

Marine Protected Species

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INTRODUCTION

The Monument protects habitat for many marine mammal species, including 24 species of cetaceans that have been sighted in the Hawaiian Islands Exclusive Economic Zone (EEZ), and the critically endangered Hawaiian monk seal. (Figure 6.1). Twenty three species of cetaceans were observed and identified to the species level during a 2002 survey (Barlow et al., 2004). Four of these species are on the U.S. Endangered Species list, including the humpback whale (*Megaptera novaeangliae*), sperm whale (*Physeter macrocephalus*), fin whale (*Balaenoptera physalus*) and sei whale (*Balaenoptera borealis*; <http://www.nmfs.noaa.gov/pr/species/esa/mammals.htm>). In addition, the false killer whale (*Pseudorca crassidens*) is listed as a strategic stock under the 1994 amendments to the Marine Mammal Protection Act (MMPA). Each of these species has been observed within the Monument boundaries (Barlow et al., 2004; Johnston et al., 2007; NMFS, unpublished data). Several of the cetacean species observed within the Hawaiian Islands EEZ are found there year-round (e.g., spinner dolphins, false killer whales, rough-toothed dolphins). Others occur there only seasonally and in some cases are known to migrate long distances to use the area for breeding (e.g., humpback whales).



Figure 6.1. The Monument protects habitat for many marine mammal species, including several species of dolphins and whales. A spinner dolphin (left) and humpback whales (right) are pictured here. Photos: PIFSC and D. Shapiro.

In addition to providing important habitat to cetaceans, the Monument is also the primary habitat for the federally endangered Hawaiian monk seal (*Monachus schauinslandi*; Figure 6.2). The six main Hawaiian monk seal subpopulations are completely contained within the Monument boundaries. The Hawaiian monk seal population is estimated to have declined by 60% since the 1950s (Antonelis et al., 2006), and is currently estimated at just under 1,200 individuals. Because of its small population size and swift rate of decline, the Hawaiian monk seal is the focus of intense conservation efforts.



Figure 6.2. The Monument is home to the six primary Hawaiian monk seal subpopulations (left). The area also protects nesting habitat of the green turtle (right). The Hawaiian monk seal is listed as endangered and the green turtle is listed as threatened under the U.S. Endangered Species Act. Photos: J. Watt.

Finally, the Monument provides the primary nesting habitat for the green turtle (*Chelonia mydas*; Figure 6.2) in the Hawaiian Archipelago, listed as Threatened under the U.S. Endangered Species Act (ESA). Green, loggerhead (*Caretta caretta*), hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*) and

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olive ridley (*Lepidochelys olivacea*) turtles use the Monument for foraging habitat and as migration pathways. Although the Hawaiian green turtle population has been increasing over the past three decades, individuals still nest primarily at French Frigate Shoals in the Northwestern Hawaiian Islands (NWHI).

CETACEANS

Available Data

Most of what is known about cetaceans found within the Hawaiian EEZ comes from data collected within the waters surrounding the Main Hawaiian Islands (MHI). Although somewhat limited, information on the occurrence of cetacean species within the Monument comes from historical whaling records, documented opportunistic sightings and stranding records, data collected during ship-based surveys, and species-specific (e.g., spinner dolphin) photo-identification and genetic research.

Charles Townsend (1935) used whaling logbooks to record locations of certain whale species onto charts of both the Atlantic and Pacific Oceans. The Wildlife Conservation Society digitized the charts and made them available to the general public (http://www.wcs.org/sw-high_tech_tools/landscapeecology/townsend_charts). Data on sperm whale sightings within the Hawaiian EEZ, including the Monument, are extracted from these records (see Species Descriptions section, sperm whale).

Edward W. Shallenberger (1981) collected information from published and unpublished literature, field notes, ships' logs, and interviews with knowledgeable people in order to document the occurrence and status of cetacean species found in Hawaiian waters, including the NWHI.

The *Atoll Research Bulletin* produced a series of publications on the natural history of the NWHI in which records of cetacean species were documented from opportunistic sightings and stranding events (Rice, 1960; Amerson, 1971; Woodward, 1972; Amerson et al., 1974; Nitta and Henderson, 1993). These records are more anecdotal in nature and lack precise location data (i.e., latitude/longitude points), however, they are useful for generalizing about the occurrence of certain species within the Monument.

Precise data regarding the occurrence of cetaceans in the Monument come from recent ship-based surveys within the 200 nm EEZ surrounding the Hawaiian Islands (Barlow et al., 2004; Johnston et al., 2007; NMFS, unpublished data). In 2002, Barlow et al. (2004) conducted standard ship-based visual line-transect surveys, from two ships, for all cetacean species in the Hawaiian Islands EEZ. Search effort included a total of 24,738 km (13,357 nm) over 157 survey days. Acoustic monitoring, photo-documentation, biopsy and behavioral studies were conducted concurrently. Line-transect surveys resulted in observations of 23 cetacean species within the Hawaiian Islands EEZ, with 15 of those species seen within the boundaries of the Monument (see Species Descriptions section and Figure 6.3; Barlow et al., 2004). Abundance estimates and densities per 1,000 km² were calculated for 19 of the 23 cetacean species observed (Table 6.1; see Cetaceans Abundance Estimates section on page 210; Barlow, 2006).

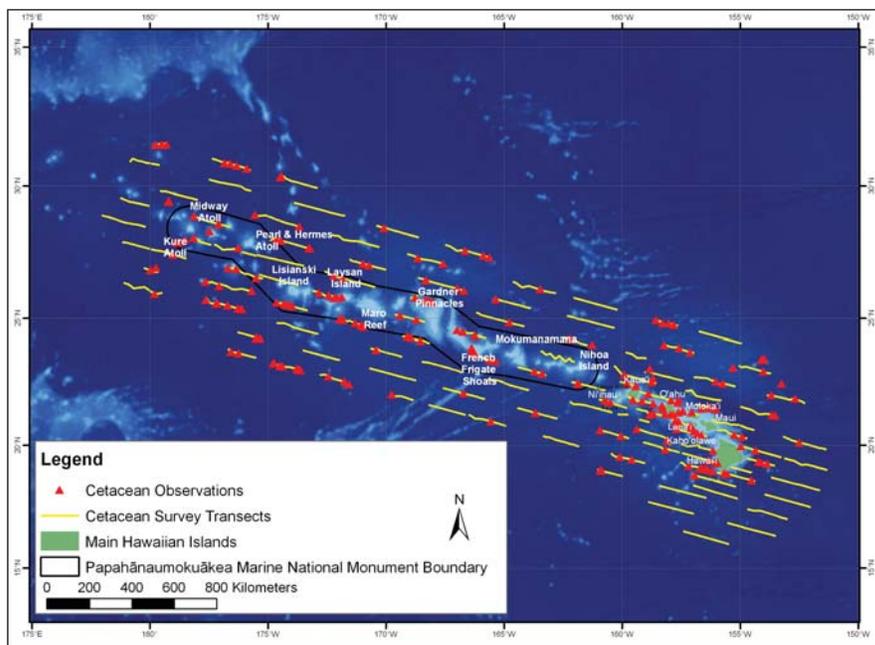


Figure 6.3. Cetacean Observations and Survey Transects. Sources: Barlow et al., 2004; Johnston et al., 2007; NMFS, unpublished; Townsend, 1935; map: K. Keller.

Table 6.1. Estimated abundance of 19 cetacean species in the MHI and outer Hawaiian Islands EEZ. Overall abundances, overall densities, and coefficients of variation (CV) are pooled from the MHI and outer EEZ estimates. Pooled abundance and density estimates are given for delphinids and beaked whales. Asterisk (*) indicates a more recent estimate of false killer whale abundance in offshore waters of the Hawaiian EEZ (484 individuals, CV=0.93) comes from Barlow and Rankin (2007). Source: Barlow, 2006.

SPECIES	MAIN ISLAND ABUNDANCE (n)	OUTER EEZ ABUNDANCE (n)	OVERALL ABUNDANCE (n)	OVERALL DENSITY PER 1,000 km ² (D)	CV
Offshore spotted dolphin	4,283	4,695	8,978	3.66	0.48
Striped dolphin	660	12,483	13,143	5.36	0.46
Spinner dolphin	1,488	1,863	3,351	1.37	0.74
Rough-toothed dolphin	1,713	6,997	8,709	3.55	0.45
Bottlenose dolphin	465	2,750	3,215	1.31	0.59
Risso's dolphin	513	1,859	2,372	0.97	0.65
Fraser's dolphin	0	10,226	10,226	4.17	1.16
Melon-headed whale	0	2,950	2,950	1.20	1.17
Pygmy killer whale	956	0	956	0.39	0.83
False killer whale *	0	236	236	0.10	1.13
Short-finned pilot whale	3,190	5,680	8,870	3.62	0.38
Killer whale	0	349	349	0.14	0.98
Sperm whale	126	6,793	6,919	2.82	0.81
Pygmy sperm whale	0	7,138	7,138	2.91	1.12
Dwarf sperm whale	0	17,519	17,519	7.14	0.74
Blainville's beaked whale	0	2,872	2,872	1.17	1.25
Cuvier's beaked whale	0	15,242	15,242	6.21	1.43
Longman's beaked whale	0	1,007	1,007	0.41	1.26
Bryde's whale	0	469	469	0.19	0.45
Delphinids pooled	13,267	50,087	63,354	25.83	
Beaked whales pooled	371	19,121	19,492	7.95	

The work of Johnston et al. (2007) focused on visual and acoustic observations of humpback whales from Oahu to Midway Atoll in the NWHI during March and April 2007. Search effort covered 1,690 km over 12 survey days. Surveys were focused on areas near atolls and islands, and tracklines generally followed the 183 m (1,000 fathom) isobath, however, some tracklines were in deeper waters (Johnston et al., 2007; NMFS, unpublished data). Observations were conducted following standard distance sampling/line transect methods for cetaceans, similar to those employed in Barlow et al. (2004). During the surveys, sightings of all cetaceans were recorded, including location and group size estimates (NMFS, unpublished data). Additionally, acoustic monitoring, photo-documentation and biopsy sampling were conducted. These surveys resulted in the detection of 44 groups of eight cetacean species. Seven of these species were observed within Monument boundaries (Johnston et al., 2007; NMFS, unpublished data). In the Species Description section (below) these surveys will be referred to as the NWHI survey.

Other species-specific cetacean work within the Monument includes research on the social patterns and population structure of spinner dolphins (*Stenella longirostris*) at Midway Atoll (Karczmarski et al., 1998; 1999; Rickards et al., 2001; Karczmarski et al., 2005) and the genetic diversity of spinner dolphins within the Hawaiian Archipelago (Andrews et al., 2006). The photo-identification and behavioral research at Midway Atoll consisted of land and small boat-based surveys conducted in 1998 through 2001, totaling 1,104 effort hours. Results of this work indicate that a resident spinner dolphin population is present at Midway, but that movement of individuals between Midway, Kure Atoll, and Pearl and Hermes Atoll occurs (Karczmarski et al., 1998; 1999; Rickards et al., 2001; Karczmarski et al., 2005). The analysis of biopsy samples taken from various locations within the Hawaiian Archipelago (e.g., Hawaii, Maui/Lanai, Oahu, Niihau, French Frigate Shoals, Pearl and Hermes Atoll, Midway Atoll and Kure Atoll) indicates a genetic distinction among separate spinner dolphin populations (Andrews et al., 2006).

Species Descriptions

Description, range and habitat information is taken from the following sources: Tomich (1986), Ridgeway and Harrison (1994), Ridgeway and Harrison (1999), Perrin et al. (2002), Reeves et al. (2002), and OBIS SEAMAP (an online data source that compiles information from various published sources, <http://seamap.env.duke.edu/>).

Offshore Pantropical Spotted Dolphin (*Stenella attenuata*)

Three subspecies of the pantropical spotted dolphin are recognized worldwide and differ in body size, coloration and skull characteristics. Their lengths range from 1.6 m to 2.6 m and their average weight is 114 kg. In general, the pantropical spotted dolphin has a moderately slender body; a relatively small dorsal fin that is strongly falcate (back-curved or shaped like a sickle); and a long, slender beak. The basic color pattern includes a dark gray dorsal cape that dips low onto the sides below and forward of the dorsal fin and a lighter gray ventral (belly) color that widens along the sides of the peduncle, or tailstock. Adults have a black “mask” and a dark jaw-to-flipper stripe. The pattern of spotting and striping on adults can be extremely complex and variable; in Hawaii animals have very little dorsal spotting. Calves are born without spots, and juveniles develop them first on their ventral side. The tip of the beak is white and more conspicuous in some populations, including those found in the waters surrounding the Hawaiian Archipelago.

Pantropical spotted dolphins are found in all tropical to warm temperate oceanic waters between 40°N and 40°S. In the Pacific Ocean, the stocks are separated into the offshore eastern tropical Pacific, the coastal waters between Baja California and the northwestern coast of South America, and the near-shore waters around the Hawaiian Islands.

Pantropical spotted dolphins are found throughout the Hawaiian Archipelago and are common on the leeward sides of the islands as well as at shallow offshore banks (Shallenberger, 1981; Tomich, 1986). A series of 12 aerial surveys (1993-1998) within 46 km of the coastline surrounding the MHI resulted in observations of 23 groups of spotted dolphins, with an average size of 42.8 individuals (Mobley et al., 2000). Baird et al. (2003) recorded 25 sightings around the MHI in May and June of 2003 with a mean group size of 77.1 individuals. Baird et al. (2006) determined that the peak in sighting rates off the MHI occurred in water depths of 1,000-2,000 m. Within the Hawaiian EEZ, during the 2002 (August –November) ship-based survey, Barlow et al. (2004) recorded 12 sightings of spotted dolphins in groups as large as 80 individuals (Figure 6.4). One sighting of 74 individuals occurred within the Monument boundaries (Barlow et al., 2004).

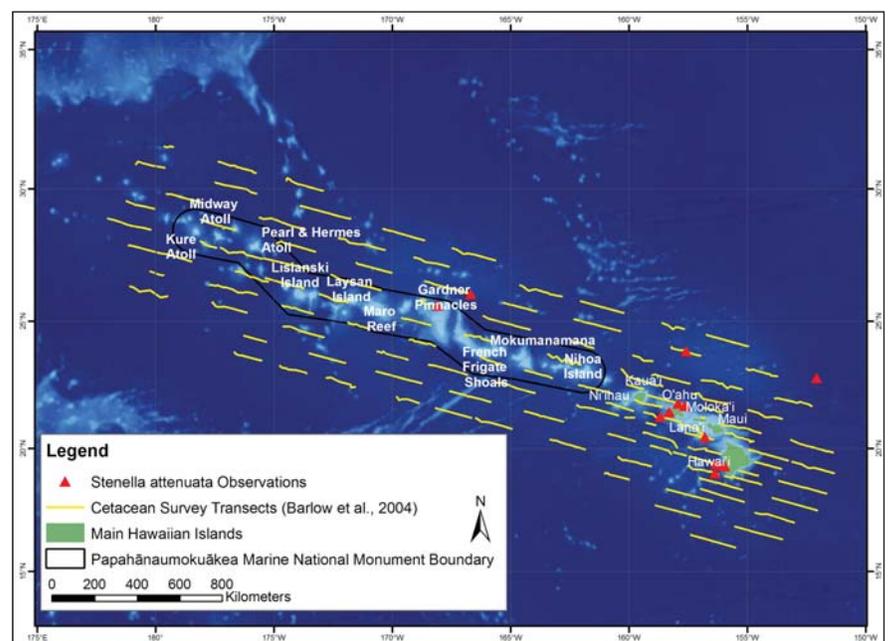


Figure 6.4. Pantropical spotted dolphin observations from 2002 survey of the Hawaiian Island EEZ. Source: Barlow et al., 2004; map: K. Keller.

Striped Dolphin (*Stenella coeruleoalba*)

The striped dolphin reaches a maximum length of 2.7 m and a maximum weight of 160 kg. It has a small to medium-sized robust body; a prominent falcate dorsal fin; and a long, well-defined beak. The color pattern is a combination of bluish-gray and white. The cape, beak, fins and tail are dark blue-gray. The ventral side, or belly, is white. On each side of the body a narrow black stripe runs from the beak to the eye and then diverges; one branch runs from to the pectoral flipper and the other continues along the side to the anal region. A bluish

or light gray shoulder blaze is present above the side stripe and below and anterior to the dorsal fin. The markings and boldness of the stripes vary with individual and geographical location.

Striped dolphins are primarily found in tropical and warm temperate waters that are oceanic and deep from 50°N to 40°S. They occur in the U.S. off the west coast, in the northwestern Atlantic, in the Gulf of Mexico and in the waters off of the Hawaiian Islands. This species associates with upwelling areas and convergence zones.

Striped dolphins are considered rare in Hawaiian waters (Shallenberger, 1981; Tomich, 1986). Baird et al. (2005a) suggested that they are likely to “use the [Hawaiian] islands seasonally (in warm-water periods).” In June 2003, Baird et al. (2003) recorded one sighting of striped dolphins off of Niihau, in approximately 2,800 m depth, with a mean group size of 45. Barlow et al. (2004) recorded 12 sightings of striped dolphins within the Hawaiian EEZ, between August and November, with a mean group size of 12.8 individuals (Figure 6.5). Three of these sightings occurred within the Monument boundaries (Barlow et al., 2004).

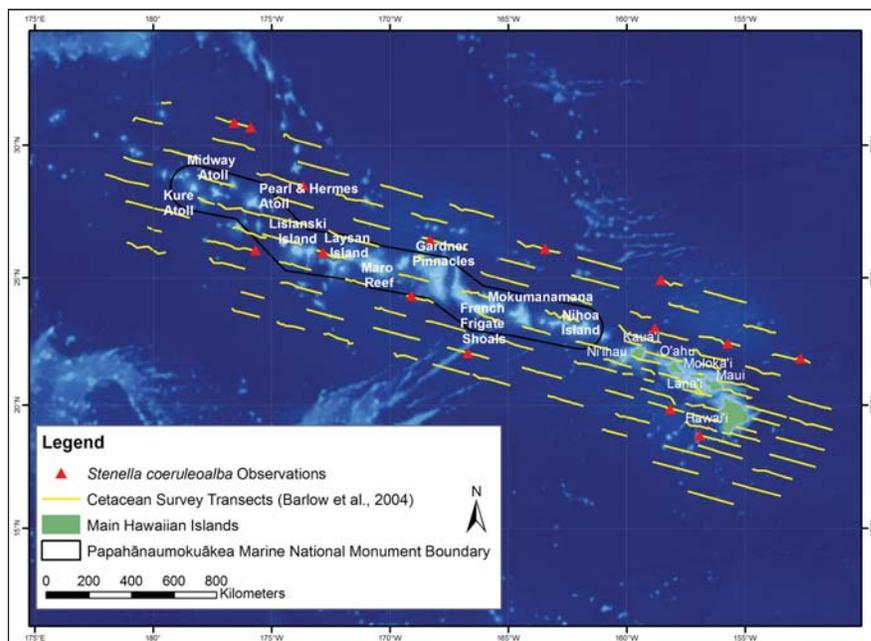


Figure 6.5. Striped dolphin observations from 2002 survey of the Hawaiian Island EEZ. Source: Barlow et al., 2004; map: K. Keller.

Spinner Dolphin (*Stenella longirostris*)

Four subspecies of spinner dolphins are recognized worldwide and include *Stenella longirostris longirostris* (Hawaiian or Gray's), *S.l. orientalis* (Eastern), *S.l. centroamericana* (Central American) and *S.l. roseiventris* (Dwarf). They vary regionally in both form and color pattern. Generally, the spinner dolphin body is slender and small, reaching maximum lengths of 2.4 m and 78 kg. The melon is relatively flat and the beak is long and slender. The dorsal fin shape varies from moderately falcate to triangular. The color pattern is defined by a dark dorsal cape that does not dip low along the sides (like the spotted dolphin, a similar-looking species), lighter gray sides, and a light gray or white ventral side.

Spinner dolphins are found in all tropical and subtropical oceans between 30°N and 30°S. *Stenella longirostris longirostris* is the most widely spread subspecies and is typically found around oceanic islands in the Atlantic, Indian, western and central Pacific Oceans. Spinner dolphins associated with the islands in the Hawaiian Archipelago often use shallow inshore waters to rest and socialize during the day and move offshore at night to feed (Norris and Dohl, 1980).

Hawaiian spinner dolphins are resident throughout the Hawaiian Islands, including the NWHI (Norris and Dohl, 1980; Shallenberger, 1981; Tomich, 1986; Karczmarski, 2005). Historical reports demonstrate the presence of spinner dolphins in the NWHI at French Frigate Shoals, Pearl and Hermes Atoll and Kure Atoll (Amerson, 1971; Woodward, 1972; Amerson et al., 1974). According to Amerson et al. (1974), prior to 1968 there had been no reported sightings of spinner dolphin at Pearl and Hermes Atoll. Photo-identification research (2006-2008) indicates the presence of a resident population at Pearl and Hermes Atoll (NMFS, unpublished data). Shallenberger (1981) recorded sightings at Laysan, Lisianski and Maro Reef. However, photo-identification and behavioral research at Midway Atoll (1998-2001) demonstrated that a resident population of spinner dolphins was present, but the population size changed from 1998 (n= 260 individuals) to 2001 (n=140 individuals) due to the immigration of individuals to Kure Atoll (Rickards et al., 2001; Karczmarski et al., 2005). During the

2002 (August – November) Hawaiian EEZ survey, eight sightings of spinner dolphins were recorded; three of these sightings were within the Monument boundaries (Barlow et al., 2004; Figure 6.6). During the 2007 (March-April) NWHI survey, two groups of spinner dolphins were observed at Gardner Pinnacles (NMFS, unpublished data). Genetic data from spinner dolphins in the MHI suggest that limited genetic exchange is occurring from one island to the next (Andrews et al., 2006; Baird et al., 2005a; Galver, 2002). Andrews et al. (2006) also found that the spinner dolphin populations in the NWHI (Midway, Pearl and Hermes and Kure) are genetically homogenous and distinct.

