

(S.E. = 474) for the entire North Pacific (Calambokidis et al., 1997). Cerchio (1998) estimated that about 4,000 animals visit Hawaii annually. Aerial surveys conducted between 1976 and 1990 found a significant increase in sighting rates of humpbacks over that time (Mobley et al., 1999a), consistent with the increase in photographic estimates. Finally, aerial survey data using line-transect methodologies were conducted in 1993, 1995 and 1998. Hawaiian population estimates derived from the sighting data in Table 3.2-1 show an increase from 2717 (+/- 608) in 1993, to 3284 (+/- 646) in 1995 and 3852 (+/- 777) in 1998 (Mobley et al., 1999b).

Humpback whales typically migrate between tropical/sub-tropical and temperate/polar latitudes. The whales occupy tropical areas during winter months when they are breeding and calving, and polar areas during the spring, summer, and fall, 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). Maximum diving depths for humpbacks are approximately 150 m (492 ft) (but usually <60 m [197 ft]), with a very deep dive (240 m [787 ft]) recorded off Bermuda (Hamilton et al., 1997). They may remain submerged for up to 21 min (Dolphin, 1987). Humpback whales are endangered under the Endangered Species Act (ESA) and protected under the Convention on International Trade in Endangered Species (CITES).

Three sounds are produced by humpback whales: "songs" produced in late fall, winter, and spring by single animals; sounds produced by groups of humpback whales (possibly associated with aggressive behavior among males) on the winter breeding grounds; and sounds produced on the summer feeding grounds. The frequencies of these songs range from 40 Hz or lower, up to 4 kHz, with components of up to 8 kHz (Thompson et al., 1979). Source levels average 155 dB and range from 144 to 174 dB (Thompson et al., 1979). The songs appear to have an effective range of approximately 10 to 20 km. Sounds often associated with possible aggressive behavior by males (Tyack, 1983; Silber, 1986) are quite different from songs, extending from 50 Hz to 10 kHz (or higher), with most energy in components below 3 kHz. These sounds appear to have an effective range of up to 9 km (Tyack and Whitehead, 1983). Sounds are produced less frequently on the summer feeding grounds and are at approximately 20-2000 Hz, with median durations of 0.2-0.8 sec and source levels of 175-192 dB (Thompson et al., 1986).

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 100-fathom (fm) (183-m [600-ft]) 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 (4593 ft). Cow/calf pairs appear to prefer very shallow water less than 18 m (10 fm [60 ft]) (Glockner and Venus, 1983). At Kuili off the Big Island, Smultea (1989) found significantly more cow/calf pairs in water <55 m (180.5 ft) 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

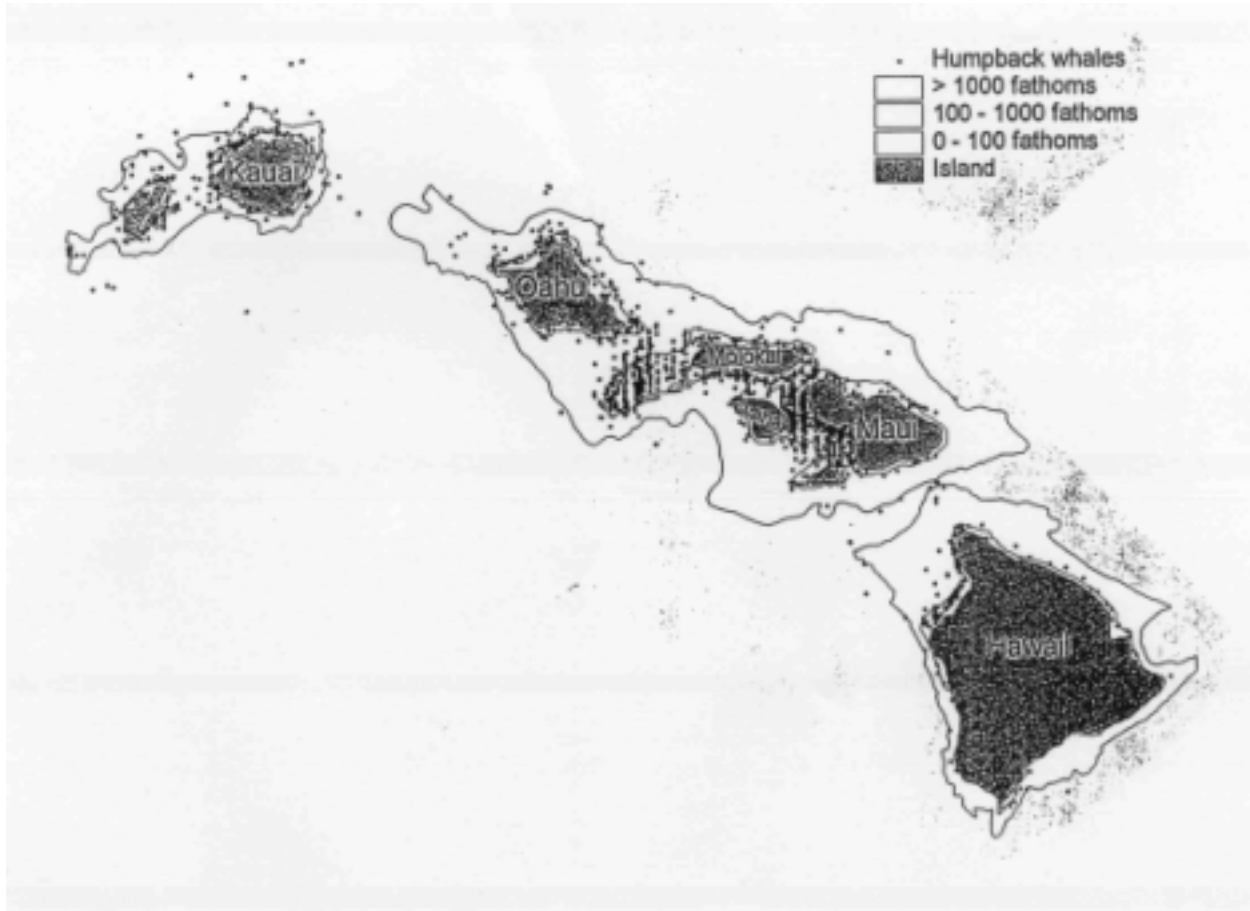


Figure 3.2-1 1993-1998 Sightings of Humpback Whales (Mobley et al., 1999b)

(Salden, 1988; Glockner-Ferrari and Ferrari, 1990). Figure 3.2-1 depicts the locations of humpback whale sightings during the 1993-1998 MMRP aerial surveys (Mobley et al., 1999b).

Humpback calves are found most often in the “four-island” region, consisting of Maui, Molokai, Lanai, and Kahoolawe. Statewide aerial surveys conducted between 1993 and 1998 found that 67% of the calves were found in that area (Mobley et al., 1999b). During those surveys, 26,966 nautical miles (49,941 km) of effort were flown and 1,678 pods of humpbacks were seen. Approximately 16% of the calves were seen off Kauai. During shore-based scan samples conducted from Princeville, Kauai, on the north shore in 1994 and 1998, 571 pods were sighted, 17 of which had calves (Frankel, pers. comm.).

Humpback whales are rarely, if ever, seen near Midway Atoll, and it is not thought to support breeding or feeding of this species; thus, the potential for visits to the atoll by humpbacks is low.

Fin Whales

The fin whale is widely distributed and is found in all oceans of the world in pelagic and coastal areas. Most populations appear to be recovering from commercial whaling, and the global population estimate is about 100,000-150,000 (Maser et al., 1981; US Department of Commerce, 1983). They are currently endangered under the ESA and protected under CITES.

Fin whales feed primarily upon planktonic crustaceans, but also take fish and squid (Gambell, 1985; Piatt et al., 1989; Piatt and Methven, 1992). 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, pers. obs). Croll and Tershy (pers. obs.) recorded dive depths of 100-200 m (330-660 ft), with maximum depths of 300 m (1,000 ft). 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 (1722 ft) (Charif et al., submitted). Foraging areas tend to occur along continental shelves with productive upwellings or thermal fronts (Gaskin, 1972; Sergeant, 1977; Nature Conservancy Council, 1979). They 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).

It is assumed that distribution and movement patterns consist of seasonal migrations between higher latitudes for foraging and lower latitudes for mating and calving (Lockyer, 1984, Mackintosh, 1965). Recent 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). Swimming speeds can be very high, with average rates between 9-12 kilometers per hour (km/hr) (5-7 kt) (Ray et al., 1978; Watkins, 1981). 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).

Fin whales produce a variety of low frequency sounds, primarily in the 15-200 Hz band (Watkins, 1981; Watkins et al., 1987; Edds, 1988; Thompson et al., 1992;). The most typical signals are long, patterned sequences of short duration (0.5-2 seconds) infrasonic pulses in the 18-35 Hz range (Patterson and Hamilton, 1964; Watkins et al., 1987). Estimated source levels are as high as 186 dB (Patterson and Hamilton, 1964; Watkins et al., 1987; 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 FM calls in the 20-70 Hz band are associated with animals in social groups (Clark, pers. obs.; McDonald, pers. comm.; Watkins, 1981; Edds, 1988; McDonald et al., 1995). The seasonality of the bouts of patterned sounds suggests that these are male reproductive displays (Watkins et al., 1987), while the individual counter-calling data of McDonald et al. (1995) suggest that the more variable calls are contact calls.

There are no data on hearing sensitivity for fin whales. In a study of the morphology of the mysticete auditory mechanics, Ketten (1994) hypothesized that the fin whale has excellent LF hearing.

Fin whales, while uncommon in tropical waters, may occur within 200 nm (370 km) of Hawaii during winter months, when they disperse throughout the lowest latitudes of their distribution (Balcomb, 1987). A single fin whale sighting occurred approximately 37 km (20 nm) north of Kauai in 1994 (Mobley et al., 1996). No fin whales have been observed near Midway Atoll.

Blue Whales

The blue whale occurs in all oceans of the world. They are primarily pelagic but are found along shelf areas during feeding (Yochem and Leatherwood, 1985). The global population estimate is about 11,200-13,000 individuals U.S. Department of Commerce, 1983; Maser et al., 1981) with some stocks at extremely low levels as a result of commercial whaling. Blue whales are currently endangered under the ESA and protected under CITES.

