. Those marine birds which remain offshore during most of the year, and do not dive below the surface to forage for food are also unlikely to be affected by either the MMRP activities or ATOC source sound transmissions. The seabirds that would appear to be most susceptible are those species that dive. There are fifteen species that perform this feat that could possibly inhabit the study area.

4.3.2.5.1 Potential Direct and Indirect Effects on Seabirds

• Hearing capability of seabirds: Dooling (1978) summarizes psychophysical investigations of hearing in a number of avian species during the 1968-1978 timeframe. He notes that behavioral measurements of absolute auditory sensitivity in a wide variety of birds show a region of maximum sensitivity between 1 and 5 kHz. On the basis of this general measure, birds fall between two other major vertebrate groups: reptiles and mammals, but avian hearing performance is clearly inferior to that for mammals above and below the 1-5 kHz range of frequencies. Possible exceptions to this general picture include the oilbird (*Steatornis caripensis*) and growing evidence that some pigeon species (*Columba spp.*) are sensitive to infrasound at moderate intensity levels. Neither of these avian species inhabit the central California offshore area.

Fay (1988) states that the outer ear of birds includes a feather-covered external canal, with no pinna, as it is usually conceived. The feathers covering the external canal seem to be specially adapted for minimizing air turbulence (and thus noise) during flight. Fay goes on to discuss the bird middle ear, which is similar to those of amphibians and reptiles, in that it has a single major ossicle, the columella or stapes. The efficiency and frequency response of bird ears is not unlike that of mammals below about 2 kHz. Fay notes that the inner ear of birds includes a cochlea, in addition to an associated lagena, and the vestibular saccule, utricle, and semi-circular canal cristae. The function of the lagena is not known, but may serve as a very low frequency sound detector. The cochlea is elongated and slightly "bent," similar to the auditory papillae of some reptiles. A cross-section of the bird basilar membrane and papilla shows many rows of hair cells which vary in height across the membrane. Fay says that there is, as yet, no clear evidence for a classification of inner and outer hair cells as there is among mammals.

Audiograms in air for about 22 different bird species show their best sensitivity to be in the frequency range of 1-3 kHz as shown in figure 4.3.2.5.1-1. Among the 22 audiograms available, the species that would be most closely related to seabirds is a mallard duck, which had a hearing threshold in air of about 70 db re 20 μPa at 75 Hz (extrapolated) (Trainer, 1946). Applying the formula for conversion of sound pressure level from air to water, albeit a speculative technique in this case, the duck's threshold would be 131.7 dB re 1 μPa.

• Potential for physical auditory effects: Seabirds that forage for food at sea by plunging or diving beneath the surface would be more likely impacted than surface feeders. Seabirds that perch or hover at the surface but do not plunge dive are obviously less at risk, and the potential for any significant number of these animals to be on the water's surface within the 130 dB sound field (see Section 2) during acoustic transmission is very low. Any seabirds in the area could fly away if they detected and were annoyed by the 5 min ramp-up sound prior to the main signal transmission.

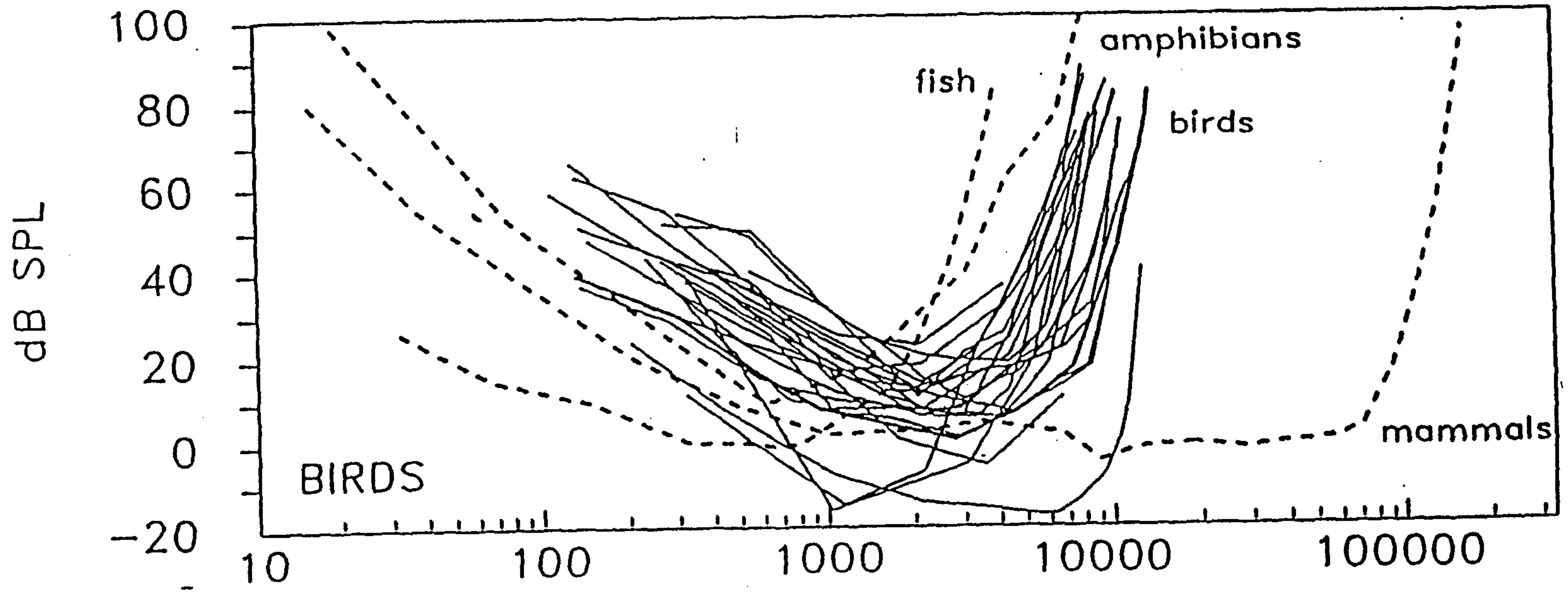


Figure 4.3.2.5.1-1 **Available valid bird audiograms**
Heavy line encloses threshold points, excluding about 10% of the lowest thresholds, providing a reasonable envelope for the hearing range of birds.
(From Fay, 1988)

Using the mallard duck's audiogram measurements as a rough order-of-magnitude example, its underwater hearing threshold equates to a sound field of only 0.00073 km^2 area around the source site within which the seabird would have to be located (with its head below the surface) to hear the signal during source transmission. Therefore, any impacts are anticipated to be negligible. If a seabird's threshold is lower than the example given, the sound field area would expand proportionally.

Because of the lack of audiometric data that is directly relatable to seabirds, another way to attempt to ascertain the potential impact of the acoustic source transmissions on deep-diving seabirds is the conversion of known safe underwater explosion thresholds to sound pressure levels that can be related to the ATOC sound field parameters, although it should be emphasized that the criteria of Yelverton et al. (1973) apply to sharp shock-wave pulses. Yelverton calculated the safe underwater explosion thresholds for seabirds to be the following:

- Seabirds on the surface: 30 psi-msec
- Seabirds diving below the surface: 20 psi-msec

In converting to decibels, numerical calculations yield the relationship [1 psi-msec = 6.895 Pa-sec], given the assumption that explosive source level units are Pa-sec, and spherical spreading is used for transmission loss. It can be derived from these values that an acoustic transmission of 195 dB source level attenuates to below 15 psi-msec within 100 m range from the source. Therefore, with the ATOC source at 850 m depth, no seabirds, either on the surface or during a dive, would ever be subjected to received levels near 20 psi-msec.

Based on the above information, it is anticipated that any effects on seabirds, either directly or indirectly, as a result of MMRP activities or acoustic transmissions, would be negligible.

4.3.2.4.2 Potential Cumulative Effects on Seabirds

Activities that could potentially be considered to interact in a cumulative sense to affect seabird species in the region off the central California coast include noise-generating activities: e.g., merchant shipping, commercial fishing, recreational water sports, marine and nearshore construction and resort operations.

Noise increases from other potential future sources are speculative; there are no known projects or trends that would have noise impacts cumulating with the ATOC sound transmissions. As discussed in this EIS/EIR, direct impacts on most marine animals are expected to range from uncertain to negligible. No significant impacts are anticipated when the current project is added to other cumulative changes in the environment.

Since the potential for direct impacts on seabirds is anticipated to be negligible, and given the speculative nature of any increase in other noise sources, any cumulative impact on seabirds is anticipated to be negligible.

4.3.2.4.3 Summary and Conclusions Concerning the Potential Effects on Seabirds

This section summarizes the information regarding potential effects of the ATOC source operations and MMRP on seabirds. Where there is no potential effect or no likely effect even from maximum potential exposures, the project is considered not to have significant impacts on that species

No significant adverse effects are anticipated for any species of seabird. Research data on a mallard duck suggests that [seabirds] do not hear low frequency sounds well, which supports the premise that the source transmissions should produce negligible impacts on seabirds.

Because the relevant factors are similar at each of the alternate sites, negligible impacts would be expected at all of them.

Table 4.1-1 summarizes the potential direct and indirect effects, and potential cumulative effects on seabirds. Given the large number of species, the lack of quantifiable, calibrated information for most species, and the general lack of significant impacts, no species-by-species table of potential impacts is presented for seabirds.

4.3.2.6 Threatened, Endangered and Special Status Species

Table 3.3.7-1 lists all twenty of the threatened, endangered, or special status marine species that could occur offshore from the central California coast. All five mysticetes (blue, fin, sei, humpback, and right whales) are addressed in Section 4.3.1.1. The one odontocete (sperm whale) is addressed in Section 4.3.1.2. The three pinnipeds (northern fur seal, Guadalupe fur seal, and Steller sea lion) and the one fissiped (southern sea otter) are addressed in Section 4.3.1.3. The four sea turtles (leatherback, green, olive ridley and loggerhead) are addressed in Section 4.3.2.1. Three of the birds (California brown pelican, short-tailed albatross, and marbled mullet) are addressed in Section 4.3.2.5. The western snowy plover is addressed in Section 4.3.2.8.

The peregrine falcon, which is not classified as a seabird, is included in the listing because they prey upon a number of the seabird species and thus would be affected indirectly if the latter would be affected adversely by the ATOC sound transmissions, the MMRP activities, or the cable runs from source to shore. Section 4.3.2.5 concludes that the potential for any impacts on seabirds is negligible.

Major producers of chinook salmon are Puget Sound streams in Washington, the Columbia River, the Umpqua and Rogue Rivers in Oregon, and the Klamath and Sacramento Rivers of California (NOAA, 1993). Production of chinook salmon tends to fluctuate widely due to varying escapement and ocean survival. Environmental conditions, such as El Niño, tend to depress abundance. Some stocks are severely depressed, including the Sacramento River winter-run chinook salmon (*Oncorhynchus tshawytscha*). Two factors indicate that there should be minimal, if any, impact from the ATOC project or MMRP activities on this species:

- chinook salmon are considered a "non-specialist" relative to hearing capability, with an estimated sound pressure detection threshold at 75 Hz of approximately 105 dB (Hawkins and Johnstone, 1978),

- based on analyses in previous sections, chinook salmon's primary oceanic habitat area is generally located to the north of the proposed action site in the northeast Pacific fishing area (southern boundary established at 40 deg N by the Food and Agricultural Organization [FAO], 1988); although they are known to occur in the study area.

Table 4.1-1 summarizes the potential effects of the proposed source transmissions on these species.

4.3.2.7 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 are addressed throughout this EIS/EIR and include the following:

- Monterey Bay National Marine Sanctuary (see Section 1 chart).
- Gulf of the Farallones National Marine Sanctuary (including the Farallon Island National Wildlife Refuge, the Farallon Island Game Refuge, and Areas of Special Biological Significance [ASBS]) (see Section 3 chart).

Nearshore areas in general are addressed in Section 4.3.2.8. Specific areas include the following (see Section 3 map):

- Pt. Lobos Ecological Reserve
- Carmel Bay Ecological Reserve
- California Sea Otter Game Refuge
- Julia Pfeiffer Burns State Park
- Hopkins Marine Life Refuge
- Pacific Grove Marine Gardens Fish Refuge
- Golden Gate National Recreation Area
- James V. Fitzgerald Marine Reserve

These areas are all so close to shore (where the ATOC sound fields are so attenuated due to upslope acoustic interference and cancellation from bottom and surface interactions) that minimal, if any, impacts are anticipated on species found therein, due to ATOC or MMRP activities.

4.3.2.8 Nearshore and Landfall Biota

Section 3 lists the species that could be expected to inhabit the region along the cable routes (for Sur Ridge, Sur Slope and Pioneer Seamount) in the shallow subtidal zone (area between the low tide level and 20 m depth), the intertidal zone (area between low and high tide), and the terrestrial (onshore) area. The potential effects of low frequency sound on marine mammals (particularly the southern sea otter in this area), sea turtles (particularly the green sea turtle in this area), fish, invertebrates, plankton, and seabirds have been addressed in previous sections. Given the lack of significant benthic biota at depths >20 m that could be affected due to cable and source installation, this subsection focuses on the nearshore zone. Since ATOC source transmissions should have no effect on marine plant or animal species in nearshore water depths <20 m, attention can be directed toward any possible impact the cable itself may have on biota along its route, up onto the shore.

4.3.2.8.1 Potential Direct and Indirect Effects on Nearshore and Landfall Biota

In the shallow subtidal zone, kelp bed communities (particularly bull kelp and feather boa kelp) would only be affected if the cable happened to be laid across one or more of the plants themselves. Even if this were to occur, it would not likely have any permanent or long-range effects on this resource. Nonetheless, kelp forests and beds will be avoided during facility installations. Invertebrate communities, such as red abalone and various species of crabs and fish, such as rockfish, lingcod, surfperch, salmon, and halibut would not be affected by the cable, either during or after its installation. Most species would merely move away during installation and return thereafter.

In the intertidal habitats, red algae forms wiry clumps on the rocks, and coraline algae grows as rough encrusting shapes on rocks. Sea palms grow on rocks exposed to waves at low tide. Sea lettuce species are widespread along the California coast and are common on intertidal rocks in the study area. Surf grass is an unusual seagrass found in the study area; it lives on rocks exposed to wave action, and some species can be exposed at low tide. It is probably inevitable that the cable route will traverse one or more of these marine plant habitats, but it is unknown if such an intrusion will impact individual or groups of individual plants. In general, the overall impact of the cable on the marine plant species in the intertidal zone should be negligible. Likewise, mussels, snails, barnacles, limpets, and sea anemones that are expected to be found in this zone would only be affected during the actual laying of the cable, and then only if the cable happened to be laid over an animal. Once the cable is in place, the status of the intertidal biota would rapidly return to an environmental steady-state condition. Intertidal fish, such as sculpins and blennies, would be unaffected by the cable installation activities and subsequent operation.

The cable landfall for the Sur Ridge and Sur Slope alternatives is located at the site of existing U.S. Navy cables at Pt. Sur. Thus, it can be assumed that any seabird roosting sites (particularly for Brandt's cormorant, pelagic cormorant and western gulls) that might be affected would have been relocated long ago when the Navy cable was brought ashore. Birds that do not nest, but may spend time, in the area of Pt. Sur or Pillar Point (cable landfall for the Pioneer Seamount alternative), such as the black swift and the western snowy plover, would not be affected by the cable placement on land. Monarch butterflies that have been observed in trees near Pt. Sur would also be unaffected by the cable land crossing.

Plant species in the vicinity of Pt. Sur that have been addressed in Section 3 include locations of the rare Little Sur manzanita shrub. The cable landfall would be approximately 2 km away and thus would have no effect on this terrestrial plant. Other plants that could be expected in both the Pt. Sur and Pillar Point landfall sites include yellow bush lupine, wild buckwheat, coenothus and coyote brush, none of which are expected to be disturbed due to cable installation. Plant species indigenous to Pillar Point include Monterey cypress, coyote bush, foxtail barley and English plantain, all of which would be avoided during cable installation. Thus, there should be no effect on any plant life caused by the cable installation at either the Pt. Sur or the Pillar Point sites. Likewise, other birds (vultures, hawks, kites, jays, wrens, juncos) and mammals (e.g., coyotes, chipmunks and squirrels) that may be found at either site, should not be affected by either the installation or the operation of the cable on land. All species local to the onshore sites (Pt. Sur, Pillar Point) that are listed in the California Division of Fish and Game's Natural Diversity Database of 1993 have been evaluated, and none are expected to be affected by the execution of any of the alternatives proposed.

4.3.2.8.2 Potential Cumulative Effects on Nearshore and Landfall Biota

It is expected that the potential for cumulative impacts on nearshore and landfall biota due to the installation of the cable would be unlikely, given the lack of anticipated projects that would have impacts that could cumulate with this project and the lack of impacts from the project itself. In fact, the only known nearshore project that would have the potential to cumulate with ATOC activities in the area is the proposed bluff restoration activities scheduled by the U.S. Air Force, and that will have impacts that are generally beneficial in nature and, in any event, will be less than significant.

4.3.2.8.3 Summary and Conclusions Concerning the Potential Effects on Nearshore and Landfall Biota

This section summarizes the information on potential effects of the ATOC source cable on nearshore and landfall biota.

Minimal effects are anticipated on any plant or animal species expected in the shallow subtidal, intertidal, or terrestrial zones where the cable would be installed and operated. The cable installation and subsequent operation should produce negligible impacts on the biota along the cable route from the 20-meter depth contour, shoreward to the landfall. There is minimal difference between the two alternate landfall sites proposed, as neither of them should produce any significant impacts on the nearshore or landfall biota.

Table 4.1-1 summarizes the potential direct and indirect effects, and potential cumulative effects on nearshore and landfall biota.

4.4 POTENTIAL EFFECTS ON THE ECONOMIC ENVIRONMENT

This section addresses the potential effects of the proposed action on central California's economic environment. Direct effects are the potential for increased economic activity due to the project. Indirect effects refer to the potential effects on central California's economy should any adverse impacts on marine mammals or other species discussed above occur.

Standard of Significance

Generally speaking, economic effects of a project are outside the scope of NEPA and CEQA. However, economic effects can result in environmental impacts where, for example, economic development induced by a project could result in population growth. Economic effects can also answer the question of whether an environmental effect is significant. Under CEQA, beneficial economic effects can also support a statement of overriding considerations that allow project approval despite one or more significant impacts. Economic effects generally are not considered significant unless they would result in substantial public service and infrastructure costs that would not be offset by project revenues, or where the project would otherwise impose substantial costs on non-participants.

4.4.1 POTENTIAL DIRECT AND INDIRECT EFFECTS ON THE ECONOMIC ENVIRONMENT

The continental shelf and slope off central California support an economically valuable range of commercial fisheries utilizing a variety of retrieval methods. In 1987, a combined total of over 15,000,000 kg of fish, with an ex-vessel value of almost $15 million was landed at the ports of Moss Landing, Monterey, Santa Cruz, and Princeton. The retail value of the fish to the local economy was $30-$45 million (NOAA, 1992).

The ATOC project and MMRP, however, should have minimal potential impacts on commercial fishing. The Pioneer Seamount area is only lightly exploited and it is not anticipated that ATOC sound transmissions or MMRP activities would reduce the success of those fishing efforts. The source is relatively small and located at 980 m, so would not interfere with fishing equipment, as there is little or no bottom fishing on the seamount. The cable, while it would run through established trawling areas, would be unarmored and laid to minimize the potential for any interference with bottom trawling equipment. If a trawler does encounter the cable, the most likely outcome would be severing of the cable, which is an impact on the project, not the fishermen. Since the Pioneer Seamount proposal does not include an independent VLA and associated data cable, it would also present lower potential impediments to fishing activities than the previous Sur Ridge proposal, which included such facilities. Any potential economic impact due to fishermen not believing the aforementioned and avoiding the area of the cable would be determined through interaction with the PCFFA (see CEQA Mitigation Measures 10-1 and 11-1).

Direct effects of the MMRP and the ATOC project would be limited to the beneficial impact of program expenditures on the central California 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 California, and they are almost all protected from exploitation. Commercial fishing is an important economic activity, but it is not anticipated that the MMRP or sound transmissions would have a significant adverse impact on fishes or invertebrates, as discussed above. Direct effects on the economy through reduction of tourism could occur if significant changes in marine mammal abundance or behavior would occur. Reduction in tourism, for example, could result from impairment of such tourist-related activities as whale/dolphin/seal watching and sport fishing. As discussed above, potential impacts on certain species of whales (i.e., sperm and beaked), elephant seals, and leatherback sea turtles are uncertain; however, for most other species, including sport fishes, less than significant impacts would be expected. The possibility that transient whales would alter their courses slightly to avoid the 130 dB (or 120 dB) sound field could have an effect on area whale-watching enterprises. Such a dramatic change in behavior is uncertain.

Because of the general absence of tourism at the Pioneer Seamount and any selected remote autonomous source locations, 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.

4.4.2 POTENTIAL CUMULATIVE EFFECTS ON THE ECONOMIC ENVIRONMENT

• Merchant shipping and other vessel-related activities: If the abundance of whales, odontocetes, pinnipeds, sea turtles or fish were to be appreciably decreased, it could be surmised that a proportional decrease in tourist activity could occur. This could be related directly to the level of merchant shipping (fish catch transfers, and long-range transport out of central California). Other vessels would include such commercial activities as whale-watching tours, which would obviously be impacted if there were fewer whales in the area. Previously presented data and information have quantified the potential for acoustic source transmissions adding to any cumulative effect. 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 any of the alternatives.

• 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 MMRP aerial surveys and observations. Therefore, there should be no impact on any economic base related to aircraft operations.

• Scientific research activities: No potential change in the cumulative effect of ongoing and planned scientific research being conducted on mysticetes, odontocetes, pinnipeds, sea turtles or fish would be expected by the addition of MMRP activities related to acoustic sound transmissions. MMRP research has been designated as *bona fide* and non-duplicative in nature, and would be coordinated and integrated with all associated marine animal research to ensure maximum cost-leveraging and scientific synergism. Thus, the potential for any impact on the economic environment due to any of the alternatives would be expected to be positive.

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

4.5 POTENTIAL EFFECTS ON THE SOCIAL ENVIRONMENT

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

4.5.1 HUMAN ENVIRONMENT

4.5.1.1 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 any of the alternatives being implemented.

• Educational institutions: As previously stated, opportunities for direct interaction and hands-on marine animal data display and analysis would be offered to central California educational and environmental institutions. Thus, the potential for any direct or indirect effects on local educational establishments would be expected to be only positive in nature. Such interaction would not be readily available at Pioneer Seamount or a deep-water site. However, every effort would be made to facilitate connectivity of all data collection activities and results with educational institutes in the central California region. Thus, the MMRP research scientists could provide access to their data for students to explore and manipulate and learn about the process of marine science. By making such information available to the local teachers, students and interested community members through education efforts, the positive impact of the ATOC/MMRP project is increased greatly.

• Recreational and leisure activities: Whale, dolphin, seal, and sea turtle-watching, and sport fishing have been covered previously. The only other human activity that could potentially be impacted by the proposed acoustic source sound transmissions would be recreational diving. Impacts are expected to be nonexistent since nearly all recreational diving occurs in the nearshore region. However, the following discussion is provided for completeness.

Low frequency sound transmitted in the vicinity of humans underwater could potentially produce one or more of the following effects, all of which will be addressed in the following paragraphs:

1) Potential impact on hearing sensitivity; e.g., temporary threshold shift (TTS)
2) Potential resonance of air-containing cavities; e.g., intrathoracic (thoracic pertains to the chest cavity, encompassing the heart, lungs, some of the respiratory passages, and the esophagus)
3) Potential impact on mechanoreceptor cell function (e.g., Pacinian corpuscles)
4) Potential human acoustic annoyance

Potential Impact on Hearing Sensitivity

Loud underwater noise could potentially impact a diver's hearing depending, of course, on the noise's frequency, source level, pulse characteristics and length, and the range of the diver from the source itself. Some experiments dealing with underwater thresholds of audibility have been conducted, beginning with Sivian's work in 1943, continuing up to today. The results of these experiments are so disparate that it is very difficult to establish a direct relationship between underwater and in-air hearing for humans with a great deal of confidence. If a realistic transformation between water and air could be determined, then in-air noise exposure limits could easily be applied to the underwater environment. Kirkland and Pence (1989) evaluated all known experiments as to potential weaknesses or areas of uncertainty in an effort to establish their validity and better define the air vs. water hearing relationship in the case of humans. Some of the key deficiencies noted have included high or unknown ambient noise levels, a lack of monitoring of the actual in-water sound field at the diver's position, and a lack of objective information on the quality of each subject's hearing (i.e., no in-air hearing sensitivity data). On the basis of these key deficiencies, the results of a number of the experiments in question, Kirkland and Pence concluded, can be set aside as being relatively unreliable, and the remaining better experiments can be further evaluated as a group, namely the seven following reports:

- Hamilton (1957): "Underwater Hearing Thresholds"
- Smith, P. (1965): "Bone Conduction, Air Conduction, and Underwater Hearing"
- Hollien et al. (1967): "Underwater Hearing Thresholds in Man"
- Hollien et al. (1969): "Effect of Air Bubbles in the External Auditory Meatus on Underwater Hearing Thresholds"
- Hollien et al. (1969): "Underwater Hearing Thresholds in Man as a Function of Water Depth"
- Smith, P. (1969): "Underwater Hearing in Man: I. Sensitivity"
- Hollien et al. (1975): "Contribution of the External Auditory Meatus to Auditory Sensitivity Underwater"

The agreement among the results obtained by these three investigators, although not perfect, was generally good. Using their data, an average corrected underwater human hearing threshold of audibility (for young listeners with normal hearing) as a function of frequency can be derived (Figure 4.5.1.1-1). Adjustments were made to the original data to account for the different hearing sensitivities of the subjects and, where appropriate, for the change in audiometric standards that occurred during the 1964-1970 timeframe (ASA Z24.5-1951, changing to ISO 389-1964 or ANSI S3.6-1969). Underwater thresholds represented by this average curve are generally lower than those presented by most of the other investigators, lending a measure of conservatism to the results. Given that these are the best data available, because the low end of the frequency spectrum portrayed is just above 100 Hz, the average curve must be extrapolated down to 75 Hz. Audiograms of other mammals (monkey, rat, cow, elephant, dog, oppossum, bat), some birds (canary, barn owl) and a reptile (turtle) all display linear progression (upwards) below 100 Hz, indicating direct extrapolation of the humans' audiogram beyond 100 Hz to 75 Hz is justifiable. This technique yields a minimum audibility level of 82 dB re 20 μPa which, in turn, must be converted to the standard of 1 μPa by adding 26 dB (Table 4.5.1.1-1) to attain the required value of 108 dB re 1 μPa for minimum human audible threshold in water for a frequency of 75 Hz.

Temporary threshold shifts have been produced in humans for frequencies between 700-5600 Hz (human's most sensitive hearing range) with underwater sound sources at 150-180 dB re 1 μPa (Montague and Strickland, 1961). As previously discussed, the value of 80 dB should be added to 108 dB to arrive at 188 dB for the level at which TTS could possible occur in humans at 75 Hz. Thus, for this to occur, the diver would have to virtually be touching the acoustic source during the short transmission period, which is literally an impossibility because of the 980 m source depth. Therefore, it is safe to predict that the proposed acoustic source transmissions should have no direct or indirect environmental effects on human hearing capability.

Potential Resonance of Air-Containing Cavities

High levels of underwater narrowband noise have been found to cause non-auditory effects. Montague and Strickland (1961), Molvaer (1981) and Smith (1985) have reported temporary threshold shifts, nausea or vertigo resulting from close (near-field) exposure to underwater tools and tones in the range of source levels 156-216 dB re 1 μPa. In tests ensonifying divers with a sweep oscillator producing acoustic energy in the frequency band of 10-32 Hz, Nishi (1972) reports "little discomfort at ranges greater than 4.6 m for all frequencies in the band (180 dB re 1 μPa). The discomfort which was experienced seemed to be greater when the frequency of the sound emitted was at the upper end of the band."