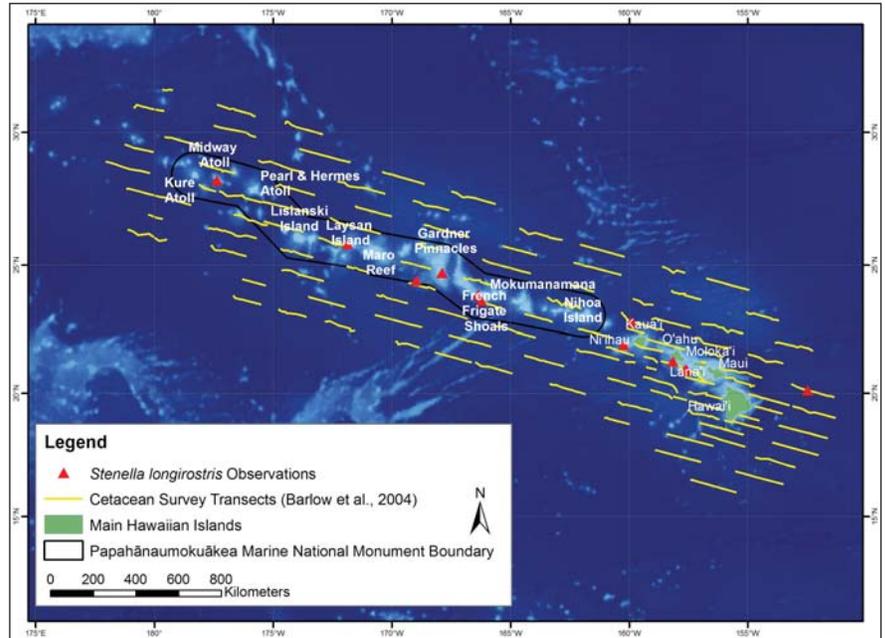


Figure 6.6. Spinner dolphin observations in Hawaiian Island EEZ. Sources: Barlow et al., 2004; Johnston et al., 2007; NFMS, unpublished; map: K. Keller.

Rough-toothed Dolphin (*Steno bredanensis*)

The rough-toothed dolphin has a moderately robust body shape; it reaches a maximum length of 2.7 m and a maximum weight of 160 kg. The dorsal fin is tall, moderately falcate and located at mid-back. The pectoral flippers are relatively large. The head is small and lacks a crease between the melon and the long beak. The color pattern is muted but defined by a dark dorsal cape, lighter gray sides and a white belly. Most rough-toothed dolphins have a mottled appearance from dark spotting on the sides, throat and belly. White scarring (from cookie cutter shark bites or other rough-toothed dolphins) is typical. The upper surface of the beak is dark and the lips and ventral surface are white.

Rough-toothed dolphins occur in deep warm temperate and tropical waters worldwide, between 45°N and 35°S.

Rough-toothed dolphins are observed in deep water around all of the MHI (Shallenberger, 1981; Tomich, 1986; Figure 6.7). Research conducted between 2000 and 2006 in the MHI (Baird et al., in press b) demonstrated that rough-toothed dolphins use the area year-round and are most commonly found in waters greater than 1,500 m deep. Within the waters of the NWHI, Shallenberger (1981) noted sightings of rough-toothed dolphins as far north as Mokumanamana. Nitta and Henderson (1993) reported a sighting at French Frigate Shoals. During the 2002 (August – November) Hawaiian EEZ survey, 19 groups of rough-toothed dolphins were observed ranging in size from two to 15 individuals; three of these sightings were within the Monument boundaries (Barlow et al., 2004). During the 2007

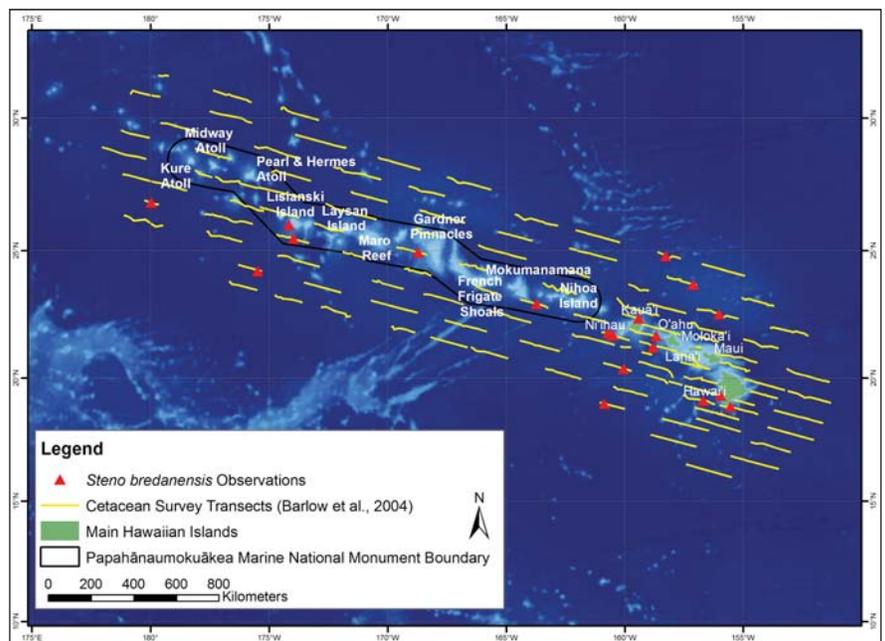


Figure 6.7. Rough-toothed dolphin observations in Hawaiian Island EEZ. Sources: Barlow et al., 2004; Johnston et al., 2007; NFMS, unpublished; map: K. Keller.

(March-April) NWHI survey, one group of rough-toothed dolphins was observed near Lisianski Island (NMFS, unpublished data).

Bottlenose Dolphin (*Tursiops truncatus*)

The bottlenose dolphin is characterized by coastal and offshore ecotypes that are morphologically distinct, in which the offshore animals tend to be larger in size. In general, the bottlenose dolphin has a wide head and robust body that reaches a length of 2.5 m to 3.8 m and a maximum weight of 500 kg. Males are typically larger than females. The beak is short, and there is a distinct crease where it meets the melon. The pectoral flippers are long, and the dorsal fin is moderately tall and falcate. The color pattern ranges from a dark gray dorsal cape to lighter gray sides but lacks a distinct demarcation. The belly tends to be off-white or pinkish.

The bottlenose dolphin occurs worldwide in tropical and temperate waters within the range of 45°N and 45°S. Coastal populations are found along continents and around most oceanic islands, where they move into or reside in bays, estuaries and lower bodies of rivers. Pelagic, or offshore populations tend to reside far offshore as in the Gulf Stream of the North Atlantic and the eastern tropical Pacific.

Bottlenose dolphins are distributed throughout the Hawaiian Archipelago and occur regularly in the waters surrounding the MHI (Shallenberger, 1981; Tomich, 1986). Research within the MHI suggests that individuals are resident to particular islands, not mixing between islands (Baird et al., 2003; Baird et al., 2006; Baird et al., in press a). Sightings of dolphins in the MHI occurred in average depths of 222 m (Baird et al., 2003). Baird et al. (2006) demonstrated that off Kauai and Niihau there are two existing populations of bottlenose dolphins that are distinguished by depth preference, however, they are not reproductively isolated as individuals move between the two populations. Historical reports demonstrate the presence of bottlenose dolphins in the NWHI at Laysan Island, French Frigate Shoals, Kure Atoll, and Pearl and Hermes Atoll (Rice, 1960; Amerson, 1971; Woodward, 1972; Amerson et al., 1974). During the 2002 (August – November) Hawaiian EEZ survey, 14 groups of bottlenose dolphins were observed and ranged in size from 4 to 28 individuals; one of these sightings was within Monument boundaries, southeast of Midway Atoll (Barlow et al., 2004; Figure 6.8). During the 2007 (March-April) NWHI survey, three groups of bottlenose dolphins were observed near Nihoa, Mokumanamana and Laysan Islands (NMFS, unpublished data).

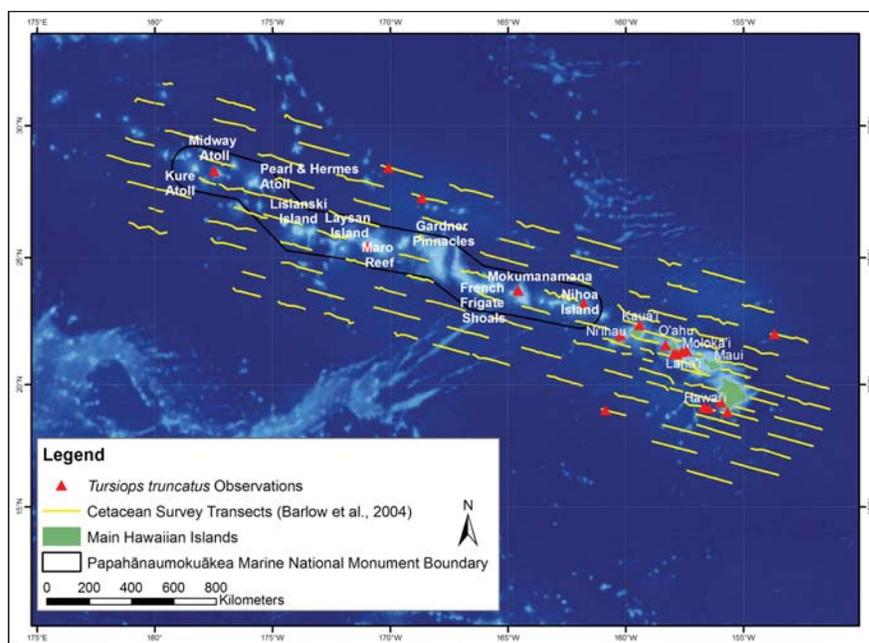


Figure 6.8. Bottlenose dolphin observations in the Hawaiian Island EEZ. Sources: Barlow et al., 2004; Johnston et al., 2007; NMFS, unpublished; map: K. Keller.

Risso's Dolphin (*Grampus griseus*)

The Risso's dolphin has a bulbous, beakless head with a distinguishable longitudinal crease along the center of the melon. It has a robust body that tapers to a narrow tailstock and reaches a length of 2.6 m to 4 m and a weight of 300 to 500 kg. The dorsal fin is tall, erect and moderately falcate; and the pectoral fins are long and sickle-shaped. The color pattern can be variable from black, dark gray, brown or white and typically lightens as an individual ages. Most adults are heavily scarred with teeth rakes of other dolphins, cookie cutter shark bites and circular marks from their prey (e.g., squid).

Risso's dolphins are extensively distributed throughout tropical and warm temperate waters. They are generally found in offshore waters deeper than 1,000 m and with surface temperatures of 10 to 28°C. Although migration patterns are unknown, seasonal shifts in population density are recognized and presumed to be related to changes in water temperature and prey (e.g., squid) abundance.

Sightings of Risso's dolphins are rare in Hawaiian waters (Shallenberger, 1981; Tomich, 1986). During a series of aerial surveys (in 1993, 1995 and 1998) in the MHI only two individuals were seen (Mobley et al., 2000), however, these surveys only covered waters within 46 km (25 nm) of the coast. Stranding records from five events also demonstrate the presence of Risso's dolphins within the MHI (Nitta, 1991; Maldini, 2005). During the 2002 (August-November) Hawaiian EEZ survey, seven groups of Risso's dolphins were observed (Figure 6.9). In five of these sightings, other cetacean species were present and included short-finned pilot whales, bottlenose dolphins, sei or Bryde's whales, and unidentified small dolphins (Barlow et al., 2004). In October 2002, a group of eight individuals was seen south of Lisianski Island (Barlow et al., 2004).

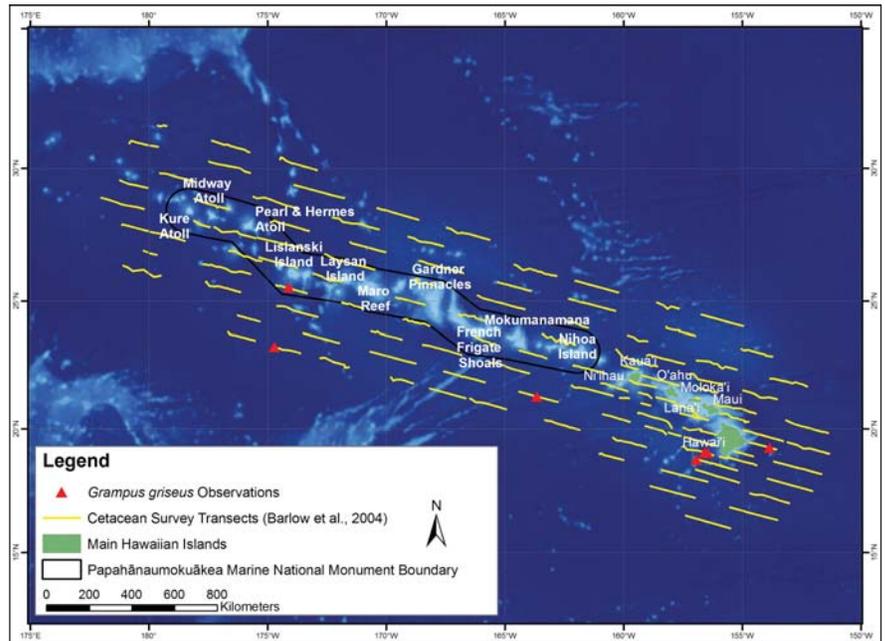


Figure 6.9. Risso's dolphin observations from 2002 survey of the Hawaiian Island EEZ. Source: Barlow et al., 2004; map: K. Keller.

Fraser's Dolphin (*Lagenodelphis hosei*)

The Fraser's dolphin has a stocky body and grows to a maximum length of 2.7 m and a maximum weight of 210 kg. It has small appendages and a small, well-defined beak. The dorsal fin is triangular to slightly falcate and is more erect in males than females. The color pattern is characterized by a dark, grayish-blue dorsal cape; lighter gray sides; a whitish belly; a distinctive dark stripe on each side that runs from the eye to the anus; and a dark flipper stripe that merges with the side stripe along the lower jaw.

The Fraser's dolphin is a pantropical species that is generally found between 30°N and 30°S. It is primarily an oceanic species and found in waters deeper than 1,000 m, however, it has also been found in areas where deep water approaches the coast.

The first documentation of Fraser's dolphins in Hawaiian waters occurred during the 2002 Hawaiian EEZ survey (Barlow et al., 2004; Figure 6.10). Two groups, comprised of 47 and 171 individuals, were observed within the Hawaiian EEZ (outside of Monument waters) in November (Barlow et al., 2004).

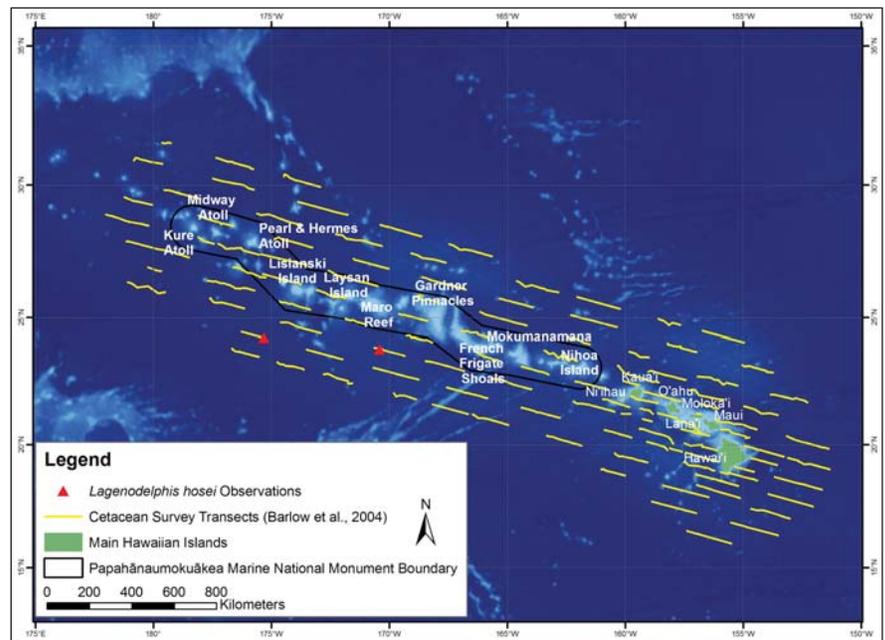


Figure 6.10. Fraser's dolphin observations from 2002 survey of the Hawaiian Island EEZ. Source: Barlow et al., 2004; map: K. Keller.

Melon-headed Whale (*Peponocephala electra*)

The melon-headed whale has a moderately robust body that tapers at both ends. This whale can reach a length of 2.7 m and a weight of 275 kg. The head is narrow, triangular shaped, and has no beak. The dorsal fin is tall (as much as 30 cm), falcate and positioned at mid back. The general color pattern has an overall gray or black appearance with variable lighter gray ventral markings and white lips. The face has a dark mask over the eyes, which helps to distinguish this species from others that are similar looking (e.g., pygmy killer and false killer whales).

The melon-headed whale is a pantropical species that is found in deep waters between 40°N and 35°S.

Melon-headed whales have been observed somewhat regularly in the waters surrounding the MHI (Shallenberger, 1981; Mobley et al., 2000; Baird et al., 2003; Baird et al., 2005a). The first record is from Hilo Bay in 1841 when a group of 60 animals were driven ashore by natives (Tomich, 1986). Shallenberger (1981) noted that a group of 75-150 melon-headed whales was seen regularly off the Kohala coast of Hawaii. During 12 aerial surveys (within 46 km from the coast of the MHI) in 1993-1998, Mobley et al. (2000) observed three groups with an average of 13.5 individuals per group. Between 2000 and 2005, Baird et al. (2005a) observed 18 groups with an average of 305 individuals per group (in the MHI). Three sightings within 2003 were in an average water depth of 1,100 m (Baird et al., 2003). During the 2002 (August-November) Hawaiian EEZ survey, Barlow et al. (2004) observed one group of 171 melon-headed whales within the northwestern portion of the EEZ (outside of Monument waters; Figure 6.11).

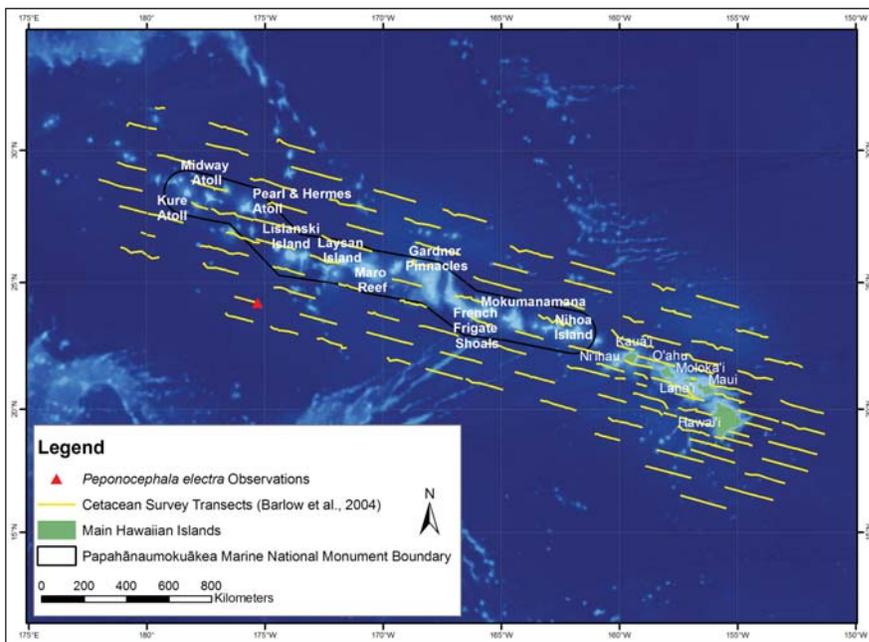


Figure 6.11. Melon-headed whale observations from 2002 survey of the Hawaiian Island EEZ. Source: Barlow et al., 2004; map: K. Keller.

Pygmy Killer Whale (*Feresa attenuata*)

The pygmy killer whale has a moderately robust body that tapers more toward the back half. It grows to a length of 2.6 m and a weight of 170 kg. The head is rounded with no beak. The dorsal fin is tall, falcate and positioned slightly behind the mid back. The color pattern is mostly dark gray to black with white markings on the lips and belly. Areas of lighter gray extend along the sides from the eye to the anus.

The pygmy killer whale is a pantropical species that is found between 40°N and 35°S. It is one of the most poorly known species of odontocetes.

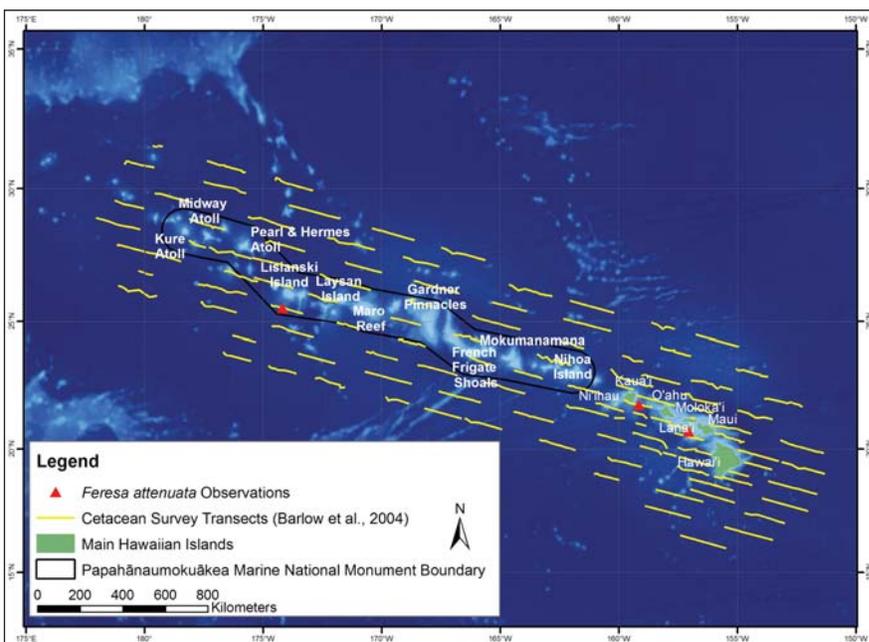


Figure 6.12. Pygmy killer whale observations from 2002 survey of the Hawaiian Island EEZ. Source: Barlow et al., 2004; map: K. Keller.

Pygmy killer whales have been observed off the leeward coasts of Oahu and Hawaii on numerous occasions in groups as large as 100 individuals, but typically in groups smaller than 50 individuals (Shallenberger, 1981; Tomich, 1986). Between 2000 and 2005, six groups of pygmy killer whales with an average group size of 11.5 individuals were observed in the MHI (Baird et al., 2005a). Baird et al. (2003) observed one group of 13 individuals off of Kauai/Niihau in 613 m depth. A long-term study of opportunistic sightings of pygmy killer whales suggests that a small population of year-round residents is located off the island of Hawaii (McSweeney et al., in press). Barlow et al. (2004) observed three groups of pygmy killer whales within the Hawaiian EEZ (Figure 6.12). One group of five individuals was seen within the Monument boundaries near Midway Atoll (Barlow et al., 2004).

False Killer Whale (*Pseudorca crassidens*)

The false killer whale has a relatively slender body that grows to a length 6 m and a weight of 2,000 kg. The head is small and conical with the melon overhanging the tip of the lower jaw. The dorsal fin is moderately tall, falcate and positioned at mid back. The flippers are broad at the base, narrow at the tip and have a bulge in the middle of the leading edge that is a distinguishing feature. The color pattern appears dark gray to black over the entire body with lighter gray patches on the throat and chest.

False killer whales are distributed throughout all tropical and warm-temperate waters, generally occurring between 50°N and 50°S. They are typically found in waters deeper than 1,000 m.

