

## **APPENDIX H**

# **ENDANGERED SPECIES ACT SECTION 7 CONSULTATION BIOLOGICAL OPINION**

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**ENDANGERED SPECIES ACT  
SECTION 7 CONSULTATION  
BIOLOGICAL OPINION**

**Agency:** Department of Defense, Office of Naval Research (ONR) and  
Marine Mammal Conservation Division, National Marine Fisheries Service

**Activity:** Funding of, and the Continued Use of, the Sound Source for the North  
Pacific Acoustic Laboratory off Kauai, Hawaii

**Issuance Regulations for a Small Take Authorization under the Marine  
Mammal Protection Act and for Incidental Take associated with the  
Continued Use of the Acoustic Thermometry of Ocean Climate Sound  
Source for the North Pacific Acoustic Laboratory off Kauai, Hawaii**

**Conducted by:** National Marine Fisheries Service, Southwest Region

**Approved by:** Don Knowles

**Date of Issuance:** 4-26-01

**ABSTRACT**

To comply with the requirements of the Endangered Species Act of 1973, the National Marine Fisheries Service (NMFS) has prepared a biological opinion on a proposal by the Office of Naval Research to fund, and continue use of, the sound source for the North Pacific Acoustic Laboratory (NPAL) and a proposal by the NMFS' Marine Mammal Conservation Division to issue regulations for a small take authorization under the Marine Mammal Protection Act for the continued use of the sound source. Operation of the NPAL sound source would introduce low frequency sound into the marine environment for the purposes of studying acoustic thermometry and long-range propagation of low-frequency sounds. The portion of the North Pacific Ocean closest to the sound source would have the loudest addition of sounds from the transmissions, with the sounds attenuating to levels below ambient towards the receiving arrays.

The area under consideration in the biological opinion includes the North Pacific Ocean between the NPAL sound source and the receiving arrays used to detect the transmissions, pursuant to the definition of the action area in Interagency Consultation regulations (50 CFR 402.02). However, the area where effects on listed species would be detectable is in the vicinity of the NPAL source. There is no evidence that listed species, particularly the endangered baleen whales which are considered the most sensitive to low frequency sounds, can detect or respond to sounds that have dropped much below the level of ambient noise. The region from any sound source to the point at which sounds reach ambient levels is termed the zone of audibility (Richardson et al., 1995). Listed species would not likely be adversely affected by the NPAL transmissions outside the NPAL zone of audibility.

The potential effects of the transmissions were analyzed for the 25 endangered and threatened species that occur within the action area. The evidence available for this assessment of the effects of sound associated with the NPAL sound source on listed marine species is limited to information on the physics of low frequency sounds in the ocean environment and current, but limited, knowledge of how marine animals behaviorally respond to low frequency sound. The evidence available for the analyses includes results of studies of how marine mammals and other marine organisms respond, physically and behaviorally, to sound sources.

Based on information about the species' geographic distribution and hearing abilities of the listed species, NMFS concludes that the Steller sea lion (eastern and western populations) and listed salmonid species are not likely to be affected by continuation of NPAL sound source operation. Steller sea lions and the listed salmonids are located near the receiving arrays where the NPAL transmissions would be below ambient levels. Based on information on the hearing and diving abilities of the following listed sea turtles, the leatherback sea turtle (*Dermochelys coriacea*), green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricata*), loggerhead sea turtle (*Caretta caretta*), and olive ridley sea turtle (*Lepidochelys olivacea*) would not likely be adversely affected. These sea turtle species have an insensitive ear and would not likely be within an ensounded area that would elicit behavioral responses.

Based on published and unpublished studies, the NPAL transmissions may result in temporary alterations in communications or behavior of humpback whales (*Megaptera novaeangliae*) and sperm whales (*Physeter macrocephalus*). Response behaviors were observed by these species in the vicinity of the experimental sound sources during studies. Response behaviors include longer dive times of humpback whales during NPAL transmissions and distribution of sperm whales further away from an NPAL sound source when it was operating. The biological significance of these possible response behaviors is not known, but is not expected to affect the reproductive or survival capabilities of these species. There is also potential for blue (*Balaenoptera musculus*), fin (*B. physalus*), sei (*B. borealis*), or right whales (*Eubalaena glacialis*) to experience short-term masking of communication or environmental sounds due to the NPAL transmissions. NPAL transmissions would also result in a low probability of effects to Hawaiian monk seals (*Monachus schauinslandi*), which are occasionally found around Kauai. Any adverse effects that may occur would not likely affect the reproduction and survival of these species and thus, would not result in reductions in numbers and reproduction of these species. Therefore, NMFS concludes that the proposed action is not likely to jeopardize the continued existence of any endangered species or threatened species.

## **INTRODUCTION**

Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531, et seq.) requires that each federal agency shall ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When the action of a federal agency may affect a protected species, that agency is required to consult with either the National Marine Fisheries Service or the U.S. Fish and Wildlife Service, depending upon the protected species that may be affected. For the actions described in this document, the action agency is the Office of Naval Research of the Department of Defense and the Marine Mammal Conservation Division of NMFS.

This document constitutes NMFS' biological opinion on our review of the proposed continued use of the sound source off of Kauai, Hawaii, for the North Pacific Acoustic Laboratory's research efforts and the proposed rule for a small take authorization under the Marine Mammal Protection Act for incidental take associated with the sound source. This biological opinion has been prepared in accordance with section 7 of the ESA. It is based on information provided in the Draft Environmental Impact Statement, Biological Assessment, published and unpublished scientific information, and other sources of information. A complete administrative record for this consultation is on file at the NMFS Pacific Islands Area Office.

## **CONSULTATION HISTORY**

On September 28, 1995, the National Marine Fisheries Service (NMFS) completed a section 7 consultation with the Advanced Research Projects Agency of the Department of Defense and the Permits and Documentation Division of the National Marine Fisheries Service for the Acoustic Thermometry of Ocean Climate (ATOC) sound source in Kauai, Hawaii, and the adjunct scientific research permit to examine the potential for effects on protected species from the operation of a sound source. The section 7

consultation assessed the Hawaii project of the Advanced Research Projects Agency ATOC proof of concept study and concluded that although there was the potential for some of the species to be affected by the sound source operation, the likelihood of any effect was low, and the extent of the effects would not jeopardize any listed species.

Two sound sources were installed for the ATOC feasibility study, one at Kauai and other on Pioneer Seamount off central California. The signals transmitted were received by receiving arrays spread over the North Pacific. The Pioneer source began transmitting in late 1995 and was turned off at the end of 1998. The other sound source and its power cable were installed on the sea floor at a depth of 807 m, 14 km north of Kaiehu Point, Kauai, Hawaii, and began transmissions in late 1997. In conjunction with the ATOC proof of concept study, ARPA funded a scientific research project called the Marine Mammal Research Program. The studies examined the potential effects of low frequency sound on marine mammals and sea turtles in waters off the island of Kauai and California.

The Marine Mammal Research Program was designed to study the reactions of cetacean species in the vicinity of the sound sources off California and Hawaii. In Hawaii, the humpback whale was chosen for study because it is presumed to have excellent low-frequency hearing sensitivity. If consistently obvious reactions were noted for the humpback whales, then studies of other species assumed to be less susceptible would be necessary. A variety of techniques were employed to study the behavior and distribution of humpback whales of Hawaii. Baseline studies were conducted around Kauai in 1993, 1994, and 1995 during conditions when the ATOC sound source was not operating. In 1996, playback studies were completed off the Island of Hawaii to test the responses of humpbacks to the source signal. In 1998, behavioral studies were conducted at the Kauai study site using the operational sound source. In these different efforts, humpback whale abundance and distribution was studied with two approaches. Aerial surveys were conducted to examine the statewide distribution of humpbacks and other marine animal species. Shore-based studies were conducted to assess the abundance and distribution of humpback whales in the nearshore waters, where whales are found most often (summary of the research program from Frankel and Clark, unpub. report). Similar studies were also conducted for the Pioneer Seamount sound source.

Neither the California nor the Hawaii Marine Mammal Research Program found any overt, short-term behavioral responses by marine mammals to the transmissions of the sound sources. Calambokidis et al. (1998) surveyed the waters in an 80 km by 80 km (43 nm by 43 nm) box centered on the California sound source, and Mobley et al. (1999a) surveyed the waters within 40 km (22 nm) of the Kauai sound source. Only humpback whales were seen in sufficient numbers in the survey area around the Kauai source to permit quantitative assessments of distributional changes from 1994 (when the source was off) to 1998 (when the source was on). The distance from each sighting to the sound source and the distance from each sighting to shore were computed, and the mean distances compared between the two years. The mean distance offshore and distance from the source were both slightly greater for humpback whales during 1998 (when the source was on); however, these differences were not significant. Statistical analyses of aerial survey data showed some subtle shifts in the distribution of humpback, and possibly sperm, whales away from the Pioneer Seamount source during transmission periods (Calambokidis et al. 1998). No statistically significant shifts in distribution were found for any other species of marine mammal. Visual observation data from the Kauai research program showed a similar small shift in mean distance of humpback whales away from the Kauai source during transmission periods.

On February 7, 2000, NMFS sent a letter to the Office of Naval Research responding to a request for a species list. The list included only the listed species that may occur within 8 nautical miles north of Kauai, Hawaii at the site of the sound source. The request for the species list asked for species in the area surrounding the sound source location. However, during the consultation NMFS determined that the area that needs to be considered is where direct and indirect effects may occur. The Office of Naval Research (ONR) requested formal consultation on the project in a letter dated June 23, 2000.

NMFS provided ONR a draft of the biological opinion on March 14, 2001. ONR transmitted comments on the biological opinion on March 21, 2001. The comments allowed for corrections to the description of the action and expressed concerns for the extent of the action area. NMFS provided another draft of the biological opinion on April 20, 2001 and a discussion on the action area and other issues was held on April 26, 2001.

## **BIOLOGICAL OPINION**

### **DESCRIPTION OF THE PROPOSED ACTIONS**

The U.S. Navy's Office of Naval Research proposes to fund the Scripps Institution of Oceanography (Scripps) and the Applied Physics Laboratory of the University of Washington to continue operating the sound source for the North Pacific Acoustic Laboratory (NPAL) program in Kauai, Hawaii. The purpose of the proposed action is to study the way sound behaves as it travels over long ranges in the ocean, and in studying ocean circulation and structure, is to increase fundamental understanding of the U.S. Navy's operating environment. Specifically, the action is designed to study (a) the feasibility and value of large-scale acoustic thermometry; (b) the behavior of long-range underwater sound transmissions; and (c) possible long-term effects from sound transmissions on marine life, particularly marine mammals.

In a separate, but related action, the National Marine Fisheries Service's Marine Mammal Conservation Division proposes to promulgate regulations that would allow Scripps and Applied Physics Laboratory a small take authorization pursuant to section 101(a)(5) of the Marine Mammal Protection Act (MMPA).

#### **Operation of the NPAL Sound Source**

In order to study the acoustic thermometry and long range propagation of sound transmissions, NPAL would transmit signals from the sound source located off of Kauai, Hawaii, and pick up the transmissions using receiving arrays. The receiving arrays are located in the North Pacific Ocean south of the Aleutian Islands and along the west coast of the continental United States, as well as other locations, as shown in Figure 1.

Under the proposed action, the seabed power cable and sound source would remain in their present locations at Kauai and transmissions would continue with approximately the same signal parameters and transmission schedule used in the previous ATOC project. The typical transmission schedule involves 20-minute transmissions every four hours (six total over the course of a day), every fourth day, with each transmission preceded by a 5-minute ramp-up period during which the signal intensity would be gradually increased, representing an average duty cycle of 2 percent. Duty cycles could be increased to 8 percent, during short-term testing or short-term long-range acoustic propagation studies. Increases to an 8 percent duty cycle would not occur during the peak humpback season, January through April. (ONR, 2000). The transmissions would continue for 5 years.

The NPAL signals transmitted by the source would have a center frequency of 75 Hertz (Hz) and a bandwidth of approximately 35 Hz (i.e., sound transmissions are in the frequency band of 57.5-92.5 Hz). Approximately 260 Watts of acoustic power would be radiated during transmission. At 1 meter (m) (3.3 feet) from the source, the sound intensity would be about 195 decibels (dB) referenced to the water

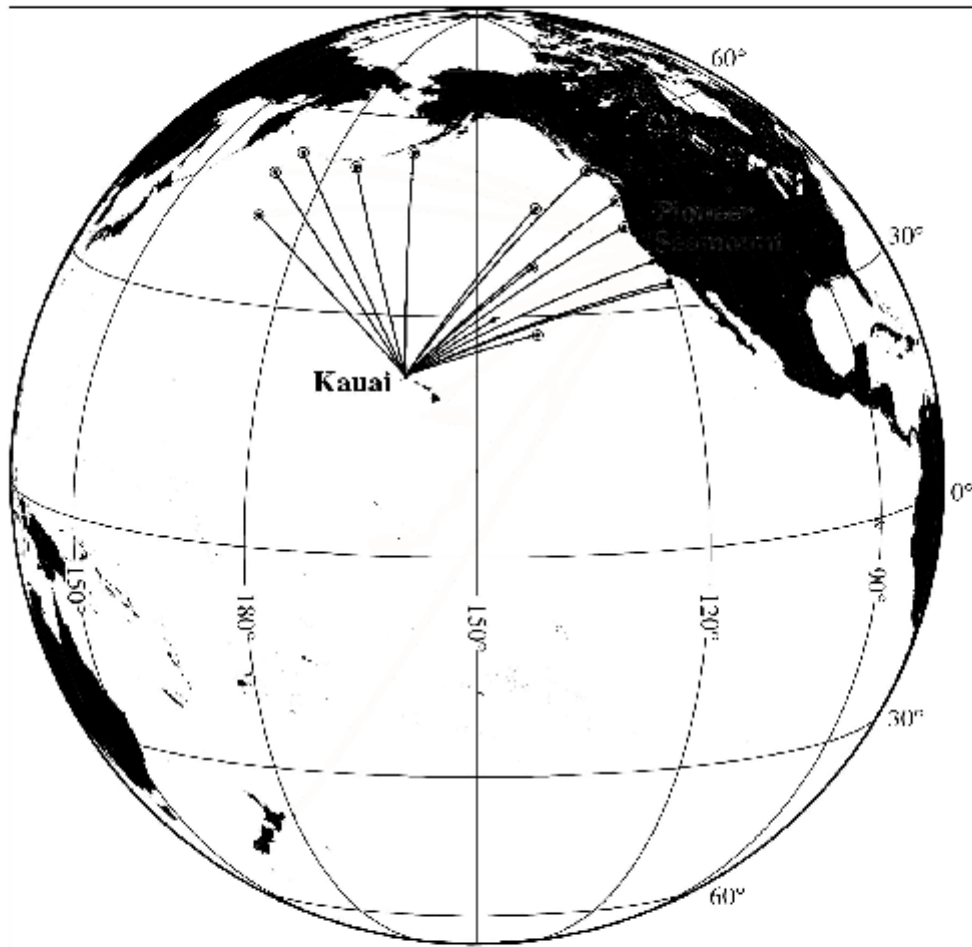


Figure 1. Location of ATOC source and receiving arrays

standard of 1 microPascal ( $\mu\text{Pa}$ )<sup>1</sup>. The sound levels are reduced to 16-20 dB below ambient levels at the furthest receiving arrays. These signal parameters and source level were found in the ATOC project to provide adequate, but not excessive, signal-to-noise ratios at the receiver ranges of interest.

The source signal is a digital sequence of codes that has been optimized for decoding at the distant underwater receivers. The transmission length of 20 minutes is designed to spread the energy over time, at much lower levels, than if the signals were sent as short, loud pulses of the same total energy. Although the sounds cannot be heard in the usual sense over most of the transmission path or at the receivers, they are detected and timed using advanced digital signal processing techniques, similar to those used by NASA to retrieve data from deep space satellites. Weak but carefully constructed signals of long duration can be extracted from below-ambient noise levels. As a result, the waveform parameters minimize the received levels to which marine animals are exposed while optimizing reception. Results from the first phase of the ATOC feasibility study demonstrate that these source characteristics provide adequate, but not excessive, signal-to-noise ratios at the receiver ranges of interest.

To provide for short-term, long-range acoustic propagation studies, the proposed action includes the possibility of an 8 percent duty cycle for up to 2 months out of each year. The 8 percent duty cycle would not occur during the peak humpback season (January - April). The transmission schedule during the 2-month period would not include transmissions longer than 2 hours in duration. As an example, one possible 8 percent transmission schedule could include 20-minute transmissions at four hour intervals every day, instead of every fourth day. Another possible schedule would involve transmitting the 20-minute signal on the hour for 24 hours followed by 72 hours of no transmissions, repeated up to 15 times over the 2-month 8 percent duty cycle period.

The proposed action also has a component designed to investigate the possible effects of the operation of the sound on marine mammals and sea turtles. This part of the proposed action is called "marine mammal monitoring and studies". The objectives of the monitoring and studies are to advance the understanding of the potential for long-term effects from the acoustic transmissions on listed species, by performing aerial surveys to monitor the distribution, and abundance of marine animals in the vicinity of the sound source (ONR, 2000). The studies would involve 8 aerial surveys per year during the humpback whale winter breeding season. Not all of the methods for analyzing the results of the surveys have yet been determined. Boat-based surveys and on-shore observations would not be a part of the monitoring and studies. The aerial surveys will provide data to be analyzed in combination with survey data from 1993-1998. For this aspect of the monitoring and studies, the same protocol would be followed to maintain a consistent basis of comparison.

During the years 1993-98, aerial surveys of marine mammals resident in the waters surrounding Kauai were performed as part of the ATOC Marine Mammal Research Program, with a focus on humpback whales. Data were collected during the humpback winter breeding season (February - April) for a total of three baseline years when the Kauai ATOC source was not transmitting (1993, 1994, and 1995) and for one year when it was transmitting (1998). The survey followed north-south systematic lines spaced 14 nm apart in channel waters, 7 nm apart in major island regions, and 3.5 nm within a 40-km radius of the sound source (Mobley et al. 1999b).

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<sup>1</sup>Sound measurements can be expressed in two forms: intensity and pressure. The intensity of the sound is the average rate at which energy is transmitted through a unit area in a specified direction, expressed in Watts per square meter ( $\text{W}/\text{m}^2$ ). Acoustic intensity is rarely measured directly. Instead, when acousticians refer to intensities or powers, they derive it from ratios of pressures. To present sound measurements as ratios of pressures that can be compared to one another, a standard reference pressure needs to be used. The American National Standard and the international (metric) standard is to use 1 microPascal ( $\mu\text{Pa}$ ) as the reference pressure for underwater sound and 20  $\mu\text{Pa}$  as the reference pressure for airborne sound. All sound measurements presented in this biological opinion are with reference to 1  $\mu\text{Pa}$ .