While many authors discuss the importance of air-containing structures within the human body relative to sound-induced motion underwater, the importance of hyperbaric effects have not been generally noted. In order to derive some initial information, reinterpretation of Young et al.'s (1985) experimental results can be carried out. Young made measurements of intrathoracic (internal lung) pressure on ten healthy young male subjects exposed to an airblast. While such data are typically interpreted relative to time, it is valuable to reinterpret this information for the "at surface" condition (Figure 4.5.1.1-2). Note that the model indicates a peak response to incident sound at just over 100 Hz, which is in agreement with other published results. This

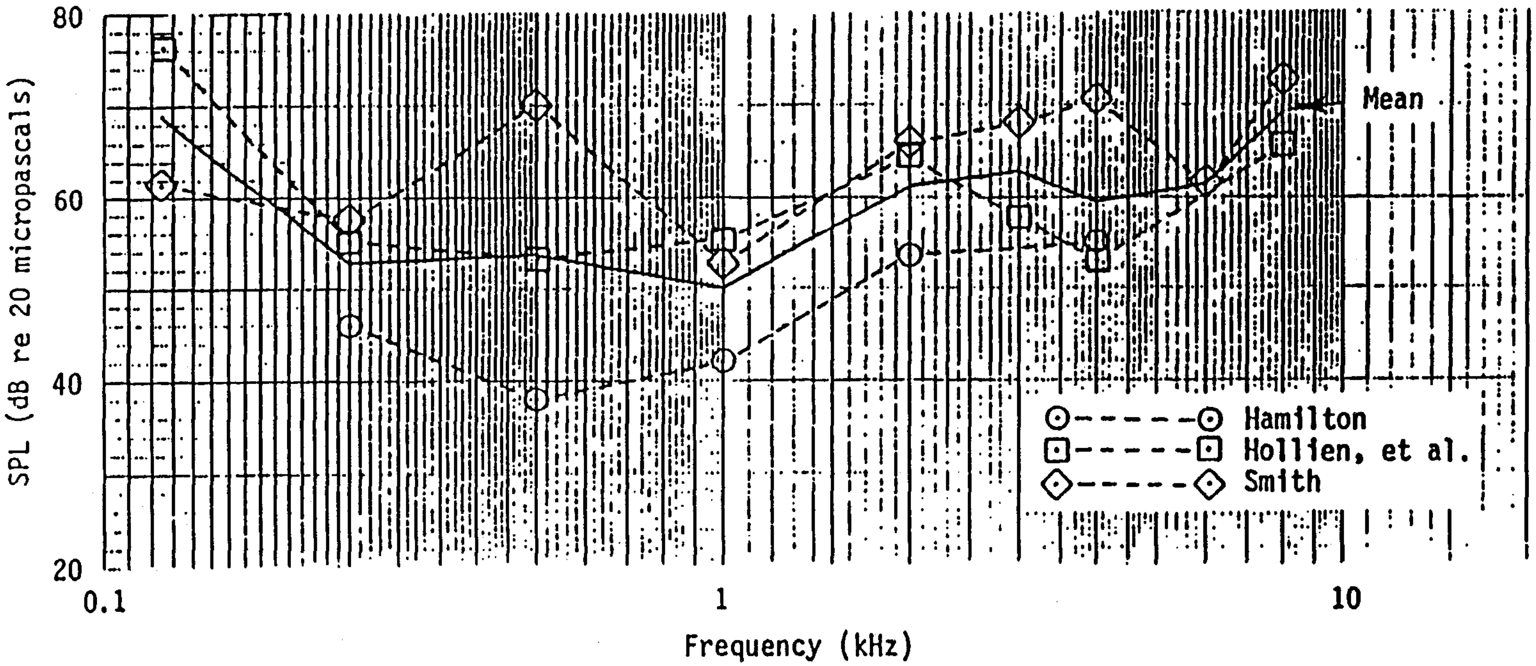


Figure 4.5.1.1-1 Average corrected underwater thresholds of audibility over all experiments conducted by each of three investigators. The overall mean is based upon treating each experimental group as an independent data point (Hamilton-one experiment, Hollien-three experiments, Smith-two experiments)

Note that the single data point at six kHz is from only a single experiment bv one investigator and, therefore, does not represent a realistic average. (from Kirkland and Pence, 1989)

To Convert		Add or subtract according to sign	
From	To		
SPL re 1 $dyne/cm^2$	SPL re 20 micropascals	+73.98 dB	
SPL re 1 microbar (μb)	"	+73.98	
SPL re 1 micropascal (μPa)	"	-26.02	
SPL re 0.0002 $dyne/cm^2$	"	0	
SPL re 2×10^{-5} $newton/m^2$	"	0	
		air	sea water
IL re 10^{-16} $watt/cm^2$	"	0[a]	+35.83[b]
IL re 10^{-12} $watt/m^2$	"	0[a]	+35.83[b]

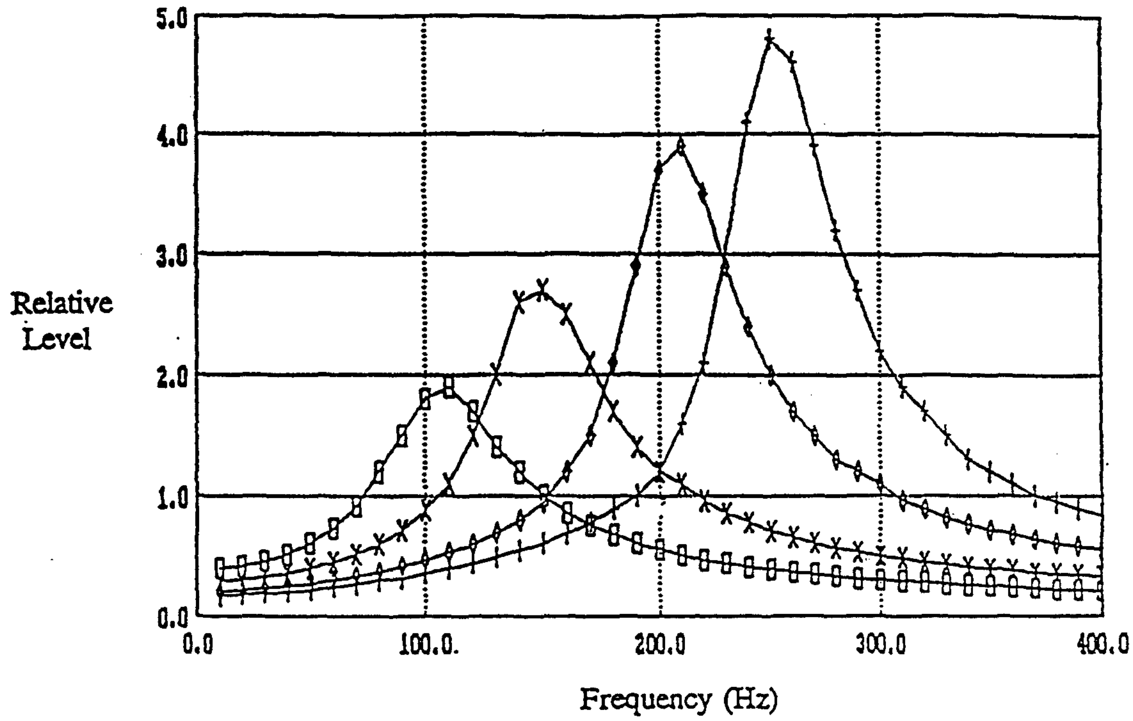
[a]The conversion value of 0 dB is only valid when the characteristic impedance of the medium ($\rho_0 c$) is equal to 400 newton-sec/m^3 (or 40 dyne-sec/cm^3). The impedance $\rho_0 c$ for air will depend upon temperature and pressure. For example, at 22°C and 0.751 m Hg $\rho_0 c = 407$ newton-sec/m^3. For these conditions, the intensity level would be 0.1 dB smaller than the sound pressure level. The exact relationship between intensity level and SPL is $IL = SPL + 10 \log_{10} 400/\rho_0 c$ dB, where $\rho_0 c$ has the units newton-sec/m^3. (Example and equation from Beranek, 1986, pg. 14.)

[b]The conversion value of +35.83 dB is based upon a sea water density (ρ_0) of 1.026 gm/cm^3 and a nominal sound speed (c) of 4900 ft/sec (1493.5 m/sec). The sound speed in water depends upon temperature, salinity, and pressure.

Some symbols and units:

- watt: unit of electrical power, 1 watt = 1 joule/sec = 10^7 erg/sec = 10^7 dyne-cm/sec = 1 N-m/sec.
- SPL: sound pressure level.
- IL: intensity level.
- dyne: unit of force, 1 dyne = 1 gm-cm/sec^2.
- pascal: unit of pressure, 1 Pa = 1 N/m^2 = 10 dyne/cm^2.
- newton: unit of force, 1 N = 1 kg-m/sec^2.
- microbar: unit of pressure, 1 microbar = 1 dyne/cm^2.
- rayl: unit of impedance, 1 rayl = 1 dyne-sec/cm^3, 1 mks rayl = 1 newton-sec/m^3.

Table 4.5.1.1-1 Conversion of sound levels using various references to sound levels re 20 micropascals



□ Surface
x 10 m depth
◇ 30 m depth
+ 50 m depth

Figure 4.5.1.1-2 Estimated ratio between intrathoracic pressure and incident pressure (from Young, 1985).

intrathoracic pressure is about twice that of the external incident pressure at the resonant frequency, indicating a degree of enhancement of the pressure by resonance.

The increase in resonant frequency of air-containing structures with depth has been understood for a considerable time, probably commencing with Minnaert's (1933) study of bubble noise. Therefore, the resonant frequency of an air-containing space of a diver is expected to increase with depth as the square root of the absolute pressure; thus, if the thorax resonates at 100 Hz at the surface, it may be expected to resonate at 200 Hz at 30 m depth, and 250 Hz at 50 m depth. Recent experimental results, for approximately 1.5 m distance from the diver (unpub., 1993; restricted access due to military security classification), indicated that there are two ranges of frequency at which divers experience effects of low frequency noise. The most significant was at a frequency of about 100 Hz at source levels of about 160 dB re 1 μPa-m: resonance of the diver's face mask and possibly sinuses. The next most significant was at a frequency of about 20 Hz at 160 dB source level, and corresponded to the classic thoracic resonance. At higher frequencies at the same source level, no repeatable effects were observed other than a sensation of loudness.

With this information, the question of whether there would be any possibility that the proposed acoustic source transmissions could cause resonance of diver air-containing cavities can be addressed. At the surface, 20 Hz and 100 Hz appear to be the critical frequencies, the former for potential intrathoracic resonance, and 160 dB can be considered to be the level that could potentially cause hazardous disturbance to divers. The proposed source transmissions, which would be on a maximum of 8% of the time, would have a center frequency 55 Hz higher than the 20 Hz level, and 25 Hz lower than the 100 Hz level. The following summarizes the differentials between the proposed received values and the data presented:

	CRITICAL FREQUENCIES	PROPOSED FREQUENCY (difference in center frequency)	CRITICAL RECEIVED LEVEL	MAXIMUM RECEIVED LEVEL (DIFFERENCE)
SURFACE	20 Hz 100 Hz	57.5-92.5 Hz (+55 Hz) 57.5-92.5 Hz (-25 Hz)	160 dB	135 dB (-25 dB)
30 m DEPTH	40 Hz 200 Hz	57.5-92.5 Hz (+35 Hz) 57.5-92.5 Hz (-125 Hz)	160 dB	136.6 dB (-23.4 dB)
50 m DEPTH	50 Hz 250 Hz	57.5-92.5 Hz (+25 Hz) 57.5-92.5 Hz (-175 Hz)	160 dB	137 dB (-23 dB)

Given the above evidence, plus the fact that ATOC source energy is spread across a 35 Hz bandwidth, not concentrated in a narrowband tone as the stated experimental data were, it is safe to conclude that the potential for the proposed source causing resonance of any diver air-containing cavities would be negligible.

Potential Impact on Mechanoreceptor Cell Function

Mechanoreceptors (skin nerve fibers) can be classified as displacement, velocity, or acceleration detectors. They can be fatiguing or non-fatiguing. That is, they can become saturated and fail to respond to an above-threshold stimulus, or they can always respond to an above-threshold stimulus. There are only two acceleration mechanoreceptors in the human body, and only one of them is non-fatiguing--the Pacinian corpuscle. These then appear to be the receptors that would logically be associated with a vibration-produced response throughout the body when exposed to waterborne low frequency sinusoidal excitation.

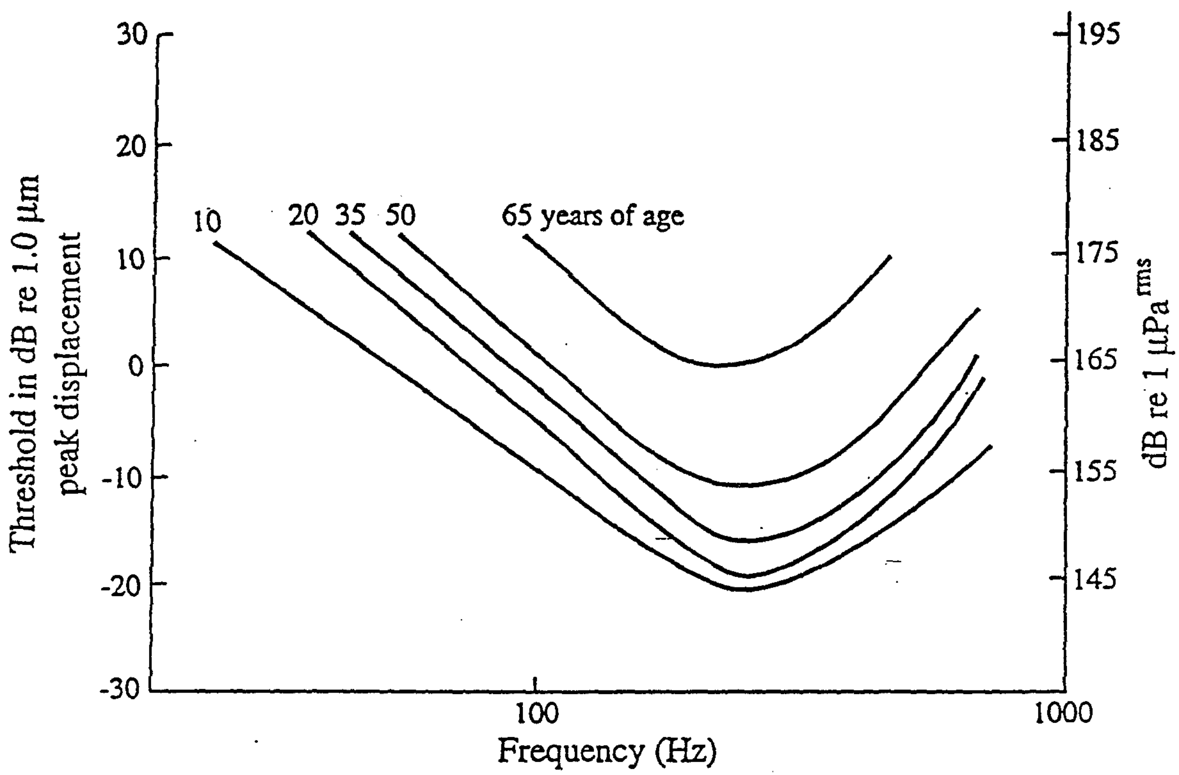
The Pacinian corpuscle receptors are free floating and deeply buried in the skin, designed to respond to vibrations, while not responding to either steady pressure or constant velocity. They are distributed throughout the body in such a manner as to appear to serve a tactile and vibration sensing function. Their neural interconnections to the central nervous system are such that they override displacement sensors while lowering the threshold on acceleration sensors. Pacinian corpuscles are tuned to frequencies of 150-300 Hz, but respond to frequencies in the range of 60-900 Hz (Woolley and Ellison, 1993). They have an "all or none" nerve impulse, and respond to vibrations whose peak displacements are as small as 1 μm. The response of a Pacinian corpuscle to two or more non-co-located pressures is to sum them.

The frequency response curves of Pacinian corpuscles in some mammals (e.g., cats) are known to scale according to resonances in extremities (Woolley and Ellison, 1993). This lends strength to the argument that they are meant to respond to possibly harmful and, certainly, meaningful vibrations. The waterborne path of excitation of the Pacinian corpuscles of a diver may be considered an unusual one from the physiological viewpoint. The good fluid coupling will simultaneously allow excitation of Pacinian corpuscles throughout the body. Their neurological response of lowering the threshold of the acceleration receptors and sustaining the lower threshold could potentially contribute to additional sensations felt by a diver exposed to low frequency transmissions. It is fairly certain that the Pacinian corpuscles themselves are not being damaged, nor are they sensing damage. The noci receptors are the damage sensors and they are not at all excited by the sound levels being considered here.

If tactile and/or vibratory sensations felt by a diver were due to Pacinian corpuscle excitation, it seems logical that a very conservative criterion for in-water acoustic received level would be the Pacinian corpuscle threshold itself. Thus, if the Pacinian corpuscle could not "detect" the acoustic excitation, it can be considered to be at a safe level. In Figure 4.5.1.1-3 the threshold of the Pacinian corpuscle is plotted for humans. This is the minimum received level (right ordinate axis) necessary to just cause the Pacinian corpuscle to respond with a nerve impulse. The threshold is indicated by a line for each of the ages of the human in question (10, 20, 35, 50, 65 years of age). Note that at 75 Hz, for a 20 year-old, the threshold is approximately 165 dB. For a diver to be exposed to this received level from the proposed ATOC source transmissions, he/she would have to be within 30 m of the source at depth greater than 820 m. Therefore, it can be concluded that the potential for the proposed source causing any direct or indirect impact on humans' mechanoreceptor cell function would be virtually zero.

Potential Human Acoustic Annoyance

Almost all human diving activity off the central California coast takes place within 2 km of the shoreline. As previously stated the minimum audible human threshold in water at 75 Hz is



(From Kenshalo, 1978)

Figure 4.5.1.1-3 Threshold dependence of Pacinian corpuscles

estimated to be about 108 dB. Based on the best FEPE acoustic performance prediction computer modeling available, the possibility of ATOC sound signals incurring the level of transmission loss that would allow a received level of 108 dB to reach to within 2 km of the shore is low. The interference caused by the intense bottom and surface interaction of the sound rays as they travel from the ATOC source upslope into the shallow water nearshore regions will tend to cause cancellation and degradation of the sound field.

Thus, the possibility of any diver being exposed to a received level loud enough to hear it is unlikely. Add to this the fact that the source would be operating only 2%-8% of the time, and the potential for any human acoustic annoyance is very low. Hollein (pers. comm., 1995) believes that there would be negligible impacts on diving activities if the ATOC source is located at the proposed site (Pioneer Seamount). Nevertheless, local diving organizations, and the local chapters of the Professional Association of Dive Instructors (PADI) and the National Association of Underwater Instructors (NAUI) would be contacted to help assess whether any divers hear, or are acutely or chronically annoyed, by ATOC emissions. If it is verified that substantial annoyance occurs that is directly relatable to ATOC source transmissions, operations would be temporarily suspended pending discussions with NMFS, MMRP AB, MMC, and the PRSRG.

4.5.1.2 Potential Cumulative Effects on the Human Environment

The following refers to only those alternatives that would affect the human environment in the Sur Ridge, Sur Slope or deep water moored autonomous 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 any 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 zero. 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.

4.6 OTHER IMPACTS

Although potential habitat and biological resources impacts are the principal area of concern and the focus of this EIS/EIR, a number of other negligible impacts are presented by the proposed project and its alternatives. These include vessel and aircraft traffic (MMRP activities), construction impacts (laying cable, installing the source, etc.), consistency with land use plans and policies (discussed below in Section 5), cultural and historical resource impacts (potential presence of shipwrecks, etc., at the facility site), visual impacts (ATOC cable runs through the surf zone, beach and bluff), employment, population and public services (researchers and others doing work in California), air pollution (from vessel and aircraft activities), energy impacts (discussed in Section 6.3), hazardous materials and wastes (battery usage on moored autonomous sources), and cumulative impacts of the proposed action.

These additional impacts are each discussed briefly below. Where applicable, the impacts presented by alternatives will also be addressed. Except where otherwise noted, additional impacts from the no action alternative are assumed to be nonexistent. Any additional mitigation measures are identified.

4.6.1 INCREASES IN VESSEL AND AIRCRAFT TRAFFIC

A project will generally be considered to have significant transportation impacts if it will add significantly 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 waterways and airways.

During the MMRP Pilot Study, minor increases would occur in vessel and aircraft traffic off the central California coast (maximum 30 days of flight operations and 20 days of vessel operations). Since the source would be powered from shore, it would not require maintenance that would result in increased vessel trips. All ATOC and MMRP vessel and aircraft trips are well within the capacity of the local waterways and airways, and do not constitute a significant impact (under CEQA).

The moored autonomous source alternative (Alternative 4) would result in greater levels of vessel traffic than the preferred alternative, since supply and maintenance trips would need to be made from some distance; however, that traffic would mostly occur at locations some distance from inhabited areas; i.e., on the high seas. Since the logistics of aerial MMRP observations would likely prove prohibitively difficult for the moored autonomous source alternative, that alternative could result in significantly lower aircraft traffic than the preferred alternative, but that reduction would come at the expense of the MMRP.

CEQA Impact 12: Minor increases in vessel and aircraft traffic would occur in the project vicinity.

CEQA Mitigation Measure 12-1: Vessel and aircraft traffic would be kept to a minimum, consistent with the requirements of the MMRP protocols and ATOC program requirements. Where possible, trips would be consolidated or other measures taken to reduce the aircraft and vessel traffic levels resulting from the project.

4.6.2 DIRECT CONSTRUCTION AND MAINTENANCE IMPACTS

The ATOC source was constructed in Seattle, Washington and will be transported to the source site. Other than minor vessel traffic and resulting air pollution, installation and maintenance of the source are not anticipated to result in any environmental impacts. No alteration to the seabed would occur.

Cable installation activities associated with the Pioneer Seamount alternative would include removal of the cable previously placed from the Sur Ridge site to the 3-mile limit offshore Pt. Sur, which would result in minor localized disturbance of the seafloor in areas where the cable has self-buried during its approximately 18 month residence there. Disturbance of the seabed when that cable (extended to reach Pioneer Seamount) is relaid would be minor.

As described in Section 1, as part of the ATOC project, a number of existing subsea listening facilities in various eastern and North Pacific Ocean locations would be modified and, where necessary, refurbished to be used for ATOC purposes. None of the work on these existing stations should have any environmental impacts, since no new facilities will be constructed, and all of the improvements are to or within existing structures, rights of way, or equipment.

The ATOC project would also install up to two autonomous VLA listening arrays at other Pacific locations. They are powered by battery packs, but have relatively small power requirements (as compared to Alternative 4, Moored Autonomous Source), such that the risk from leakage of battery fluids should be very minor.

Furthermore, construction and operation of a moored autonomous source would likely have somewhat greater construction and maintenance impacts, due to the longer travel distances from the staging location that would be required.

4.6.3 CULTURAL AND HISTORICAL RESOURCES

Federal law, 36 C.F.R., Part 800, provides that environmental analyses need only consider impacts on significant cultural resources, defined for purposes of this EIS as resources listed on the National Register of Historic Places, eligible for listing in the National Register, or designated as a National Historic Landmark. The UC Regents' Guidelines indicate that a project will generally be considered to have a significant impact on cultural and historical resources if it would disrupt or adversely affect a prehistoric or archaeological site, a property of historic or cultural significance to a community or ethnic or social group, a paleontological site, or a local landmark of local cultural/historical importance.

The Governor's Office of Planning and Research has issued further guidance in determining whether significant impacts will occur to historic resources under the provisions of CEQA. For the purposes of CEQA, a significant adverse impact will occur where there is a "substantial adverse change" such as demolition, destruction, relocation, or alteration activities that would impair the significance of the historic resource.

As described in Section 3.4.6, a literature and archival review was performed for the preferred action site area at Pt. Sur and for the proposed action site at Pioneer Seamount/Pillar Point. As no cultural resources were identified onshore at either landfall site, no impacts to prehistoric cultural resources are anticipated. Nonetheless, a standard mitigation measure commonly applied to University of California projects directs that appropriate actions be taken if previously unidentified cultural resources are encountered during construction. Therefore, a qualified archaeologist would be retained to survey the area to be involved in the onshore portion of the cable prior to construction and, if necessary, he/she would monitor the trenching activities.

Offshore, a number of shipwrecks are recorded in the general vicinity of Pt. Sur, but none near Pioneer Seamount (see Section 3.4.6). The precise locations of many of these shipwrecks are unknown. However, diver surveys of the Pt. Sur cable route out to approximately 1 km noted no visible evidence of shipwrecks along the proposed cable route. Even if an unidentified shipwreck is encountered along the cable route, no adverse effect as defined under NEPA or CEQA would occur, since the passive laying of these narrow gauge cables would not result in any damage or alteration to the wreckage. Furthermore, to avoid the cultural resource, as well as to prevent potential damage to the cables, if any shipwrecks are identified during the deployment of the cables, the wreckage would be avoided by a minor adjustment to the cable route.

In addition, a sidescan sonar survey of the Pioneer Seamount cable route identified no shipwrecks or similar cultural/historical resources along the proposed route. Onshore, a cultural/historical resources survey undertaken by the Air Force in connection with their proposed bluff restoration activities concluded that there are no such resources in the onshore project area (Air Force, 1994).

CEQA Impact 13: Although there are no recorded archaeological sites along the onshore cable route, previously unidentified cultural resources could be impacted by the construction required for the ATOC source power cable.

CEQA Mitigation Measure 13-1: A qualified archaeologist would be retained to visit the ATOC activity site and determine whether monitoring of the cable installation is required. If required, he/she would monitor installation activities and specific measures recommended would be implemented to avoid any significant impacts to cultural resource materials.

CEQA Impact 14: Unidentified shipwrecks could possibly be encountered along the proposed cable route for the ATOC source cable.

CEQA Mitigation Measure 14-1: If shipwrecks or other resources are identified, they would be avoided during installation of the ATOC facilities.

4.6.4 VISUAL IMPACTS

Visual impacts are generally considered significant (under CEQA) if they violate applicable guidelines relating to visual quality, significantly alter the existing natural views including changes in natural terrain, or if they significantly change the existing visual quality of the region or eliminate visual resources.

For the Pt. Sur landfall, all onshore facilities shoreward of the bluff would be either underground or in existing buildings, so no visual impacts would result. That segment of the cables from the bluff to the surf line, enclosed in two pipes, would be visible from the immediate vicinity (Figure 4.6.4-1), but not from any locations to which the public has general access. The cable landfall would be at the same location as existing Navy cables, which presently affect the visual landscape. The Pt. Sur cable landfall would therefore result in visual impacts, but those impacts are considered to be minimal given the minor scope of those facilities and the existing setting, with similar facilities in the immediate vicinity.

As stated in Section 1.1.6, for the Pillar Point landfall, the cable would be buried across a beach and up a bluff face inside an existing ravine to the Pillar Point Air Force Station, then buried across the perimeter road and through a trench to the terminal building (Figure 4.6.4-2). Therefore, since the onshore cable installation at Pillar Point would be undertaken in conjunction with the previously planned bluff restoration activities of the U.S. Air Force, and since the cable would be entirely underground, no visual impacts would occur (with the possible exception of minor temporary visual impacts following the cable laying and before completion of the bluff restoration).

4.6.5 EMPLOYMENT, POPULATION, AND PUBLIC SERVICES

A project generally will be considered to have a significant impact (as defined by CEQA) 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 MMRP research team consists of no more than 22 personnel at any time, most of which are either affiliated with, or stage their research efforts from UCSC. In comparison to the overall level of employment opportunities in California and current population levels, this additional employment and population is minor. In addition, no significant effects (as defined by CEQA) on public services, such as police, fire protection, schools, and housing, are anticipated to result from the proposed project.

4.6.6 AIR POLLUTION

A project will be considered to have a significant impact (as defined by CEQA) 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. Generally, air quality in the vicinity of the proposed project is good to excellent. All vessel and aircraft traffic associated with the project generates some air pollution, but at levels well below those that would cause or contribute to air quality violations. In a worst-case scenario, 2 vessels and 2 aircraft would be conducting research operations simultaneously, but their combined emissions would not exceed 150 lb/day of ROG or NOX, the criteria of significance for ozone procedures within the north central coast air basin.

All other alternatives, except the no project alternative, would have somewhat increased air pollution impacts when compared to the preferred alternative (Sur Ridge). Locating the source site at Pioneer Seamount (proposed action) could involve increased use of vessels to

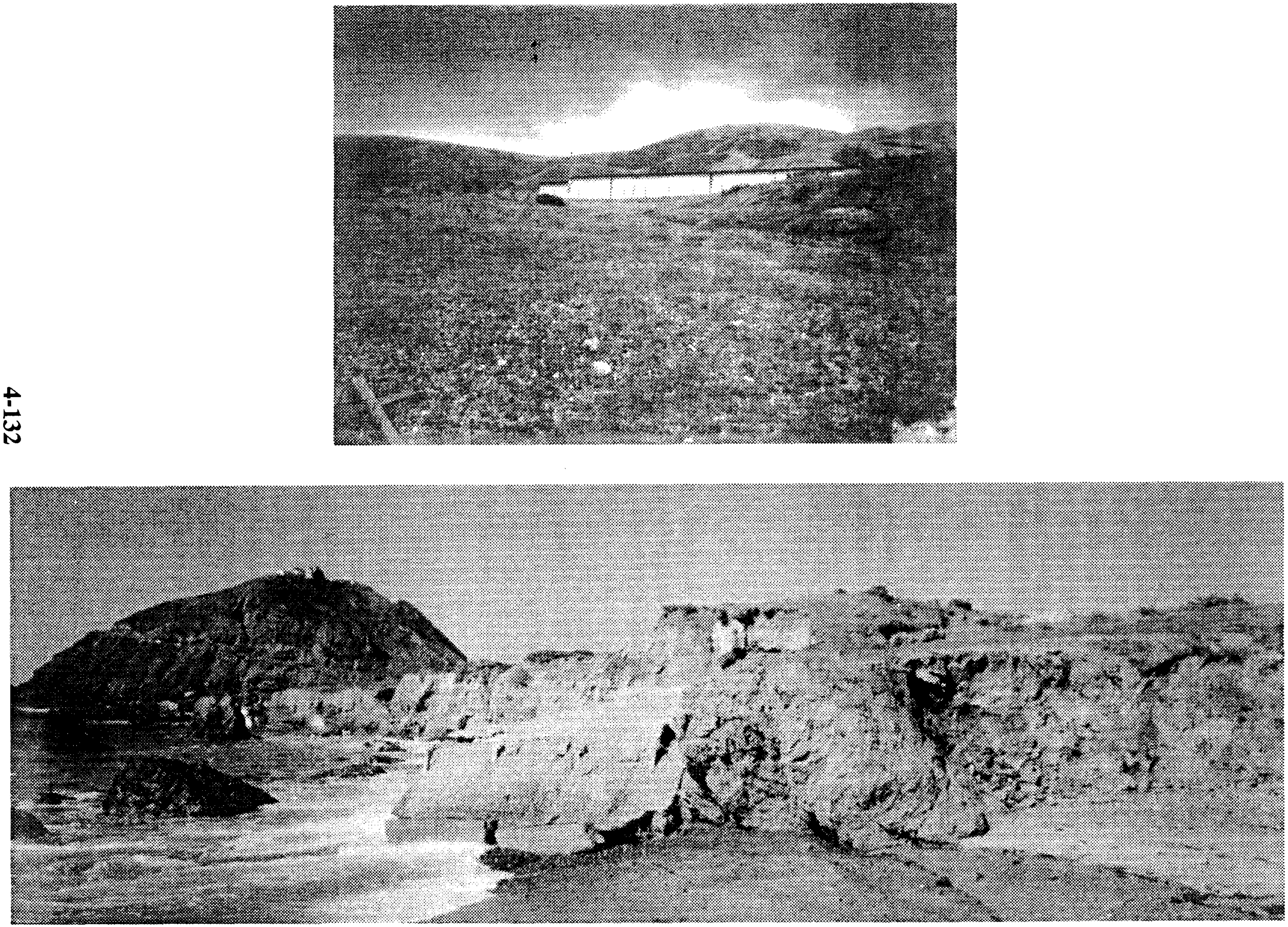
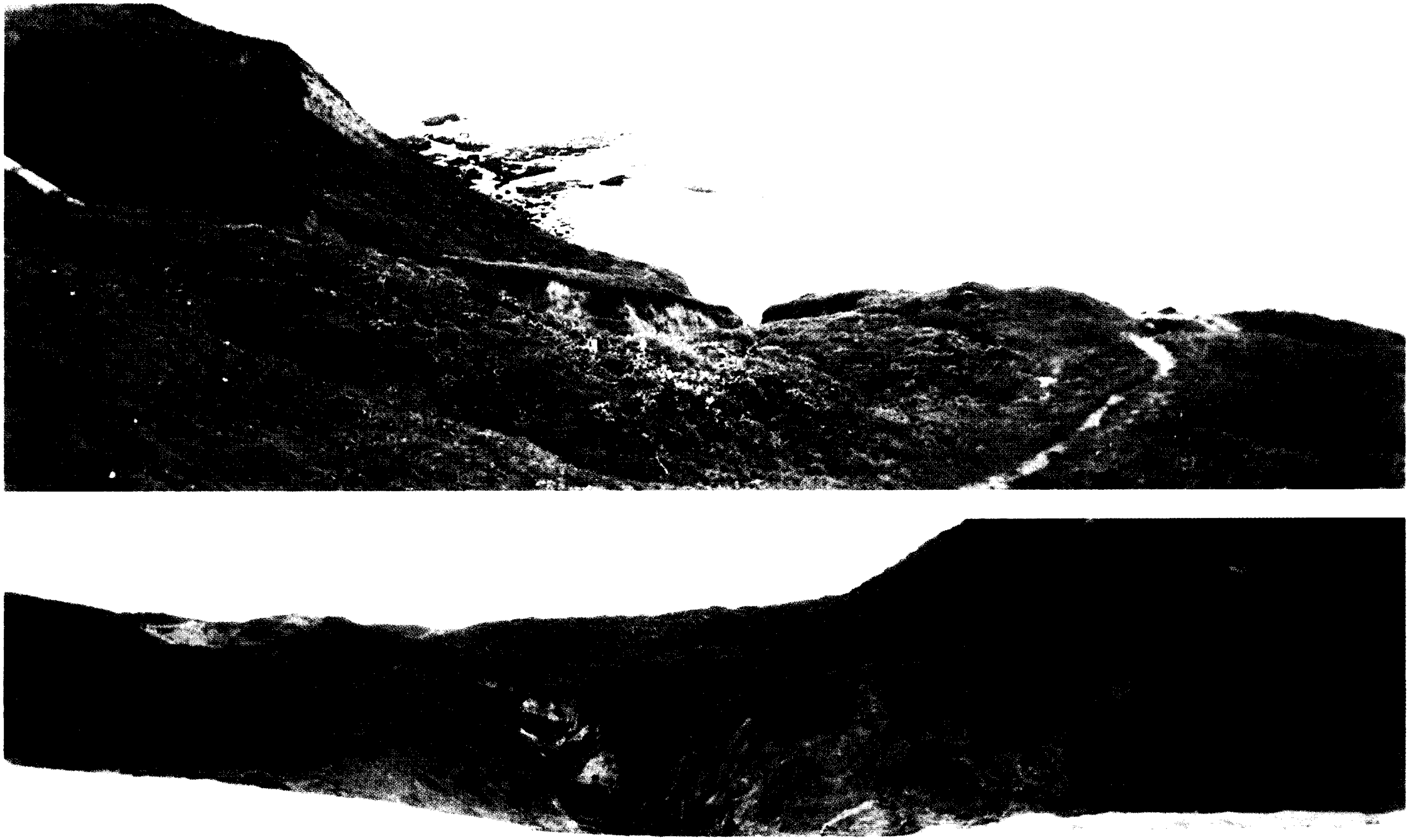


Figure 4.6.4-1 Pt. Sur cable landfall (photographs).