Two populations of false killer whales are recognized within the Hawaiian EEZ (Chivers et al., 2007). Genetic and photographic evidence demonstrate the presence of an offshore population closely related to animals found in the eastern North Pacific (and Palmyra Atoll), and an inshore population that is demographically distinct (Chivers et al., 2007; Baird et al., 2008). Both populations are listed as one strategic stock under the amendments to the MMPA as a result of interactions with Hawaii longline fisheries (<http://www.nmfs.noaa.gov/pr/species/esa/mammals.htm>). According to Baird et al. (2008), false killer whales are observed infrequently in the nearshore waters of the MHI. Between 1986 and 2006, only 50 groups of false killer whales were encountered (Baird et al., 2008). During aerial surveys within 46 km of the coast-line (1993-1998) Mobley et al. (2000) observed 21 groups. Baird et al. (2008) encountered false killer whales in depths between 48 m and 4,331 m depth. During the 2002 survey, Barlow et al. (2004) observed two groups of two and 19 individuals within the northwestern portion of the Hawaiian EEZ in August and September 2002, respectively (Figure 6.13). During the 2007 NWHI survey, one group of false killer whales was observed near Lisianski Island (NMFS, unpublished data).

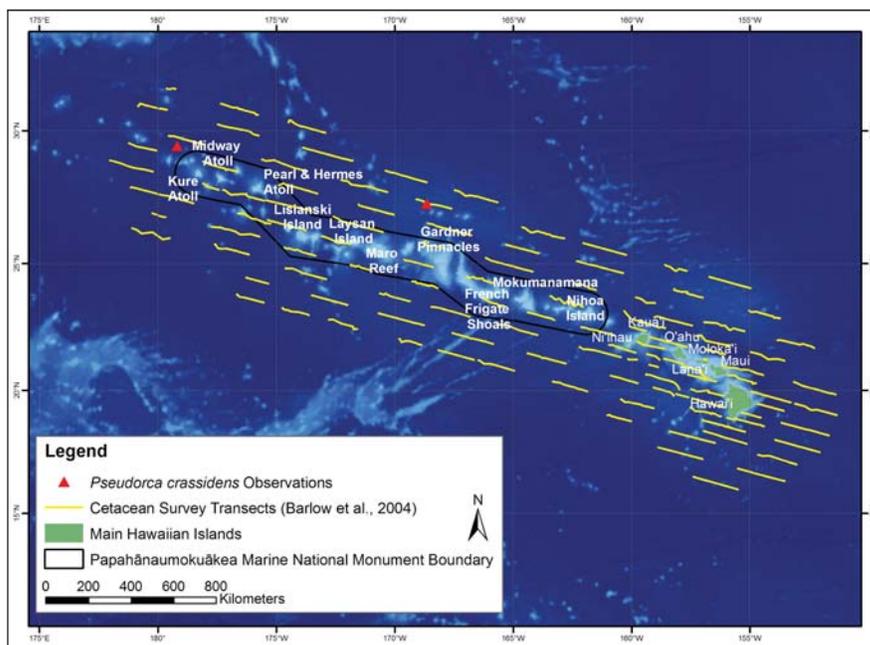


Figure 6.13. False killer whale observations from 2002 survey of the Hawaiian Island EEZ. Source: Barlow et al., 2004; map: K. Keller.

Short-finned Pilot Whale (*Globicephala macrorhynchus*)

The short-finned pilot whale has a large, bulbous head in which the melon protrudes beyond the mouthline. The beak is very short and the mouthline is noticeably upturned toward the eye. The dorsal fin is falcate, set forward of the midbody, broad at the base and long relative to its height. Males have distinctly broader dorsal fins than females. The species is relatively large with females reaching lengths of 5.5 m and weights of 1,000 kg and males reaching lengths of 6.1 m and weights of 3,000 kg. The color pattern is generally black or dark brown with a light gray throat patch, saddle behind the dorsal fin and streak behind the eye.

The short-finned pilot whale is a tropical to warm-temperate species found between 50°N and 40°S. They typically occur in deep water.

Short-finned pilot whales are seen throughout the year in the MHI (Shallenberger, 1981; Mobley et al., 2000; Baird et al., 2003). Shallenberger (1981) noted that group sizes were often greater than 100 individuals and rarely smaller than 30 individuals. Aerial surveys conducted within 46 km of the coastline within the MHI (1993-1998) resulted in 73 observed groups of pilot whales with an average group size of 8.4 individuals (Mobley et al., 2000). A summary of sighting data from 2000 to 2005 resulted in 80 observed groups of pilot whales with an average of 20 individuals per group (Baird et al., 2005a). Data from May and June of 2003 demonstrated that the average depth of sighting locations for 17 groups of pilot whales within the MHI was 1,142 m (Baird et al., 2003). During the 2002 survey of the Hawaiian EEZ, Barlow et al. (2004) observed 25

groups of pilot whales, ranging in size from 2 to 28 individuals (Figure 6.14). Four sightings were within the Monument boundaries (Barlow et al., 2004). During the 2007 (March-April) NWHI survey, four groups of pilot whales were observed within the Monument between Pearl and Hermes Atoll and Midway Atoll, near French Frigate Shoals and at Gardener Pinnacles (NMFS, unpublished data).

Killer Whale (*Orcinus orca*)

The killer whale has a stocky body with a conical shaped head that lacks a prominent beak. This is the largest of the delphinid species with females growing to a maximum length of 8.0 m and an average weight of 3,000 kg and males growing to a maximum length of 9.0 m and an average weight of 6,000 kg. The dorsal fin is large, ranging in size from 0.9 m for females to 1.8 m for males. The shape of the dorsal fin is variable, from falcate in females and juveniles to tall and erect in males. The color pattern of the killer whale is its most distinctive feature. The dorsal side of the body is black, as are the pectoral flippers. The ventral side of the body is white and lobes extend from the belly along each side behind the dorsal fin. Distinct white patches are located slightly above and behind the eyes. A gray to white shaded saddle is located on the back behind the dorsal fin.

Killer whales are considered the most widespread cetacean. They can be found in any marine region but are more abundant in cool temperate regions. In the Pacific Northwest, two different groups of killer whales have been identified. Both the “transients” and “residents” are present year-round, however the “transients” have larger home ranges and prey on marine mammals, while resident pods target fish as their primary prey. Whether this pattern is universal is unknown. Movements of killer whales appear to be driven by food availability (American Cetacean Society, 1995 -2007).

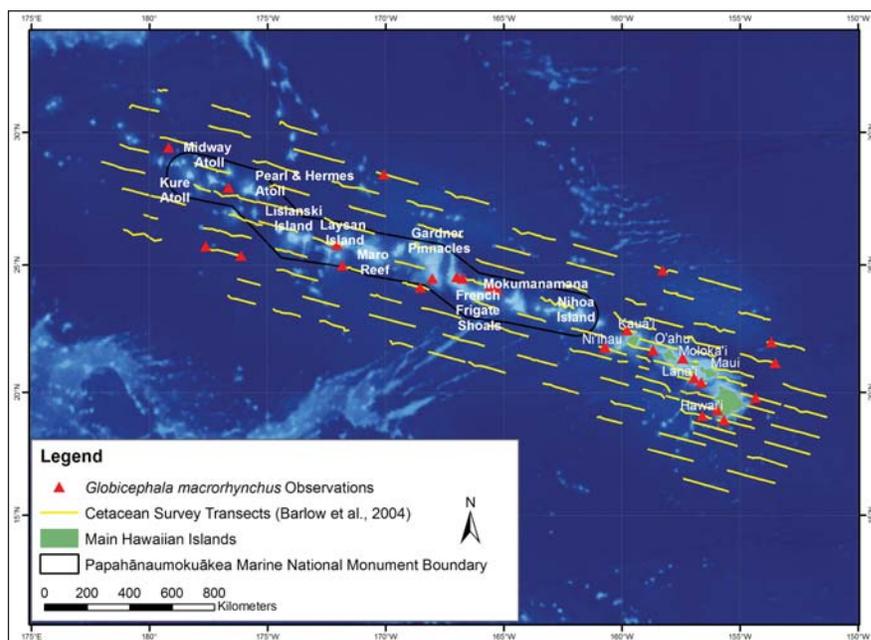


Figure 6.14. Short-finned pilot whale observations in the Hawaiian Island EEZ. Sources: Barlow et al., 2004; Johnston et al., 2007; NMFS unpublished; map: K. Keller.

Although infrequent, sightings of killer whales have been documented in the Hawaiian EEZ (Shallenberger, 1981; Tomich, 1986; Baird et al., 2005b). Baird et al. (2005b) reported 21 records of killer whale sightings within the Hawaiian EEZ between 1994 and 2004. During an aerial survey in March of 2000, Mobley et al. (2001) observed a group of killer whales west of Niihau. In May of 2003, Baird et al. (2003) observed one group of four individuals off the west side of the island of Hawaii in 773 m depth. Barlow et al. (2004) observed two groups of killer whales, each consisting of two individuals, in September and November of 2002 (Figure 6.15). The November sighting occurred just north of French Frigate Shoals (Barlow et al., 2004).

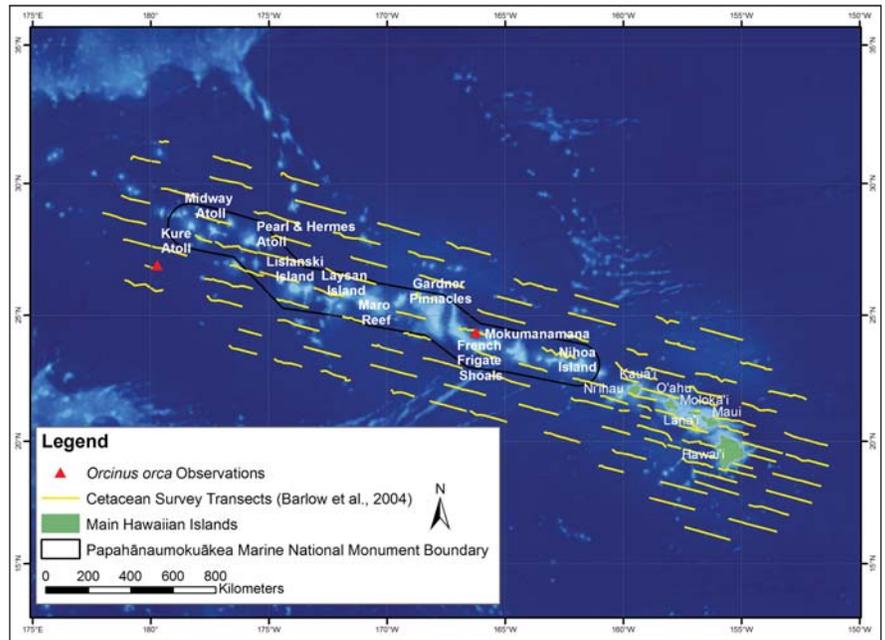


Figure 6.15. Killer whale observations from 2002 survey of the Hawaiian Island EEZ. Source: Barlow et al., 2004; map: K. Keller.

Sperm Whale (*Physeter macrocephalus*)

The sperm whale is large and distinctive, with a huge square head comprising approximately one-third of its total length. Adult females can reach 12 m in length and 24,000 kg in weight. Adult males are larger, reaching 18 m and weighing up to 57,000 kg. The blowhole is set at the front of the head and skewed to the left. The dorsal fin is small and rounded. The skin behind the head is wrinkled. The color pattern is black to brownish-gray with white around the mouth and belly.

Sperm whales are cosmopolitan in their distribution and inhabit waters from the equator to the edge of the polar ice packs. Only adult male sperm whales will move between higher and lower latitudes, while females, calves and juveniles are generally found in more tropical and subtropical waters year around. The breeding grounds are located in the tropical and subtropical waters of the lower latitudes. Sperm whales are primarily found in waters greater than 600 m deep.

Data from the Townsend (1935) charts indicate that occurrences of sperm whales around the Hawaiian archipelago were common (Figure 6.16). The whaling industry decimated their numbers, and currently the species is listed as Endangered under the ESA (<http://www.nmfs.noaa.gov/pr/species/esa/mammals.htm>). Shallenberger (1981) reported occasional sightings and stranding events within the MHI. Sperm whales were the most frequently observed species within the Hawaiian EEZ between August and December 2002 (Barlow et al., 2004). Barlow et al. (2004) observed 46 groups ranging in size from one to six individuals. Twelve of these sightings were within the Monument boundaries (Barlow et al., 2004).

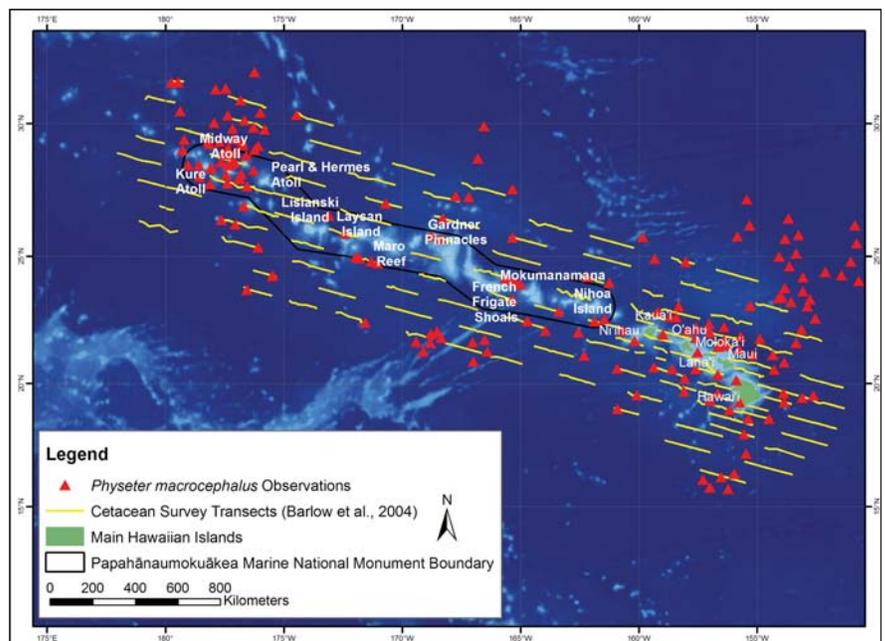


Figure 6.16. Sperm whale observations around the Hawaiian archipelago. Sources: Barlow et al., 2004; Johnston et al., 2007; NFMS, unpublished; Townsend, 1935; map: K. Keller.

During the 2007 (March-April) NWHI survey, seven groups of sperm whales were observed within the Monument (NMFS, unpublished data).

Pygmy Sperm Whale (*Kogia breviceps*)

The pygmy sperm whale has a small, robust body with a bulbous, square-shaped head with a pointed snout, a narrow mouth and undershot lower jaw. It ranges from 2.8 m to 3.5 m in length and reaches a maximum weight of 450 kg. The blowhole is set far back on the head and offset to the left. The dorsal fin is small, falcate and located behind the midpoint of the body. The pectoral flippers are small and located unusually close to the head. Coloration ranges from a dark gray on the back to pinkish-white on the belly, and there are half-moon shaped markings between the eye and the flipper, sometimes referred to as “false-gills”. The pygmy sperm whale closely resembles the dwarf sperm whale.

The pygmy sperm whale occurs in tropical to temperate regions worldwide and is generally found in deep waters seaward of the continental shelf. Pygmy sperm whales are thought to be non-migratory and are generally found singly or in small groups up to five individuals.

Pygmy sperm whales are observed occasionally within Hawaiian waters. Shallenberger (1981) combines the two *Kogia* species into one section because of the possible misidentification of each species. Most data come from strandings in the MHI, which have occurred on Kauai, Oahu, Molokai and Maui (Shallenberger, 1981). In June 2003, Baird et al. (2003) observed one group of two individuals between Kauai and Niihau in 700 m depth. Two lone individuals were observed within the northwestern portion of the Hawaiian EEZ by Barlow et al. (2004; Figure 6.17) in November 2002. Within the Monument there is a single record, from 1923, of a beach cast skeleton that was identified as a pygmy sperm whale (Amerson, 1971). It was this event that led to the naming of Whale Island at French Frigate Shoals (Amerson, 1971).

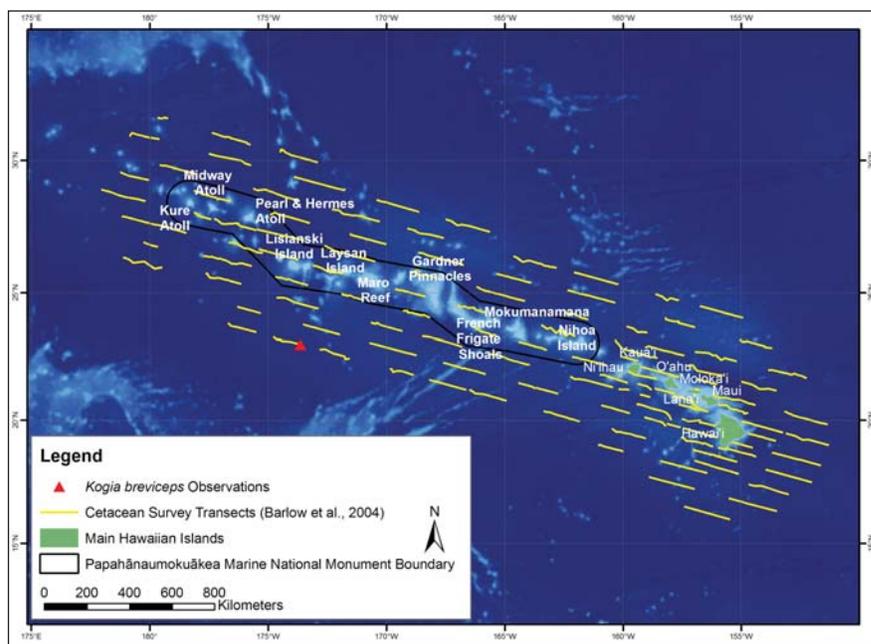


Figure 6.17. Pygmy sperm whale observations from 2002 survey of the Hawaiian Island EEZ. Source: Barlow et al., 2004; map: K. Keller.

Dwarf Sperm Whale (*Kogia sima*)

The dwarf sperm whale is nearly identical in appearance to the pygmy sperm whale; however, the dwarf sperm whale has a dorsal fin that is more prominent and positioned further forward on its back. Additionally, the dwarf sperm whale is a smaller whale, reaching a length of 2.7 m and weighing approximately 275 kg.

The dwarf sperm whale is a tropical and temperate species, generally found in offshore waters, but somewhat more coastal than the pygmy sperm whale. There is no evidence to suggest that the dwarf sperm whale migrates.

Shallenberger (1981) combines the two *Kogia* species into one section because of the possible misidentification of each species. Stranding events have been recorded on Oahu and Hawaii (Tomich, 1986). In May and June of 2003, Baird et al. (2003) encountered eight groups of dwarf sperm whales near Lanai, Kauai and Niihau. The average group size was two individuals, and they were observed in waters with an average depth of

2,004 m (Baird et al., 2003). Barlow et al. (2004) observed dwarf sperm whales on five occasions within the Hawaiian EEZ in October and November 2002 (Figure 6.18). The species was observed singly or in groups of up to three individuals (Barlow et al., 2004).

Blainville's Beaked Whale (*Mesoplodon densirostris*)

The Blainville's beaked whale, sometimes called the dense-beaked whale, has a robust body that is compressed laterally. It is a medium-sized whale that reaches 5.8 m in length and 3,500 kg in weight. The dorsal fin is small, falcate and positioned approximately two-thirds down the length of the body. The color pattern is silver-gray to brown on the dorsal surface with lighter gray to white on the belly. Blainville's beaked whales are typically covered with white or pale-gray circular marks or scars that are likely caused by cookie cutter sharks. They have a distinct mouthline that sweeps up at the middle of the lower jaw. Males have a tooth protruding from each side of the lower jaw at this site.

Blainville's beaked whales are a tropical and temperate species and are considered the most widely distributed mesoplodont. They are found primarily in deep waters, 500-1,000 m. There is no evidence of seasonal movements or migrations.

Blainville's beaked whales have been observed in the MHI off of Oahu, Hawaii, Kauai and Molokai (Shallenberger, 1981; Tomich, 1986; Mobley et al., 2000, Baird et al., 2003). Group sizes range from two to seven individuals (Shallenberger, 1981; Tomich, 1986; Mobley et al., 2000; Baird et al., 2003). Five groups observed by Baird et al. (2003) were in average water depths of 1,304 m. Recent satellite tagging studies off the west coast of the island of Hawaii suggest that this population of Blainville's beaked whales is island-associated and exhibits strong site fidelity (Schorr et al., In press). Within the Monument boundaries, the earliest record of Blainville's beaked whales is from a stranding event of two individuals at Midway Atoll in April 1961 (Galbreath, 1963; Shallenberger, 1981). Barlow et al. (2004) observed Blainville's beaked whales (one to two individuals per sighting) within Monument waters in September and October 2002 (Figure 6.19).

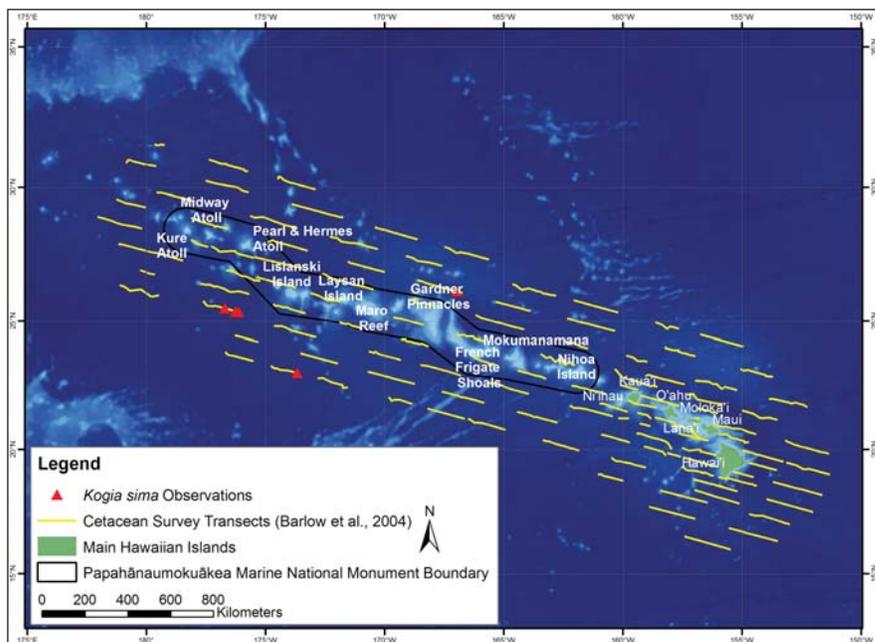


Figure 6.18. Dwarf sperm whale observations from 2002 survey of the Hawaiian Island EEZ. Source: Barlow et al., 2004; map: K. Keller.

