3 AFFECTED ENVIRONMENT

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

3.1 PHYSICAL ENVIRONMENT

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

3.1.1 Site Description

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

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

3.1.2 Meteorology

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

3.1.3 Physical Oceanography

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

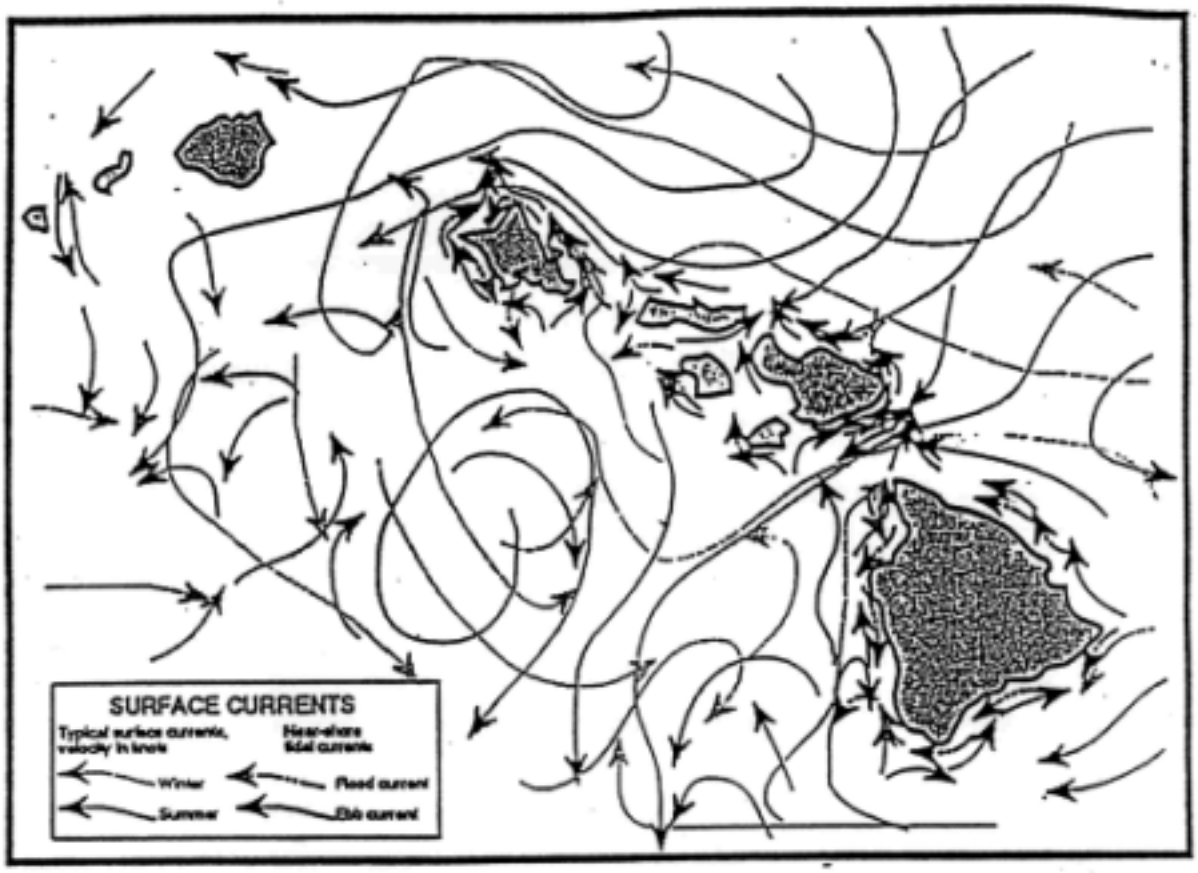
3.1.4 Water Column Characteristics

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

3.1.4.1 Temperature-Salinity Properties

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

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



(from NOAA, 1994)

Figure 3.1-1 General Current flow among Hawaiian Islands

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

3.1.4.2 Dissolved Oxygen

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

3.1.4.3 Existing Noise Setting

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

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

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

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

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

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

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

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

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

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

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

3.1.5 Regional Geography and Geology

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

3.1.5.1 Regional Subsea Geography

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

3.1.5.2 Seismic Activity

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

3.1.5.3 Bottom Conditions

The sea bottom at the Kauai site is composed of mixed sand, coral, and basalt throughout. Coral and sand predominates in shallow, near-shore waters of less than 100-m (328-ft) depth. In water depths ranging between 45 and 67 m (148 and 220 ft), the exposed reef is dissected by large sand-

bottom surge channels. Erosion-based basaltic sediments are found as water depth increases, with large sand ripples on the western edge of the shelf off Kauai (SSI, 1993).

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

3.2 BIOLOGICAL ENVIRONMENT

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

3.2.1 Species Screening

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

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

- Does the area receiving sound from the proposed sound source overlap the distribution of this species? If so,
- Is the species capable of being physically affected by LF sound? Are acoustic impedance mismatches large enough to enable LF sound to have a physical effect?
- Can the species sense LF sound?