In the proposed action, the monitoring and studies will include eight surveys from February through early April. The surveys would be scheduled eight days apart to match the NPAL transmission schedule. Based on an average of seven humpback sightings per survey observed during the 1998 season, and assuming a moderate sized effect due to the NPAL transmissions, eight surveys should produce a minimum of 56 sightings of humpback whales, which would result in an estimated power of 0.80 (i.e., there would be an 80 percent probability of detecting a change in distribution if an effect is present) (Welkowitz et al. 1991).

Sightings of all marine mammal and sea turtle species would be made by two experienced observers, one on each side of the aircraft. Sightings would be called to a person recording data who would note the species sighted, number of individuals, presence or absence of a calf, angle to the sighting, and any apparent reaction to the aircraft. Additionally, GPS locations and altitude (measured by a radar altimeter) would be automatically recorded at 30-sec intervals and whenever a sighting is made.

Data collected from proposed surveys would be analyzed with the past survey results to examine long-term population shifts in distribution and abundance. The aerial surveys may also be used to further study behavioral response of marine mammals and turtles. Methods for analyzing the results of the surveys will be developed. The following monitoring program elements are proposed:

1. Annual reports of the results obtained would include numbers and locations of all marine mammal and sea turtle sightings. The annual report would be submitted to NMFS as part of the Letter of Authorization permitting process, with copies submitted to the Hawaii Department of Land and Natural Resources and the Hawaiian Islands Humpback Whale National Marine Sanctuary.
2. For humpback whales, any apparent avoidance reactions in response to the NPAL source would be assessed by examining the distance from the source to each sighting as well as distance offshore, based on GPS position data.
3. Visual aerial surveys capable of detecting the following acute or short-term effects (the capability of the surveys to identify the effects are mentioned in parentheses):
  - Animal dead or disabled (primary capability)
  - Increase in number of beached animals (potential/limited capability)
  - Increase in number of animals struck by vessels (potential/limited capability)
  - Repeated/prolonged activity (blowing, time on surface, etc.) (potential/limited capability)
  - Abnormal number of animals present/absent (primary capability)
  - Abnormal mother-calf activity (potential/limited capability)
4. If at any time a marine mammal monitoring and studies team member positively identifies an acute or short-term effect, the information would be immediately communicated to the monitoring/studies leader. If the leader ascertains that an acoustic transmission (i.e., during the 5-minute ramp-up or the 20-minute transmission) coincided with the observed response, he would contact the Barking Sands shore termination site and Scripps, and suspend source operations immediately until further notice. The monitoring/studies leader would collate all pertinent information relative to the incident and contact NMFS to inform them of the situation. NMFS, in consultation with the leader, would make the determination as to the severity of the situation, based upon the knowledge of the species type, the animal's location relative to the source, the source level at the time of the incident, the estimated received level at the animal, and whether there were any other noise sources in the vicinity, etc. Based upon analysis of the information supplied, NMFS would recommend that one of the following options be executed:
  - Continue experiment as planned;

- Continue experiment with modifications to maximum source level or duty cycle; or
  - Suspend experiment pending consultation with Scripps and NMFS.
5. At the conclusion of the five-year period, the seabed power cable would be abandoned in place. This would have the two-fold benefit of avoiding disturbances to sensitive military instrumentation in the vicinity and the benthic environment. The source or transducer would be abandoned in place as well, unless it appeared to still be in sufficiently good condition to warrant recovery. Since the proposed action includes abandoning the seabed power cable in place, there is no potential for physical impacts which are likely to affect listed species. Recovery of the sound source will require separate consultation as appropriate. This part of the proposed action is not considered further in this biological consultation.

### **Small Take Authorization**

To ensure compliance with the MMPA, Scripps applied for a small take authorization under the MMPA for incidental take that may occur during operation of the NPAL source on May 21, 2000. Section 101(a)(5)(A) of the Marine Mammal Protection Act directs the Secretary of Commerce to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals if certain findings are made and regulations governing the take are issued. A notice of proposed rulemaking and a request for comments was published in the Federal Register on December 22, 2000 (65 FR 80815).

The regulations would authorize incidental take of the following listed marine mammals as well as other marine mammals: humpback whales, fin whales, blue whales, sperm whales, and Hawaiian monk seals. The proposed rule includes several mitigation measures: (a) operate at the minimum duty cycle necessary for conducting large-scale acoustic thermometry and long-range propagation objectives, (b) not increase its duty cycle for long-range propagation studies during the months of January through April, (c) operate at the minimum power level necessary for conducting large-scale acoustic thermometry and long-range propagation objectives, and (d) precede all transmissions from the acoustic source by a 5-minute ramp-up of the acoustic source's power.

The rules also include several requirements for monitoring and reporting. These are summarized as followed: (a) the holder of the small take authorization must notify the Southwest Regional Administrator at least 2 weeks prior to commencing monitoring activities, (b) the holder must conduct a minimum of eight surveys each year from February through early April in the area off the north shore of Kauai, Hawaii, (c) the holder must, through coordination with marine mammal stranding networks in Hawaii, monitor strandings of marine mammals to detect long-term trends in stranding and the potential relationship to the North Pacific Acoustic Laboratory acoustic source, (d) activities related to the monitoring described in (b) and (c), or in the Letter of Authorization issued under 50 CFR 216.106 and section 216.176 of the proposed rule may be conducted without the need for a separate scientific research permit, (e) at its discretion, NMFS may place an observer on any aircraft involved in marine mammal surveys in order to monitor the impact on marine mammals, (f) the holder must annually submit a report to the Office of Protected Resources, NMFS, no later than 120 days after the conclusion of humpback whale aerial survey monitoring program. This report must contain the results, if any, of coordination with coastal marine mammal stranding networks, (g) a final comprehensive report must be submitted to the Office Protected Resources, NMFS no later than 240 days after completion of the final year of the humpback whale aerial surveys.

As noted in the description of the NPAL operation and marine mammal monitoring and studies, these measures and requirements have been adopted into the proposed NPAL operation.

## Action Area

The sound source and cable are located in offshore waters approximately 8 nm north of the island of Kauai, Hawaii. The receiving arrays are located generally along the northern and western rim of the North Pacific Ocean. Figure 2 shows the area over which the transmissions would travel. The action area includes the parts of the North Pacific Ocean between these devices and where direct and indirect effects may occur. Because of uncertainty regarding the sound transmissions, a more precise definition of the action area cannot be stated.

The portion of the action area nearest to the Kauai sound source will have the loudest addition of noise from operation of the NPAL sound source. Average ambient noise levels in the 60-90 Hz band offshore central Kauai can be 76-98 dB (with various degrees of shipping traffic) and are expected to be higher (~105 dB) when humpback whales are present. Noise generated by the NPAL source would diminish to 120 dB within an area bounded by 22°00' and 23°00' North latitude and 160°10' and 158°45' West longitude.

The received level from the NPAL source is not expected to exceed 137 dB at the water's surface anywhere in the vicinity of the sound source. The received level in the top 100 m has been measured to decrease to about 120 dB at 5 km (2.7 nm) shoreward of the source. The near-surface received level is predicted to decrease to about 120 dB at 7.5 km (4 nm) seaward of the source. Underwater sound levels in the immediate vicinity of the source are expected to be: 140 dB at 245 m depth (562 m range around the source); 145 dB at 491 m depth (316 m range around the source); 150 dB at 629 m depth (178 m range around the source); and 165 dB at 775 m depth (32 m range around the source) (ONR 2000; Advanced Research Projects Agency and NMFS 1995) (See Figure 3).

## STATUS OF THE SPECIES AND ENVIRONMENTAL BASELINE

NMFS has determined that the action being considered in this biological opinion may affect the following species and critical habitat provided protection under the Endangered Species Act of 1973 (16 U.S.C. 1531 *et seq.*; ESA):

Blue whale	<i>Balaenoptera musculus</i>	Endangered
Fin whale	<i>Balaenoptera physalus</i>	Endangered
Humpback whale	<i>Megaptera novaeangliae</i>	Endangered
Right whale	<i>Eubalaena glacialis</i>	Endangered
Sei whale	<i>Balaenoptera borealis</i>	Endangered
Sperm whale	<i>Physeter macrocephalus</i>	Endangered
Hawaiian monk seal	<i>Monachus schauinslandi</i>	Endangered

Critical habitat has been designated for the right whale in the Atlantic Ocean in Cape Cod Bay, Great South Channel, and off Georgia and Florida (50 CFR 226.203). NMFS concluded that the proposed action is not likely to affect this critical habitat because it is not included in the action area.

NMFS also recognizes that gray whales (*Eschrichtius robustus*) occur in the action area. Although gray whales were removed from the list of threatened and endangered species in 1994 (59 FR 31094), NMFS has a continuing obligation to monitor the status of this species. This biological opinion will not assess whether the proposed acoustic thermometry project plans are likely to jeopardize the continued existence of gray whales; however, this opinion will include a general assessment of the effects of the action on gray whales as part of NMFS' continuing responsibility to monitor the status of the species.

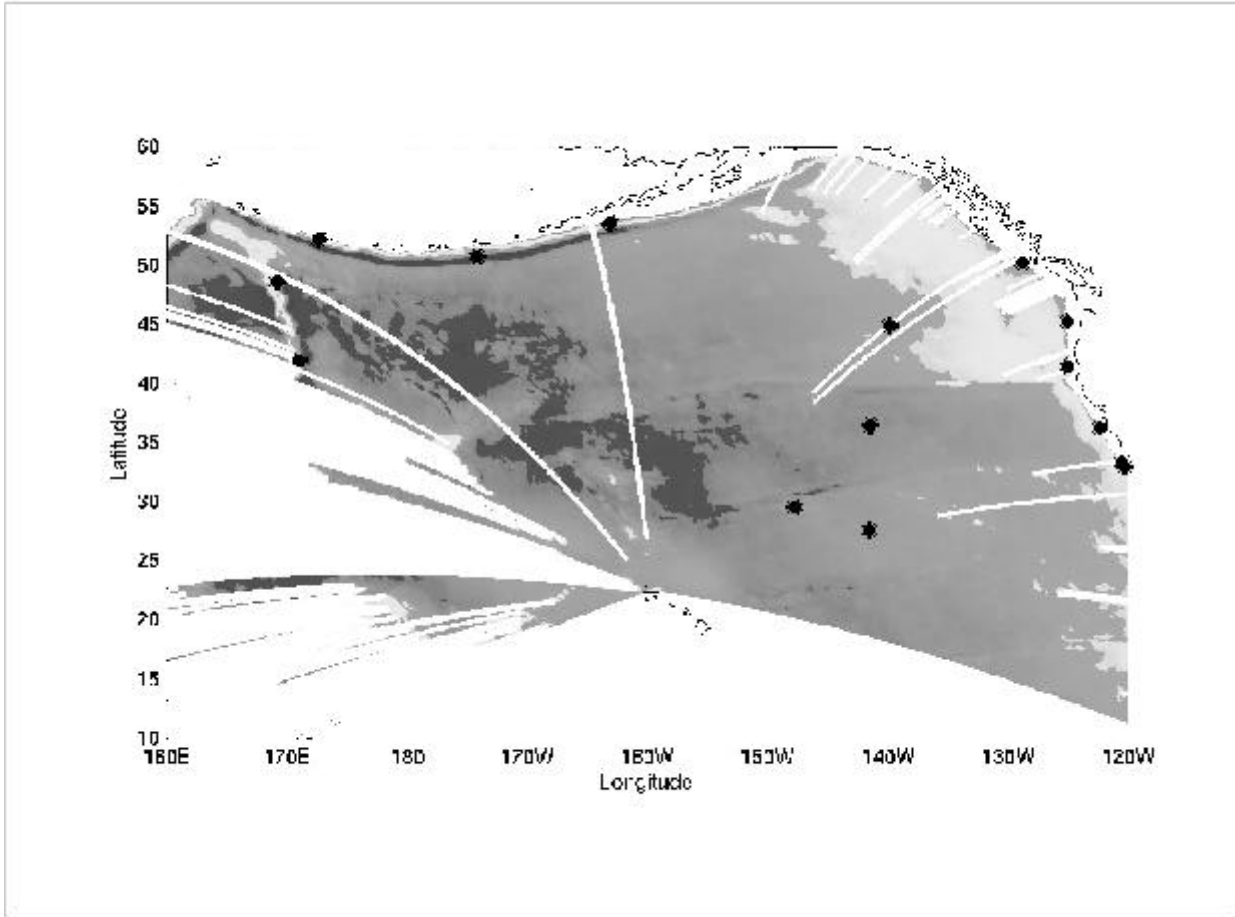


Figure 2. Kauai site shadow plot for bathymetric features 1000m below the sound channel axis (from the Draft Environmental Impact Statement for the North Pacific Acoustic Laboratory, 2000)

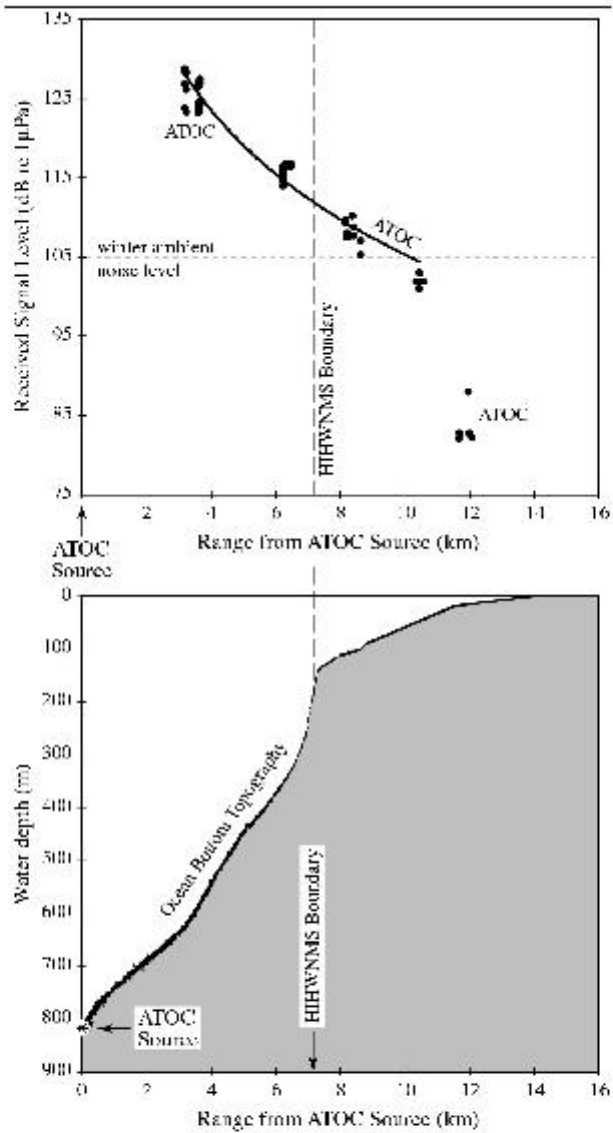


Figure 3. Measured received level as a function of range. The bathymetry underlying the measurements is shown (Frankel and Clark 2000). HIHWNMS refers to the Hawaiian Islands Humpback Whale National Marine Sanctuary

## Species not discussed further in this opinion

The species listed below were also considered in this opinion. Brief explanations for why these species are not discussed further in this opinion are provided below.

Steller sea lion (western population)	<i>Eumetopias jubatus</i>	Endangered
Steller sea lion (eastern population)		Threatened
Chinook salmon (Puget Sound)	<i>Oncorhynchus tshawytscha</i>	Threatened
Chinook salmon (Lower Columbia River)		Threatened
Chinook salmon (Upper Columbia River Spring)		Endangered
Chinook salmon (Upper Willamette River)		Threatened
Chinook salmon (Snake River spring/summer)		Threatened
Chinook salmon (Snake River fall)		Threatened
Sockeye salmon (Snake River)	<i>Oncorhynchus nerka</i>	Endangered
Steelhead (Upper Columbia River)	<i>Oncorhynchus mykiss</i>	Endangered
Steelhead (Middle Columbia River)		Threatened
Steelhead (Lower Columbia River)		Threatened
Steelhead (Upper Willamette River)		Threatened
Steelhead (Snake River Basin)		Threatened
Leatherback sea turtle	<i>Dermochelys coriacea</i>	Endangered
Green sea turtle	<i>Chelonia mydas</i>	Endangered
Hawksbill sea turtle	<i>Eretmochelys imbricata</i>	Endangered
Loggerhead turtle	<i>Caretta caretta</i>	Threatened
Olive ridley turtle	<i>Lepidochelys olivacea</i>	Endangered

Marine habitat of the Steller sea lion (eastern and western populations) and designated critical habitat for this species also occur within the action area, towards the receiving arrays. Sea lions appear to use vocalizations as part of their social behavior and are able to hear well above and below water; however, there are no data on the response of sea lions to low frequency sounds. However, data from studies of the effects of low frequency sounds on elephant seals (*Mirounga* spp.), which are considered more sensitive to low frequency sounds than other pinnipeds (Croll et al. 1999, Kastak 1996, LeBoeuf and Peterson 1969), suggest that elephant seals did not experience short-term changes in behavior in response to low frequency sounds. Based on these data, Steller sea lions probably would not experience behavioral responses to the NPAL transmissions, which would be below ambient levels in their habitat. Further, sea lions generally have shallow dives (Gallo-Reynoso 1994, Reeves et al. 1992), which would protect them from exposure to the transmission. For these reasons, NMFS concludes that the NPAL source is not likely to affect these species or their designated critical habitat.

The evolutionarily significant units of chinook salmon, sockeye salmon, and steelhead listed above also occur within the action area. These anadromous salmon spend portions of their life cycle in freshwater streams, outside of the action area, and a portion in the Pacific Ocean. These species migrate to the Gulf of Alaska and other waters along the edges of the Pacific Ocean. Although salmon have been known to avoid loud, low frequency sounds (see Croll et al. 1999), NPAL signals in the areas occupied by salmon would be weak, at ambient or below-ambient levels. In addition, sound generated by the NPAL source will occur at depths much greater than depths used by salmon rearing in the North Pacific Ocean. The NPAL source will generate sounds 800 meters below the surface while salmon rearing in the ocean use depths less than 100 feet; this vertical separation would prevent salmon from being adversely affected by sounds generated by NPAL source. Any effects from the proposed action to the listed salmon is unlikely to occur. Thus, these species are not likely to be affected.

NMFS determined that several of the species listed above would not likely be adversely affected by the proposed NPAL source transmissions, based on the best scientific and commercial data available. Brief

explanations for this determination are discussed below; these species are also not considered further in this opinion.

