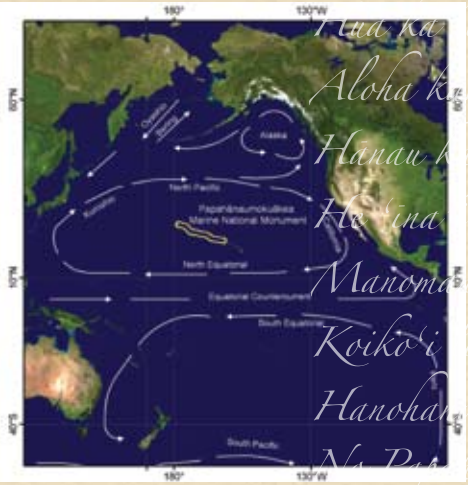
2.

Malamalama ka lā nui o Kane puka i Ha'ena'e
'Apakau ke kukuna i ka 'ili kai o nā kai 'ewalu
He 'ike makawalu ka'u e 'ano'i nei,
'O nā au walu o Kanaloa Haunawela noho i ka moana nui
He Hu'akai ka makani o Lehua 'au i ke kai
Kū'ono'ono ka lua o Kuhaimoana i ke kapa 'ehukai o Ka'ula
'O Kū i ka loulu, ulu a'e ke aloha no Nihoa moku manu
Manu o kū i ka 'ahui, he alaka'i na ka lāhui
'O Hinapuko'a
'O Hinapūhalako'a
'O Hina kupukupu
'O Hinaikamalama
I ua ka 'ohua, lu'u ke koholā
Aloha kahi limu kala, kia'i 'ia e ka 'akalu [illegible] puka
Hanau ka pe'a, puka ka pe'ape'a i ke kai
He 'ina [illegible] ka 'ina, 'ono i ka huna o ka pa'akai
Manomano ka 'ike li'u o ka houpō o Kanaloa
Koiko'i [illegible] o ka'u luhi ia
Hanohano [illegible] 'aina kupuna [illegible] o nā moku le'ia
Na Pa[illegible] nāumokuāk[illegible] la le'ina
Na Kaunani Kahaunaele a me Halealoha



Description and History of Property

2. Description and History of the Property

2.a Description of the Property

Introduction

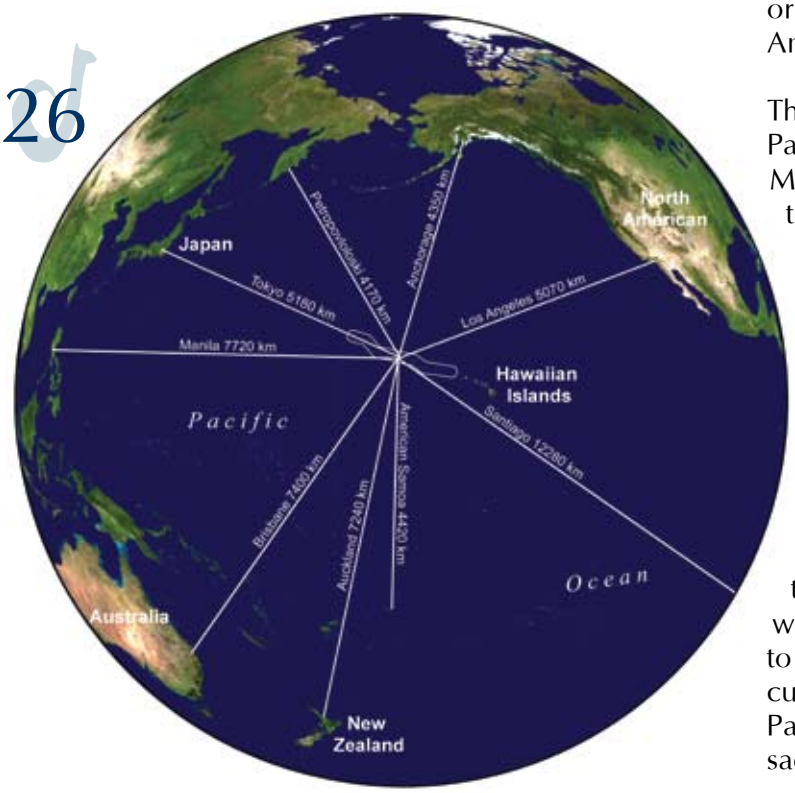
As one of the world's largest protected marine areas, Papahānaumokuākea Marine National Monument includes a vast area of the Pacific. Extending for a distance of roughly 1,930 kilometers by 185 kilometers, the property covers an area of approximately 362,075 square kilometers (140,000 square miles) (see Section 1 for maps of the property.) At both the regional and global levels, Papahānaumokuākea is a rich natural and cultural reserve of outstanding spiritual, scientific, conservation and aesthetic value. As a nomination for a mixed natural-cultural World Heritage site, this section addresses the property's natural and cultural aspects in turn.

Threatened Green Turtles basking on East Island, French Frigate Shoals (Photo: George Balazs)

Papahānaumokuākea Marine National Monument is located between approximately 22° N and 30° N latitude and 161° W and 180° W longitude within the north central Pacific Ocean. When overlain on the continental United States, this property would cover the distance from Washington, D.C. to the midwest, or within Europe, the distance from Amsterdam to Moscow.

The islands and atolls of Papahānaumokuākea Marine National Monument constitute the northwestern three quarters of the one of the world's longest and most remote island chains. This expansive stretch of islands is referred to as the Northwestern Hawaiian Islands (NWHI), in past decades as the Leeward or Kūpuna Islands (Islands of the Revered Elders or Ancestors), and now as Papahānaumokuākea (see box). The area has played and continues to play a significant role in the culture and traditions of Native Hawaiians. From the time of the first Polynesian voyagers who peopled the Hawaiian Archipelago to the present renaissance of Hawaiian culture, Native Hawaiians have considered Papahānaumokuākea a profoundly sacred place.

Significant archaeological sites, strong oral traditions, and the living culture's continuing



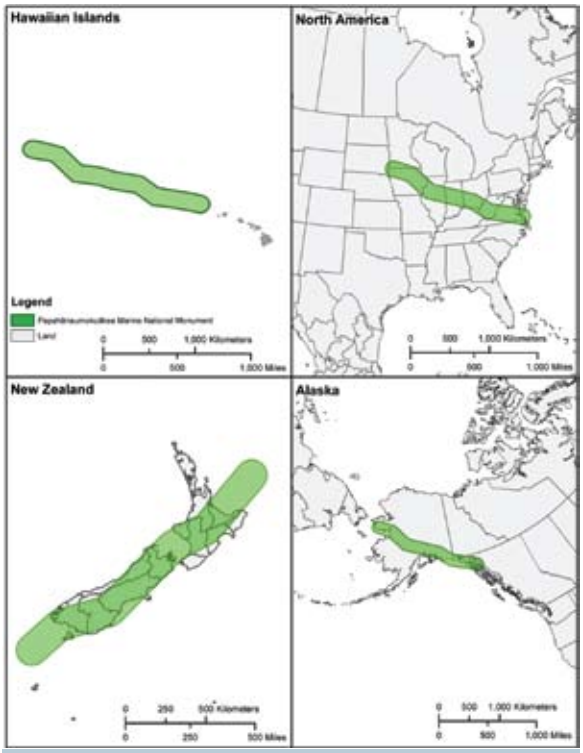
Papahānaumokuākea Marine National Monument's distance from major metropolitan areas

association with the region confirm a deep relationship between the Hawaiian people and Papahānaumokuākea. Today, the region's exceptional natural integrity is fundamental to the perpetuation of the Hawaiian culture; Papahānaumokuākea is known as one of the last "places of abundance," where Native Hawaiians can interact with and experience an intact and abundant natural world similar to the world of their ancestors. All archipelagic wildlife are regarded as ancestors to Native Hawaiians (Malo 1951); the region itself is revered as the place from where spirits come and to which they return after death. The geological and natural life forms defined in this section are inhabitants of the NWHI and referred to in the Kumulipo, a genealogical *oli* (chant) that frames the evolution of life from the simplest of creatures to the most complex. In the Native Hawaiian worldview, the interface between natural and cultural resources is seamless. Hence, Papahānaumokuākea is a longstanding site of outstanding associative value to the living Hawaiian culture, and ultimately the global community.

Hānau Moku – The Birth of the Islands

Birth—creation—is a central pillar of traditional cultures across the globe. In Native Hawaiian culture, human life comes not only from two biological parents, but from a complex spiritual and literal genealogy that ties humans with a bond of kinship to everything else, both living and non-living, in the natural world. Pō, the primordial female darkness from which all life springs and to which it returns after death, is seen as giving birth to the world, its natural components, all of the Hawaiian gods, and humans. The union of her progeny, Kumulipo and Pōʻele, gives rise to all the creatures of the world, beginning in the oceans with the coral polyp—a genealogy that, like current theories of evolution, starts with the simplest known life form and moves to the more complex.

Native Hawaiians view the rising of magma from deep within the earth as the birthing of the islands—the physical manifestation of the union between the earth mother,



Papahānaumokuākea Marine National Monument superimposed over other land masses

Papahānaumoku (literally, "goddess who gives birth to the islands"), and the sky father, Wākea. The symbolism of this union is also the foundation for the name of the property: Papahānaumokuākea.

In the Native Hawaiian culture, *kūpuna* (elders, or ancestors) are accorded reverence and respect, and are looked to as teachers by right of their greater experience. Native Hawaiians consider the islands of Papahānaumokuākea (also called the Kūpuna Islands in recent times) to be their *kūpuna*. Each island is a teacher, and each island has its own unique story and message. As the younger generation, humans are tasked to *mālama* (care for) the *kūpuna*. It is also humankind's *kuleana* (responsibility) to take the time to listen to their wisdom.

The following box describes how the property received its name. Native Hawaiian practitioners undertook a deliberative and thoughtful process to give the region a name reflective of both its natural and cultural heritage, as well as its future as a vast and sacred protected place.

The Naming of Papahānaumokuākea

Native Hawaiian artist Solomon Enos renders deities Papa and Wakea's creation of the Hawaiian Islands
http://www.solomonenosgallery.com/

For Native Hawaiians, place names are an important way to preserve information about an area's geology, its history, natural and supernatural phenomenon specific to it, or its uses by gods and men. As a place changes over time, so may its name. Historically, Native Hawaiians referred to the Northwestern Hawaiian Islands as Nā Moku Manamana (Branching Islands), Nā Moku Papapa (Flat Islands) and nā papa kahakukea o Lono (the low white-marked isles of Lono (one of the four principal Hawaiian gods)) (Kepā Maly 2 November 2008, personal communication; Fornander 1918). In recent times, Native Hawaiians have called the isles of this region the Kūpuna (Revered Elder) Islands.

The name Papahānaumokuākea was given to the region by a group of Native Hawaiian cultural practitioners and *kūpuna* when the area was designated as a federal monument. The name specifically relates to one of the stories contained within the Kumulipo: the *mo'olelo* which tells the story of Papahānaumoku (a mother figure who is personified in the earth) and Wākea (a father figure who is personified in the expansive sky). These two figures, either together or separately, are responsible for the creation or birthing of the entire archipelago, and they are the most recognized ancestors of the Native Hawaiian people (Beckwith 1951, Malo 1951, Fornander 1918). The name Papahānaumokuākea is reflective of the region's natural and cultural heritage and its future as a vast, sacred, protected and procreative place.