Top: Pillar Point overlooking ravine (proposed cable route) and cove, at low tide.
Bottom: Proposed Pillar Point cable landing site, looking shoreward, at low tide.

Figure 4.6.4-2 Pillar Point landfall (photographs)

support activities at this more remote location, increasing air pollution impacts somewhat, but to a less than significant degree. Similarly, the use of moored autonomous sources, which would require servicing by vessels at more remote locations, would increase air pollution impacts. Since this air pollution would occur at locations where current air quality conditions are good to excellent, no cumulative impacts would result from any alternative.

CEQA Impact 15: ATOC and MMRP vessels and aircraft would create minor amounts of air pollution.

CEQA Mitigation Measure 15-1: All ATOC/MMRP vessels and aircraft would be equipped with required air pollution controls.

4.6.7 HAZARDOUS MATERIALS AND WASTES

The ATOC source and cable installation involves no use of hazardous materials and would not produce any hazardous wastes. The MMRP would not use hazardous materials or generate any hazardous wastes.

Moored autonomous sources would need to be powered by batteries which, if they were to leak or if recovery of the sources could not occur at the end of their useful lives, could add minor amounts of hazardous materials to the marine environment. However, any toxic discharge should be neutralized quickly in seawater.

4.6.8 CUMULATIVE IMPACTS OF THE KAUAI AND SUR RIDGE ATOC SOURCES

No direct physical cumulative impacts of the proposed Pioneer Seamount and Kauai ATOC sources would occur. Those facilities are independent and separated by a distance greater than 3700 km. The sound sources at Kauai and Pioneer Seamount are not planned to be operated concurrently, but the minimum range at which a marine animal might be exposed to both source transmissions sequentially would be 1850 km from either source. At that range, the received sound levels should be on the order of 85 dB in the deep sound channel, and 88 dB at 100 m depth (based on FEPE transmission loss calculations and estimated attenuation values due to absorption and thermal discontinuities [e.g., ocean fronts and eddies] from the 1991 HIFT and the 1994 AET), which are within the range of ambient noise conditions an animal would normally be subjected to in the open ocean. It should be noted that ambient noise conditions in the deep sound channel (800-1000 m depth in the study area) are approximately 2-3 dB lower than near the surface (Morris, 1978).

Only migrating species would have any potential for direct cumulative impacts as a result of the two sources. The only species that might migrate between these two sites is the humpback whale. This could possibly occur with animals that summer offshore California and winter in Hawaii. However, it is generally believed that one or more groups of humpbacks move directly between the Hawaiian Islands and the Aleutian Islands/Gulf of Alaska; and one or more groups move between Mexico and the Gulf of Alaska (via California waters) (Winn and Winn, unpub.).

Thus, the potential for cumulative effects on the same population would be expected to be negligible.

In the event that similar impacts to different populations of the same species at both locations were to occur, this could be considered a cumulative impact to the species as a whole. The MMRP is intended to determine whether potential impacts to habitats or biological resources may occur. Any cumulative impacts to separate populations of species at the two sites would be mitigated through measures at the respective sites.

5 CONSISTENCY WITH FEDERAL, STATE AND LOCAL REQUIREMENTS, PLANS AND POLICIES

This section addresses the federal, state and local permitting, and other regulatory requirements that do, or may, apply to the California ATOC facilities at the Pt. Sur, Sur Slope and Pioneer Seamount alternate sites. The requirements applicable to a moored autonomous source site are not discussed because the site location under that alternative is not known and the regulatory requirements would vary significantly depending upon that location. It also analyzes the MMRP and ATOC feasibility operations in relation to applicable plans and policies, including the State of California Coastal Management Program, the Monterey Bay National Marine Sanctuary Management Plan, the Humpback Whale and Steller Sea Lion Recovery Plans, and the Gray Whale Monitoring Plan.

All MMRP activities would comply with all applicable federal laws and regulations, and with applicable regional, state, and local land use plans, policies and regulations. Scripps is the applicant for most governmental approvals for the proposed action, and is the coordinator of the overall ATOC program. Cooperating institutions include, among others, the Cornell University Bioacoustic Research Program, and the University of California at Santa Cruz. Certain MMRP operations are being carried out under existing permits held by those organizations.

The regulatory programs applicable to the MMRP are summarized in Table 1.1.3-1.

This section first considers federal regulatory requirements, including the current SRP, consultation under Section 7 of the Endangered Species Act, a permit from the Monterey Bay National Marine Sanctuary, and nationwide permits under Rivers and Harbors Act Section 10. It next considers State of California regulatory programs that might be applicable to the proposed ATOC California facilities, in particular state consideration of a coastal development permit for ATOC facilities within the 3 nm (5.6 km) band of state ocean waters. It then reviews the consistency of the project with applicable plans and policies. It concludes with a listing of regulatory programs considered but found not to apply to the ATOC project or the MMRP.

5.1 FEDERAL PROGRAMS AND REQUIREMENTS

This section describes the federal regulatory programs that apply to the California MMRP, including the scientific research permit (SRP) process administered by NMFS, Section 7 consultation under the Endangered Species Act, permitting activities of the Monterey Bay National Marine Sanctuary and Section 10 of the Rivers and Harbors Act, and the Coastal Zone Management Act (CZMA).

5.1.2 SCIENTIFIC RESEARCH PERMIT

As discussed above, a principal use of this EIS/EIR will be to support consideration of a Scientific Research Permit under the MMPA and ESA. Key requirements for a SRP are listed here:

- The proposed taking is for "purposes of scientific research . . ."
- The taking has been reviewed by the Marine Mammal Commission and the Committee of Scientific Advisors on Marine Mammals, which must review any taking which is consistent with the purposes and policies of the MMPA.
- The taking is required to further a *bona fide* scientific purpose.

Other requirements for issuance of SRPs are set forth in regulations adopted by NMFS under the MMPA and ESA. NMFS recommended that Scripps apply for a SRP, rather than an Incidental Harassment Authorization of marine mammals and endangered species, in light of the need for additional *bona fide* research on the effects of low frequency sound on marine mammals and sea turtles. Although an incidental take permit might also have been appropriate, selection of a SRP will enhance environmental protection.

Scripps' application for a SRP for the California MMRP and ATOC projects is currently pending, and will be considered following the completion of the Final EIS/EIR.

5.1.3 ENDANGERED SPECIES ACT SECTION 7 CONSULTATION

Given the potential effect of the ATOC project and MMRP on endangered species, NMFS has concluded that consultation under Section 7 of the Endangered Species Act is required. By letter dated August 15, 1994, ARPA requested consultation under Section 7. This consultation is currently underway, and is addressing potential impacts at the proposed Pioneer Seamount site.

The responsibility for Section 7 consultation rests with NMFS for all species that are under its ESA jurisdiction. Consultations regarding other species are made with the U.S. Fish and Wildlife Service. A review of the species potentially affected by the California MMRP and ATOC projects indicates that only endangered species regulated by NMFS may be affected.

The consultation process centers around a biological assessment. As allowed by the Section 7 regulations, this EIS/EIR contains the analysis and supporting information necessary to constitute the biological assessment required for the Section 7 consultation.

NMFS will issue its findings regarding the Section 7 consultation after review and consideration of the information presented in this EIS/EIR.

5.1.4 MONTEREY BAY NATIONAL MARINE SANCTUARY PERMITTING REQUIREMENTS

The Monterey Bay National Marine Sanctuary (MBNMS) was designated in 1992 by Congress (P.L. 102-587), in accordance with the National Marine Sanctuaries Act (NMSA; also known as Title III of the Marine Protection, Research, and Sanctuaries Act), 16 U.S.C. Sections 1431 et seq. The Sanctuary encompasses an area of approximately 13,720 km^2 of coastal and ocean waters extending from near the Gulf of Farallones outside of San Francisco Bay in the north to Cambria on the central California coast in the south. It extends from the mean high-water line seaward to approximately the 914 m depth contour. The Sanctuary is managed by the Sanctuaries and Reserves Division (SRD) of the National Oceanic and Atmospheric Administration (NOAA).

The installation of ATOC facilities in the Sanctuary is subject to a permit requirement under regulations promulgated by the SRD. On July 26, 1993, a permit application was made by Scripps to the MBNMS Manager, to conduct research activities in the MBNMS. The permit was issued on August 5, 1993. The permit allows Scripps to "conduct seabed installations supporting the ATOC project" but required all installation activities to be completed before July, 1994. Due to project delays, installation was not completed by that date. With regard to the Sur Slope and Pioneer Seamount alternatives, only cables would be installed within the MBNMS and the ATOC sound source would be located outside the Sanctuary. A revised permit application has been submitted to SRD to allow installation of a cable to serve the Pioneer Seamount site. The details of the cable installation will be designed in consultation with the MBNMS and in accordance with the terms of any sanctuary permit.

5.1.5 RIVERS AND HARBORS ACT SECTION 10

None of the California ATOC installations proposed outside of the 3 nm (5.6 km) band is subject to Corps of Engineers permitting requirements. In addition, the Corps has informed Scripps that cables are not considered "fill" under Section 404 of the Clean Water Act, and therefore no permits are required under Section 404.

However, cables laid within the 3 nm (5.6 km) area are subject to the Section 10 requirements of the Rivers and Harbors Act, which is administered by the Corps. Authorization under one or more Section 10 nationwide permits (NWP) will be requested. The four NWPs applicable to the ATOC cables are NWP 5 for scientific measurement devices, NWP 6 for survey activities, NWP 12 for cables, and NWP 18 for small structures less than 25 cubic meters in volume. Scripps is requesting confirmation from the Corps that one or more of these NWPs address Section 10 permitting requirements for the ATOC cables.

5.1.6 COASTAL ZONE MANAGEMENT ACT SECTION 307 COORDINATION AND COOPERATION

The federal Coastal Zone Management Act (CZMA, 16 U.S.C. Section 1451 et seq.) establishes a voluntary program for states to develop coastal management programs. Once such a program is federally approved, all federal actions affecting the coastal zone must be consistent with the enforceable policies of a state coastal management program. Direct federal actions must be consistent to the maximum extent practicable. Activities requiring federal licenses or permits, or federal assistance to state or local governments must be fully consistent. This federal consistency requirement applies to federal actions affecting the coastal zone, regardless of whether they will occur within or outside of the coastal zone. It also ensures that federal agencies and federal permit applicants coordinate and cooperate with state coastal management agencies. Following the agency's consistency determination or applicant's certification, the state coastal management agency then reviews the activity for consistency with the state coastal management program.

As discussed in section 5.3.3, Scripps certified the consistency of the ATOC project with the California Coastal Management Program.

5.2 PROJECT APPROVAL BY THE UNIVERSITY OF CALIFORNIA, SAN DIEGO

As described in Section 1, the University of California, San Diego's (UCSD) Scripps Institution of Oceanography will be the primary entity carrying out the ATOC project; therefore UCSD is the state lead agency for the purposes of implementing the requirements of the California Environmental Quality Act (CEQA). Following the completion of the Final EIS/EIR for the ATOC project, UCSD is responsible for certifying that the Final EIS/EIR has been completed in compliance with CEQA. After considering the Final EIS/EIR, and in conjunction with making findings regarding the potential for significant effects associated with the project, the Chancellor of UCSD will decide whether or how to approve or carry out the project. In accordance with CEQA, UCSD shall not decide to approve or carry out the project unless the project is determined not to have significant effects on the environment, or potentially significant effects have been eliminated or substantially lessened where feasible, and it can be determined that any remaining significant effects on the environmental are found to be unavoidable or are acceptable due to overriding concerns as described in CEQA.

If UCSD approves the project, a Notice of Determination will be filed with the State Clearinghouse indicating that the project has been approved and describing the project and associated environmental findings regarding the potential significance of any impacts that may result from the project. The filing of this Notice of Determination will conclude the CEQA process and UCSD's approval process.

5.3 REVIEW OF THE ATOC PROJECT BY THE STATE OF CALIFORNIA

This section evaluates state regulatory programs that do or may apply to ATOC facilities at the California alternate sites. These include California Coastal Commission consideration of a coastal development permit for the cable in state waters, State Lands Commission authorization to use state lands for the cable route, and California Coastal Commission federal consistency review under the Coastal Zone Management Act.

5.3.1 COASTAL DEVELOPMENT PERMIT FOR CABLE INSTALLATIONS

Permit requirements of the California Coastal Act (Division 20, Cal. Pub. Resources Code, PRC) apply to portions of the project in the California coastal zone. The coastal zone includes state ocean waters, which extend from the mean high tide line seaward for 3 nm (5.6 km), and a shoreline band, which extends inland for 1000 yd (914 m) or more.

The cable installation in state waters will require a coastal development permit from the California Coastal Commission. The Commission will review the permit application for consistency with the policies of the Coastal Act.

Under the Pt. Sur and Sur Ridge alternatives, an approximate 360 ft (110 m) segment of the cable onshore would be located within a Navy easement on privately owned lands and on land the Navy owns. Any review of this portion of the project by the Coastal Commission will take place pursuant to the federal consistency authority, discussed below in section 5.4.2. The onshore portion of the cable is considered exempt from county coastal development permit requirements; confirmation of that conclusion has been requested from the Monterey County Planning and Building Department. At Pillar Point, the landfall for the cable under the Pioneer Seamount alternative, the Air Force facility abuts the high tide line and there is no intervening private property. Therefore, no county permit requirements are applicable.

5.3.2 STATE LANDS COMMISSION PERMIT FOR USE OF STATE LANDS

The State of California owns the seabed between the 3 nm (5.6 km) limit and the mean high tide line. At its discretion, the California State Lands Commission issues leases and permits allowing the installation of facilities on the state-owned seabed. On December 17, 1993, the Department of the Navy; Naval Postgraduate School, Monterey, applied to the State Lands Commission for a right of way permit to install the seabed cables to support the ATOC facility. On March 8, 1994, Scripps notified the State Lands Commission that Scripps was taking over the application previously submitted by the Navy. On March 10, 1995, this application was revised to reflect the change in the proposed source location to Pioneer Seamount. This application is now pending the completion of the environmental review process described in this EIS/EIR.

5.3.3 STATE OF CALIFORNIA REVIEW UNDER COASTAL ZONE MANAGEMENT ACT

The federal Coastal Zone Management Act (CZMA, 16 U.S.C. Section 1451 et seq.) establishes a voluntary program for states to develop coastal management programs. Once such a program is federally approved, the state is authorized to review certain projects, including projects which require federal funding, permits or licenses, for consistency with the state coastal management program (CZMA Section 1456[c]). This "federal consistency" authority extends to projects which "affect any land or water use or natural resource of the coastal zone," regardless of whether the project is located within or outside the coastal zone. Federal permit and license activities are automatically subject to consistency review if they are listed in the state program. Otherwise the state must seek approval from the federal Office of Ocean and Coastal Resource Management (OCRM) to review the unlisted activity (15 C.F.R. Section 930.54).

California's coastal management program has been federally approved and the Coastal Commission designated as the agency to conduct federal consistency review. It is anticipated that federal consistency review would be coordinated with approval of a coastal development permit for portions of the ATOC project within the coastal zone. Other portions of ATOC, including portions outside the coastal zone, may be subject to federal consistency review. The program provides for review of federal permits outside the coastal zone. However, for federal permits or licenses which apply to ATOC activities outside the zone that are not listed in California's program, the Commission would have to request approval from OCRM to review the unlisted activity, and OCRM would have to determine that the activity "can be reasonably expected to affect the coastal zone of the State" (15 C.F.R. Section 930.54).

By letter dated November, 29, 1994, Scripps certified the consistency of the ATOC project with the California Coastal Management Program (CCMP), with a reservation of objections based on the threshold criteria for consistency review. The Commission responded by requesting permission from OCRM to undertake consistency review. In response to the Commission's request and Scripps' reservation, OCRM on January 27, 1995, provided additional written guidance concerning some of these issues, without ruling on the Commission's request. Subsequently, OCRM on March 10, 1995, granted the Commission's request to review Scripps' application for a MBNMS permit, requiring that review to be completed by July 24, 1995. In March, Scripps also reaffirmed its consistency certification and modified it to address the Pioneer Seamount alternative, particularly in light of the greater distance of the Pioneer Seamount source site from the California coastal zone and the corresponding reduction of impacts. The analytical basis for a conclusion that ATOC and MMRP activities are consistent with the CCMP is contained in section 5.4.1, below.

5.4 CONSISTENCY OF THE PROJECT WITH APPLICABLE PLANS AND POLICIES

This section of the EIS/EIR analyzes the consistency of the ATOC project and MMRP with established plans and policies that do or may apply to them. This analysis is closely related to that contained in Section 4, since the conclusion that the ATOC project and MMRP are consistent with applicable programs is based largely on the anticipated low level of potential impacts on coastal and marine resources. The plans and policies considered below include the California Coastal Act and closely related Coastal Management Program, Monterey Bay National Marine Sanctuary Management Plan, Sea Otter Game Refuge, Gray Whale Monitoring Plan, and recovery plans for the humpback and right whales, and Steller sea lion.

5.4.1 CALIFORNIA COASTAL ACT

The California Coastal Commission's action on the coastal development permit application will be based upon the provisions of the California Coastal Act. As further noted at Section 5.4.2, below, the Coastal Act is also the principal component of the CCMP and will therefore form the main basis of federal consistency review.

The policies of Chapter 3 of the Coastal Act form the basic standard of review for permit and federal consistency matters. These policies are interpreted in light of legislative findings, state goals, and interpretive directions contained elsewhere in the Act.

Concern about sea level rise and its possible effect on coastal areas is reflected in a 1992 amendment of the Coastal Act, adding Section 30006.5:

The Legislature further finds and declares that sound and timely scientific recommendations are necessary for many coastal planning, conservation, and development decisions and that the commission should, in addition to developing its own expertise in significant applicable fields of science, interact with members of the scientific and academic communities in the social, physical, and natural sciences so that the commission may receive technical advice and recommendations with regard to its decision making, especially with regard to issues such as coastal erosion and geology, marine biodiversity, wetland restoration, and the question of sea-level rise, desalination plants, and the cumulative impact of coastal zone developments.

Since a principal objective of the ATOC program is to assist in the understanding of global climate change, which is the cause of sea level rise, the program directly supports this policy.

Another legislative goal, stated in Section 30001.5, reflects the Coastal Act process of weighing and balancing competing uses of coastal resources:

[T]he basic goals of the state for the coastal zone are to: (a) Protect, maintain, and, where feasible, enhance and restore the overall quality of the coastal zone environment and its natural and artificial resources; (b) Assure orderly, balanced utilization and conservation of coastal zone resources taking into account the social and economic needs of the people of the state.

Weighing of the possible beneficial and non-beneficial effects of the MMRP and ATOC activities shows their consistency with this basic Coastal Act goal. The MMRP and ATOC programs will provide important information about marine mammal and other aquatic resources, and should in the long term provide important data on global warming issues of vital importance to protection of coastal resources. As described in greater detail in Section 4, given the distance between the proposed ATOC sound source and the coastal zone (over 35 km at the Pt. Sur site, over 45 km at the Sur Slope site, and over 80 km at the Pioneer Seamount site), potential impacts of the sound emissions on coastal zone resources are expected to be minor or non-existent.

The Chapter 3 policies are organized into several groups. Each is discussed below.

Public Access and Recreation Policies

Public access to and along the shoreline and recreational uses of the shoreline and water are fostered and protected by Sections 30210-30224 and Sections 30251-30252 of the Coastal Act. The MMRP and ATOC programs would have no effect upon these uses. For the Pt. Sur and Sur Slope alternate sites, the two ATOC cables supplying power to the sound source and transmitting data from a vertical line array would be buried in a 2-4 ft (0.6-1.2 m) deep trench along an existing cable easement from a building at the Pt. Sur Naval Facility, to the top of the bluff, encased in hard-cased steel and standard split pipe down the bluff face, and across the beach. The cables would cross the bluff and transition down through the surf zone inside a nominal 4 in (10.2 cm) diameter pipe, and follow an existing sea bottom cable route to the sound source on the ocean floor 22 nm (40 km) offshore.

The landfall site for the cable under the Pioneer Seamount alternative is on the western edge of the Pillar Point Air Force Tracking Station, which is located near the town of Princeton-by-the-Sea in San Mateo County. It is proposed that the cable be laid from the Pillar Point Air Force Tracking Station west down the bluff face, through an existing ravine, across the beachfront (approximately 50 yards at a normal low tide), through the cove, out to the state territorial three mile limit. The onshore portion of the cable would be installed during bluff restoration activities anticipated to be undertaken by the Air Force during late spring, 1995. Those bluff restoration activities will include measures to remediate erosion that has occurred and to prevent future bluff erosion. The proposed cable is approximately 3 inches in diameter, and would be buried along the entire shore route and through the surf zone.

Onshore and at landfall, the Pt. Sur facilities would not be located in an area in or through which the public has access. The surrounding countryside is open grazing land, with no established public access or recreational provisions. Because the cables will be buried and other onshore facilities will be housed in existing facilities, there will be minimal visual impact or potential for interference with any public access or recreational use that might be established in the future. While the public does have access to the beach where the cables at Pillar Point would come onshore, the cable would be underground and have no effect upon recreational uses, except during the one-day installation activities, which would be scheduled mid-week during low usage periods.

Offshore, the cables and sound source will rest on the seabed, away from any possible interference with public boating or other recreational uses of the water.

Public recreational boating in the immediate Pt. Sur area is limited to occasional sailing and fishing. Most recreational fishing from skiffs is contained in sheltered areas of Monterey and Carmel Bays. However, the Big Sur coast in general is a popular area for recreational fishing party boats, and boats take whale-watchers and nature observers out into the ocean around the project vicinity. Two hundred and fifty berths at the Monterey marina are used by non-commercial boats. The MMRP monitoring vessel, operating a maximum of 3 times a week in the project vicinity, would not have a perceptible impact on these recreational uses of the area. See Section 4.5 of this EIS/EIR. Under the Pioneer Seamount alternative, approximately 8 cruises in total would be made during which elephant seals are translocated and observations made during the transit to and/or from the release sites. These cruises would probably be made from Santa Cruz harbor, but might be made from Monterey or Moss Landing. In any event, impacts on recreational boating would be imperceptible.

Marine Environment Policies

Several marine environment policies of the Coastal Act have possible relevance to the proposed project:

Marine resources shall be maintained, enhanced and, where feasible, restored. Special protection shall be given to areas and species of special biological or economic significance. Uses of the marine environment shall be carried out in a manner that will sustain the biological productivity of coastal waters and that will maintain healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes. PRC Section 30230.

The economic, commercial, and recreational importance of fishing shall be recognized and protected. PRC Section 30234.5.

Section 4 of this EIS/EIR describes in detail the potential for the proposed project to impact any marine resources. Marine mammals will be closely monitored for signs of negative impacts from the project, and the sound transmissions will be terminated if observers find that the sound transmissions cause detrimental effects to marine mammals, as is described in more detail in Appendix C. With these mitigation measures in place, the proposed action is fully consistent with these policies.

The diking, filling, or dredging of open coastal waters ... shall be permitted ... where there is no feasible less environmentally damaging alternative, and where feasible mitigation measures have been provided to minimize adverse environmental effects, and shall be limited to coastal-dependent industrial facilities, including commercial fishing facilities ... incidental public service purposes, including but not limited to burying cables ... nature study ... or similar resource-dependent activities. PRC Section 30233.

To the extent that the Coastal Act defines "fill" to include any substance or material placed in a submerged area, the two power cables which will run from the Pt. Sur Naval Facility to the sound source 22 nm (40 km) offshore could be subject to this policy. The cables will be either encased in standard pipe or protectively armored, which are considered the least detrimental methods of laying subsea cable. They will rest on the ocean bottom without being anchored which also minimizes their effects. The cables will be buried from the terminal building at the Naval Facility to the bluff, where they will transition through the surf zone inside a 4-in (10.2 cm) split pipe or drill pipe. The proposed single 3-in cable installation at Pillar Point would not be enclosed in split pipe, but instead be armored and buried through the beach and shallow intertidal zone.

There is no feasible alternative at the present time to the use of cabled installations. While a moored autonomous source may prove feasible after further development, no such source is available for the initial ATOC phase.

The MMRP and ATOC studies constitute both nature study and resource-dependent activities, for which fill is allowed under PRC Section 30233 provided the mitigation and alternatives requirements are met. Other uses allowed by that section also indicate the consistency of this project with the intent of Section 30233. The burying of cables for incidental public service purposes is allowed. Laying of cables is the only ATOC or MMRP use proposed within the coastal zone. Also allowed under Section 30233 (and given priority over other uses, under Section 30255) is fill for coastal-dependent industrial facilities, defined as those which require a site on or adjacent to the sea to be able to function at all. See PRC Section 30101. The ATOC and MMRP facilities and activities are "coastal-dependent."

> *Facilities serving the commercial fishing and recreational boating industries shall be protected and, where feasible, upgraded.* PRC Section 30234.

Activities associated with the MMRP and the ATOC program are consistent with the protection of commercial or recreational boating facilities. The main facility in the area is the Monterey Harbor which consists of two wharves and two boat launch ramps, with additional moorings in open water between the breakwater and the wharves. The MMRP provides for boat-based visual and acoustic tracking of marine mammals around the project vicinity. It is anticipated that the 17-m R/V SHANA RAE or a comparable vessel would be the vessel utilized for these tasks. Approximately 8 cruises total would be required under the Pioneer Seamount alternative, and these cruises would most likely be made from Santa Cruz harbor, but could be made from either Monterey or Moss Landing. See Appendix C of this EIS/EIR for details.

Other marine resource policies of minimizing waste water discharges and protecting against hazardous substance spillage are not affected by the MMRP and ATOC programs because none of the proposed activities will involve any waste water discharges or transportation or development of hazardous substances.

Similarly marine resource policies relating to revetments, breakwaters, seawalls, harbor channels, dams and stream alterations will not be affected by the MMRP and ATOC programs which do not involve such structures or construction.

Land Resources Policies

The Coastal Act contains the following principal policy to protect sensitive habitat areas:

> *Environmentally sensitive habitat areas shall be protected against any significant disruption of habitat values, and only uses dependent on those resources shall be allowed within those areas.* PRC Section 30240.