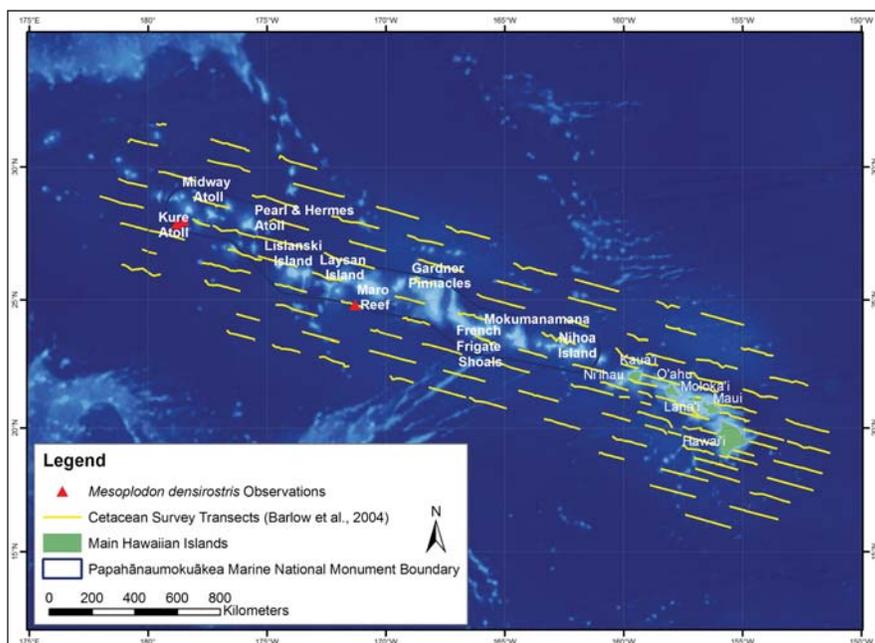


Figure 6.19. Blainville's beaked whale observations from 2002 survey of the Hawaiian Island EEZ. Source: Barlow et al., 2004; map: K. Keller.

Cuvier's Beaked Whale (*Ziphius cavirostris*)

Cuvier's beaked whale has a long, stocky body. Adults range in length from 5 m to 7.5 m and weigh from 2,000 kg to 3,000 kg. The head is small, the melon is steeply tapered and the beak is short and poorly-defined. Mature males have two teeth protruding from the front of the lower jaw. The dorsal fin is small, falcate and located approximately two-thirds back along the length of the body. The color pattern varies from dark gray to light brown, with the head and neck, and eventually the body, becoming lighter in color as the whale ages. This is particularly pronounced in males. Scars from cookie cutter sharks can give a mottled appearance to the sides and belly.

Cuvier's beaked whales occur in all offshore waters except those in the polar regions. They are primarily found in waters greater than 1,000 m deep.

Cuvier's beaked whales are observed infrequently within the Hawaiian EEZ. Shallenberger (1981) noted two sightings off of Lanai and Maui. Aerial surveys of the MHI conducted during 1993, 1995 and 1998 resulted in seven observed groups of Cuvier's beaked whales with an average group size of three individuals (Mobley et al., 2000). During a 10 year period (1990-2006), McSweeney et al. (2007) encountered Cuvier's beaked whales on 35 occasions off the west coast of the island of Hawaii. Re-sightings of individuals during this time suggest some degree of site fidelity and the presence of a resident population. Stranding events at Midway Atoll and Pearl and Hermes Atoll demonstrate the presence of Cuvier's beaked whales within the Monument (Shallengberger, 1981). In addition, Barlow et al. (2004) observed groups within the Monument, at Gardener Pinnacles and north of Mokumanamana in August of 2002 (Figure 6.20).

Longman's Beaked Whale (*Indopacetus pacificus*)

The Longman's beaked whale, sometimes referred to as the tropical bottlenose whale, can reach 9 m in length. It has a bulbous head and moderately long beak, from which two teeth erupt in males. The dorsal fin is pointed, falcate, and located behind the midpoint of the body. The color varies from brown to bluish gray, and the head and sides can be a lighter color in younger animals. This species has been misidentified as the southern bottlenose whale.

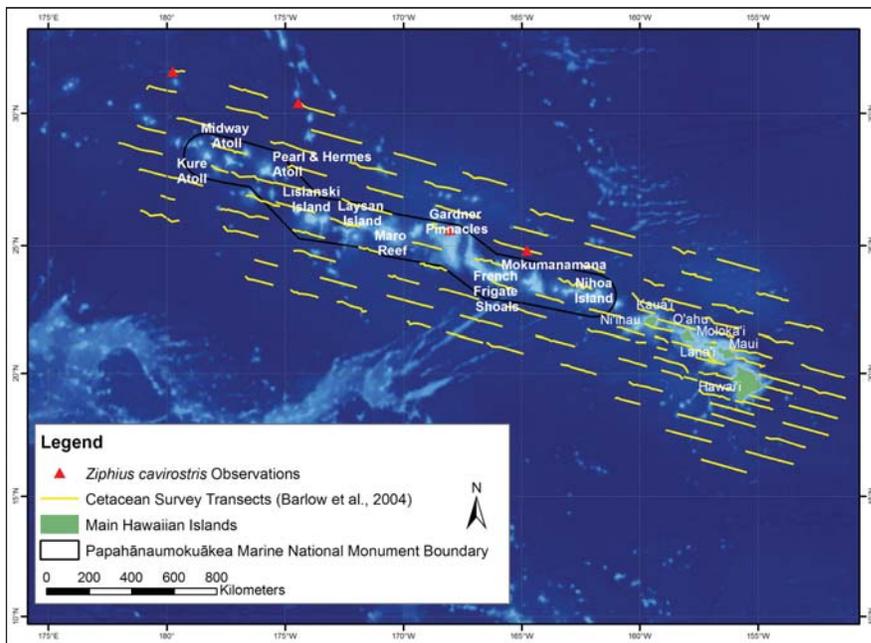


Figure 6.20. Cuvier's beaked whale observations from 2002 survey of the Hawaiian Island EEZ. Source: Barlow et al., 2004; map: K. Keller.

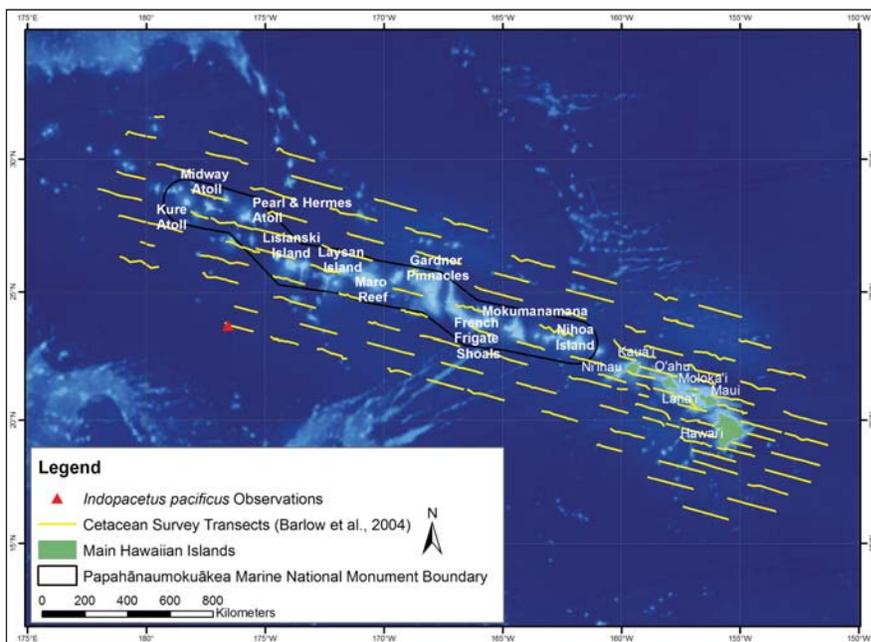


Figure 6.21. Longman's beaked whale observations from 2002 survey of the Hawaiian Island EEZ. Source: Barlow et al., 2004; map: K. Keller.

Little is known about the range of Longman’s beaked whale, but it is thought to occur primarily in pelagic waters within the Indo-Pacific region.

Longman’s beaked whale is rare in Hawaiian waters. There are only two confirmed sightings within the Hawaiian EEZ. The first was made in November 2002 when Barlow et al. (2004) observed one group of four individuals within the northwestern portion of the EEZ (Figure 6.21). The second confirmed sighting was a group of 30-35 individuals off of the west coast of the island of Hawaii in 2007 (<http://www.cascadiaresearch.org/robin/August2007.htm>).

Minke Whale (*Balaenoptera acutorostrata*)

Minke whales are the smallest of the baleen whales. At least two subspecies of the common minke whale are recognized and include the North Pacific (*B.a.scammoni*) and North Atlantic (*B.a. acutorostrata*). The dwarf minke whale is considered a potential third subspecies but has not been given an official scientific name. The common minke whale has a small, slender body and a pointed triangular head with a well-defined longitudinal ridge along the rostrum. Adults range in length from 7 m to 10.7 m and weigh as much as 9,200 kg. Females are slightly longer than males. The falcate dorsal fin is set approximately two-thirds back along the length of the body. The color pattern is black or dark gray on the dorsal side with a lighter gray chevron across the back and white on the belly. A white band across the middle of the pectoral flippers is a distinctive characteristic of this species.

Common minke whales occur in the North Atlantic and North Pacific and migrate from the polar and temperate waters in the summer to the tropical waters in the winter. They are frequently observed in coastal or shelf waters, rather than deep offshore habitats. In the eastern Pacific, minke whales are found from the Bering Sea south to the coast of Baja California, and in the western Pacific they are found from the Sea of Okhotsk to the Sea of Japan. The winter distribution of North Pacific minke whales can be inferred from the distribution of their distinctive calls (termed “boings”). Boings are heard primarily between 15°N and 30°N in the months of November through March (Rankin and Barlow 2005). Shallenberger (1981) lists the minke whale under “animals sighted in Hawaiian waters but not considered part of the normal cetacean fauna.” One minke whale was observed within the Hawaiian EEZ by Barlow et al. (2004) in November 2002 (Figure 6.22).

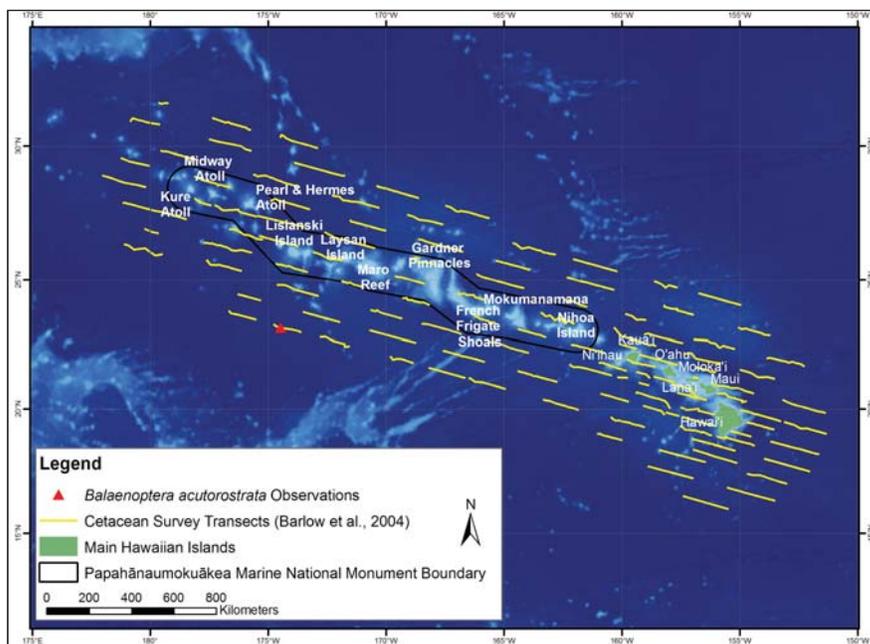


Figure 6.22. Minke whale observations from 2002 survey of the Hawaiian Island EEZ. Source: Barlow et al., 2004; map: K. Keller.

Bryde’s Whale (*Balaenoptera edeni*)

The Bryde’s whale has a long, slender body with a pointed rostrum. Females are larger than males and can reach a length of 15.5 m and a weight of 40,000 kg. Three ridges extend from the blowhole to the tip of the rostrum, which is a diagnostic feature of this species. The dorsal fin is extremely falcate, tall (up to 45 cm), and positioned two-thirds of the way along the length of the body. The color pattern is gray on the dorsal side and white on the belly, sometimes with banding or chevrons.

Bryde’s whales are found in tropical and subtropical waters of the Pacific, Atlantic and Indian Oceans. They are rarely seen north or south of 40°. The whales are often seen at nearshore upwellings but are also occasionally found offshore. Some evidence suggests that there are two forms of the Bryde’s whale, an inshore and an offshore that may differ in reproductive cycles and diet. The Bryde’s whale is not as migratory as the sei whale, but limited migration does take place in some populations (offshore form), while other populations are resident year-around (inshore form).

Shallenberger (1981) listed the Bryde’s whale as a rare species in Hawaiian waters. He noted one confirmed sighting 87 km southeast of Nihoa in April of 1977 (Shallenberger, 1981). Tomich (1986) cites Leatherwood et al. (1982) as noting that Bryde’s whales are “relatively abundant over shallows northwest of Hawaii and near Midway Islands.” During the 2007 NWHI survey, a single Bryde’s whale was observed off the east coast of Nihoa (NMFS, unpublished data). During August through October of the 2002 Hawaiian EEZ survey, Barlow et al. (2004) observed 14 groups of Bryde’s whales (Figure 6.23). With the exception of two sightings, in which there were two whales present, all were of single whales. Six of the sightings were within the Monument boundaries (Barlow et al., 2004).

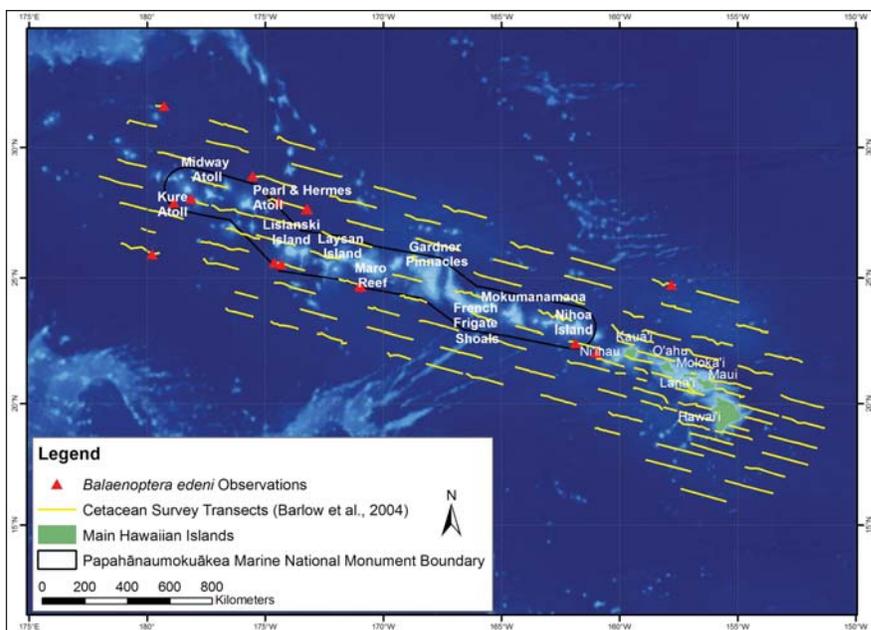


Figure 6.23. Bryde’s whale observations in the Hawaiian Island EEZ. Sources: Barlow et al., 2004; Johnston et al., 2007; NMFS, unpublished; map: K. Keller.

Sei Whale (*Balaenoptera borealis*)

Sei whales are similar in appearance to Bryde’s whales, with a gray dorsal and white ventral surface, and with the dorsal fin rising at a steep angle from the back. Adults reach a maximum of 20 m in length, and may weigh as much as 45,000 kg. Sei whales have only a single rostral ridge and lack the two additional parallel longitudinal ridges that are evident in the Bryde’s whales.

Sei whales are found from the tropics to polar regions in the northern and southern hemispheres, but most often occur in the mid-latitude temperate zones. They are migratory open-ocean whales, not often observed near the coasts. The species is listed as Endangered under the ESA (<http://www.nmfs.noaa.gov/pr/species/esa/mammals.htm>).

Neither Shallenberger (1981) nor Tomich (1986) mention sei whales. Individual sei whales were observed on several occasions within the Hawaiian

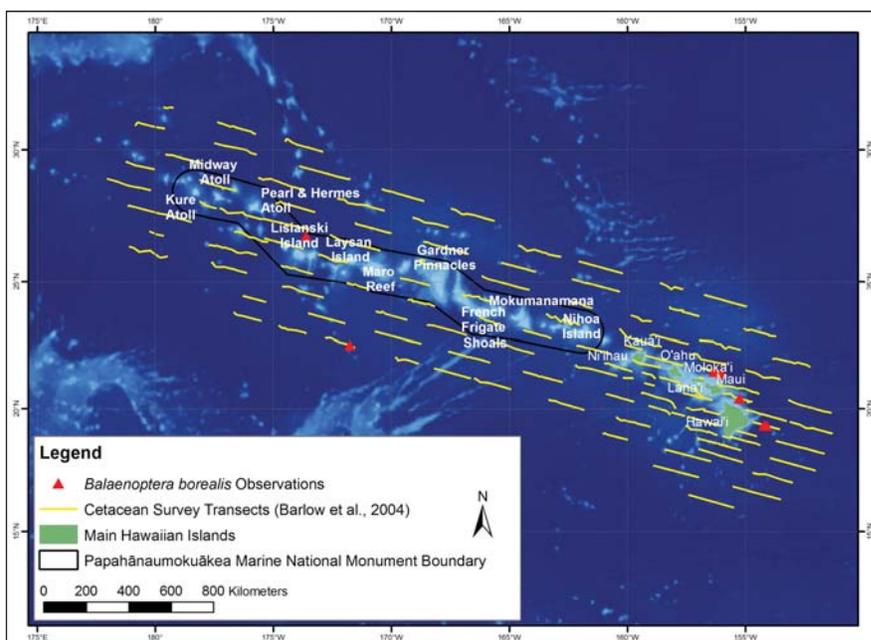


Figure 6.24. Sei whale observations in the Hawaiian Island EEZ. Sources: Barlow et al., 2004; Johnston et al., 2007; NMFS, unpublished; map: K. Keller.

EEZ (but outside of Monument waters) by Barlow et al. (2004) in November 2002 (Figure 6.24). In April 2007, during the NWHI survey a single sei whale was observed between Laysan and Lisianski Islands (NMFS, unpublished data).

Fin Whale (*Balaenoptera physalus*)

Similar to the Bryde's and sei whales, fin whales are dark brown or gray dorsally and white ventrally. Fin whales are significantly larger reaching a length of 24 m and a weight of 120,000 kg. The dorsal fin is variable and either pointed or falcate. Fin whales have a distinctive asymmetrical color pattern on the lower jaw; the right side (including baleen) is white and the left side is dark gray or black. In addition, most individuals have a v-shaped chevron across the back of the head and a swirled blaze on the right side of the head.

Fin whales are found in all oceans of the world, but primarily occur in cooler temperate regions and concentrate on shelf and in coastal waters. They can be found over a broad latitudinal range throughout the year, however, some appear to migrate, spending the summer in the northern polar region and the winter in warmer waters of lower latitudes. Like the sei whale, fin whales are listed as Endangered under the ESA (<http://www.nmfs.noaa.gov/pr/species/esa/mammals.htm>).

Shallenberger (1981) listed fin whales as rare in Hawaiian waters. He reported on two sightings off of Oahu and one stranding on Maui (Shallenberger, 1981). In February 1994, a single fin whale was observed near Kauai (Mobley et al. 1996). Acoustic recordings have also detected the presence of fin whales off Oahu and Midway (Thompson and Friedl, 1982; McDonald and Fox, 1999). During the period of September through November 2002, Barlow et al. (2004) observed five groups of fin whales within the Hawaiian EEZ (Figure 6.25). A single individual was observed within the Monument between Maro Reef and Laysan Island (Barlow et al., 2004).

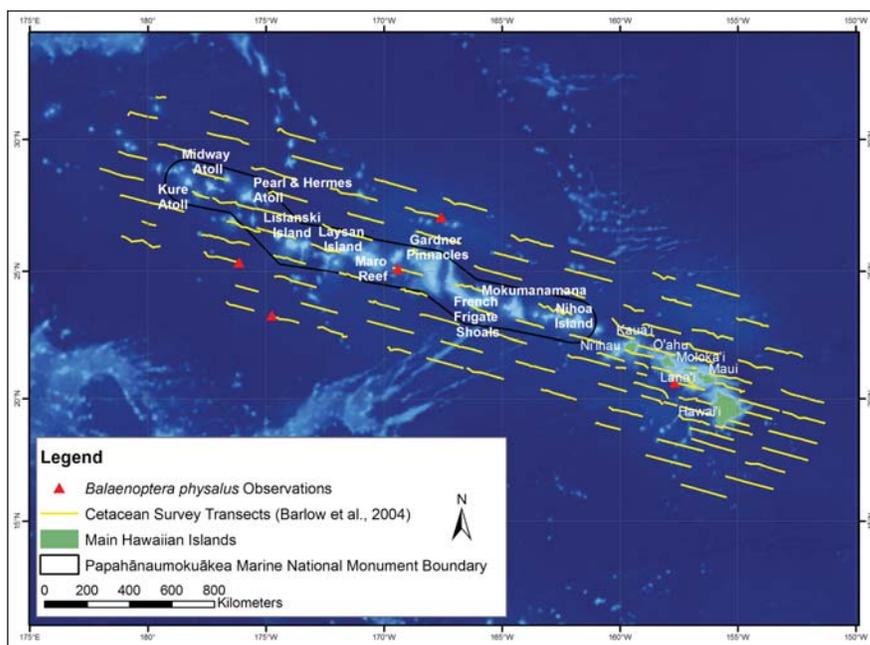


Figure 6.25. Fin whale observations from 2002 survey of the Hawaiian Island EEZ. Source: Barlow et al., 2004; map: K. Keller.

Humpback Whale (*Megaptera novaeangliae*)

The humpback whale has a large, robust body that reaches a maximum length of 17 m and a maximum weight of 40,000 kg. Females are slightly larger than males. Humpbacks have very long flippers (up to one-third the length of the body). The head and lower jaw are covered in tubercles. The dorsal fin is variable from tall and falcate to a small hump. The large flukes are concave with a serrated trailing edge. The color pattern is variable. It can be black on the dorsal side and black, white, or mottled black and white on the ventral side.

Humpback whales are found in all of the major oceans and occur primarily in coastal waters (Figure 6.26). They are a migratory species and spend the summer in the polar regions and the winter in tropical waters. Four stocks are believed to occur in the North Pacific, including one that winters in the central North Pacific and Hawaii. Multiple stocks also occur in the North Atlantic, Northern Indian Ocean and in the southern hemisphere. Humpback whales are listed as Endangered under the ESA (<http://www.nmfs.noaa.gov/pr/species/esa/mammals.htm>).