The preservation of these names, together, as Papahānaumokuākea, strengthens Hawai'i's cultural foundation and grounds Hawaiians to an important part of their historical past. Taken apart, "Papa" (earth mother), "hānau" (birth), "moku" (small island or land division), and "ākea" (wide) bespeak a fertile woman giving birth to a wide stretch of islands beneath a benevolent sky, the dramatic imagery of which is on full display in the region.

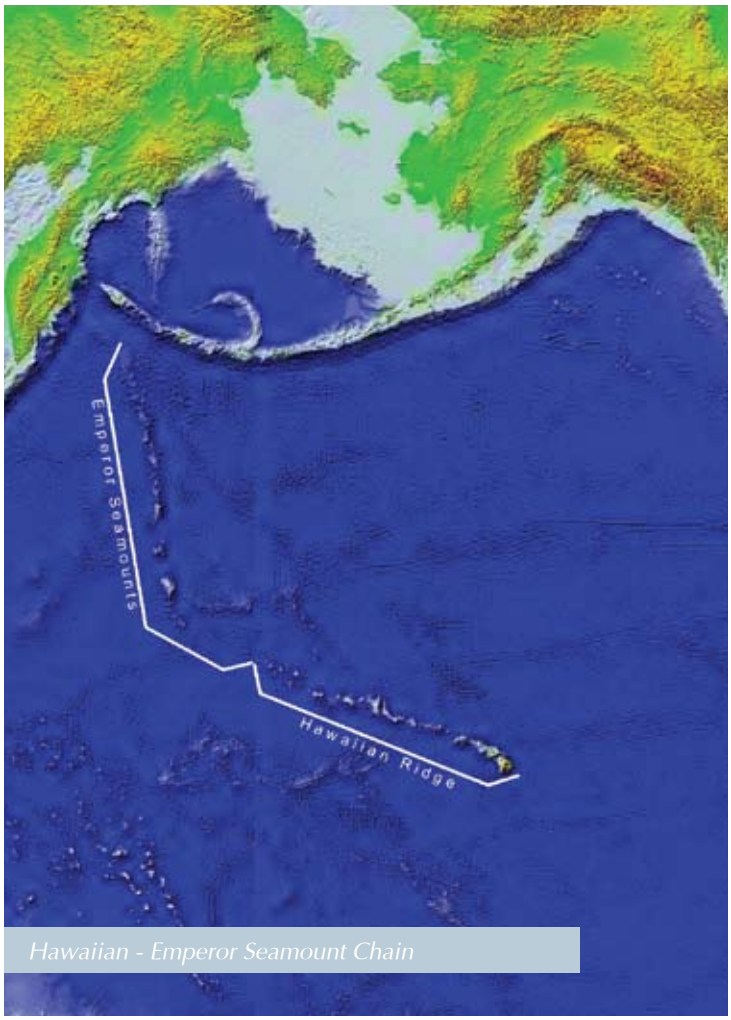
Papahānaumokuākea describes a hope for regeneration, which Hawaiians hope to see not only in their Kūpuna Islands, but in the main Hawaiian Islands and their culture as well. Papahānaumokuākea is a name that will encourage abundance and energize the continued procreative forces of earth, sea and sky. It reminds everyone that spiritual inspiration supports the physical world. Papahānaumokuākea will help to continue life for everything that procreates and gives birth; it is a continuum and everything that is part and parcel of Native Hawaiians' home world, the Hawaiian Archipelago.

Dr. Pualani Kanahele at the podium during the cultural bestowing of the NWHI's new placename, Papahānaumokuākea (Photo: PMNM)

Natural Processes and Systems in Papahānaumokuākea

Geology

Beginning 250 kilometers northwest of the main Hawaiian Island of Niʻihau, the ten islands and atolls of this Pacific chain extend for 1,931 kilometers. None of the included islands is more than five square kilometers in size, and all but four have an average mean height less than ten meters above sea level. As a group, these islands represent a classic geomorphological sequence, consisting of highly eroded high islands, near-atolls with volcanic pinnacles jutting from surrounding lagoons, true ring-shaped atolls with roughly circular rims and central lagoons, and secondarily raised atolls, one of which has an interior hypersaline lake. In addition, more than 30 submerged ancillary banks and seamounts have been discovered around these islands.



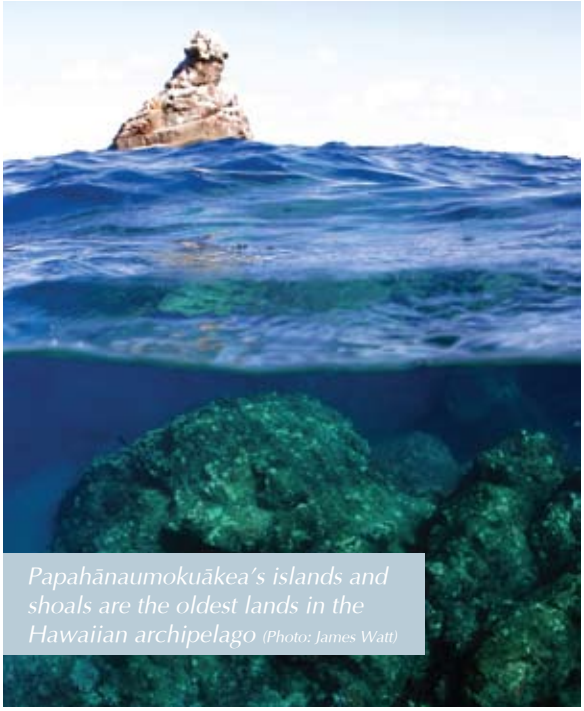
Hawaiian - Emperor Seamount Chain

The geological progression along the Hawaiian Ridge continues northwestward beyond the last emergent island, Kure Atoll, as a chain of submerged platforms that makes a sudden northward bend to become the Emperor Seamounts, which extend across the entire North Pacific to the base of the Kamchatka Peninsula in Russia. This unbroken chain of progressively more senescent volcanic structures essentially tracks the movement of the Pacific tectonic plate over the past 80 million years, and has provided some of soundest evidence upon which current theories of hotspot-mediated island formation and global plate tectonic movements have been based.

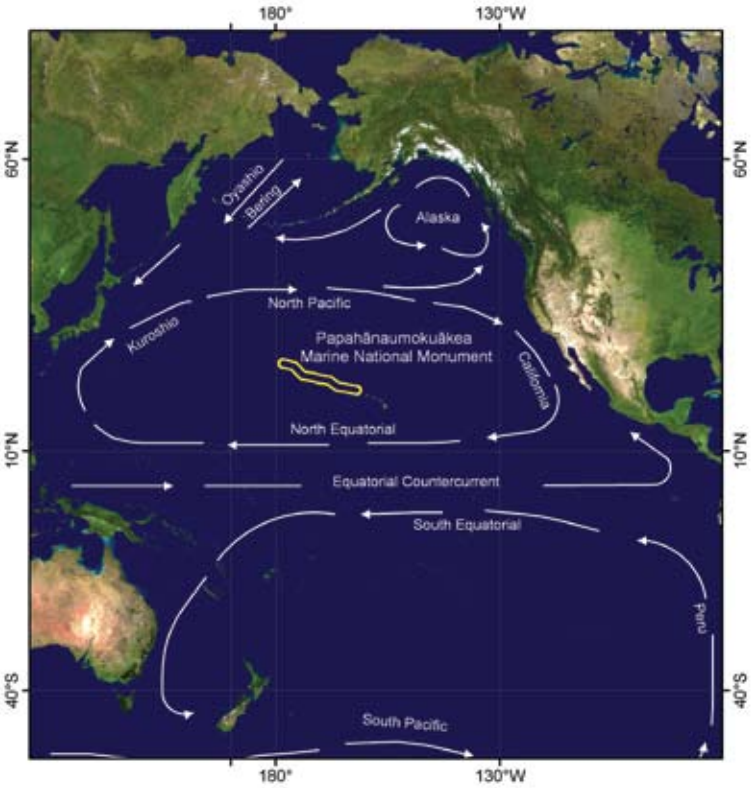
Formed millions of years ago, these islands were created by a deep-sea volcanic "hotspot" now located south of the island of Hawaiʻi, which formed a sequential series of underwater shield volcanoes that became islands as they rose above the ocean's surface. These once-lofty islands have been transported northwest by the movements of the Pacific Plate to their current locations (Dalrymple et al. 1974). Due to the pervasive and unrelenting forces of subsidence and erosion, all that remains today are small patches of ancient land, shoals and reefs that lie where significant mountains once loomed. Nowhere else in the world is this progression illustrated in such an unambiguous and linear fashion. Papahānaumokuākea also includes a unique example of an atoll at the critical "Darwin Point," the northernmost threshold for coral reef existence. Kure Atoll is the northernmost coral reef in the world, and has reached the latitude at which coral growth rates, which decrease in cooler temperatures, are matched by the rate of subsidence of the island.

Oceanography

Among the dominant natural controls over the ecosystems of Papahānaumokuākea Marine National Monument are climatic and oceanographic forces. The area lies at the northern edge of the oligotrophic tropical Pacific, near the 18 °C sea surface isotherm, a major ecological transition zone in the northern Pacific. This boundary, also known as the "Transition Zone Chlorophyll Front," varies in position both seasonally and annually, and periodically moves across the property boundary surrounding the northern atolls of Kure and Midway. This, in turn, influences overall ocean productivity, and the resultant recruitment success of many species such as Hawaiian Monk Seals and ocean-feeding seabirds (Polovina et al. 2008; Baker, Polovina and Howell 2007). The northernmost atolls are also in a position where they are occasionally affected by an episodic eastward extension of the Western Pacific warm pool, which can lead to higher summer ocean temperatures at Kure than are found in the more "tropical" waters of the main Hawaiian Islands further to the south. This can cause greater temperature fluxes that can in turn influence the home ranges and diversity of many species. This interplay of oceanography and climate is not fully understood, but adds a level of dynamics not seen in most other tropical atoll ecosystems and is a useful natural laboratory for understanding phenomena such as periodic coral bleaching and the effects of the Pacific Decadal Oscillation, El Niño and La Niña ocean circulation patterns.



Papahānaumokuākea's islands and shoals are the oldest lands in the Hawaiian archipelago (Photo: James Watt)



Major circulation patterns of the Pacific Ocean

Ocean currents, waves, temperature, nutrients, and other oceanographic parameters and conditions influence ecosystem composition, structure, and function in Papahānaumokuākea on both temporal and spatial scales. Spatial variability in oceanographic conditions ranges from a localized temperature regime that may affect a small portion of a reef to a temperature regime that influences Papahānaumokuākea as a whole. Temporal variability in ocean conditions may range from hourly and daily changes to seasonal, annual, or decadal cycles in nutrient inputs, sea level heights, current patterns, and other large-scale

Papahānaumokuākea encompasses intact reef and pelagic ecosystems (Photo: PMNM)

oceanographic processes (Polovina et al. 1994). Currents play an important role in the dispersal and recruitment of marine life in Papahānaumokuākea on both scales.