Blue whales grow to lengths of more than 30 m (98.4 ft). Blue whales feed almost exclusively on euphausiids, or krill, with dive depths tracking the depths of prey schools (Rice, 1978; Croll et al., 1999). 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 and Tershy, pers. obs.). Croll and Tershy (pers. obs.) found that the dive depths of blue whales foraging off the coast of California during the day averaged 132 m (433 ft) with a maximum recorded depth of 204 m (672 ft) and a mean dive duration of 7.2 minutes. Nighttime dives are generally less than 50 m (165 ft) in depth (Croll and Tershy, pers. obs.; Croll et al., 1999). Important foraging areas include the edges of continental shelves and ice edges in polar regions (Yochem and Leatherwood, 1985; Reilly and Thayer, 1990). Swimming speeds during feeding are in the 0-6.5 km/hr (0-3.5 kt) range.

Traditionally, it was assumed that distribution and movement patterns consisted of seasonal migrations between higher latitudes for foraging and lower latitudes for mating and calving

(Lockyer, 1984; Mackintosh, 1965). More recent 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). Swimming speeds during migration are between 5-33 km/hr (2.7-17.8 kt) (Lockyer, 1981; Gagnon and Clark, 1993).

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 some time during the fall and winter when blue whales are in middle latitudes.

Blue whales produce a variety of LF sounds in a 10-100 Hz band (Cummings and Thompson, 1971; Edds, 1982; Thompson and Friedl, 1982; Alling and Payne, 1991; 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. Estimated source levels are as high as 188 dB (Cummings and Thompson, 1971). 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 frequency-modulated (FM) calls in the 30-90 Hz band are associated with animals in social groups (Clark, pers. obs.; McDonald, pers. comm.). The seasonality and structure of long, patterned sounds suggest that these are male song 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.

There are no data on hearing sensitivity for blue whales. In a study of the morphology of the auditory mechanics, Ketten (1994) hypothesized that the blue whale has excellent LF hearing.

Blue whales have never been observed in the Hawaiian archipelago; however, their range could overlap the study area. The range of blue whales also overlaps the Midway Atoll region; however, none have been reported near this site.

Northern Right Whales

Northern right whales occur in both the Atlantic and Pacific oceans. The Northern Pacific population is estimated at 100 animals, making the northern right whale the most endangered large whale in the world. Several of the stocks are nearly extinct or extremely endangered. From late winter to fall they breed and give birth in temperate shallow areas, migrating into higher latitudes where they feed in coastal waters during the winter through fall. Right whales are endangered under ESA and protected under CITES.

Right whales feed primarily on copepods but sometimes feed on euphausiids (krill) along coastal areas (Omura, 1958; Omura et al., 1969). They have been known to occasionally move offshore into deep water, presumably for feeding (Mate et al., 1997). They typically feed by surface skimming but will on occasion dive through the water column to reach deeper layers of food (Jefferson et al., 1993). Northern right whales dive as deep as 306 m (1,000 ft) (Mate et al., 1992). In the Great South Channel, average northern right whale dive times were nearly two

minutes; the average dive depth was 7.3 m (24 ft) and the maximum at 85.3 m (280 ft) (Winn et al., 1994). On the outer continental shelf of the US, the average northern right whale diving time was about 7 minutes (CETAP, 1982). Six northern right whales tracked by satellite had average swim speeds of 1-3.5 km/hr (0.5-1.9 kt); average speeds in breeding areas ranged from 0-4 km/hr (0-2.2 kt) (Mate et al., 1997).

Maximum source levels for right whale calls have been estimated at 172-187 dB (Cummings et al., 1972; Clark, 1982). Northern right whales produce LF moans below 400 Hz (Watkins and Schevill, 1972; Thompson et al., 1979; Spero, 1981). There are no data on hearing sensitivity for right whales. In a study of the morphology of the auditory mechanics, Ketten (1994) hypothesized that right whales have excellent LF hearing.

Right whales can be found in nearshore habitats and bays from the Bering Sea to central Baja California. A single right whale was observed in 1979 near Maui (Herman et al., 1980). Right whales are typically observed in temperate and subpolar waters. It is highly unlikely that this species occurs within the Kauai study area. No right whales have ever been reported in the vicinity of Midway Atoll.

Bryde's Whale

The Bryde's whale is found in low densities throughout the tropical and subtropical waters of the world (Omura, 1959). They are most commonly encountered in waters warmer than 15-20°C (60-70°F), between 40°N and 40°S latitudes. Population estimates for most regions are not available. In the western North Pacific, estimates range from 10,000 (Best, 1975) to 49,000 (Ohsumi, 1978). Nishiwaki (1972) speculated that due to this species' limited migration and confined distribution, the total world population is likely to be relatively small.

Bryde's whales feed primarily on schooling fish (i.e., sardines, herring, pilchard, mackerel) and euphausiids (Best, 1960; Nemoto and Kawamura, 1977; Cummings, 1985a; Tershy, 1992; Tershy et al., 1993). Tershy (1992) reports that Bryde's whales increased feeding around dawn and dusk. Cummings (1985a) reports that Bryde's whales come to the surface as often as every minute and dive for as long as 20 minutes. Dive depths are not known but are assumed to be similar to those of blue and fin whales.

Best (1960) reported that Bryde's whales breed throughout the year off South Africa, and Tershy et al. (1990) reported Bryde's whale calves present throughout the year in the Gulf of California. However, Best (1975) also reported that the offshore population off South Africa bred only in the fall. Data on the speed of travel are not available, but are assumed to be similar to those of blue and fin whales (Croll and Tershy, pers. obs.). There is some evidence that Bryde's whales remain resident in areas throughout the year, migrating only short distances (Best, 1960; Tershy, 1992). Based on limited sound recordings, Bryde's whales are known to produce a variety of short-duration (0.2 to 1.5 second), FM sounds in the 70-245 Hz band (Cummings, 1985a; Edds et al., 1993). Source levels were estimated at 156 dB. The function of Bryde's whale vocalizations is not known, but sounds are assumed to be used for communication.

There are no data on hearing sensitivity for the Bryde's whale. By comparison to what little is known about Balaenopterid auditory mechanics, it is assumed that the Bryde's whale has excellent LF hearing (Ketten, 1994).

Bryde's whales are very rare around the main Hawaiian Islands, but are somewhat more common around Midway Atoll (Leatherwood et al., 1988).

Minke Whales

The minke whale is found throughout all oceans of the world. As with other balaenopterids, minke whales migrate to higher latitudes where they feed during the late spring through early fall and to lower latitudes where they breed during the fall through winter. They have been commercially exploited since at least 1923 (Kellogg, 1931), but global populations appear to be healthy.

When traveling, minke whales surface once or twice before sounding (Horwood, 1981) and are thus easily missed. Because they feed on small schooling fish near the surface, dive depths are likely to be relatively shallow (less than 300 m or 1,000 ft). Normal swimming speed has been reported as 6.1 km/hr (3.2 kt) (Lockyer, 1981). During migration, speeds of up to 25.9 km/hr (14 kt) have been observed (Lockyer, 1981). Folkow and Blix (1993) radio-tagged four minke whales and reported that surfacing rates were significantly higher during the day than at night. Markussen et al. (1992) modeled the activity budget of minke whales and assumed that 6 hr/day is spent in resting or sleeping, 14 hours per day is spent swimming at 6.1 km/hr (3.3 kt), and 4 hours per day is spent swimming at 25.9 km/hr (14 kt).

Breeding appears to take place during the winter in warmer waters, but little is known of breeding areas (Kasamatsu et al., 1995). Kasamatsu et al. (1995) also suggested that breeding populations are relatively dispersed in open waters.

Minkes produce a variety of sounds, primarily in the 80-5,000 Hz range. In the Northern Hemisphere, sounds recorded include "grunts," "thumps," and "ratchets" from 80-850 Hz and pings and clicks from 3.3-20 kHz. Most sounds during the winter consist of 10-60 second sequences of short 100-300 microsecond pulses (Schevill and Watkins, 1972; Winn and Perkins, 1976; Thompson et al., 1979; Leatherwood et al., 1981; Mellinger and Clark, 1997; Gademke, pers. comm.). Sounds recorded in the Southern Hemisphere include "whistle series, clanging bell series, clicks, screeches, low frequency grunts, and frequency modulated sweeps" (Leatherwood et al., 1981). The function of minke whale vocalizations is unknown, but they are assumed to be used for communication. There are no data on hearing sensitivity for the minke whale. By comparison to what little is known about Balaenopteran auditory mechanics, it is assumed that the minke whale has excellent LF hearing (Ketten, 1994).

Minke whales are sometimes seen around the northwest islands of Hawaii (Leatherwood et al., 1988).

3.2.2.2 Odontocetes

Sixteen species of toothed whales and dolphins may be found in the Kauai and Midway Atoll areas. Aerial survey sightings within 35 km (18.9 nm) of the Kauai site during the MMRP are listed in Table 3.2-1 (Mobley et al., 1999b).

The following species of odontocetes were sighted in or near the proposed area during surveys conducted between 1993 and 1998 by the University of Hawaii under NMFS permit No. 810: sperm whales (*Physeter macrocephalus*), short-finned pilot whales (*Globicephala macrorhynchus*), beaked whales (*Ziphius cavirostris*, *Berardius bairdi*, and *Mesoplodon* spp.), spinner and spotted dolphins (*Stenella* spp.), bottlenose dolphins (*Tursiops truncatus*), and rough-toothed dolphins (*Steno bredanensis*).

Other species believed to inhabit the area include pygmy sperm whales (*Kogia breviceps*), dwarf sperm whales (*Kogia simus*), striped dolphins (*Stenella coeruleoalba*), killer whales (*Orcinus orca*), false killer whales (*Pseudorca crassidens*), pygmy killer whales (*Feresa attenuata*), and melon-headed whales (*Peponocephala electra*). Based on the limited density data available, it is believed that the population abundance of these species is quite small.