Humpback whales within the MHI have been extensively studied for nearly four decades (Herman and Antinaja, 1977; Shallenberger, 1977; Herman et al., 1980; Shallenberger, 1981; Calalmonkidis et al., 2008) and individ-

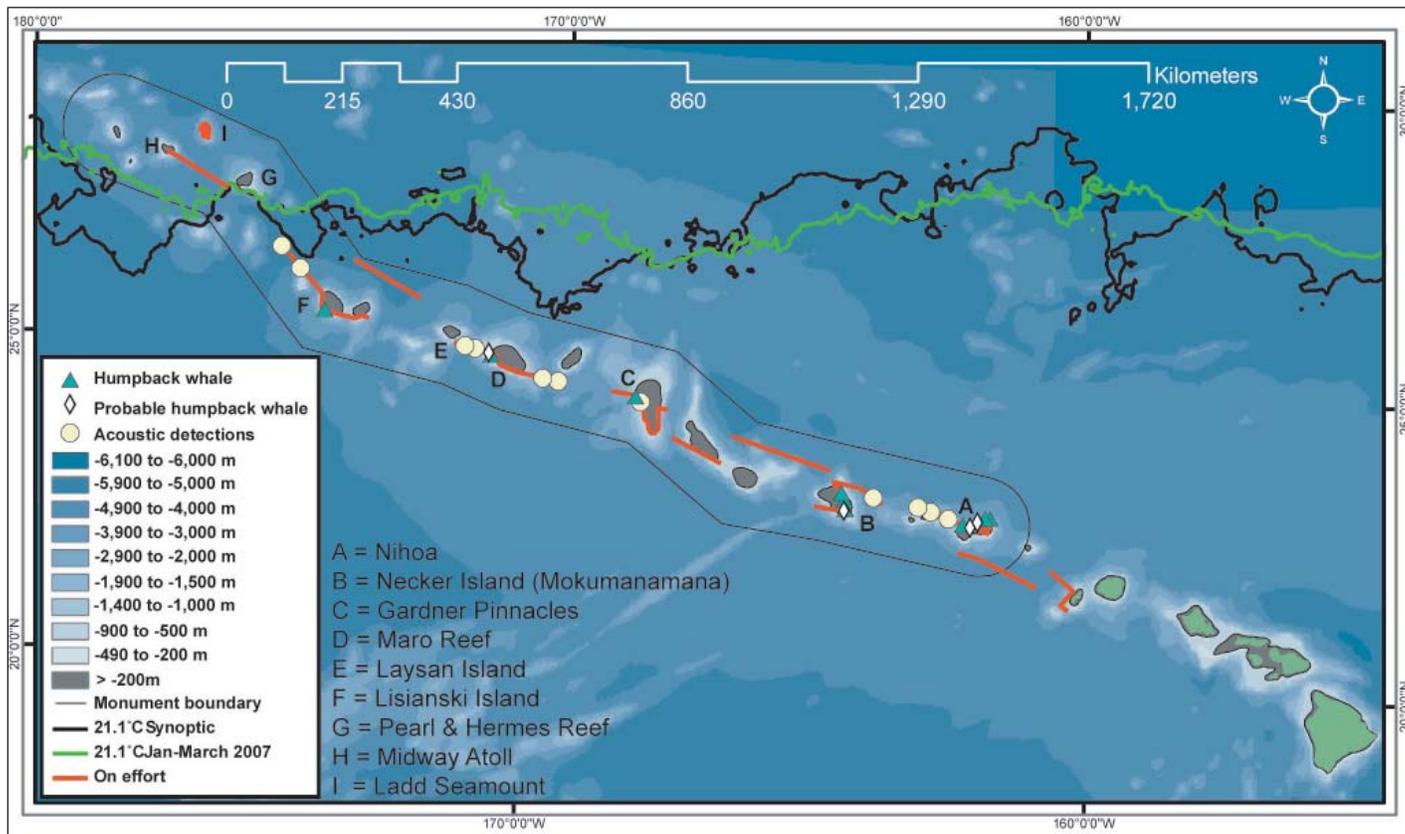


Figure 6.26. Humpback whale modeled habitat. A = Nihoa; B = Mokumanamana; C = Gardner Pinnacles; D = Maro Reef; E = Laysan Island; F = Lisianski Island; G = Pearl and Hermes Atoll; H = Midway Atoll; and I = Ladd Seamount. Map: Johnston et al., 2007.

ual whales photographed in Hawaii are also known from records in the northern feeding grounds in Alaska and British Columbia (Calambokidis et al., 2008). The whales migrate to the waters surrounding the Hawaiian Islands beginning in November and remain there until late May (Shallenberger, 1981). While in Hawaiian waters, they are found exclusively in shallow waters less than 183 m (Shallenberger, 1981; Johnston et al., 2007). Humpback whales may use the waters of the NWHI throughout the winter months, and were observed within the Monument boundaries near Nihoa, Mokumanamana, Gardner Pinnacles, Maro Reef and Lisianski Island (Johnston et al., 2007). Nine groups were observed, two of which contained calves (Johnston et al., 2007; Figure 6.27). Johnston et al. (2007) modeled the availability of humpback whale wintering habitat within the Monument based on bathymetric and sea surface temperature data. This modeling indicates potential available humpback whale habitat at all islands and atolls in the NWHI (and at Maro Reef and Ladd Seamount) south of the 21.1°C sea surface temperature cline. These areas in 2007 totaled 14,700 km², compared to 7,200 km² of humpback wintering habitat available in the MHI (Johnston et al., 2007). Surveys (aerial and ship-based) of the NWHI conducted in 1976-1977 (November-April) returned no sightings of hump-

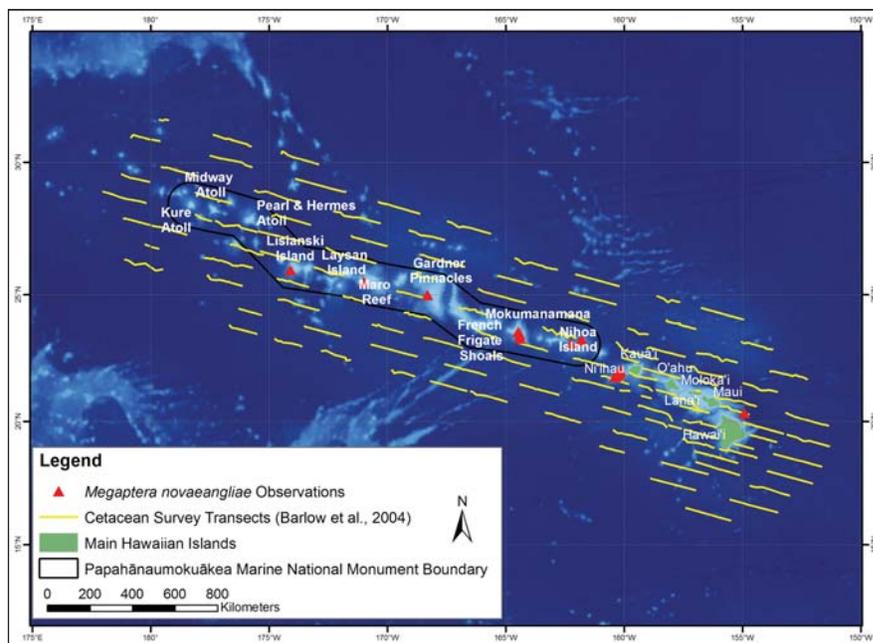


Figure 6.27. Humpback whale observations in the Hawaiian Island EEZ. Sources: Barlow et al., 2004; Johnston et al., 2007; NMFS, unpublished; map: K. Keller.

back whale wintering habitat within the Monument based on bathymetric and sea surface temperature data. This modeling indicates potential available humpback whale habitat at all islands and atolls in the NWHI (and at Maro Reef and Ladd Seamount) south of the 21.1°C sea surface temperature cline. These areas in 2007 totaled 14,700 km², compared to 7,200 km² of humpback wintering habitat available in the MHI (Johnston et al., 2007). Surveys (aerial and ship-based) of the NWHI conducted in 1976-1977 (November-April) returned no sightings of hump-

back whales (Herman et al., 1980). However, since the mid-1990s, regular sightings of humpback whales each year from January through March have been made by U.S. Fish and Wildlife Service staff stationed at French Frigate Shoals (A. Anders, pers. comm.). One reported opportunistic sighting of a mother and calf at French Frigate Shoals in February 1977 was dismissed as a “straggler” (Herman et al., 1980). This may suggest that the NWHI provide winter habitat for an expanding humpback whale population (Johnston et al., 2007).

Additional Cetacean Species

In addition to the 23 species described above, two other cetacean species have been detected within the Hawaiian Islands EEZ, including the North Pacific right whale (*Eubalaena japonica*) and blue whale (*Balaenoptera musculus*; Barlow, 2006). North Pacific Right whales have been observed in the waters surrounding the MHI on two confirmed occasions (Rountree et al., 1980; Tomich, 1986). The first record comes from a whaling ship’s logbook from 1851 in which a single “straggler” was observed 250 nm west of Maui (Rountree et al., 1980). Tomich (1986) noted a sighting of an individual right whale swimming among a group of humpback whales between Maui and Lanai in March 1979. Blue whales have been detected, based on vocalizations, off of the coast of Oahu and it was suggested that they migrate past the Hawaiian Islands twice a year (Thompson and Friedl, 1982). Twenty hertz signals, similar to those recorded by Thompson and Friedl (1982), have also been reported near Midway Atoll (Tomich, 1986).

Cetacean Abundance Estimates

The 2002 cetacean survey conducted by Barlow et al. (2004) in the Hawaiian Islands EEZ allowed for the calculation of abundance and density estimates for 19 of the 23 species observed (see Barlow 2006 for description of analytical methods).

PINNIPEDS

The Hawaiian monk seal (*Monachus schauinslandi*; Figure 6.28) was listed as Depleted under the MMPA and Endangered under the ESA in 1976. The current population estimates are around 1,100-1,200 individual seals, the majority of which live in the NWHI.

The genus *Monachus* is a wide ranging species and is found in several different geographic areas around the world (Figure 6.29). The genus includes the Mediterranean monk seal (*Monachus monachus*), the Caribbean monk seal (*Monachus tropicalis*) and the Hawaiian monk seal. The Mediterranean monk seal is critically endangered and the Caribbean monk seal is assumed to have gone extinct in the last 50 years (Kenyan, 1977; see Boyd and Stanfield). The Hawaiian monk seal populations are estimated to have declined by 60% since the 1950s (Antonelis et al., 2006).

Range

Based on anatomical features and DNA analysis researchers estimate that Hawaiian monk seals arrived in Hawaii 14-15 million years ago (Repenning et al., 1979) and split from the *Monachus* ancestors around 11.8 to 13.8 million years ago (Flyer et al., 2005). Hawaiian monk seals occur within the Hawaiian EEZ and the main subpopulations occur in the NWHI. A smaller but potentially increasing population of seals inhabit the MHI and there have been occurrences including a documented pupping and relocations of aggressive males to Johnston Atoll. The monk seal metapopulation can be divided into six major and two smaller subpopulations in the NWHI and one in the MHI (Figure 6.30). These subpopulations are further grouped into management units.



Figure 6.28. There are an estimated 1,200 Hawaiian monk seals, the majority of which live in the NWHI. In 1976 the species was listed as Endangered under the ESA. Photo: J. Watt.

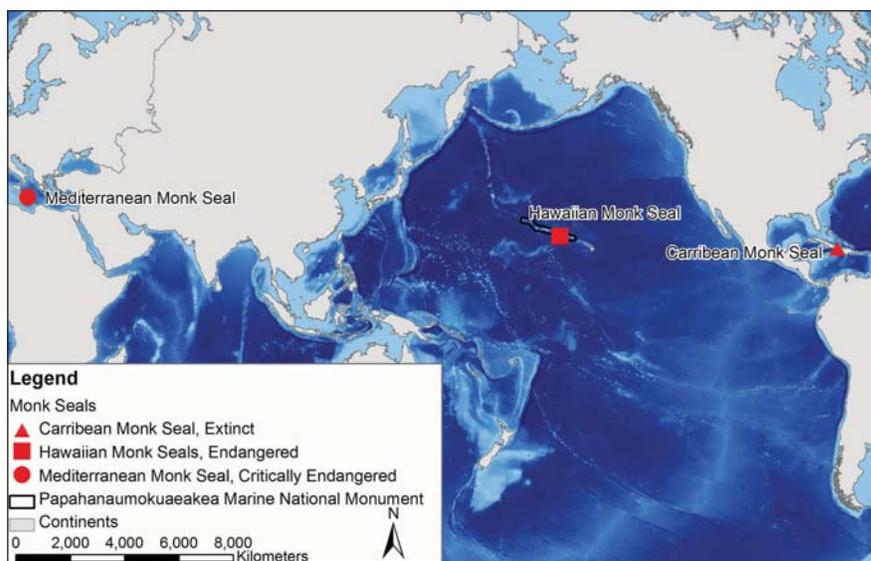


Figure 6.29. Worldwide distribution of monk seals. Source: ESRI; map: K. Keller.

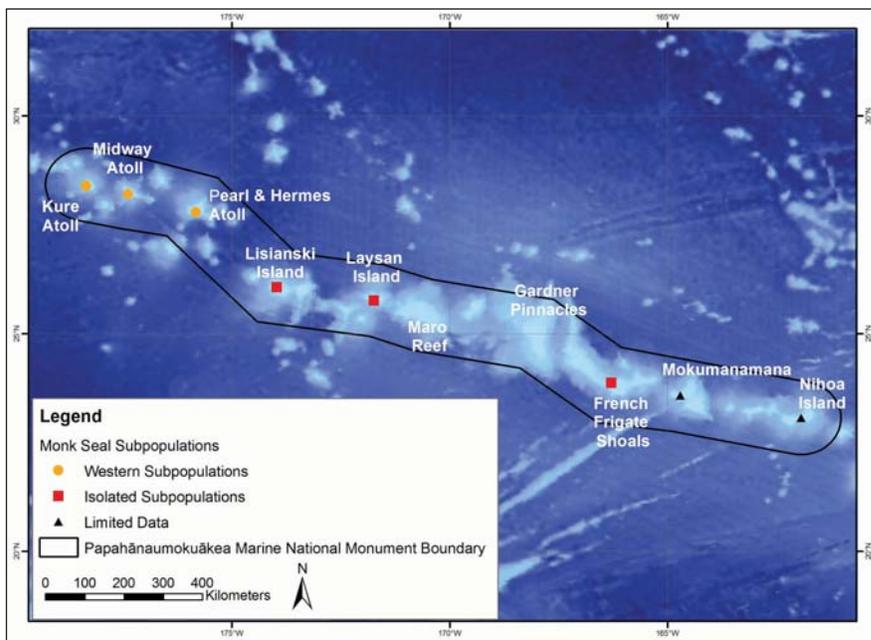


Figure 6.30. Hawaiian monk seal subpopulations. Source: NMFS, unpub data; map: K. Keller.

Available Data

The U.S. Fish and Wildlife Service conducted periodic monitoring of Hawaiian monk seals from the late 1950s until the late 1970s when the National Marine Fisheries Service (NMFS) assumed responsibility for recovery of the species and commenced monitoring activities. NMFS began an annual monitoring of Hawaiian monk seals at most major sites in the early 1980s. There is no historic data for estimating population size prior to the surveys of the 1950s or to estimate carrying capacity. It is likely that upon arriving in the MHI, Polynesian settlers extirpated the local population of seals. The surveys of the NWHI in the 1950s were too soon after World War II for the population to have plausibly recovered from the impact of the military disturbance, and some military presence was still having a negative effect on the monk seals at that time.

The first range-wide surveys of Hawaiian monk seals were conducted in the late 1950s (Kenyon and Rice, 1959; Rice, 1960). Additional counts were conducted at Midway Atoll in 1956-1958 (Rice, 1960) and at Kure Atoll in 1963-1965 (Wirtz, 1968). Surveys were repeated throughout the 1960s and 1970s, and while the methods were not standardized, complete beach counts are roughly comparable between the two survey periods.

Since the early 1980s NMFS has been conducting annual surveys using standardized methods to estimate the population of Hawaiian monk seals. The work is conducted at field camps that are active from approximately April through August (Figure 6.31). All of the field camps collect information on the numbers of seals in the subpopulations based on counts of uniquely-identified seals. In addition any births, deaths, serious injuries and entanglements are documented. Necropsies are conducted on dead seals and seal feces are collected to evaluate dietary information.

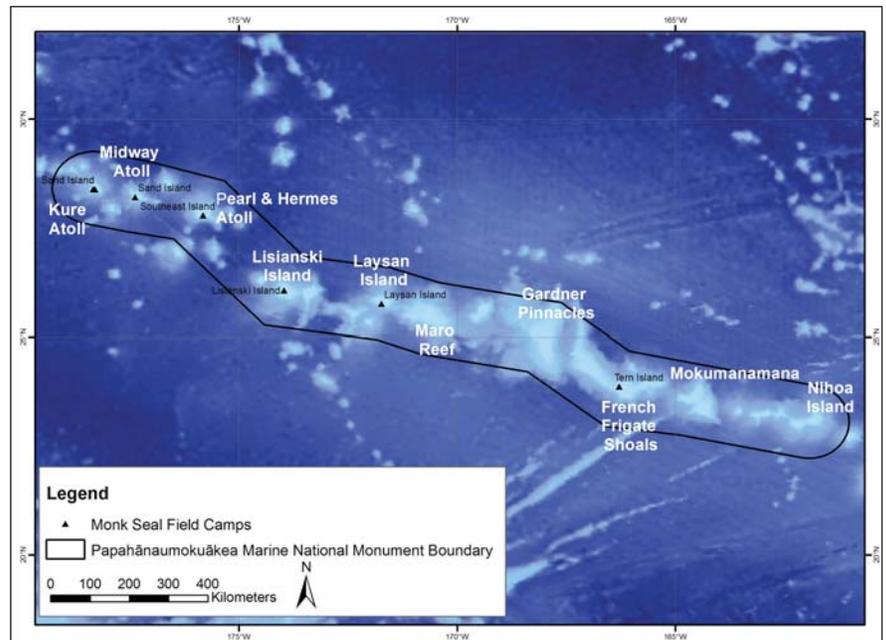


Figure 6.31. Hawaiian monk seal field camps. Map: K. Keller.

Habitat Use and Foraging Behavior

Between 1996 and 2002, the movements and diving patterns of 147 Hawaiian monk seals have been monitored with satellite-linked radio transmitters at the six breeding colonies in the NWHI (42 adult males, 35 adult females, 29 juvenile males, 14 juvenile females, 12 weaned male pups, 15 weaned female pups; Abernathy and Siniff, 1998; Stewart, 2004a, b; Stewart and Yochem, 2004a, b, c).

Parrish et al. (2000) attached animal borne imaging systems (Crittercams) to 24 adult and subadult male monk seals at French Frigate Shoals. The Crittercams recorded the habitat depth and bottom type at locations where monk seals were seen capturing prey items. Recent studies have focused on characterizing juvenile monk seal habitat use and foraging behavior at French Frigate Shoals using Crittercams and time-depth recorders (TDRs).

Abundance

NMFS field camps were initiated in the early 1980s using systematic surveys for estimating abundance of the Hawaiian monk seal populations. The abundance of monk seals at the six main reproductive sites in the NWHI is estimated by direct enumeration. At those locations the majority of individual seals can be identified by flipper-tags that have routinely been applied to weaned pups since the early 1980s, bleach marks placed annu-

ally, and by natural features such as scars and distinctive pelage patterns (Harting et al., 2007). The methods are different at Mokumanamana and Nihoa Islands because they are difficult to reach and there are no regular field camps at those sites.

The methods used to derive estimates of monk seal abundance, and the abundance at locations within the Monument and in the MHI are as follows:

- Main reproductive sub-populations in the NWHI of French Frigate Shoals, Laysan, Lisianski, Pearl and Hermes Atoll, Midway Islands and Kure Atoll: total enumeration of individuals when possible, otherwise capture-recapture estimates or minimum abundance (Baker, 2004; Baker et al., 2006).
- Mokumanamana and Nihoa Islands: corrected mean beach counts made during most recent five years at Mokumanamana and Nihoa Islands. A correction factor (2.89 ± 0.06 ; NMFS, unpubl. data) derived from observations at the main reproductive sites is applied.
- MHI: Minimum abundance consisting of the total number of uniquely identifiable seals observed alive during a calendar year. Sightings are non-systematic and collected by NMFS, and reported by volunteers, partner agencies and the general public.

Beach Counts

Methods

Beach counts are conducted at least eight times annually per site to calculate a mean value that serves as a trend index for long-term comparisons. The beach counts include a count of all the seals found on the island or group of islands within an atoll during a single mid-day survey.

Uses

Direct enumeration data cannot be used for comparing historical counts; however, a measure of long-term trend is derived from the mean of all of the beach counts that have been conducted with varying frequency since the late 1950s. These beach counts provide a useful index because the general methodologies of counts during these 45 years are roughly comparable.

Limitations

A consideration when interpreting the mean beach counts is that the relationship between the mean beach counts and the actual population size is uncertain. That is, all of the factors that might cause beach counts to deviate from the true abundance (for example, changes in haul out patterns over time) are not known, and hence appropriate correction factors have not been determined. Eberhardt et al. (1999) concluded that, "beach counts may be very poor guides to year-to-year trends. However, beach counts are valuable indicators of long-term trends." NMFS is currently investigating other approaches for estimating total abundance to better characterize long- and short-term trends.

Habitat Use

Terrestrial Habitat Use

Monk seals use terrestrial habitat for haul-out areas to rest and pupping. Haul-out areas for resting generally consist of sandy beaches, but virtually all substrates, including emergent reef and shipwrecks, are used at various islands. Monk seals also use the vegetation behind the beaches, when available, as a shelter from wind and rain. Pups are born on various substrates; however, sandy beaches with shallow protected water near shore seem to be preferred habitat for pupping and nursing (Westlake and Gilmartin, 1990).

Marine Habitat Use

Monk seals spend approximately two-thirds of their time in the marine habitat (MMRP, unpublished data). They are primarily benthic foragers (Goodman-Lowe et al., 1998), and will search for food in coral reef habitat and on substrate composed of talus and sand on marine terraces of atolls and banks to depths exceeding 500 m (Parrish et al., 2000, 2002; Parrish and Abernathy, 2006). Parrish et al. (2002) also described monk seals foraging in corals below 300 m in subphotic zones (Parrish et al., 2002).