Surface currents in the NWHI are highly variable in both speed and direction (Firing and Brainard 2006), with long-term average surface flow being from east to west in response to the prevailing northeast trade wind conditions. The direction of surface water flow also accounts for certain unusual biogeographic relationships between Papahānaumokuākea and other allochthonous areas, such as Johnston Atoll to the south (Grigg 1981), as well as patterns of endemism, population structure, and density of reef fish within the archipelago itself (DeMartini and Friedlander 2006) (Figure 2.1). The highly variable nature of the surface currents is due in large part to eddies created by local island effects on large-scale circulation. The distribution of corals and other shallow-water organisms is also influenced by exposure to ocean waves. The size and strength of ocean wave events have annual, interannual, and decadal time scales. Annual extratropical storms (storms that originate outside of tropical latitudes) create high waves during the winter, greatly affecting marine and terrestrial areas, as the elevation of a large portion of terrestrial habitat is less than the height of some of the waves that pass through.

Tinker's Butterflyfish (Chaetodon tinkeri) is found at Johnston Atoll and in the Hawaiian Islands; illustrating the oceanographic and biodiversity links between the two regions. (Photo: L.A. Rocha, HIMB)

Natural Habitats

Papahānaumokuākea also supports a diverse and unique array of both marine and terrestrial flora and fauna. With a spectrum of elevations ranging from abyssal ocean basins at depths of more than 4,600 meters below sea level to rugged hill slopes and cliff tops on Nihoa and Mokumanamana at elevations up to 275 meters above sea level, the property represents a complete holistic cross section of a Pacific archipelagic ecosystem. Habitats encompassed within the property include deep pelagic basins, submarine escarpments, deep and shallow coral reefs, shallow lagoons, littoral shores, dunes, and dry grasslands and shrublands. Twenty-five percent of the nearly 7,000 known marine species found in the region are found nowhere else on earth, and a significant number of the terrestrial plants, birds and insects are endemic. Papahānaumokuākea also provides habitat for 23 plant and animal species formally listed under the Endangered Species Act (ESA) as threatened and endangered. Papahānaumokuākea's isolation from continental land masses and minimal human footprint allow the study of natural habitats and ecosystem dynamics, including the response to climatic variability and global climate change, in a relatively undisturbed setting. The protective measures in place contain the necessary elements to support the key ecological processes that are essential for the long-term conservation of the ecosystems and the biological diversity they contain throughout Papahānaumokuākea.

The terrestrial and marine habitats of the Northwestern Hawaiian Islands are integrally linked, particularly on the atolls. It is through the synergistic process of terrestrial erosion and coral growth that atolls are formed. The islands of an atoll are a part of the reef. Shallow-water habitats range from exposed boulders and large underwater banks formed from the basaltic remnants of former high islands at Nihoa, Mokumanamana and Gardner Pinnacles, to the extensive coral reef habitats in the protected lagoons of the atolls. The shallow-water habitat includes intricate and reticulated reefs that form a complex network of reef crest, back reef, patch reef, and lagoons with high coral cover. Outer reef habitat is exposed to much higher wave energy and includes fore-reef and reef slope environments with spur and groove channels and varying percentages of coral cover directly related to wave exposure.

The total land area of the NWHI is extremely small at 1,400 hectares, but crucially important for the survival of both marine and terrestrial species, many that spend part or most of the year at sea and come ashore to breed, nest or pup such as turtles, seabirds and monk seals. All the low islands are mostly arid with no fresh water resources, except during seasonal rains. Nihoa, Mokumanamana and Laysan have small fresh water seeps. Only the higher and larger islands of Nihoa, Laysan, Lisianski, and Midway support year-round vegetation; many of the smaller and lower islands are periodically overwashed by seawater.

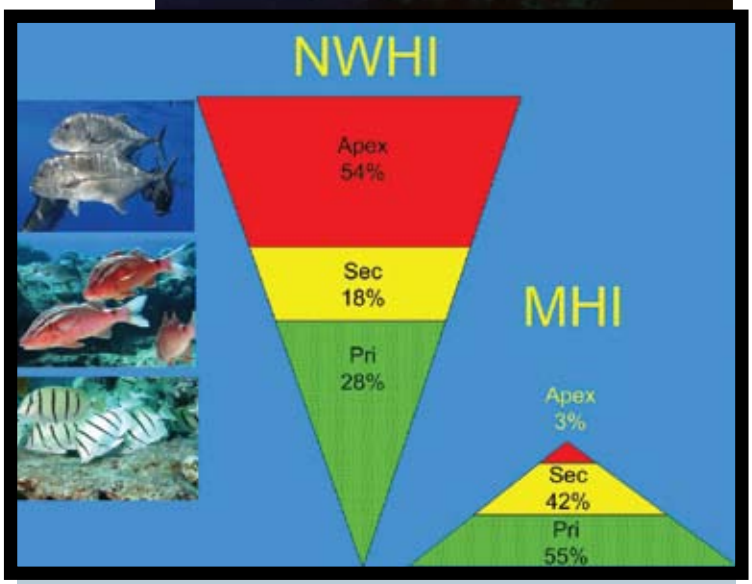


Figure 2.1a: *Biomass comparisons between the Northwestern Hawaiian Islands (NWHI) and the main Hawaiian Islands (MHI) by trophic group. (Apex = apex predators, Sec = secondary consumers, Pri = primary consumers)*
(Photo: James Watt, Figure: Alan Friedlander)

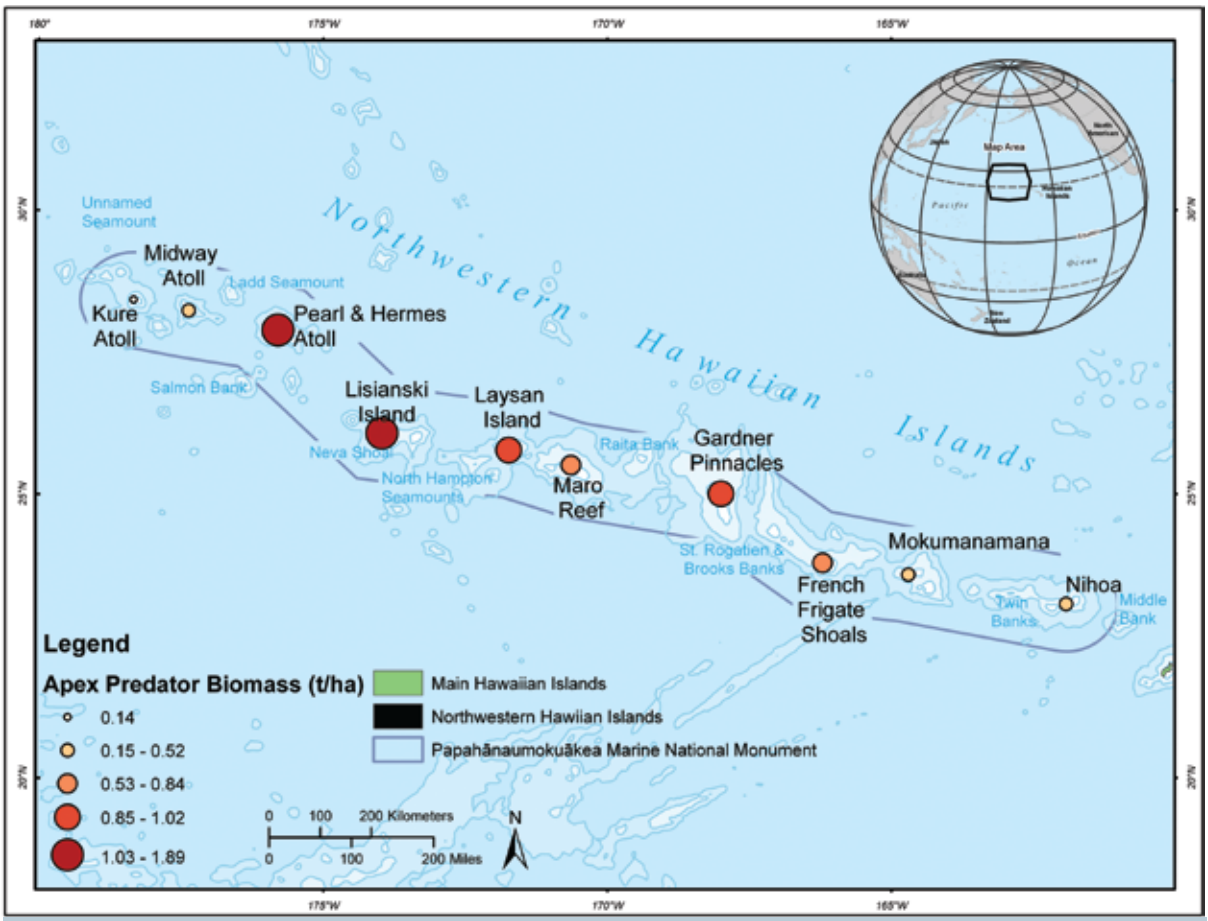


Figure 2.1b: *Geographic pattern of apex predator biomass density (tons/ha) in the NWHI (data from surveys conducted 2000-2002).*

Top Predator Dominated Ecosystem

The shallow marine component of the property is nearly pristine, and has been described as a "top predator dominated ecosystem," an increasingly rare phenomenon in the world's oceans (Friedlander and DeMartini 2002). Recent research suggests that the global oceans have lost more than 90% of large predatory fishes (Meyers and Worm 2003). Large, predatory fish such as sharks, Giant Trevally, and groupers that are heavily depleted by fishing and therefore rarely seen in populated areas of the world are extremely abundant in the waters of Papahānaumokuākea. With low fishing pressure and physical isolation from human impacts, the average biomass of fish in Papahānaumokuākea is three times greater than in the main Hawaiian Islands. More than 54% of the total biomass consists of apex predators such as large jacks or trevally, sharks and other species (Figures 2.1a and 2.1b).

Marine Endemism

Papahānaumokuākea is characterized by a high degree of endemism in reef fish species, particularly at the northern end of the chain, with endemics comprising over 50% of the population in terms of numerical abundance (DeMartini and Friedlander 2004) (Figure 2.2). Endemism of corals is also high, with 30% of species being found only in the Hawaiian Archipelago. These endemics also account for 37%–53% of visible stony corals found in Papahānaumokuākea in all shallow reef areas surveyed (Friedlander et al. 2005). Fifteen of the 17 endemic species are in the genera Montipora, Porites, or Pocillopora. Due to Papahānaumokuākea's remoteness, studies of small benthic or cryptic species are sparse, but with the inception of National Monument status, there have been increased efforts to document these groups. Preliminary faunal inventories indicate that many constituent species remain undocumented, and even new coral species are still being discovered

Endemic Sea Life

This tailored attunement of species to a specific place is called endemism. No other coral reefs of similar size and expanse on the planet have a higher rate of endemism than Hawaii's.