Sperm Whales

Sperm whales, although listed as endangered, are considered to be the most abundant of the large whale species, numbering an estimated 1,900,000 animals worldwide (Rice, 1989). Berzin (1971) reported that they are restricted to waters deeper than 300 m (984 ft), while Watkins (1977) and Whitehead and Weilgart (pers. comm., 1993) reported that they are usually not found in waters less than 1000 m (3281 ft) deep. While deep water is their typical habitat, sperm whales have been observed near Long Island, NY, in waters of 41-55 m (135-180 ft) (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 (6562 ft), and may remain submerged for an hour or more (Watkins, 1993). Sperm whales feed primarily on buoyant, relatively slow-moving squid (Clark et al., 1993), but may also eat a variety of fish (Caldwell and Caldwell, 1983). Sperm whales are endangered under ESA and protected under CITES.

Stock definition (i.e., identification of separate stocks) and stock structure (i.e., sex and age composition associated with future reproductive success) are not well understood in sperm whales, although well established populations occur in each major ocean basin. There also is uncertainty about the methods and models used to estimate historical and present abundances (e.g., International Whaling Commission [IWC], 1988). As such, a full assessment of the status of the individual stocks is not possible at this time. Table 3.2-1 lists the best estimate of sperm whale stock in the Kauai area.

During summer, sperm whales migrate to higher latitudes, with mature males migrating much farther north than females and younger males. In the Pacific Ocean, females and younger whales usually remain in tropical and temperate waters (between 40°N and 45°S Latitude [Rice, 1978]),

while males continue north to the Gulf of Alaska, Aleutian Islands, and the Bering Sea, or south to the Antarctic. Females and younger animals may be restricted in their migrations by an intolerance to low water temperatures. Breeding herds are confined almost exclusively to warmer waters, and many of the larger males return to lower latitudes in the winter to breed. Sperm whales in the Pacific Ocean during this time are usually distributed below 40°N Latitude. Historically, sperm whaling grounds in the Pacific south of 40°N Latitude were located around the Hawaiian Islands, among other areas. Sperm whales are considered fairly common around Midway Atoll (Leatherwood et al., 1988).

Pygmy and Dwarf Sperm Whales

The pygmy and dwarf sperm whales are small, relatively solitary, apparently deep-diving, whales that live in temperate to tropical deep waters from 60°N to 40°S around the world. They are especially common along continental shelf breaks (Evans, 1987; Jefferson et al., 1993). Very little is known about any aspect of their biology, although they are thought to be relatively abundant. Based on their geographic distribution and the habitat of their preferred prey, it is likely that both species are deep divers. In the Gulf of California, dwarf sperm whales dive for as long as 43 minutes (Breese and Tershy, 1993). Surface behavior of *Kogia* spp. in the Gulf of California consisted of resting at the surface for approximately one minute, followed by a brief dive of less than three minutes (Willis and Baird, 1998). In the same area, 59 dive intervals of *Kogia* spp. indicated a median dive time of 8.6 minutes and a median resting time at the surface of 1.2 minutes; dives up to 25 minutes and resting periods at the surface of up to 3 minutes were common (Willis and Baird, 1998).

There are no data on vocalizations in the wild for either pygmy or dwarf sperm whales. Recent recordings from captive pygmy sperm whales indicate that they produce sounds between 60 and 200 kHz with peak frequencies at 120-130 kHz (Santoro et al., 1989; Carder et al., 1995). Thomas et al., (1990) recorded a LF sweep ascending sound, heard singly or in pairs, between 1.3 and 1.5 kHz from a captive pygmy sperm whale. An auditory brainstem response study indicates that pygmy sperm whales have their best underwater hearing range between 90-150 kHz (Carder et al., 1995).

Killer Whales

The killer whale is perhaps the most cosmopolitan of all marine mammals, found in all the world's oceans from about 80°N to 77°S (Leatherwood and Dahlheim, 1978). However, they appear to be more common within 800 km (430 nm) of major continents in cold temperate to subpolar waters (Mitchell, 1975). None were observed during the MMRP surveys. The killer whale is the largest member of the family Delphinidae and one of the best-studied species. They have perhaps the most diverse food habits of any marine mammal, feeding on fishes, cephalopods, pinnipeds, sea otters, whales, dolphins, seabirds, and marine turtles (Hoyt, 1981; Gaskin, 1982; Jefferson et al., 1991). They have low reproductive rates.

The deepest dive recorded by a killer whale is 265 m (870 ft), reached by a trained individual (Ridgway, 1986). In the Bering Sea there is some suggestion that killer whales prey on fish at

water depths of 200-300 m (660-990 ft) or more (Yano and Dahlheim, 1995a, 1995b). In southern British Columbia and northwestern Washington State, killer whales spend more than 70 percent of their time in the upper 20 m (66 ft) of the water column; but they dive to 100 m (330 ft) or more, with a maximum recorded dive of 201 m (660 ft) (Baird et al., 1998). Dive durations recorded range from 1 to 10 minutes (Norris and Prescott, 1961; Lenfant, 1969; Baird et al., 1998). Swimming speeds usually are 6-10 km/hr (3.2-5.4 kt), but they can achieve speeds up to 40 km/hr (22 kt) (Lang, 1966).

Killer whales have perhaps one of the most stable and cohesive animal societies, in which vocalizations play an essential role. Their signals carry information regarding geographic origin, individual identity, pod membership, and activity level. As they use stealth for hunting marine mammal prey, hearing is critical to success (Thomas et al., 1981; Hoelzel and Osborne, 1986; Bain, 1989). Killer whales produce sounds as low as 100 Hz and as high as 85 kHz with dominant frequencies at 1-20 kHz (Schevill and Watkins, 1966; Diercks et al., 1971, 1973; Evans, 1973; Steiner et al., 1979; Awbrey et al., 1982; Ford and Fisher, 1983; Ford, 1989). Killer whales listen underwater to sounds equal to or softer than 120 dB in the range of <500 Hz to 105 kHz (Hall and Johnson, 1972; Bain et al., 1993). Their best underwater hearing occurs at 15 kHz, where the threshold level is 34 dB (Hall and Johnson, 1972).

False Killer and Pygmy Killer Whales

False killer whales and pygmy killer whales are found infrequently in Hawaiian waters during all seasons (Balcomb, 1987). Both species travel in groups of half a dozen to over several hundred individuals. Prey for these species include many species taken by humans, such as dolphin fish or mahi mahi (*Coryphaena hippurus*) and squid. False killer and pygmy killer whales likely are able to dive as deep as killer whales, but probably no deeper. Mobley et al. (1999b) reported 324 individuals during the statewide MMRP surveys (Table 3.2-1). No false killer whales or pygmy killer whales have been reported near Midway Atoll.

Pilot Whales

Pilot whales are among the most ubiquitous and numerous of all cetaceans, occurring worldwide in all but polar seas (Balcomb, 1987). Off the Hawaiian Islands, the most abundant pilot whale species is the short-finned pilot whale. This species occurs year-round in Hawaiian waters in herds of 20-40 individuals, with aggregations of over 100 occasionally observed. Radiometric studies have shown that these whales can dive to depths of at least 610 m (2000 ft) (Leatherwood and Reeves, 1983), feeding on squid and fish (Caldwell and Caldwell, 1983). A total of 774 short-finned pilot whales were reported in the 1993-1998 statewide surveys (Mobley et al., 1999b). No pilot whales have been reported off Midway Atoll.

Beaked Whales

Three species of beaked whales, including Baird's, Blainville's, and Cuvier's beaked whale occur in Hawaiian waters (Balcomb, 1987). Overall, there is much uncertainty about the number and seasonal distribution of beaked whales. While it is extremely unlikely to find Baird's beaked whales around the main Hawaiian Islands, 16 individuals were observed in the 1993-1998 aerial

survey effort (Mobley et al., 1999b). In recent years, a few individuals were identified and photographed in Hawaii. Two Blainsville's beaked whales were reported to have stranded on Midway Atoll (Leatherwood et al., 1988). The most widely distributed of all beaked whales, Cuvier's beaked whale, occur year-round in deep offshore Hawaiian waters. Mobley et al. (1999b) reports sightings of 13 Cuvier's beaked whales during the 1993-1998 statewide aerial surveys. Similar to the other beaked whales off Hawaii, Cuvier's beaked whales have only been observed and photographed on rare occasions. Most beaked whales are thought to forage offshore in relatively deep water (Leatherwood et al., 1987; Mead, 1989), diving as deep as 1000 m (3281 ft) (Matsuura, 1943; Pike, 1953; Tomilin, 1957; Balcomb, 1987), feeding on various fish and squid (Balcomb, 1987). Three Cuvier's beaked whales been reported to have stranded on Midway Atoll (Galbreath, 1963).

Melon-headed Whales

Melon-headed whales are poorly-known, small odontocetes. They have a distribution from 20°S to 20°N (Jefferson and Barros, 1997). Melon-headed whales feed on mesopelagic squid found down to 1,500 m (4,920 ft) deep, so they appear to feed deep in the water column (Jefferson and Barros, 1997). Melon-headed whale sounds are low level, with maximum source levels estimated at 155 dB for whistles and 165 dB for click bursts. Individual click bursts of 0.1 to 0.2 seconds with 40 or more clicks at repetition rates up to about 1,200/second have frequency emphases between 20 and 40 kHz. Dominant frequencies of whistles are 8-12 kHz, with both upswept and downswept frequency modulation (Watkins et al., 1997).

Bottlenose Dolphins

Bottlenose dolphins are probably the best known of all cetaceans due to their inherent presence around vessels and their high survival rate and adaptability in captivity (Balcomb, 1987). Around Hawaii, there are numerous populations of this species occupying harbors and coastlines. Bottlenose dolphins feed on a wide variety of fish, squid, shrimp, and crab (Caldwell and Caldwell, 1983). They can dive to maximum depths of up to 535 m (1755 ft), remaining submerged for up to 8 min (Kanwisher and Ridgway, 1986). Bottlenose dolphins have been reported near Midway Atoll (Shallenberger, 1981).