At Pt. Sur, no sensitive onshore habitats would be affected by the proposed project, which consists of mostly buried cables located in an open grazing field and transitioning through the bluff and surf zone. At Pillar Point, no incremental modification to onshore habitats would occur, since the cable installation would occur in connection with a previously planned bluff restoration project to be undertaken by the Air Force. This project was analyzed in a September, 1994, Final Environmental Assessment for Erosion Repair at Pillar Point Air Force Station (EA), which identified no significant effects on sensitive habitats as a result of the restoration activities. As discussed in detail in Section 4, all offshore habitat impacts will be minimized through the mitigation measures included in the project.

Archeological and paleontological resources are also protected. Surveys have concluded that no archeological or cultural resources are found at the project site. A nearby candidate for the National Register of Historical Places, the Pt. Sur Lighthouse, erected in 1899, will not be affected in any way by the proposed project. The Air Force Pillar Point EA discussed above surveyed the onshore area through which the cable would be laid and concluded that no archaeological or cultural resources are located there. An offshore survey, including a literature search and a physical survey with side-scan sonar, similarly identified no such resources.

None of the other land resources policies protecting agricultural lands and timberlands are relevant to this project.

Development Policies

PRC Section 30250 encourages location of new development within existing facilities. This policy will be followed for all new facilities within the coastal zone; all are to be located within existing structures or rights-of-way.

Policies concerning the location of development seek to protect the scenic and visual qualities of coastal areas. As discussed above in connection with public access policies, the MMRP and ATOC program will have no effect on scenic or visual resources.

PRC Section 30253 seeks to minimize risks to life and property from geologic instability, flood, fire hazards, and erosion, and to minimize energy consumption and air pollution. None of the MMRP or ATOC activities will conflict with these policies. ATOC research, by contributing to knowledge of ocean climate change, could indirectly help address the problem of shoreline erosion and the resulting risks to life and property. By combining passive listening monitoring and visual surveys of marine mammals to the same vessel, the MMRP will keep the number of vessel trips to a minimum. This will save energy and minimize air pollution.

None of the other development policies limiting new development, maintaining and enhancing public access, limiting public works facilities, and sewage treatment plants are relevant to this project.

Industrial Development Policies

None of the policies concerning location or expansion of industrial facilities, the use of tanker facilities and liquefied natural gas terminals, oil and gas development, petrochemical refineries, thermal electric generating plants or offshore oil transportation are relevant to the proposed project.

Conclusion

The proposed project is consistent with the relevant policies of the Coastal Act and will contribute to realization of the legislative goal expressed in Section 30006.5 to address questions relating to sea level rise.

5.4.2 CALIFORNIA COASTAL MANAGEMENT PROGRAM

In conducting federal consistency review under the federal Coastal Zone Management Act ("CZMA"), the California Coastal Commission uses as the standard of review the California Coastal Management Program. The policies of the Program are contained in the California Coastal Act, state regulations which implement the Act (Cal. Admin. Code, Title 14, Sections 13001-13666.3), two state statutes not relevant here, and Chapter 11 of the final Program EIS and Program description approved by the U. S. Department of Commerce.

Chapter 11 of the Coastal Management Program assembles and amplifies the various program components which make provision for a national interest in California coastal zone resources and provide for a balancing of local interests with larger-than-local interests. The CZMA includes a finding that "[t]here is a national interest in the effective management, beneficial use, protection, and development of the coastal zone." The 1990 Amendments to the CZMA added the requirement for state coastal management programs to include provisions for addressing the adverse effects of sea level rise upon coastal resources. The national interest considerations are reflected in provisions of the Coastal Act.

The issues addressed by the MMRP and ATOC program are of broad importance. Additions to the scant knowledge concerning marine mammals' response to low frequency sound should support ocean use decision-makers on a national and international scale. Contributions of the ATOC research to understanding of ocean climate should have similarly broad significance. Thus, consideration of these research activities should be a part of any federal consistency review of the MMRP and ATOC program conducted by the Coastal Commission.

In federal consistency review, substantive analysis is based upon the enforceable policies of the state Coastal Management Program, with the Chapter 3 policies of the Coastal Act as the primary standard of review. For this project, the federal consistency analysis will be essentially the same as described above in connection with the coastal development permit application. However, consistency findings are required only with enforceable, mandatory policies of the management program. Other provisions of the management program that are in the nature of recommendations need only be given adequate consideration (15 C.F.R. Section 930.58).

The certified Monterey County Local Coastal Program may be given consideration upon request of the County. Monterey County passed a Coastal Implementation Plan in 1988, after which it was certified by the California Coastal Commission and approved as part of the state program by OCRM. The Plan divides the coastal zone in Monterey County into eighteen districts with different land use regulations for each district. The Pt. Sur Naval Facility is located in district PQP (CZ) - Public/Quasi-Public Coastal Zone District. The purpose of the PQP district is to accommodate areas under the control of public agencies. All public and quasi-public uses of the land are permitted, including coastal-dependent development and moderate intensity recreational uses. Specifically, educational and research facilities are principal permitted uses in the PQP zone. Zoning regulations restrict building height, setbacks, site coverage and signage. None of these restrictions apply to the proposed project, which is consistent with all of the regulations for the PQP Coastal Zone District.

In addition, the Pt. Sur Naval Facility is surrounded by the El Sur Ranch, which is located in a Watershed and Scenic Conservation Coastal Zone (WSC CZ) District. The cables which transmit power to the source and hydrophones will traverse a small portion of land within the WSC CZ, but none of the developmental or use restrictions for this zone apply to the proposed project, which is consistent with all of the regulations for the WSC CZ District.

Under the San Mateo County LCP, the San Mateo County coast is divided into urban areas, rural areas, rural service centers, and rural residential areas. The LCP goals are to maintain the separation between rural and urban areas, and to direct new development to existing urban and rural service centers. Designations under the LCP are generally made by reference to existing general planning documents. The Pillar Point Air Force Station, as a federal facility, is not subject to local land use controls and as such is not the subject of planning requirements imposed by San Mateo County. The San Mateo County General Plan designates the land adjacent to this federal facility as General Open Space, with a zoning designation for these adjacent areas of Resource Management/Coastal Zone. The San Mateo County LCP Land Use Map designates the Pillar Point Air Station proper as Open Space, and includes it within the areas classified as "Urban." The Locating and Planning New Development Component generally limits the location, density and scope of residential and commercial development in the urban area of the coastal zone. However, since the ATOC cable is not a residential, commercial or similar development, and does not comprise a development unit under the LCP subject to density restrictions, these limitations are inapplicable. The cable landfall does not impact the location of new development nor does it affect the existing rural/urban mix, and is therefore consistent with these policies.

Conclusion

The proposed MMRP and ATOC activities are consistent with the California Coastal Management Program. In particular, the activities are consistent with the Chapter 3 policies and should further the national interest in increased knowledge of ocean climate change and marine mammal response to sound in the ocean. To the extent that the activities will have any effect upon land or water uses, or natural resources of the California Coastal Zone, those effects are not expected to be major, and may be of a beneficial nature, as discussed above.

5.4.3 MONTEREY BAY NATIONAL MARINE SANCTUARY MANAGEMENT PLAN

The Monterey Bay National Marine Sanctuary (MBNMS) is managed by the Sanctuaries and Reserves Division (SRD) of NOAA. In 1992 the SRD issued a Final Management Plan and regulations for the Sanctuary. The Management Plan is divided into four programs: resource protection, research, education and administration. The authors of this EIS/EIR believe that the ATOC project and MMRP are consistent with the goals and objectives of the Management Plan, and the two activities would actively contribute to the research and education goals contained in the Management Plan.

Resource Protection Program

The highest priority management goal for the Sanctuaries is the protection of its marine environment, resources and qualities. One principal mechanism in place to meet this goal exists in the form of Sanctuary regulations, which prohibit a narrow range of activities to protect Sanctuary resources and qualities. The MBNMS regulations are found at 15 C.F.R. Part 944. The ATOC project must operate in strict compliance with Sanctuary regulations as well as all other applicable local, state and federal statutes and regulations, and all required permits will be obtained before beginning the project. As discussed above, the Sanctuary implements its program, in part, through Sanctuary regulations which require persons to obtain a permit to conduct an otherwise prohibited activity. Prior to issuing a Sanctuary permit, the Director of OCRM, or designee, must find that the proposed activity will have only negligible, short-term adverse effects on Sanctuary resources and qualities.

SRD's comments on the DEIS/EIR set forth SRD's view, including that locating the ATOC source within the MBNMS would be inconsistent with the MBNMS regulations, as in SRD's opinion there is unsufficient evidence to find "only negligible, short-term adverse effects." Consequently, OCRM concluded that it would not be appropriate to site the ATOC sound source--and thus the zone of greatest ecological risk--within a national marine sanctuary, however valuable the resulting research might be. As a result the preferred Sur Ridge alternative has been disqualified, and the Pioneer Seamount alternative has become the proposed source site. A revised permit application was filed in April, 1995 with SRD to reflect the change in location to Pioneer Seamount/Pillar Point.

Research Program

As described in the management plan, "The purpose of Sanctuary research activities is to improve understanding of the Monterey Bay environment, resources and qualities, to resolve specific management problems, and to coordinate and facilitate information flow between the various research institutions, agencies and organizations.""

Research goals for the MBNMS are divided into three project categories: baseline studies, monitoring, and predictive studies. The MMRP and ATOC programs are consistent with, and should further the goals in each of these areas. For example, the Management Plan calls for baseline studies to determine the abundance and distribution of species living in and transiting the Sanctuary. Monitoring program goals include studies to monitor population dynamics and fluctuations in the abundance of whale, pinniped, and seabird species. The goals of predictive studies include analyzing the causes and consequences of ecosystem changes and determining the range of whales, pinnipeds and seabirds in the Sanctuary.

The proposed MMRP will collect detailed passive acoustic data on vocalizing whales, conduct satellite and recoverable tagging of "indicator species" (blue whales, northern elephant seals, and California sea lions) to determine at-sea behavior patterns, track whales with hydrophones from a vessel, and carry out aerial surveys of numerous species in the project vicinity. The ultimate goal of the ATOC program is to determine long-term global ocean climate changes. The data collected from the ATOC program will contribute to a predictive computer model of global climate changes. All of the research data collected during the MMRP will be available to the SRD, MBNMS staff, and the Sanctuary Advisory Council, for integration with other research data used to inform management decisions and further Management Plan goals.

Education Program

The data resulting from the MMRP will be made available to the MBNMS staff for use in educational programs to further public awareness and understanding of the significance of the Sanctuary. This would contribute to the Management Plan goal of incorporating research results into educational programs.

Administration Program

Neither the MMRP nor the ATOC program will interfere with or have any adverse effect on the administration of the MBNMS.

Conclusion

MMRP and ATOC program activities must be conducted pursuant to a permit issued by the SRD for activities within the Monterey Bay National Marine Sanctuary. Activities are consistent with the MBNMS Management Plan, and should contribute positively to the research and education goals of the Plan.

5.4.4 SEA OTTER GAME REFUGE

The California Fish and Game Commission established the California Sea Otter Game Refuge in 1959 to include the areas of Monterey and San Luis Obispo Counties west of Highway 1, between the Carmel River in the north and Santa Rosa Creek in the south. The offshore portion of the Refuge is wholly contained within the Monterey Bay National Marine Sanctuary.

Recreational fishing and hunting of birds and mammals regulated by the California Department of Fish and Game is prohibited within this Refuge. It is also prohibited to fly any aircraft less than 1000 ft (305 m) above water or land within the Refuge, without a permit. Other than these general statutes which apply to all game refuges in California, there are no specific rules, regulations, or management plans for the Sea Otter Game Refuge. The MBNMS regulations apply to the portion of the Refuge located within Sanctuary boundaries.

The proposed activities would be consistent with the MBNMS regulations and management plan goals as described in section 5.4.2 above, and would, therefore, also be consistent with the purpose of the California Sea Otter Game Refuge. A permit will be sought for any flights required below the 1000 ft restriction zone.

In addition, the United States Fish and Wildlife Service is in the process of preparing a recovery plan for the California population of sea otters. While the details of this plan are not yet final, given the anticipated lack of impact of the ATOC project and MMRP on sea otters, the project would be consistent with the upcoming sea otter recovery plan.

5.4.5 GRAY WHALE MONITORING PLAN

The Endangered Species Act (16 U.S.C. Section 1531 et seq) requires monitoring the status of formerly endangered species which are removed from the List of Endangered and Threatened Wildlife. In 1994 the eastern North Pacific gray whale was removed from the federal endangered species list. NMFS has been given the mandate to monitor the status of the gray whale for five years following delisting.

NMFS developed a 5-Year Plan for Research and Monitoring of the Eastern North Pacific Population of Gray Whales which outlines goals and objectives of the monitoring plan. The MMRP and ATOC programs would be consistent with the monitoring plan.

Consistency with the Monitoring Plan Goals

The Gray Whale Monitoring Plan sets out five main goals: 1) monitor the status of the gray whale and habitats essential to its survival; 2) continue monitoring the level and frequency of gray whale mortality; 3) evaluate the results of status determinations; 4) continue monitoring the magnitude and composition of the subsistence harvest of gray whales by Russians; and 5) monitor the concentrations of chemical contaminants in gray whales. The MMRP and ATOC programs should support the first two goals, and do not affect the last three.

The monitoring of the status of the gray whale is an important goal because if at any time during the five-year monitoring the species' well-being is at risk, the Endangered Species Act provides for emergency protective measures. The Monitoring Plan calls for surveys of both southbound (Goals 1.11) and northbound (Goal 1.22) migrations. The MMRP's visual and passive acoustic surveys will include monitoring of any gray whales in the project vicinity, and this information will be available to NMFS for integration with other survey data.

The Monitoring Plan also calls for monitoring the number of strandings along the west coast, and the number of animals taken under the small take exemption of the MMPA. The MMRP will provide NMFS with data on any strandings observed in the project vicinity, and on the results of the monitoring program pursuant to the MMPA permit.

In conclusion, since the purpose of the Gray Whale Monitoring Plan is to track the progress of the gray whale for five years after de-listing, the proposed MMRP can further this purpose by providing the results of surveys of marine mammals to NMFS for integration with other survey data.

5.4.6 HUMPBACK WHALE FINAL RECOVERY PLAN

To aid in the conservation of the humpback, NOAA directed the Humpback Whale Recovery Team to prepare a Recovery Plan. The Humpback Whale Final Recovery Plan was approved by NMFS in 1991.

The Recovery Plan sets out a series of recommended 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 ATOC MMRP is consistent with, and will further, the goals of the Recovery Plan, as discussed below.

Many of the goals of the Recovery Plan depend on increasing the knowledge of the whale, its habits and habitat. Goal 1.14, for example, calls for basic information on the whale's behavior. Goal 3.5 requires information about habitat use to determine management actions, and Goal 3.412 is to accumulate data on sightings. Other goals call for photographic surveys (Goal 3.522), and underwater listening stations (Goal 3.4232). These goals reflect components of the ATOC MMRP.

Additionally, the MMRP would acoustically monitor humpback whales for vocal behaviors (singing, calling, social sounds) and movement patterns, both during ATOC sound transmissions and between signals, as is specifically called for in Goal 3.5232. The whales will also be visually surveyed from ships and by air for surface behaviors (blow intervals, duration at surface, etc.) and movement patterns (swimming direction, speed, etc.).

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." However, Goal 1.3111 is hesitant about recommending additional noise research because of the expense and possible ambiguous results. The MMRP would attempt to reconcile both of these goals. It will measure comparative sound levels of endemic noise-producing sources in the study area, including commercial shipping, whale-watching vessels, recreation power boats, and low-flying aircraft. In addition, it will provide controlled study data on the response of marine mammals to underwater low frequency sound. This important information is needed to assess accurately the impacts of noise and to implement Goal 1.3111 to reduce noise disturbance in California.

The ATOC experiment would increase somewhat the overall amount of undersea noise at the source location. Any increase would be expected to be slight compared to current noise levels. If the MMRP provides evidence that existing subsea noises are adversely affecting marine mammals, and if noise controls are adopted as a result, the net effect of the ATOC program and MMRP may be a lessening in ambient subsea noise levels offshore central California.

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). ATOC and its MMRP should provide increased knowledge of the oceans and marine mammal behavior, which will enable continuing education of the public with regard to our oceans and their inhabitants, including humpback whales. An important component of the ATOC experiment is the cooperative element. Eighteen universities and research laboratories in eight countries are involved in this experiment. ATOC would support international cooperation on global ocean issues, which can be applied to humpback whale preservation.

In conclusion, the ATOC experiment and particularly its marine mammal research component, would further the goals of the Humpback Whale Final Recovery Plan by providing needed scientific data on the whale, its behavior and habitats, educating the public about marine mammal issues, and promoting international cooperation on global ocean research and preservation of marine mammals.

5.4.7 STELLER SEA LION RECOVERY PLAN

To aid in the conservation and recovery of the Steller sea lion NOAA directed the Steller Sea Lion Recovery Team to prepare a Recovery Plan. The Final Recovery Plan for Steller Sea Lions was approved by NMFS in December, 1992. The Plan proposes to minimize human-induced activities that may be detrimental to the survival or recovery of the sea lion population. Immediate objectives are to identify factors that are limiting the population, actions necessary to stop the population decline, and actions necessary to allow the population to increase.

The ATOC project is consistent with the Recovery Plan goals and objectives. Neither the ATOC transmissions, nor the MMRP will have any direct effect on the Steller sea lion; and the MMRP could contribute important information needed to implement the Recovery Plan.

Potential Effect of ATOC on Steller Sea Lions

The Pt. Sur alternative ATOC source site is approximately 40 km off Pt. Sur, at a depth of approximately 850 m. The Pioneer Seamount alternative source site would be located approximately 88 km off Pillar Point, at a depth of approximately 980 m. Most large rookeries and haul-out sites for the Steller sea lion are in the Gulf of Alaska and the Aleutian Islands. The sea lions have historically also used the Farallon Islands as a rookery and haul out, but their use of the Farallon Islands as a breeding site has declined in recent years. Año Nuevo is the Steller sea lion's southernmost breeding site. Because the source under all three alternatives would be far below the normal diving depths of Steller sea lions, and significantly distant from their known breeding sites, the ATOC transmissions should not have any direct effect on the Steller sea lion.

MMRP Consistency with the Steller Sea Lion Recovery Plan

Six out of the seven objective areas outlined in the Recovery Plan call for more information about the Steller sea lion, including identification of habitat requirements and stocks, monitoring of status, trends, and health, assessment of causes of mortality, and investigation of feeding ecology. (The seventh area is the implementation of the Plan itself.)

While the MMRP does not target the Steller sea lion as an indicator species, monitoring activities will collect data on Steller sea lion sightings. The MMRP includes visual surveys and observations of marine mammals by aircraft and boat, before, during, and between sound transmissions. These surveys would obtain data on seasonal presence/absence and relative sighting densities of all marine mammals in the project vicinity. Aerial surveys would collect data in an a 40x 40 km box around the sound source, and vessel surveys within approximately 10 km of the source. All of the data collected would be made available to NMFS for use in implementing Recovery Plan objectives.

5.4.8 NORTHERN RIGHT WHALE RECOVERY PLAN

The Recovery Plan for the federally listed endangered northern right whale (*Eubalaena glacialis*) was approved by NMFS in 1991. The Plan is divided into two sections, each giving separate goals and objectives for the Atlantic and the Northern Pacific populations of right whales. Because less is known about Pacific right whales, and no critical habitat has been identified for that population, the plan recommends concentrating funds and programs on the Atlantic population, and combining recovery efforts for the Pacific population with other species, especially the humpback whale. The Plan recommends that research on the North Pacific right whale focus on compiling and analyzing opportunistic sighting reports.

The MMRP component of the ATOC program is consistent with the goals of the Recovery Plan for the northern right whale, as is described below.

Consistency with Recovery Plan Goals

The Recovery Plan states:

> *The Recovery Team has been unable to identify any area in the North Pacific Ocean where northern right whales occur with such regularity and in such numbers as to justify, at the present time, a major research effort. However, the Team does recommend that every effort be made to try to secure as much information as possible about any northern right whale that should be sighted in the Pacific.*

The Recovery Plan also sets out seven objectives, the first three of which call for more information about the northern right whale in order to determine its population size, essential habitats, and potential conflicts with vessel traffic. The MMRP can contribute information toward these objectives by collecting data on any right whale sightings.

The MMRP includes visual surveys and observations of marine mammals by aircraft and boat, before, during, and between sound transmissions. These surveys will obtain data on seasonal presence/absence and relative sighting densities of all marine mammals in the project vicinity, including right whales, should any be sighted. Aerial surveys will collect data in a 40x40 km box around the sound source, and vessel surveys within approximately 10 km of the source. All of the data collected will be made available to NMFS.

Neither ATOC transmissions nor the MMRP component should have any effect on the other four recovery objectives: enforcing the whale-protection laws, continuing the international ban on hunting, reducing injuries by fishing gear, and collecting data on dead or stranded right whales.

In conclusion, the ATOC sound transmissions are not expected to have an impact on the northern right whale because there are no known right whale habitats or migration routes within the project vicinity, and because right whales are shallow divers, which normally frequent the continental shelves. The MMRP can further Recovery Plan goals by providing data obtained from any sightings of right whales.

5.4.9 GOLDEN GATE NATIONAL RECREATION AREA

In 1972 Congress established the Golden Gate National Recreation Area (GGNRA) composed of certain portions of Marin and San Francisco Counties. The Recreation Area was expanded into San Mateo County with the addition of Sweeney Ridge in 1980, and the Phleger Estate in 1992. The Recreation Area includes the designated lands and offshore water seaward to 1/4 mile from the mean-high tide line. The purpose of the Golden Gate National Recreation Area is to provide needed recreational open space for the urban San Francisco Bay area. It is managed by the U.S. Parks Service. The ATOC cable would pass through approximately 1/4 mile of the GGNRA offshore of the western edge of Pillar Point. No permit from the U.S. Parks Service is necessary for laying the cable through this portion of the Recreation Area.

5.4.10 FITZGERALD MARINE RESERVE

The James V. Fitzgerald Marine Reserve was created by the California legislature in 1969 for the protection of fish and game. It extends from the mean high tide line, 1000 ft into the ocean off San Mateo County. The Reserve, like other fish and game refuges throughout California, is managed by the California Department of Fish and Game. Regular California fishing and hunting regulations do not apply within the Reserve. Instead taking or possessing fish, shellfish, abalone, invertebrates or marine plant life is prohibited or severely restricted within the Reserve. There are no state permit requirements applicable to laying the ATOC cable through the Fitzgerald Reserve.

5.5 REGULATORY PROGRAMS THAT DO NOT APPLY TO THE ATOC PROJECT

Other than the regulatory programs discussed above, no additional permits or regulatory requirements are considered applicable to the ATOC project or MMRP. Potentially applicable programs that were considered in coming to this conclusion include the following:

- County land use requirements
- Endangered Species Act review by the U.S. Fish and Wildlife Service
- Clean Water Act
- Outer Continental Shelf Lands Act/ Rivers and Harbors Act Section 10 in the OCS
- Title I, Marine Protection, Research and Sanctuaries Act (ocean dumping)
- National Historic Preservation Act
- Federal General Conformity Rule (Clean Air Act)

6 ADDITIONAL ISSUES

This section of the EIS/EIR addresses a number of ancillary issues under NEPA and CEQA, including the relationship of short-term uses and long-term productivity, irreversible and irretrievable commitments of resources, energy and natural or depletable resource requirements, conservation potential, and environmental justice considerations.

6.1 THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF THE ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

NEPA and CEQA require consideration of the relationship of short-term uses and long-term productivity. For purposes of this EIS/EIR, the term "short-term" refers to timeframes on the order of 2-4 yrs; "long-term" refers to five years or greater. Other than the remote potential for long-term effects (addressed in detail in Section 4) which, at this time, must be stated as unknown, there will be no exploitation of resources by either the ATOC project or the MMRP over the short term at the expense of long-term productivity.

The proposed action would not be expected to result in adverse environmental effects that would have the potential for permanently altering the physical, biological, economic or social resources of California. The MMRP and ATOC activities would not be expected to result in environmental effects which could permanently narrow the range of beneficial uses of the environment by California residents, or pose any long-term risks to the health, safety, or general welfare of the public.

The proposed project will result in local short-term increases in boat traffic and air traffic as part of the MMRP. Shipboard visual and acoustic surveys will also be conducted as part of the MMRP. Shipboard line-transect methodology will be used to determine the relative abundance and distribution of marine mammals and sea turtles. Refer to Appendix C for further information regarding short-term aerial and shipboard survey activities.

The project could result in minor short-term, and possibly long-term changes in the local marine environment as a result of the operation of the ATOC sound source. As discussed in Section 4 of this EIS/EIR, the operation of the ATOC source is not anticipated to adversely affect the maintenance and enhancement of the long-term productivity of the environment.

The MMRP research proposed would have the potential for beneficial biological, economic and social implications in the long-term. Results of the marine animal research would help to quantify the marine animal inventory for the proposed study area. Identification and quantification of the effects of low frequency sound on marine animals would help California determine the need for possible operational restrictions on endemic human-made noise sources (e.g., merchant ship traffic, whale-watching boats). Similarly, the ATOC project could provide important information supporting governmental policies and regulations to curb global warming. As stated in the discussion of project objectives (Section 1), there are important justifications for proceeding with the project at this time in order to develop a method of measuring global climate change. Proceeding with the project at this time will not foreclose options to implement alternative global climate change study methodologies in the future.

6.2 SIGNIFICANT IRREVERSIBLE ENVIRONMENTAL CHANGES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION SHOULD IT BE IMPLEMENTED; IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Overall effects on marine populations are expected to be negligible should the proposed action be implemented. The installation of the cable, the listening arrays, and the ATOC sound source would be completely reversible, as these instruments and equipment can be removed from the site should the project be discontinued. Furthermore, the project is not expected to result in significant irreversible changes to the marine environment because protective measures are included in the proposed project protocol to minimize any irreversible harm to marine mammals or other organisms in the affected environment (See Appendix C).

Use of nonrenewable resources during the initial and continued phases of the project will be limited to the raw materials required to construct the sound source, cable and associated equipment, the use of energy and fuels associated with the operation of ships and aircraft required for the marine mammal survey activities, and the power necessary to operate the ATOC sound source. None of these uses would constitute a significant irreversible commitment of resources.

Several of the alternatives, specifically the moored autonomous source, Sur Slope, and Pioneer Seamount alternatives, would result in increased vessel and other usage of fuels because these alternate sites are located further from shore than the proposed action site, resulting in somewhat greater irreversible impacts as compared to the proposed project, but still at a less than significant level.

6.3 ENERGY AND RESOURCE REQUIREMENTS; CONSERVATION POTENTIAL

As discussed above, MMRP aircraft and vessel operations would use less than significant amounts of fuel. In addition, power for the ATOC source will be supplied from the onshore grid. Those power requirements, when the source is operating, are estimated to be less then 2 kw input (due to power line losses and inefficiencies, the source will produce an acoustic output of approximately 260 w). Taking into account the relatively low duty cycle of the ATOC source, the electricity requirements to power the ATOC source will be substantially less than that of an average-size single family home.

Anticipated energy requirements of the ATOC Program and associated Marine Mammal Research Program will be well within the energy supply capacity of the California fuel supply and power grid. No new power generation capacity or energy supply facilities would be required for ATOC acoustic signal generation, or for related MMRP activities.

Other than the various structural materials used for fabrication of the ATOC acoustic source system, and fuels, no significant natural or depletable resources are required for the implementation of the ATOC Program or the MMRP.

6.4 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 will not result in any appreciable growth-inducing effects. The proposed project could foster some very limited amount of economic activity as a result of the use of ships/boats and 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 significantly affect the environment, either individually or cumulatively.

6.5 ENVIRONMENTAL JUSTICE

On February 11, 1994, the President signed an Executive Order on Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. The proposed project would cause no adverse environmental effects on any minority communities and/or low-income communities. Furthermore, the public, including minority communities and low-income communities, have full and open access to this EIS/EIR and all public information that was compiled and incorporated in its development.