Saddle Wrasse
hinālea lauwili,
Thalassoma duperreyi

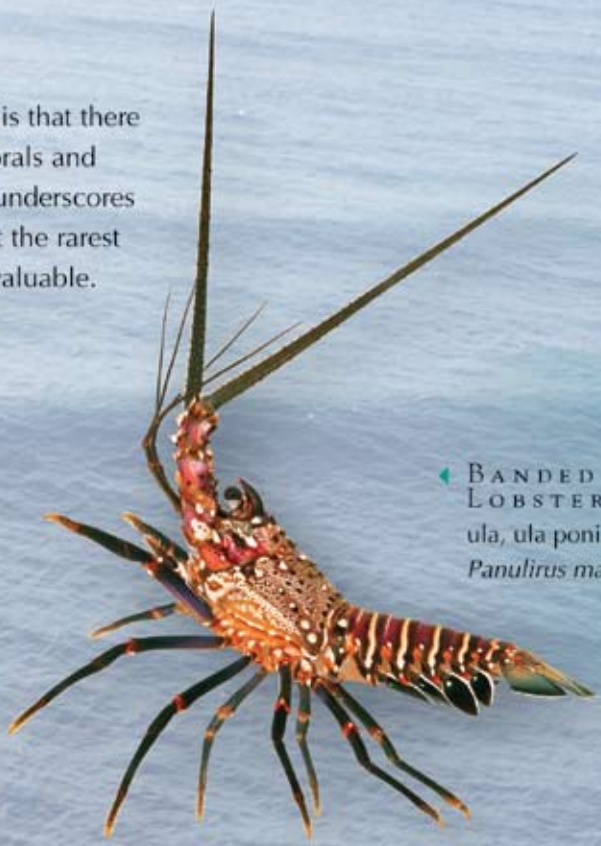
Chocolate Chip Sea Cucumber
loli, *Holothuria* sp.

Hawaiian Monk Seal
ʻĪlioholoikauaua,
Monachus schauinslandi

Bandit Angelfish
Apolemichthys arcuatus

The downside of Hawaii's endemism is that there is no replacement pool should our corals and marine life perish. This vulnerability underscores one of nature's hard-won lessons: that the rarest of creatures are sometimes the most valuable.

Masked Angelfish
(female above, male below)
Genicanthus personatus



Banded Spiny Lobster
ula, ula poni, ula hiwa,
Panulirus marginatus

Species photos © David Littschwager and Susan Middleton

Papahānaumokuākea contains countless endemics, and is home to many rare, threatened and endangered species, including 22 IUCN Red-Listed species, many for whom it is the last or only refuge anywhere on earth.

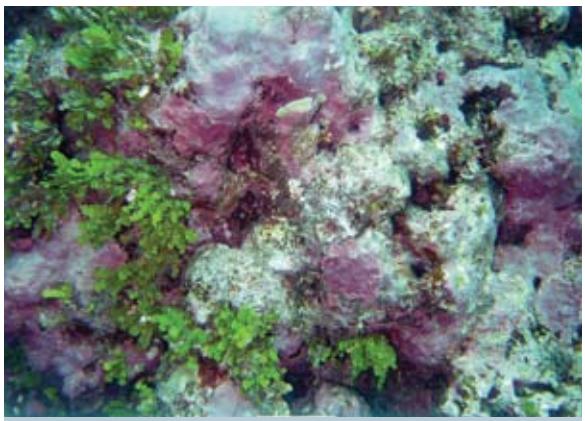
Figure 2.2: Percent fish endemism at each of ten emergent Papahānaumokuākea reefs
(data from surveys conducted 2000–2002)

(Waddell and Clarke 2008). Given this, it is expected that the marine species lists of Papahānaumokuākea will continue to expand as improving funding, technology and research tools allow exploration and documentation of the region's reefs.

Marine and Bird Life in Papahānaumokuākea

Algae

The marine algal flora in Papahānaumokuākea are diverse and abundant, although community dynamics are poorly understood. There are 353 species of macroalgae and two seagrass species known in Papahānaumokuākea (McDermid and Abbott 2006). Large numbers of Indo-Pacific algal species have been documented here that are not present in the main Hawaiian Islands, such as the green calcareous alga (*Halimeda velasquezii*). The species composition of the macroalgae community is relatively similar throughout Papahānaumokuākea, with representatives of the Chlorophyta, Rhodophyta, Phaeophyta, branched coralline, crustose coralline, Cyanophyta, and turf algae occurring in varying combinations, with green algae having the largest biomass and area coverage (Vroom and Page 2006). Green algae in the genus Halimeda, which contributes greatly to sand formation, was found in more than 70%



Healthy native algal species abound in Papahānaumokuākea (Photo: Amy Baco-Taylor)

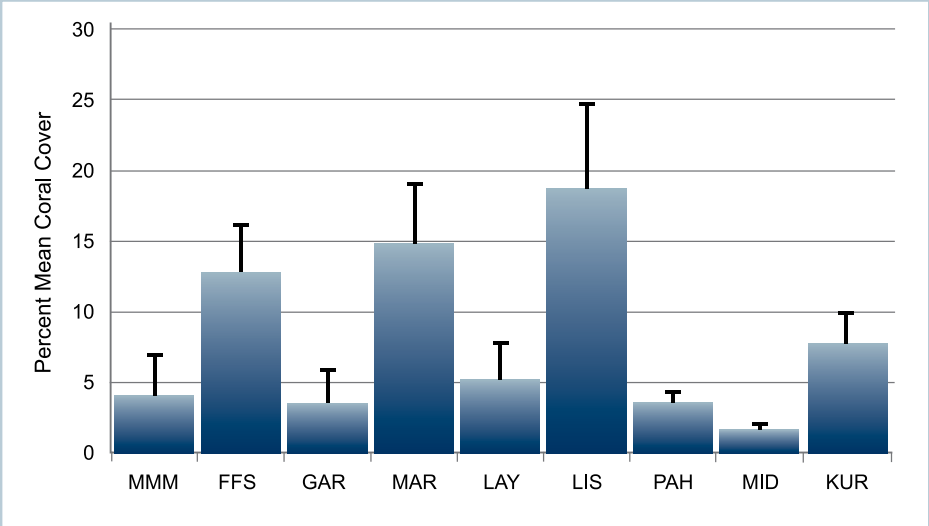


Figure 2.3: *Mean coral cover (+/- SE) by site, within Papahānaumokuākea. Data are derived from PIFSC–CRED towed diver surveys in 2003*

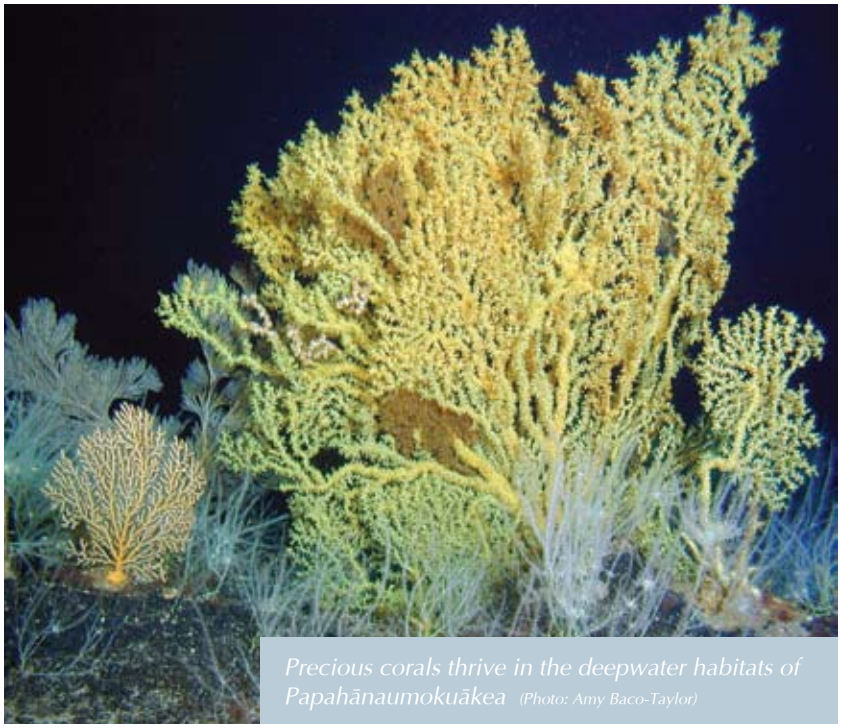
Live coral cover is highest in the middle of the chain, with Lisianski Island and Maro Reef having 59.3% and 64.1% of their respective available substrate covered with living corals (Maragos et al. 2004) (Figure 2.3). Coral cover varies significantly across Papahānaumokuākea from these high rates at Maro and at Lisianski to minimal coverage at most of the other reef sites. Coral species richness is also highest in the middle of the chain, reaching a maximum of 41 reported coral species at French Frigate Shoals (Maragos et al. 2004).

of all quadrates during area-wide surveys in 2004 (Vroom and Page 2006). An island-specific checklist of the nonvascular plants of Papahānaumokuākea can be found in Eldredge (2002). In contrast to the main Hawaiian Islands, where alien species and invasive algae have overgrown many coral reefs, the reefs of Papahānaumokuākea are largely free of alien algae, and high natural herbivory results in natural algal assemblages.

Corals

Fifty-seven species of stony corals are known in the shallow subtropical waters (depths of less than 33 meters) of Papahānaumokuākea, with an additional 28 species that are currently either undetermined or undescribed (Miller et al. 2004, 2006; Waddell and Clarke 2008). Despite Papahānaumokuākea's high latitudes (which makes coral growth progressively more difficult), a similar number of species of coral have been reported for the NWHI as the main Hawaiian Islands, with 59 recorded species (Friedlander et al. 2005).

Stony corals are less abundant and diverse at the northern end of the archipelago (Kure, Midway, and Pearl and Hermes), and off the exposed basalt islands to the southeast (Nihoa, Mokumanamana, La Pérouse, and Gardner) (Figure 2.4). At these sites, soft corals such as Sinularia and Palythoa are more abundant. Table coral in the genus Acropora is not found anywhere in the main



Precious corals thrive in the deepwater habitats of Papahānaumokuākea (Photo: Amy Baco-Taylor)

Hawaiian Islands, but seven species are recorded for Mokumanamana, Gardner, Pearl and Hermes, Neva, French Frigate Shoals, Maro, and Laysan, with the highest number of species and colonies at French Frigate Shoals. These colonies of coral may have been established from larvae traveling in currents or eddies from Johnston Atoll, 724.2 kilometers to the south (Grigg 1981; Maragos and Jokiel 1986).