The following sea turtles were also initially considered for analyses in this consultation: leatherback turtle, green sea turtle, hawksbill sea turtle, loggerhead turtle, olive ridley sea turtle. Although, these species can hear low frequency sounds, such as the NPAL source, they have an insensitive ear. Specifically, the minimum sound turtles can hear is about 132 dB (Gentry, pers. comm., Ridgway et al. 1960, Barthol et al. 1999). Information on the behavioral response is limited. However, green sea turtles were observed to avoid passing through a sound barrier created by an array of air guns with a broad band spectrum of 20-1,000 Hz; received levels were 141-150 dB (O'Hara and Wilcox 1990). The probability that a sea turtle would be within an ensounded area that would elicit a behavioral response is low because most of the turtles make shallow dives (300 m dive observed for the olive ridley sea turtle). As for the leatherback sea turtles, which can dive to depths of 1000 m, the opportunity for a behavioral response is also considered to be low because 95% of their dives are less than 200 m deep, which would prevent their exposure to the NPAL transmission levels that could elicit a behavioral response. Sea turtles were not observed during the aerial surveys conducted during the research program, and the vicinity of the NPAL source is not known as an important feeding or breeding area for sea turtles. Thus, the sea turtles are not likely to be adversely affected by NPAL source transmissions.

Critical habitat has been designated for the Hawaiian monk seal in the Pacific Ocean. In May 1988, NMFS designated critical habitat for the Hawaiian monk seal out from shore to 20 fathoms in 10 areas of the Northwestern Hawaiian Islands. Critical habitat for these species includes "all beach areas, sand spits and islets, including all beach crest vegetation to its deepest extent inland, lagoon waters, inner reef waters, and ocean waters out to a depth of 20 fathoms around the following: Kure Atoll, Midway Islands, except Sand Island and its harbor, Pearl and Hermes Reef, Lisianski Island, Laysan Island, Maro Reef, Gardner Pinnacles, French Frigate Shoals, Necker Island, and Nihoa Island" (50 CFR 226.201). These areas would not be affected by the proposed action because the NPAL source transmits sounds to propagate in the deep sound channel. Designated critical habitat is not near the NPAL source. Thus, sound levels towards the surface (top 20 fathoms) would not be changed by the NPAL transmissions.

### **Species considered in this opinion**

The following subsections are synopses of the current state of knowledge on the life history, distribution, and population trends of these species and that NMFS expects may be incidentally taken as a result of the proposed action. Information on the acoustic communication, diving behavior, and hearing ability of these species is also included to provide the background for the discussion of the effects of the action. In addition, the Status of the Species and the Environmental Baseline, typically two separate sections in a Biological Opinion, are combined here because the status of the species and the factors affecting them are similar both within the action area and throughout their range in the Pacific Ocean.

#### ***Blue Whale***

##### *Species description and distribution*

Blue whales are the largest living mammal species. They may measure over 30 m in length and weigh up to 160 metric tons (Mackintosh 1942). Like other baleen whales, they have fringed baleen plates instead of teeth, and ventral grooves which filter large quantities of water during feeding. Blue whales are found in all major oceans, including the continental shelf in coastal shelves and far offshore in pelagic environments of the North Pacific (Rice 1974, Donovan 1984).

At least three subspecies of blue whales have been designated, but only one (*B. m. musculus*) occurs in the northern hemisphere. In addition to these subspecies, the International Whaling Commission's (IWC) Scientific Committee has formally recognized one blue whale stock in the North Pacific (Donovan,

1991), although there is increasing evidence that more than one stock occurs in the Pacific Ocean (Gilpatrick et al. 1997, Barlow et al. 1995, Mizroch *et al.* 1984, Ohsumi and Wada 1974). There have been no confirmed sightings or strandings of blue whales in the Hawaiian Islands area, but recordings of vocalizations (Thompson and Friedl, 1982) suggest that blue whales are present within the U.S. Exclusive Economic Zone (U.S. EEZ) around Hawaii. The recordings showed peaks in summer and winter. Blue whale calls have also been recorded in Alaskan waters from 1995 to 1999 in every season although the whales have not been seen. Most of these calls occurred in fall and winter in the Gulf of Alaska suggesting that some blue whales remain in the area (as opposed to migrating through it).

#### *Life history information*

Blue whale reproductive activities occur primarily in winter (see Yochem and Leatherwood 1985). Gestation takes 10-12 months, followed by a nursing period that continues for about 6-7 months. They reach sexual maturity at about 5 years of age (see Yochem and Leatherwood 1985). The age distribution of blue whales is unknown and little information exists on natural sources of mortality (such as disease) and mortality rates. Killer whales are known to attack blue whales, but the rate of these attacks or their effect on blue whale populations is unknown.

Important foraging areas include the edges of continental shelves and ice edges in polar regions (Yochem and Leatherwood, 1985; Reilly and Thayer, 1990). Data indicate that some summer feeding takes place at low latitudes in "upwelling-modified" waters (Reilly and Thayer, 1990), and that some whales remain year-round at either low or high latitudes (Yochem and Leatherwood, 1985; Clark and Charif, 1998). The euphausiid species *Thysanoëssa inermis*, *Thysanoëssa longipes*, *Thysanoëssa raschi*, and *Nematoscelis megalops* have been listed as prey of blue whales in the North Pacific (Kawamura 1980; Yochem and Leatherwood 1985). Although some stomachs of blue whales have been found to contain a mixture of euphausiids and copepods or amphipods (Nemoto 1957; Nemoto and Kawamura 1977), it is likely that the copepods and amphipods were consumed adventitiously or incidentally. Reports that blue whales feed on small, schooling fish and squid in the western Pacific (Mizue 1951; Sleptsov 1955) have been interpreted as suggesting that the zooplankton blue whales prefer are less available there (Nemoto 1957). Other baleen whales whose range overlaps with the range of blue whales could potentially compete with blue whales for food (Nemoto 1970). However, there is no evidence of competition and the highly migratory behavior of blue whales may help them avoid competition with other baleen whales (Clapham and Brownell 1996).

#### *Diving and social behavior*

Generally, blue whales make 5-20 shallow dives at 12-20 second intervals followed by a deep dive of 3-30 minutes (Mackintosh, 1965; Leatherwood et al. 1976; Maser et al. 1981; Yochem and Leatherwood, 1985; Strong 1990; Croll et al. 1999). Croll et al. (1999) found that the dive depths of blue whales foraging off the coast of California during the day averaged 132 m with a maximum recorded depth of 204 m and a mean dive duration of 7.2 minutes. Nighttime dives are generally less than 50 m in depth (Croll et al. 1999).

Blue whales are usually found swimming alone or in groups of two or three (Ruud 1956; Slijper 1962; Nemoto 1964; Mackintosh 1965; Pike and MacAskie 1969; Aguayo 1974). However, larger foraging aggregations and aggregations mixed with other rorquals such as fin whales are regularly reported (Schoenherr 1991; Fiedler et al. 1998; Croll and Tershy pers. obs.). Little is known of the mating behavior of blue whales.

#### *Vocalizations and hearing*

Known vocalizations of blue whales include a variety of sounds described as low frequency moans or long pulses (Cummings and Thompson 1971, 1977; Edds 1982, Thompson and Friedl 1982; Edds-Walton

1997). Blue whales produce a variety of low frequency sounds in the 10-100 Hz band (Cummings and Thompson 1971; Edds 1982; Thompson and Friedl 1982; McDonald et al. 1995; Clark and Fristrup 1997; Rivers 1997; Ljungblad et al. in press). The most typical signals are very long, patterned sequences of tonal infrasonic sounds in the 15-40 Hz range. The sounds last several tens of seconds. Estimated source levels are as high as 180-190 dB (Cummings and Thompson 1971). Ketten (1997) reports the frequencies of maximum energy between 12 and 18 Hz. In temperate waters, intense bouts of long patterned sounds are very common from fall through spring, but these also occur to a lesser extent during the summer in high latitude feeding areas. Short sequences of rapid calls in the 30-90 Hz band are associated with animals in social groups (see Croll et al. 1999). The seasonality and structure of long patterned sounds suggest that these sounds are male displays for attracting females and/or competing with other males. The context for the 30-90 Hz calls suggests that they are communicative but not related to a reproductive function. Vocalizations attributed to blue whales have been recorded in presumed foraging areas, along migration routes, and during the presumed breeding season (Beamish and Mitchell 1971; Cummings and Thompson 1971, 1977, 1994; Cummings and Fish 1972; Thompson et al. 1996; Rivers 1997; Tyack 1997; Clark et al. 1998).

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, 1971). A short, 390 Hz pulse also is produced during the moan. One estimate of the overall source level was as high as 188 dB, with most energy in the 1/3-octave bands centered at 20, 25, and 31.5 Hz, and also included secondary components estimates near 50 and 63 Hz (Cummings and Thompson, 1971).

The function of vocalizations produced by blue whales is unknown. Hypothesized functions include: 1) maintenance of inter-individual distance, 2) species and individual recognition, 3) contextual information transmission (e.g., feeding, alarm, courtship), 4) maintenance of social organization (e.g., contact calls between females and offspring), 5) location of topographic features, and 6) location of prey resources (review by Thompson et al. 1979). Responses to conspecific sounds have been demonstrated in a number of mysticetes, and there is no reason to believe that blue whales do not communicate similarly (Edds-Walton 1997). The low-frequency sounds produced by blue whales can, in theory, travel long distances, and it is possible that such long-distance communication occurs (Payne and Webb 1971; Edds-Walton 1997). The long-range sounds may also be used for echolocation in orientation or navigation (Tyack 1999).

Cetaceans have an auditory anatomy that follows the basic mammalian pattern, with some modifications to adapt to the demands of hearing in the sea. The typical mammalian ear is divided into the outer ear, middle ear, and inner ear. The outer ear is separated from the inner ear by the tympanic membrane, or eardrum. In terrestrial mammals, the outer ear, eardrum, and middle ear function to transmit airborne sound to the inner ear, where the sound is detected in a fluid. Since cetaceans already live in a fluid medium, they do not require this matching, and thus do not have an air-filled external ear canal. The inner ear is where sound energy is converted into neural signals that are transmitted to the central nervous system via the auditory nerve. Acoustic energy causes the basilar membrane in the cochlea to vibrate. Sensory cells at different positions along the basilar membrane are excited by different frequencies of sound (Tyack 1999). Baleen whales have inner ears that appear to be specialized for low-frequency hearing.

In a study of the morphology of the blue whale auditory apparatus, Ketten (1997) hypothesized that blue whales have acute infrasonic hearing. No studies have directly measured the sound sensitivity of blue whales.

#### *Listing status*

Blue whales have been listed as endangered under the ESA since 1973. They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the Marine

Mammal Protection Act of 1972. The North Pacific stock is also listed as “low risk, conservation dependent” under the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). Critical habitat has not been designated for blue whales.

#### *Population status and trends*

There are no reliable estimates of blue whale abundance in the North Pacific Ocean. Nevertheless, Gambell (1976) estimated there were about 4,900 blue whales in the North Pacific before whaling began. Wade and Gerrodette (1993) and Barlow et al. (1997) estimated there were a minimum of 3,300 blue whales in the North Pacific Ocean in the 1990s.

#### *Impacts of human activity on the species*

From 1889 to 1965 approximately 5,761 blue whales were taken from the North Pacific Ocean (NMFS 1998). Evidence of a population decline can be seen in the catch data from Japan. In 1912, 236 blue whales were caught, in 1913, 58 whales, in 1914, 123 whales, and from 1915 to 1965, the catch numbers declined continuously (Mizroch et al. 1984). In the eastern North Pacific, 239 blue whales were taken off the California coast in 1926. And, in the late 1950s and early 1960s, Japan caught 70 blue whales per year off the Aleutian Islands (Mizroch et al. 1984). The IWC banned commercial whaling in the North Pacific in 1966, since that time there have been no reported blue whale takes. Nevertheless, Soviet whaling probably continued after the ban so Soviet catch reports under-represent the number of blue whales killed by whalers (as cited in Forney and Brownell 1996). Surveys conducted in these former whaling areas in the 1980s and 1990s failed to find any blue whales (Forney and Brownell 1996). There are no reports of fisheries-related mortality or serious injury in any of the blue whale stocks. Blue whale interaction with fisheries may go undetected because the whales are not observed after they swim away with a portion of the net. However, fishers report that large blue and fin whales usually swim through their nets without entangling and with very little damage to the net (Barlow et al. 1997).

In 1980, 1986, 1987, and 1993, ship strikes have been implicated in the deaths of blue whales off California (Barlow et al. 1997). In addition, several photo-identified blue whales from California waters were observed with large scars on their dorsal areas that may have been caused by ship strikes. Studies have shown that blue whales respond to approaching ships in a variety of ways, depending on the behavior of the animals at the time of approach, and speed and direction of the approaching vessel. While feeding, blue whales react less rapidly and with less obvious avoidance behavior than whales that are not feeding (Sears et al. 1983). Within the St. Lawrence Estuary, blue whales are believed to be affected by large amounts of recreational and commercial vessel traffic. Blue whales in the St. Lawrence appeared more likely to react to these vessels when boats made fast, erratic approaches or sudden changes in direction or speed (Edds and Macfarlane 1987, Macfarlane 1981). The number of blue whales struck and killed by ships is unknown because the whales do not always strand or examinations of blue whales that have stranded did not identify the traumas that could have been caused by ship collisions. In the California/Mexico stock, annual incidental mortality due to ship strikes averaged 0.2 whales during 1991-1995 (Barlow et al. 1997), but we cannot determine if this reflects the actual number of blue whales struck and killed by ships. Blue whales do not appear to be disturbed by noise from seismic exploration. When noise pulses from air guns were produced off Oregon, blue whales continued vocalizing at the same rate as before the pulses, suggesting that at least their vocalization behavior was undisturbed by the noise (McDonald *et al.* 1993).

### ***Fin Whale***

#### *Species description and distribution*

Fin whales are distributed widely in the world's oceans. In the northern hemisphere, most migrate seasonally from high Arctic feeding areas in summer to low latitude breeding and calving areas in winter.

Other groups may remain year-round in a particular area, depending on food supply. The IWC's Scientific Committee recognizes two management stocks in the North Pacific: (1) the east China Sea, and (2) the rest of the North Pacific (Donovan, 1991). Mizroch et al. (1984a) suggested five possible stocks within the North Pacific based on histological and tagging experiments (1) east and west Pacific that intermingle around the Aleutian Islands; (2) east China Sea; (3) British Columbia; (4) southern/central California to the Gulf of Alaska; and (5) Gulf of California (Rice 1974, Tershy et al. 1993). However, NMFS considers stock structure in the North Pacific to be equivocal, and recognizes three stocks: (1) Alaska (northeast Pacific), (2) California/Oregon/ Washington, and (3) Hawaii (Barlow et al. 1997, Hill and DeMaster 1998).

Fin whales were reported as occurring immediately offshore throughout the North Pacific from central Baja California to Japan and as far north as the Chukchi Sea (Rice 1974). Data indicate that some whales remain year-round at high latitudes (Clark and Charif, 1998) and other areas such as the Gulf of California (J. Urban, UABCS, La Paz, BCS. Mexico, pers. comm.), migrating only short distances of 100-200 km (53.9-107.9 nm) (Agler et al. 1993). In the Gulf of Alaska, fin whales appear to congregate in the waters around Kodiak Island and south of Prince William Sound. In recent years, small numbers of fin whales have been observed south of the Aleutian Islands (Forney and Brownell 1996), in the Gulf of Alaska (including Shelikof Strait), and in the southeastern Bering Sea (Leatherwood et al. 1986). Fin whale concentrations in the northern areas of the North Pacific and Bering Sea generally form along frontal boundaries, or mixing zones between coastal and oceanic waters, which themselves correspond roughly to the 200-m isobath (which is the shelf edge; Nasu 1974).

Acoustic data collected from 1995 to 1999 from hydrophone arrays showed fin whales vocalizing in Alaskan waters during all seasons, with a peak in occurrence in midwinter. Fin whales are rare in Hawaiian waters, but may occur within 200 nm (370 km) of Hawaii during winter months, when some of the fin whales disperse throughout the lowest latitudes of their distribution (Balcomb 1987). Acoustic recordings (Thompson and Friedl 1982) suggest that fin whales migrate into Hawaiian waters (the U.S. EEZ surrounding the Hawaiian Archipelago) primarily during the fall and winter. More recently, McDonald and Fox (1999) reported an average of 0.027 calling fin whales per 1000 km<sup>2</sup> (grouped in 8 hour periods) based on passive acoustic recording within about 16 km of the north shore of Oahu. A single fin whale sighting occurred approximately 37 km (20 nm) north of Kauai in 1994 (Mobley et al. 1996). Two confirmed sightings and one stranding comprise the records for fin whales in this region (not including whaling records) (Nitta 1987).

#### *Life history information*

Fin whales become sexually mature between six to ten years of age, depending on density-dependent factors (Gambell 1985). Reproductive activities for fin whales occur primarily in the winter. Gestation lasts about 12 months and nursing occurs for 6-11 months (Perry et al. 1999). The age distribution of fin whales in the North Pacific is unknown. Calving and mating occur in late fall and winter (Millais 1906; Mackintosh and Wheeler 1929; Nishiwaki 1952; Tomilin 1957). Specific breeding areas are unknown and mating is assumed to occur in pelagic waters, presumably some time during the winter when whales are in mid-latitudes. Fin whales commonly travel in herds ranging from between 6-12 individuals, to nearly 100 or more (Balcomb 1987).

Foraging areas tend to occur along continental shelves with productive upwellings or thermal fronts (Gaskin 1972; Sergeant 1977; Nature Conservancy Council 1979). Fin whales tend to avoid tropical and pack ice waters (Meredith and Campbell 1988), with the northern limit set by ice and the southern limit by warm water of approximately 15°C (60°F) (Sergeant 1977). Fin whales in the North Pacific feed on euphausiids, calanoid copepods, and schooling fish such as herring, pollock, Atka mackerel, and capelin (Calkins 1986; Nemoto 1957, 1970; Kawamura 1982). Euphausiids may be preferred prey, and competition may occur with other baleen whales or other consumers of these prey types. Natural sources and rates of mortality are largely unknown, but Aguilar and Lockyer (1987) suggest annual natural

mortality rates may range between 0.04 and 0.06 (based on studies of northeast Atlantic fin whales). The occurrence of the nematode, *Crassicauda boopis*, appears to increase the potential for kidney failure in fin whales and may be preventing some fin whale stocks from recovering from whaling (Lambertsen 1992, as cited in Perry et al. 1999). Killer whale or shark attacks may result in serious injury or death in very young and sick whales (Perry et al. 1999). NMFS has no records of fin whales being killed or injured by commercial fisheries operating in the North Pacific (Ferrero et al. 2000).

#### *Diving and social behavior*

Generally, fin whales make 5-20 shallow dives 13-20 seconds in duration followed by a deep dive of 1.5 to 15 minutes (Gambell 1985; Strong 1990; Croll and Tershy 1999). Croll and Tershy (1999) recorded dive depths of 100-200 m, with maximum depths of 300 m. Dive depths and duration were significantly shorter at night than during the day, presumably in response to the daily vertical migrations of prey schools. An estimate of dive depth based on the acoustical properties of received fin whale calls was 525 m (Charif et al. submitted).

Fin whales are often found singly or in pairs, but also commonly form larger groupings greater than 3 individuals, particularly while feeding. Tershy et al. (1993) described group foraging behavior where 2-4 animals swam less than 50m apart in an echelon formation and lunged synchronously, right side down. They found that group composition was not stable: membership and group size changed frequently during feeding events.