Spinner Dolphins

Spinner dolphins (*Stenella longirostris*) are found in tropical oceans throughout the world (Balcomb, 1987). In Hawaiian waters, they gather in large herds at night, offshore and in deep channels between the islands, for feeding. They disperse during the day into smaller groups and move into nearshore resting habitats (Balcomb, 1987). A total of 1596 spinner dolphins were reported during recent 1993-1998 statewide aerial surveys (Mobley et al., 1999b). Feeding habits and diving depths of this species are largely unknown, but it is unlikely they dive deeper than bottlenose dolphin (535 m [1755 ft]). Spinner dolphins are seen regularly around Midway in large numbers (Norris et al., 1994).

Rough-toothed Dolphins

Rough-toothed dolphins are relatively common in the vicinity of the Hawaiian Islands in offshore waters, typically occurring over bottom depths greater than 500 m (1640 ft) (Balcomb, 1987). This species usually travels in groups of 3-4 individuals with sometimes many small groups utilizing one area. Rough-toothed dolphins feed primarily on pelagic invertebrates, such as squid and octopus (Caldwell and Caldwell, 1983). Only 136 rough-toothed dolphins were reported in the 1993-1998 statewide aerial surveys (Mobley et al., 1999b) and were regularly seen from a survey vessel in the vicinity of the ATOC source location (Frankel, pers. obs.). This species is probably capable of diving to relatively moderate depths (e.g., 300 m [984 ft]), based on the type of prey consumed (Balcomb, 1987).

Spotted Dolphins

Several species of spotted dolphins inhabit tropical oceans and seas worldwide (Balcomb, 1987). In the vicinity of the Hawaiian Islands, the most common species of spotted dolphin is *Stenella attenuata*. These dolphins travel in large herds, sometimes exceeding 1000 individuals. They feed primarily in offshore waters on squid and fish (Balcomb, 1987; Caldwell and Caldwell, 1983), and probably are able to dive to moderate depths (e.g., 300 m [984 ft]). Mobley et al. (1999b) reported sighting 849 spotted dolphins in the statewide surveys.

Although little site-specific information exists on most of the above dolphin species in the vicinity of Midway Atoll, it is likely that some of these species are present in offshore waters near the atoll.

3.2.2.3 Pinnipeds

The Hawaiian monk seal or ilio-holo-i-ka-uaua (*Monachus schauinslandi*) occurs only in the Hawaiian Islands, where its greatest distribution is in the small, mostly uninhabited chain of islands and atolls stretching 1100 nm (2037 km) northwest of the main Hawaiian Islands, most of which are included in the Hawaiian National Wildlife Refuge (USFWS, 1984; Tomich, 1986). Hawaiian monk seals are listed as endangered under the ESA and protected under CITES.

This is the only pinniped species known to occur within the general study region. Monk seals are reported from around the main Hawaiian Islands (USFWS, 1984). They tend to stay near land (Tomich, 1986), and small numbers (1-4) are regularly seen around Kauai and each of the other main Hawaiian Islands (Nitta, pers. comm., 1995). There is a small undetermined population on Niihau. Most pups are born between March and May, but pupping has been recorded year-round (U.S. Dept. of Commerce, 1986). A single female gave birth to a female pup on the north coast of Kauai in 1988 (Reeves et al., 1992) and a pup was born in the Poipu Beach area during the

summer of 1989 (Naughton, pers. comm., 1990a). There were three monk seal sightings on Kauai in 1993 (Anahola, Kipu Kai, and Kapaa). One monk seal was observed off the north shore of Kauai during recent shore-based MMRP surveys (Smultea et al., 1994). Virtually nothing is known about the distribution and movement patterns of this species when they are at sea (Gilmartin, 1983; U.S. Dept. of Commerce, 1986).

Counts of Hawaiian monk seals have been made since the late 1950s at the atolls, islands, and reefs where they haul out on the northwest Hawaiian Islands (NMFS, 1991). In 1982, the highest count for all atolls was about 50% of those made in 1957-58. NMFS (1991) estimates that currently the monk seal population is slightly more than 1000 animals. By most recent counts, it appears that the population is declining at about 5%/yr (Ragen, pers. comm., 1995). However, based on data collected at the five major haul-outs, the number of births recorded in 1990 declined by 23% from the average annual levels recorded between 1983 and 1989 (NMFS, 1991).

At the breeding islands, monk seals feed on octopus, spiny lobster, eels, bottom fish, and reef fish (Rice, 1960; Gilmartin, 1983). Limited data on diving patterns indicate that for adult males about half of their foraging activity is shallower than 35 m (114.8 ft) (NMFS, 1991); however, recent time-depth recorder information from a tagged monk seal revealed that it dove to at least 500 m (1640.5 ft) (Ragen, pers. comm., 1995).

Hawaiian monk seals breed primarily at Laysan Island, Lisianski Island, and Pearl and Hermes Reefs (Tomich, 1986). They are also known to use the Midway Islands, among other northwest Hawaiian Islands (USFWS, 1984). The colony on Midway was virtually eliminated during the active use by the U.S. Navy. However, the beach count of 24 seals in 1998 was the highest since 1960. Furthermore, 11 pups were born at Midway in both 1997 and 1998. Twenty of the 22 pups were successfully weaned (MMC, 1999). These encouraging findings suggest that the seals at Midway may reestablish the atoll as a major breeding site.

3.2.3 Sea Turtles

Five species of sea turtle occur in the Pacific Ocean near the Hawaiian Islands: the green or honu (*Chelonia mydas*), loggerhead (*Caretta caretta*), leatherback (*Dermochelys coriacea*), hawksbill or à (*Eretmochelys imbricata*), and olive ridley (*Lepidochelys olivacea*). Hawksbills and leatherbacks are listed at the federal and state levels as endangered (DLNR, 1996). Olive ridley, loggerhead, and green sea turtles are listed as threatened at the federal and state levels (DLNR, 1996) in Hawaiian waters.

The distribution of each species has been determined from one or more of the following: 1) observations of adult females emerging to nest on beaches and/or adult males basking on beaches or other substrates; 2) observations of turtle tracks, hatchlings, or egg shells on beaches; 3) reports of incidental capture by commercial fisheries; 4) incidental observations by fishermen or other mariners; 5) mark-recapture studies of adult females; and 6) radio and satellite telemetry studies of adult males and females. All five species have worldwide extensive ranges. However, genetic analysis of sea turtles has revealed in recent years (i.e., many published accounts) that discrete non-inter-breeding stocks of sea turtles make up these "worldwide extensive ranges" of the various species. It is generally believed that all sea turtle species spend the first few years of their life in pelagic waters, occurring in driftlines and convergence zones, where they find refuge and food in the items that accumulate in surface circulation features (Carr, 1986, 1987). The most accurate abundance estimates in the study region are for adult female green turtles and hawksbills that nest annually on Hawaiian beaches. Leatherbacks and olive ridleys do not nest

regularly, or in great numbers, in the Hawaiian Islands, and loggerheads do not nest in the Hawaiian Islands at all. Table 3.2-1 provides estimates for the potential stocks of these five sea turtle species in the area off the north coast of Kauai.

Green Sea Turtle

The green sea turtle is considered the most abundant sea turtle in Hawaiian waters. Its population consists of an estimated 1400 adult females (NMFS, 1992). Green turtles tagged in the Hawaiian Archipelago rarely are recaptured or observed elsewhere. Notable exceptions are Johnston Atoll, about 1200 km (650 nm) to the southwest (NMFS, 1992); and two recoveries in the western Pacific (one in Japan and one in the northern Philippines) (Balazs, 1983). The lack of recaptures, in addition to research concluding Hawaiian green turtles are genetically distinct (Bowen et al., 1992), suggests that these turtles are essentially restricted (or geographically limited) to this area of the Pacific Ocean.

Green sea turtles primarily occur in coastal waters, where they forage on algae and seagrass (Balazs, 1980; NMFS/SWFSC, 1993), suggesting they are limited to the photic zone (i.e., upper water column through which light may penetrate) surrounding islands and continents. During the breeding season, adult green sea turtles undertake long distance, oceanic migrations from feeding areas located throughout the Hawaiian Archipelago, to nesting beaches at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl Reef and Hermes Reef, Kure Atoll, and Midway Atoll (Balazs, 1980; NMFS, 1992; Balazs, 1993). Four postnesting female green turtles were fitted with satellite transmitters to monitor their migrations from French Frigate Shoals (Balazs, 1994). All four turtles migrated to Oahu, with three of them traveling south of Kauai, over open ocean. The fourth migrated along the chain of islands, swam toward the southern edge of Kauai, traveled north along the east coast, and then veered off towards Oahu (Balazs, 1994). These are the only green sea turtles that have been tracked and none of them were "Kauai" turtles (i.e., turtles that returned to resident foraging pastures on the island of Kauai). The nearshore waters of Kauai, especially the north shore area, are important habitats for post-pelagic subadult and adult green sea turtles (Balazs, 1980, 1983).

Green sea turtle breeding may occur along oceanic migration routes, but appears to be most concentrated at nearshore nesting beaches from mid-April through early June (Balazs, 1980; NMFS, 1992). Approximately 90% of green turtle nesting in the Hawaiian Islands occurs at French Frigate Shoals, with an estimated 100-250 animals laying eggs along the shore annually between May and September. Average age at first reproduction in the Hawaiian Islands has been estimated to be 25 yrs (NMFS, 1992). From July through October, the hatchlings emerge from nests and swim offshore, where they tend to accumulate in surface driftlines. Juvenile and subadult green turtles (35-82 cm [13.8-32.3 in] carapace length) are abundant nearshore Hawaii, Maui, Kaho'olawe, Molokai, Oahu, Kauai, and Niihau Islands (NMFS-Southwest Fisheries Science Center [SWFSC], 1993). Adults are benthic herbivores, suggesting that they are restricted to photic zones (i.e., upper oceanic surface layer through which light may penetrate, corresponding to water depths ranging from the surface to approximately 150-200 m [500-656 ft]) surrounding islands and continents. Because green sea turtles feed in the photic zone and prefer warm water temperatures above 15°C (Eckert, pers. comm., 1994), they are not expected to dive regularly to depths greater than 200 m (656.2 ft) (beyond the photic zone). This species

is reported as a relatively regular visitor to Midway Atoll, being observed in the shallow lagoon areas, as well as in offshore habitats but does not appear to breed there (NMFS and USFWS, 1998a).