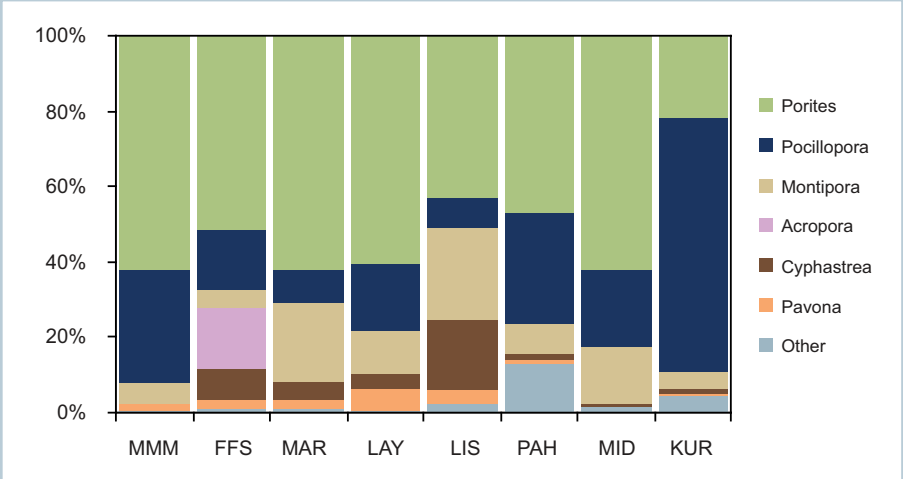
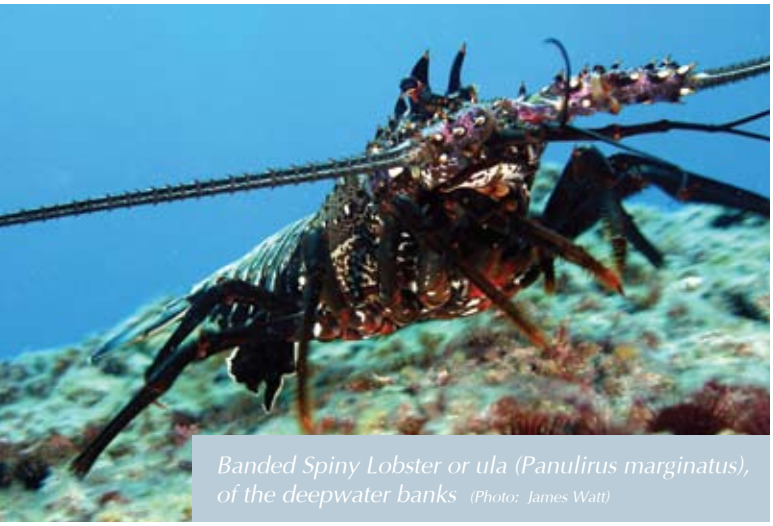


Figure 2.4: *Relative abundance of coral taxa genera throughout Papahānaumokuākea* (Data are derived from colony counts within belt transects during 2006 surveys)

Benthic shallow-water invertebrates

With the exception of coral and lobster species, the marine invertebrates of Papahānaumokuākea are very poorly known. Only two comprehensive collections of these groups of animals were conducted prior to 2000: the 1902 *Albatross* Expedition, in which the collected organisms were deposited at the Smithsonian Institution, and the 1923 *Tanager* Expedition, in which the collection was deposited at the Bishop Museum. In 2000, the NWHI Reef Assessment and Monitoring Program was established, and it continues to the present to assess the biota of all ten emergent reef areas and shallow waters (<20 meters) in Papahānaumokuākea (Friedlander et al. 2005). While this work is ongoing, a number of new species have already been recorded for Hawai'i, some of which may turn out to be endemic to Papahānaumokuākea (DeFelice et al. 2002).

Other-worldly texture of mushroom corals; shown here, Fungia scutaria (Photo: James Watt)



Banded Spiny Lobster or ula (Panulirus marginatus), of the deepwater banks (Photo: James Watt)

By 2005, a total of 838 species from 12 orders had been identified. Many species are still being worked on by taxonomic experts around the world and have yet to be identified (Friedlander et al. 2005). In 2006, a Census of Marine Life research expedition explored the biodiversity of small, understudied, or lesser known invertebrate, algal, and microbial species at French Frigate Shoals. Although thorough taxonomic identifications and molecular analyses of the samples collected will take many years to complete, preliminary findings suggest that approximately 2,300 unique morphospecies were collected and photographed during the 16 days of sampling (Fig 2.5). An estimated 30–50 collected specimens are thought to be species new to science, including new species of crabs, corals, sea cucumbers, sea squirts, worms, sea stars, snails and clams. From this expedition, well over a hundred new species records, including

sponges, corals, anemones, flatworms, segmented worms, hermit crabs, crabs, sea slugs, bivalves, gastropods, octopus, sea cucumbers, sea stars, and sea squirts, will likely be identified for French Frigate Shoals. Relatively high diversity was found for sponges, bryozoans, eulimid gastropods, hermit crabs, echinoderms, and ascidians, but other invertebrates, including corallimorph anemones, galatheid squat lobsters, porcellanid crabs, pea crabs, and coral barnacles, had strikingly low diversity or were absent. Interestingly, about one third of all invertebrate morphospecies collected were either found only once or found at only one site. A possible new family of ascidian (sea squirt) for Papahānaumokuākea, Mogulidae, was collected. Likewise, a new species of coral that could not even be identified to family level was found and photographed. An estimated 48 new species records of Opisthobranch mollusks for French Frigate Shoals were collected, 27 of which appear to be new records for Papahānaumokuākea.

A Stocky Hawkfish or po'o pa'a (Cirrhitus pinnulatus) peers from Kure Atoll's reefs (Photo: James Watt)

Reef fish

The extreme isolation of Papahānaumokuākea and its distance from the diverse fish population centers of the Western Pacific contribute to a lower fish species richness relative to other sites (Mac et al. 1998). A total of 258 species have been documented from Midway Atoll (Randall et al. 1993). Total species richness observed on surveys show a positive linear relationship with the total area of reef in shallow waters, a relationship that is consistent with most theories of island biogeography and likely reflects the greater diversity of habitats at larger islands or atolls (Waddell and Clarke 2008). Although part of one continuous chain, fish assemblages differ among reef types. The three true atolls (Kure, Midway and Pearl and Hermes) as well as the partial atoll French Frigate Shoals, contain fish assemblages that are different from the basalt islands of Mokumanamana, Gardner Pinnacles and Nihoa. In addition to fish species differing with various island types, species also differ among latitudinal gradients. Many species of wrasses and damselfish exhibit a higher latitudinal bias; they are found significantly more often at northern sites (Kure and Midway Atolls) than at more southern locations.

Papahānaumokuākea's long-term protection from fishing pressure has resulted in high standing stocks of fish that are more than 260% greater than the main Hawaiian Islands. As mentioned above, the fish community of the coral reef ecosystem of

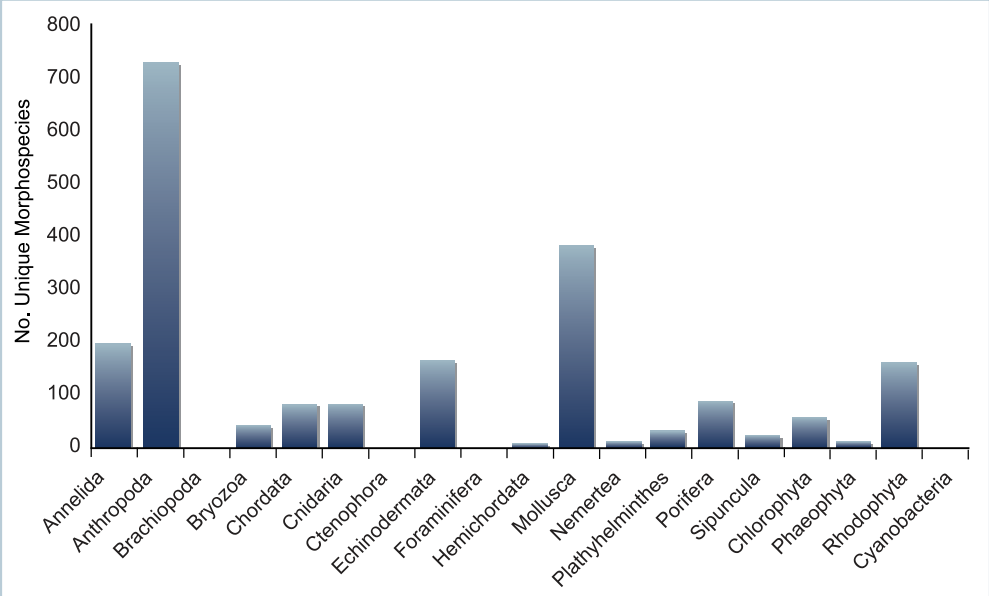


Figure 2.5: *Unique morphospecies collected at FFS by phylum in 2006 surveys*

Papahānaumokuākea also shows a very different structure than the main Hawaiian Islands and most other places in the world. The shallow-reef fish community is remarkable in the abundance and size of fish in the highest trophic levels. Apex predator biomass on forereef habitats in Papahānaumokuākea is 1.3 metric tons per hectare, compared to less than 0.05 metric tons per hectare on fore-reef habitats in the main Hawaiian Islands (Fig 2.6).

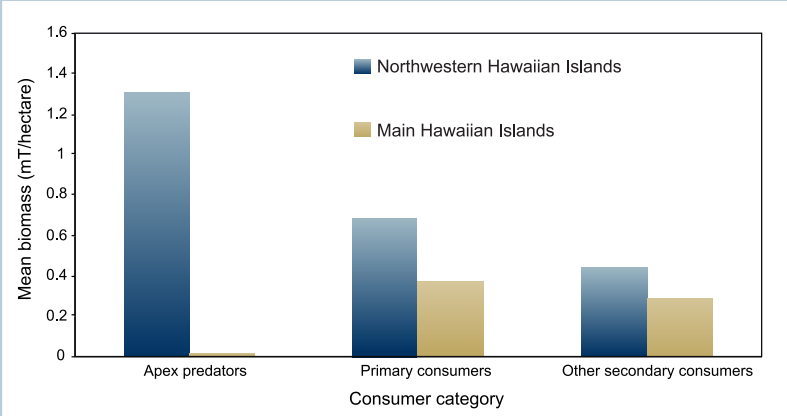


Figure 2.6: *Comparison of biomass in major trophic guilds between the Northwestern Hawaiian Islands and the main Hawaiian Islands*
(Source: Friedlander and DeMartini 2002 Data are derived from colony counts within belt transects during 2006 surveys)

Areas with the highest apex predator biomass include Pearl and Hermes Atoll, followed by Lisianski and Laysan Islands.