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APPENDIX B

List of Acronyms & Abbreviations
&
Glossary of Terms

List of Acronyms & Abbreviations

ADL	Acoustic Data Logger
ALACE/PALACE	(Profiling) Autonomous Lagrangian Circulation Explorer
AN	Ambient noise.
API	American Petroleum Institute
ARPA	Advanced Research Projects Agency
ASBS	Areas of Significant Biological Significance
ATOC	Acoustic Thermometry of Ocean Climate
AVHRR	Advanced Very High Resolution Radiometer (NOAA)
AVLA	Autonomous Vertical Line Array
BT	Bathythermograph
CalCOFI	California Cooperative Fisheries Investigations
CCM	California Coastal Commission
CDFG	California Department of Fish and Game
CEQA	California Environmental Quality Act
CNES TOPEX	Center for National Environmental Studies Ocean Topography Experiment
CPY	Current Potential Yield
CTD	Conductivity-Temperature-Depth
CZMA	Coastal Zone Management Act
DAS	Data Acquisition System
dB	Decibel
DEIS	Draft Environmental Impact Statement
DEIS/EIR	Draft Environmental Impact Statement/Environmental Impact Report
DO	Dissolved Oxygen
DoD	Department of Defense
DSL	Deep Scattering Layer
EEZ	Economic Exclusion Zone
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ERM	Exact Repeat Mission
ERS-1	European Space Agency Satellite
ESA	Endangered Species Act
ETP	Eastern Tropical Pacific
FEIS	Final Environmental Impact Statement

FEIS/EIR	Final Environmental Impact Statement/Environmental Impact Report
FEPE	Finite Element Parabolic Equation
FWS	Fish and Wildlife Service
GAMOT	Global Acoustic Mapping of Ocean Temperature
GCM	Global Climate Model
Geosat-ERM	Geosat-Exact Repeat Mission
GOF	Gulf of Farallones
GOFNMS	Gulf of the Farallones National Marine Sanctuary
GPS	Global Positioning System
HIFT	Heard Island Feasibility Test
HiTS	Historic Temporal Shipping Density Model
HLA	Horizontal Line Array
HRPT	High Resolution Picture Transmission
IAP	[Russian] Institute of Applied Physics
IRAS	Integrated Rainform Analysis System
IUSS	Integrated Undersea Surveillance System
Leq	Level Equivalent (source level)
LF	Low Frequency (100-1000 Hz)
LTPY	Long-term Potential Yield
MBARI	Monterey Bay Aquarium Research Institute
MBNMS	Monterey Bay-National Marine Sanctuary
MIT	Massachusetts Institute of Technology
MMC	Marine Mammal Commission
MMPA	Marine Mammal Protection Act
MMRP	Marine Mammal Research Program
MMS	Minerals Management Service
NASA	National Aeronautics and Space Administration
NAUI	National Association of Underwater Instructors
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NMML	National Marine Mammal Laboratory
NMSA	National Marine Sanctuaries Act
NOA	Notice of Availability
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NOTAM	Notice to Mariners

NPTZ	North Pacific Transition Zone
NRL	Naval Research Laboratory
NWP	Nationwide Permit
OCRM	Ocean and Coastal Resources Management
OCS	Outer Continental Shelf
OMZ	Oxygen Minimum Zone
ONR	Office of Naval Research
OTIS	Ocean Thermal Interpolation System
PADI	Professional Association of Dive Instructors
PCFFA	Pacific Coast Federation of Fishermen Association
PE	Parabolic Equation
POA&M	Plan of Action and Milestones
PRBO	Point Reyes Bird Observatory
PRSRG	Pacific Regional Scientific Review Group
PTS	Permanent Threshold Shift
RAY	Recent Average yield
ROD	Record of Decision
ROV	Remotely Operated Vehicle
SAC	Sanctuary Advisory Council (MBNMS)
SCB	Southern California Bight
SERDP	Strategic Environmental Research & Development Program
SL	Source Level
SLTDR	Satellite-Linked Time/Depth Recorder (animal tag)
SMMR	Scanning Multichannel Microwave Radiometer
SOFAR	Sound Fixing and Ranging
SOSUS	Sound Surveillance System
SRD	Sanctuaries and Reserves Division, NOAA
SRP	Scientific Research Permit
SSH	Sea Surface Height
SSP	Sound Speed Profile
SST	Sea Surface Temperature
SWFSC	Southwest Fisheries Science Center
TDR	Time/Depth Recorder (animal tag)
TMMC	The Marine Mammal Center
TTS	Temporary Threshold Shift
UCSC	University of California , Santa Cruz

UCSD	University of California, San Diego
UHF	Ultra High Frequency(>1000 kHz)
VHF	Very High Frequency (>100 kHz)
VLA	Vertical Line Array
VRT	VHF Radio Tag
WHOI	Woods Hole Oceanographic Institute
WMO	World Meteorological Organization
WSC CZ	Watershed and Scenic Conservation Coastal Zone
XBT	Expendable Bathythermograph
XCTD	Expendable Conductivity-Temperature-Depth
ZOI	Zone of Influence

Glossary of Terms

acoustic energy — The energy of an acoustic wave, measured in joules or watt-seconds.

acoustic power — The energy per unit time, measured in watts. The acoustic power is proportional to acoustic pressure squared.

acoustic pressure — Pressure variations around an ambient static pressure (such as the hydrostatic pressure in water at some depth) at acoustic frequencies.

ambient noise — The composite noise from all sources in a given environment excluding noise inherent in the measuring equipment and platform.

auditory sensitivity — An animal's hearing sensitivity as a function of frequency.

auditory threshold — The minimum amplitude of sound that can be perceived by an animal in the absence of significant background noise.

bandpass filter — A filter with high- and lowpass cutoff frequencies to pass only a band of frequencies.

beneficial impact — Impact conducive to the promotion of well-being.

critical band — The frequency band within which background noise can effect detection of a sound signal at a particular frequency.

cylindrical spreading — Sound spreading for cylindrical waves. The transmission loss for cylindrical spreading is given by

$10 \log_{10}(\text{Range}/R_o)$, where R_o is some reference range. The received level diminishes by 3 dB when range doubles, and by 10 dB for a tenfold increase in range.

cylindrical wave — A sound wave whose fronts are cylindrically shaped. For a point source in shallow water, a cylindrical wave forms at distances large compared to the water depth because of the way reflected sound from the surface and bottom reinforces the direct wave.

decibel (dB) — A logarithmically based relative pressure of sound strength. A sound pressure P can be expressed in dB as a sound pressure level of $20 \log_{10}(P/P_{ref})$, where P_{ref} is a reference pressure (usually a standard pressure like 1 μPa). Note that 20 log(X) is the same as $10 \log(X^2)$, where X^2 is the mean square sound pressure and is proportional to power, intensity or energy.

delay	The time in seconds by which one waveform lags behind another. For example, reflected sound will usually be delayed in reaching a receiver compared to directly traveling sound.
Doppler shift	The change in the frequency of a received signal caused by motion of the source, the receiver, or both.
duty cycle	The percentage of time a given event or activity occurs. The term is usually applied to a periodic activity; i.e., an activity in which the on-off cycle repeats with the same duration of each cycle.
fathom	The common unit of depth in the ocean, equal to six feet (or 1.83 meters).
frequency	The rate at which a repetitive event occurs, measured in Hertz (cycles per second).
Hertz	Cycles per second.
hydrophone	A transducer for detecting underwater sound pressures; an underwater microphone.
infrasonic	A term used to refer to sound energy at frequencies too low to be audible to humans - generally, frequencies below 20 Hz.
masking	The obscuring of sounds of interest by stronger interfering sounds.
minimal impact	Constituting the least possible degree of impact.
octave band	A frequency band whose upper limit in Hertz is twice the lower limit.
peak level	The sound level (in dB) associated with the maximum amplitude of a sound.
point source	A point from which sound is radiated, useful in describing source levels by a pressure level at unit distance.
propagation loss	The loss of sound power with increasing distance from the source. Identical to transmission loss. It is usually expressed in dB referenced to a unit distance like 1 m. Propagation loss includes spreading, absorption and scattering losses.
reflection	The physical process by which a traveling wave is returned from a boundary. The angle of reflection equals the angle of incidence.

refraction — The physical process by which a sound wave passing through a boundary between two media is bent. Refraction may also occur when the physical properties of a single medium change along the propagation path.

scattering — The irregular reflection, refraction or diffraction of sound in many directions.

shadow zone — The region in which refraction effects cause exclusion of sound.

sound channel — A horizontal layer which is bounded by levels at which the velocity of propagation is greater than at any depth within the layer.

sound pressure level (SPL) — The measure in decibels of sound pressure. The common unit is dB re 1 μPa.

source level (SL) — A description of the strength of an acoustic source in terms of the acoustic pressure expected a hypothetical reference distance away from the source, typically 1 m. Source level is given in units of dB re 1 μPa-m.

spherical spreading — Sound spreading for spherical waves. The transmission loss for spherical spreading is given by $20 \log_{10}(\text{Range}/R_O)$ where R_O is some reference range. The received level diminishes by 6 dB when range doubles, and by 20 dB for a tenfold increase in range.

spreading loss — The loss of acoustic pressure with increasing distance from the source due to the spreading waveforms.

threshold of detectability — The level at which a sound is just detectable.

traffic noise — That portion of ambient noise which is caused by shipping.

transducer — A device for changing energy in one form (i.e., mechanical) into energy in another form (i.e., electrical).

transmission loss (TL) — The loss of sound power with increasing distance from the source. Identical to propagation loss. It is expressed in dB referenced to a unit distance, like 1 m.

ultrasonic — Sound energy at frequencies too high to be audible to humans - generally, frequencies above 20,000 Hz.

waveform — The functional form, or shape, of a signal or noise vs. time.

wavelength The length of a single cycle of a periodic waveform. The wavelength l, frequency f and speed of sound c are related by the expression c = f*l.

APPENDIX C

Research Protocol for the California Marine Mammal Research Program of the ATOC Experiment

RESEARCH PROTOCOL FOR THE CALIFORNIA MARINE MAMMAL RESEARCH PROGRAM OF THE ACOUSTIC THERMOMETRY OF OCEAN CLIMATE EXPERIMENT

POTENTIAL EFFECTS OF LOW FREQUENCY SOUND ON DISTRIBUTION AND BEHAVIOR OF MARINE MAMMALS: AN EXPERIMENTAL APPROACH

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INTRODUCTION

The marine mammal research program (MMRP) described here is motivated by the paucity of data regarding the possible impact of low frequency sounds on marine animals (particularly marine mammals and sea turtles); therefore, it is difficult to predict levels, areas, and scales of influence. In order to rectify this situation we would: 1) carry out a broad-based research program to investigate the potential effects of low frequency sound transmissions on marine animals, and 2) study the behavior of marine animals off the central California coast.

Previous studies of marine mammal responses to human-made noise have examined short-term behavioral responses to broadband industrial and recreational vessel noise (Malme et al., 1983, 1984, 1985), but there are minimal data on potential effects of sounds with low frequency, high source level characteristics. Most of the recent efforts on the potential effects of low frequency sound on marine mammals have concentrated on mysticetes because studies of recorded sound production and anatomy indicated a higher probability for better low frequency hearing (Ketten, 1992). The zone of influence has typically been defined by NMFS as the range at which 50% of exposed individuals respond with a detectable change in swim direction. For gray whales, the received levels associated with the 50% avoidance response varied between 116 and 124 dB re 1 μPa-m, depending on the source characteristics (Malme et al., 1984). The area in which the received level was >120 dB was estimated by NMFS to inscribe the zone of influence. This value appears to be roughly constant among gray (Malme et al., 1984, 1986, 1988; Tyack et al., 1991), bowhead (Richardson et al., 1991), and humpback whales (Malme et al., 1985). However, these results are qualified by species, social context and acoustic source characteristics. In general, observations indicate that mysticetes show fewer and less pronounced short-term behavioral responses to sources with constant and predictable acoustic characteristics than they do to sources with variable and unpredictable acoustic parameters (Malme et al., 1984; Richardson et al., 1985c; Richardson et al., 1990; Richardson et al., 1991), but this has not been quantified.

Studies of the potential effect of low frequency sound on marine animals would proceed in two phases. Phase one would consist of a Pilot Study (when ATOC source transmissions would be manipulated to assess potential effects on marine animals), and phase two would be a follow-on research period (when transmissions would be optimized for ATOC feasibility operations). Phase one has been preceded by preliminary baseline data collection via aerial surveys and vessel observations starting approximately June 1994 at Sur Ridge (when it was the proposed action site) and aerial surveys at Pioneer Seamount (after the proposed action site changed) (see Table 1.1.2-1 and Table 2.2.1.1-1). The MMRP would continue throughout Phase two including all, or most, of the research methodologies employed during the Pilot Study, but perhaps involving reallocation of effort among techniques to optimize the assessment capabilities (given what would by then have been learned during the Pilot Study)

The Pilot Study would consist of three components which would be conducted in parallel: 1) studies which would examine the potential changes in behavior and habitat utilization of marine animals in the vicinity of the Pioneer Seamount (Figure C-1); 2) playback studies which would examine potential responses of several cetaceans and sea turtles to low frequency sounds from a portable sound projector deployed from a boat (in Hawaii (Big Island) as part of the Kauai MMRP, off the Azores or Dominica, and off Trinidad); and 3) audiometric measurements on captive odontocetes (in Hawaii). A three-pronged approach is necessary because no approach alone would sufficiently address the issue of how low frequency sound may affect marine animals. Measurements in the study area (Figure C-1) are necessary because it is not possible to accurately simulate the sound field from a projector located in 980 m of water. Cetacean and sea turtle playback studies, and odontocete audiometrics would be carried out in response to broad-based, non site-specific bioacoustic research issues on the potential effects of low frequency sound on those animals. These studies would not be under the direct supervision of the California MMRP Principal Investigator; the MMRP Director would be responsible for the planning and oversight of the execution and data reporting of these efforts.

The overall rationale behind the combination of approaches included here is to determine, using established scientific methods, as well as some newly developed techniques, what species would be in the area where they would be exposed to the operational ATOC source, how many animals would be in this area throughout the year, and what species would most likely be prone to being affected by the ATOC source. To be affected, it is presumed that an animal would have to be able to hear the sound, and respond to it in some meaningful way (Table C-1). The research data collection methods discussed in this protocol include the observation of direct evidence of effects; e.g., changes in distribution and behavior during or after ATOC transmissions.

Surveys and observations, both aerial and shipboard, would be conducted in order to determine which species are present in the study area, and their sighting distributions, densities, and seasonality. Based on the results of statistical power analyses (Attachment C-7), data would be collected to evaluate changes in behavior and distribution for free-ranging animals in the study area, using a combination of aerial and shipboard surveys/observations, passive acoustic, and tagging techniques. Potential changes in diving behavior of free-ranging northern elephant seals in the vicinity of the proposed ATOC source site would be measured using telemetry tags attached to the animals. The acoustic behavior of baleen whales in the vicinity of the source site would be measured using a vertical line array (VLA) of hydrophones attached to the source itself, a towed hydrophone horizontal line array (HLA) deployed from a survey vessel, and sonobuoys deployed from the survey/observation aircraft, while remote acoustic detections for the study area would be made using the SOSUS array off Pt. Sur.

For one species believed to be relatively sensitive to low frequency sound and fairly common in the study area (humpback whale) and two that could possibly have some low frequency hearing capability (sperm whale, leatherback sea turtle), scaled playback studies would be conducted by scientists with species-specific expertise--humpback whales off Hawaii (as part of the Kauai MMRP), sperm whales off the Azores or Dominica Island, and leatherbacks off Trinidad. Playback studies measure behavioral responses of animals to sounds and alone cannot predict changes in habitat utilization. However, scaled playback studies do provide a direct method of determining whether or not these animals might react to an ATOC-like sound and, as such, allow us to assess to what extent these sounds could potentially impact certain critical behaviors (e.g., breeding, nursing, feeding).

For certain animal groups, including odontocetes, that are believed not to have good low frequency hearing, but for which some species probably occur in the study area, audiometric studies (including TTS analysis in air and water, as feasible) are being conducted by scientists with species-specific expertise in order to better determine low frequency hearing thresholds.

The originally proposed MMRP Research Protocol was designed to measure the potential effects of low frequency sound on marine animals in parallel with the ATOC feasibility operations. However, this approach was criticized for not providing adequate controls. Additional concerns were expressed that since so little is known about the potential effects of low frequency sound on marine animals, it would be prudent to study possible effects in advance of the ATOC feasibility operations. In an effort to address these concerns, ATOC program management has provided the MMRP the opportunity to design and implement a research effort, herein called the Pilot Study. The MMRP Research Protocol has been designed to address the potential effects of low frequency sound on marine animal behavior, relative abundance and distribution. Utilization of an experimental protocol for the Pilot Study with controls and replication would increase the power for detecting any possible acute or short-term effects of low frequency sound on marine animals. Table C-1 summarizes the MMRP research methodologies and capabilities for the Pilot Study.

EXPERIMENTAL OVERVIEW

This research protocol is based on a reasonable set of scientific assumptions surrounding the null hypotheses discussed below: 1) reactions from marine animals are unlikely at ATOC received levels <120 dB or at distances >20 km; 2) a Pilot Study in September 1995 - February 1996 timeframe of one year would be adequate; 3) marine mammal distribution and behavior would be similar during the 1-4 days after the start of a transmission period, and during the 5-7 days after the start of a control (off) period. The procedures that make up this research protocol are designed to validate these assumptions during the study.

The Pilot Study would start soon after all necessary permits have been obtained, and last approximately 6 months into the winter of 1995. If approval is obtained in this timeframe, initial phases of the Pilot Study would rely primarily on aerial surveys/observations, remote acoustic measurements and satellite and recoverable tagging studies.

During the Pilot Study we would be measuring the potential effects of the operational ATOC source transmissions on marine animals. Therefore, it is imperative that the source operate on the same duty cycle as that anticipated for the ATOC feasibility operations (i.e., 24 hr/day). The Pilot Study (4 days on, 7 days off) allows for an initial 24 hrs for animals to respond to the transmissions, and another 3 days of transmissions to complete surveys and observations. The 7 day control interval was designed to allow a 4 day period for the study area to return to steady-state, followed by 3 days to complete control surveys and observations. Based on typical swim speeds of most marine mammals (1-2 m/sec), 3-4 days of no transmissions should allow animals sufficient time to return to a naive, steady-state situation, and allow new animals time to enter the study area.

During the Pilot Study currently planned for September 1995 - February 1996, the following pattern of source transmissions would be used, maximizing the number of sampling periods (replication): four days with six transmissions per day, followed by seven days of no transmissions. Following successful completion of the Pilot Study, ATOC feasibility operations (climate-related studies at 2% duty cycle) would employ 20-min transmissions every 4 hrs for one day (6 transmissions/day) followed by three days of no transmissions.

The sampling protocol during the Pilot Study would be as follows: control surveys and observations would be conducted for 1-2 days before transmissions begin, followed by surveys 1-2 days after transmissions begin. The duration of the on (transmission) and off (control) periods may fluctuate by ± 1-3 days to accommodate for weather and/or equipment problems. Therefore, the on period may be 2-7 days and the off period 4-10 days. If surveys can be completed early during each period, the duration of the sampling periods would be reduced; whereas, if weather prevents sampling, the duration may be extended. In this manner, the Pilot Study design is basically a paired sample (one off period paired with an on period). This pattern would be repeated for approximately 6 months before the proposed start of the ATOC feasibility operations. Source level of the first 3 experimental periods (i.e., approximately 1 month of the Pilot Study) would be at 185 dB (1/10th of the proposed operational source level), which should produce approximately 120 dB received level at the surface (980 m above the source). Because of the lower received levels associated with 185 dB ATOC source levels, the MMRP Research Team must attempt to measure, record and document all of the shipping traffic passing through the study area to minimize the potential for misinterpreting some behavioral response for a reaction to ATOC when it actually was due to a ship. If no biologically significant (i.e., acute or short-term as defined in Table C-1) effect is observed, transmission source level during the following experimental periods would be 195 dB. If acute or adverse short-term effects (Table C-1) are observed, source transmissions would be suspended and the procedures cited in this appendix would be initiated.

Data obtained from all scientific methods (boat, plane, passive acoustic arrays, tags, playbacks, audiometrics) would be processed and analyzed during the Pilot Study so that modifications to the sound usage could be implemented and tested during the Pilot Study. Every two months status reports of the results of ongoing pertinent data analyses would be disseminated throughout the Pilot Study to the MMRP Advisory Board (Dr. W. J. Richardson, LGL Ltd.; Dr. W. T. Ellison, MAI; Dr. P. Tyack, WHOI; Dr. J. Thomas, W. Illinois University; Dr. J. Zeh, University of Washington; Dr. D. DeMaster, NMML; Dr. R. Hofman, MMC), the NMFS, MBNMS, GOFNMS, and the Pacific Regional Scientific Review Group (PRSRG). Upon completion of the Pilot Study (approximately 30 days after) a two-day workshop would be convened to present and discuss the findings with colleagues, interested parties (e.g., The Marine Mammal Center [TMMC] and the Pacific Coast Federation of Fishermen Associations [PCFFA]), and the public. This would allow open discussion, and more public comment and understanding of the potential effects of the ATOC signals on marine animals.

Approximately six months after completion of the MMRP Pilot Study Quicklook and, assuming permission was granted to commence ATOC feasibility operations, the MMRP Final Report would be available. This would be based mostly on in-depth scientific analysis of the research data collected during the Pilot Study but also incorporating data collected during the intervening six-month period, as feasible. Furthermore, if one or more species would show a measurable population change (most likely ascertained from aerial survey techniques) during the Pilot Study, all known and quantifiable extrinsic oceanic events (natural and human-made) would be included to the greatest extent feasible in analysing the Pilot Study data to attempt to ascertain the most likely reason for the change.

As detailed in this section, surveys and observations would be performed from aircraft before, during, and after sound transmissions during the Pilot Study. Cetacean vocalizations and other oceanic sounds would be monitored from various passive hydrophone arrays, and empirical sound field data would be collected using a vessel-towed HLA and sonobuoys. Preliminary observations on the behavior, distribution, and abundance of marine mammals were obtained from July to December 1994 in the vicinity of Sur Ridge (preferred site). Research protocols for behavioral observations, tagging studies, and survey designs were developed and tested. Based on statistical power analyses (Attachment C-7), we would expect to be able to detect major changes in relative abundance, distribution, vocalization and other detectable behaviors of the species targeted for detailed study, that may be caused by the experimental sound transmissions. Although the likelihood of ATOC sound transmissions causing a marine animal stranding is negligible, we would use the excellent Marine Mammal Stranding Network that currently exists within the Monterey Bay/central California region as the cornerstone of our network. This, and our association with all appropriate state environmental activities, and TMMC--the primary responder for stranded marine mammals and sea turtles in central California, would increase the probability of the recovery of all stranded large cetaceans and most small marine mammals.

ATOC sound production would be suspended promptly if any of the acute or short-term responses (Table C-1) were observed during any transmission period. The National Marine Fisheries Service (NMFS-Southwest Region), TMMC, the Marine Mammal Commission, and the managers of the MBNMS and GOFNMS would immediately be consulted to help evaluate the biological significance of such an observation, and to determine whether the experiment should be modified or terminated. Termination would be considered appropriate if the observations indicate that animals are being injured or harmed by or, as a consequence of, the sound transmissions, or the sound transmissions are interfering with biologically important functions, such as calving, nursing, calf rearing, breeding, or feeding.

At the conclusion of the Pilot Study, the survey and behavioral observation data would be analyzed for less obvious, but statistically significant, changes in distribution, movement patterns, activity patterns, and biologically important behaviors possibly caused by the experimental sound transmission. If the study results indicate that the sound transmissions are likely to have negligible short-term effects, they would be used to help design a long-term monitoring program to assess whether the ATOC feasibility operations would have negligible long-term effects. The following would be considered non-negligible long-term effects, if related to ATOC sound transmissions:

- avoidance or abandonment of previous high-use areas;
- increase in at-sea observations of dead animals or strandings of either live or dead animals (on the Farallon Islands or on the coast between 37° 10'N and 37° 40'N) in association with sound-caused hearing damage or other sound-caused trauma;
- increased incidence of emaciated and/or diseased marine mammals (which could be attributed to stress factors); or
- decrease in calving/pupping rates and/or total population size.

Other non-negligible effects would be determined on a case-by-case basis.

During ATOC feasibility operations (post Pilot-Study phase), a MMRP research effort would continue, probably including all, or most, of the aforementioned methodologies, but perhaps involving reallocation of effort among techniques to optimize the assessment capabilities (given what would by then have been learned during the Pilot Study). Procedures for conducting this follow-on research phase may fall under the guidelines prescribed in MMPA Section 101(a)(5)(Rev. 1994), whereby the Secretaries of the Interior and Commerce can authorize the unintentional taking of small numbers of marine mammals incidental to offshore oil and gas development, and other such activities. However, the Pilot Study would be conducted under a SRP and would be an integral part of the overall scientific research effort to evaluate potential effects of ATOC sound transmissions on marine animals.

The most direct indication from these data for potential long-term changes (to adults, juveniles, calves or pups) would be the displacement of animals from the vicinity of the ATOC source, or systematic modifications in behavioral patterns or vocal behaviors (e.g., movements away from the source area, significant and persistent change in respiration rates, cessation of vocalizations, or interruption of whale vocal sequences). Every attempt would be made to determine the relationship between the strength of any observed response and the received level of the ATOC sound at the location of the affected animal.

OBJECTIVES

The primary objectives of the California MMRP are to: 1) Assess the potential effects of ATOC sound transmissions on the relative distribution and abundance of marine animals (particularly marine mammals and sea turtles) within the 120 dB sound field (modeled at 100 m depth) (planned studies include areas outside the 120 dB sound field, for comparison), so as to minimize uncertainties associated with determination of the significance of any effects; 2) obtain information to help evaluate what effects the ATOC sound transmissions could potentially have on the relative distribution, abundance and diving behavior of marine mammals and sea turtles; 3) identify mitigation measures to avoid the potential disruption of behavioral patterns of local marine animals, particularly marine mammals and sea turtles; 4) assess the level of any responses of indicator species to ATOC sound signals, particularly whether any marine mammal or sea turtle demonstrates an acute or short-term response (Table C-1) to low frequency sound transmissions with ATOC source sharacteristics. Associated with this immediate set of objectives are several fundamental issues: 1) what is the low frequency hearing capability of mysticetes, odontocetes, pinnipeds and sea turtles? 2) to what depths do the various species dive and how long do they remain at depth? 3) which of these species are known to produce (and by inference rely on) low frequency sounds for survival?

PROPOSED MEASUREMENTS

During the Pilot Study, marine animal densities, distributions, and behaviors would be documented in the Pioneer Seamount area during both control and transmission periods. Specific methodologies include: 1) aerial surveys/observations; 2) acoustic measurements of marine mammal vocalizations and ship noise using ship-towed hydrophones, the source vertical line array, SOSUS, and sonobuoys; 3) shipboard behavioral observations, 4) shipboard photo identification, and 5) satellite and TDR tagging. Furthermore, technology either recently developed (elephant seal heart rate recorders) or under development (acoustic data loggers for elephant seals [B.J. Le Boeuf & D.P. Costa PI's]; a satellite-linked acoustic event recorder for use on blue whales [B. Mate & C. Clark PI's]) may be implemented. Remotely operated vehicle (ROV) video operations in the vicinity of the seafloor surrounding the source site are also being considered, and may be implemented if suitable equipment and launch platform are available. Because the greatest possible effect of the ATOC transmissions on marine animals would be expected closest to the source, most monitoring would be within a 40 x 40 km box around the source. The entire study area (particularly pertinent to aerial surveys) encompasses an 80 x 80 km box.

DESCRIPTION OF MARINE ANIMALS IN STUDY AREA:

The study area for the proposed research lies off the central California coast (Figure C-1), where in places the marine fauna is diverse and abundant, with seasonality of occurrence reported for many species. The marine animal description was mostly derived from a review of marine mammal stocks offshore California recently completed by NMFS/SWFSC (Barlow, in prep.; Forney, 1993). An additional ship-based census was conducted during September-October 1993 (NOAA Ship McARTHUR Cruise No. AR-93-02) up to 550 km (300 nm) offshore between 29 deg N and 40 deg N. The other source of abundance data was extracted from aerial surveys sponsored by Mineral Management Service (MMS) conducted between 1980 and 1983 (Dohl et al., 1983; Bonnell et al., 1983). Additionally, populations of humpback and blue whales were estimated using data from mark-recapture photo-ID methods (Calambokidis and Steiger, 1995). See section 3 of this EIS/EIR for detailed descriptions of all marine animals in the study area.

PROCEDURES AND RESEARCH TECHNIQUES

To assess the potential effects of low frequency sound on marine animals we would use a variety of methodologies, including aerial surveys/observations, shipboard visual surveys/ observations, passive acoustic monitoring, behavioral observations, photo-identification, field playback and audiometric testing, and VHF/TDR tagging. The combination of these methods should allow the MMRP Research Team to adequately sample the species and area of interest. The highest priority research efforts would concentrate on the study of species believed to be the most likely to react to the sound transmissions (mysticetes [blue, humpback, fin whales]; odontocetes [beaked and possibly sperm whales]; pinnipeds [possibly elephant seals]; and sea turtles [possibly the leatherback]). We are confident that the Pilot Study can be completed as proposed with the indicator species selected: humpback and sperm whales, northern elephant seals, and leatherback sea turtles. Moreover, because of their known deep-diving capability, any sperm whales found within 5 km of the source site (approximate area of 130 dB sound field at 100 m depth) would be monitored via aerial or vessel surveys/observations in an attempt to assess whether they are adversely affected by the low frequency sound transmissions.

As per CEQA Mitigation Measure 9-1 (sea turtles) and 10-1 (fish), available data on some prey species (e.g., fish, invertebrates, zooplankton) would be analyzed to the extent feasible by University of California-Santa Cruz (UCSC) scientists, and incorporated into other MMRP field work as soon as feasible, so that an attempt could be made at meaningful correlations between marine mammal abundance and behavior, and prey abundance and distribution.

Source Shut-Down Guidelines

If at any time an MMRP Research Team (MRT) member positively identifies the occurrence of an acute behavioral response (#6 in Table C-1), the information would be immediately communicated to the MRT Leader (Dr. D. P. Costa, UCSC). If the MRT Leader ascertains that an acoustic transmission (i.e., during the 5-min ramp-up or the 20-min transmission) coincided with the observed response, he/she would contact the Pillar Point shore termination site and Scripps, and suspend source operations immediately until further notice. The MRT Leader would collate all pertinent information relative to the incident and contact the MMRP Director (Dr. C. W. Clark, Cornell University) and NMFS (Office of Protected Resources; A. Terbush or J. Drevenak) to inform them of the situation. NMFS, in consultation with the MMRP Director, 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 direct that one of the following options be executed:

- Continue experiment as planned;
- Continue experiment with modifications to maximum source level or repetition rate; or
- Suspend experiment pending consultation with Scripps and NMFS.

Regardless of the decision, within 24 hr a written summary of the incident would be forwarded to Scripps, NMFS, the MMRP Advisory Board Chairman, and the PRSRG.

Start-up Protocol

At the beginning of each of the first two experimental periods for both the start of the 185 dB transmission series and the start of the 195 dB transmission series (note: an "experimental period" includes both a 4-day transmision period and a 7-day control period) we would initiate the use of a series of observational platforms. Three to four days before the first transmissions, a complete aerial survey of the study area would be conducted. On the first day of transmissions, a modified aerial survey would be conducted within a 10 km square surrounding the source site prior to transmission. If no marine mammals can be found within the 10 km square, the search area would be expanded to a larger radius. This would be used to identify the location and distribution of marine animals near the source, and to help place the observation vessel near the animals. The plane would also survey during some of the transmission times for the early transmission periods. Also, on the first day of transmissions, a vessel would be located within 5 km of the source, and would traverse the area within 5 km radius attempting to locate a suitable focal animal or animals for observations (particularly large baleen whales). The aircraft crew would help vector the vessel to animals, remaining above 305 m altitude to minimize any potential reaction from the observed animal(s) that could be caused by the aircraft's presence. These focal animal(s) would be observed for as long as possible (30 min-2 hrs) before the transmissions begin and for approximately 1 hr after the 20-min transmission. The observers aboard the vessel would not know the time transmissions begin or terminate (i.e., they would be blind to the timing of transmissions, which would occur whether or not animals were located). These observations are not meant to be quantitative, but serve as a means of detecting any immediate and dramatic effects (i.e., acute or short-term responses).