Hawksbill Sea Turtles

Juvenile, sub-adult, and adult hawksbills occur in Hawaiian waters, but are uncommon. Hawksbills generally are associated with coral reefs or other hard substrate areas, where they forage primarily on sponges (Meylan, 1988). An estimated 12 hawksbills nest on Hawaii and Molokai each year from July through November (NMFS, 1992). Hawksbill migration routes are unknown. No hawksbill turtles have been reported in the vicinity of Midway Atoll, although they may occasionally feed there (NMFS and USFWS, 1998b).

Leatherback Sea Turtles

Adult leatherbacks are commonly sighted in the Pacific Ocean near the Hawaiian Archipelago, primarily over deep, oceanic waters (Wetherall, 1993). They forage on jellyfish and other gelatinous pelagic invertebrates (Leary, 1957; Mortimer, 1981; den Hartog and Van Nierop, 1984) at depths that sometimes correspond with the deep scattering layer (Eckert et al., 1989). This species has been recorded to dive (two occasions) to depths exceeding 1000 m (3281 ft). However, Eckert et al. (1986) reported that the average diving depth and duration of dives for leatherbacks were approximately 62 m (203 ft) and 10 min/dive, respectively. Leatherbacks undertake extensive migrations (Pritchard, 1976), following depth contours (Morreale et al., 1993) for hundreds, or even thousands, of kilometers (nautical miles). Females may nest at several beaches, spatially separated by hundreds of kilometers (nautical miles), within a nesting season. Migratory and reproductive information on leatherbacks, in addition to preliminary results from genetic studies (Dutton, pers. comm. 1993), suggests that they are wide-ranging and not restricted to any one region. There has been an alarming decline in the number of nesting females in Malaysia (1950: 1800 females; 1987: 100 females) (Marquez, 1990). Leatherbacks do not nest regularly in the Hawaiian Islands, although there is one report of an unsuccessful nesting attempt on Maui, and one unconfirmed nesting on Kauai (Eckert, 1993). No leatherback turtles have been reported in the vicinity of Midway Atoll (NMFS and USFWS, 1998c).

Olive Ridley Sea Turtles

Olive ridley sea turtles are not common in Hawaiian waters, although they are the most abundant sea turtle in the eastern Pacific Ocean (Pitman, 1990). They are nomadic migrants that swim hundreds to thousands of kilometers (nautical miles) during migrations (Marquez, 1990), foraging on salps, tunicates, pelagic crustaceans, and other invertebrates (Fritts, 1981; Mortimer, 1981). Olive ridleys spend a large portion of their time at the surface (Byles and Plotkin, 1993; Pitman, 1993), but have been reported to dive to depths of nearly 300 m (984 ft) in the Sea of Cortez (Eckert, pers. comm., 1994). Post-nesting females can travel over 9000 km (4860 m) in 16 months. The reproductive cycle is nearly annual with greater than 60% of the females nesting every year (Eckert, 1993). However, very little is known about the behavior and movements of males (Eckert, 1993).

Most records of this species in Hawaiian waters are of sub-adults stranded after becoming entangled in ocean debris or discarded fishing gear (Balazs, 1985), or captured incidentally by pelagic longline fisheries. There is only one report of a successful nesting in the Hawaiian Islands region, on Maui (Balazs and Hau, 1986). No olive ridleys have been reported in the vicinity of Midway Atoll.

Loggerhead Sea Turtles

Loggerhead sea turtles are large, widespread turtles that feed primarily on benthic invertebrates (Ernst et al., 1994; Bjornal, 1997). Loggerheads reside and nest in subtropical to temperate areas and, in some populations, they have long cross-basin migrations between feeding and nesting areas. As hatchlings they undertake long developmental migrations. Turtles hatched in Japan cross the Pacific to spend some years living off the U.S. and Mexican coasts.

Loggerhead sea turtles are rare in Hawaiian nearshore waters, with only four documented occurrences: two juveniles from the southeastern part of the archipelago, one juvenile removed from the stomach of a tiger shark captured near Kure Atoll, and one adult female sighted near Oahu (Eckert, 1993).

3.2.4 Fish

Hawaiian waters are comprised of a broad range of onshore to offshore habitats, from sandy beaches and rocky tidepools, to coral reefs and submerged basaltic terraces and banks, to pelagic and soft substrate ecosystems. Diverse coral reef and nearshore reef fish, deepwater demersal (bottomfish), and migratory pelagic fish (those that spend part or all of their lives in the water column) are characteristic of these habitats. Epipelagic (surface to approximately 200 m [656 ft] depth), mesopelagic (between 200 and 1000 m [656 and 3281 ft]), and bathypelagic (>1000 m [3281 ft] depth) zones also support a wide variety of fish species, including some which are important components of the Hawaiian Islands commercial and sport fisheries. Section 3.2.4.1 discusses some of the common demersal (bottom-dwelling) species on nearshore and offshore areas in the vicinity of Kauai and Midway Atoll. Common epipelagic, mesopelagic, and bathypelagic species are discussed in Section 3.2.4.2.

3.2.4.1 Demersal Species

Demersal fish are defined as those species living on or near the sea floor. Nearshore habitats and reef fish from approximately 0 to 50 m (0 to 160 ft) depth off the north shore of Kauai were described in 1980, as part of the EIS for the Princeville community development (Grigg and Dollar, 1980). Surveys were conducted from Haena Point to Kilauea Lighthouse. Similar to other islands within the Hawaiian Archipelago, rough basaltic substrates off north Kauai support a diverse tropical reef fish fauna (Grigg, 1993). Common nearshore demersal fish families observed off north Kauai include squirrelfish (Holocentridae); snappers (Lutjanidae) such as Onaga, Ehu, Opakapaka, and Ta'ape; goatfish (Mullidae) such as Weke, Weke-ula, Kumu, Maono, and Moano Kea; and sea chubs (Kyphosidae) (Grigg and Dollar, 1980). The primary

diet for most of these species include crustaceans and other benthic invertebrates associated with rock and coral rubble bottoms (Hobson, 1974).

During fish spawning seasons, the northeastern to southern coasts of Kauai support abundant and diverse nearshore reef fisheries (Smith, 1993). The most common fish species include bigeye scad or Akule/Hahalalu, mackerel scad or Opeku, goatfish such as white/green Weke, and squirrelfish or U'u. Although abundance and biomass data are not available for these species, the nearshore reef study area community probably has relatively high fish densities. Additional fish families that contribute to the relatively high diversity include damselfish (Pomacentridae), wrasses (Labridae), parrotfish (Scaridae), surgeonfish (Acanthuridae), and mackerel jacks (Carangidae) (Grigg and Dollar, 1980).

Deepwater demersal fish assemblages between 50 and approximately 400 m (160 and 1310 ft) depths on offshore banks and the deep-reef slopes off Kauai are dominated by snappers and grouper (Serranidae) such as Hapu'upu'u. Densities in these areas are probably relatively high, and deepwater snapper in Hawaii have been commercially exploited since the early part of the century (Haight et al., 1993). Similar to other shelf and slope communities throughout the Pacific ocean, fish densities and biomass decrease as depth increases. Rattails (Macrouridae) and cod (Moridae) are dominant residents of the deepwater complex (including the bathypelagic zone), and comprise the highest biomass in this area. These species feed on a variety of prey, including krill, shrimp, crabs, and small fish (Love, 1991).

The deep-sea benthic fish of the Hawaiian Archipelago, were described by Chave and Mundy (1994). More than 250 benthic fish species were photographed and videotaped by Hawaii Undersea Research Laboratory (HURL) submersibles at depths ranging between 40 and 2000 m (130 and 6560 ft). Most of the species observed occurred close to hard substrates, holes, ledges, or caves. Large schools of fish were observed over sand-bottom habitats in troughs when the bottom currents were strong. Chave and Mundy (1994) found 3 species restricted to the Northwest Hawaiian Islands, although their survey only extended north to French Frigate Shoals. Diversity decreases rapidly with depth from 200 to 400 m (660 to 1310 ft). The deepest species observed were rattails, halosaurids, and congrid (conger eels).

3.2.4.2 Pelagic Species

The surface waters of the ocean to depths of nearly 200 m (660 ft) (epipelagic zone) represent an enormous, although relatively featureless, habitat for fish (Moyle and Cech, 1988). Epipelagic waters are typically well-lighted, well-mixed, and capable of supporting actively photosynthesizing algae. At depths between 200 and approximately 1000 m (660 and 3280 ft) (mesopelagic zone), light decreases rapidly, as does temperature and dissolved oxygen concentrations, while pressure increases. At depths greater than 1000 m (3280 ft) (bathypelagic zone), conditions are characterized by complete darkness, low temperatures, low oxygen concentrations, and great pressure. Each of these zones is distinguished by characteristic fish assemblages.

Epipelagic fish can be distinguished based on two ecological types. Ocean forms are those that spend all or part of their life in the open ocean, while neritic forms spend all or part of their life in shallower waters of the island shelf and island offshore areas (Moyle and Cech, 1988).

Hawaii's pelagic fisheries are relatively small in comparison with other Pacific pelagic fisheries (NMFS, 1991), but comprise a large proportion of the commercial and recreational catch in the state (Pooley, 1993). Off Kauai, higher total landings, including yellowfin tuna or Ahi, are taken on the leeward (southwestern) side of the island (Smith, 1993). Other common epipelagic fish species found off Kauai include jack fish (primarily *Caranx* spp.), bigeye scad, and mackerel scad.

The larger migratory pelagic fish that comprise a substantial part of Hawaii's commercial, recreational, and sport and game fish fisheries include Ahi, albacore (*Thunnus alalunga*), skipjack tuna or Aku (*Katsuwonus pelamis*), blue marlin or A'u (*Makaira nigricans*), striped marlin or A'u (*Tetrapturus audax*), broadbill swordfish or Shutome (*Xiphias gladius*), dolphinfish or mahi mahi (*Coryphaena hippurus* and *C. equiselis*), wahoo or Ono (*Acanthocybium solandri*), shortbill spearfish (*Tetrapturus angustirostris*), sailfish (*Istiophorus platypterus*), and black marlin (*Makaira indica*). Abundance data are not available for most of these species. However, additional information on their contribution to Hawaii's fisheries is discussed in Section 3.3.1.