The largest study of monk seal foraging ranges and diving behavior was conducted using tagging information from 1996 to 2002 (Abernathy and Siniff, 1998; Stewart 2004a, b; Stewart and Yochem, 2004a, b, c). During this time the movements and diving patterns of 147 Hawaiian monk seals were monitored with satellite-linked radio transmitters at the six breeding colonies in the NWHI. Spatial dispersal of foraging seals indicates that they forage extensively within the lagoons at French Frigate Shoals, Pearl and Hermes Atoll, Midway Atoll and Kure Atoll, and on the outer slopes of those atolls and seaward of Laysan and Lisianski Island. Seals also foraged along the submarine ridges between these atolls and islands and at virtually all nearby seamounts. A fixed kernel density estimate method was used to determine the extent of foraging areas (Stewart et al., 2006; Figure 6.32). Primary foraging occurred in areas with high bathymetric relief or focused within the lagoon areas. At the majority of the islands and atolls 95% of the foraging occurred within 38 km and 75% occurred within 20 km of center of the island or atoll (Stewart et al., 2006). French Frigate Shoals did not follow this same pattern, however, with 95% of the foraging occurring within 50-58 km of the center of the atoll (Stewart et al., 2006). Seals at all of the colonies foraged outside of the colonies but there was no distinct pattern (Stewart et al., 2006; Table 6.2). Distances traveled to forage from haul out sites also varied with a seal's age and sex and with the seal's colony of seal origin. Foraging distances ranged overall from less than 1 km up to 217 km (Abernathy, 1999; Stewart, 2004a, b; Stewart and Yochem, 2004a, b, c; Stewart et al., 2006)

In addition to looking at the distances seals foraged from their colonies, the diving behavior was also monitored (Stewart et al., 2006; Table 6.2). Most frequently, seals dove to depths less than 150 m, though there were secondary diving modes at various depths up to 500 m. There was some variation in seals foraging depth between the island and atolls. At Pearl and Hermes Atoll 90 % of dives and at French Frigate Shoals 60 – 80% of dives were to depths of less than 40 m. The remaining 10 – 20% of dives occurred in depths greater than 40 m with some occurring as deep at 500 m. At Kure Atoll, Midway Atoll, Lisianski Island and Laysan Island seals regularly dived to depths greater than 40 m (Stewart et al., 2006).

Foraging areas seem to vary between age groups, islands and individuals (Figure 6.33). Weaned pups at Kure Atoll and Midway Atoll did not range as far as adults whereas at Lisianski Island and Laysan Islands, adults and weaned pups exhibited similar foraging distances (Stewart et al., 2006). Further analy-

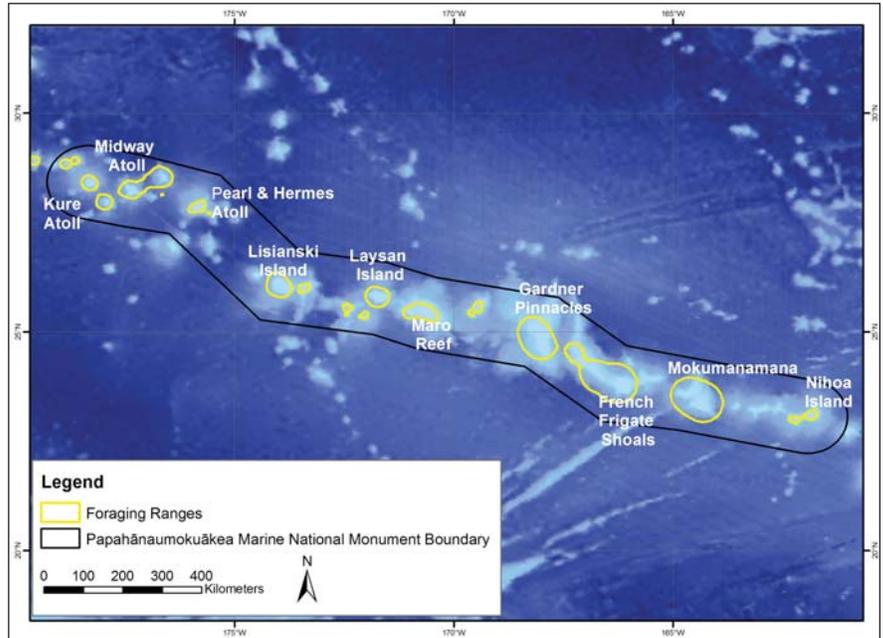


Figure 6.32. Hawaiian monk seal foraging ranges. Source: Stewart et al., 2006; map: K. Keller.

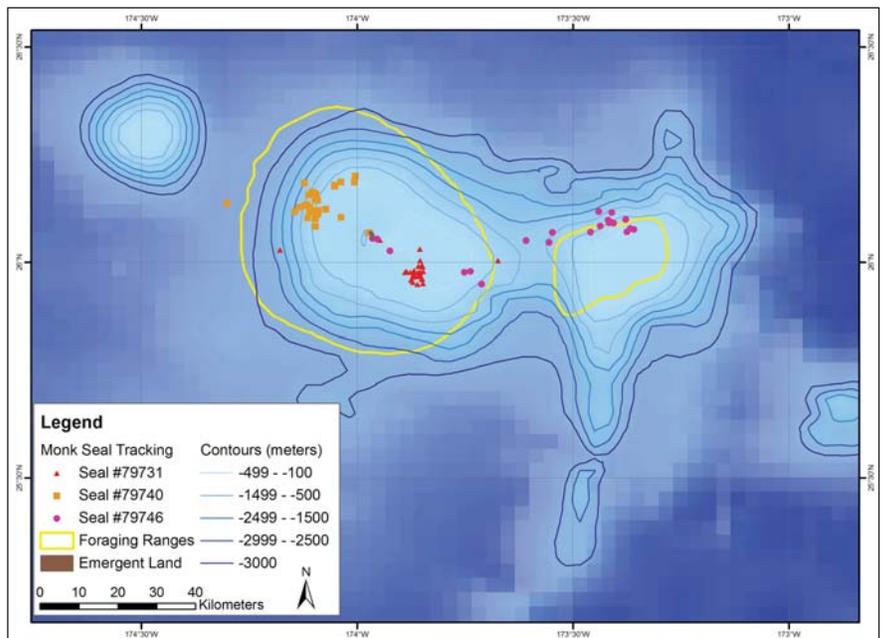


Figure 6.33. Examples of individual seal movements at Lisianski Island. Source: NMFS, unpub data; Stewart et al., 2006; map: K. Keller.

Table 6.2. Percentages of monitored Hawaiian monk seals at each colony that foraged at various sites in the NWHI. Source: Stewart et al., 2006.

FEATURE NAME	KURE ATOLL				MIDWAY ATOLL				PEARL AND HERMES ATOLL			LISIANSKI ISLAND				LAYSAN ISLAND				FRENCH FRIGATE SHOALS	
	WP (5)	J (11)	AM (4)	AF (4)	WP (4)	J (8)	AM (2)	AF (3)	J (6)	AM (9)	AF (9)	WP (8)	J (9)	AM (4)	AF (5)	WP (10)	J (10)	AM (5)	AF (5)	AM (17)	AF (17)
Un-named Kure Seamount 1			50																		
Un-named Kure Seamount 2			50																		
Un-named Kure Seamount 3			50																		
Kure Atoll	100	100	100	100		13	50	33													
Nero Seamount			25	25		13	50	33													
Midway Atoll				25	100	100	100	66													
Ladd Seamount				25				33	100	100	100										
Pearl and-Hermes Atoll								33													
Un-named PHR																					
Lisianski/ Neva Shoals												100	100	100	100						
Pioneer Bank												38	22		20						
Northampton W													11			30	30	20	40		
Northampton E													11					40	40		
Laysan													22		20	100	90	100	100		
Un-named Laysan 1													11								
Maro Reef													22			70	60	60	80		
Raita Bank																30	30	40	40		
Gardner Pinnacles																				6	30
St. Rogatien Banks																				12	10
Brooks Bank																				59	30
French Frigate Shoals																				100	80
Mokumana-mana																					10

sis was conducted to examine the relationship between habitat use and diet composition. In the early 1990s 24 seals were tracked with satellite receivers and depth recorders at French Frigate Shoals (Parrish et al., 2000). In this study habitat use and diet of the monk seals were compared at different ecological zones. The analysis indicates that the seals foraging was focused more on the transitional slope areas. Generally the seals used all of the ecological zones proportionally to available habitat. The study also looked at the seals' diet and the availability of prey species in each zone. The diet derived from scat analysis did not correlate with the prey species composition in any of the individual zones which was expected as seals generally used multiple habitats over the course of foraging trips. An analysis of the dissimilarity index of prey biomass density found that the prey guilds documented in the bank and slope areas had the least deviation (Parrish and Abernathy, 2006).

Satellite tagging data provide basic information on where the seals travel but do not provide specific information about seal behavior during their dives so seal mounted video cameras were utilized to examine habitat use, prey selection, and foraging behavior. Parrish et al. (2000) found that the diurnal pattern of foraging by male adults occurred mainly at the 60 m isobath using data collected from Crittercams. A few seals foraged at depths of more than 300 m.

Crittercams also showed that even though much of the seals' time was spent in the shallow areas (<10 m) near colonies, the majority of the time searching occurred at greater depths (50 – 60 m). In addition, there was evidence of seals consuming prey at deeper depths. Seals targeted habitats that were low-relief and areas composed of loose talus fragments provided the best foraging habitat. In this habitat seals are able to dislodge the talus fragments and easily locate the prey species. The second most searched habitat type was sand-dominated areas where prey was easily accessible. These two habitats were more frequently searched and potentially provide higher return of prey for search effort than more complex coral habitats that offer more hiding locations for prey species (Parrish et al., 2000).

Recent studies have focused on characterizing juvenile monk seal habitat use and foraging behavior at French Frigate Shoals using Crittercams and TDRs. Juvenile seals forage in the same habitats commonly used by adults, but may lack the size and strength to forage as successfully as their adult counterparts (Parrish et al., 2005). Dive records have indicated that most dives occurred at depths less than 200 m, but occasionally some exceeded 200 m. Substantial variability among the pups in depth, duration and temporal patterns of dives was noted (NMFS, unpublished data).

Population Status and Trends

Current Abundance and Distribution of Populations

Hawaiian monk seals occur as a single meta-population, with subpopulations distributed among eight NWHI locations from Nihoa Island to Kure Atoll, as well as a small and likely growing subpopulation in the MHI. There has been variation in the population dynamics between the subpopulations, with differences in environmental conditions and levels of human disturbance contributing to this variation (NMFS, 2007; Figure 6.34).

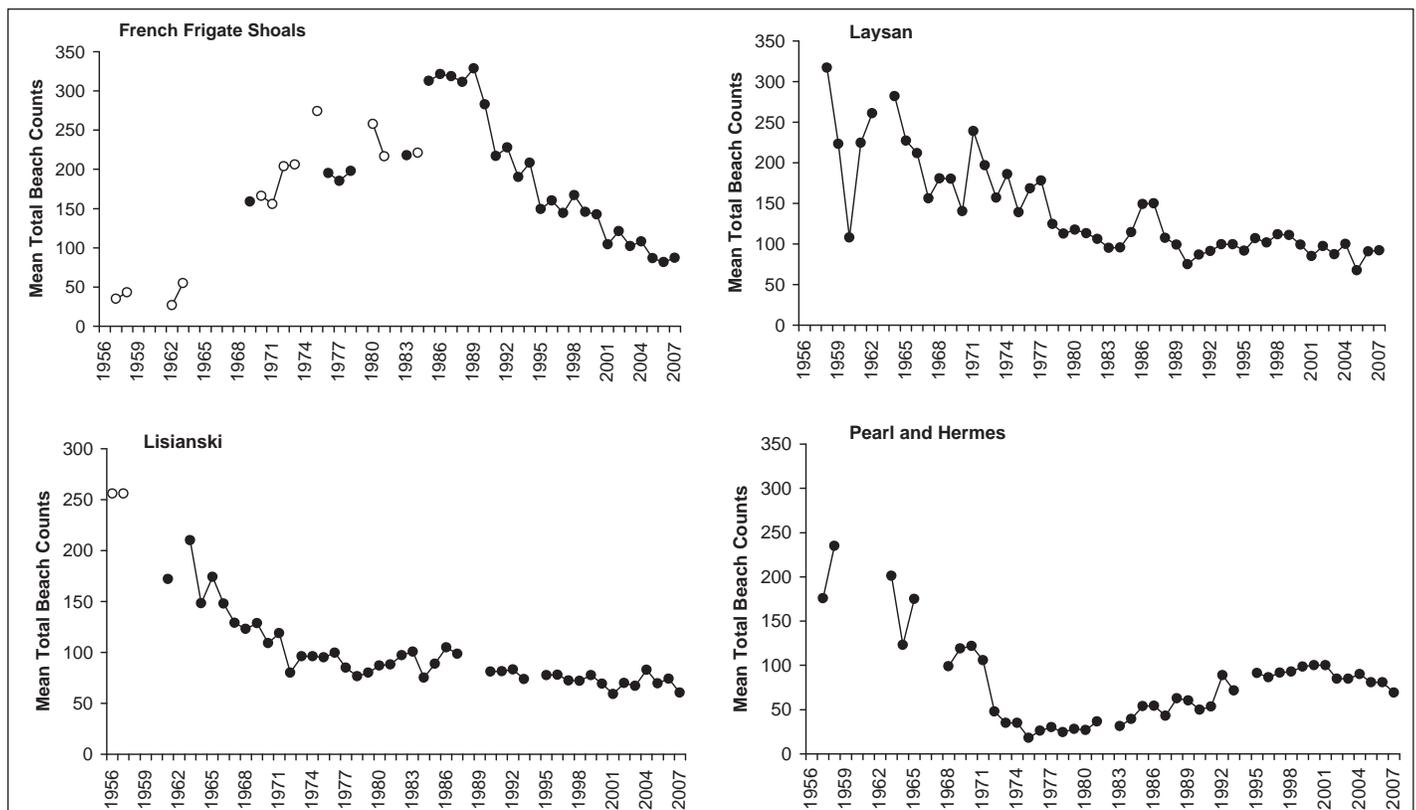


Figure 6.34. Population trend index (mean beach counts) from individual Hawaiian monk seal subpopulations (---o--- indicates less reliable historical counts). Source: NOAA PIFSC, unpublished data.

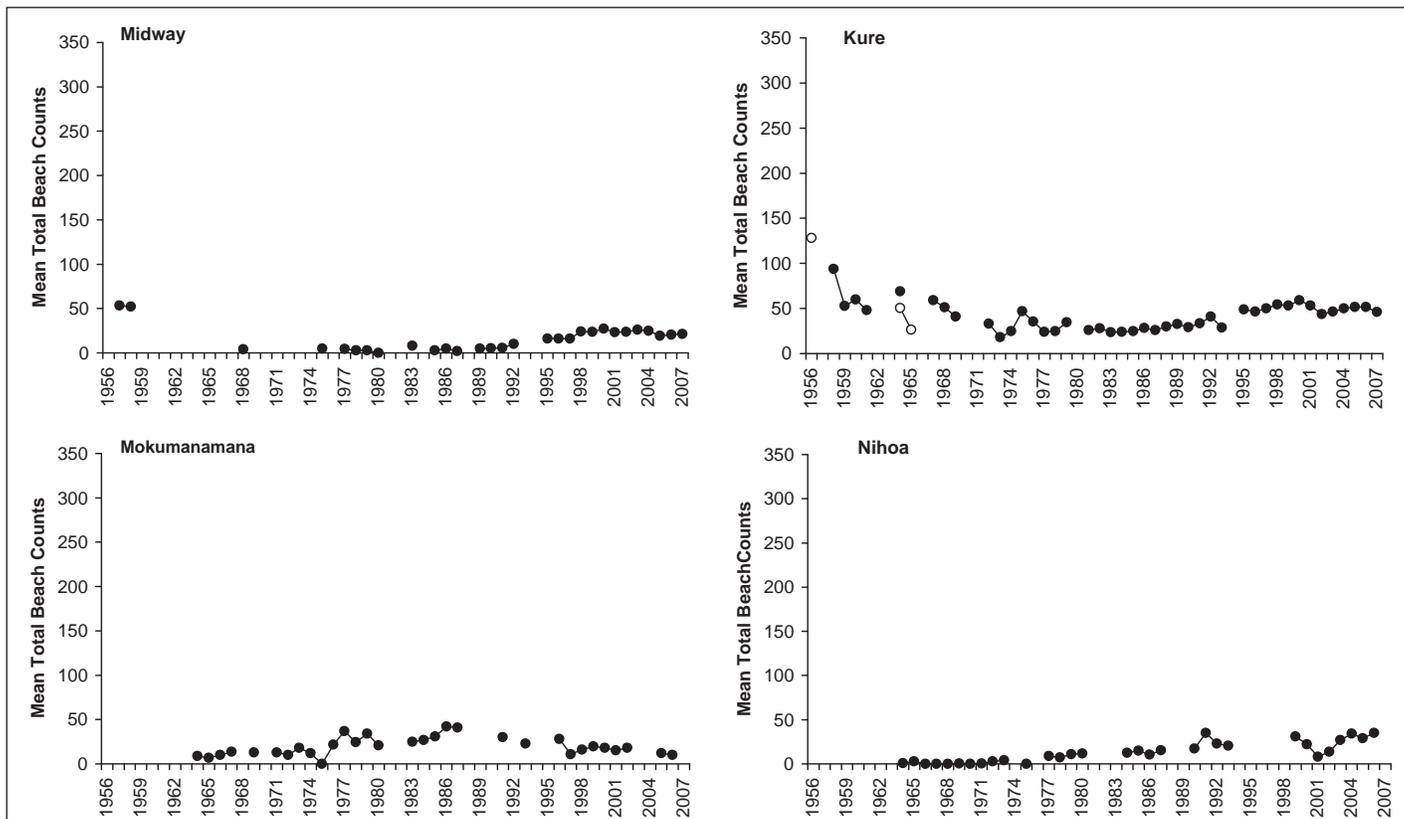


Figure 6.34 (continued). Population trend index (mean beach counts) from individual Hawaiian monk seal subpopulations (–o– indicates less reliable historical counts). Source: NOAA PIFSC, unpublished data.

Population Trends Across the Northwestern Hawaiian Islands

The six major subpopulations in the NWHI can be divided into the three western subpopulations at Kure Atoll, Midway Atoll and Pearl and Hermes Atoll; and the more geographically isolated populations found at Laysan and Lisianski Islands, as well as French Frigate Shoals. The higher exchange of individuals between the western subpopulations may contribute to observed similarities in population dynamics among these sites, and these islands may, in certain circumstances, be considered a single management unit. Table 6.3 illustrates the variation in abundance estimates between the different islands and atolls in 2007.

Table 6.3. Estimated 2007 monk seal abundance for each population segment. Nmin calculated at Mokumanamana and Nihoa Islands according to the methods of Wade and Angliss (1997). Source: NMFS, unpublished data.

SITE	ESTIMATION METHOD	Nmin	Nbest
French Frigate Shoals	Minimum	228	228
Laysan Island	Minimum	209	209
Lisianski Island	Total enumeration	174	174
Pearl and Hermes Atoll	Minimum	154	154
Midway Island	Minimum	65	65
Kure Atoll	Minimum	105	105
Mokumanamana	Corrected beach counts	31.4	42
Nihoa Island	Corrected beach counts	72.2	78.7
Main Hawaiian Islands	Minimum	88	88
Total		1,126.60	1,143.70

The estimated probabilities of sighting an animal is 90% for all years of data at French Frigate Shoals, Laysan Island, Midway Atoll and Kure Atoll, approximately 85% at Lisianski Island, and approximately 80% at Pearl and Hermes Atoll (Harting, 2002). Therefore, the numbers may underestimate the size of those subpopulations by 10%-20%. The methods used for the other population components (Mokumanamana, Nihoa and the MHI), while somewhat less accurate, are the best possible under current budget and logistical constraints. Because the other population segments represent relatively small proportions of the total population, errors in their abundance estimates do not greatly distort the estimated total population size. For example the best estimate of the total population size in 2005 was 1,247 seals. To determine a minimum population estimate (Nmin) for the total population that accounts for the statistical uncertainty in the abundance estimates, as is done for

stock assessment reports required by the MMPA (Wade and Angliss, 1997), a combination of enumeration and minimum estimates was used. The number of seals identified in 2005 at the main reproductive sites was 1,065 seals, including 163 pups. Minimum population sizes for Mokumanamana and Nihoa Islands (based on the formula provided by Wade and Angliss, 1997) were 34 and 39, respectively, and a total of 77 seals were identified in the MHI. Using that procedure, minimum population size estimate for the total population is the sum of these estimates, or 1,215 seals.

Long-term and Recent Population Trends

Beach counts are used as an index of the population size. Based on the beach counts from the 1950s to 2001 it appears that the species declined by approximately 50% between the late 1950s and the mid 1970s (Kenyon, 1973; Johnson et al., 1982). Beach counts of non-pups (juveniles, sub-adults and adults) declined by 68% between the years 1958 and 2005.

Based on the very limited window of data availability, the largest counts of monk seals observed at many islands were obtained around 1958. Three exceptions to this were French Frigate Shoals, where the maximum count was obtained in 1985, Mokumanamana where the maximum was obtained in 1977, and Nihoa where the maximum was obtained in 1991. The sum, across all sites in the NWHI, of the maximum counts, whenever obtained, totals 1,541, corresponding, after a very uncertain correction, to an estimated population size of around 3,000. There is evidence, at a minimum, that the available habitat was probably capable of supporting at least 3,000 monk seals in the NWHI plus an unknown number in the MHI.

More recent data indicate that non-pup beach counts declined rapidly from 1985 to 1993, became relatively stable for several years, then declined again beginning in 1998. Models estimate that the total counts declined 8.1% per year until 1993 (Carretta et al., 2005). The trend in total abundance of Hawaiian monk seals is shown in Figure 6.35. A log-linear regression of estimated abundance from 1998 (the first year for which a reliable total abundance estimate has been obtained) to 2006 estimates that abundance declined $-3.9\% \text{ yr}^{-1}$ (NMFS, unpublished data).