Aerial Visual and Acoustic Surveys/Observations

The following null hypotheses would be tested during the Pilot Study:

H_0: There is no detectable difference in sighting rate, distribution, orientation, general activity, or group size of different species (or groups of species) between surveys conducted when the source is on and when it is off, and as a function of distance from the source.

H_0: There is no detectable difference in cetacean acoustic behavior (i.e., call types, rates, structure, or sequence patterns) between measurements from recordings made when the source is on and when it is off, and as a function of distance from the source.

If marine animals observed from a plane were determined to exhibit a detectable difference in one or more of the above listed parameters during source transmissions, this would result in rejection of the null hypothesis.

The primary objectives of the aerial surveys/observations are:

- to identify which species are present in the study area;

- to monitor and record data on shipping traffic in the study area;

- to provide estimates of relative density and relative abundance of the more common species in the study area; and

- to evaluate whether low frequency sound (from ATOC and shipping) alters the habitat utilization (occurrence, distribution), or behavior of marine animals in the study area, particularly at the beginning of each of the first two experimental periods for both the start of the 185 dB transmission series and the start of the 195 dB transmission series.

Mr. John Calambokidis of Cascadia Research Collective would be responsible for the aerial visual and acoustic surveys/observations. During the Pilot Study, approximately 15 paired aerial surveys would consist of one survey during each 7 day period when the source is off and one survey during the 4 day period while the source is on (i.e., transmitting 6 times/day) for the duration of the approximate six month Pilot Study. In addition, a total of 4 modified surveys would be conducted--one prior to each of the first two experimental periods for both the start of the 185 dB transmission series and the start of the 195 dB transmission series. Surveys/ observations would be conducted using standard line-transect methodology. The survey area would be an 80 km x 80 km square centered at the proposed ATOC source site on Pioneer Seamount. Transect lines would be parallel and run east-west at 5 km intervals (Attachment C-1). Transect lines would be flown at a nominal altitude of 305 m (1000 ft) at a nominal 100 kts airspeed.

Biological data collected would be: species, number, perpendicular distance from the transect, direction of travel, and general behavior. Date, time, and position (using a GPS system) would be recorded each minute. Beaufort state, cloud cover, sighting conditions, and glare would be noted at the beginning and end of each transect and when significant changes occur (Attachment C-2). The data collected would be used to determine the distribution and abundance (and density) of marine animals in the study area, and test whether abundance, distribution, and behaviors of marine animals might be altered with the presence of low frequency sound.

All motorized surface vessels observed during the course of normal aerial survey operations would be monitored and tracked to the greatest extent feasible, including recording estimates of vessel size, position, course and speed. The goal would be to acquire these data on a half-hourly basis as long as the vessel was inside the 40 x 40 km internal grid of the study area.

The survey aircraft would be a twin-engine Partenavia P-68 specifically outfitted for aerial surveys. This aircraft has been used extensively in past surveys conducted along the California coast by Southwest Fisheries Science Center (SWFSC). It is equipped with bubble windows on each side of the aircraft that allow full downward visibility and an opening in the bottom allowing photography or a dedicated downward-viewing observer. The Observer model of this aircraft, likely available for most surveys, also has a Plexiglas nose that provides an excellent view for the pilot and recorder (in the co-pilot seat) that would help when circling a group off-transect to confirm species identification and group size. An onboard global positioning system (GPS) would be used for accurate position information and navigation.

Five personnel would be used on each survey: pilot, recorder/navigator, two side observers, and a center observer. The use of an observer looking through a downward hatch would be beneficial because it: 1) is similar to the current methodology used by SWFSC during aerial surveys and was recommended for these surveys, 2) would provide critical near-transect sightings for small species that occur in small groups, especially Pacific white-sided dolphins, and sea turtles and 3) would be used as an independent observer to evaluate the rate at which sightings are missed by the side observers.

When a sighting is made, the aircraft would continue on transect until the animal(s) is/are abeam and the observer has determined the angle to the sighting using a hand-held clinometer. The belly observer would use calibrated graduations on the belly opening to determine angle to sightings. To confirm species identification and group size, sightings of most species, except the most common (such as California sea lions) would be circled with the aircraft. Data would be recorded using an onboard Data Acquisition System (DAS) that was developed by Cascadia and widely used by Cascadia and SWFSC.

Several statistical procedures would be used to test the null hypotheses. The simplest, which would require the least assumptions, would be a non-parametric paired rank test. This would test for a consistent pattern of differences between the two samples for all of the paired sampling surveys. Standard NOAA/NMFS research methods and photography would be used to determine if there were statistical impact on the animals' behavior due to the presence of the aircraft.

In addition to standard aerial visual survey and observation procedures, the aircraft would monitor and record shipping data in the study area, and deploy sonobuoys (e.g., Magnavox AN/SSQ-57A [SPL]) on an opportunistic basis to record cetacean vocalizations, and ambient noise (including shipping noise) and source received levels in the vicinity of the marine animals being observed. This technique would be particularly beneficial when observations are underway in areas where there is no other effective way to measure received signal level at the animal(s) under observation. If utilized, sonobuoys would be deployed >400 m from the animals to minimize any potential disturbance caused by the sonobuoy itself. Recordings of the signal from the sonobuoy would be made with a stereo DAT recorder (capable of recording from 10 Hz up to 10 kHz). The signal would be received on a radio receiver (e.g., ICOM7000 with pre-amp) connected to an externally-mounted antenna on the aircraft. Recordings would be made continuously after the sonobuoy enters the water until the aircraft is out of range of the buoy.

Shipboard Visual and Acoustic Surveys/Observations

Shipboard visual and acoustic surveys/observations would test the following null hypotheses:

H_0: There is no detectable difference in sighting rate, distribution, orientation, general activity, or group size of different species between surveys/observations conducted when the source is on and when it is off, and as a function of distance from the source.

H_0: There is no detectable difference in abundance and distribution of fish and zooplankton in the DSL between measurements made when the source is on and when it is off, and as a function of distance from the source.

If marine animals observed from a vessel were determined to exhibit a detectable difference in one or more of the above listed parameters during source transmissions, this would result in rejection of the null hypothesis.

We propose to use shipboard line transect methodology, passive acoustic surveys with a towed array, and active acoustic surveys of the deep scattering layer (using 38 and 200 kHz Simrad hydroacoustic systems), to characterize marine mammal acoustic activity, and assess relative changes in the abundance and distribution of fish and zooplankton (in the DSL). Shipboard line transect methodology would be used to attempt to determine the relative abundance and distribution of marine animals within a 10 x 10 km box around the proposed source site at Pioneer Seamount. However, relatively more effort would be allocated within 5 km of the source site. An equal number of surveys would be scheduled for when the sound source is on and for when the source was off (control). In addition, four special surveys would be conducted--one prior to each of the first two experimental periods for both the start of the 185 dB transmission series and the start of the 195 dB transmission series.

Shipboard surveys/observations would be conducted aboard the 17-m R/V SHANA RAE or 18-m R/V JOHN H. MARTIN. Two observers would be positioned as high on the vessel as possible (approximately 6 m above the waterline), and each would observe a 90° arc (one from the track line to port abeam, the other from the track line to starboard abeam). Transect lines would be stratified such that efforts would be concentrated within 10 km of the proposed source site. The goal would be to conduct 10 hrs of surveys per day. There would be adequate visual observers such that they would be rotated every 20-30 min to minimize fatigue.

During transects, the following data would be collected: bearing and distance to animal(s), species, number per sighting, perpendicular distance from transect line (using angle and distance to sighting), direction of travel, behavior (e.g., slow swimming, fast swimming, surface resting), location, and environmental data (sea state, cloud cover, sea surface temperature, and water depth). These data would be used to determine: species composition and density, and activities of marine animals. Data regarding species composition, density, and behaviors of marine animals before source transmissions begin would be compared with data collected during and after transmission periods.

Acoustic surveys, using a 16-element passive hydrophone array towed behind the survey vessel, and the MBARI acoustic beamformer onboard, would be conducted to attempt to acoustically sample for cetaceans in conjunction with the visual survey effort. This should enable us to make detections for presence and absence, a general idea of the rates of acoustic encounters, and to start to compile information on the vocal behaviors (types of sounds and some rates of vocal activity) of species in the study area. Acoustic signals (10 Hz-20 kHz) would be monitored and recorded (64 channel TEAC recorder) continuously. One person would monitor the array; when a marine mammal vocalization is encountered they would note the following: species, signal strength, ship's position, and time. Because the array has a beam pattern optimized to be perpendicular to the vessel track, it would effectively sample a nominal area out to 10s of kilometers for loud, low frequency signals (e.g., blue, humpback whales), but probably out to only a kilometer for lower source level, high frequency signals (e.g., toothed whales). The Cornell Bioacoustic Research Program would be responsible for carrying out the bioacoustic research and analysis, in coordination with MBARI on the application and testing of the towed array and beamformer. One experienced marine mammal bioacoustician would participate on each dedicated cruise to oversee the bioacoustic work. Assuming that vocalizing animal(s) or group(s) would remain vocally active for periods >10 min, we should be able to compute bearings in near real-time using the MBARI beamformer and/or time-delay hyperbolic fixing.

This array has 16 elements, capable of acoustic detections within the 10 Hz - 20 kHz bandwidth, and when it is moving, it should have enough array gain to discern both vocalizing whales and shipping quickly over time. If it is possible to measure received level directly at the animal (perhaps via sonobuoy), using transmission loss models, one can estimate the likely band of ranges in which the whale is located. With this system, this can be further refined by bearing rate clues and estimated animal swim speeds. Also, this system may be significantly impacted by own ship noise, where two factors come into play: 1) the side lobes of a 16 element array have to be large and if the ship noise is loud or nearby, or both, this, not ambient noise may determine the noise floor, and 2) detections on forward beams and own ship bottom bounce beams will be affected. This system should have the potential to locate whales out to a range of about 4 times the array length when tied into a Cornell whale localization system, and using sparse array time-difference fixing.

Systematic empirical measurements of the upper water column acoustic field of the transmitted source signal would be made with the 16-element towed array, particularly shoreward from the projector site. Recordings would be made at different depths (ambient noise--including other noise sources, and source received levels) and simultaneously recorded on the aforementioned multi-channel DAT recorder. The empirical measurements would be taken with the vessel-towed HLA at a set of approximately 20 pre-determined stations (with the vessel stopped, allowing the tail of the HLA to sink so that the array would act like a VLA), located at specific ranges and bearings from the source site, with at least two samples taken from each of the stations (during transmission and non-transmission periods) during the course of the Pilot Study. Any cetacean vocalizations recorded at this time would also be included in the data sets.

The depth and backscatter signal strength of the acoustic scattering field (particularly the deep scattering layer [DSL]) would also be recorded during shipboard surveys, using Simrad systems operating at 38 and 200 kHz. This frequency band would allow collection of krill and fish data (approximate depth, relative distribution, and relative densities), and is outside the hearing capability of mysticetes. These systems would be operated on an opportunistic basis, so as to minimize transmissions during odontocete surveys or observations, but with a goal of collecting data for at least 1 hr during every 6 hr period. Depth and strength of the backscatter signal would be compared between periods of transmission (4 day on periods) and non-transmission (7 day off periods). These data, in turn, could be used as a covariate in interpreting distribution of some mammal species.

During shipboard surveys, the following environmental data would be recorded every 15 min: sea surface temperature, wave height, wave length, Beaufort sea state, wind direction and speed, glare conditions, and cloud cover. The vessel would deploy a small CTD system, including a processing system, that would allow direct strip-recorder readout and input into the computer data base. CTDs would be used during calm weather (<SS3) and when the vessel is not in transit to conduct vertical casts spaced in a grid across the survey area to determine temperature and salinity that would help calibrate the acoustic propagation model.

VLA-Based Acoustic Detection of Mysticetes

The rate and frequency of whale vocalizations would be used to test the following null hypothesis.

> **H_0: There is no detectable difference in mysticete acoustic behavior (i.e., call types, rates, structure, or sequence patterns) between measurements made when the source is on and when it is off, and as a function of distance from the source.**

If mysticetes were determined to exhibit a detectable difference in one or more of the above listed acoustic behaviors during source transmissions, this would result in rejection of the null hypothesis.

The ATOC source vertical line array (VLA) is 100 m long, made up of four REFTEK 100H78A hydrophones, spaced at 33 m, with the following acoustic specifications: 1) sensitivity (Rs) -196 dbV re 1 V; 2) attenuation (Total) 1.5 dB; 3) noise bandwidth (NBW) 0-200 Hz; 4) amplitude bandwidth (ABW) 0-1000 Hz; 5) amplifier gain (G) 74 dB; 6) noise crest factor (NCF) 3 dB; signal-to-noise ratio (SNR) approximately -22.5 dB. The array is buoyed up from the source by a syntactic foam float. Thus, each of the four hydrophones has a calibrated frequency response within the 10-1000 Hz band, and acoustic data from the array would be available 24 hrs a day (less the 25 min [5 min ramp-up + 20 min transmission] transmission periods). This array has no array gain and whale detections will be impacted by any nearby shipping. If one can measure received level at the animal directly, using transmission loss models, one can estimate the likely band of ranges in which the whale is located. This will be more complicated because azimuthal dependence must be accounted for.

Dr. Christopher W. Clark, Director of the Bioacoustics Research Program at the Cornell Laboratory of Ornithology, is responsible for the VLA-based bioacoustic research. The VLA allows for detection of vocalizing whales out to approximately 20-40 km. Continuous acoustic recordings of all four channels would be provided by the Applied Physics Laboratory (University of Washington, Seattle), which is responsible for the collection of data from the array. Bioacoustic analysis of these data would be accomplished using an advanced version of the Cornell Canary system (Frankel, 1994). This system is equipped with selectable sampling rates from 100 to 12,000 Hz, and real-time spectographic display of up to eight channels. Using this system, we would monitor bioacoustic activity, identify sounds by species, and characterize these signals by their vocal features and rates of occurrence. Comparisons of features and rates (both prior to and after transmissions) would be accomplished using parametric and non-parametric statistics, following known bioacoustic analyses procedures used and developed at Cornell's Bioacoustics Research Program facility.

The acoustic sampling protocol would coincide with aerial surveys for comparison. Marine mammal distribution and behavior would be examined in relation to measured or estimated sound exposure (ATOC and other noise sources). Sound levels at animal locations would be estimated based on received sound levels at the array, whale and source locations, and a validated acoustic propagation loss model (e.g., FEPE). We would also acquire data on the ambient sound field (including shipping noise) in the Pioneer Seamount area during the Pilot Study, and follow-on MMRP research period. An important component of understanding the potential responses of animals to the ATOC sound source is an understanding of the existing natural and human-made low frequency noises the animals are subjected to on a regular basis (e.g., storms, oil tankers, cargo ships, fishing vessels). Such data are essential for the informed management of marine resources, independent of the MMRP research program. The MMRP Research Team would attempt to differentiate the potential effects of the ATOC transmissions from shipping noise through signal recognition techniques and time/space correlation of ship tracks (from aerial surveys) with VLA/HLA-received noise levels.

The application of source VLA hydrophones has the potential of providing long-term monitoring of the vocal behavior of nearby mysticetes in the vicinity of Pioneer Seamount. It also provides a mechanism for detecting associations between the operation of the source and potential changes in vocal behaviors (e.g., if whales change calling rates after source transmissions). From this perspective, VLA hydropones may, in the long run, provide critical insights into whether or not the source would affect the species that we strongly suspect are dependent on low frequency acoustics. Sequences of their calls have very characteristic temporal and frequency features, particularly inter-pulse intervals. Blues and fins have also been tracked in the northeast Pacific Ocean, several hundred kilometers north of the Pioneer Seamount (Clark, pers. obs., 1991; D'Spain et al., 1993a; Stafford and Mate, 1994).

Recordings collected during all duty cycles (0%, 2%, 8%) would be analysed and compared to determine if changes in acoustic behavior occur and, if they do, how long those changes last. Of particular interest are any discernible changes in vocal rates at the termination of source transmissions. A number of research techniques would be pursued to optimize the monitoring of animals in the Pioneer Seamount area using the VLA: 1) ship and/or total ambient noise level, as measured by the VLA, can be used as a covariate to explain a substantial part of the variation in numbers of calls detected; 2) this should make it easier to find ATOC or other effects on the residual variation in call counts; and 3) supplemental data on received levels, as well as numbers of calls will be factored into the analysis.

Aerial survey schedules would be coordinated to take advantage of opportunities to match visual sightings and VLA acoustic detections Any visual/acoustic matches would be valuable for calibrating and ground-truthing the array detections.

SOSUS-Based Acoustic Detection of Mysticetes

In addition to the ship-based acoustic measurements, we would utilize the decommissioned Navy SOSUS array (fixed seafloor-mounted 650 m-long horizontal line array, HLA) off Pt. Sur. Dr. Christopher W. Clark, Cornell University, would be responsible for the SOSUS-based acoustic research. Currently the terminus of this array is accessible at the Pt. Sur Naval Facility. However, efforts are underway to directly link this system to the Naval Postgraduate School (NPS), and the Monterey Bay Aquarium Research Institute (MBARI). The bottom-mounted SOSUS HLA allows detection of vocalizing baleen whales to ranges that encompass the 120 dB sound field around the proposed source site on Pioneer Seamount. It should have enough array gain to discern both whales and shipping if both are not in the same or adjacent beams. Acoustic monitoring of vocalizing whales would be carried out with the advanced version of the Cornell Canary system. The rate and frequency of whale vocalizations would be used to test the same hypothesis as that for the VLA-based acoustic detection of mysticetes (see above), with particular emphasis on the area containing the Pioneer Seamount. Data collected at this site would provide another way of comparing bioacoustic variability between a control (Pt. Sur) and experimental (Pioneer Seamount) region.

Photo-Identification

A separate effort to photographically identify large whales in the vicinity of the Pioneer Seamount would be carried out by Cascadia Research Collective. This would be in addition to ongoing photographic identification efforts currently carried out by Cascadia in southern and central California. Photographic identification research on humpback and blue whales has been successfully conducted off California since 1986. Recognition of individuals allows long-term assessments of stock structure, population size, movements (migrations), birth and death rates, survival, and growth (Calambokidis et al., 1990a, 1990b, 1993). The purpose of the research under the aegis of the MMRP would be to document specific individual cetaceans (particularly blue and humpback whales), that are present in the area around Pioneer Seamount. These data would support the goal of attempting to recognize any possible long-term effects of the ATOC transmissions on individual animals.

Also, the presence of these species in the study area could be assessed in order to indicate habitat use or importance. In most cases, this would be extremely difficult to assess, but in our effort to test for potential long-term effects, photo-identification is appropriate. Fortunately, virtually all of the humpback whales that feed off the California coast have been individually recognized; a total of 645 through 1993 (Calambokidis and Steiger, 1995). Further, 642 blue whales have been identified through 1993, out of an estimated population off California of 2000 individuals (Calambokidis and Steiger, 1995).

Blue, humpback, and killer (when available) whales would be approached to within 30 m and photographed using a 35 mm SLR camera with a 70-300 mm lens (Calambokidis et al., 1993). The right or left flank of blue whales, dorsal fin of killer whales, and underside of flukes of humpback whales would be photographed. Photo-identification efforts are planned to be conducted off the California coast, but only part of this effort (near Pioneer Seamount) would be funded by the ATOC project. The ATOC-funded segments would occur from the vessel used for elephant seal translocations, and from the towed array vessel on an opportunistic basis. These photographs would be compared to others collected and catalogued by Cascadia Research Collective and other research groups. We would also approach and photograph other whale species, if encountered.

The MMRP Advisory Board is firmly of the opinion that specific photo-ID work should not be attempted near the ATOC source site while other types of studies (visual or acoustic) of the occurrence and behavior of marine animals are underway there. There is too much risk that the results of those studies would be confounded, or could be perceived as potentially confounded, by boat disturbance associated with the photo-ID work. The MMRP Director endorses this recommendation.

Movements of those individuals known to have frequented the Pioneer Seamount area during source transmissions would be compared with others located outside the study area, in support of a long-term measure of the possible effects of low frequency sound exposure. Cascadia Research Collective would analyze and archive all photo-ID data.

Satellite and Recoverable Tag-Based Behavioral Studies of Marine Mammals of Special Interest

Northern Elephant Seals

Satellite and recoverable tag-based behavioral studies of marine mammals of special interest would address the following null hypothesis:

H_0: There is no detectable change in the following behaviors of northern elephant seals between times when the source is on and when it is off, and as a function of distance from the source: dive duration, dive depth, duration at surface, direction of travel, and swimming speed.

If northern elephant seals were determined to exhibit a detectable difference in one or more of the above listed behaviors during source transmissions, this would result in rejection of the null hypothesis.

This species was chosen for the following reasons: northern elephant seals are believed to have some low frequency hearing capability, are relatively abundant in the Monterey Bay area, are deep divers (up to 1500 m depth), and make good research subjects. Four types of tags would be used to study these animals: 1) time-depth recorder (TDR), 2) satellite-linked TDR (SLTDR), 3) acoustic data logger (ADL), and 4) VHF radio tag (VRT). The devices would be deployed in combinations on the indicator species to relate received sound levels to changes in dive depth or duration, and any avoidance of the source by monitoring changes in swim speed and/or direction.

Tagging individuals with VRTs and/or TDRs has advantages for obtaining accurate and detailed information on movements, dive depth and duration, duration at surface, and swimming speed (Costa, 1993; Le Boeuf and Laws, 1994). Tracking an individual with an attached radio tag provides individual-specific data that usually is of greater detail and duration than can be obtained using visual techniques. Radio tracking allows animals to be monitored at great distances (decreasing biases associated with potential disturbance), at nighttime; and greater amounts of data can be gathered than with visual techniques alone.

To test the effects of low frequency sound on elephant seals we would use two sampling periods. Tags placed on individuals during the transmission period (4 days), would allow us to compare whether the average dive duration, dive depth, duration at surface, direction of travel, and swimming speed differ between 20 min periods of source transmissions vs. the intervening silent periods. Assuming normality and homogeneity, we would use a two-sample t-test to determine differences in the means of variables between source on and off periods. If parametric statistics are inappropriate, we would use either a nonparametric two-sample rank test or resampling statistics (randomization tests).

In all tagging efforts, preliminary results would be used to assess required sample sizes and whether each approach is providing results useful in evaluating potential effects of low frequency sound on marine animals. The level of effort assigned to each component would be adjusted up or down accordingly. There have been no documented instances of tags causing animals to move slower such that their ability to catch food was impaired or their vulnerability to predators was increased.

Dr. Daniel Costa (UCSC) and Dr. Burney J. Le Boeuf (UCSC) would be responsible for the elephant seal research, which would consist of two parts: 1) migration studies in which adult male elephant seals are expected to swim over or near the source site on both departure and return during natural migrations, and 2) translocation studies in which juvenile elephant seals would be released beyond the source site, with a relatively high probability (approximately 50%) that they would pass over or near the source (i.e., within the 120 dB sound field) in returning to their Año Nuevo rookeries.

A minimum of 15 adult male elephant seals that are deemed to be near departure would be instrumented with ARGOS satellite tags and TDRs in August/September 1995 at Año Nuevo mainland. There is a good chance that some of these animals would pass within 12-18 km of the source site (within the 120 dB sound field) on both departure to and return from their foraging grounds. Adult males are a good choice for this part of the study as their 3 month migration allows a single instrument deployment to obtain data on two natural passes in the vicinity of the source. This allows a short-term natural migration study that would yield results by mid-December (when the males return). Previous studies have demonstrated that satellite tracks on migrating animals are based on intermittent position fixes accurate to within 1-2 km, so that the diving behavior can be analyzed from a period in which the animal was in the vicinity of the sound source (Figure C-2). Because of the intermittent nature of the position fixes, tracks of the elephant seals in the vicinity of Pioneer Seamount would have an accuracy less than 1-2 km. Adult male elephant seals exhibit a highly regular continuous diving pattern while in the initial transit periods of their migrations (Le Boeuf et al., 1993). Potential changes in diving behavior due to proximity to the source site would be most evident during this period. Recovery rate expected for breeding age males is over 80%.

A minimum of 24 juvenile elephant seals would be tagged with ARGOS satellite tags and separate TDR's (12 for control data collection to pass through the Pioneer Seamount area when the source is off, and 12 for source transmission data collection, during normal source duty cycle) from haul-out sites at Año Nuevo. These animals would be transported from Año Nuevo mainland to Long Marine Laboratory, where they would be instrumented, then transported by vessel to an area due west of the Pioneer Seamount source site. This protocol increases the potential that released seals would swim through the source site area (or actively avoid it) in returning, while being tracked by satellite. These animals would have an expected return rate of 3-5 days, at which time the instruments would be recovered and data downloaded for analysis. The TDR's deployed on these animals would measure depth, swim velocity and heart rate. These data would allow tests for startle response (rapid change in heart rate), as well as any change in diving behavior or swim speed when the satellite tracks indicate that the animal was in the vicinity of the source.

Experiments conducted over the last three years showed a higher rate of return; 70 of 79 translocated juveniles returned "home" to Año Nuevo. Five additional seals were recaptured at sites along the Big Sur coast (G. Oliver, P. Morris, and B. Le Boeuf, unpub. data, 1993) for a total recapture rate of 94.9%. When the seals were released at a site where they had to travel across deep water, they exhibited a deep diving pattern indistinguishable from that of free-ranging seals of the same age and sex (Le Boeuf, 1994). Time to return to the capture site was on the order of 4.0 ± 2.0 days. Experiments carried out during the fall of 1994 and the winter of 1995 have shown that elephant seals can be reliably followed with ARGOS satellite tags, and that they usually pass by Pioneer Seamount on their normal northward migrations. Furthermore, we have successfully translocated 15 animals equivalent distances from Año Nuevo and they have returned within a few days (Figure C-3).

The value of the translocation paradigm is that it makes it possible to conduct acoustic monitoring during diving in a matter of days. This is important because studies of the free-ranging dive pattern must be conducted over a period of months (a minimum of 3.5 months and a maximum of 8 months), the periods that the animals are at sea (Le Boeuf, 1994). Moreover, two year-old juveniles dive to the same mean depths and exhibit the same mean dive durations as adult males and adult females (Le Boeuf and Laws, 1994). By the end of the fourth trip to sea, when juveniles average 270 ±26 kg, the adult diving pattern and migratory pattern is set. Being able to conduct short-term acoustic-diving studies on translocated seals allows a flexible, efficient approach by reducing costly long-term experiments.

Under support from ONR we also are developing ADLs for deployment on elephant seals. Once developed, these units would be deployed on the seals used in the translocation paradigm. ADLs would be deployed in combination with other instruments we have used successfully (TDRs, swim speed recorders, heart rate and EKG recorders, and ambient temperature) and standard physical and physiological measures (mass, standard length, fat to lean mass from ultrasound measurement of blubber). Thus, we would obtain received level at the seal which would allow us to relate acoustic data to diving performance, energetics, change in orientation; and heart rate, a correlate of stress or startle, that may fluctuate with an intense intermittent sound source (Culik et al., 1989, 1990).

Cetacean Playback Studies

Cetacean playback studies would attempt to address the following null hypotheses:

H_0: There is no detectable difference between the surface respiration patterns (dive duration, surface duration, blow rate) in individual whales when a low frequency sound source with ATOC characteristics is on and when it is off.

H_0: There is no detectable difference in the general movements, speeds, directions and activity of individual whales when a low frequency sound source with ATOC characteristics is on and when it is off.

If cetaceans were determined to exhibit a detectable difference in one or more of the above listed behaviors during source transmissions, this would result in rejection of the null hypothesis.

The proposed research would study the potential effects of low frequency sounds on the behavior of baleen whales (humpback whales, *Megaptera novaeangliae*), as part of the Kauai MMRP, led by Dr. Adam Frankel of Cornell University, and toothed whales (sperm whales, *Physeter macrocephalus*), led by Dr. Jonathan Gordon of Oxford University, England (and the International Fund for Animal Welfare). We would examine whether the exposure to these sounds results in detectable alterations in surface respiration patterns, movements, swimming velocities or diving behavior. To maximize the potential for achieving the MMRP's goals and objectives, playback studies would be conducted in locations where sperm and humpback whales are known to be abundant at certain times of the year. Playback studies of sperm whales would be conducted in the Azores or Dominica during June - August/September 1995, and humpback whales (as part of the Kauai MMRP) off the Kona Coast of Hawaii during December 1995 - March 1996.

Sperm whales

Plans are to conduct approximately five weeks of field work during the June-September 1995 timeframe. The Azores is the preferred study site (Dominica is considered as the alternate location). The research platform would be the 14 m ketch *Song of the Whale*, owned and operated as a research vessel by the International Fund for Animal Welfare. This boat has already been specially equipped for conducting benign research on sperm whales. Field work would be conducted by long-term members of the boat's research party, several of whom were involved in a behavioral assessment of the effects of whale-watching boats on sperm whales off New Zealand, conducted under contract to the New Zealand Department of Conservation.

It is envisaged that two weeks of research would be conducted in one block during the June-July 1995 timeframe, then three weeks during the August-September 1995 timeframe. This would allow the results of the first research period to be analysed and used to adapt research protocols before the second research period was undertaken. A J-13 electrodynamic (moving coil) transducer will be used, weighing 55 kg in air, with the capability of producing reliable source levels of 162 dB. M-sequences (see Section 1) with center frequencies of 75, 200, 400, and 800 Hz will be used. The 800 Hz tone is included because sperm whales have been known to react to this frequency in past experiments (Tyack, pers. comm., 1995). This will provide a behavioral comparison to the 75 Hz m-sequence playback.

Playback of sounds to sperm whales at the surface: During bouts of feeding, sperm whales spend about 10 min at the surface breathing between deep dives, which last up to 40 min. While on the surface, their behavior is very predictable. They normally swim slowly in a fixed direction, breath regularly, typically take virtually the same number of breaths on each surfacing and make few, if any, vocalizations. They usually end their surfacings by raising their flukes above the water, diving, then beginning to vocalize (clicks) again when they reach a depth of about 200 m. At the surface, the animal(s) can be observed visually and simple behaviors, such as headings and blow rates, can be scored using event-recording computers. A large quantity of such data has already been collected by the *Song of the Whale* research team from undisturbed whales in this area of the Azores. The whale's behavior would also be recorded on video and continuous underwater recordings would be made. The range to the animals would be measured using photographic techniques so that received levels of playback sounds can be calcalulated (from a propagation loss model) and their surface movements can be plotted. In calm conditions, ranges may also be measured with radar.