#### *Vocalizations and hearing*

Underwater sounds of the fin whale are one of the most studied *Balaenoptera* sounds. Fin whales produce a variety of low-frequency sounds in the 10-200 Hz band (Watkins 1981; Watkins et al. 1987a; Edds 1988; Thompson et al. 1992). The most typical signals are long, patterned sequences of short duration (0.5-2s) infrasonic pulses in the 18-35 Hz range (Patterson and Hamilton 1964). Estimated source levels are as high as 190 dB (Patterson and Hamilton 1964; Watkins et al. 1987a; Thompson et al. 1992; McDonald et al. 1995). In temperate waters intense bouts of long patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clark and Charif 1998). Short sequences of rapid pulses in the 20-70 Hz band are associated with animals in social groups (McDonald et al. 1995; Clark pers. comm.; McDonald pers. comm.). Each pulse lasts on the order of one second and contains twenty cycles (Tyack 1999).

Particularly in the breeding season, fin whales produce series of pulses in a regularly repeating pattern. These bouts of pulsing may last for longer than one day (Tyack 1999). The seasonality and stereotypy of the bouts of patterned sounds suggest that these sounds are male reproductive displays (Watkins et al. 1987a), while the individual counter-calling data of McDonald et al. (1995) suggest that the more variable calls are contact calls. Some authors feel there is geographic differences in the frequency, duration and repetition of the pulses (Thompson et al. 1992). As with other mysticete sounds, the function of vocalizations produced by fin whales is unknown. Hypothesized functions are the same as for the blue whale. Responses to conspecific sounds have been demonstrated in a number of mysticetes, and there is no reason to believe that fin whales do not communicate similarly (Edds-Walton 1997). The low-frequency sounds produced by fin whales have the potential to travel over long distances, and it is possible that long-distance communication occurs in fin whales (Payne and Webb 1971; Edds-Walton 1997). Also, there is speculation that the sounds may function for long-range echolocation of large-scale geographic targets such as seamounts, which might be used for orientation and navigation (Tyack 1999).

A description of the anatomy of the ear for cetaceans is provided in the description of the blue whale above. No studies have directly measured the sound sensitivity of fin whales. Presumably fin whales are able to receive sound signals of the same frequency they are producing. In a study of the morphology of

the mysticete auditory apparatus, Ketten (1997) hypothesized that large mysticetes have acute infrasonic hearing.

### *Listing status*

In the North Pacific, the IWC began management of commercial whaling for fin whales in 1969; fin whales were fully protected from commercial whaling in 1976 (Allen 1980). Fin whales were listed as endangered under the ESA. They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the Marine Mammal Protection Act of 1972. Fin whales are listed as endangered on the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). Critical habitat has not been designated for fin whales.

### *Population status and trends*

Prior to exploitation by whaling vessels, the North Pacific population consisted of an estimated 42,000-45,000 fin whales (Ohsumi and Wada 1974). Between 1914 and 1975, over 26,040 fin whales were harvested throughout the North Pacific ( in Perry et al. 1999). Catches in the North Pacific and Bering Sea ranged from 1,000 to 1,500 fin whales annually during the 1950's and 1960's. However, not all Soviet catches were reported (cited in Ferrero et al. 2000). In the early 1970s, the entire North Pacific population had been reduced to between 13,620 and 18,630 fin whales (Ohsumi and Wada 1974). During the early 1970s, 8,520-10,970 fin whales were surveyed in the eastern half of the North Pacific (Braham 1991). If these historic estimates are statistically reliable, the population size of fin whales has not increased significantly over the past 20 years despite an international ban on whaling in the North Pacific. The current status and trend of the fin whale population in the North Pacific is largely unknown. Based on the available information, it is feasible that the North Pacific population as a whole has failed to increase significantly over the past 20 years, despite an international ban on whaling in the North Pacific. The only contrary evidence comes from investigators conducting seabird surveys around the Pribilof Islands in 1975-1978 and 1987-1989. These investigators observed more fin whales in the second survey and suggested they were more abundant in the survey area (Baretta and Hunt 1994). A survey for whales in the central Bering Sea in 1999 tentatively estimated the fin whale population was about 4,951 animals (95% C.I.: 2,833-8,653).

### *Impacts of human activity on this species*

As early as the mid-seventeenth century, the Japanese were capturing fin, blue, and other large whales using a fairly primitive open-water netting technique (Tønnessen and Johnsen 1982, Cherfas 1989). In 1864, explosive harpoons and steam-powered catcher boats were introduced in Norway, allowing the large-scale exploitation of previously unobtainable whale species. The North Pacific and Antarctic whaling operations soon added this “modern” equipment to their arsenal. After blue whales were depleted in most areas, the smaller fin whale became the focus of whaling operations and more than 700,000 fin whales were landed in the twentieth century. In the North Pacific, there are no reports of fin whale deaths caused by fishery-related activities (Hill et al. 1997), although conflicts between fin whales and drift gillnet fisheries may occur (Barlow et al. 1997). Because of their size, strength, and distribution, it would probably be difficult to assess potential interactions between fin whales and fisheries; for example, fishermen have reported that large blue and fin whales usually swim through their nets without entangling and with very little damage to the net (Barlow et al. 1997). It is possible that ship strikes affect all fin whale stocks but go unreported because injured or killed animals do not strand. In the North Pacific, one death due to ship collision was reported in 1991 (Barlow et al. 1997).

## ***Humpback Whale***

### *Species description and distribution*

NMFS recognizes four stocks of humpback whales in the North Pacific basin, based on genetic and photo-identification studies: two Eastern North Pacific stocks, one Central North Pacific stock and one Western Pacific stock (Hill and DeMaster 1998).

Humpback whales typically migrate between tropical/sub-tropical and temperate/polar latitudes. Humpback whales feed on krill and small schooling fish on their summer grounds. The whales occupy tropical areas during winter months when they are breeding and calving, and polar areas during the spring, summer, and fall, when they are feeding, primarily on small schooling fish and krill (Caldwell and Caldwell 1983). It is believed that minimal feeding occurs in wintering grounds, such as the Hawaiian Islands (Balcomb 1987; Salden 1987). Humpback whales summer throughout the central and western portions of the Gulf of Alaska, including Prince William Sound, around Kodiak Island (including Shelikof Strait and the Barren Islands), and along the southern coastline of the Alaska Peninsula. The continental shelf of the Aleutian Islands and Alaska Peninsula were once considered the center of the North Pacific humpback whale population (Berzin and Rovnin 1966; Nishiwaki 1966). The northern Bering Sea, Bering Strait, and the southern Chukchi Sea along the Chukchi Peninsula appear to form the northern extreme of the humpback whale's range (Nikulin 1946, Berzin and Rovnin 1966).

Humpback whales occur off all eight Hawaiian Islands, but particularly within the shallow waters of the "four-island" region (Kaho'olawe, Molokai, Lanai, Maui), the northwestern coast of the Big Island, and the waters around Niihau, Kauai and Oahu (Wolman and Jurasz 1977; Herman et al. 1980; Baker and Herman, 1981). The largest concentrations of humpbacks in Hawaiian waters can be found on Penguin Bank west of Molokai (Balcomb 1987). The whales are generally found in shallow water shoreward of the 182 m depth contour (Herman and Antinaja 1977), although Frankel et al. (1989) reported some vocalizing individuals up to 20 km (10.8 nm) off South Kohala on the west coast of the Big Island, over bottom depths of 1400 m. Cow/calf pairs appear to prefer very shallow water less than 18 m (10 fm) (Glockner and Venus 1983). At Kuili off the Big Island, Smultea (1989) found significantly more cow/calf pairs in water <55 m deep. Some results suggest that habitat use patterns of nearshore waters by females and calves near Maui may have changed (decreased), potentially due to increasing vessel and other human activities (Salden 1988; Glockner-Ferrari and Ferrari 1990).

### *Life history information*

Humpback whale reproductive activities occur primarily in winter. They become sexually mature at age four to six. Annual pregnancy rates have been estimated at about 0.40-0.42 (NMFS unpublished and Nishiwaki 1959) and female humpback whales are believed to become pregnant every two to three years. Cows will nurse their calves for up to 12 months. The age distribution of the humpback whale population is unknown, but the portion of calves in various populations has been estimated at about 4-12% (Chittleborough 1965, Whitehead 1982, Bauer 1986, Herman et al. 1980, and Clapham and Mayo 1987). The information available does not identify natural causes of death among humpback whales or their number and frequency over time, but potential causes of natural mortality are believed to include parasites, disease, predation (killer whales, false killer whales, and sharks), biotoxins, and entrapment in ice. Humpback whales exhibit a wide range of foraging behaviors, and feed on a range of prey types including small schooling fishes, euphausiids, and other large zooplankton. Fish prey in the North Pacific include herring, anchovy, capelin, pollock, Atka mackerel, eulachon, sand lance, pollack, Pacific cod, saffron cod, arctic cod, juvenile salmon, and rockfish. In the waters west of the Attu Islands and south of Amchitka Island, Atka mackerel were preferred prey of humpback whales (Nemoto 1957). Invertebrate prey include euphausiids, mysids, amphipods, shrimps, and copepods.

### *Diving and social behavior*

In Hawaiian waters, their distribution is almost exclusively within the 1820 m isobath and usually within 182 m. Maximum diving depths for humpbacks are approximately 150 m (but usually <60 m), with a very deep dive (240 m) recorded off Bermuda (Hamilton et al. 1997). They may remain submerged for up to 21 minutes (Dolphin, 1987). Dives on feeding grounds ranged from 2.1 - 5.1 minutes in the north Atlantic (Goodyear unpubl. manus.). In southeast Alaska average dive times were 2.8 minutes for feeding whales, 3.0 minutes for non feeding whales, and 4.3 for resting whales (Dolphin 1987). In the Gulf of California humpback whale dive times averaged 3.5 minutes (Strong 1989). Because most humpback prey is likely found above 300 m most humpback dives are probably relatively shallow.

Humpback social behavior is reviewed by Clapham (1996). They form small unstable groups during the breeding season. During the feeding season they form small groups that occasionally aggregate on concentrations of food. Feeding groups are sometimes stable for long periods of times. There is good evidence of some territoriality on feeding grounds (Clapham 1994, 1996), and on wintering ground (Tyack 1981). On the breeding grounds males sing long complex songs directed towards females, other males or both. The breeding season can best be described as a floating lek or male dominance polygyny (Clapham 1996). Intermale competition for proximity to females can be intense as expected by the sex ratio on the breeding grounds may be as high as 2.4:1.

### *Vocalizations and hearing*

Humpbacks produce a great variety of sounds. During the breeding season males sing long complex songs, with frequencies in the 25-5000 Hz range and intensities as high as 181 dB (Payne 1970; Winn et al. 1970; Thompson et al. 1986). 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 six to 12 mi (10 to 20 km). Animals in mating groups produce a variety of sounds (Tyack 1981; Tyack and Whitehead 1983, Silber 1986). Sounds are produced less frequently on the summer feeding grounds. Feeding groups produce distinctive sounds ranging from 20 Hz to 2 kHz, with median durations of 0.2-0.8 sec and source levels of 175-192 dB (Thompson et al. 1986). These sounds are attractive and appear to rally animals to the feeding activity (D'Vincent et al. 1985; Sharpe and Dill 1997). In summary, humpback whales produce at least three kinds of sounds: 1) complex songs with components ranging from at least 20Hz - 4 kHz with estimated source levels from 144 - 174 dB; these are mostly sung by males on the breeding grounds (Payne 1970; Winn et al. 1970; Richardson et al. 1995), 2) social sounds in the breeding areas that extend from 50Hz to more than 10 kHz with most energy below 3kHz (Tyack and Whitehead 1983, Richardson et al. 1995), and 3) feeding area vocalizations that are less frequent, but tend to be 20Hz - 2 kHz with estimated sources levels in excess of 175 dB (Thompson et al. 1986; Richardson et al. 1995). Sounds often associated with possible aggressive behavior by males (Tyack and Whitehead 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).

A description of the anatomy of the ear for cetaceans is provided in the description of the blue whale above. Humpback whales respond to low frequency sound. Humpback whales have been known to react to low frequency industrial noises at estimated received levels of 115 - 124 dB (Malme et al. 1985), and to conspecific calls at received levels as low as 102dB (Frankel et al. 1995).

### *Listing status*

The IWC first protected humpback whales in the North Pacific in 1965. Humpback whales were listed as endangered under the ESA in 1973. They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the Marine Mammal Protection Act of 1972. Critical habitat has not been designated for the species.

### *Population status and trends*

An estimated 394 humpback whales constitute the western North Pacific stock (Calambokidis et al. 1997). Waite et al. (1999) identified 127 individual humpback whales in the Kodiak Island region between 1991 and 1994 and estimated there were 651 whales in this region (95% CI:356-1,523). Waite et al. (1999) also estimated that 200 humpback whales regularly feed in Prince William Sound. Subsequently, based on mark-recapture analysis of photo-identification studies, several investigators concluded that the central North Pacific stock consists of at least 4,000 humpback whales (Calambokidis et al. 1997, Ferrero et al. 2000). Other than these estimates of the size of the humpback whale population, the available information is not sufficient to determine population trends.

Estimates of the number of individuals in the Northern Pacific stock have recently risen. Estimates in the 1980's ranged from 1407 to 2,100 (Baker, 1985; Darling and Morowitz, 1986; Baker and Herman, 1987), while recent estimates of abundances were approximately 6,000 in the North Pacific (Calambokidis et al. 1997; Cerchio 1998; Mobley et al. 1999b).

Cerchio (1998) estimated that about 4,000 animals visit Hawaii annually. Aerial surveys using line-transect methodologies were conducted in 1993, 1995 and 1998. Hawaii population estimates derived from the sighting data show an increase from 2717 (+/- 608) in 1993, to 3284 (+/- 646) in 1995 and 3852 (+/- 777) in 1998 (Mobley et al. 1999b). The high numbers observed in 1998 can be attributed to better sighting conditions in 1998 than in the previous years.

### *Impacts of human activity on the species*

In the 1990s, no more than 3 humpback whales were killed annually in U.S. waters by commercial fishing operations in the Atlantic and Pacific Oceans. Between 1990 and 1997, no humpback whale deaths have been attributed to interactions with groundfish trawl, longline and pot fisheries in water around Alaska (Hill and DeMaster 1999). Humpback whales have been injured or killed elsewhere along the mainland U.S. and Hawaii (Barlow et al. 1997). In 1991, a humpback whale was observed entangled in longline gear and released alive (Hill et al. 1997). In 1995, a humpback whale in Maui waters was found trailing numerous lines (not fishery-related) and entangled in mooring lines. The whale was successfully released, but subsequently stranded and was attacked and killed by tiger sharks in the surf zone. In 1996, a humpback whale calf was found stranded on Oahu with evidence of vessel collision (propeller cuts; NMFS unpub. data). Also in 1996, a vessel from Pacific Missile Range Facility in Hawaii rescued an entangled humpback, removing two crabpot floats from the whale; the gear was traced to a recreational fisherman in southeast Alaska. No information is available on the number of humpback whales that have been killed or seriously injured by interactions with fishing fleets outside of U.S. waters in the North Pacific Ocean.

Humpback whales seem to respond to moving sound sources, such as whale-watching vessels, fishing vessels, recreational vessels, and low-flying aircraft (Beach and Weinrich 1989, Clapham et al. 1993, Atkins and Swartz 1989). Their responses to noise are variable and have been correlated with the size, composition, and behavior of the whales when the noises occurred (Herman et al. 1980, Watkins et al. 1981, Krieger and Wing 1986). Several investigators have suggested that noise may have caused humpback whales to avoid or leave feeding or nursery areas (Jurasz and Jurasz 1979, Dean et al. 1985), while others have suggested that humpback whales may become habituated to vessel traffic and its associated noise. Still other researchers suggest that humpback whales may become more vulnerable to vessel strikes once they habituate to vessel traffic (Swingle et al. 1993; Wiley et al. 1995). In Hawaii, regulations prohibit boats from approaching within 91 m of adult whales and within 274 m in areas protected for mothers with a calf. Likewise, in Alaska, the number of cruise ships entering Glacier Bay has been limited to reduce possible disturbance.

Many humpback whales are killed by ship strikes along both coasts of the U.S. On the Pacific coast, a humpback whale is killed about every other year by ship strikes (Barlow et al. 1997). On the Atlantic coast, 6 out of 20 humpback whales stranded along the mid-Atlantic coast showed signs of major ship strike injuries (Wiley et al. 1995). Almost no information is available on the number of humpback whales killed or seriously injured by ship strikes outside of U.S. waters.

## ***Right Whale***

### *Species description and distribution*

Right whales have occurred historically in all the world's oceans from temperate to subarctic latitudes. The IWC currently recognizes two species of northern right whales: *Eubalaena glacialis* in the North Atlantic and *E. japonica* in the North Pacific. However, right whales in the North Atlantic, North Pacific, and the southern hemisphere of both oceans are currently listed under the ESA as one species: right whales (which includes *E. glacialis*, *E. japonica*, and *E. australis*). For the purposes of ESA Section 7(a)(2) consultations, NMFS recognizes three major populations of right whales: North Pacific, North Atlantic, and Southern Hemisphere.

Very little is known of the size and distribution of right whales in the North Pacific and very few of these animals have been seen in the past 20 years. In 1996, a group of 3 or 4 right whales (which may have included a calf) were observed in the middle shelf of the Bering Sea, west of Bristol Bay and east of the Pribilof Islands (Goddard and Rugh 1998). In June 1998, a lone whale was observed on historic whaling grounds near Albatross Bank off Kodiak Island, Alaska (Waite and Hobbs 1999). Surveys conducted in July of 1997 - 2000 in Bristol Bay reported observations of lone animals or small groups of right whales in the same area as the 1996 sighting (Hill and DeMaster 1998, Perry et al. 1999). Historical whaling records (Maury 1852, Townsend 1935, Scarff 1986) indicate the right whale ranged across the North Pacific above 35°N lat. They summered in the North Pacific Ocean and southern Bering Sea from April or May to September, with a peak in sightings in coastal waters of Alaska in June and July (Maury 1852, Townsend 1935, Omura 1958, Klumov 1962, Omura et al. 1969). Their summer range extended north of the Bering Strait (Omura et al. 1969). However, they were particularly abundant in the Gulf of Alaska from 145° to 151°W (Berzin and Rovnin 1966), and apparently concentrated in the Gulf of Alaska, especially south of Kodiak Islands and in the Eastern Aleutian Islands and southern Bering Sea shelf waters (Braham and Rice, 1984).

The winter distribution patterns of right whales in the Pacific are virtually unknown, although some right whales have been sighted as far south as 27°N in the eastern North Pacific. They have also been sighted in Hawaii (Herman et al. 1980), California (Scarff 1986), Washington and British Columbia. Their migration patterns are unknown, but are believed to include north-south movements between summer and winter feeding areas. The scarcity of right whales is the result of an 800-year history of whaling that continued into the 1960s (Klumov 1962). Of all of the large whales, right whales are believed to have the highest risk of extinction in the foreseeable future. Recent data suggest an estimated population of 300 in the North Atlantic and a small, unknown number of individuals in the North Pacific. The southern right whale, in contrast, has shown signs of a slow recovery over the past 20 years.