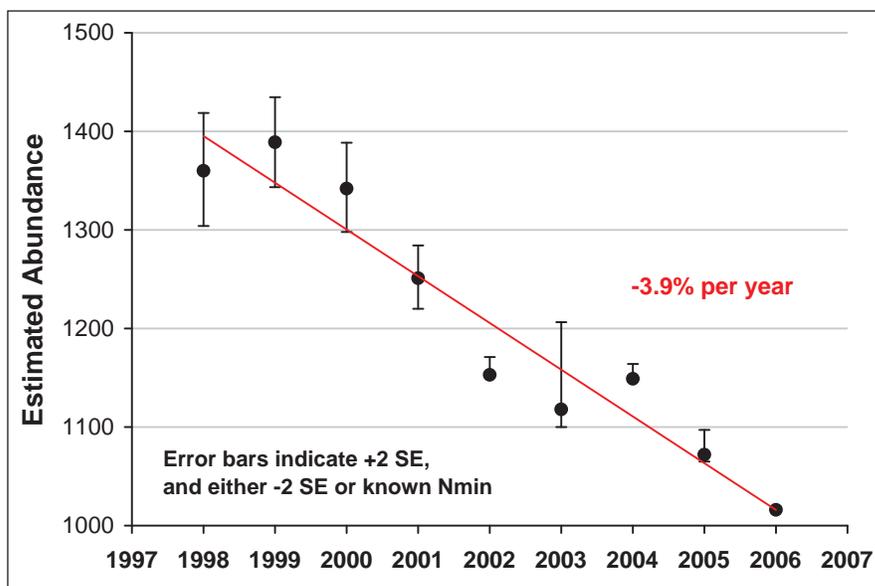


Figure 6.35. The long-term combined trend at the main NWHI sites masks a diversity of trends within the individual Hawaiian monk seal sub-populations. The population dynamics at the different atolls have varied considerably and current demographic variability among the island populations probably reflects a combination of human and environmental/natural influences. Source: Gerrodette and Gilmartin, 1990; Polovina et al., 1994; Craig and Ragen, 1999; Ragen, 1999.

The Population Trends by Island and Atoll

In addition to examining the overall trend in the Hawaiian monk seal population it is also important to examine each island and atoll. Each subpopulation exhibits different population dynamics that reflect their unique histories and environmental conditions (Figure 6.34).

Kure Atoll

The Hawaiian monk seal population at Kure Atoll has been impacted over the years by human disturbance. Beginning with sailors stranded after the ship wreck of the *Parker* who killed seals for food and continuing with disturbance caused by the U.S. Coast Guard (USCG) LORAN station. In the late 1970s NMFS began efforts with the USCG to reduce the level of disturbance to the Hawaiian monk seals. USCG decommissioned the LORAN station in 1992. Since 1992 state of Hawaii Department of Land and Natural Resources and the Ma-

rine Mammal Research Program (MMRP) field camps are the only human presence at Kure Atoll during the summer months.

The population dynamics of monk seals have varied with these changes in human disturbance at Kure Atoll (Figure 6.34). After the construction of the LORAN station in the late 1950s and early 1960s the seal population declined abruptly. As efforts were made in the 1980s to reduce disturbance to the seals there was a corresponding increase in pup survival (Gerrodette and Gilmartin, 1990; Gilmartin, pers. comm.). From 1983-2000 the beach count data shows a 5% increase per year. Since 2000 as seen at other islands and atolls there has been high juvenile mortality. The increase in the population until 2000 has been attributed to the reduction of human disturbance by USCG regulations and the closure of the LORAN station (Gilmartin et al., 1986). In addition 54 immature female seals were released at Kure and reached reproductive maturity by the early 1990s. (NMFS, 2007). Recent trends indicate a decline in the Kure population.

Midway Atoll

Midway Atoll has also had a history of human disturbance, starting in 1859, which has impacted the Hawaiian monk seal population (Figure 6.34). The monk seal population was depleted by the late 1800s and partially recovered in the early 1900s. Human activities in the early 1900s included attempts to blast a ship channel, installation of a cable station, construction of an airport and other World War II military activities. After World War II the human population peaked at 3,500 and was reduced to 250 by 1978 (NMFS, 2007). The 1957-1958 monk seal surveys recorded a mean of 57 seals but by 1968 only one seal was observed (Kenyon, 1972). There were occasional sightings in low numbers during the 1980s (NMFS, 2007). Midway's small monk seal population saw increases in the early 1990s as management efforts were increased to reduce disturbance. By 1988 the U.S. Fish and Wildlife Service (USFWS) was actively participating in the management of wildlife at Midway Atoll in conjunction with the U.S. Navy. Since 1988, the USFWS has restricted the numbers of staff and visitors to Midway Atoll. Hawaiian monk seal beach counts increased during the 1990s but this was primarily due to immigration of individuals from Pearl and Hermes Atoll and Kure Atoll. In addition to immigrants, there were increases in total births. In 1996 the Navy transferred Midway Atoll to the USFWS and further measures were put in place to reduce disturbance to monk seals. There was a short five year increase in beach counts from 1995 – 2000 followed by a decline since 2000.

Pearl and Hermes Atoll

Impacts on the seal population at Pearl and Hermes Atoll started in 1859 when a sealing expedition visited the atoll. In the late 1920s pearl oysters were harvested and construction occurred on the islands. The U.S. military occupied the atoll in 1961 during construction of an observation tower. The atoll is now unoccupied except for NMFS summer field camps.

The Pearl and Hermes Atoll seal population declined by an estimated 90% after the 1950s (Figure 6.34). From the mid-1970s to 2000 beach counts have increased. Specifically from 1983 to 2000 counts increased an average of 6%. As seen at Kure Atoll and Midway Atoll counts have declined since 2000.

Lisianski Island

Lisianski Island is the site of many 1900s ship wrecks and as seen with other wreck sites stranded sailors relied on monk seals as well as other species for food. Harvesting expeditions also occurred during this time. Today the island is unoccupied except for monk seal field camps.

Beach counts have declined since the late 1950s and have remained low since then (Figure 6.34). The island is estimated to be below the carrying capacity but the cause for low population size is unknown.

Laysan Island

The 1857 Hawaiian vessel *Manuokawai* reported Hawaiian monk seals at Laysan Island. By the 1900s seal expeditions and guano miners had nearly extirpated the seal population. For several years the Japanese collected eggs and feathers from the island but since this collection was halted in 1915, the island has been relatively undisturbed by human presence. The only activities since that time have been survey and scientific

expeditions. Beginning in the early 1990s the USFWS has had a small year round field camp on Laysan, and NMFS has conducted seasonal field camps on the island.

As on other islands, Laysan's monk seal population declined in the late 1950s. The population has seen some increases but is still below the historic high. Ciguatera is suspected in a mass die off of 50 seals in 1978, but was not conclusively proven. In the early 1980s the sex ratio at Laysan was male biased resulting in 45 confirmed deaths due to male aggression from 1982 – 1994. From 1983 – 1994 an average of 4% of the Laysan adult females died from injuries related to male aggression (Johanos et al., 1999). Interventions to remove subordinate males and correct the sex ratio were successfully undertaken in the mid-90s and have resulted in substantially fewer occurrences of male aggression. Even though juvenile survival at Laysan is better than French Frigate Shoals there are still concerns about food limitations. There is still not a good understanding of the underlying causes or the lack of recovery of the monk seal population at Laysan Island.

French Frigate Shoals

French Frigate Shoals did not have the same guano resources that other islands in the NWHI did. As a result, the atoll was not mined; however, there is still documentation of harvesting occurring in 1882 of sharks, turtles, beche-de-mer and birds. The highest level of use occurred during World War II when a Naval airbase was built on Tern Island in 1942. A USCG LORAN station was established and maintained on East Island from 1943 - 1952. The Naval airbase on Tern Island was decommissioned in 1946 but the USCG maintained the island as a LORAN station from 1952-1979. Since the closure of the USCG LORAN station the USFWS has operated a field station on Tern Island.

French Frigate Shoals currently supports the largest monk seal colony in the NWHI (Figure 6.34). The monk seal population at East Island and Tern Island were impacted by disturbances caused by the military and USCG presence; however, after the closure of the LORAN station in East Island, numbers of monk seals using the island increased until the 1980s. After the USCG left Tern Island the presence of seals at the island increased until 1989. Since 1989 the French Frigate Shoals population has declined by as much as 75%. Juvenile survival rates have declined during this time. Survival in the mid-1980s for weaning to age two was as high as 90% but dropped to a low of 8% in 1997. One result of the low survival rates is an imbalance in the age structure of the population. The overall population is expected to decline in coming years as fewer females reach reproductive age and older females die.

Mokumanamana and Nihoa Island

Population monitoring visits to Mokumanamana and Nihoa Islands are infrequent and brief, so enumeration is not possible at these sites. Counts of seals at those islands tended to increase from approximately 1970 to 1990 (Figure 6.34). The increase in counts may have been due to an influx of seals from French Frigate Shoals, which was growing at that time. During a seven-day period at Mokumanamana in 1993, 14 tagged seals were sighted, all of which had been marked as pups at French Frigate Shoals (Finn and Rice, 1994). During the same period, 12 tagged seals were sighted at Nihoa Island, 10 of which were from French Frigate Shoals (Ragen and Finn, 1996).

The Main Hawaiian Islands

The number of documented monk seal sightings in the MHI increased during the 1990s. Historical abundance data for the MHI are limited, as there were no systematic surveys of monk seals conducted prior to 2000. Births in the MHI have become more frequent. The known number of annual births in the MHI before and during the 1990s was usually zero and never exceeded four, but seven births were recorded in 2000 and 12 in 2001 (Baker and Johanos, 2004). More recently, a minimum of 88 individual seals have been identified in the MHI (NMFS, unpublished data).

MARINE TURTLES

Covering more than 360,000 km² of subtropical waters in the North Pacific, the Monument provides critical breeding and nesting habitat for the green turtle (Figure 6.36), and foraging habitat and migration pathways for green loggerhead, hawksbill and leatherback (Figure 6.36) turtles. Although olive ridley turtles have not been sighted within the Monument, their known distribution in the tropical Pacific indicates that they likely also use waters of the NWHI (Papahānaumokuākea Marine National Monument, 2008). These five marine turtle species are all protected under the ESA due to threats to beach nesting habitat and from incidental bycatch, marine debris entanglement, and vessel strikes (<http://www.nmfs.noaa.gov/pr/species/turtles/>).

Although four marine turtle species have been documented in Monument waters, the extensive nesting of green turtles in the NWHI has allowed for multi-island surveys, capture-mark-recapture work and long-term population studies of this species (Figure 6.37). Based on green turtle basking and nesting surveys across islands/atolls and over time, the species basks throughout the NWHI (Figure 6.38), but nests at only a subset of the islands (Figure 6.39).



Figure 6.36. Leatherback turtles (left) and the Hawaiian green turtle (right) can be found in the Monument. Photos: NOAA National Marine Sanctuaries.

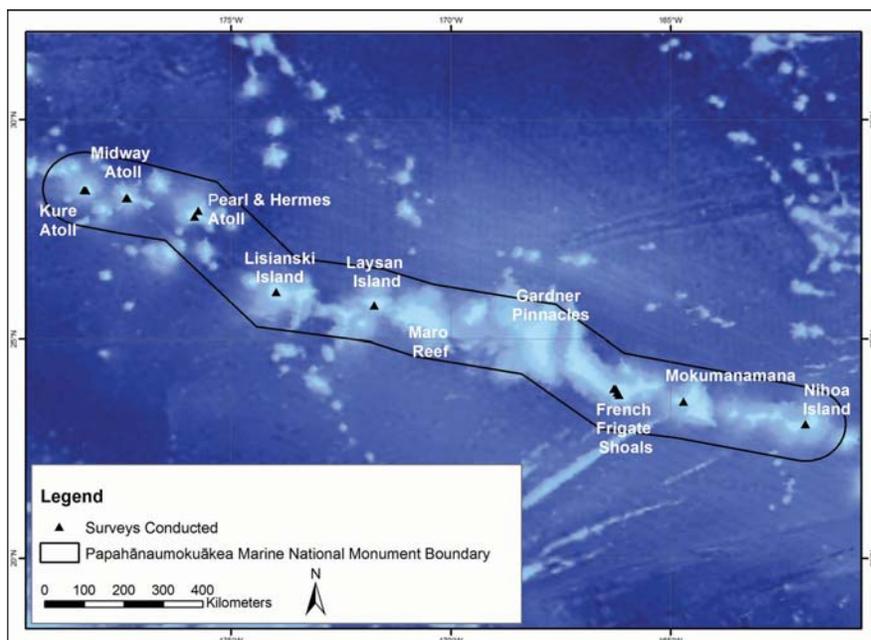


Figure 6.37. Locations of green turtle basking and nesting attempt surveys conducted within the NWHI. Map: K. Keller.

Monitoring Efforts by Island: Data and Methodology

French Frigate Shoals

More than 90% of Hawaiian green turtle nesting occurs at French Frigate Shoals, with over 50% of nesting occurring on East Island. In addition to intensive study of green turtles at this atoll, annually since 1973, early observations were made by military personnel, fishermen and scientists at French Frigate Shoals beginning in 1859. Amerson (1971) summarizes all known observations of basking green turtles and nest attempts from 1859 through 1969.

The largest data set on green turtles in the NWHI consists of 35 years of research, beginning in 1973, on the nesting population on East Island, French Frigate Shoals (Balazs and Chaloupka, 2006). Between 1973 and 1981, the work was a partnership between the Hawaii Institute of Marine Biology (University of Hawaii) and the USFWS, and since 1982 a collaboration between USFWS and the NOAA Pacific Islands Fisheries Science Center (PIFSC). From 1973 through the present time, annual surveys have been conducted on the number of individual female turtles going ashore each night during the nesting season (Balazs, 1976, 1980; Wetherall et al., 1998). Prior to 1996, unique individuals were identified based on double-tagging with external flipper tags; since that year, all individuals have been double-tagged with passive integrated transponders. Tagging studies have shown that nesting-island site fidelity is very high within the Hawaiian rookery, such that annual nesting

abundance and trend estimates are not confounded by substantial immigration or emigration (Dizon and Balazs, 1982; Niethammer et al., 1997).

Annual nesting abundance at East Island, French Frigate Shoals, has been estimated by the PIFSC using a Horvitz-Thompson type estimator: $N_i = n_i/p_i$, where N_i = number female nesters in year i , n_i = number of uniquely-identified female nesters in year i , and p_i = probability of sighting a unique female that nests in year i . The value p_i was estimated based upon census data from >1,100 nesters during a five-year season-long saturation tagging and re-sighting program at the atoll from 1988-1992. Trends in nester abundance from 1973-2004 were estimated by Balazs and Chaloupka (2004, 2006) using a Bayesian smoothing spline regression that was fitted to the Horvitz-Thompson nest abundance series (Balazs and Chaloupka, 2004, 2006).

Other Islands and Atolls

Data on the number of green turtle pits and number of basking turtles at other islands and atolls in the northwestern chain have been collected in some years from 1982 through 2008. Number of pits does not indicate a specific number of nesting attempts by turtles, as each nesting attempt may consist of one too many pits; however, pits are likely indicative of some level of attempted nesting on the islands on which they have been observed (S. Kubis Hargrove, pers. comm.). On Laysan Island, NMFS personnel counted the number of turtle pits and basking turtles from March through June 1982 (Kam, 1986). In 2007, USFWS personnel surveyed the perimeter of Laysan Island regularly throughout the green turtle nesting season and monitored active nests for hatching (Payne et al., 2007). On Lisianski Island, NMFS personnel counted the number of pits dug and number of basking turtles through various portions of the nesting season each year from 1982 to 1987, and 2006 and 2007 (Kam, 1985; Kam, 1986; Alcorn et al., 1988; Johanos and Withrow, 1988; Westlake and Siepmann, 1988; Kubis, 2008; M. Snover, pers. comm.). Similar counts were done at Pearl and Hermes Atoll in 1982, 1990, 1991, 2006, and 2007 (Kam, 1986; Finn et al., 1993; Kubis, 2008; M. Snover, pers. comm.). At Midway Atoll, the first observation of nesting occurred in 2006, and nests were also documented in 2007 and 2008 (John Klavitter, pers. comm.). In addition to pit counts at these islands and atolls, in 2006 NMFS personnel quantified the mean numbers of basking turtles from May through August at all islands and atolls north of Mokumanamana (B. Becker, M. Snover, pers. comm.).

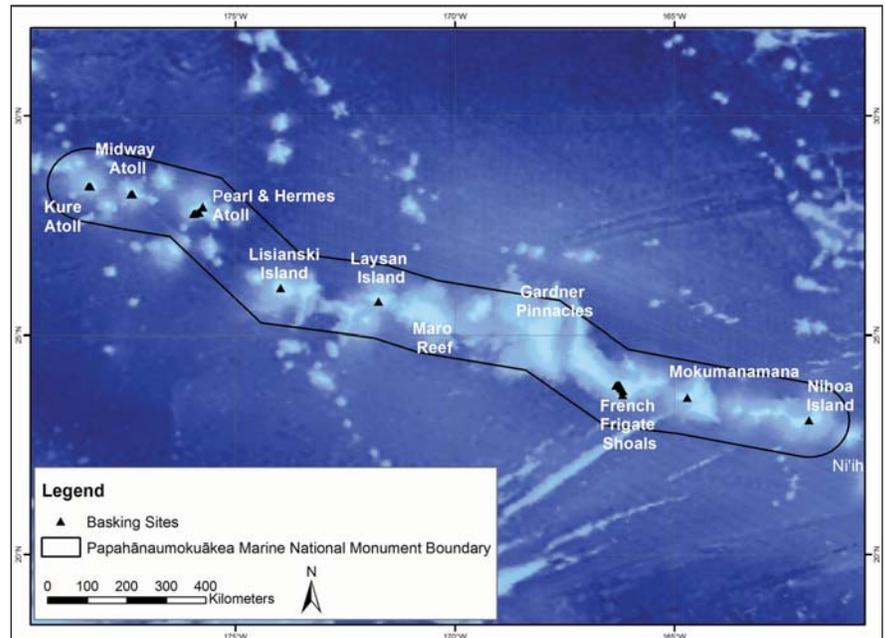


Figure 6.38. Islands and atolls at which green turtles have been observed to bask. Map: K. Keller.

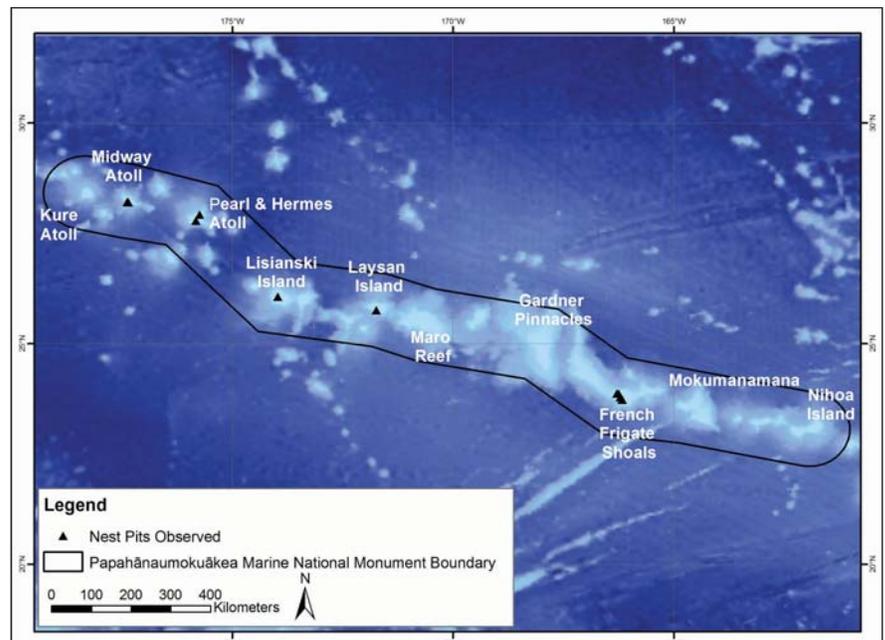


Figure 6.39. Islands and atolls at which green turtle nesting attempts (pits) have been observed. Map: K. Keller.

Results and Discussion

French Frigate Shoals

Amerson (1971) reports that green turtles were first recorded at French Frigate Shoals by personnel on the USS *Fenimore Cooper* in 1859. In 1882, the crew of the Japanese-owned schooner *Ada* reported collecting 1,543 pounds of turtle shell and 47 gallons of turtle oil from approximately 350 turtles. In 1914, green turtles were observed basking at French Frigate Shoals by the USS *Rainbow's* hydrographic survey team, and in 1923, members of the *Tanager Expedition* also reported observing turtles and turtle eggs at the atoll. They also reported evidence of previous turtle slaughter (Amerson, 1971).

From the early 1920s through the late 1960s, U.S. Department of Interior, NOAA and the Smithsonian Institution personnel reported observing green turtles basking on most of the islands within French Frigate Shoals, including Tern, Trig, Whaleskate, Round, East, Gin, Little Gin and Disappearing Islands. The largest numbers of baskers during this time period were reported on East Island in the 1960s, with the highest number recorded (86 turtles) in September 1966. Turtle pits were also recorded through the late 1960s on Tern, Trig, Whaleskate, Round, East, Gin and Little Gin Islands (Amerson, 1971).

More recently, NOAA personnel have quantified the number of green turtles basking on all islands within French Frigate Shoals during the nesting season. In 2006, an average of 143 turtles was observed basking at any one time.

Results of Balazs and Chaloupka's research on green turtles nesting at East Island, French Frigate Shoals, indicate annually variable nesting population sizes, ranging from just under 100 to more than 500 female turtles each year from 1973 to 2004 (Figure 6.40). Estimation of nesting population trends indicates an increase in annual population size of approximately 5.7% per year (95% CI: 5.3 - 6.1%) over that 32-year time period (Figure 6.40; Balazs and Chaloupka, 2006).