Where possible, the experimental protocol would involve observing and recording data on surfacings of the same animal before, during, and after playback signal transmissions. The activities of the boat would be standardized with minimum engine/generator on time 2 hrs prior to, during, and 1 hr after playback episodes, and the playback vessel anchored or passively drifting to simulate the stationary ATOC source.

Playback of sound to vocalizing sperm whales at unknown ranges: Previously, research scientists have reported that sperm whales alter their vocalizations in response to novel stimuli (Tyack, 1993; Mate and Stafford, 1994). It is typical to hear a number of sperm whales clicking when in the vicinity of a feeding group. These animals may be spread out over several kilometers. The intensity and relative frequency emphasis of their vocalizations gives some indication of range and these same cues can be used to follow the vocal output of specific individual whales. Bearings to individual whales (which can be determined by the difference of time of arrival of clicks at hydrophones in an array) also helps in recognizing vocalizations coming from different individuals. Playing back sounds in such situations and analysing for changes in vocal behavior would be relatively simple experiments to perform. The main limitation would be that the ranges to the whales involved are not known; however, such experiments could be useful as a first step in qualitatively assessing reactions to various noise sources, including the playback sounds. It is also the approach which could be used to assess habituation to long-term playbacks.

Ocean thermal structure would be monitored with XBTs or CTD casts, and incorporated into the research results. Recorded sound emissions from the animals would be characterized using acoustic signal analysis programs (e.g., Fistrup et al., 1992; Fistrup and Watkins, 1992) and examined within the context of the whales' behavior in relation to the distribution of prey, thermal structure, and proximity of conspecifics.

Odontocete Audiometrics

Odontocete audiometric measurements would attempt to determine the low frequency hearing threshold (in dB re 1μPa) of three species of odontocetes that may inhabit the study area, and if feasible, the level at which TTS occurs (both in air and water).

Dr. Whitlow Au and Dr. Paul Nachtigall of the Hawaii Institute of Marine Biology, Kailua, HI are examining the hearing capabilities of captive cetaceans (false killer whale [*Pseudorca crassidens*], Risso's dolphin [*Grampus griseus*], and bottlenose dolphin [*Tursiops truncatus*]) under a separate funding grant. ATOC program funding would supplement their research to include measurements in the lower frequency band, down to the ATOC source frequency of 75 Hz.

Testing would be conducted at Sag Harbor in Kaneohe Bay, Oahu within a 9.2 x 12.3 m wire mesh floating enclosure that is about 4.5 m deep. Water depth is about 5 m (varying with tides) with a soft mud bottom. Animals are initially trained to station themselves inside a padded metal hoop with a vertical extension. The hoop station is located in the center of the enclosure, 3 m from the projecting transducer. The hoop is positioned so as to align the center of the subject's lower jaw with the center of the sound source of the projecting transducer. Both the hydrophone and hoop are positioned underwater at a depth of approximately 1 m. Located in the linear path between the hydrophone and the hoop is an acoustic baffle constructed of aluminum measuring 61 x 46 x 1.6 cm with a layer of cork on the side facing the projecting hydrophone. This has proved valuable for reducing the scattered sound waves reflected off the bottom and the water's surface. The received level at the animal is determined by placing an NRL standard hydrophone receiver (H-52) in a position within the hoop corresponding to the subject's lower jaw. Signals generated for the study are produced using a Quatech Inc. WSE-10 board installed in a Compaq Portable III computer. The outgoing sinusoidal signal is then fed into a signal shaping box that includes a 1 dB step attenuator and a remote controller that is used to initiate the trial sequence and the trial condition (signal present or absent). The signal is turned on and off gradually (ramped up and down) with a linear rise and fall time of 160 ms. The signal is amplified with a David Hafler Co. Model P-230 amplifier. The outgoing feed is then run into the J-13 projecting hydrophone. Generally, voltages are set so as to achieve an initial received level at the hoop of 20-30 dB above the ambient noise floor. This level can be determined by measuring the received signal with the H-52 hydrophone. The received signal is then passed through a Krohn-Hite filter Model 3500 before viewing on a Tektronix oscilloscope Model 22. At each frequency, the non-attenuated signal is measured and photographed. Each frequency is examined and a response curve is generated for the projecting hydrophone, serving as the reference for determination of received levels collected from behavioral data. During these calibrations, it has been determined that the acoustic baffle is necessary to assure a constant amplitude signal.

A go/no-go testing paradigm has been selected for use in these studies. The subjects are trained to respond when an audible signal is detected by leaving the listening hoop and touching a ball positioned above the water mounted on the pen deck. In the no-go condition, the subject has been trained to remain in the hoop until signaled to leave. Each test trial begins with a 2 sec interval during which an underwater light signals the start of the trial. This is followed by a 3 sec interval of the test tone (or silence in the case of a no-go), followed by 10 sec of light. In the course of data collection, the subject is reinforced on a fixed schedule, receiving rewards only for correct responses (both go and no-go responses). Each data session is conducted using a specific frequency, adjusting the signal's attenuation using a modified method of limits, or staircase technique. The presentation of the trial condition is governed by the Compaq computer programmed with a Gellerman series, in which the trials are presented in blocks of 10 with no more than 3 of one type in a row. The session is structured in two parts, a 10 trial warm-up session, followed by the data session. The warm-up session has been designed to give the subject 10 trials with the stimuli presented well within a comfortable level for hearing and is used to determine the subject's general attentiveness to the task and willingness to perform. The subject is required to score >80% correct within the warm-up session before advancing into the data session. The length of the data session varies, and is determined by the number of trials needed to collect 10 reversals.

Reversals are defined by the procedure used to present the stimuli. Each session following the warm-up session starts at a level where the animal comfortably demonstrates that it hears the tone. Each time a tone is presented, it is reduced in amplitude by 4 dB until the animal misses one. At that point, the process is reversed and the tones are increased by 2 dB each time until the animal demonstrates that it hears the tone. When the animal indicates that it hears the tone, the process is once again reversed and the amplitude is lowered in 2 dB steps. This procedure is continued until a total of 6-10 such reversals are obtained. A threshold is defined by obtaining 2 consecutive sessions with mean amplitude levels of the reversals differing by less than 3 dB.

Preliminary results indicate that the false killer whale and Risso's dolphin hearing threshold at 75 Hz is no better than 145 dB (see Section 4).

Sea Turtle Playback Studies

Sea turtle playback studies would attempt to address the following null hypotheses:

H_0: There is no detectable difference in the general movement speed and directional change frequency of individuals when a low frequency sound source with ATOC characteristics is on and when it is off, and as a function of distance from the source.

H_0: There is no detectable difference in the diving behavior (dive depth, duration, swim speed, heart rate, and bottom time interval) of individuals when a low frequency sound source with ATOC characteristics is on and when it is off, and as a function of distance from the source.

If leatherback sea turtles were determined to exhibit a detectable difference in one or more of the above listed behaviors during source transmissions, this would result in rejection of the null hypothesis.

Dr. Scott Eckert of Hubbs Sea World Research Institute, San Diego, CA would be the team leader for this research effort on leatherback sea turtles to take place offshore of Trinidad, West Indies during the March-July 1996 time period.

Matura Bay (beach) on the island of Trinidad supports nesting by more than 500 female leatherback sea turtles annually. Each turtle will nest up to 10 times (average 5 times) during the nesting season, which extends from March through July (peak activity in May). Eggs are deposited in nests every 10 days and tend to be on the same beach. This relatively predictable behavior means that the species lends itself well to the deployment of recoverable data collection equipment, such as TDRs. VHF and satellite tracking data indicate that during the 10 day internesting interval, the species remains within 20-30 km of the nesting beach, though they are quite active during that time. Behavioral patterns, including swim speeds, dive depths, dive durations, surface durations, diet influence, etc., are well documented in a series of studies conducted in the Caribbean, Pacific (Mexico), and Malaysia.

For this project, 10 leatherbacks would be equipped with VHF and depth-sensitive sonic transmitters, as well as TDRs, Heart Rate Recorders, and Velocity Recorders while nesting at Matura Bay. The VHF transmitters allow accurate location of the turtles up to 4-5 km range (surface-surface; greater range if the receiver is elevated). Twenty-four hours after nesting (the time in which the data indicates the turtle will settle into "typical" behavioral patterns), the turtle would be located by radio and sonic transmitter, and monitored from a sailing vessel (e.g., catamaran). Turtle behavior (surfacing rate, dive depths, dive duration, direction of movement) would be monitored continuously by both the turtle's onboard recorders, and by the boat-based tracking crew. Ambient noise levels would also be recorded during the approach, using a small passive 4-element VLA over the side. The turtle would be followed at a distance of approximately 0.5 km. Once the behavior of the turtle appears regular, the playback evolution would commence. See sperm whale section above for playback equipment specifications and employment procedures.

Behavioral monitoring would continue for up to 3 hrs after cessation of the playback transmission, or until behavior returns to pre-test patterns; ambient noise measurements would continue to be made every 30 min. The 3 hr period is based on the time it takes corticosteroids to wash out of the bloodstream of homeotherms, and may not be entirely appropriate for leatherback sea turtles, but would serve as a viable starting point. Subsequent data analysis would examine all aspects of turtle behavior, including diving, surfacing, swim speed, and direction of swimming, before, during, and after each playback evolution.

TIMETABLE

Aerial Visual and Acoustic Surveys/Observations

1 complete survey during each control period (7 day source off period) and each transmission period (4 day source on period). We plan on approximately 3 control and 3 transmission periods each month, weather permitting, adding up to approximately 15 replicates for each control and transmission interval for a total of approximately 30 aerial survey/observation efforts during September 1995 - February 1996.

1 modified survey prior to each of the first two 185 dB transmission periods, and each of the first two 195 dB transmission periods (total 4 surveys).

Shipboard Visual and Acoustic Surveys/Observations; and Photo-Identification

Sep 95 - Feb 96: approximately 18 cruises (9 control; 9 transmission).
additional dedicated photo-ID effort at Pioneer Seamount as weather permits.
1 modified survey/observation evolution prior to each of the first two 185 dB transmission periods, and each of the first two 195 dB transmission periods (4 cruises total).

VLA-Based Acoustic Detection of Mysticetes

Data collection during all transmission and control periods. Special emphasis would be given to periods with aerial surveys/observations and vessel cruises. Anticipated start date September 1995.

SOSUS-Based Acoustic Detection of Mysticetes

Data collection during all transmission and control periods. Special emphasis would be given to periods with aerial surveys/observations and vessel cruises. Anticipated start date August/September 1995.

Tagging Studies

Northern Elephant Seals

Aug-Dec 1995: 15 departure migration animals (adult males) from Año Nuevo
24 return migration animals (juveniles) from Año Nuevo (12 control, 12 transmission)

Cetacean Playback Studies

Humpback Whales (as part of the Kauai MMRP)

Dec 1995- Mar 1996: 80 (approximate) playback experiments using J-13 sound source deployed from a vessel.

Sperm Whales

June-Aug/Sep 1995: 40 (approximate) playback experiments using J-13 (or similar) sound source deployed from a vessel.

Odontocete Audiometrics

Dec 1994-November 1995: 1 false killer whale, 1 Risso's dolphin, 1 bottlenose dolphin.

Sea Turtle Playback Studies

March-July 1996: 40 (approximate) playback experiments on leatherbacks using J-13 (or similar) sound source from a vessel.

PERMITS AUTHORIZING THIS RESEARCH

Each permit cited below authorizes marine animal research in accordance with the requirements and stipulations set forth in the individual permit. Research that would be conducted in conjunction with acoustic thermometry measurement activities would be performed on an opportunistic basis, taking advantage of both scheduled and random low frequency sound transmissions to study the potential effects on marine animals.

Aerial Visual and Acoustic Surveys/Observations

Currently under the auspices of a NMFS aerial and boat survey permit # 938 held by Moss Landing Marine Laboratory, Moss Landing, CA; principal investigators Dr. James Harvey, Dr. Daniel P. Costa, Mr. John Calambokidis, and Ms. Dawn Goley.

Shipboard Visual and Acoustic Surveys/Observations

Currently under the auspices of a NMFS aerial and boat survey permit # 938 held by Moss Landing Marine Laboratory, Moss Landing, CA; principal investigators Dr. James Harvey, Dr. Daniel P. Costa, Mr. John Calambokidis, and Ms. Dawn Goley.

Photo-Identification

Marine Mammal Permit # 855 issued to Dr. John Calambokidis, Cascadia Research Collective, Waterstreet Building Suite 201, 218 West Fourth Ave, Olympia, WA 98501. Issued in 1992 and is valid through 1998 to take blue, humpback and gray whales for photo-ID research off California, Oregon, and Washington.

Northern Elephant Seal Research

NMFS Marine Mammal Permit # 836 issued to Dr. Le Boeuf, Dr. Ortiz and Dr. Costa, Institute of Marine Science, University of California, Santa Cruz. Originally issued June 1993 and reauthorized June 1994 for northern elephant seal research in California waters.

Cetacean Playback Studies

Humpback whales

NMFS Marine Mammal Permit pending to Dr. Adam Frankel of University of Hawaii, for the taking of up to 1000 humpback whales in state waters along the Kona Coast, Island of Hawaii.

Sperm whales

No permit required for Dr. Jonathan Gordon of the University of Oxford to conduct playback studies on sperm whales in Azores and/or Madiera Islands waters.

Odontocete Audiometrics

NMFS Marine Mammal Permit and University of Hawaii Animal Use Protocol certification 93-004-2 issued to Dr. Whitlow Au and Dr. Paul Nachtigall of the Hawaii Institute of Marine Biology, Kailua, HI, for the capture of and audiometric measurements of small odontocetes.

Sea Turtle Playback Studies

Trinidad research permitted through ongoing program administered by the Wildlife Section of the Forestry Department of the Government of Trinidad and Tobago.

TABLES

RESEARCH DATA COLLECTION METHODS / POTENTIAL RESPONSE	Aerial Visual Survey/ Obs	Aerial Acous-tic Obs	Vessel Visual Obs	Vessel Acous-tic Survey/ Obs (pass & active)	VLA-Based Acous-tic (pass.)	SOSUS Based Acous-tic (pass.)	Photo-ID (aerial & vessel)	Tags (TDR) (e-seal)	Tags (SL-TDR) (e-seal)	Tags (ADL) (e-seal)	Tags (VRT) (e-seal)	Ceta-cean Play-back Studies	Odonto-cete Audio-metrics	Sea Turtle Play-back Studies
1. Change in Swim Pattern/direction	o	o	o	o	o	o	o	•	•		•	•		•
2. Change in Ventilation Rate	o		•				o	•	•		o	•		•
3. Change in Vocalization Pattern/Rate		•		•	•	•				o		•		
4. Change in Surface Activity														
a. Feeding/Socializing/Nursing	o	o		o	o		o	o	o		o	o		o
b. Aerial Activity			•				o				o	•		
5. Change in Diving Behavior														
a. Dive Depth	o						o	•	•		o	o		o
b. Dive Duration		o	•	o			•	•	•		•	•		•
6. a. Acute Response[1]														
• Animal dead or disabled	•		•				o	o	•	o	•			
• Increase in number of beached animals								o	o		o			
• Increase in number of animals struck by vessels	o		o				o	o	o	o	•			
b. Short-Term Response[1]														
• Potential injurious activity (outside known baseline activities)														
• Repeated/prolonged activity (vocalizations, blowing, time on surface, etc.)	o	•	o	•	•	•	•	o	o	o	•			
• Abnormal number of animals present/absent	•	o	•	o	o	o	•							
• Abnormal mother-calf activity	o		o				•				o			
7. Long-Term Changes														
a. Habituation	•	o	•	o	•	•	•	o	o					
b. Displacement	•	o	•	o	o	o	•	o	o					
c. Cessation/disruption of significant biological activity (i.e., viability or reproductive potential)[1]														
• Animals obviously and consistently avoid area (or are attracted to it) when source "on"; do not return (or depart) when it is "off."	•	o	•	o	o	o	•	o	o	•		•		•
PHYSICAL AUDITORY EFFECTS														
1. Hearing threshold/TTS level												o	•	o

[1]Source shut-down guidelines if observed in relation to source transmission.

Determination Capability: • Primary Capability o Potential/Limited Capability Blank = No Capability

Table C-1 MMRP research protocol methodology matrix

FIGURES

PIONEER SEAMOUNT MMRP STUDY AREAS

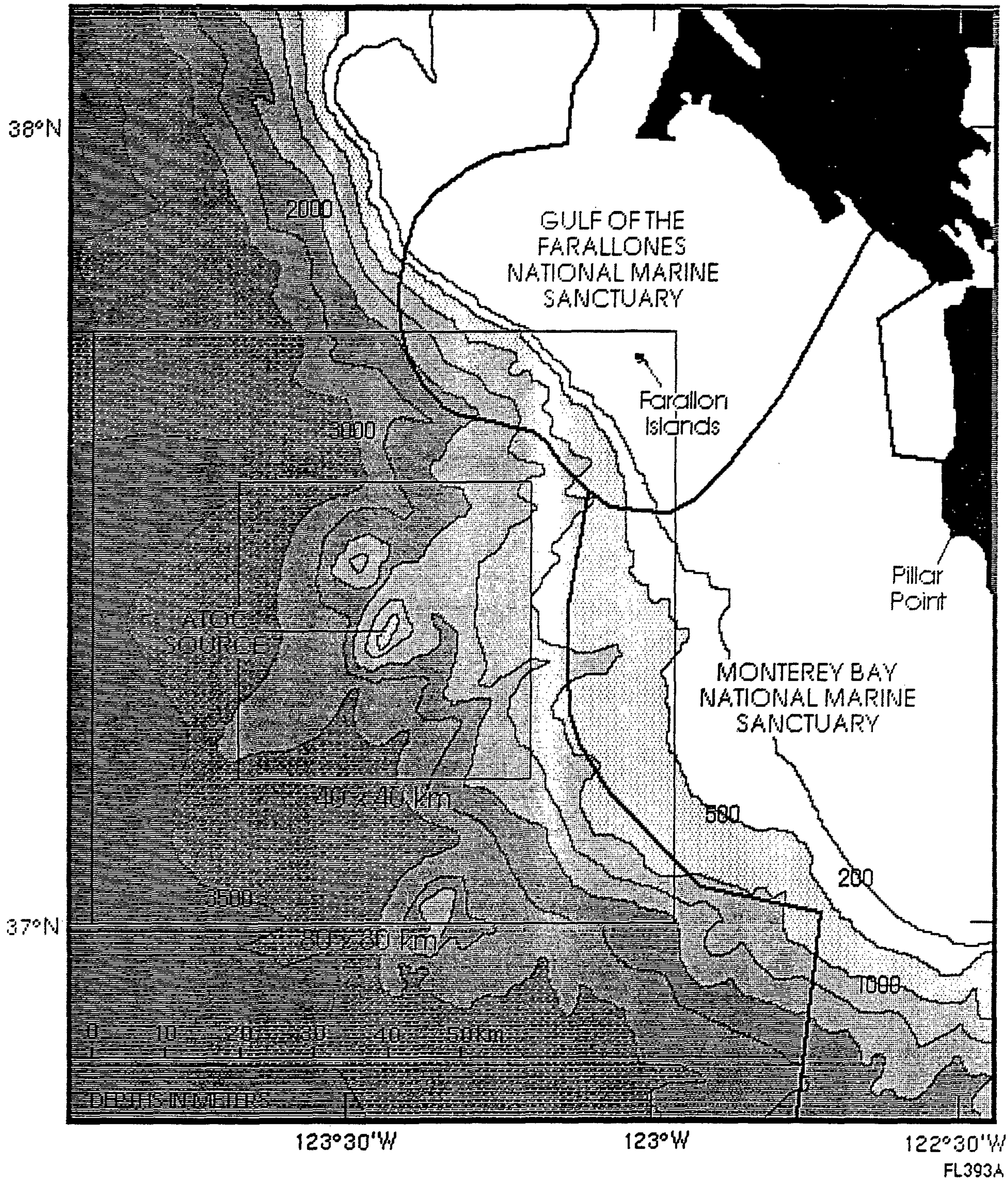

Figure C-1. Pioneer Seamount MMRP study areas.

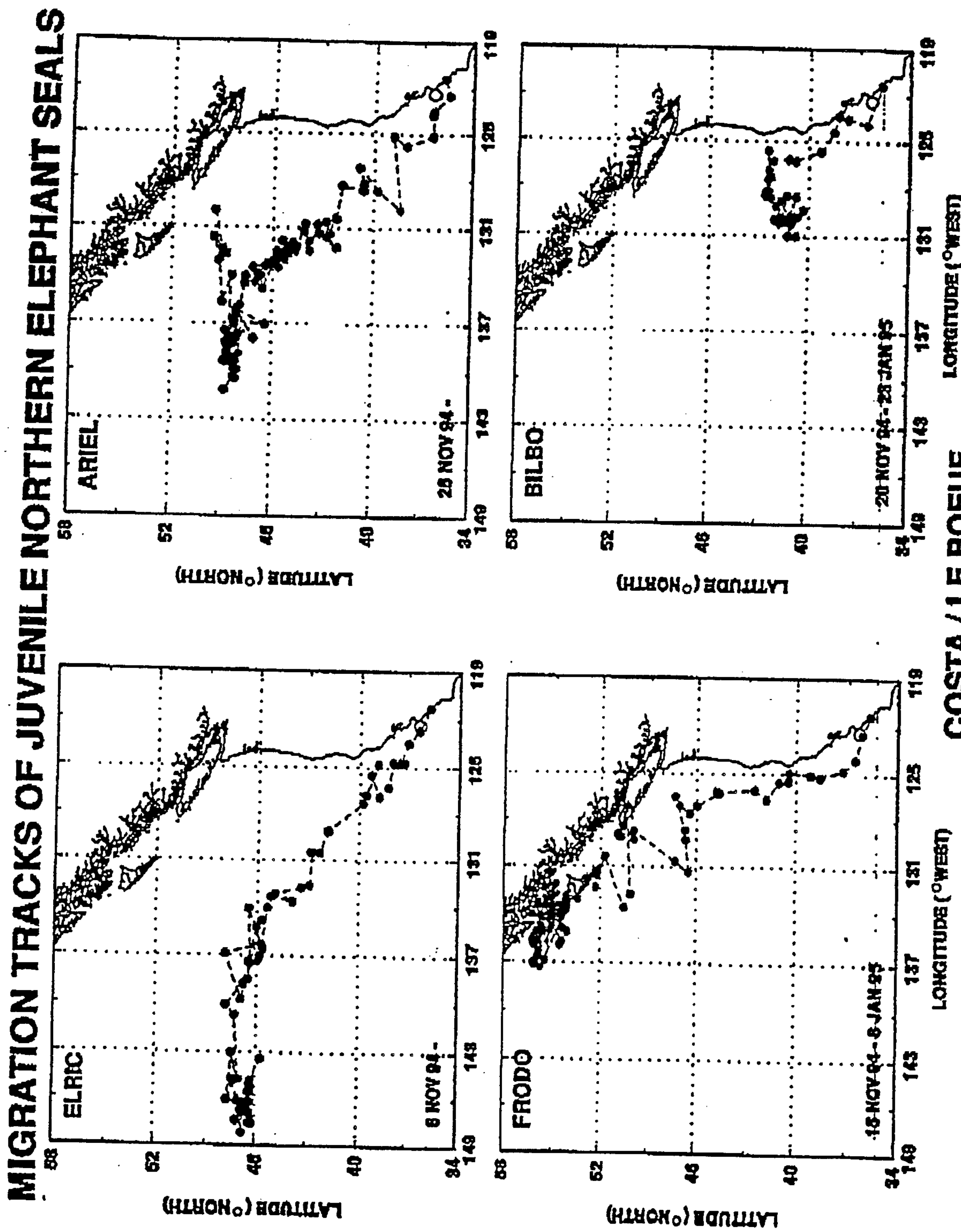

Figure C-2. Northern elephant seal migration tracks.

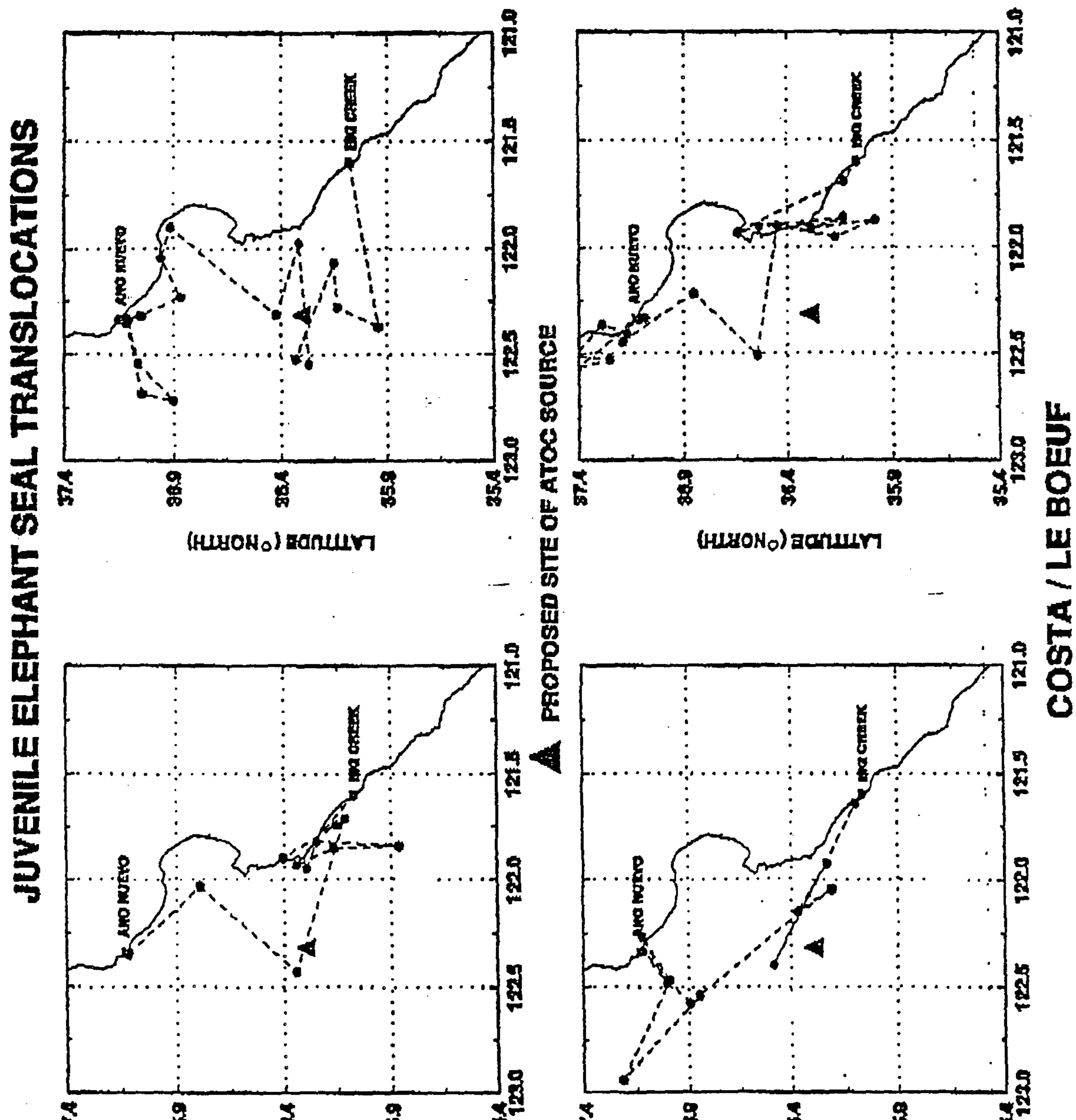

Figure C-3. Northern elephant seal translocation tracks.

ATTACHMENTS

Attachment C-1

TRANSECT LINES FOR AERIAL SURVEY - Pioneer Seamount

Source position	37	20.555	123	26.6
Radius (km)	40			
Radius (nmi)	21.598			
Limits of 40 km square				
SE	36	59.0	122	59.5
NW	37	42.2	123	53.9
Borders of study area				
SE	36	59	123	0
NW	37	42	123	54

TRANSECT LINES AND WAYPOINTS

	Waypoint no.		Latitude		Longitudes			
Line	W	E			W wpt		E wpt	
1	1	2	37	40.7	123	54	123	0
2	3	4	37	38	123	54	123	0
3	5	6	37	35.3	123	54	123	0
4	7	8	37	32.6	123	54	123	0
5	9	10	37	29.9	123	54	123	0
6	11	12	37	27.2	123	54	123	0
7	13	14	37	24.5	123	54	123	0
8	15	16	37	21.8	123	54	123	0
9	17	18	37	19.1	123	54	123	0
10	19	20	37	16.4	123	54	123	0
11	21	22	37	13.7	123	54	123	0
12	23	24	37	11	123	54	123	0
13	25	26	37	8.3	123	54	123	0
14	27	28	37	5.6	123	54	123	0
15	29	30	37	2.9	123	54	123	0
16	31	32	37	0.2	123	54	123	0

Attachment C-2
ATOC Surveys Data Codes

The DAS (data acquisition system) used for this survey has been tested on several other surveys. It is designed to record sightings, time and location with greater ease and accuracy than available with paper. All function key inputs immediately record time and position and "stack" the inputs to be filled in sequentially as the recorder can get to them. For all entries the record type, date, time, and position are recorded automatically.

The major points of operations follow:

F1-F4 keys: Sighting
Log sightings as they occur with these buttons. The number used corresponds with the positions. 1=left, 2=center, 3=right, 4=other. The center observer or other code is only used if the sighting passes abeam of the aircraft and was missed by the other observers. An entry is made in the comment field to indicate sightings made by a side observer which was also seen concurrently or previously by the center observer (and kept silent). The shift

Species ID: Species (use first letters of Genus and Species)
Best Group Size:Number of animals seen.
Minimum: Minimum number of animals
Maximum: Maximum number of animals
Calves: Number of calves in group
Angle: Clinometer angle in degrees when the plane passes abeam the spot the animal was first seen.
Orientation: Magnetic bearing for the heading of the animals
Primary behavior:Selected from list
Other behavior:Selected from list
Observer : Initials of observer. Recorded automatically from positions as noted with Shift F3
Altitude: In feet (transfers automatically from F8 parameters, change if needed)
Comments: "C" indicates also seen prior or concurrently to announcement by the center observer. Other miscelaneous notes

F5= STR TRN: Start transect
Line Number: Use starting waypoint number.
Block Number: Block number
Start WPT Number: Starting waypoint number.
End WPT Number: End waypoint number.