### *Life history information*

In both northern and southern hemispheres, right whales have been observed in the lower latitudes and more coastal waters during winter, and then tend to migrate to higher latitudes during the summer. Calving may occur in winter months when their distribution is more coastal, but the lack of sighting information suggests that calving may occur farther offshore. In summer and fall in both hemispheres, the distribution of right whales appears linked to the distribution of their principal zooplankton prey (Winn et al. 1986). Essentially no information is available on the calving grounds or feeding habits of right whales in the North Pacific. Right whales in the North Pacific are known to prey on a variety of zooplankton

species including *Calanus plumchrus*, *C. cristatus*, *Euphausia pacifica*, *Metridia* spp., and copepods of the genus *Neocalanus*. This is similar to the feeding habits of right whales in the Gulf of Maine, which feed on zooplankton (primarily copepods) (see NMFS 1991b, Murison and Gaskin 1989). Right whales may compete with sympatric sei whales and many other predators or consumers of zooplankton in the eastern North Pacific and Bering Sea. Killer whales are suspected as possible predators, but no data from the North Pacific support this speculation (Scarff 1986).

#### *Diving and social behavior*

Northern right whales dive as deep as 306 m (Mate et al 1992). In the Great South Channel, average diving time is close to two minutes; average dive depth is 7.3 m with a maximum of 85.3 m (Winn et al. 1994). In the U.S. Outer Continental Shelf the average diving time is about 7 minutes (CETAP 1982).

Northern right whales are mostly seen in groups of less than 12, most often singles or pairs (review by Jefferson et al. 1993). Larger groups may form on feeding or breeding grounds (review by Jefferson et al. 1993). In the North Pacific, most recent sightings have been of singles or pairs; however, two groups numbering six to ten and more than three whales were sighted in the northeastern Pacific (Goddard and Rugh 1998).

#### *Vocalizations and hearing*

A description of the anatomy of the ear for cetaceans is provided in the description of the blue whale above. Limited data indicate that northern right whales produce moans of less than 400 Hz in frequency (Watkins and Schevill 1972; Thompson et al. 1979; Spero 1981). Apparently, right whales use low frequency sounds as contact calls while summering in the Bay of Fundy (Spero 1981).

#### *Listing status*

Since 1949, the northern right whale has been protected from commercial whaling by the IWC. Right whales (both *E. glacialis* and *E. australis*) are listed as endangered under the ESA. They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the Marine Mammal Protection Act of 1972. NMFS designated critical habitat for the North Atlantic population of right whales on June 3, 1994 (59 FR 28793 ). Critical habitat has not been designated for right whales in the Pacific Ocean.

#### *Population status and trends*

The population dynamics of right whales are unknown. The recovery plan for this species suggests that its pre-exploitation abundance was higher than 11,000, based on a known harvest of over 11,000 by U.S. whalers with additional numbers struck and lost (Brownell et al. 1986). Current population estimates range from a low of 100-200 (Braham and Rice 1984) to a high of 220-500 (Berzin and Yablokov 1978 [in Berzin and Vladimirov 1981]), but Hill and DeMaster (1998) argue that it is not possible to produce a reliable estimate of population size or trends for the right whale in the North Pacific. No population projections are available. Several researchers have suggested that the recovery of right whales in the northern hemisphere has been slowed by other whales that compete with right whales for food (Rice 1974, Scarff 1986). Mitchell (1975) analyzed trophic interactions among baleen whales in the western north Atlantic and noted that the foraging grounds of right whales overlapped with the foraging grounds of sei whales and both preferentially feed on copepods. Reeves et al. (1978) noted that several species of whales feed on copepods in the eastern north Pacific, so that the foraging pattern and success of right whales would be affected by other whales as well. Mitchell (1975) argued that the right whale population in the north Atlantic had been depleted by several centuries of whaling before steam-driven boats allowed whalers to hunt sei whales; from this, he hypothesized that the decline of the right whale population made

more food available to sei whales and helped their population to grow. He then suggested that the larger sei whale population competes with the smaller right whale population and slows or prevents its recovery.

### *Impacts of human activity on the species*

Before whaling began in the North Pacific Ocean, right whales were considered common or abundant in the North Pacific (Webb 1988). By 1900, observations of right whales in the North Pacific had become so rare, it was impossible to know their population status or trend. In the Atlantic Ocean, the major known sources of anthropogenic mortality and injury of right whales include entanglement in commercial fishing gear and ship strikes. Scarff (1986) concluded that entanglement in fishing gear, noise, or continued hunting by countries who are not members of the IWC were not serious threats to right whales in the North Pacific. However, Scarff (1986) concluded that right whales in the North Pacific are particularly vulnerable to ship strikes and marine pollution because of their habit of feeding at, or near, the water surface. Undersea exploration and development of mineral deposits, and the dredging of major shipping channels are continued threats to the coastal habitat of the right whale in both the North Atlantic and North Pacific. Offshore oil and gas activities have been proposed off the coast of the mid- and south-Atlantic U.S. and are currently being conducted in the Bering Sea and in eastern North Pacific. In Russian waters, two fishery-related mortalities have been reported and offshore oil and gas development could potentially affect northern right whale habitat (Perry et al. 1999).

### *Sei Whale*

#### *Species description and distribution*

Sei whales are distributed in all of the world's oceans, except the Arctic Ocean. The IWC's Scientific Committee groups all of the sei whales in the entire North Pacific Ocean into one stock (Donovan 1991). However, some mark-recapture, catch distribution, and morphological research indicated that more than one stock exists; one between 175°W and 155°W longitude, and another east of 155° W longitude (Masaki 1976, 1977). During the winter, sei whales are found from 20° to 23° N and during the summer from 35° to 50° N (Masaki 1976, 1977). Horwood (1987) reported that 75 to 85% of the total North Pacific population of sei whales resides east of 180° longitude. In the North Pacific Ocean, sei whales have been reported primarily south of the Aleutian Islands, in Shelikof Strait and waters surrounding Kodiak Island, in the Gulf of Alaska, and inside waters of southeast Alaska (Nasu 1974, Leatherwood et al. 1982). Sei whales have been occasionally reported from the Bering Sea and in low numbers on the central Bering Sea shelf (Hill and DeMaster 1998). Masaki (1977) reported sei whales concentrating in the northern and western Bering Sea from July through September, although other researchers question these observations because no other surveys have ever reported sei whales in the northern and western Bering Sea. Horwood (1987) evaluated the Japanese sighting data and concluded that sei whales rarely occur in the Bering Sea. Within the U.S. EEZ, there is a significant lack of information regarding the distribution of sei whales in the eastern north Pacific (see Perry et al. 1999).

#### *Life history information*

Reproductive activities for sei whales occur primarily in winter. Gestation is about 12.7 months and the calving interval is about 3 years (Rice 1977). Sei whales become sexually mature at about age 10 (Rice 1977). The age structure of the sei whale population is unknown. Rice (1977) estimated total annual mortality for adult females as 0.088 and adult males as 0.103. Andrews (1916) suggested that killer whales attacked sei whales less frequently than fin and blue whales in the same areas. Sei whales in the North Pacific feed on euphausiids and copepods, which make up about 95% of their diets (Calkins 1986). The balance of their diet consists of squid and schooling fish, including smelt, sand lance, Arctic cod, rockfish, pollock, capelin, and Atka mackerel (Nemoto and Kawamura 1977). Rice (1977) suggested that the diverse diet of sei whales may allow them greater opportunity to take advantage of variable prey resources, but may also increase their potential for competition with commercial fisheries. Endoparasitic

helminths are commonly found in sei whales and can result in pathogenic effects when infestations occur in the liver and kidneys (Rice 1977).

#### *Diving and social behavior*

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

Sei whales are usually found in small groups of up to 6 individuals, but also commonly form larger groupings on the feeding grounds (Gambell 1985).

#### *Vocalizations and hearing*

No studies have been published on the vocal behavior of sei whales. No studies have directly measured the sound sensitivity of sei whales (Croll et al. 1999). A description of the anatomy of the ear for cetaceans is provided in the description of the blue whale above.

#### *Listing status*

In the North Pacific, the IWC began management of commercial taking of sei whales in 1970 (Allen 1980). Sei whales were listed as endangered under the ESA in 1973. They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the Marine Mammal Protection Act of 1972. They are listed as endangered under the IUCN Red List of Threatened Animals (Baillie and Groombridge 1996). Critical habitat has not been designated for sei whales.

#### *Population status and trends*

Sei whale abundance prior to commercial whaling in the North Pacific has been estimated at 42,000 sei whales (Tillman 1977). Japanese and Soviet catches of sei whales in the North Pacific and Bering Sea increased from 260 whales in 1962 to over 4,500 in 1968 and 1969, after which the sei whale population declined rapidly (Mizroch et al. 1984). When commercial whaling for sei whales ended in 1974, the population of sei whales in the North Pacific had been reduced to between 7,260 and 12,620 animals (Tillman 1977). Current abundance or trends are not known for stocks in the North Pacific. In California waters, only one confirmed and five possible sei whale sightings were recorded during 1991, 1992, and 1993 aerial and ship surveys (Carretta and Forney 1993, Mangels and Gerrodette 1994). No sightings were confirmed off Washington and Oregon during recent aerial surveys. Several researchers have suggested that the recovery of right whales in the northern hemisphere has been slowed by other whales that compete with right whales for food. Mitchell (1975) analyzed trophic interactions among baleen whales in the western north Atlantic and noted that the foraging grounds of right whales overlapped with the foraging grounds of sei whales and both preferentially feed on copepods. Mitchell (1975) argued that the right whale population in the north Atlantic had been depleted by several centuries of whaling before steam-driven boats allowed whalers to hunt sei whales; from this, he hypothesized that the decline of the right whale population made more food available to sei whales and helped their population to grow. He then suggested that the larger sei whale population competes with the smaller right whale population and slows or prevents its recovery. Reeves et al. (1978) noted that several species feed on copepods in the eastern north Pacific, so the foraging pattern of sei whales may affect the foraging success of right whales.

#### *Impacts of human activity on the species*

From 1910 to 1975, approximately 74,215 sei whales were caught in the entire North Pacific Ocean (Horwood 1987, Perry et al. 1999). From the early 1900s, Japanese whaling operations consisted of a

large proportion of sei whales: 300 to 600 sei whales were killed per year from 1911 to 1955. The sei whale catch peaked in 1959, when 1,340 sei whales were killed. In 1971, after a decade of high sei whale catch numbers, sei whales were scarce in Japanese waters. In the eastern north Pacific, the sei whale population appeared to number about 40,000 animals until whaling began in 1963; by 1974, the sei whale population had been reduced to about 8,000 animals (Tilman 1977). No recent reports indicate sei whales are being killed or seriously injured as a result of fishing activities in any eastern North Pacific fishery (Perry et al. 1999). However, Barlow et al. (1997) note that a conflict may exist in the offshore drift gillnet fishery. It is possible that ship strikes affect all stocks of sei whale, but go unreported because the injured or killed animals do not strand.

## ***Sperm Whale***

### *Species description and distribution*

Sperm whales are distributed in all of the world's oceans. Several authors have recommended three or more stocks of sperm whales in the North Pacific for management purposes (Kasuya 1991, Bannister and Mitchell 1980). However, the IWC's Scientific Committee designated two sperm whale stocks in the North Pacific: a western and eastern stock (Donovan 1991). The line separating these stocks has been debated since their acceptance by the IWC's Scientific Committee. For stock assessment purposes, NMFS recognizes three discrete population "centers" of sperm whales: (1) Alaska, (2) California/Oregon/Washington, and (3) Hawaii. Sperm whales are found throughout the North Pacific and are distributed broadly from tropical and temperate waters to the Bering Sea as far north as Cape Navarin. Mature female and immature sperm whales of both sexes are found in more temperate and tropical waters from the equator to around 45°N throughout the year. These groups of adult females and immature sperm whales are rarely found at latitudes higher than 50°N and 50°S (Reeves and Whitehead 1997). Sexually mature males join these groups throughout the winter.

A 1997 survey to investigate sperm whale stock structure and abundance in the eastern temperate North Pacific area did not detect a seasonal distribution pattern between the U. S. EEZ off California and areas farther west, out to Hawaii (Forney et al. 2000). A 1997 survey, which combined visual and acoustic line-transect methods, resulted in estimates of 24,000 (CV=0.46) sperm whales based on visual sightings, and 39,200 sperm whales (CV=0.60) based on acoustic detections and visual group size estimates (Forney et al. 2000). An analysis for the eastern tropical Pacific estimates abundance at 22,700 sperm whales (95% C. I. = 14,800-34,000; Forney et al. 2000).

For all stocks, the sperm whale is generally believed to engage in summer migrations, with mature males migrating north to the Gulf of Alaska, Aleutian Islands, and the Bering Sea, or south to the Antarctic. Females, calves and younger males, which usually remain below 40°N latitude in more tropical and temperate waters (Rice, 1989), may be restricted in their migrations by an intolerance to low water temperatures. Mature males return to the warmer waters of the lower latitudes south of 40°N during the winter breeding season. Sperm whales may be found singly and in groups as large as fifty or more individuals, with solitary mature breeding males joining groups only during the breeding season (Gosho, et al. 1984). During this time, sperm whales in the Pacific Ocean are usually distributed below 40°N Latitude. Historically, sperm whaling grounds in the Pacific were from 20- 40°N and from 150- 160°W and were located around the Hawaiian Islands, among other areas (Leatherwood, et al. 1988).

Sperm whales have a strong preference for the 1,000 m depth contour and seaward. Berzin (1971) reported that they are restricted to waters deeper than 300 m, while Watkins (1977) and Reeves and Whitehead (1997) reported that they are usually not found in waters less than 1000 m deep. While deep water is their typical habitat, sperm whales have been observed near Long Island, NY, in waters of 41-55 m (Scott and Sadove, 1997). When found relatively close to shore, sperm whales are usually associated with sharp increases in bottom depth where upwelling occurs and biological production is high, implying

the presence of a good food supply (Clarke, 1956). They can dive to depths of at least 2000 m, and may remain submerged for an hour or more (Watkins et al. 1993).

Sperm whales have been sighted in the Kauai Channel, the Alenuihaha Channel between Maui and the island of Hawaii, and off the island of Hawaii (Lee, 1993; Mobley et al. 1999; Forney et al. 2000). Additionally, the sounds of sperm whales have been recorded throughout the year off Oahu (Thompson and Friedl 1982). Twenty-one sperm whales were sighted during aerial surveys conducted in Hawaiian waters conducted from 1993 through 1998. Sperm whales sighted during the survey tended to be on the outer edge of a 50 - 70 km distance from the Hawaiian Islands, indicating that presence may increase with distance from shore (Mobley, pers. comm. 2000). However, from the results of these surveys, NMFS has calculated a minimum abundance of sperm whales within 46 km of Hawaii to be 43 individuals (Forney et al. 2000). In the past five years, there is only one observed stranding of a sperm whale off Kauai which occurred in 1995 (NMFS, unpublished data).

#### *Life history information*

Female sperm whales take about 9 years to become sexually mature (Kasuya 1991, as cited in Perry et al. 1999). Male sperm whales take between 9 and 20 years to become sexually mature, but will require another 10 years to become large enough to successfully compete for breeding rights (Kasuya 1991). Adult females give birth after about 15 months gestation and nurse their calves for 2 to 3 years. The calving interval is estimated to be about 4 to 6 years (Kasuya 1991). The age distribution of the sperm whale population is unknown, but sperm whales are believed to live at least 60 years (Rice 1978). Estimated annual mortality rates of sperm whales are thought to vary by age, but previous estimates of mortality rate for juveniles and adults are now considered unreliable (IWC 1980, as cited in Perry et al. 1999). Sperm whales are known for their deep foraging dives (in excess of 3 km). They feed primarily on mesopelagic squid, but also consume octopus, other invertebrates, and fish (Tomilin 1967, Tarasevich 1968, Berzin 1971). Perez (1990) estimated that their diet in the Bering Sea was 82% cephalopods (mostly squid) and 18% fish. Fish eaten in the North Pacific included salmon, lantern fishes, lancetfish, Pacific cod, pollock, saffron cod, rockfishes, sablefish, Atka mackerel, sculpins, lumpsuckers, lamprey, skates, and rattails (Tomilin 1967, Kawakami 1980, Rice 1986b). Potential sources of natural mortality in sperm whales include killer whales and papilloma virus (Lambertson et al. 1987).

#### *Diving and social behavior*

Sperm whales are likely the deepest and longest diving mammal. Typical foraging dives last 40 minutes and descend to about 400m followed by approximately 8 minutes of resting at the surface (Gordon 1987; Papastavrou et al. 1989). However, dives of over 2 hr and as deep as 3,000 m have been recorded (Clarke 1976; Watkins et al. 1985). Descent rates recorded from echo-sounders were approximately 1.7m/sec and nearly vertical (Goold and Jones 1995). There are no data on diurnal differences in dive depths in sperm whales. However, like most diving vertebrates for which there is data (e.g. orca whales, fur seals, chinstrap penguins), sperm whales probably make relatively shallow dives at night when deep scattering layer organisms move towards the surface.

The groups of closely related females and their offspring have group specific dialects (Weilgart and Whitehead 1997), alloparental guarding of young at the surface (Whitehead 1996b), and alloparental nursing (Reeves and Whitehead 1997).

#### *Vocalizations and hearing*

Sperm whales produce loud broad-band clicks from about 0.1 to 20 kHz (Weilgart and Whitehead 1993, 1997; Goold and Jones 1995). These have source levels estimated at 171 dB (Levenson 1974). Current evidence suggests that the disproportionately large head of the sperm whale is an adaptation to produce these vocalizations (Norris and Harvey 1972; Cranford 1992; but see Clarke 1979). This suggests that the

production of these loud low frequency clicks is extremely important to the survival of individual sperm whales. The function of these vocalizations is relatively well-studied (Weilgart and Whitehead 1993, 1997; Goold and Jones 1995). Long series of monotonous regularly spaced clicks are associated with feeding and are thought to be produced for echolocation. Distinctive, short, patterned series of clicks, called codas, are associated with social behavior and intragroup interactions. They are thought to be for intra-specific communication, perhaps to maintain social cohesion with the group (Weilgart and Whitehead 1993).

Generally it is believed that most odontocetes use whistle vocalization as "signature calls" to convey information about the specific identity of the sender. Sperm whales may use clicks rather than whistles for echolocation as well as for signature calls, and unique stereotyped click sequence "codas" have been recorded from individual whales over periods lasting several hours (Mullins et al. 1988; Watkins and Schevill, 1977b; Adler-Fenchel, 1980; Watkins et al. 1985b). According to Weilgart and Whitehead (1988), sperm whale clicks may convey information about the age, sex, and reproductive status of the sender.