Most mesopelagic fish species undergo vertical migrations, often moving into the epipelagic zone at night to prey on plankton and other fish (Moyle and Cech, 1988). Mesopelagic species found in Hawaiian waters are similar to those found in other areas of the Pacific. For example, lanternfish (Myctophidae), a common mesopelagic fish family, is represented in the Hawaiian waters by a variety of species including the Honolulu lanternfish (*Myctophum hollandi*). Other species likely include bristlemouths (Gonostomatidae) and some deep-sea smelts (Bathylagidae).

In contrast to mesopelagic fish, bathypelagic species are largely adapted for a sedentary existence in a habitat characterized by low levels of food and no light (Moyle and Cech, 1988). Most of the species occupying the bathypelagic zone also cross into the mesopelagic zone during diurnal vertical migrations. At depths greater than 1000 m, bathypelagic species likely to occur in Hawaiian waters include blackdragons (Idiacanthidae), dragonfish (Melanostomiidae), and tubeshoulders (Searsidae).

In addition to the most common pelagic species described above, several shark species are common inhabitants of the nearshore and offshore waters off Kauai and in the vicinity of Midway Atoll. Sharks are a diverse group, occupying shallow and deep water habitats worldwide.

Sharks and other species have been an important aspect of Hawaiian culture. For example, the Hawaiian dictionary lists nine Hawaiian Gods that were associated with sharks, with some being revered as influential spirits important to specific geographic areas (Taylor, 1993). Further, it was believed that under certain conditions a deceased relative could be reincarnated in the form of a specific shark known by a special name (Taylor, 1993). For example, a shark could be a guardian spirit or aumakua, or a fishing helper or unihipili.

Some of the most common shark species include pelagic requiem sharks (Carcharhinidae) or mano, thresher sharks (Alopiidae) such as the pelagic thresher mano' ula or laukahi, and mackerel sharks (Lamnidae) such as the great white shark or niuhi (*Carcharodon carcharius*) (NMFS, 1991). While great whites have been taken at depths over 1400 m (4590 ft) (Love, 1991), they occur mainly in continental and island inshore waters where their main prey items occur. In contrast, tiger sharks or niuhi (*Galeocerdo cuvier*) have an ecologically important role as apex predators in the offshore pelagic and deep reef ecosystems. Tiger sharks consume mainly vertebrates, such as sea turtles (Taylor, 1993), but also select various invertebrates such as lobster and squid. Tiger sharks appear to switch foraging strategies from many small prey items to fewer, larger items when they exceed 2 m (6.6 ft) in length (Lowe et al., 1996).

Pelagic requiem sharks such as various species of gray shark are the most common sharks in the main Hawaiian waters. The gray shark most often encountered around Hawaiian reefs is the sandbar shark (*Carcharhinus milberti*) or mano (Hobson and Chave, 1990). These occur in relatively shallow waters and prey on a variety of reef fish (Taylor, 1993). The grey reef shark (*Carcharhinus amblyrhynchos*) and Galapagos shark (*Carcharhinus galapagensis*) are the two other most common reef species (Wetherbee et al., 1996). The galapagos shark is probably the most common reef species off Midway (Taylor, 1993). Other species of sharks, including the whitetipped reef shark (*Triaenodon obesus*) and some species of hammerhead sharks, such as the scalloped hammerhead (*Sphyrna lewini*) or manokihikihi and the smooth hammerhead (*S. zygaena*) are abundant near reefs and in deeper offshore areas throughout the Hawaiian archipelago (Hobson and Chave, 1990) and contribute significantly to the offshore longline fishery (Taylor, 1993). Most of these species feed on various fish and invertebrates, occupying relatively shallow nearshore waters (e.g., less than 100 m [330 ft]). Thresher sharks (*Alopias pelagicus*, *A. superciliosus*, and *A. vulpinus*) are found near Kauai and Midway Atoll and are taken commercially in the vicinity of the main Hawaiian Islands, including Kauai. This species ranges in depth from the surface to nearly 150 m (490 ft) (Taylor, 1993).

Sharks at Midway differ in some behavior and distribution when compared to those in the Main Hawaiian Islands. At Midway, reef sharks will form large aggregations near shore. These aggregations may be primarily composed of pregnant females, which do not appear to feed at this time (Taylor, 1993). Tiger sharks will frequently move in close to shore to feed on sea turtle hatchlings, albatrosses and monk seals.

3.2.5 Seabirds

Seabirds are defined as those species, which obtain most of their food from the ocean and are found over water for more than half of the year (Briggs et al., 1987). Because the sound source is located at 807 m (2648 ft) depth and since the low frequency sounds generated are known to attenuate near the surface layer of the ocean and are not transmitted to the air (Figure 2.1-3), seabird species most likely to be affected are those that dive frequently to deep (greater than 20 m [66 ft]) depths. Of the following species that dive in pursuit of their prey, all are thought to be shallow water divers, capable of diving to depths of less than 20 m (66 ft).

The Hawaiian Islands support a diverse group of seabird species. Species common to the Kauai and Midway Atoll study areas include the Pacific golden plover or Kolea (*Pluvialis fulva*), great

frigatebird or Iwa (*Fregata minor*), wandering tattler or Ulili (*Heteroscelus incanus*), sooty tern or Ewa'ewa (*Sterna fuscata*), ruddy turnstones or Akekeke (*Arenaria interpres*), wedge-tailed shearwater or Ua'u Kani (*Puffinus griseus*), red-footed booby or 'A (*Sula sula*), red-tailed tropicbird or Koa'e 'ula (*Phaethon rubricauda*), white-tailed tropicbird or Koa'e kea (*Phaethon lepturus dorotheaeare*), brown noddy or Noio Koha (*Anous stolidus*), and Bulwer's petrel or 'Ou (*Bulweria bulwerii*) (HAS, 1978; USFWS, 1999). The Hawaiian dark-rumped petrel (*Pterodroma phaeopygia sandwichensis*), Bonin petrel (*P. hypoleuca*), and Newell's shearwater (*Puffinus auricularis newelli*), are also endemic seabird species.

Black-footed albatross (*Diomedea nigripes*) and Laysan albatross (*D. immutabilis*) occur within the general study area and have been recorded as breeders on Midway Atoll. Albatrosses are large seabirds that feed primarily on squid. Laysan and black-footed albatrosses have resident breeding populations on the larger Hawaiian Islands. Thousands visit Midway Atoll each winter and spring, and are occasionally seen elsewhere on the northwestern Hawaiian Islands. The historical range of the short-tailed albatross includes Hawaiian waters, and the current worldwide population is only about 400 birds, including approximately 85 breeding pairs.

In general, shearwaters, noddies and petrels use many of the Hawaiian Islands for roosting and nesting. Migratory seabirds such as ruddy turnstones, wandering tattlers, and Pacific golden plovers forage for food on the shorelines.

The Kilauea Point National Wildlife Refuge on Kauai contains the largest seabird colony in the main Hawaiian Islands. The refuge is home to Laysan albatross, wedge-tailed shearwaters, red-footed boobies, brown boobies, great frigate birds, red-tailed tropic birds, and white-tailed tropic birds.

In addition to other species listed above, the grey-backed tern (*Sterna fuscata oahuensis*), bristle-thighed curlew or Kioea (*Numenius tahitiensis*), masked booby or `A (*Sula dactylatra personata*), fairy tern (*Gygis alba rothschildi*), black (Hawaiian) noddy (*Anous tenuirostris melanogenys*), and Christmas shearwater (*P. nativitatis*) are considered endemic breeders on Midway.

The short-tailed albatross (*D. albatrus*), brown booby or `A (*Sula leucogaster plotus*), Lesser golden plover or Kolea (*Pluvialis dominica*), bristle-thighed curlew (*Numenius tahitiensis*), ruddy turnstone (*Arenaria interpres*) occur on Midway as migrants or regular visitors, but do not appear to roost there.

Three of these seabirds are listed as threatened or endangered under the federal ESA (Newell's shearwater [threatened], short-tailed albatross [endangered], and Hawaiian dark-rumped petrel [endangered]). Newell's shearwater and the Hawaiian dark-rumped petrel are also listed under Hawaii's Endangered Species Act. The short-tailed albatross is protected under CITES. Most of the seabird species potentially found in Hawaii are also protected by the Migratory Bird Treaty Act.

Of the above species that dive in pursuit of their prey, all are thought to be shallow water divers, capable of diving to depths of less than 20 m (66 ft). No known deep-diving bird species occur

in the Kauai and Midway Atoll study areas. Therefore, seabirds have been excluded from further evaluation.

3.2.6 Threatened, Endangered, and Special Status Species

This section presents information on threatened, endangered, and special status species that may occur in the study area. Table 3.2-2 lists the threatened, endangered and special status species under the federal Endangered Species Act, the Hawaii Revised Statute (HRS) 195D-4 (Endangered Species and Threatened Species), and the Convention on International Trade in Endangered Species (CITES) that may occur in the study area.

Ten threatened, endangered, and special status marine species potentially occur within the study areas of Kauai and Midway Atoll (letter from NMFS, 7 Feb. 2000). These include three mysticetes (blue, fin, and humpback whales), one odontocete (sperm whale), one pinniped (Hawaiian monk seal), and five sea turtles (leatherback, green, olive Ridley, hawksbill, and loggerhead). In addition, the critical habitat of the Hawaiian monk seal includes all beach areas, sand spits and islets, lagoon waters, inner reef waters, and ocean waters out to a depth of 36.6 m (20 fm) 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 226.11).

3.2.7 Marine Sanctuaries and Special Biological Resource Areas

The Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS) was Congressionally designated in 1992 as part of the national system of marine sanctuaries. The Sanctuary specifically recognizes the importance of humpback whales and their winter habitat. One of the sanctuary goals is to gain an accurate description of the total North Pacific humpback population and the number of individuals wintering in Hawaiian waters. The sanctuary was established to provide a mechanism to develop research protocols, allowing for the whale research community and NMFS to work closely together. The sanctuary includes the area from the highwater mark to water depths of approximately 183 m (600 ft) around the islands of Lanai, and the leeward sides of Molokai and Maui; Penguin Bank; from Upolu point to Keahole point on the Big Island; from Puaena Point eastward to Mahie Point, and from the Kapahulu Groin in Waikiki eastward to Makapuu Point on Oahu; and from Kailiu Point to Mokolea Point off Kauai's Kilauea Point National Wildlife Refuge on the north coast. The Kauai acoustic sound source is located at 807 m (2648 ft) depth approximately 7 km (3.8 nm) northwest of the Kauai's Kailiu Point portion of the HIHWNMS.