Biota of deeper bank habitats

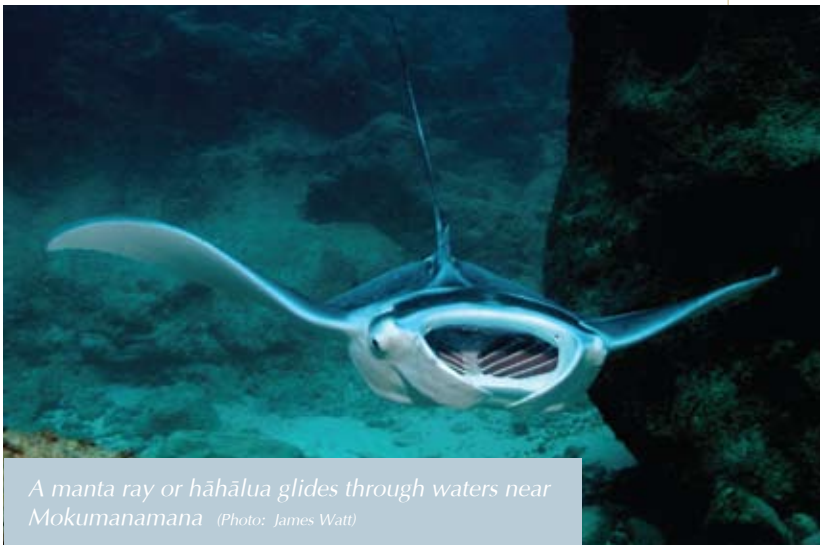
The property also contains a significant component of deeper waters that surround the island platforms, an ecosystem type typically lacking in most of the world's marine reserves. There are at least 15 banks at depths of 30 to 400 meters within Papahānaumokuākea, providing important habitat for bottomfish and lobster species, although only a few of these banks have been studied in any detail (Kelley and Ikehara 2006). These waters represent critical deepwater foraging grounds for Hawaiian Monk Seals (Parrish et al. 2002), important habitat for bottomfish and lobster species, and a spatial refuge for pelagic fishes such as tunas and their allies, which have been declared overfished in other regions throughout the world (Myers and Worm 2003). Surveys using deep-diving submersibles have established the presence of deepwater precious coral beds at depths of 365–406 meters; these include ancient gold corals whose growth rate is now estimated to be only a few centimeters every hundred years, and whose ages may exceed 2,500 years (Roark et al. 2006). At depths below 500 meters, a diverse community of octocorals and sponges flourishes; these deepwater sessile animals prefer hard substrates devoid of sediments (Baco-Taylor et al. 2006). Deeper still, the abyssal depths of Papahānaumokuākea, while harboring limited biomass, are home to numerous scantily documented fishes and invertebrates, many with remarkable adaptations to this extreme environment.

Biota of pelagic habitats

Most of Papahānaumokuākea can be considered pelagic, or deep-water, habitat. The estimated area of all parts of Papahānaumokuākea with depths greater than 1,000 fathoms (1.8 kilometers) is 304,000 square kilometers (Miller et al. 2006). The deep waters are important insofar as they support an offshore mesopelagic boundary community (Benoit-Bird et al. 2002), a thick layer of pelagic organisms that rests in the deep ocean (400–700 meters) during the day, then migrates up to shallower depths (surface to 400 meters) at night, providing a critical source of nutrition for open-ocean fishes, seabirds and marine mammals. These organisms that inhabit the upper layers of the mesopelagic zone have been surveyed at French Frigate Shoals, Lisianski, Pearl and Hermes, Midway, and Kure using echosounding technology (Lammers et al. 2006). This work confirmed the presence of a community of vertical migrators, consisting of fish, squid, and shrimp. This

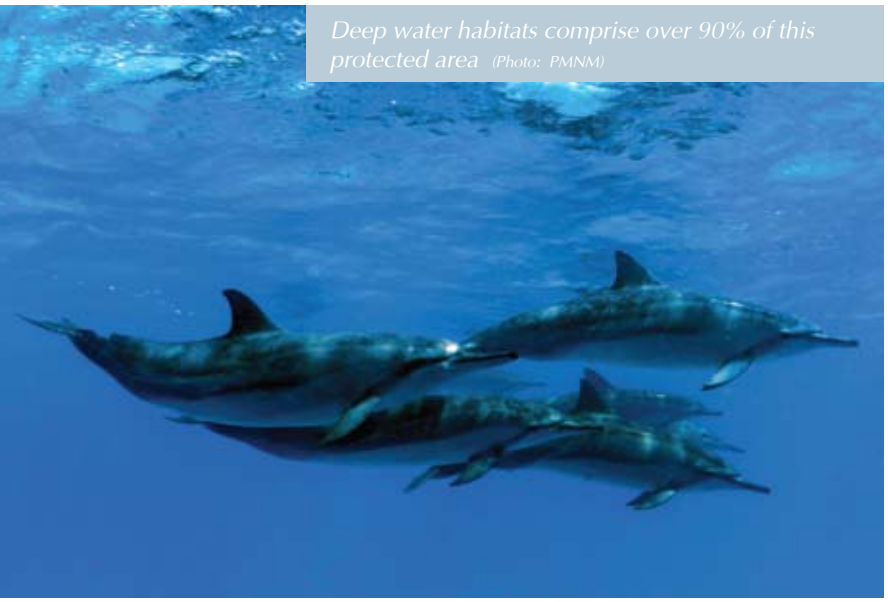
(Photo: PMNM)

temporal variability in the structure of the biotic community is important to understand as the spatial patterns are studied. Mesopelagic fishes, in particular, are important prey for bigeye tuna, which tend to live at greater depths than the other tuna species. Overall, the fauna of Papahānaumokuākea's waters below standard SCUBA diving depths remains minimally surveyed and documented, representing an enormous opportunity for future scientific research in a system largely undisturbed by trawling or other forms of resource extraction.



A manta ray or hāhālua glides through waters near Mokumanamana (Photo: James Watt)

The estimated millions of seabirds breeding in Papahānaumokuākea also depend on this pelagic habitat. They are primarily pelagic feeders that obtain the fish and squid they consume by associating with schools of large open-water predatory fish such as tuna and billfish (Fefer et al. 1984, Au and Pitman 1986). These fish—Yellowfin Tuna (*Thunnus albacares*), Skipjack Tuna (*Katsuwonus pelamis*), Mahimahi (*Coryphaena hippurus*), Wahoo (*Acanthocybium solandri*), Rainbow Runner (*Elagatis bipinnulatus*), Broadbilled Swordfish (*Xiphias gladius*), and Blue Marlin (*Makaira indica*)—are apex predators of a food web existing primarily in the epipelagic zone and found within the waters of Papahānaumokuākea. While both the predatory fish and the birds are capable of foraging throughout their pelagic ranges (which encompass the entire property and tropical Pacific Ocean), the birds are most successful at feeding their young when they can find schools of predatory fish within easy commuting range of the breeding colonies (Ashmole 1963; Feare 1976; Flint 1991). Recently fledged birds, inexperienced in this complex and demanding style of foraging, rely on abundant and local food resources to survive while they learn to locate and capture prey.



Deep water habitats comprise over 90% of this protected area (Photo: PMNM)

Marine mammals

The marine and littoral ecosystems of the property are designated critical habitat for the Hawaiian Monk Seal, the world's second most endangered pinniped. Only 1,200–1,400 individuals exist, and models predict that the population will fall below 1,000 individuals within the next five years. While a few Hawaiian Monk Seals co-exist with humans in the main Hawaiian Islands, the great majority of the population lives among the remote islands and atolls of Papahānaumokuākea Marine National Monument. Their range generally consists of the islands, banks and marine corridors within Papahānaumokuākea, although individual animals may be found beyond this extensive area, sometimes farther than 90 kilometers from shore.

Studies of the movements and diving patterns of 147 Hawaiian Monk Seals in Papahānaumokuākea (consisting of 41 adult males, 35 adult females, 29 juvenile males, 15

Hawaiian Monk Seals and Green Turtles cohabitating on the beaches of Papahānaumokuākea (Photo: George Balazs)

juvenile females, 12 weaned male pups, and 15 weaned female pups) using satellite-linked depth recorders have determined that Monk Seal foraging range covers an area of approximately 48,156 square kilometers, or almost 14% of the total area of Papahānaumokuākea. Seals forage extensively at or near their breeding sites and breeding subpopulations, and haulout sites; 95% forage within 12 km of these sites. Several banks located northwest of Kure Atoll represent the northern extent of the monk seal foraging range (Stewart 2004a). (Recent research conducted with submersibles and remotely operated vehicles by NOAA's Office of Ocean Exploration has identified these areas as important habitat for precious corals (NOAA 2003).) The main terrestrial habitat requirements include haulout areas for pupping, nursing, molting and resting. These are primarily sandy beaches, but virtually all substrates are used at various islands in Papahānaumokuākea.

The waters of Papahānaumokuākea are also home to more than 20 cetacean species, six of them federally and internationally recognized as endangered, although comparatively little is known about the distributions and ecologies of these whales and dolphins. Recent research by Johnston and others (2007) reveals that Papahānaumokuākea also may host many more humpback whales than originally thought.

More than 450 Green Turtle nesting sites have been documented in Papahānaumokuākea (Photo: James Watt)

Marine reptiles

In addition to the important habitat for marine mammals within Papahānaumokuākea, the islands and atolls are also crucial breeding, nesting, and basking habitat for the Hawaiian population of Green Turtles. More than 450 nesting sites have been observed in Papahānaumokuākea, incorporating over 90% of the total nesting area for Green Turtles. The five species of sea turtles that occur in the NWHI are the Loggerhead (*Caretta carretta*), the Green (*Chelonia mydas*), the Olive Ridley (*Lepidochelys olivacea*), the Leatherback (*Dermochelys coriacea*), and the Hawksbill (*Eretmochelys imbricata*) (Figure 2.7). Section 4 provides additional information on population trends for these species, especially the Green Turtle.