A recent study indicates that sperm whale clicks may have a wider dB range than previously thought. Clicks recorded off the coast of Norway in 1997 and 1998, an area thought to be utilized by adult foraging males, were measured for directionality and sound levels. The recorded sound levels for sperm whale clicks exceeded 220 dB. The results of these studies are 40 to 50 dB higher than the sound levels previously recognized for this species (Møhl et al. 2000). Sperm whale clicks range from <100 Hz to 30 kHz, with most energy at 2-4 kHz and 10-16 kHz, outside of the range of the NPAL sound source. Clicks are repeated at rates of 1-90 per second (Backus and Schevill, 1966; Watkins and Schevill, 1977b; Watkins et al. 1985a).

A description of the anatomy of the ear for cetaceans is provided in the description of the blue whale above. The only data on the hearing range of sperm whales are evoked potentials from a stranded neonate (Carder and Ridgway 1990). These data suggest that neonatal sperm whales respond to sounds from 2.5-60 kHz. Sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins and Schevill 1975; Watkins et al. 1985). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Sperm whales have moved out of areas after the start of air gun seismic testing (Davis et al. 1995).

Because they spend large amounts of time at depth and use low frequency sound they are likely to be vulnerable to any negative effects of low frequency sound in the ocean (Croll et al 1999). Even though sperm whales are abundant (Reeves and Whitehead 1997), because their potential rate of reproduction is so low, even small negative impacts of low frequency sound could cause population declines. Furthermore, because of their apparent role as important predators of mesopelagic squid and fish, changes in their abundance could affect the distribution and abundance of other marine species.

#### *Listing status*

Sperm whales have been protected from commercial harvest by the IWC since 1981, although the Japanese continued to harvest sperm whales in the North Pacific until 1988 (Reeves and Whitehead 1997). Sperm whales were listed as endangered under the ESA in 1973. They are also protected by the Convention on International Trade in Endangered Species of wild flora and fauna and the Marine Mammal Protection Act of 1972. Critical habitat has not been designated for sperm whales.

#### *Population status and trends*

Current estimates for population abundance, status, and trends for the Alaska stock of sperm whales are not available (Hill and DeMaster 1999). Sperm whales along the coast of California do not indicate a

trend (NMFS, in press). Approximately 258,000 sperm whales in the North Pacific were harvested by commercial whalers between 1947 and 1987 (Hill and DeMaster 1999). In particular, the Bering Sea population of sperm whales (consisting mostly of males) was severely depleted (Perry et al. 1999). Catches in the North Pacific continued to climb until 1968, when 16,357 sperm whales were harvested. Catches declined after 1968 through limits imposed by the IWC.

### *Impacts of human activity on the species*

In U.S. waters in the Pacific, sperm whales are known to have been incidentally taken only in drift gillnet operations, which killed or seriously injured an average of 9 sperm whales per year from 1991-95 (Barlow et al. 1997). Interactions between longline fisheries and sperm whales in the Gulf of Alaska have been reported over the past decade (Rice 1989, Hill and DeMaster 1999). Observers aboard Alaskan sablefish and halibut longline vessels have documented sperm whales feeding on longline-caught fish in the Gulf of Alaska. During 1997, the first entanglement of a sperm whale in Alaska's longline fishery was recorded, although the animal was not seriously injured (Hill and DeMaster 1998). The available evidence does not indicate sperm whales are being killed or seriously injured as a result of these interactions, although the nature and extent of interactions between sperm whales and long-line gear is not yet clear. In 2000, the Japanese Whaling Association announced that it proposed to kill 10 sperm whales in the Pacific Ocean for research purposes, which was the first time sperm whales have been taken since the international ban on commercial whaling took effect in 1987. Despite protests from the U.S. government and members of the IWC, the Japanese government plans to conduct this research. The implications of this action for the status and trend of sperm whales is uncertain.

### *Hawaiian monk seal*

#### *Species description and distribution*

The Hawaiian monk seal is the most endangered pinniped species in U.S. waters and the second most endangered pinniped in the world, next to the Mediterranean monk seal. Hawaiian monk seals are found primarily in the Northwestern Hawaiian Islands (NWHI), which extend more than 2000 km northwest of the Main Hawaiian Islands (MHI; includes the Islands of Niihau, Kauai, Oahu, Molokai, Lanai, Kahoolawe, Maui, and Hawaii). Major breeding populations occur at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, and Kure Atoll (Forney et al. 1999). Smaller breeding populations are found at Nihoa and Necker Islands, and a number of seals are distributed throughout the MHI (Forney et al. 1999). Reported sightings on the MHI have become increasingly more common, and births have been reported on all of the main Hawaiian islands except Lanai and Hawaii (NMFS, unpubl. data). In 1994, twenty-one adult male Hawaiian monk seals were relocated from Laysan Island to the MHI in an attempt to equalize the sex ratio at Laysan Island. Some of these males were radio tagged, and all were flipper-tagged. All but two were resighted near their release sites, but their survival to 1997 is unknown (Forney et al. 1999). Sporadic sightings of monk seals on the MHI indicate total abundance (including the twenty-one released males) to be approximately 40 seals (Forney et al. 1999). Additionally, sightings of Hawaiian monk seals have occurred on at least three occasions at the remote Pacific location of Johnston Atoll (excluding nine adult males translocated from Laysan Island in 1984).

#### *Life history information*

There is no obvious sexual dimorphism between male and female Hawaiian monk seals. Sex is determined by observing their ventral sides (Kenyon and Rice, 1959). Females have two pairs of teats, often appear larger and fatter than adult males (Kenyon and Rice, 1959), and may have dorsal mating scars (Hiruki et al. 1993). Males have a penile opening, often have scars along their necks inflicted by other males (Hiruki et al. 1993), and may be darker than females (Kenyon and Rice, 1959). Adults weigh up to 270 kg and may be more than 7 feet long (Kenyon and Rice, 1959).

Hawaiian monk seals do not form breeding colonies or harems (Kenyon and Rice, 1959; Johanos et al. 1994). Mating, which occurs in water and is rarely observed, is inferred from male-female association patterns and from mounting injuries (Johanos et al. 1994). As members of the genus *Monachus*, the only tropical phocids, they experience an asynchronous breeding season lasting from February through September (Johanos et al. 1994).

Pupping patterns vary wildly; not all females give birth in consecutive years (Kenyon and Rice, 1959; Johanos et al. 1994). Females that do give birth in consecutive years pup later each season, while female that skip a year or more give birth earlier the next season (Johanos et al. 1994). The mean interval for births in consecutive years was found to be 381 days (Johanos et al. 1994). Birth rates vary depending on breeding location and year, with approximately 30 - 70 % of all adult females giving birth in any given year (Johanos et al. 1994; Ragen and Lavigne, 1999). Females give birth from February to August, with the peak of births occurring in late March/early April (Johanos et al. 1994), although pupping has been recorded year round (U.S. Dept. of Commerce, 1986). They prefer to give birth on beaches with shallow water next to the shoreline and coral reefs surrounding the area, apparently to afford protection to the pup (Westlake and Gilmartin, 1990).

Newborn pups weigh 15 - 17 kg and measure 95 - 100 cm long (Kenyon and Rice, 1959). Pups are black at birth and undergo a post-natal molt late in the nursing period. Nursing lasts, on average, 39 days (Johanos et al. 1994), during which time the mother remains constantly near her pup in and out of water (Kenyon and Rice, 1959). The mother appears to fast and rapidly loses weight through lactation. At the end of lactation, she abandons her pup and swims offshore to feed (Kenyon and Rice, 1959; Wirtz, 1968; Johnson and Johnson, 1984). At weaning, pups normally weigh between 59 - 90 kg (Kenyon and Rice, 1959).

Their distribution, destinations, routes, food sources, and causes of the movements when not traveling between islands are not well known (Johnson, 1979). Approximately 10 - 15% of monk seals migrate among the breeding populations (Johnson and Kridler, 1983; NMFS unpubl. data). At the breeding islands, monk seals feed on octopus, spiny lobster, eels, bottom-dwelling fish and reef fish (Rice, 1960; Gilmartin, 1983; Goodman-Lowe, 1998).

#### *Population status and trends*

Two periods of human-related decline of the Hawaiian monk seal are recorded. The first occurred in the 1800's, where sealers, crews of wrecked vessels, and guano and feather hunters hunted the population to near extinction (Dill and Bryan, 1912; Kenyon, 1959). During subsequent years, expeditions to the NWHI reported increasing numbers of seals (Bailey, 1952). A survey in 1958 indicated partial recovery of the species to over 1000 seals (Rice, 1960).

A second period of human-related decline occurred from the late 1950's to the mid- 1970's. During this period, beach counts of Hawaiian monk seals in the NWHI declined by 50% primarily due to human disturbance at the western most populations, where military and U.S. Coast Guard operations occurred. Human disturbance on these beaches caused pregnant females to abandon preferred pupping sites and nursing females to abandon their pups (Kenyon, 1972; Gerrodette and Gilmartin, 1990). As a result of this decline, the Hawaiian monk seal was listed as endangered in 1976 under the U.S. Endangered Species Act of 1973 and depleted under the Marine Mammal Protection Act of 1972 (Gilmartin 1983).

Between 1958 and 1997, a decline of 60% was observed in the total mean beach counts at the main breeding populations. From 1985 to 1997, the species declined by 4% per year, and is therefore characterized as a strategic stock (Forney et al. 1999). This downward trend is expected to continue, mainly due to poor pup and juvenile survival in recent years at the largest breeding population, French Frigate Shoals (Forney et al. 1999; Craig and Ragen 1999).

In 1987, the population for five of the major breeding populations and Necker Is. was estimated to be 1,718 seals, including 202 pups of the year (Gilmartin 1988). This compares with 1,488 seals estimated for 1983 (Gerrodette 1985). In 1992, the Hawaiian monk seal population was estimated to be 1580 (SE = 147) (Ragen 1993). The best estimate of total abundance for 1993 was 1,406 (SE = 131). In 1997, a total of 1295 seals, including pups, were observed at the main reproductive populations, representing 90% or more of the seals (NMFS, unpubl. data). The current total monk seal population is estimated to be between 1,300 and 1,400 individuals (NMFS, 2000).

Small numbers (one to four) of monk seals are regularly seen around Kauai and each of the other MHI (Nitta, pers. comm., 1995). On Niihau, a single aerial survey conducted in September 2000 counted 29 seals hauled out on the beach, potentially indicating a population up to three times that number; the same survey counted 7 seals on Kauai (NMFS, unpubl. data). Popping in the MHI was first recorded in 1962 with a birth reported on Kauai. In 1988, a single female gave birth to a female pup on the north coast of Kauai, Haiena Point (Reeves et al. 1992). In 1991, one pup was born on Kauai in the Poipu Beach area, one pup was born on the North shore of Oahu, and one pup was born on Niihau. In 1992, a pup was born on Kauai (North Kapa'a). In 1996, one pup was born on Oahu (Kaneohe Bay) and one was born on Molokai. In 1997, one pup was born on Oahu (Paradise Cove), one was born on Molokai, and one was born on Maui. In 1998, the only documented birth of twins occurred on Oahu (both pups died around the time of birth). Two other pups were born in 1998, one on Molokai and one on Maui. In 1999, one pup was born on Kauai at the Pacific Missile Range Facility; one pup was born on Molokai and one pup was born on Maui. In 2000, seven pups were born in the MHI. Two were born on Niihau, four were born on Kauai, and one was born on Molokai (NMFS Southwest Fishery Science Center Honolulu Laboratory, unpubl. data). The increase in documented births may be due to increased awareness and a better-educated public (i.e., knowing where to report monk seal sightings), but seems to reflect a genuine increase in the monk seal population in the MHI. Monk seal sightings on Kauai have increased in recent years, with frequent haul-out behavior observed at the south shore. For example, in the winter of 2000, eight monk seals (all molting) were observed at one time on Kauai at Poipu Beach (NMFS Southwest Fishery Science Center Honolulu Laboratory, unpubl. data). This contrasts with only one monk seal observation off the north shore of Kauai during 1994 shore-based MMRP surveys (Smultea et al. 1994).

### *Diving behavior*

Data from a study conducted on seven adult male Hawaiian monk seals at Lisianski Island in 1980, in which radio tags and maximum-multiple-depth recorders were used, revealed a majority (59%) of dives were in the 10 to 40 m depth range. The remaining dives were deeper than 40 m, with a maximum depth of 121 m recorded (DeLong et al. 1984). In 1982, an additional eight seals were similarly tagged at Lisianski, which included five adult males, one subadult female, one juvenile male, and one juvenile female (Schlexer, 1984). All seals made dives to depths greater than 36 m; no adult male seals made dives deeper than 70 m. The subadult and juvenile females showed a dive pattern different than the adult males whereby fewer dives were made in the shallow range (0 to 40 m) and many dives were made to depths greater than 40 m, with the deepest dive recorded at 150- 180 m (Schlexer, 1984). Recent time-depth recorder information from tagged monk seals revealed that some seals dive to deeper than 300 m, with some dives recorded deeper than 500 m (Parish et al. 2000). Hawaiian monk seals can stay submerged for at least 20 minutes (Reeves et al. 1992).

### *Vocalizations and hearing*

Studies on the vocal behavior of monk seals are limited. A six month study on a young captive male Hawaiian monk seal revealed an audiogram showing a somewhat narrower hearing range than for other pinnipeds. The seal's hearing was most sensitive (20 dB above maximum sensitivity) underwater between 12 and 28 kHz. Below 8 kHz, the Hawaiian monk seal's hearing was less sensitive than measured in other pinnipeds (Thomas et al. 1990). Job *et al.* (1995) found that female Hawaiian monk seals do not identify pups from their vocalizations.

## *Impacts of human activity on the species*

Hawaiian monk seals have been reduced to near extinction. The main threats could include commercial hunting, intentional harassment, entanglement in fishing gear, habitat modifications on breeding beaches on Midway and French Frigate, pollution, and unintentional human disturbance (Kenyon 1981; Gerrodette and Gilmartin 1990; Riedman 1990; Reeves *et al.* 1992).

## **EFFECTS OF THE ACTIONS**

This biological opinion assesses the effects of the Navy's proposed employment of the NPAL sound source on endangered species of cetaceans and critical habitat that has been designated for them. In the *Description of the Action* section of this Opinion, NMFS provided an overview of the Navy's proposed program and NMFS' proposed authorization for incidental take of cetaceans by the NPAL sound source for the purposes of the Marine Mammal Protection Act. In the *Status of the Species* section of this Opinion, NMFS provided an overview of the numerous species that may be adversely affected by the NPAL sound source.

In this section of a biological opinion, NMFS assesses the probable direct and indirect effects of the NPAL sound source and of interrelated, and interdependent actions on threatened and endangered species and designated critical habitat. The purpose of this assessment is to determine if it is reasonable to expect that the Navy's NPAL sound source will have direct or indirect effects on threatened and endangered species that appreciably reduce their likelihood of surviving and recovering in the wild [which is the "jeopardy" standard established by 50 CFR 402.02]. The purpose of this assessment is also to determine if it is reasonable to expect the Navy's NPAL sound source will appreciably diminish the value of designated critical habitat for both the survival and recovery of threatened and endangered species in the wild [which is the "destruction or adverse modification" standard established by 50 CFR 402.02].

NMFS approaches these analyses by first evaluating the available evidence to identify the direct and indirect physical, chemical, and biotic effects of a proposed action on individual members of listed species or aspects of a species' environment. NMFS then evaluates the available evidence to identify the species' probable responses to those effects to determine if those effects could reasonably be expected to reduce a species' reproduction, numbers, or distribution by changing its vital rates (rates of birth, death, immigration, or emigration). NMFS then uses the evidence available to determine if these reductions, if there are any, could reasonably be expected to reduce a species' likelihood of surviving and recovering in the wild. If NMFS concludes that an action could reasonably be expected to reduce a species' likelihood of surviving and recovering in the wild, NMFS' final task is determining whether that reduction is likely to be "appreciable."

## **Approach to the Assessment**

The NPAL sound source will introduce low frequency sound into the marine environment. These sounds will have physical effects on the marine environment, but only in the form of sound energy. There is no evidence of other direct or indirect physical, chemical, or biotic effects of the proposed action. Therefore, this section of this opinion will examine the effects of the low frequency sound on the marine environment and the probable responses of listed cetaceans to these sounds to determine if the action can be expected to affect the species' likelihood of surviving and recovering in the wild. Specifically, we will evaluate the available evidence to determine if the proposed action can be expected to physically injure, harm, or harass listed cetaceans.

NMFS defines harm to include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). The ESA does not define

harassment nor has NMFS defined this term, pursuant to the ESA, through regulation. However, the Marine Mammal Protection Act of 1972, as amended, defines harassment as any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild or has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [16 U.S.C. 1362(18)(A)]. The latter portion of this definition (that is “...causing disruption of behavioral patterns including...migration, breathing, nursing, breeding, feeding, or sheltering”) is almost identical to the U.S. Fish and Wildlife Service’s regulatory definition of “harass”<sup>2</sup>.

For this biological opinion, we will define harassment as a disturbance resulting from a human action that disrupts one or more behavioral patterns that are essential to an individual animal’s life history or to the animal’s contribution to a population, or both. We are particularly concerned about injuries that may manifest themselves as an animal that fails to feed successfully, breed successfully (which can result from feeding failure), or complete its life history because of changes in its behavioral patterns. In the latter two of these examples, the effects on an individual animal could disadvantage a population because the individual’s breeding success will have been reduced.

### **Evidence available for the assessment**

The evidence available for this assessment of the effects of sound transmissions associated with the NPAL sound source was variable. Many investigators have studied the physics of low frequency sound in ocean environments and we can address these effects with a fairly high level of confidence. Many investigators have also begun to study how marine mammals and other marine organisms respond, physically and behaviorally, to sound sources. Despite these studies, we remain largely ignorant of how marine mammals respond to human-generated sounds in the marine environment. We still need more information on the basic hearing capabilities of marine mammals, on how marine mammals use natural sound to communicate and its importance to their normal behavioral routines, on whether low-frequency sounds affect marine mammal behavior and physiology (including the non-auditory physiology), and on sound pressure levels that produce temporary and permanent hearing loss in marine mammals (see NRC 2000 for further discussion of these unknowns).

We also remain ignorant of how marine mammals interpret sounds generally, including human-generated sounds, and how sounds affect their cognitive processes and their behavior. We do not know – and, perhaps, cannot know – how marine mammals interpret various sounds in the ocean environment and the relationship between those interpretations and marine mammal behavior. On a basic level, we do not know if or when marine mammals would classify a sound as a pollutant in their environment (noise), although this information is relevant to an analysis of the effects of the NPAL sound source on threatened and endangered species. Despite its relevance, this information is not available for this biological opinion and may never become available because we may never learn how marine mammals interpret sounds and how they adjust their behavior based on the sounds they hear. Therefore, while we recognize the limitations of the available data, we have drawn conclusions from the information available on the physics of low frequency sounds in the ocean environment and current knowledge of how marine mammals behaviorally respond to low frequency sound.