The Kilauea Point National Wildlife Refuge on Kauai consists of thirty-one acres of cliffs and headlands jutting up to 61 m (200 ft) above the surf. It contains the largest seabird colony and one of the most important seabird nesting sites in the main Hawaiian Islands. It is administered by a resident U.S. Fish and Wildlife Service (USFWS) representative.

Hanalei National Wildlife Refuge includes 917 acres of river bottom land, taro farms, and wooded slopes in the Hanalei River Valley on the northern coast of Kauai. The refuge was established in 1972 to provide essential habitat for Hawaiian waterbirds, including the koloa maoli (Hawaiian

Table 3.2-2 Threatened, Endangered, and Special Status Species.

Common Name	Scientific Name	Federal Endangered Species Act Status	Hawaiian Endangered Species Act Status	CITES Status
Mysticetes				
Blue whale	<i>Balaenoptera musculus</i>	Endangered		Protected
Fin whale	<i>Balaenoptera physalus</i>	Endangered	Endangered	Protected
Humpback whale	<i>Megaptera novaeangliae</i>	Endangered	Endangered	Protected
Odontocetes				
Sperm whale	<i>Physeter macrocephalus</i>	Endangered	Endangered	Protected
Pinnipeds				
Hawaiian monk seal	<i>Monachus schauinslandi</i>	Endangered	Endangered	Protected
Sea Turtles				
Green sea turtle	<i>Chelonia mydas</i>	Threatened	Threatened	Protected
Leatherback sea turtle	<i>Dermochelys coriacea</i>	Endangered	Endangered	Protected
Olive ridley sea turtle	<i>Lepidochelys olivacea</i>	Threatened	Threatened	Protected
Hawksbill sea turtle	<i>Eretmochelys imbricata</i>	Endangered	Endangered	Protected
Loggerhead	<i>Caretta caretta</i>	Threatened	Threatened	Protected
Seabirds				
Newell's shearwater	<i>Puffinus auricularis newelli</i>	Threatened	Threatened	
Short-tailed albatross	<i>Diomedea albatrus</i>	Endangered		Protected
Hawaiian dark-rumped petrel	<i>Pterodroma phaeopygia sandwichensis</i>	Endangered	Endangered	

duck), 'alae ke'oke'o (Hawaiian coot), 'alae 'ula (Hawaiian moorhen), and ae'o (Hawaiian stilt). Because of past overhunting, introduced predators, and loss of wetlands, these species are endangered. Properly managed taro farms provide a traditional Hawaiian food, and habitat where native waterbirds feed, nest, loaf, and rear their young. The boundary of the refuge does not extend beyond the mouth of the Hanalei River in Hanalei Bay.

The Hawaiian Island National Wildlife Refuge is a chain of eight islands, reefs, and atolls extending 800 miles northwest from the main Hawaiian Islands. Nihoa and Necker Islands, Gardner Pinnacles, and La Perouse Pinnacle are cores of old volcanic cones, with sheer cliffs of basalt and no beaches. Laysan and Lisianski Islands are low, flat, sandy islands surrounded by submerged fringing coral reefs. French Frigate Shoals and Pearl and Hermes Reef are true atolls, each with several small, sandy, partially-vegetated islets within a fringing coral reef. Maro Reef has only two small coral heads protruding from the ocean. Two permanent employees maintain a field station at Tern Island, French Frigate Shoals. The Hawaiian Islands NWR was established in 1909 by Executive Order 1019 of President Theodore Roosevelt. The Order "set apart" the "islets and reefs" of the Hawaiian Islands NWR "as a preserve and breeding ground for native birds." Endangered wildlife of the refuge includes the Laysan duck, Laysan finch, Nihoa finch, and Nihoa millerbird. In addition, almost the entire population of the endangered Hawaiian monk seal and virtually the entire Hawaiian breeding population of threatened green sea turtles inhabit the refuge.

Midway Atoll was transferred from the U.S. Navy to the U.S. Fish and Wildlife Service (USFWS) in 1996. The atoll has since been designated a National Wildlife Refuge. There are about a half million nesting pairs of seabirds on the islands. The monk seal colony is showing signs of recovery. Green sea turtles and spinner dolphins are found in the lagoon. The Phoenix Corporation runs a small ecotourism concession on the island, in partnership with the USFWS. The Oceanic Society is also running ecotourism/research volunteer programs at Midway.

Essential fish habitat (EFH) has been designated in and around Hawaii. Assessment of the EFH is included as Section 4.2.6.

3.2.8 Biological Environment Along the Cable Route

The cable route at the Kauai site extends over island shelf and slope habitats and shallow, sandy bottom subtidal areas (as shallow as 24 m [79 ft]). Regional geography and geology for the Kauai and Midway Atoll sites were previously described in Section 3.1.5. Plants and animals in these areas are highly dependent on the subsea geology and geography described in these sections. The cable for the Kauai source crosses only one reef, offshore from Barking Sands, passing through surge channels in the reef. After crossing the reef area, the cable lies on sand and soft-bottom areas. A similar cable route is expected for the alternate site at Midway Atoll.

Shallow nearshore communities (depths 24-50 m [79-164 ft]) likely are characterized by a variety of fish families, including wrasses (Labridae), goatfish (Mullidae), and damselfish (Pomacentridae). Species within these families comprise complex coral reef communities. Invertebrates likely to occur at these depths include lobster, crab, sea stars, and sea urchins. Reef-building corals likely will dominate the shallow subtidal areas.

In water depths ranging between 45 and 67 m (148 and 220 ft), the cable crosses the outer face of the offshore reef. This part of the reef is dissected by frequent surge channels, which can be characterized as having similar abundances and diversity as nearby adjacent reefs.

Deeper shelf and slope communities can be characterized as moderately diverse habitats. Fish such as tunas, jacks, and scad will predominate. At deeper depths (over the island shelf and slope) off Kauai and Midway Atoll, sandy bottom species such as rattails, skates, and cod-like fish predominate (Chave and Mundy, 1994).

3.3 ECONOMIC ENVIRONMENT

3.3.1 Commercial, Recreational, and Potential Fisheries

Expansion and diversification of pelagic fisheries and growth in some recreational fisheries led to overexploitation of many fishery stocks in Hawaiian waters during the late 1980's and 1990's (Pooley, 1993). However, recent changes in Hawaiian commercial fisheries, such as reduction in limited entry of permits for bottomfish and lobster, moratoria to new longline fishermen, closed seasons and quotas for lobster, and some area closures have improved some fisheries (Pooley, 1993). All of the above changes are aimed at preserving Hawaiian fisheries.

Hawaii's commercial fishery exceeded \$50 million in ex-vessel revenues in 1990, based on a total catch of over 22 million pounds (approximately 10 million kg) (Pooley, 1993). The longline tuna fishery accounted for nearly \$29 million of this total. During calendar year 1993, Kauai fishermen caught 17,050 kg (37,588 lbs) of fish in Fisheries Statistical Area No. 523, which encompasses the area offshore of the north Kauai coast. Approximately 15,615 kg (34,425 lbs) were caught by trollers and 1255 kg (2,767 lbs) by bottom fishermen (DLNR, 1994).

Most of the commercial fishing in Hawaii is conducted on the submerged shelves, banks, and slopes of the populated islands and the northwestern Hawaiian Islands. Some of the seamounts in the vicinity of the study area support limited fisheries, with substantially less commercial value than nearshore reef areas (MMS, 1987). Although commercial fishing occurs offshore of nearly all the Hawaiian Islands (including Kauai), none (except the rare tuna fishing boat) occurs in the offshore waters near Midway Atoll (MMS, 1987).

Off Kauai, nearshore fisheries target a variety of fish such as bigeye scad, goatfish, surgeonfish, and squirrelfish. These species are easily accessible in small boats throughout the island. A significant fishery for white crab or Kona crab exists off Niihau (Smith, 1993).

The most commonly caught commercial bottomfish in Hawaii are several species of snapper, grouper, and jacks (Pooley, 1993). Lobster are the primary epifaunal invertebrate collected commercially. Pelagic fisheries off Hawaii include marlin, swordfish, sailfish, mahi mahi, and several tuna species. Pelagic sharks also comprise a significant part of the commercial catch, with blue sharks, mako, and threshers taken in the highest numbers.

Hawaii's nearshore fisheries are quite productive; however, a deepwater fishery also exists for snappers and some tuna (Haight et al., 1993). In fact, the nearshore fisheries produce only a small fraction of the total catch as reported from Hawaiian fisheries on an annual basis (Diaz-Soltero, pers. comm., 1995). Some invertebrates, such as pandalid shrimp are collected in commercial traps at depths between 350 and 825 m (1150 and 2710 ft). At these deeper depths, some species of black coral are taken by commercial divers for the coral jewelry industry (Grigg, 1993; Grigg pers. comm., 1994). Black coral is taken by commercial divers off Maui and off the west and southern coast of Kauai. However, it is unlikely that black coral is taken in the Kauai study area.

The distinction between recreational and commercial fisheries in Hawaii's small boat fleets is extremely difficult. This is due to the fact that many commercial fishermen hold full-time and part-time jobs which provide more income than fishing (Pooley, 1993). Furthermore, charter boat captains usually retain their catch for sale at local markets. These issues have led to many problems in compiling recreational fishery data.

3.3.2 Mariculture/Aquaculture

Mariculture, or aquaculture, is the farming of aquatic or marine organisms, such as fish, molluscs, crustaceans, and algae. It is currently one of the fastest growing industries in Hawaii, with an annual growth rate in revenues of nearly 13% and an estimated income of over \$21 million in 1989 (DLNR, 1990). The variety of organisms raised through aquaculture has increased steadily since 1979, currently representing over 35 different species, including marine shrimp, Chinese catfish, tilapia, carp, rainbow trout, abalone, nori, ogo, spirulina, oysters, salmon, and lobster (DLNR, 1990). Potential new species include mahi mahi, Japanese flounder, baitfish, giant clams, limpets, and sea cucumbers. Ceatech USA has recently opened an aquaculture facility near Kekaha to raise shrimp.