The increase in green turtle nesting population size at French Frigate Shoals (Figure 6.41) may be attributed in part to increased protections under the ESA, as harvesting of turtles on land or in waters surrounding the Hawaiian Islands was prohibited beginning in the late-1970s. However, human impacts on beach nesting habitat at French Frigate Shoals also changed dramatically over the last half of the 20th century. From the late 1930s to early 1950s, the U.S. Navy and USCG operated Naval Air and Long Range Navigation stations on East Island; during that time, turtle nesting and basking reportedly greatly decreased (Amerson, 1971). After the decommissioning of the Naval Air Station and relocation of the USCG LORAN station from East Island to Tern Island in

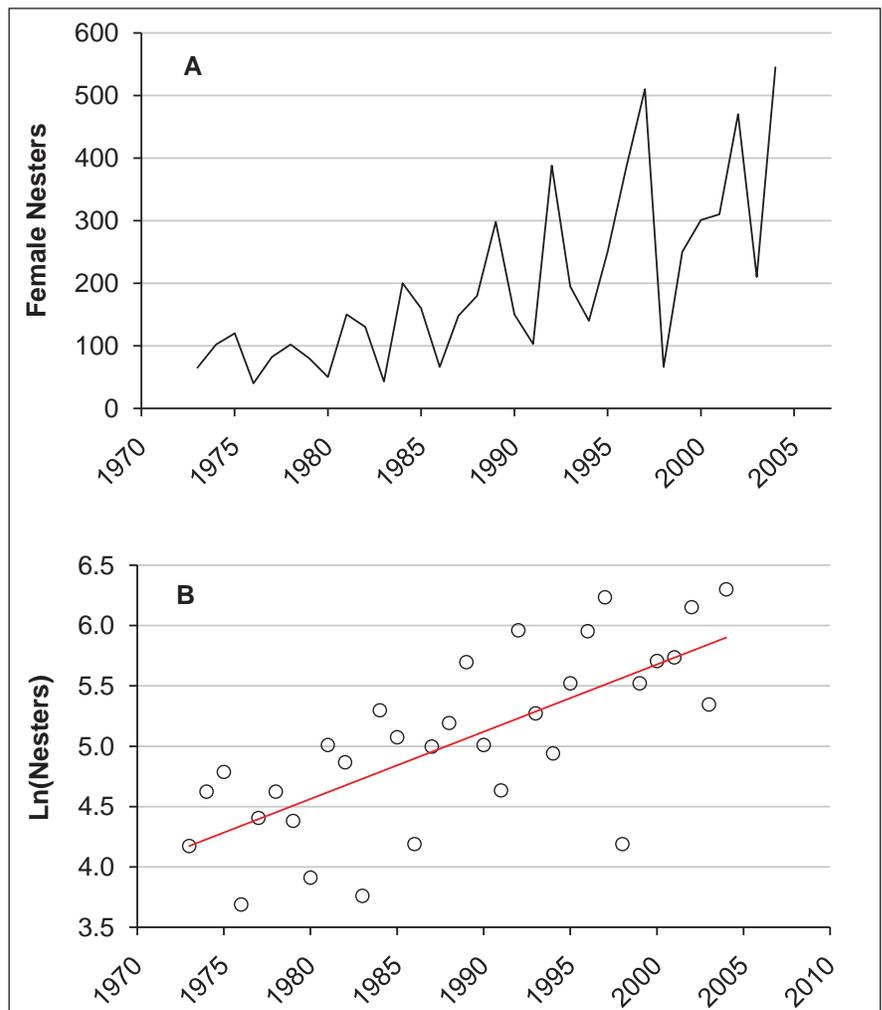


Figure 6.40. Trends in green turtle nester abundance at East Island, French Frigate Shoals, 1973-2004. Panel A shows time series plot of the Horvitz-Thompson estimate of number of female turtles nesting each year over the 32-year period. Panel B shows estimated long-term trend in nester abundance derived using Bayesian smoothing spline regression model, which was fitted to the Horvitz-Thompson nester series shown in panel A. Red curve is mean annual nester abundance. Source: Balazs and Chaloupka, 2006.

1954, numbers of nest attempts on East Island began to increase through the late 1960s (Amerson, 1971). The number of nest at French Frigate Shoals continued to increase through 2004 (Balazs and Chaloupka, 2006), and during the 2008 season, an estimated 589 females nested at East Island (G. Balazs, pers. comm.).

Other Islands and Atolls

Numbers of green turtle nesting and basking are much lower at the other islands and atolls in the northwestern chain, relative to French Frigate Shoals. The islands of Nihoa and Mokumanamana contain only small areas of basking habitat, while Laysan, Lisianski, and the islands of Pearl and Hermes Atoll have small numbers of nesting green turtles each year (fewer than 100 turtle pits per island or atoll). Midway and Kure Atolls have relatively extensive areas of beach habitat, but only one nest per year has been observed at Midway Atoll since 2006 (John Klavitter, USFWS, pers. comm.), and nesting has never been observed at Kure Atoll (Kubis, 2008). The following sections provide results of pit and basking turtle counts for Nihoa, Mokumanamana, Laysan, Lisianski, Pearl and Hermes Atoll, Midway Atoll and Kure Atoll for some years from 1982 through 2008.

The islands of Nihoa and Mokumanamana contain only small areas of basking habitat, while Laysan, Lisianski, and the islands of Pearl and Hermes Atoll have small numbers of nesting green turtles each year (fewer than 100 turtle pits per island or atoll). Midway and Kure Atolls have relatively extensive areas of beach habitat, but only one nest per year has been observed at Midway Atoll since 2006 (John Klavitter, USFWS, pers. comm.), and nesting has never been observed at Kure Atoll (Kubis, 2008). The following sections provide results of pit and basking turtle counts for Nihoa, Mokumanamana, Laysan, Lisianski, Pearl and Hermes Atoll, Midway Atoll and Kure Atoll for some years from 1982 through 2008.

Nihoa and Mokumanamana

The two high islands of the northwestern chain, Nihoa and Mokumanamana, each contain habitat for basking and/or nesting, although consisting of only several square meters. There is a small sand beach at Nihoa, but only rocky shoreline on Mokumanamana. Green turtles have not been observed nesting on either of these islands, but basking has been observed (Kubis, 2008). In 1983, NOAA personnel recorded a mean of 1.5 basking turtles per day on Mokumanamana from 24 July through 6 August (Morrow and Buelna, 1985).

Laysan Island

In 1982, NOAA personnel on Laysan Island observed 12 green turtle nest excavations, consisting of 45 pits, between 25 May and 30 June. In addition, a mean of 2.6 turtles were observed basking each day during the period 16 March through 30 June (Kam, 1986).

In 2005 and 2006, USFWS personnel noted a “few” green turtle pits on Laysan from April through October (C. Rehkemper, USFWS, pers. comm.), and in 2006 NMFS personnel recorded 0.2 turtles basking at any one time during the nesting season (M. Snover, NMFS, pers. comm.).

In 2007, USFWS located a total of 50 green turtle nests on Laysan (Figure 6.42). Of 24 nests that were monitored from May through early September, an estimated 1,403 eggs were laid, with clutch sizes ranging from 55 to 111 (mean = 87.8, $n = 16$ nests). Hatching success at the 24 monitored nests was 85.6%. Incubation periods ranged from 60-75 days (mean = 67.5), with incubation period shortening over the course of the season (Payne et al., 2007).



Figure 6.41. Green turtle laying eggs, French Frigate Shoals, June 2002. Photo: NOAA.



Figure 6.42. Green turtle nest on Laysan Island, 26 June 2007. Photo: USFWS.

Lisianski Island

NMFS personnel counted turtle pits and basking green turtles on Lisianski Island during parts of the nesting season in some years between 1982 and 2007. Results of these counts indicate a range of 15 to 47 pits observed per year, and a mean of 2.0 to 5.4 turtles basking on the island per day (Table 6.4). Figure 6.43 indicates the locations of pits observed on Lisianski Island in 1982 and 1983.

Table 6.4. Observations of pits and basking green turtles on Lisianski Island, 1982–2007.

YEAR	DATES	OBSERVATIONS	REFERENCE
1982	May – Aug	23 excavation sites consisting of 47 pits	Kam (1986)
1982	8 Jul – 13 Sep	Mean of 5.4 baskers/day	Kam (1986)
1983	31 May – 9 Aug	19 pits (Figure 6.43)	Kam (1985)
1984	2 Jul – 6 Aug	91 pits	Alcorn et al. (1988)
1985	17 Jun – 20 Jul	78 pits	Alcorn et al. (1988)
1986	5 – 26 Aug	15 pits	Westlake and Siepmann (1988)
1987	1 – 4 Jun; 5 – 29 Aug	34 pits	Johanos and Withrow (1988)
1987	7 – 27 Aug	Mean of 2.0 baskers/day	Johanos and Withrow (1988)
2006	May – Aug	Mean of 2.9 baskers/day	Melissa Snover, NMFS (pers. comm.)
2007	May – Jun	Nests observed but not counted	Kubis (2008)

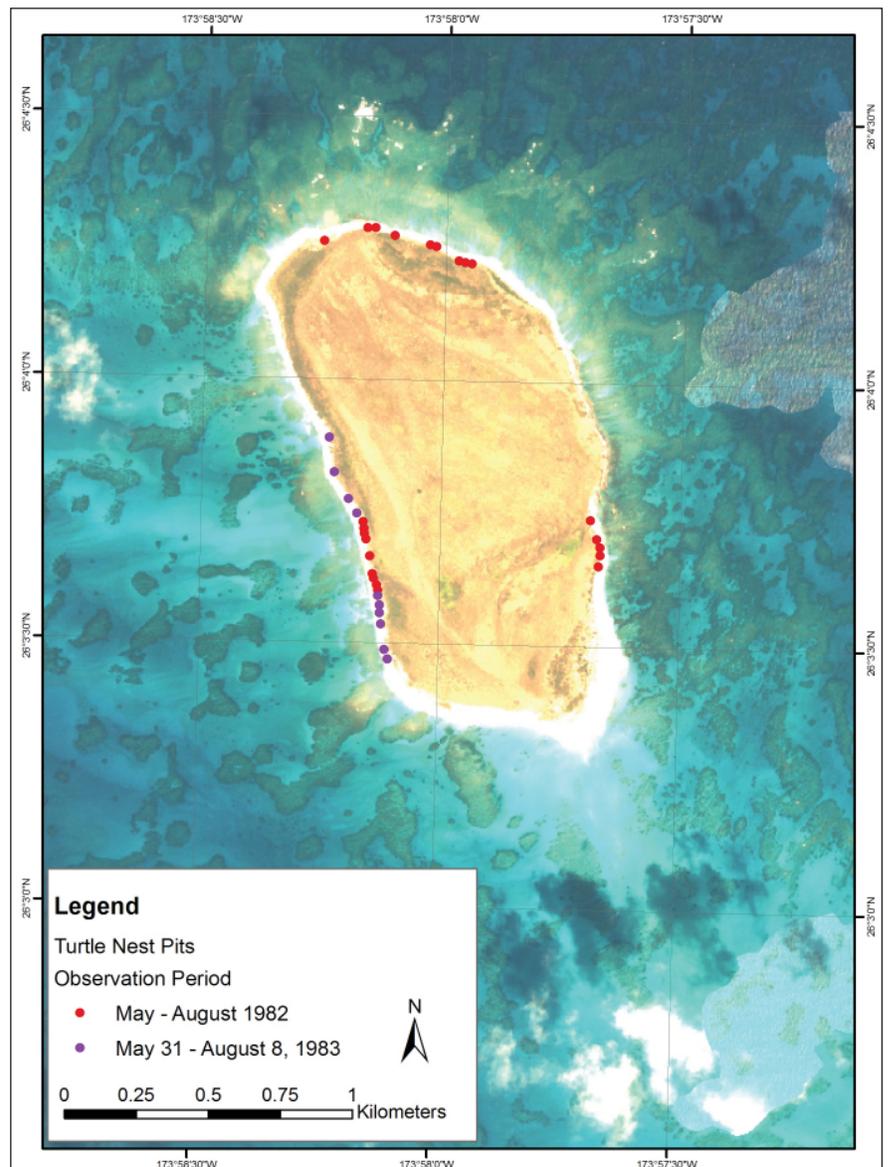


Figure 6.43. Locations of green turtle pits on Lisianski Island May – August 1982 and May – August 1983. Sources: Kam, 1986 and 1985.

Pearl and Hermes Atoll

NMFS personnel observed turtle pits and basking green turtles at Pearl and Hermes Atoll (on North, Southeast and Seal Kittery Islands) during parts of the nesting season in some years between 1982 and 2007 (Kam, 1986; Finn et al., 1993; Kubis, 2008). Count data indicate a range of one to 13 pits observed per year, and a mean of 10.0 to 12.6 turtles basking on North and Southeast Islands per day (Table 6.5). Figure 6.44 indicates the locations of pits observed on North and Southeast Islands in 1982.

Midway Atoll

One green turtle nest per year has been found at Midway Atoll since 2006. In 2006, a single nest was located on Spit Island, and in 2007 and 2008 one nest per year was found on Sand Island (J. Klavitter, USFWS, pers. comm.). All three nests (2006, 2007, and 2008) hatched successfully. The nest laid in 2008 was estimated to have contained 89 eggs, 65 of which hatched successfully (J. Klavitter, USFWS, pers. comm.; Figures 6.45 and Figure 6.46). In 2006, NMFS personnel observed 4.5 basking turtles at any one time at Midway Atoll (M. Snover, pers. comm.).

Kure Atoll

Nesting by green turtles has never been observed at Kure Atoll (Kubis, 2008). Biological monitoring and research on other species has been conducted by NMFS and Hawaii Department of Land and Natural Resources personnel at Kure over a period of many years, so it is unlikely that nesting has occurred but has remained unobserved. Green turtles have been observed basking at Kure Atoll in small numbers. In 2006, NMFS personnel observed 0.7 basking turtles at any one time during a total of eight observation days (M. Snover, NMFS, pers. comm.).

Table 6.5. Observations of pits and basking green turtles at Pearl and Hermes Atoll, 1982–2007.

YEAR	DATES	ISLAND	OBSERVATIONS	REFERENCE
1982	5 Jul	North Island	13 pits (Figure 6.44)	Kam (1986)
1982	2 – 5 Jul	Southeast Island	9 pits (Figure 6.44)	Kam (1986)
1982	2 – 6 Jul	North and Southeast	Mean of 10 baskers/day	Kam (1986)
1990	8 – 9 Jun	North Island	2 pits	Finn et al. (1993)
1991	1 Aug – 13 Sep	Southeast Island	1 pit	Finn et al. (1993)
2006	May - Aug	Not specified	12.6 baskers/day	Melissa Snover, NMFS (pers. comm.)
2007	May-Jun	Not specified	Nests observed but not counted	Kubis (2008)

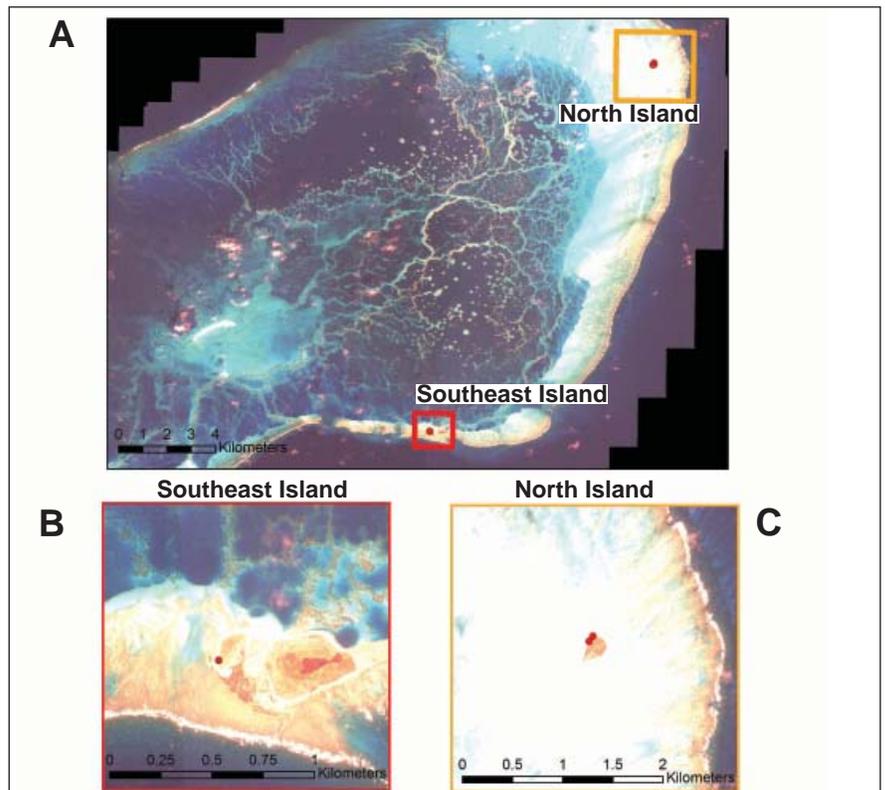


Figure 6.44. Panel A: locations of green turtle pits observed at Pearl and Hermes atoll in 1982. Panel B indicates locations of pits on Southeast Island; panel C indicates pit locations on North Island. Source: Kam, 1986.



Figure 6.45. Green turtle tracks and nest on Sand Island, Midway Atoll, May 2008. The left panel shows turtle tracks and the right panel shows an active nest. Photos: T. Summers, USFWS.

Conclusions and Management Action

Green turtles have been observed basking at all of the islands and atolls within the Monument, but nesting attempts have been limited to the islands and atolls from French Frigate Shoals to Midway Atoll. As previously described, more than 90% of green turtle nesting occurs at French Frigate Shoals, with a range of approximately 100 to 550 females digging approximately 450 to 2,500 nests each year (Table 6.6). In contrast, between 15 and 91 pits have been observed on Laysan and Lisianski Islands in any one year, 1-13 pits per island at Pearl and Hermes Atoll per year, and only one nest per year at Midway Atoll between 2006 and 2008 (Table 6.5). As the number of nesting females on East Island, French Frigate Shoals has increased over the last three decades, the numbers of nests at Laysan, Lisianski, and Pearl and Hermes Atoll may have also increased over time. Additional periodic counts of pits and/or mark-resighting of nesting females at those locations in future years will help to more precisely estimate the subpopulation sizes of nesting green turtles throughout the Monument.

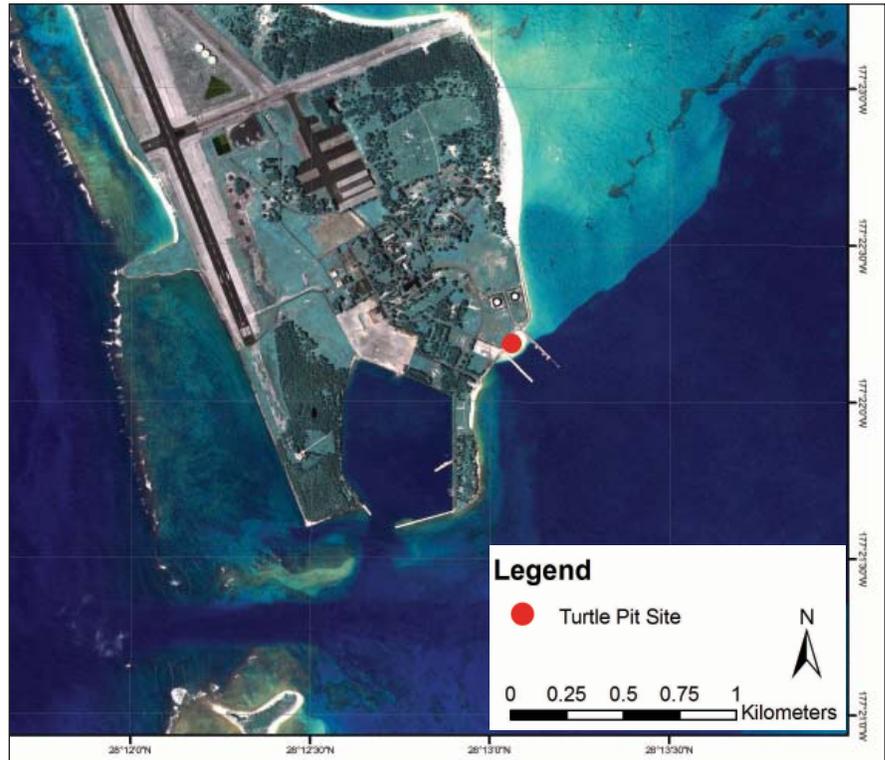


Figure 6.46. Location of green turtle nest on Sand Island, Midway Atoll, in 2008. Source: J. Klavitter; map: K. Keller.

Table 6.6. Numbers of green turtle nest pits observed on all islands and atolls in the NWHI between 1982 and 2008. Dash (-) indicates data not collected or not available; plus sign (+) indicates observed pits but not counted; and zero (0) indicates true count of zero.

ISLAND/ATOLL	1982	1983	1984	1985	1986	1987	1990	1991	2006	2007	2008
Nihoa	0	0	0	0	0	0	0	0	0	0	0
Mokumanamana	0	0	0	0	0	0	0	0	0	0	0
French Frigate Shoals: East Island†	585*	158*	896*	729*	311*	644*	675*	482*	1,904*	1,566*	2,430*
Laysan	45	-	-	-	-	-	-	-	-	50	-
Lisianski	47	19	91	78	15	34	-	-	-	+	-
Pearl and Hermes Atoll: North Island	13	-	-	-	-	-	2	-	-	+	-
Pearl and Hermes Atoll: Southeast Island	9	-	-	-	-	-	-	1	-	+	-
Midway Atoll:	-	-	-	-	-	-	-	-	-	-	-
Spit Island	0	0	0	0	0	0	0	0	1	0	0
Midway Atoll:											
Sand Island	0	0	0	0	0	0	0	0	0	1	1
Kure Atoll	0	0	0	0	0	0	0	0	0	0	0

†Pits have also been observed but not counted in all years on Tern, Trig, Gin and Little Gin Islands at French Frigate Shoals.

*Numbers of pits at East Island, French Frigate Shoals, are estimates based upon numbers of nesting females (Stacy Kubis Hargrove, pers. comm.). Individual turtles lay three to six (mean = 4.5) clutches per season (http://www.fpir.noaa.gov/PRD/prd_green_sea_turtle.html), so estimates of number of nest pits was obtained by multiplying the number of nesting females per year by 4.5.

Papahānaumokuākea Marine National Monument's Draft Management Plan (PMNM, 2008) describes a strategy and three activities to manage green turtle habitat within the Monument, based upon the Recovery Plan for U.S. Pacific Populations of the Green Turtle (*Chelonia mydas*; NMFS and USFWS, 1998). Strategy TES-3 of the Monument's Draft Management Plan is to "Ensure that nesting populations of green turtles at source beaches are stable or increasing over the life of the plan" (the life of the plan being 15 years). The first activity planned to achieve this strategy includes the continuation of data collection to monitor nesting turtles on East Island, French Frigate Shoals (with the largest numbers of nesting turtles in the Monument), and the periodic reassessment of the distribution of nesting activity on the other islands and atolls within the NWHI (PMNM, 2008). The second activity to achieve Strategy TES-3 is the protection and management of nesting habitat, including prevention of introduction of mammalian predators such as rats, reduction of artificial light near nesting beaches, prohibition of habitat alteration, and the regulation of human access and activities. Management actions to delay habitat loss due to sea level rise are also advised, but specific activities related to the slowing of climate-change-induced habitat loss are not described (PMNM, 2008). Finally, Strategy TES-3 will be attained by protecting and managing foraging areas and migration routes within the Monument, including identification and mapping of these areas, and management of vessel transit and discharge, and minimization of the introduction of contaminants (PMNM, 2008).

EXISTING DATA GAPS

It is important to develop and regularly update a database of population structure and dynamics for protected species. The database will help managers make effective decisions and determine the effects of previous decisions and events (e.g., climate events, management decisions, research programs, disease outbreaks, etc.). Specific opportunities include research to improve the understanding of:

- The essential habitats and ecological requirements of protected species, to minimize anthropogenic threats and the effect of catastrophic events;
- The diet and foraging behavior of the Hawaiian monk seals throughout different life stages in order to understand the effect of food availability on the population;
- Time budgets, diving, and movement characteristics and energetics of the Hawaiian monk seal, stratified by representative sub-populations, age, and sex classes;
- An appropriate and sensitive assay for biotoxins and metabolites in tissue of monk seals and prey species;
- The effects of climate change on nesting sites of protected species, e.g., the effect of sea level rise on nesting sites of the green sea turtle and Hawaiian monk seal;
- The Allee effect (i.e., that for smaller populations, the reproduction rates and survival of individuals decrease) and thresholds for phase shift;
- Cetacean presence and behavior in the NWHI at different times of the year; and
- The presence/absence of other turtle species and nesting sites at other locations in the NWHI.

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