The primary sources of information on the effects of low frequency sound on marine mammals were three National Research Council reports (NRC 1994, 1996, 2000), a book published by Richardson et al. (1995) on marine mammals and noise, the Navy’s Low Frequency Sound Scientific Research Program (which was developed to address questions associated with SURTASS LFA), ATOC Marine Mammal Research Program (which was developed to address questions associated with the ATOC project, which

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<sup>2</sup> An intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3)

also used low frequency sound), several models the Navy developed for its Environmental Impact Statement on SURTASS LFA, and several scientific papers (Croll et al. 1999, Frankel and Clark 1998, Tyack 2000, Whitlow et al. 1997).

## Effects Analysis

In order to understand the biological significance of the risk of the effects of sound, it is necessary to determine how this risk might affect a population of marine mammals, starting with acoustic criteria. First, the marine mammal must be able to hear low frequency sound. There is no evidence that listed species, particularly the endangered baleen whales which are considered the most sensitive to low frequency sounds, can detect or respond to sounds that have dropped much below the level of ambient noise. Richardson et al. (1995) state that it is unlikely that man-made sounds with received levels slightly less than the background noise level in the corresponding band would cause disturbance even if faintly audible. Thus, listed species would not likely be adversely affected by the NPAL transmissions outside of the NPAL zone of audibility (Richardson et al. 1995). The effects on listed marine mammals and the Hawaiian monk seal focuses on the portion of the action area that is within this zone of audibility.

Second, the animal must experience a reaction to the low frequency sound that is more than momentary. Third, any effect from low frequency sound must involve a significant behavioral change in a biologically important activity, such as feeding, breeding, or migration, all of which are potentially important for reproductive success of the population. The following is a discussion of the effects of continuation of the NPAL source transmissions on the endangered mysticetes, sperm whale, and Hawaiian monk seal.

The typical transmission schedule involves 20-minute transmissions every four hours (six total over the course of a day), every fourth day, with each transmission preceded by a 5-minute ramp-up period during which the signal intensity would be gradually increased, representing an average duty cycle of 2 percent. Duty cycles could be increased to 8 percent, during short-term testing or short-term long-range acoustic propagation studies. Increases to an 8 percent duty cycle would not occur during the peak humpback season, January through April. The transmissions would continue for 5 years. The NPAL signals transmitted by the source would have a center frequency of 75 Hertz (Hz) and a bandwidth of approximately 35 Hz (i.e., sound transmissions are in the frequency band of 57.5-92.5 Hz). At 1 meter (m) (3.3 feet) from the source, the sound intensity would be about 195 dB. The 8 percent duty cycle would not occur during the peak humpback season (January - April). The transmission schedule during the 2-month period would include no single transmission longer than 2 hours in duration. As an example, one possible 8 percent transmission schedule could include 20-minute transmissions at four hour intervals every day, instead of every fourth day. Another possible schedule would involve transmitting the 20-minute signal on the hour for 24 hours followed by 72 hours of no transmissions, repeated up to 15 times over the 2-month 8 percent duty cycle period.

The proposed action would only add sound to the marine environment. Existing loud frequency sound sources in the Pacific Ocean include, but are not limited to, natural seismic activity, vessel traffic, airgun arrays, and oil exploration and drilling. Ambient sound levels in portions of the Pacific Ocean north of Kauai would be increased during transmission of the NPAL source. This action is not expected to alter the chemical component of the ocean but may have biotic effects on marine organisms. The ocean is an environment in which sound is the best form for communication over distances, as sight can be for terrestrial animals. Marine animals, having adapted to living in water, probably obtain much information about their environment by listening to the sounds from other natural sources, aside from members of their own species. Examples include surf noise and sounds from predators such as killer whales. Marine mammals, and other animals rely on vocalization and hearing in order to communicate among a species or obtain information about their environment. Acoustic communication plays a significant role in the life history of cetaceans and other marine species. Whales may hear one another at ranges of up to hundreds of kilometers, but they see one another underwater at ranges of no more than tens of meters. As

mentioned in the status of the species, baleen whales, sperm whales, and monk seals use a variety of songs, calls, echolocation pulses, and other sounds in communication and navigation.

Our analyses tried to determine the potential for injury and behavioral impacts from received sound levels, masking of sounds used in communication and echolocation, and indirect effects associated with changes in the abundance and distribution of the prey base for threatened or endangered species. Finally, our analyses tried to determine if these effects could change or disrupt biological important behavioral activities, such as feeding, nursing, or breeding, that could cause populations of listed species to decline. The analysis examines effects of the addition of noise to ambient conditions on individual humpback, fin, blue, sei, and sperm whales or Hawaiian monk seals. The analysis was organized to address the following categories of effects:

- Permanent or temporary shift in the threshold of audibility (permanent threshold shift or temporary threshold shift)
- Avoidance or other direct behavioral responses to the sound source, as well as habituation
- Masking of communication or echolocation pulses
- Reduction of prey resources

The analyses for each species utilizes the results of the Marine Mammal Research Program available as published articles and unpublished reports, as well as other acoustic and cetacean behavior information, as it represents the best scientific and commercial information available for understanding the potential for impacts on the species in the action area. For the topics for which there is no data on the species, inferences have been made from existing data on other marine mammals, because the marine mammals have similar ear structures and are adapted to similar underwater environments.

### **Project Effects on Mysticetes**

Although 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)(Ketten, 1994), and likely hear best in the frequency range of their calls (Myrberg, 1978; Turl, 1980). Baleen whale vocalizations range from below 10 Hz, to 25 kHz, with principal energy in the 50-300 Hz band (Ljungblad et al. 1980). Refer to the status of the species discussions for information on the each listed species considered here.

#### ***Direct effects on mysticetes***

##### *Changes to hearing sensitivity*

Few data on the effects of non-explosive sounds on hearing thresholds of marine mammals have been obtained. However, it is generally accepted that received sound levels must far exceed the animal's hearing threshold for there to be any non-serious injury such as a temporary threshold shift (TTS; temporary reduction in hearing sensitivity). Received levels must be even higher for the risk of permanent threshold shift (PTS; permanent reduction in hearing sensitivity) to exist.

Some marine mammals tolerate, at least for a few hours, continuous sound at received levels above 120 dB. However, others exhibit avoidance when the noise level reaches approximately 120 dB. It is doubtful that many marine mammals would remain for long in areas where received levels of continuous underwater noise are 140 dB or higher at frequencies to which the animals are most sensitive (Richardson et al. 1995). The NPAL source, located 800 m below sea level, is expected to emit sounds at 195 dB at 1 meter. The level is expected to attenuate to 140 dB approximately 550 m above the source (250 m below the surface), which is the maximum known dive depth of a humpback whale. This is the same received level it would experience at a distance of 100 m from another vocalizing humpback whale. Humpback whales emit vocalizations at 180 dB. The received levels from the Kauai source are, therefore, similar to those experienced by humpback whales in their day-to-day activities.

Humpback whales are the most commonly observed large cetacean in the vicinity of the NPAL sound source. Humpbacks generally transit the area, swimming parallel along the coast. Although humpbacks may be capable of diving past 200 m, it is unlikely that they would be found in the area around the sound source where received levels exceed 160 dB. Blue, fin, and right whales are believed to dive deeper than 500 m on occasion. Sei whales may dive to 300 m. Blue, right, and sei whales were not observed in the area near the NPAL source (Mobley et al. 1999a). It is unlikely that these whales would be exposed to levels near the NPAL source that has the possibility of causing PTS or TTS because these species are rare in the area and, if they were in the area, they would have to dive deeply during the transmission of the NPAL signal to be exposed. The number of individual animals that could sustain displacement or even TTS would be negligible.

#### *Auditory interference or masking*

Masking refers to environmental noise that interferes with the ability of an animal to detect a specific sound signal. The masking occurs when the environmental noise frequencies are similar to the signal that the animal uses or when ambient levels are much higher than the signal. Masking in marine mammals is a function of the animal's hearing sensitivity, ambient noise source level, and animal distance from the source. Masking processes in baleen whales are difficult to study, and little or no data on hearing sensitivity are available for these species. Mysticetes and other marine mammals are likely adapted to cope with some masking.

During the proposed sound transmissions (maximum 8% duty cycle), noise intensity in the vicinity of the sound source, and out to a radius of approximately 12 to 25 km, would be greater than ambient levels. This increase in noise has the potential to interfere with the detection of acoustic signals, such as communication calls, and other environmental sounds that may be important to mysticetes. For an animal close to the operating NPAL source, it would be able to hear only nearby animals. Thus, for humpback whales that are close to the NPAL source, it is likely that animals close to one another will be able to continue communications. This is an important adaptation that will allow calf and pod interactions to continue during the NPAL transmissions or other natural or anthropogenic sound.

Given that humpbacks use low frequency songs to advertise themselves to improve their chances of mating, masking could be expected to result in interruption of the advertisements and reduce the chances of mating. The reduction of the chances for mating is not expected to be substantial because it would only occur during the 5 minute ramp-up and 20 minute transmission of the NPAL source and is likely to mask only singers in a limited area around the NPAL source.

Outside of the vicinity of the sound source, the blue, fin, sei, and right whale may be affected by masking from the NPAL source. As described in the Status of the Species section, blue and fin whales can apparently respond to one another over distances of at least 20-25 km (Watkins, 1981). There is a potential to reduce the radius of the communication ranges of mysticetes if ambient noise levels are increased, and other factors such as directionality of the noise source, and the animal's hearing sensitivity and directional hearing capability remain relatively constant. Masking of their communication could disrupt social interactions or lead to disorientation if sounds were being relied upon to navigate. The masking effects are expected to be limited. For species with broad spectrum hearing, such as mysticetes, masking from the NPAL source would likely affect a narrow bandwidth because the frequency range of the NPAL source is 35 Hz. These species could be reasonably expected to have adapted to some masking of low frequency communication from natural sources (such as earthquakes). Because the NPAL source has a duty cycle of 2% and most transmissions would be 25 minutes long, fin and blue whales could be expected to use their adaptations to remedy any missed opportunities in mating or disorientation occurring as a result of NPAL transmissions.

Thus, the interruptions in behavior from the masking effects would be minor during the 2% duty cycle for humpback whales, fin, blue, sei, and right whales and would not likely result in declines in population

numbers of these species. During periods of operation above the 2% duty cycle (up to 8%), the potential for masking effects would be greater. However, the higher duty cycle would occur only for a portion of the year outside of the humpback breeding season. Any adverse effects are expected to affect individuals temporarily, during exposure to the masking properties of the transmission signal.

### *Behavioral effects*

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.

Possible short-term reactions of mysticetes disturbed by human-made noise include interruption of feeding, resting, or social activities, and abrupt diving or swimming away (Finley, 1982; Calkins, 1983). Various studies and reported observations for a number of different mysticete species indicate variability in the responses to sounds of relatively high intensity (Bowles, et al. 1994; Malme et al. 1984; Maybaum, 1989; Mobley et al. 1988; Richardson et al. 1985; Richardson et al. 1995). In most instances, responses are affected by species, age and sex class, social context, habitat, habituation, and sound source characteristics.

There is variability in sensitivity and response to human-made noise between and within marine mammal species and a paucity of information about the consequences of short-term disruptions on marine mammals. Disturbance of marine mammals as a result of human-made noise, if intense enough, can result in interruption (at least briefly) of normal behavioral and social interactions with conspecifics, an increase in energy cost (whether or not feeding was disrupted or a fleeing response was elicited), and displacement to a less preferred habitat. Displacement also can have the benefit of removing the animal from a location where there might be more serious consequences had the animal remained (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).

Although there is little definitive information about the long-term effects of short-term disturbance reactions, isolated disturbance incidents probably have minimal or no lasting effects and the energetic consequences of most single disturbance incidents are likely insignificant. However, recurrent incidents of interrupted feeding, nursing and resting, if sufficiently frequent, can have negative effects on individual animals. The threshold at which the frequency and duration of disturbance that might initiate negative effects are not well known, and would likely depend on the species, area, feeding requirements, and reproductive status of the marine mammals involved. Animals most severely affected would likely be pregnant or lactating females and other animals subject to heavy natural energy drain.

A few marine mammal species exhibit extreme avoidance reactions to very low levels of industrial noise. Bowhead whales avoid airgun arrays by distances (up to 20 km) at which airgun sounds barely exceed background noise levels (LGL, 1998). Also, gray whales avoid industrial sounds in their migratory pathway when received levels reach approximately 120 dB (Malme et al. 1984). Experiments with migrating gray whales found that for animals exposed to industrial sounds placed directly in their migratory path, there was a 50% probability that a whale would avoid the area around the source when the received level was 116-124 dB (Malme et al. 1983; Malme et al. 1984). Similar response levels were measured for bowhead whales (summarized in Richardson et al. 1995; Richardson and Malme 1993). However, when similar noises were played to feeding humpbacks in Alaska, they did not show any response, even at received levels of 116 dB (Malme et al. 1985) and humpback whales on the breeding ground did not stop singing during underwater explosions (Payne and McVay 1971). Many other species tolerate, at least for a few hours, continuous sound received at levels greater than 120 dB (Richardson et al. 1995). Richardson et al. (1995) predicted that most marine mammals with hearing sensitivity below 100 Hz would not remain in areas where received levels of continuous noise remain at or above 140 dB, unless hearing was previously impaired. These results lead to a cautionary rule-of-thumb that whales

would show an avoidance response to man-made sounds at received levels greater than 120 dB (Frankel and Clark, unpub. report).

As for the blue and fin whales, the Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) sonar research program (U.S. Navy, 2000. SURTASS LFA Sonar Final Environmental Impact Statement) indicate that these species do not exhibit obvious responses from the LFA source array of 18 projectors (received levels were from 120 to 155 dB). Some cessation of humpback whale song and some apparent avoidance responses were displayed as a result of the LFA sound transmissions (received levels ranged from 120 to 150 dB). Of the whales that did stop singing, “most” resumed singing within less than an hour of the possible response. Those humpback whales that did not stop singing sang longer songs during the period of LFA transmissions, and returned to baseline conditions after transmissions stopped. It is therefore not likely that blue, fin, or humpback whales will show pronounced responses to the 120 dB sound field at the surface above the NPAL source. Sei and right whales are expected to respond, or not respond, similar to the whales that have been tested.

Neither the California nor the Hawaii Marine Mammal Research Program found any overt or obvious short-term changes in the behavior of humpback whales or elephant seals in response to the playback of NPAL-like sounds or to transmissions of the sound sources. In 1996, the behavioral responses of humpback whales to the playback of ATOC-like signals (maximum received level of 130 dB) were studied. Humpback whales showed no overt responses to these ATOC playbacks (Frankel and Clark, 1998). By contrast, the single playback of a humpback whale feeding call provoked dramatic changes similar to those seen in previous playback experiments (Mobley et al. 1988). In 1996 and 1998, the behavior of humpback whales was observed from a shore-station on the north coast of Kauai while a low-frequency noise similar to the ATOC source was played (Frankel and Clark 1998) and the Kauai ATOC source was transmitting (Frankel and Clark 2000). Both experiments were conducted using similar methods. Observations of humpback whale movements were made during control (no playback or transmissions) and experiment conditions. Statistical analyses revealed some subtle changes in the behavior of humpback whales in response to the playback of ATOC-like sounds and to the transmissions of the ATOC Kauai source (Frankel and Clark, 1998; 2000). Both studies found that the distance and time between successive whale surfacings (segment length and segment duration) increased slightly with increasing received levels. This result is not what would be predicted if the animals had been stressed by the sound source. Rather, it would be expected that the animals would have remained at the surface longer because of the lower received levels there as longer dive durations would correspond to increased exposure to the sound source. No statistically significant changes were found in any other behaviors. The biological significance of the increase in distance and time between successive surfacings is not known.

Costa et al. (1998) and Mobley et al. (1999) showed no statistically significant changes in the abundance of humpback and sperm whales from the control periods, when the source was not operating, to the experimental periods, when it was on. Aerial surveys around the ATOC source reveal no statistically significant shift in distance from the source when it was on or off for the humpback whale (Mobley et al 1999). However, statistical analyses of aerial survey data showed some shifts in the distribution of humpback whales away from the Pioneer Seamount ATOC source during transmission periods (Calambokidis 1998). The Pioneer Seamount surveys is based on 372 sightings as opposed to 28 sighting reported by Mobley et al. (1999) and therefore is statistically more powerful. Any responses by humpback whales that may result during NPAL transmissions is expected to result in temporary disruption of essential biological behaviors. The transmissions occur at a 2% duty cycle during the humpback breeding season and, thus, minimal disturbance to humpback whales are anticipated. Therefore, the NPAL transmissions may adversely affect humpback whales, but would not lead to population level effects.

Given the apparent low seasonal presence of blue, sei, right, and fin whales near the main Hawaiian islands, it is unlikely that any of these species will be present within the sound field over the five year

period of sound source operation. Therefore, they should be not be exposed to the NPAL source at the high levels and operation of the source is not expected to result in direct behavioral responses by these species.

#### *Habituation to the NPAL source*

Richardson et al. (1995) defined habituation 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. Although relatively few studies of habituation in marine mammals have been done, several cases of apparent habituation have been reported for baleen whales (Watkins, 1986; Dolphin, 1987; Malme et al. 1985; Richardson et al. 1985, 1990) 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. The rate and intensity of exposure to a stimulus to maintain habituation (e.g., whether animals exposed and habituated to a disturbance during one year would still be habituated the next year) is not known.

Around Cape Cod, Watkins (1986) suggested that reactions of various species of baleen whales changed over the years as whale-watching cruises became popular. Some species, particularly humpback and fin whales, appear to 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 to 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, 1990) found that some bowheads remained near dredges and drill ships that were producing continuous noise, even though bowheads exhibited at least weak avoidance reactions at the onset of about the same levels of drill ship or dredge noise. These observations suggest that marine mammals, like other animals, over time, tend to become less sensitive to noise and disturbance to which they are repeatedly exposed in some cases, unless there is a threat associated with the stimulus.

The effects of substantial disturbance, which might result from a stationary and continuously noisy human activity near a marine mammal concentration area, could be mitigated in part by the degree to which the marine mammals habituate. Habituation effects can also limit the direct impact of a stimulus, in this instance the received levels. Habituation can be detrimental, however, if it leads to a lack of response to hazardous situations or results in masking. If animals fail to habituate and 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. Studies to date show that humpback whales at least respond with longer dive times to the ATOC source, and no change in distribution or abundance were observed during ATOC transmission. Habituation of the humpback whales to the NPAL sounds could occur, but these whales generally move along the coast and will not likely remain in the area of the NPAL sounds, reducing the chances of habituation.

The habituation of blue, fin, sei, and right whales to the NPAL source would not be detectable. These species would generally be exposed to NPAL transmissions at a reduced level because they are rare around Kauai.

#### *Long-term effects*

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

Depending upon the circumstances, changes in marine mammal use of an area may be quite slow and difficult to detect, particularly if abandonment thresholds are not acute. If marine mammals did react to noise from human activities by reduced use of certain areas, in many cases there would be insufficient reliable and systematic information (including baseline data) to document the trend. Conversely, it may be easier to document cases where marine mammals remain in an area where sounds are introduced.