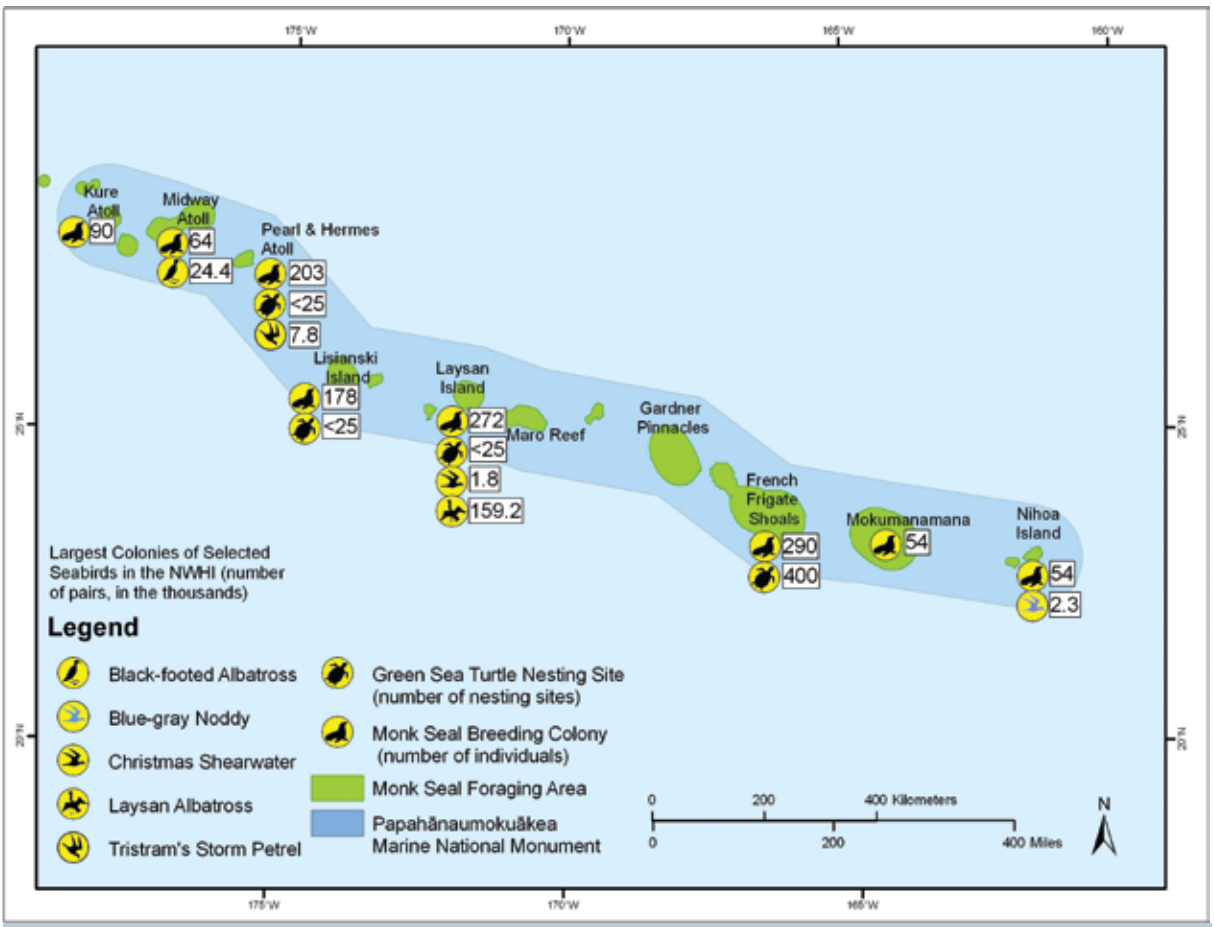
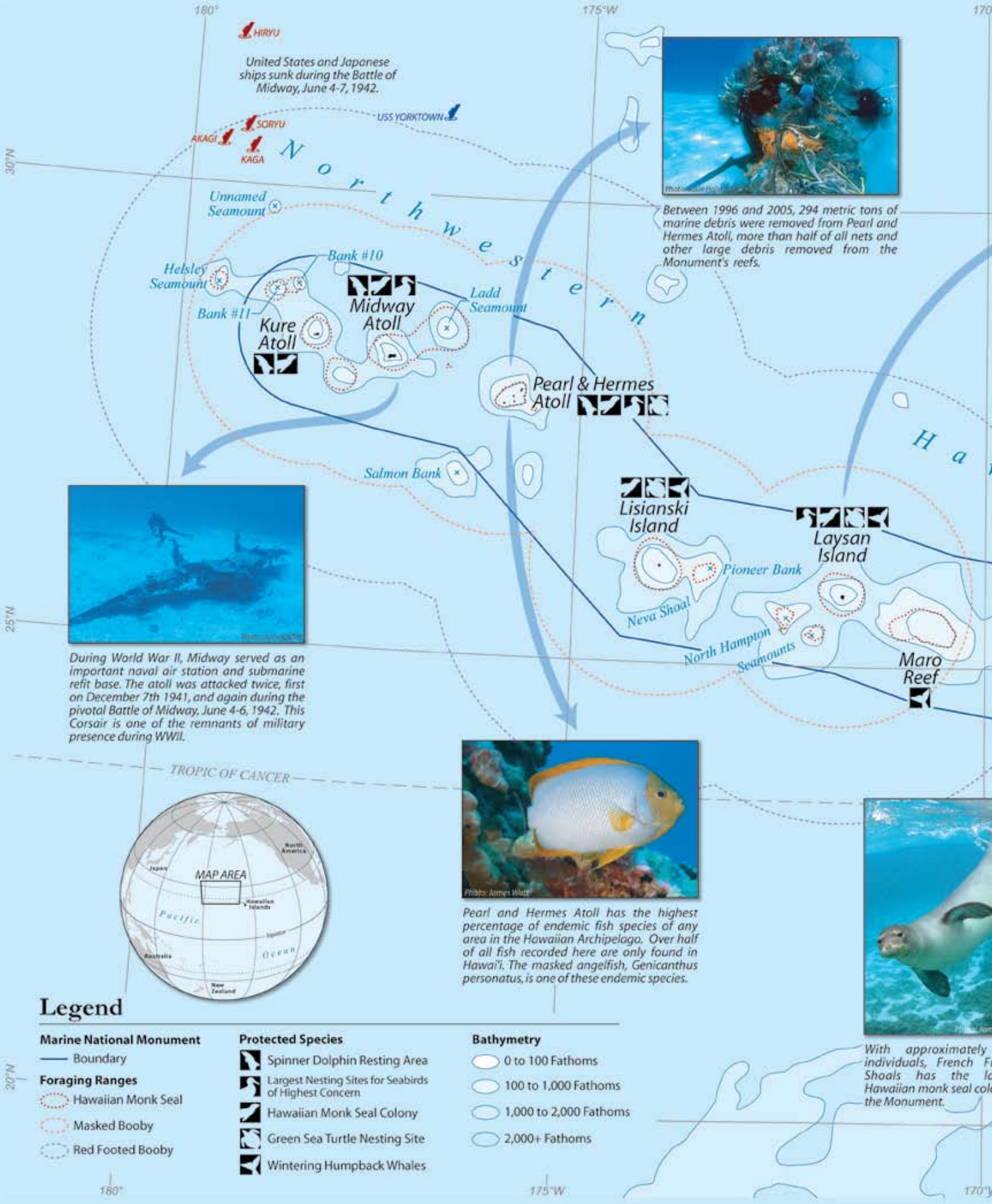


Figure 2.7: Population sizes and nesting sites of rare seabird species, Green Turtles and Hawaiian Monk Seals in the Pacific Island region (Sources: Stewart 2004a; Balazs and Ellis 2000; Kushlan et al. 2002; Fefer et al. 1984)

Seabirds

In addition to the purely terrestrial biota, more than 14 million seabirds rely on the tiny islets in the chain, 5.5 million of which nest annually. This includes 99% of the world's Laysan Albatrosses (listed as vulnerable by the International Union for Conservation of Nature (IUCN), 98% of the world's Black-footed Albatrosses (listed as endangered by the IUCN), and important populations of the Short-tailed Albatross (listed as endangered by the IUCN). The small islands and atolls of the property thus form a major portion of the current total tropical seabird nesting habitat of the United States as a whole. Eleven of the 21 species were classified as highly imperiled or of high conservation concern at the broad scale of the North American Waterbird Conservation Plan (eastern north Pacific, western north Atlantic, and Caribbean) (Table 2.1). At the regional scale (Pacific Islands), six species were included in these highest-concern categories: Laysan, Black-footed, and Short-tailed Albatrosses; Christmas Shearwater; Tristram's Storm-Petrel; and Blue-gray Noddy. The importance of Papahānaumokuākea to seabirds is further discussed in Section 3.

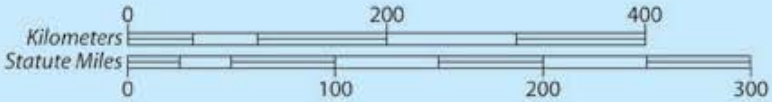
Papahānaumokuākea protects colonies of global significance for 14 million seabirds, representing 21 species (Photo: James Watt)


180°
175°W
170
30°N
25°N
20°N
HIRYU
United States and Japanese ships sunk during the Battle of Midway, June 4-7, 1942.
USS YORKTOWN
SORYU
AKAGI
KAGA
Northwestern
Unnamed Seamount
Helsley Seamount
Bank #10
Bank #11
Midway Atoll
Ladd Seamount
Kure Atoll
Pearl & Hermes Atoll
Salmon Bank
Lisianski Island
Laysan Island
Pioneer Bank
Neva Shoal
North Hampton Seamounts
Maro Reef
Ha
Between 1996 and 2005, 294 metric tons of marine debris were removed from Pearl and Hermes Atoll, more than half of all nets and other large debris removed from the Monument's reefs.
During World War II, Midway served as an important naval air station and submarine refit base. The atoll was attacked twice, first on December 7th 1941, and again during the pivotal Battle of Midway, June 4-6, 1942. This Corsair is one of the remnants of military presence during WWII.
TROPIC OF CANCER
MAP AREA
Japan
North America
Hawaiian Islands
Pacific
Ocean
Equator
Australia
New Zealand
Photo: James Watt
Pearl and Hermes Atoll has the highest percentage of endemic fish species of any area in the Hawaiian Archipelago. Over half of all fish recorded here are only found in Hawai'i. The masked angelfish, Genicanthus personatus, is one of these endemic species.
With approximately individuals, French F Shoals has the la Hawaiian monk seal colo the Monument.
Legend
Marine National Monument
Boundary
Foraging Ranges
Hawaiian Monk Seal
Masked Booby
Red Footed Booby
Protected Species
Spinner Dolphin Resting Area
Largest Nesting Sites for Seabirds of Highest Concern
Hawaiian Monk Seal Colony
Green Sea Turtle Nesting Site
Wintering Humpback Whales
Bathymetry
0 to 100 Fathoms
100 to 1,000 Fathoms
1,000 to 2,000 Fathoms
2,000+ Fathoms

PAPAHĀNAUMOKUĀKEA
MARINE NATIONAL MONUMENT

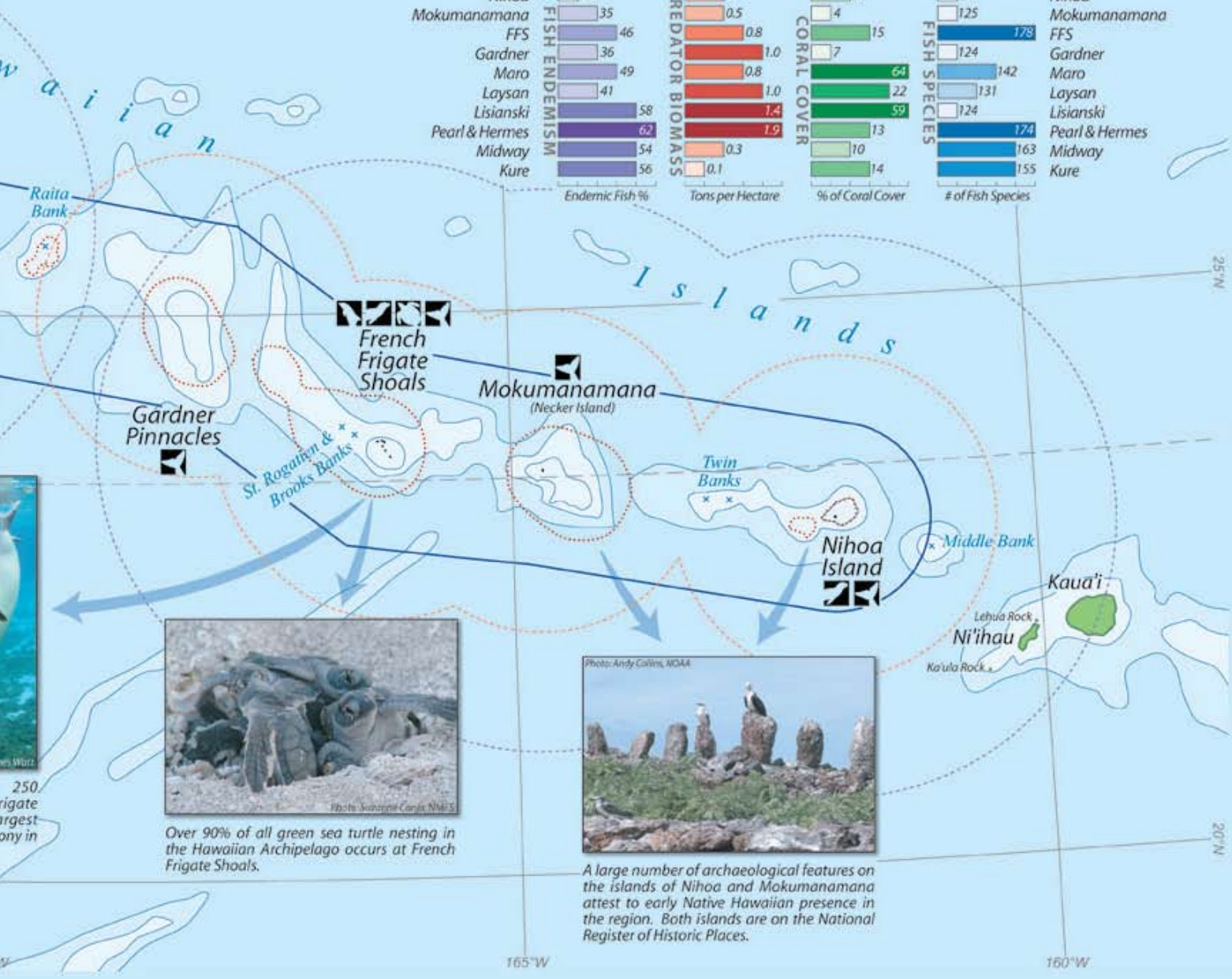
Produced by NOAA's National Marine Sanctuaries Program