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

In cases where direct evidence of acoustic sensitivity was lacking for a species, reasonable indirect evidence was used to support the evaluation (e.g., there is no direct evidence that a species hears LF sound but good evidence that the species produces LF sound). In cases where important biological information was not available or was insufficient for one species, but data were available for a related species, the comparable data were used.

3.2.1.1 Invertebrates

Several invertebrate groups can be eliminated from further consideration because: 1) they do not have delicate organs or tissues whose acoustic impedance is significantly different from water; and 2) there is no evidence of auditory capabilities in the LF range used by the sound source. These include plankton, phytoplankton, zooplankton, ichthyoplankton, benthic infauna, demersal epifauna (corals, molluscs, barnacles), and echinoderms (urchins, sea stars, sea cucumbers). Siphonophores and some other jelly plankton do have air-filled bladders, but because of their size, they do not have a resonance frequency sensitive to the low frequencies used.

Among invertebrates, only cephalopods (octopus and squid) and decapods (lobster, shrimp, and crab) are known to sense LF sound (Offutt, 1970; Budelmann and Young, 1994). Based on Budelmann's measurements, the cephalopod threshold for hearing for far-field sound waves is estimated to be 146 dB. The hearing threshold for the American lobster has been determined to be approximately 150 dB in the LF range (Offutt, 1970). Given these high levels of hearing thresholds, operations of the sound source would not impact on these animals. Therefore, cephalopods and decapods have been eliminated from further consideration because of their poor LF hearing sensitivity.

3.2.1.2 Vertebrates

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

Baleen Whales (Mysticetes)

All 11 species of baleen whales produce LF sounds (summarized in Richardson et al., 1995). Sounds may be used as contact calls, for mating displays, for maintaining the cohesion of the migratory herd, and possibly for navigation and food finding. Although there are no direct data on auditory thresholds for any mysticete species, anatomical evidence strongly suggests that their inner ears are well adapted for low frequency hearing (Ketten, 1998). Therefore, sound perception and production are assumed to be critical for mysticete survival. For this reason all mysticete species are considered sensitive to LF sound. However, only six species of mysticetes, or baleen whales, are known to be frequently or infrequently found in the Kauai and/or Midway Atoll areas. This includes the humpback (*Megaptera novaeangliae*), fin (*Balaenoptera physalus*), blue (*Balaenoptera musculus*), northern right (*Eubalaena glacialis*), Bryde's (*Balaenoptera borealis*), and minke (*Balaenoptera acutorostrata*) whales.

Toothed Whales (Odontocetes)

There are at least 70 species of odontocetes; some species classifications are under study, and the exact number of beaked whales is not known. Odontocetes include dolphins, porpoises, beaked whales, blackfish (long-finned pilot, pygmy killer, false killer, melon-headed, short-finned pilot),

killer whales, and sperm whales. Sixteen of these species may potentially inhabit ocean areas where the sound source might operate -- especially several species of pelagic dolphins, beaked whales, sperm whales, and blackfish. Many of these species are known to use high frequency clicks for echolocation (Au, 1993). All species studied to date hear best in the mid to high frequency range, and so are less likely to be directly affected by exposure to LF sounds than mysticetes (Au, 1993). Like mysticetes, odontocetes depend on acoustic perception and production for communication, food finding, and probably for navigation and orientation.

Pinnipeds

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

Sea Turtles

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

Fishes

In general, fishes perceive sound in the 50-2000 Hz band, and peak sensitivity lies below 800 Hz. Of the estimated 27,000 fish species only a small percentage have been studied in terms of audition or sound production. There are no known fish species that are deaf. Of those studied, many fishes produce vocalizations in the low frequency band. Hearing or sound production is documented in 247 species comprising 58 families and 19 orders. Although there are diverse morphological and physiological mechanisms of hearing in fishes, hearing capabilities seem relatively homogenous within orders (Popper and Fay, 1993).

Seabirds

There are more than 270 species of seabirds in five orders. There are few data on hearing in seabirds and even less on underwater hearing. Studies with other species have shown that birds are highly sensitive to LF sounds in air. While it is likely that many diving seabirds can hear LF sound, there is no evidence that seabirds use sound underwater. Seabirds that are known to occur in the area of the sound source are generally shallow divers (less than 20 m [66 ft]). In addition, seabirds spend a very small fraction of their time submerged, and they can rapidly disperse to other areas if disturbed. Details of the seabirds in the areas of Kauai and Midway Atoll are discussed in Section 3.2.5. However, because these birds are all shallow divers, there should be

negligible potential for impact to them, including those that may be listed as threatened, endangered, or special status. For these reasons, seabirds have been excluded from further evaluation.

3.2.2 Marine Mammals

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

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

3.2.2.1 Mysticetes

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

<u>Humpback Whales</u>

Humpback whales occur worldwide in both coastal and open ocean areas, with estimated abundances of approximately 6,000 in the North Pacific (Calambokidis et al., 1997; Cerchio, 1998; Mobley et al., 1999c). Estimates of the number of individuals in the Northern Pacific stock have recently risen. Estimates in the 1980's ranged from 1407 to 2,100 (Baker, 1985; Darling and Morowitz, 1986; Baker and Herman, 1987). Photographic resight studies estimate 6,010 animals