Although the potential significance of permanent displacement is difficult to determine, Richardson et al. (1995) 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, permanent displacement is unlikely to be critical either to individuals or to the population. They noted, however, that effects of displacement would be problematic 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. (1995), the presence of marine mammals in an ensonified area does not prove that the population or individuals therein are unaffected by the noise. For example, 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, marine mammals may stay in an area despite the presence of a noise disturbance if there are no alternative areas that meet their requirements (Brodie, 1981). In response to such situations, animals may experience stress, resulting in physiological responses. Todd et al. (1996) found that humpback whales on feeding grounds did not alter short-term behavior or distribution in response to explosions with received levels of about 150dB at 350Hz. However, at least two individuals were likely killed by the blasts and extensive had mechanical injuries in their ears (Ketten et al. 1993; Todd et al. 1996). The explosions may also have increased the number of humpback whales entangled in fishing nets (Todd et al. 1996).

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, Curry, 1999). 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).

The potential for long-term impacts from exposures to the project sound fields is unknown, but is being examined concurrently with the NPAL transmissions. So far, the aerial surveys from 1994-1998 (Mobley et al. 1999a) do not indicate a change in abundance of humpback whales, which are expected to be affected more so than other mysticetes.

### ***Indirect effects on mysticetes***

There are likely to be few if any indirect effects on listed mysticetes from the project. The principal indirect effect would be any potential impact on the food chain that ultimately could affect mysticetes in the vicinity of the study area. Since the waters off the north shore of Kauai are not known to include significant feeding areas for baleen whales during the winter breeding season, particularly off the north shore of Kauai, no effects on mysticete prey are expected from the proposed project.

### **Project Effects on the Sperm Whale**

The generally accepted method for determining the potential for harm to the auditory system from introduced sound is to first characterize the hearing capabilities of the subject species. As with humpback whales, it is assumed that a species can hear the noises it is capable of producing. For odontocete species, however, additional studies have been conducted (on species other than sperm whales) to determine hearing sensitivities. These studies indicate the odontocete hearing sensitivity is best above about 10

kHz. It is hypothesized that the sensitivity of odontocetes to high frequency sounds is related to their use of very high frequency (VHF) sound pulses for echolocation and moderately high frequency calls for communication.

### *Direct effects on sperm whales*

#### *Changes to hearing sensitivity*

Although the sperm whale inner ear resembles that of most dolphins, and is tailored for ultrasonic (>20 kHz) reception, there are indications that the sperm whale may have hearing capability at low frequencies (Carder and Ridgway, 1990), and the species is known to be sensitive to changes in its acoustic environment (Watkins and Schevill, 1975; Watkins et al. 1985a, 1985b). 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). Based on inner ear anatomy Ketten (1994) noted that the predicted functional lower limit of hearing for sperm whale should be near 100 Hz.

Sperm whales are capable of diving deeper than 800 m. Such dives near the NPAL source could result in PTS or TTS. Aerial survey data from 1993 to 1998 indicated that sperm whales are generally found relatively far offshore of Kauai many kilometers outside of the calculated 120 dB sound field for the previous ATOC project. The data for all the surveys combined (1993-1998) show that most sperm whale sightings were on the fringes of the survey area, at about 50 - 70 km from shore. Thus, most of the sightings were of individuals located outside the area where sound levels would be potentially harmful. There was, however, an observation of three sperm whales near the ATOC sound source which occurred when the sound had been off for at least 24 hours.

Because sperm whales are not normally located within the affected area around the ATOC source, it is unlikely that any individuals will be present in the area during transmissions. Furthermore, in the unlikely event that individuals are within the affected 120-dB area, it is expected that the individuals would depart the area during ramp-up. Therefore, the probability of repeated sound exposures to the same animal sufficient to cause a PTS injury or a TTS hearing impairment, given that the proposed duty cycle is no greater than 8 percent and that the occurrence of sperm whales in the area is low, is extremely small.

#### *Masking and auditory interference*

Auditory interference or masking in odontocetes is governed by the same general principles that apply to mysticetes. Significant masking only occurs for frequencies similar to those of the masking noise. The maximum radius of influence of an introduced sound on marine mammals 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, and/or the background noise level (Richardson et al. 1995). Communication signals in beluga are subject to masking by low frequency noises of icebreakers based on laboratory, field, and modeling studies (Erbe, 2000).

Masking for sperm whales could affect communication between individuals, ability to receive information from their environment, or echolocation effectiveness. Sperm whale clicks can range to below 100 Hz, but most of the energy is concentrated at 2-4 kHz and 10-16 kHz. Although some of the lower ranges of clicks from sperm whales may be subject to masking from the sound source frequencies, due to the limited range of high sound transmissions (in an approximately 178 m radius around the sound source at 807 m depth) little, if any masking would occur as a result of NPAL source transmissions. Even if masking did occur, the effects are expected to be temporary, as sperm whales vocalize on a regular basis and the NPAL source transmits on a less than 8 percent duty cycle. Therefore, any missed opportunities for communication would be short in duration. Masking of echolocation signals are not

expected to be affected by the NPAL source because sperm whales use clicks at higher frequencies than that used for NPAL project.

#### *Potential for behavioral effects*

Behavioral disruption has the potential to affect important behavioral patterns that are essential to an individual animals' life history or to the animal's contribution to a population, or both. Impacts of this sort include behavioral manifestations which cause failure of feeding, reproduction, or another life history element due to changes in its behavioral patterns. Adoption of habitual coping behaviors may prove successful in adapting to the disturbance if the adoption fits the normal range of behavior for the individual.

As with other marine mammals, odontocetes exhibit disturbance reactions such as cessation of resting, feeding, or social interactions and/or changes in surfacing, respiration, or diving cycles, and avoidance behavior in response to certain frequencies and intensities of sound. For example, odontocetes have been observed both approaching and avoiding noisy sources, but are also relatively unresponsive to noise at low frequency (Awbrey et al. 1983). Sperm whales, however, may react to sounds at low frequencies because they can hear at low frequencies, and have been known to react to received levels of 100 dB at 3.5 kHz generated by submarine sonar (Watkins et al. 1993).

Calambokidis et al. (1998) noted sperm whales to be distributed further away from the ATOC source during experimental periods when the source was operating off of the coast of California, based on a total of 337 sperm whale sightings. The consequences of this shift is not known. A total of 8 pods were sighted within a 40-km radius during the 1994 and 1998 aerial surveys. The sightings closest to the ATOC source occurred when the source was not transmitting. A response to the ATOC source can not be detected because of the low sample size. The proposed action may result in behavioral responses in a few sperm whales over the duration of the transmissions. However, because the ATOC source area seems to support only a few sperm whales, any avoidance response would be exhibited by a few whales. If avoidance response is only a shift in the position of the whales away from the ATOC source, the consequences are expected to be minor because sperm whales are specialists of deep water habitats, and displacement to areas further off shore are not expected to disrupt biologically significant activities, such as feeding. Thus, adverse effects may occur to a few sperm whales, but would not result in population level effects.

#### *Potential for habituation*

There have been relatively few studies of habituation in marine mammals. 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).

Sperm whales occur in the vicinity of the NPAL source and occur within the action area. Habituation of the whales to the NPAL source transmission is possible, which may result in individuals closer to the NPAL source than previously recorded. Implications of habituation are not known. Changes over long periods of time of habitat utilization could be difficult to detect and the cause of the changes detected difficult to ascribe.

#### *Potential indirect effects*

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. Any effects on prey items for the sperm

whale which include primarily mesopelagic squids and fish, would be localized around the sound source. Since the sound source is not in an area known as a nursery ground for these species, these species are unlikely to be affected by the sound transmission in a way that would affect prey abundance. In addition, NPAL source area is not known to be an important sperm whale feeding area, and it is unlikely that an indirect effect of the project would be reduction in prey availability.

### **Project effects on the Hawaiian monk seal**

There have been no studies measuring the underwater vocalizations of monk seals, therefore, analogies must be made to other phocids for which information has been obtained. In general, phocids are capable of producing relatively intense underwater sounds at source levels of 95 to 178 dB at 1 m, at frequencies between 90 Hz and 150 kHz. For monk seals, there has been only one study conducted to determine hearing sensitivities. Underwater audiograms of Hawaiian monk seals indicate their best hearing is between 12 and 28 kHz at about 65 to 95 dB at 1 m (Thomas et al. 1990).

#### ***Direct effects on Hawaiian monk seals***

##### *Changes to hearing sensitivity*

The best data available on TTS in phocids is by Kastak et al. (2000) who showed that elephant seals experience TTS after a 20 minute exposure to octave-band noise at a level of about 145 dB. Presumably monk seals would respond similarly.

Monk seals can stay submerged for 20 minutes. Recent satellite tagging and time-depth recordings of monk seals show that about 10 percent of monk seal dives exceed 100 m (Parrish et al. 2000). Moreover, 3 out of 24 seals were recorded as exceeding 300 m and Ragen (ARPA/NMFS, 1994) detected monk seals diving to at least 500 m. Therefore, while it seems likely that monk seals could dive to depths where they could receive some sound levels from the NPAL source, exposure from the NPAL source is unlikely to be able to cause a TTS impairment because the monk seal would have to remain at a depth where the received level is 145 dB (approximately 316 m below sea level) for 20 minutes.

There is still potential that one or more monk seals could sustain a TTS impairment, if monk seals could incur TTS with exposures at less than 145 dB. However, because few monk seals are found off Kauai, and because current research indicates that monk seals normally feed on demersal and benthic organisms in waters shallower than 100 m (although 3 of 24 tagged seals made dives greater than 300 m), there is a low likelihood that any monk seal will experience either a TTS or PTS injury as a result of the action.

##### *Auditory interference or masking*

Significant masking occurs for frequencies similar to those of the masking noise. The maximum radius of influence of an industrial noise or NPAL 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, and/or the background noise level and frequency (Richardson et al. 1995).

It is not known to what extent monk seals experience masking from existing noise sources, including shipping. There is no evidence of a significant effect from current noise sources, but it should be recognized that such effects would be exceedingly difficult to observe. Even if direct observation of masking is possible, any masking effects on Hawaiian monk seals would be expected to be minor because of the low duty cycle of the NPAL source.

### *Behavioral effects*

There have been few studies on the effects of low frequency underwater sound on the behavior of pinnipeds. Behavior of some species has been described relative to oil drilling and production activities. Ringed seals were observed in lower densities within 3.7 km around artificial islands during drilling operations in one instance and showed no differences in density in others (Kingsley, 1986; Frost and Lowry, 1988). Ringed and bearded seals were observed approaching and diving within 50 m of an underwater sound projector emitting a steady low frequency drilling sound (>350 Hz) with a received level of about 130 dB at that distance (Richardson et al. 1995).

Pinnipeds may sometimes tolerate intense impulsive sounds with strong low frequency components in water, particularly when they are attracted to a specific area for activities such as feeding or reproduction. The limited audiometric data for Hawaiian monk seals and the variation in response by different species of pinnipeds to low frequency sounds makes it difficult to extrapolate behavioral effects. However, given the relatively poor sensitivity of monk seals to frequencies lower than 8 kHz and their limited distribution around Kauai, any potential behavioral effects would likely be limited.

### *Indirect effects on monk seals*

The principal indirect effect on Hawaiian monk seals would be the potential impact on the food chain that could ultimately affect any of the individual animals in the vicinity of the study area. The common prey species for monk seals that might occur in the study area include benthic and reef dwelling fish, eels, octopus, squid, and spiny lobsters (Rice 1964; NMFS 1980; MacDonald 1982; Watson and Peiterson 1983).

If low frequency sound transmissions were to affect any of these prey species, the impacts should be limited to the immediate vicinity of the project area with the highest received levels. Therefore, the distribution, fecundity, or other factors affecting prey availability would be within a small area and would not affect the overall availability of prey. It is unlikely that monk seals would be indirectly affected by effects of the project on prey items.

### **Summary of the potential effects on listed species**

#### *Summary of effects on mysticetes (humpback, blue, fin, sei, and right whales)*

Humpback whales are usually limited to the upper 150 m of the water column, though they have been known to dive as deep as 200 m. Average feeding depth appears to be 41-60 m. Humpbacks migrate through the project vicinity during the winter breeding season in Hawaiian waters and possibly on their way to and from their summer feeding grounds in Southeast Alaska. 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 sound transmissions could mask their vocalizations and interrupt communication among individuals. Such masking and interruption would be temporary because transmissions are 25 minutes long and operate up to an 8% duty cycle. Because of their relatively shallow diving capabilities, it is unlikely that they would experience any acute impacts such as TTS from the transmissions. As discussed above, the likelihood of an individual humpback whale remaining in the area is remote, since humpback whales typically swim parallel to the shore and at a distance from shore that is not within the area in which received levels are expected to be over 120 dB. This characteristic reduces the possibility of habituation of humpback whales to the NPAL signal. Humpback whales have been observed to increase dive times during ATOC transmission. No other response behaviors were detected. The lack of observable response behaviors does not indicate that the ATOC source is benign. However, aerial surveys conducted to date show that the distribution and abundance of humpback whales near the NPAL source has not changed. The NPAL transmissions may adversely affect humpback whales but the effects are expected to be temporary.

The potential for some masking in relation to any of the mysticetes (humpback, blue, fin, sei, or right whale) is possible, but the effects would be temporary interruptions of communication or navigation and would not likely result in the survival or reproductive abilities of individuals.

#### ***Summary of effects on sperm whales***

The sperm whale is the only listed odontocete with the potential to experience any impacts from the source transmissions. Sperm whales dive to depths of more than 2000 m and can remain submerged for an hour or more. They are usually found in the ocean at or beyond the 1000 m depth contour. Therefore, it is possible that some sperm whales could be exposed to maximum source transmissions which could result in TTS or PTS, but these effects are unlikely to occur. Limited data indicate that sperm whales may be able to hear frequencies <100 Hz, although the construction of their inner ear indicates best reception of high frequencies and ultrasonic sounds. The sounds produced by sperm whales center around two frequency bands, 2-4 kHz and 10-16 kHz, well above the frequency of the sounds transmitted. It is very unlikely that the sound transmissions would interfere with, or mask, the most common sperm whale sounds, but may affect the lowest frequencies sperm whales may use in communication, echolocation, or mechanoreception. Therefore, although the proposed sound transmissions may have the potential to adversely affect sperm whales, the likelihood of such an effect appears low because of the low numbers of sperm whales in vicinity of the NPAL sound source and the low duty cycle of transmissions. For those sperm whales that are affected, the effects would be temporary and would not lead to a reduction in the survival or reproductive capabilities of the individuals.

#### ***Summary of effects on Hawaiian monk seals***

The Hawaiian monk seal is the only pinniped likely to be found in the vicinity of the NPAL project site and study area. Based on known distribution and density of monk seals around Kauai few if any individual seals would likely be exposed to the NPAL sound source. Even if a monk seal were to dive to 500 m directly over the sound transducer, the maximum received level at that depth would be 144 dB, a level the animal would have to experience for 20 minutes continuously to experience TTS (based on Kastak and Schusterman, 2000 for elephant seals). Monk seals have not been shown to have diving capabilities for such a duration. Further, any distributional or behavioral changes, should they occur, would be extremely difficult to detect given the few individual seals that might be found within the study area. The NPAL source has a small probability of affecting individuals temporarily and in such a way that would not affect the reproductive or survival capability of the individuals.

#### **Potential effects of NMFS' proposed take regulations**

A small take authorization under the MMPA has been requested, and NMFS is proposing to issue regulations permitting the incidental taking of marine mammals during project operations. The potential effects on listed species are being evaluated in the issuance process. Some adverse effects, such as minor disturbance may occur during the course of aerial surveys to assess impacts to humpback whales, but these should be minor and not result in take. The take being authorized is for "harassment that 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" (MMPA definition of Level B harassment). This type of harassment is not expected to result in injury to animals and the disruptions to behavioral patterns are expected to be unlikely (due to the low duty cycle as well as other factors discussed previously), and if it occurs, temporary.

#### **Cumulative Effects**

"Cumulative effects" are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to

consultation. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

At this time, NMFS has no information on projects or activities of this kind in the action area. NMFS expects commercial and recreational fisheries managed by Hawaii, Alaska, and other Pacific coasts states to continue within the action area for the foreseeable future. Due to lack of good data, it is not possible to accurately estimate injury and mortality rates on humpback whales due to fisheries interactions. NMFS expects whale watching operations, vessel traffic, aircraft and helicopter tours, and research activities to continue for the foreseeable future, mostly in the winter in Hawaii and summer in Alaska. The best scientific and commercial data available provide little specific information on any long-term effects of these potential sources of disturbance on whale populations. Information on the effects of repeated harassment by research activities, vessel traffic, and whale watchers is also lacking. It appears that the number of humpback whales is not decreasing and there is insufficient information on the trends of fin, blue, sei, right, and sperm whales. Hawaiian monk seals continue to decline. Therefore, at the present time, continuation of these activities in the action area do not appear to pose any threat to humpback whales and conclusions on the cumulative effects of these disturbances can not be drawn at this time for the fin, blue, sei, right, and sperm whales, and the Hawaiian monk seal.

## **CONCLUSION**

Based on the status of the species, environmental baseline, effects of the action, and cumulative effects, NMFS concludes that the proposed action as described is not likely to jeopardize the continued existence of the endangered humpback, fin, sei, blue, right, and sperm whales or the Hawaiian monk seal, or result in the destruction or adverse modification of critical habitat considered in this biological opinion.

## **INCIDENTAL TAKE STATEMENT**

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibits the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

NMFS is not including an incidental take authorization at this time because the incidental take of marine mammals has not been authorized under section 101(a)(5) of the Marine Mammal Protection Act and/or its 1994 amendments. Following issuance of such regulations or authorizations, NMFS may amend this biological opinion to include an incidental take statement for marine mammals, as appropriate.

## **CONSERVATION RECOMMENDATIONS**

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Conservation recommendations are discretionary measures suggested to minimize or avoid adverse effects of a proposed action on listed species, to minimize or avoid adverse modification of critical habitat, or to develop additional information.

The following conservation recommendations are provided pursuant to Section 7(a)(1) of the Act to assist the project coordinators in reducing or mitigating adverse impacts to listed species that may be found within the project site resulting from the proposed project.

1. The effects of masking by low frequency anthropogenic sounds on baleen whales should be investigated through studies of similar species that are sensitive to low frequency sound. These studies should be published in scientific journals.

### **REINITIATION OF CONSULTATION**

Reinitiating of consultation and initiation of sound source shutdown procedures will be required if (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of this action that may affect listed species or critical habitat in a manner or to an extent not previously considered herein, including but not limited to information, data, or analysis indicating significant adverse impacts upon listed species or marine mammals related to low frequency sound transmissions or the initiation of a shutdown, (3) the identified action is subsequently modified in a manner that causes an effect to the listed species that was not considered in the biological opinion, or (4) a new species is listed or critical habitat designated that may be affected by the identified action.

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