3.3.3 Shipping

The Hawaiian Islands serve as a major port for international shipping, with over 91.2 million tons (82.7 billion kg) of freight worth over \$124 billion moved between the U.S. West coast, Alaska, Hawaii, and Far East ports in 1987. Of this, about 22.4 million tons (20.3 billion kg) were handled through Hawaiian ports (Corps of Engineers [COE], 1989). This shipping activity involved 21,325 vessel arrivals and departures from Hawaiian ports.

The two major shipping ports of Kauai are Nawiliwili and Port Allen. Vessel arrivals for 1989 were 1079 for Nawiliwili and 100 for Port Allen (COE, 1991). Freight traffic (tons) for Nawilili for the 5-year period 1985-89 was as follows: 1985 (933,477), 1986 (745,396), 1987 (916,422), 1988 (875,753), and 1989 (1,038,452) (COE, 1991).

3.3.4 Military Usage

The Pacific Missile Range Facility (PMRF) is the largest federal government employer on Kauai, with approximately 850 workers, including tenant organizations and civilian contractors (Pham, 1991). The total annual expenditures for PMRF, tenant organizations, and contractors was \$72.5 million for 1990. PMRF had a FY 1991 operating budget of \$50.1 million, including a payroll of \$29.6 million.

The U.S. Navy began building on Midway in 1938. The Naval Air station was commissioned on August 1, 1941. Midway Atoll was first attacked on December 7, 1941, and the famous "Battle of Midway" took place there in 1942. After the war, the U.S. Coast Guard established a LORAN (Long Range Navigation) station on the island in the 1950's. The U.S. Naval air station closed in 1993 and was vacated following cleanup activity in 1997. The atoll has been transferred to the U.S. Fish and Wildlife Service.

The U.S. Navy's Pacific Fleet, including a variety of ships and submarines, is stationed in Hawaii. No daily estimates for the number of ships or submarines likely to occur in the study region are available (P. McClaran, PMRF, pers. comm., 1994); however, based on general activity levels, it can be assumed that ship and submarine traffic in the vicinity of the Kauai and Midway Atoll sites varies between low and moderate activity levels.

3.3.5 Mineral or Energy Development

The most valuable offshore marine minerals resources in the general region of the Hawaiian Islands and Midway Atoll are cobalt-rich manganese crusts and nodules. The existence of these types of resources on Pacific seamounts has been recognized for at least 20 yrs (HDBED, 1987). Recent surveys, although preliminary in nature, indicate a large potentially exploitable resource in various deep-water (800-2400 m [2620-7870 ft]) regions off the Hawaiian Islands and Midway Atoll. Manganese crust coverage within these areas ranges from 0% (areas of thick sediment cover) to 100% (areas of thick crust "pavements"). Coverage for the Hawaiian axis (i.e., nearly 200 km [108 nm] south of Kauai) is approximately 25%, while other areas average nearly 40%. Manganese nodules, which are relatively rich in manganese, cobalt, iron, nickel, and copper, are abundant over vast areas of the seabed at depths between 4000 and 5000 m (13100 and 16400 ft) (HOMRC, 1991). Initial survey results indicate that little, if any, manganese mining would occur in the vicinity of the proposed action site due to its low crust coverage.

3.3.6 Cultural and Historical Resources

There are no known cultural or historical resources within the Kauai study area. The State Department of Land and Natural Resources, Division of Historic Resources Preservation, does not maintain information concerning shipwrecks.

In "pre-contact" Hawaii (prior to 1778), temporal rule of the islands was divided among a number of alii, or chiefs. Each of these had, in theory, unrestricted control over all the resources within his moku or districts (Meller, 1985). The ahupuaa in which the moku was subdivided, usually had attached to them ocean fishing rights, in some instances not only adjacent to their own

shores, but spreading out on each side up and down the coast for many miles (Cobb, 1908). Thus, the alii controlled all fishing rights in their jurisdiction.

Managing the ahupuaa were the konohiki or agents of the alii. The konohiki collected a portion of the harvest of both land and ocean resources on behalf of the alii from the hoaina or tenants, and placed limitations on the uses of the resources, depending on environmental conditions (Meller, 1985).

The U.S. Congress attempted to extinguish all konohiki fishing rights in the Organic Act of 1900. Section Nine of the Act provided for a 2-year period in which the owners of konohiki rights could register claims to a konohiki fishery with the Territorial Courts, or forfeit all claims to those rights (Meller, 1985). Once the claims were filed, it was the intent of the federal and territorial governments to acquire all rights to the registered konohiki fisheries through condemnation (Clay et al., 1981).

There is some uncertainty as to the total number of konohiki fishing areas and how many were registered before 1903. Meller (1985) estimates between 363 and 720 areas existed, but noted that opinions vary on how many were registered, from a low of about 100 to a high of 144. Because of this uncertainty in the number of registered rights, there is no exact figure as to the number in existence today. Khil (1978) puts the estimate for Kauai as follows: number registered, 9; number condemned, 7; number outstanding, 2. These two are both located on the south shore, at Wahiawa and Omao.

Midway Atoll was shelled by Japanese ships on December 7, 1941. The famous “Battle of Midway” took place there. A historic preservation plan to preserve several structures on the atoll is being finalized. 78 structures and objects were placed on the National Register of Historic places. Some preservation tasks are already underway.

3.4 SOCIAL ENVIRONMENT

3.4.1 Recreational Activities and Tourism

Kauai's economy is dominated by tourism and agricultural industries. Federal government employment is also a major contributor to the local economy, as discussed in Section 3.3.4.

The tourism industry and associated travel-related services employ approximately 16,000 people on Kauai (Pham, 1991). Average earnings per job in this industry was approximately \$17,900 in 1990 (Pham, 1991). The Hawaii Visitors Bureau (1991) estimated that 1.3 million people visited Kauai in 1990. Visitor expenditures for 1990 were approximately \$945 million (Hawaii Visitors Bureau, 1991).

According to Townsend (1991), the major recreational activities on Kauai are fishing, boating, diving, snorkeling, surfing, waterskiing, whale-watching, sea kayaking, parasailing (commercial), and riding pleasurecraft (private and commercial). In 1988, the Hawaii Department of Transportation issued regulations limiting commercial pleasurecraft and parasailing operations.

Whale-watching operations are subject to federal regulation with respect to humpback whales. At least two whale-watching vessel-types are in operation off Kauai:

- M/V Napali Queen and M/V Navatek II; do not anchor in Hanalei Bay.
- Power catamarans; 12 m length overall; two 200 hp outboard motors; anchor in Hanalei Bay.

Economic activities involving the ocean in Hawaii are highly diversified including tour boats, interisland cruises, charter boat and recreational fishing, yacht racing, competitive ocean swims, Hawaiian canoe races, and wind-, board-, and body-surfing events. Total direct revenue estimates for 1992 were estimated at nearly \$ 560 million (MacDonald and Deese, 1994).

The recent closing of the base at Midway has allowed numerous recreational activities to be offered. Sport fishing, diving and wildlife watching activities now take place on Midway Atoll. Due to its remote location, essentially no commercial fishing occurs in the area, although tuna boats occasionally fish the general region (Environmental Protection Agency [EPA], 1985).

3.4.2 Research and Education

Ocean research and education is extremely important for long-term success of the Hawaii Ocean Resources Management Plan. While most of the research and education activities in Hawaii are centered on Oahu, new marine resource centers and research facilities are being established on or are planned for the neighbor islands (HOMRC, 1991). The only college-level facility presently on Kauai is Kauai Community College (KCC). While KCC does not specialize in marine research, many local public school systems have formal marine education programs.

Modern support facilities at several locations in the Hawaiian Islands, primarily on Oahu, provide researchers with an extensive infrastructure for services such as satellite communication and tracking, marine laboratory analyses, marine surveying and brokering, and ship maintenance facilities. Other institutional facilities for marine research are associated with the U.S. Navy, the University of Hawaii's School of Ocean and Earth Science and Technology, the Law of the Sea Institute, and various federal government agencies, including Marine Minerals Technology Center (Department of the Interior [DOI]), the Pacific Mapping Center (Department of Commerce [DOC]/DOI), and the Center for Tropical and Subtropical Aquaculture (Department of Agriculture [DOA]). Most of these facilities are located on Oahu and the Big Island (NOAA, 1994).

No formal educational facilities exist on Midway Atoll; however, this site has functioned as a research facility for numerous agencies, most notably the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS). The Oceanic Society, a private ecotourism group, has begun funding research on Midway.

3.4.3 Water Contact Sports

Shoreline usage and water contact sports are highly important activities for Hawaii's residents and many tourist industries (HOMRC, 1991). Based on 1985 State Comprehensive Outdoor Recreation Plan (SCORP) statistics, at least 170,000 people swim or sunbathe at beaches or shorelines daily. Further, other daily usage includes almost 23,000 surfers, 25,000 fishermen (from onshore and boats), 3000 canoers and kayakers, 18,000 boaters, and more than 21,000 scuba divers (HOMRC, 1991). Other popular water sports include windsurfing, sailing, and catamaran sailing. Diving and snorkeling are some of the most popular recreational activities in Hawaii, mostly occurring around inshore coral reefs.

Generally, the north coast beaches off Kauai are the best for swimming, snorkeling, and diving in summer, and surfing in winter. Better conditions for swimming and snorkeling along the south coast occur in winter. Many locations on the north coast offer safe swimming, snorkeling, and diving, including Kalihiwai Beach Park, Ke'e, Hanalei Bay, Anini Beach, Haena, and Moloaa (Sunset Book, 1975). Some of the most popular areas on the south coast of Kauai for diving and snorkeling include Poipu Beach, and Kukuiula (AAA Tour Book, 1992).

The recent ecotourism concession brings snorkelers and divers to the nearshore waters around Midway. Sport fishing vessels operate from Midway as well. Snorkeling and diving by researchers likely occurs in the shallow nearshore and lagoon areas.

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