F6= END TRN: End transect

F7= Weather
Cloud Cover %
Beaufort sea state: see list
Glare L Conditions listed below
Glare C

Glare R
Qual L   Conditions listed below
Qual C
Qual R

Glare (by position: L, C, R)
1 = no glare problems
2 = glare problems - affects search
3 = severe glare

Vis/Qual (code of overall impression of ability to see animals)
1 = Excellent (the best)
2 = Good (most animals at surface can still be seen)
3 = Fair (conditions have definitely reduced sighting efficiency)
4 = Poor (Few animals are going to be seen in these conditions)
5 = Unacceptable (There is no point in looking)

F8 - ALT/SPD :record altitude and speed

F9 - Comment : Write comment or correction

Shift F3=OBSERVR: Record observers by position.

Shift F2=Reset sightings counter (does not affect data record)

Markers for record types
#1-4 = Sighting by position (1-L, 2-C, 3-R, 4-Other)
A = Additional sighting data after closing and circling
W = Weather
B = Begin line
E = End line
T = Turn
X = Break off line to close with sightings
R = Return to line after sighting
8 = Altitude change
O = Observer position status or change
I = Transect number update (automatic prompt at line start)
* = Automatic position and time update (every minute)
C = Comment

Behavior codes:
0-Unknown
1-Slow travel
2-Fast travel
3-Staionary
4-Feeding

5-Bow riding
6-Hauled (pinniped)
7-Tail-lobbing
8-Breaching
9-Milling
10-Fluke swish
11-Surface lunge feed
12-Bubble exhalation
13-Flick feed
14-Spy hop
15-Pec slap
16-Group affiliation
17-Group disaffiliation
18-Mud plume (ER feeding)

Vessel avoidance/reaction behavior (only used when believed causaly linked, provide reason for connection)
31-Avoidance of boat
32-Alteration of normal activities
33-Quick dive
34-Boat approach within 1 body length
35-Fluke swish in response to boat
36-Loud blows

Attachment C-3: Behavioral Protocol for Odontocetes

I. 5:00 Scan Sample

1. Time- 24 hour

2. Latitude/Longitude

3. Beaufort
   - **0**= smooth, mirror-like, no ripples
   - **1**= light ripples
   - **2**= small wavelets, not breaking
   - **3**= occasional breaking peaks and whitecaps
   - **4**= small waves, frequent whitecaps
   - **5**= moderate waves many whitecaps
   - **6**= all whitecaps, some spray
   - **7**= breaking waves, spindrift begins
   - **8**= medium high waves, foamy

4. Confidence
   Two types of odontocete observations would be recorded:
   1. Observations of the entire school
   2. Observations of the focal group (a subset of the school) if there are subgroups

   <u>Confidence that the entire school is in view</u>
   - 1= Excellent- We are confident that we can see the entire school. Environmental and behavioral conditions are such that it is likely that we would see any animal within a 5 nm radius.
   - 2= Good- We are fairly confident that the entire school is in view. Environmental and behavioral conditions are such that it is likely that we would see any animal within a 3 nm radius.
   - 3= Fair- We are not confident that the entire school is in view. Either poor environmental conditions, an extremely large and scattered group, or long-diving animals preclude exact estimates.
   - 4= Poor- We are confident that the entire school is not in view. Environmental and behavior conditions are such that sighting conditions are not workable.

   <u>Confidence that all surface behaviors of the focal group are observed</u>
   - 1= Excellent- Environmental and behavioral conditions are such that we are confident that we can see all surface behaviors.
   - 2= Good- Environmental and behavioral conditions are such that we are fairly confident that we can see all surface behaviors.
   - 3= Fair- Environmental and behavioral conditions are such that we are not confident that we can see all surface behaviors.
   - 4= Poor- Environmental and behavioral conditions are such that we are confident that we can not see all surface behaviors.

Attachment C-3: Behavioral Protocol for Odontocetes (cont.)

5. Size- number of animals

6. Spread
   Two types of odontocete observations would be recorded:
   1. Observations of the entire school
   2. Observations of the focal group (a subset of the school) if there are subgroups.
      Spread within the school= space between individuals if school is homogeneous or
      - **1**= within 2 m
      - **2**= 2- less than 10 m
      - **3**= 10 - less than 100 m
      - **4**= 100- less than 500 m

      Spread within the focal group= inter animal distance
      - **1**= within 2 m
      - **2**= 2- less than 10 m
      - **3**= 10 - less than 100 m
      - **4**= 100- less than 500 m

7. Speed- Species dependent
   - **SL**= Slow
   - **ME**= Medium
   - **FA**= Fast

8. Bearing and Distance from boat to nearest aimal; Direction- group heading

9. Polarization- percent of the group that is oriented in the same direction

10. Subgroups- number of distinct subgroups

Attachment C-3: Behavioral Protocol for Odontocetes (cont.)

11. General Behavior
    - **DM**= Directed Movement
        - polarized group all moving in the same direction during the 5 min between sample points, with less than a 15^0 deviation from course
        - animals travel at least 150 m in 5 min
    - **UM**= Undirected Movement
        - animals are not polarized
        - animals travel less than 150 m in 5 min
        - no observed organisms or behaviors strictly associated with feeding
    - **PF**= Probable Feed (characterized by, but not exclusive to):
        - prey seen in mouth
        - prey jumping at surface
        - active fluke out dives, often directed to another individual
        - increased aerial activity (species dependent)
        - birds feeding in same location
        - prey detected by hydroacoustic methods
    - **RE**= Rest
        - slow surfacings
        - animals travel less than 150 m in 5 min (SD)
        - group (or school) is polarized
        - no observed organisms or behaviors strictly associated with feeding

12. Aerial Behavior- presence or absence

13. Comments

* A critical component of these observations is the indication of a change in the variable between the 5 min samples. For example, if the shape of the group has changed more than once during this time, it would be indicated on the data sheet by an *. This would, in turn, be an indication of the variability of that behavior.

Attachment C-4: Behavioral Protocol for Mysticetes

I. Respiration Rates

- Information is to be recorded at every respiration
- exception- Latitude/Longitude is to be recorded at the end of each surfacing sequence

1. Time- 24 hour

2. Confidence- confidence that all surface behaviors are viewed
   - **1**= Excellent- Environmental and behavioral conditions are such that we are confident that we can see all surface behaviors.
   - **2**= Good- Environmental and behavioral conditions are such that we are fairly confident that we can see all surface behaviors.
   - **3**= Fair- Environmental and behavioral conditions are such that we are not confident that we can see all surface behaviors.
   - **4**= Poor- Environmental and behavioral conditions are such that we are confident that we can not see all surface behaviors.

3. General Behavior
   - **DM**= Directed Movement
     - 2 or more consecutive surfacings in the same orientation
     - animal(s) travel at least 150 m in 5 min
     - polarized movements of individuals (for groups of animals)
     - no observed organisms or behaviors strictly associated with feeding
   - **UM**= Undirected Movement
     - the orientation of 2 or more consecutive surfacings is greater than 45^0
     - animal(s) travel less than 150 m in 5 min
     - no observed organisms or behaviors strictly associated with feeding
   - **PF**= Probable Feed (characterized by, but not exclusive to):
     - surface feeding behaviors
     - lunging at surface
     - food seen coming from baleen
     - birds feeding in same location
     - prey detected by hydroacoustic methods
   - **RE**= Rest
     - slow surfacings
     - animal(s) travel less than 150 m in 5 min
     - animal(s) motionless at surface

Attachment C-4: Behavioral Protocol for Mysticetes (continued)

- no observed organisms or behaviors strictly associated with feeding

4. Group Size- number of animals

5. Animal Heading

6. Bearing and Distance from boat to nearest animal

7. Latitude/Longitude

8. Comments

II. 2:30 Scan Sample

1. Time- 24 hour

2. Size- number of animals

3. Confidence- confidence that all surface behaviors are viewed
   - **1**= Excellent- Environmental and behavioral conditions are such that we are confident that we can see all surface behaviors.
   - **2**= Good- Environmental and behavioral conditions are such that we are fairly confident that we can see all surface behaviors.
   - **3**= Fair- Environmental and behavioral conditions are such that we are not confident that we can see all surface behaviors.
   - **4**= Poor- Environmental and behavioral conditions are such that we are confident that we can not see all surface behaviors.

4. Animal Heading

5. General Behavior
   - **DM**= Directed Movement
     - 2 or more consecutive surfacings in the same orientation
     - animal(s) travel at least 150 m in 5 min
     - polarized movements of individuals (for groups of animals)
     - no observed organisms or behaviors strictly associated with feeding

Attachment C-4: Behavioral Protocol for Mysticetes (continued)

- **UM**= Undirected Movement
    - the orientation of 2 or more consecutive surfacings is greater than 45^0
    - animal(s) travel less than 150 m in 5 min
    - no observed organisms or behaviors strictly associated with feeding
- **PF**= Probable Feed (characterized by, but not exclusive to):
    - surface feeding behaviors
    - lunging at surface
    - food seen coming from baleen
    - birds feeding in same location
    - prey detected by hydroacoustic methods
- **RE**= Rest
    - slow surfacings
    - animal(s) travel less than 150 m in 5 min
    - animal(s) motionless at surface
    - no observed organisms or behaviors strictly associated with feeding

6. Aerial Behavior- presence or absence

7. Speed-Species dependent
    - **SL**= Slow
    - **ME**= Medium
    - **FA**= Fast

8. Latitude/Longitude

9. Beaufort
    - **0**= smooth, mirror-like, no ripples
    - **1**= light ripples
    - **2**= small wavelets, not breaking
    - **3**= occasional breaking peaks and whitecaps
    - **4**= small waves, frequent whitecaps
    - **5**= moderate waves many whitecaps
    - **6**= all whitecaps, some spray
    - **7**= breaking waves, spindrift begins
    - **8**= medium high waves, foamy

Attachment C-4: Behavioral Protocol for Mysticetes (continued)

10. Comments

* A critical component of these observations is the indication of a change in the variable between the 2 1/2 min samples. For example, if the shape of the group has changed more than once during this time, it would be indicated on the data sheet by an *. This would, in turn, be an indication of the variability of that behavior.

Attachment C3/C4(A): Vessel Activity Protocol

Record at the time of the scan sample (every 5:00 for odontocetes; 2:30 for mysticetes:

- Observation vessel

1. Time - 24 hr
2. Heading
3. Distance to animal(s)
4. Position to animal(s)

- Other vessel(s)

1. Type of vessel
2. Heading
3. Distance to observation vessel
4. Distance to animal(s)
5. Position to animal(s)
6. Comments

Attachment C-5: Environmental Protocol

Record every 15 min

1. Time- 24 hour
2. Latitude/Longitude
3. Temperature
4. Swell
5. Seas
6. Wind Speed
7. Beaufort
   - **0**= smooth, mirror-like, no ripples
   - **1**= light ripples
   - **2**= small wavelets, not breaking
   - **3**= occasional breaking peaks and whitecaps
   - **4**= small waves, frequent whitecaps
   - **5**= moderate waves many whitecaps
   - **6**= all whitecaps, some spray
   - **7**= breaking waves, spindrift begins
   - **8**= medium high waves, foamy
8. Sightability
   - **1**= Excellent- Surface water calm (Beaufort=0-1) with no sun glare or other environmental factors impeding ability to sight whales. Visibility > 5 km.
   - **2**= Very Good- May be slighly uneven lighting of light chop (Beaufort=0-2) but still relatively easy to sight whales. Visibility > 5 km.
   - **3**= Good- Light chop with scattered whitecaps (Beaufort=2-3), swell 2-4m, or some sun glare or other impediment (e.g., haze) in < 10% of the study area. Whales can still be detected fairly easily.
   - **4**= Fair- Choppy waves with fairly frequent whitecaps, low light conditions (e.g., heavy overcast, dawn, dusk) swell 4-6m, sun glare in < 50% of the study area. Some animals in the study area are likely to be missed.

Attachment C-5: Environmental Protocol (cont.)

- **5**= Poor- Numerous whitecaps (Beaufort=5), sun glare or haze in > 50% of the study area, or swell > 6m, impeding ability to sight whales. Many (> 50% ?) animals in the study area are likely to be missed.
- **6**= Unacceptable- Beaufort > 6, or glare, haze, or other visibility impediment in > 75% of the study area. Detection of whales unlikely unless the observer is looking directly at the place where the animals surface.

9. Prey Presence
   - record the following information from the fish finder for the 50 kHz and 200 kHz frequencies
   - presence or absence of prey
   - range (in m) in which prey is seen

10. Comments

Attachment C-6: Summary of Cetacean Behavioral Observations in the Pt. Sur area 8 July to 10 December 1994

Dawn Goley and Danielle Waples (UCSC)
16 December 1994

Behavioral observations of cetaceans have been conducted in theMonterey Bay, California area from the 7.5 m research vessel R/V *Naia II.* We have conducted surveys for 132 hrs 35 min from this platform. During these surveys, we have had 16 mysticete and 80 odontocete sightings (Table A-C-6-1). The number of individuals observed in these sightings totaled 32 mysticetes and 3666 odontocetes. We have conducted 11 mysticete (mean data collection session length = 1 hr 13 min ± 8 min) and 12 odontocete (mean data collection session length = 1 hr 48 min ± 18 min) behavioral data collection sessions.

In addition, behavioral observations of cetaceans have been conducted in the ATOC MMRP Pt. Sur (preferred site) study area from the 17 m research vessel R/V *Shana Rae*. We have conducted surveys for 91 hrs 2 min from this platform. A complete summary of the cetacean sightings are to supplied by the Moss Landing Marine Laboratory survey team at a later date. During these surveys, we conducted 4 mysticete (mean data collection session length = 1 hr 24 min ± 38 min) and 3 odontocete (mean data collection session length = 1 hr 25 min ± 38 min) behavioral data collection sessions (Table A-C-6-2).

Species	# Sightings	# Animals	Average Group Size	# Follows	Average Follow Length
Humpback whale	12	23	2 (±1)	7	1h 18m (±33m)
Blue whale	4	9	2 (±1)	4	1h 7m (±16m)
P. white-sided dolphin	17	869	51 (±48)	4	1h 28m (±37m)
Common dolphin	8	2240	280 (±357)	6	2h 3m (±3m)
Risso's dolphin	4	154	39 (±31)	2	1h 54m (±8m)
Harbor porpoise	21	68	3 (±2)	0	
Dall's porpoise	26	123	5 (±3)	0	
N. right whale dolphin	2	180	90 (±42)	0	
Bottlenose dolphin	2	32	16 (±3)	0	
TOTAL	96	3698		23	1h 32m (±22m)

Table A-C-6-1. Summary of cetacean sightings aboard R/V Naia II, 8 July-10 December 1994.

Species	# Follows	Average Follow Length
Humpback whale	3	1h 26m (±47m)
Blue whale	1	1h 17m
Risso's dolphin	2	1h 24m (±54m)
Killer whale	1	1h 26m
TOTAL	7	1h 23m (±4m)

Table A-C-6-2. Summary of cetacean follows aboard R/V _Shana Rae_, 8 July-10 December 1994.

Attachment C-7

Statistical Power Analysis
for the
California ATOC MMRP Research Protocol

Issue

Whether or not the proposed ATOC MMRP Research Protocol (ARPA et al., in press) at the proposed action site for the California ATOC MMRP, Pioneer Seamount, will have sufficient power to detect a significant difference in marine mammal population density. Statistical power analyses were conducted for four MMRP research techniques: 1) aerial visual survey (see below for levels of effort), 2) vessel-based visual survey (see below for levels of effort), 3) vessel-based acoustic survey with a towed HLA (see below for levels of effort), 4) VLA-based acoustic detection of mysticetes (continuous, 24 hrs/day). Two other passive acoustic research techniques that do not lend themselves to statistical analyses are discussed: 1) aerial acoustic observations (with sonobuoys), 2) SOSUS-based acoustic detection of mysticetes (continuous, 24 hrs/day).

Pioneer Seamount vs. Sur Ridge sighting rates

Based on a comparison of marine mammal sightings in the Sur Ridge and Pioneer Seamount areas (from 1980-82 MMS aerial surveys) (Calambokidis, pers. comm., 1995), sighting rates for humpbacks should be somewhat higher at Pioneer Seamount (vs. Sur Ridge). Therefore, the power analyses presented here should be considered conservative to an unknown degree.

Power Analyses

1) Aerial Visual Survey. Three different types of statistical analyses were performed for aerial surveys: paired t-test, z-test, and non-parametric sign test. These analyses are based on the aerial survey sightings of humpback whales in an 80 x 80 km grid centered on the preferred action site, Sur Ridge. These data were collected in 1994 and provided by John Calambokidis of Cascadia Research, Seattle. A total of nine humpbacks were sighted in four surveys covering a total of 2545 nm of track lines (C.V. = 0.336 for entire effort). Sighting rates were obtained for each survey and mean rate and S.D. for these data were 0.00396 humpbacks/nm (S.D. = 0.00256).

Paired t-Test

It was decided that a paired t-test may be an appropriate procedure to estimate the paired survey approach. During the timeframe of the aerial surveys (at least 6 months) the population density of humpbacks will fluctuate due to migration, allowing a determination of the seasonal variability in species distribution, as well as the potential for any ATOC source transmission effects (observed in the paired surveys). Therefore, an examination of the difference of before and after trials is appropriate (Green, 1989). In such an approach, the correlation between the before and after data needs to be estimated in order to calculate the S.D. of the difference of the two means (Zeh, pers. comm., 1995). There are no data with which to predict the correlation, so values of 0.0, 0.25, 0.5, and 0.75 were selected. Calculations were performed by University of

Washington, Seattle (J. Zeh) and Cornell University (A. Frankel). The results are listed in the table below:

rho	Power	No. Paired Surveys Required for Effect Size = 0.20	No. Paired Surveys Required for Effect Size = 0.50
0	0.5	59	12
0	0.6	78	14
0	0.7	101	18
0	0.8	132	23
0.25	0.5	45	9
0.25	0.6	59	11
0.25	0.7	76	14
0.25	0.8	99	18
0.5	0.5	31	7
0.5	0.6	40	8
0.5	0.7	51	10
0.5	0.8	67	12
0.75	0.5	17	5
0.75	0.6	21	5
0.75	0.7	27	6
0.75	0.8	34	7

This table indicates that given the available data to work with, 15 paired aerial surveys should be able to detect a change of 50% in sightings between the four day transmission period and the seven day control period, with a 0.7 power, if the correlation between before and after data is 0.25. If that correlation were 0.5, which is as high as can reasonably be expected, then a change of that magnitude could be detected with power > 0.9. The conclusion is that based upon the limited data available, we could reasonably expect to detect changes in encounter rates on the order of 50% between the paired surveys. However, the likelihood of getting a 50% change in encounter rates in the 80 x 80 km grid is low, given that the ATOC sound source will attenuate to less than 120 dB within 20 km of the source.

z-Test

Because of the low statistical power associated with the paired design, an alternative experimental design was developed. This technique compares the number of sightings between the inner grid box (40 x 40 km [1600 km^2] around the source, which encompasses the entire predicted 120 dB sound field) and the number of sightings in the outer grid area made up of the 80 x 80 grid box around the source less the 40 x 40 interior (leaving a "frame" of 4800 km^2) (see Figure C-1). This assumes that surveys to support this experimental design will be flown during the four-day transmission periods. The number of sightings (encounter rate) within the inner and outer survey areas is assumed to be log normally distributed. It is also assumed that the coefficient of variance (C.V.) is equal to $1/\sqrt{N}$ sightings. Calculations were performed by

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National Marine Mammal Laboratory (NMML), Seattle (D. DeMaster, J. Laake). The results are listed in the table below:

No. of Survey Days in Each Area	No. of 45 km Track Lines in Each Inner and Outer Area	Power (for sighting difference of 2x between inner and outer area)	Power (for sighting difference of 2.5x between inner and outer area)	Power (for sighting difference of 3x between inner and outer area)
12.5	300	0.55	0.73	0.82
14.5	350	0.62	0.79	0.88
16.5	400	0.67	0.84	0.91
19	450	0.72	0.88	0.94
21	500	0.77	0.91	0.96
23	550	0.80	0.93	0.97

This table indicates that given the available data to work with, 15 days of aerial surveys (assuming approximately 1100 km of track lines flown each day) should allow the detection of a difference of 2x in number of sightings between the inner and outer areas with a 0.62 power, or a difference of 2.5x with 0.79 power, or a difference of 3x with 0.88 power. The conclusion is that based upon the limited data available, we can reasonably expect to detect changes on the order of 2-3x in densities of humpback whales between the two areas during source transmission periods.

Non-Parametric Sign Test

A third methodology has also been applied: with 15 days of surveys, a non-parametric sign test would produce a significant result if 12 of the 15 paired surveys had a consistent direction of change in humpback sightings between the control and transmission periods ($p = 0.031$, one-tailed probability). A Wilcoxon signed-rank test for paired observations, where the magnitude of the difference, as well as the direction of the change, is applied, would provide even more power.

Summary

Based on analysis of all three of the above statistical analysis techniques, taking into account the MMRP objectives and asset availability, the latter two techniques will be employed for aerial surveys (z-test and non-parametric sign test).

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2) Vessel-Based Visual Survey.

Paired t-Test

It was decided that this type of test was the most appropriate procedure for the vessel-based visual surveys. See above for further discussion of this technique. These analyses were based on baseline data from the vessel-based cetacean behavioral observations (visual) carried out by UCSC in the Pt. Sur area during the time period 8 July to 10 December 1994, using random strip transects within 25 km radius of the Sur Ridge alternative site (see Attachment C-6). Based on these data, a mean of 0.16256 and standard deviation of 0.14662 were used. Calculations were performed by Cornell University (A. Frankel). The results are listed in the table below:

rho	Power	No. Paired Surveys Required for Effect Size = 0.50	No. Paired Surveys Required for Effect Size = 0.70
0.33	0.5	16	8
0.33	0.6	21	11
0.33	0.7	27	14
0.33	0.8	36	18
0.33	0.9	50	26
0.5	0.5	9	4
0.5	0.6	12	6
0.5	0.7	15	8
0.5	0.8	20	10
0.5	0.9	28	14
0.6	0.5	6	3
0.6	0.6	8	4
0.6	0.7	10	5
0.6	0.8	13	7
0.6	0.9	18	9
0.7	0.5	3	2
0.7	0.6	4	2
0.7	0.7	6	3
0.7	0.8	7	4
0.7	0.9	10	5

This table indicates that given the available data to work with, 9 paired vessel-based visual surveys should be able to detect a change of 50 % in sightings between the four day transmission period and the seven day control period, with a 0.5 power, if the correlation between before and after data is 0.5. Because power below 0.8 is generally unacceptable, the MMRP would attempt to increase the number of paired-vessel surveys up to 20. With this number of surveys, the expected power of the paired t-test would be 0.8. If this proves to be unfeasible due to platform availability, inclement weather, or budget restrictions, the objective of the vessel surveys would revert to the collection of data for descriptive analysis and for development of future surveys, and not for the purpose of testing a particular hypotheses with adequate statistical power.

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3) <u>Vessel-Based Acoustic Survey (with towed HLA)</u>.

Paired t-Test

A towed beamforming HLA has never been used for acoustic surveys of large whales. Based on data from Thomas et al. (1986), use of a single passive acoustic vessel-towed hydrophone array demonstrated an increase in ability to detect odontocetes by 32% overall, compared to visual surveys alone. In March of 1994 a two-element HLA was used in the Caribbean Sea to search for minke whales (Kraus et al., 1995) in a broad area 90-140 km north of Puerto Rico. Although no humpback was visually detected during the ten-day survey, vocalizing whales were acoustically detected on all days, and they were recorded during each of the 28 minke whale recording sessions. This situation is somewhat similar to what may be expected at the Pioneer Seamount area during the fall and spring, as humpbacks are expected to move through the area. Other data concerning rates of acoustic detection for humpbacks are available from the recent Navy Whales '93/Dual Uses project (Clark et al., 1993). In this research effort, vocalizing humpbacks were regularly detected at low encounter rates in deep water areas (e.g., the general vicinity of Bermuda) from November through early May. Both of these research projects provide some information on daily detection rates of vocalizing humpbacks during the winter period in areas not considered to be breeding or calving areas. Combining all these data yields a mean detection rate of 2.0 vocalizing whales/day, with a standard deviation of 1.38. Calculations were performed by Cornell University (C. Clark). The results are listed in the table below:

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rho	Power	No. Paired Surveys Required for Effect Size = 0.50	No. Paired Surveys Required for Effect Size = 0.70
0.33	0.5	10	5
0.33	0.6	13	6
0.33	0.7	17	8
0.33	0.8	22	11
0.33	0.9	30	15
0.5	0.5	5	3
0.5	0.6	7	4
0.5	0.7	9	5
0.5	0.8	12	6
0.5	0.9	17	9
0.6	0.5	3	2
0.6	0.6	5	2
0.6	0.7	6	3
0.6	0.8	8	4
0.6	0.9	11	5
0.7	0.5	2	1
0.7	0.6	3	1
0.7	0.7	3	2
0.7	0.8	4	2
0.7	0.9	6	3

This table indicates that given the available data to work with, 12 paired vessel-based acoustic surveys using an HLA should be able to detect a change of 50% in acoustic detections between the four-day transmission period and the seven-day control period, with a 0.8 power, if the correlation between the variances for the before and after data is 0.5. During the late spring through late summer period, vocalizing in humpbacks is rare in any part of their range (and the occurrence of humpbacks in the study area would be expected to be low), so that acoustic detection methods cannot be used during this time to evaluate the potential effects of the source transmissions on this species.

4) VLA-Based acoustic detection of mysticetes.

Paired t-Test

For the vertical line array deployed from the source on Pioneer Seamount, the acoustic data stream would be virtually continuous except specifically during the 5 min ramp-up and subsequent 20 min transmission. Values used for the vessel-based (acoustic) mean detection rate and standard deviation are also presumed valid for this analysis. Calculations were performed by Cornell University (C. Clark). The results are listed in the table below:

rho	Power	No. Paired Surveys Required for Effect Size =	No. Paired Surveys Required for Effect Size =

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		0.10	0.20
0.25	0.5	298	75
0.25	0.6	397	99
0.25	0.7	518	130
0.25	0.8	681	170
0.25	0.9	944	236
0.5	0.5	133	33
0.5	0.6	176	44
0.5	0.7	230	58
0.5	0.8	303	76
0.5	0.9	419	105
0.6	0.5	85	21
0.6	0.6	113	28
0.6	0.7	147	37
0.6	0.8	194	48
0.6	0.9	268	67
0.7	0.5	48	12
0.7	0.6	64	16
0.7	0.7	83	21
0.7	0.8	109	27
0.7	0.9	151	38

Because the VLA will be operating continuously, each transmission can be considered an individual on-off evolution; i.e., a determination of any change in the abundance and distribution of vocalizing mysticetes before vs. after each transmission. Thus, six months of Pilot Study effort, with approximately 12 days of transmissions (6 per day) each month, will offer a maximum of 432 paired acoustic detection period opportunities. This yields the ability to detect a change of 10% in acoustic detections between the two hour period before a transmission and the two hour period after the transmission, with power > 0.6, if the correlation between the variances between before and after data is 0.25, or the detection of a 10% change with power > 0.9 if the before and after correlation is 0.5. However, it must be noted that humpback seasonality restrictions (see above) would also apply here. Nevertheless, the VLA should prove to be a powerful tool in evaluating the potential impact of the source transmissions on marine mammals in the vicinity. Furthermore, through continuous monitoring of the VLA for low frequency (<1000 Hz) whale vocalizations, a reliable baseline of detection rates and the associated variability will be available under different operating conditions. By taking advantage of this technique, the sample size is effectively as large as the number of transmissions and will also enable the MMRP Research Team to account for seasonal variability in whale density and vocal behavior for blue, fin and humpback whales year-round.

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Passive Acoustic Cumulative Factor

The following two passive acoustic techniques (all part of the MMRP research protocol) would be additive factors to the aforementioned visual and acoustic efforts:

- Aerial acoustic observations (with sonobuoys)
- SOSUS-based acoustic detection of mysticetes (continuous, 24 hrs/day)

It is quite possible that passive acoustic methodologies will prove to be better than aerial surveys for detecting the presence of animals in areas of relatively low animal densities, such as Pioneer Seamount; however, acoustics may not be able to cover the entire area as thoroughly and evenly as aerial surveys.

Summary

The paucity of survey data with associated C.V.s for either the preferred action site (Sur Ridge) or the proposed action site (Pioneer Seamount) makes it difficult to perform the desired statistical power analyses. Given that it is recognized that determining population changes over a short time, in a relatively small area, and attributing them to a specific cause is quite complex, it is believed that the analyses supplied above are probably the best that can be done with the limited data available. Other factors could contribute to the confounding of the survey results; for example: 1) environmental factors (e.g., transient upwellings) that could cause changes in animal abundance and/or distribution, 2) natural short-term movements of animals into and out of the 80 x 80 km study region (possibly due to patchiness of food resources), and 3) potentially poor weather conditions that could curtail survey efforts (this would be overcome, to the greatest extent feasible, through the extension of the Pilot Study for a reasonable time period [from 6 months up to 10 months]). It appears that a combination of visual and acoustic techniques should be able to detect meaningful changes in marine mammal densities, both between the four day transmission periods and the seven day control periods, and between the inner (1600 km^2) and outer (2400 km^2) areas around the proposed source site during the four day transmission periods. With the possible cumulative effect from the higher sighting densities (humpbacks) expected at Pioneer Seamount (vs. Sur Ridge) and the additional passive acoustic data collection efforts, sufficient data points should be collected during the MMRP Pilot Study on which to base meaningful statistical results.