Over 14 million seabirds nest in the Monument and many forage in the waters surrounding the breeding colonies. Laysan Island has the greatest diversity of bird species in the Monument.



Relative Biogeographic Comparison

Data Classified as Quantiles; Friedlander and Wedding, 2006



Over 90% of all green sea turtle nesting in the Hawaiian Archipelago occurs at French Frigate Shoals.

A large number of archaeological features on the islands of Nihoa and Mokumanamana attest to early Native Hawaiian presence in the region. Both islands are on the National Register of Historic Places.

Table 2.1: Seabird species known to breed in Papahānaumokuākea Marine National Monument (FWS data)1

Common Name	Species	Estimated Number of Breeding Birds
Black-footed Albatross	*Phoebastria nigripes*	111,800
Laysan Albatross	*Phoebastria immutabilis*	1,234,000
Bonin Petrel	*Pterodroma hypoleuca*	630,000
Bulwer's Petrel	*Bulweria bulwerii*	180,000
Wedge-tailed Shearwater	*Puffinus pacificus*	450,000
Christmas Shearwater	*Puffinus nativitatis*	5,400
Tristram's Storm-Petrel	*Oceanodroma tristrami*	11,000
Red-tailed Tropicbird	*Phaethon rubricauda*	18,400
White-tailed Tropicbird	*Phaethon lepturus*	8
Masked Booby	*Sula lepturus*	3,400
Red-footed Booby	*Sula sula*	15,800
Brown Booby	*Sula leucogaster*	800
Great Frigatebird	*Fregata minor*	19,800
Little Tern	*Sternula albifrons*	20
Gray-backed Tern	*Onychoprion lunatus*	86,000
Sooty Tern	*Onychoprion fuscatus*	3,000,000
Blue-gray Noddy	*Procelsterna cerulean*	7,000
Brown Noddy	*Anous stolidus*	150,000
Black Noddy	*Anous minutus*	26,000
White Tern	*Gygis alba*	22,000
Total		**5,971,428**

1 - Laysan and Black-footed Albatrosses, Christmas Shearwater, Tristram's Storm-Petrel, and Blue-gray Noddy are on the Birds of Conservation Concern list for the Hawaiian Bird Conservation Region; Black-footed Albatrosses are on the national list.

Shorebirds

Forty-seven species of shorebirds have been recorded in Papahānaumokuākea. Most of these are classified as infrequent visitors or transients, but Papahānaumokuākea does support regionally significant populations of four migrants: Pacific Golden-Plovers (*Pluvialis fulva*), Bristle-thighed Curlews (*Numenius tahitiensis*), Wandering Tattlers (*Tringa incana*), and Ruddy Turnstones (*Arenaria interpres*). Most of these birds arrive in July and August and return to the Arctic to breed in May, but some of the younger individuals may skip breeding their first summer and remain in Papahānaumokuākea. While there, these species use all the habitats available for foraging and sometimes concentrate in large numbers in the hypersaline lake at Laysan and in the artificial water catchment pond on Sand Island at Midway Atoll. The rat-free islands of Papahānaumokuākea provide important wintering sites for the rare Bristle-thighed Curlew, because they are flightless during molt and require predator-free sites. This species and Pacific Golden-Plovers are listed as species of high conservation concern in the National and Regional Shorebird Conservation Plans (Engilis and Naughton 2004) and are designated Birds of Conservation Concern by the FWS at the regional and national scale (FWS 2002).

Bristle-thighed Curlews or kioea are listed as species of high conservation concern (Photo: James Watt)

The worldwide population of Laysan Ducks (Anas laysanensis) lives within Papahānaumokuākea
(Photo: Jimmy Breeden)

Terrestrial Life in Papahānaumokuākea

Terrestrial biota

In contrast to the marine systems of Papahānaumokuākea, the terrestrial area of the property is comparatively small, but supports significant endemic biodiversity. This includes 145 species of endemic arthropods, six species of endangered endemic plants, including an endemic palm, and four species of endemic birds, including remarkably isolated species such as the Nihoa Finch, Nihoa Millerbird, Laysan Finch, and Laysan Duck, one of the world's rarest ducks. Three of these species (Nihoa Finch, Nihoa Millerbird, and Laysan Duck) are deemed critically endangered by IUCN, and the Laysan Finch is listed as vulnerable. In addition, millions of seabirds use the area for breeding and foraging, and numerous shorebird species overwinter on the islands or transit through during their migrations to the north and south. At least six species of terrestrial plants found only in the region are listed under the U.S. Endangered Species Act, some so rare that due to the difficulty of surveying these remote islands, they have not been documented for many years. IUCN lists *Cenchrus agrimonioides* var. *laysanensis* from Laysan as extinct, though biologists hold hope that it may still exist. *Amaranthus brownii*, endemic to Nihoa, is deemed critically endangered by IUCN, while *Pritchardia remota* is considered endangered. Although still poorly documented, the terrestrial invertebrate fauna shows significant patterns of precinctive speciation, with endemic species described from Nihoa, Mokumanamana, French Frigate Shoals, Laysan, Lisianski, Pearl and Hermes, and Kure.

Terrestrial invertebrates

The native terrestrial arthropods and land snail communities of Papahānaumokuākea are the least-well-studied of the animal groups (Table 2.2), but are perhaps the most seriously affected by human activities and introductions. In particular, the many species of ants that have accidentally reached all the islands of the archipelago except Gardner Pinnacles have had enormous effects on these native terrestrial invertebrates. The entomofauna of Papahānaumokuākea includes some groups of insects that demonstrate dramatic adaptive radiations. One such group is the seedbugs, specifically the genus *Nysius*, which shows the complete range of feeding types: from host-specific plant feeders, to diverse plant hosts, to omnivorous feeding, and finally to predator/scavengers. It is a rare occurrence to find herbivory and carnivory occurring within the same genus. Nowhere else in the world is there a lineage like the Hawaiian *Nysius* in which to explore the evolution of carnivory in Heteroptera. Some of these species are single-island endemics and of particular conservation concern because of their limited ranges.

Table 2.2: *Number of terrestrial arthropod species in Papahānaumokuākea summarized by order and island*
(Source: Nishida 1998; Nishida 2001)

Terrestrial Arthropod Species	Nihoa	Mokuma-namana	French Frigate Shoals	Gardner Pinnacles	Laysan Island	Lisianski Island	Pearl and Hermes	Mid-way Atoll	Kure Atoll
Anthropoda	**221**	**84**	**108**	**11**	**234**	**59**	**109**	**507**	**155**
Arachnida	42	10	10	4	34	6	16	85	35
Insecta	174	69	94	7	195	49	87	412	115
Chilopoda	2	2	1		1		1	1	2
Anostraca					1				
Isopoda	3	3	3		3	3	5	9	3
Amphipoda						1			

Terrestrial plants

The land plants of Papahānaumokuākea are typically salt-tolerant and drought-resistant species of the beach strand and coastal scrub. The number of native species found at each site is positively correlated with island size but negatively influenced by the number of alien species occurring at the site (Table 2.3). The three sites with airstrips and a longer history of year-round human habitation have much larger populations of alien species of land plants. At least three species of Papahānaumokuākea endemic plants (*Achyranthes atollensis*, *Phyllostegia variabilis*, and *Pritchardia* species, all of Laysan Island) are believed to have gone extinct since European contact. Other native species and genera have found refuge in areas of Papahānaumokuākea where rats were never introduced, and now occur at much greater densities than they do in the main Hawaiian Islands (e.g., *Pritchardia remota* and *Sesbania tomentosa*, commonly known as *ʻōhai*).

At least six species of terrestrial plants found only in the region are listed under the U.S. Endangered Species Act.

Table 2.3: *Biogeographic description of land plants of Papahānaumokuākea Marine National Monument (number of species that have been observed at each site in previous 20 years)*

Island	Emergent Land Area (ha)	Island endemic	Indigenous to Hawai'i and other Pacific Islands	Alien	Total no. of Species
Nihoa	69	3	14	3	20
Mokumanamana	19	0	5	0	5
French Frigate Shoals	38	0	10	27	37
Gardner Pinnacles	2	0	1	0	1
Laysan Island	414	1	22	11	34
Lisianski Island	148	0	15	5	20
Pearl and Hermes Atoll	39	0	15	10	25
Midway Atoll	592	0	14	249	263
Kure Atoll	89	0	12	36	48

New Species Discovery

As further described in Section 3, the rates of marine endemism in Papahānaumokuākea are unparalleled in the Pacific and most of the world. In addition, the sheer mass of apex predators in the marine system is simply not seen in areas subject to higher levels of human impact. Overall, the property represents one of the last unspoiled marine wilderness areas remaining on the planet, and virtually every scientific exploration to the area is a voyage of discovery. In the course of one three-week research cruise in the fall of 2006, conducted as part of the global Census of Marine Life project, more than 100 cryptic species new to science were discovered at French Frigate Shoals alone. Many more such voyages are necessary in order to gain a more comprehensive understanding of insular patterns of speciation and endemism within Papahānaumokuākea as a whole, but even the data in hand strongly support international recognition of this unique ecosystem.

The endangered ʻohau, or Sesbania tomentosa
(Photo: Barbara Maxfield)

Papahānaumokuākea exemplifies how nature and culture are one (Photo: James Watt)

Papahānaumokuākea's Associative Cultural Landscape

This section describes Papahānaumokuākea's Native Hawaiian cultural heritage, specifically the elements that make the property a significant associative cultural landscape.

The World of Gods and Spirits

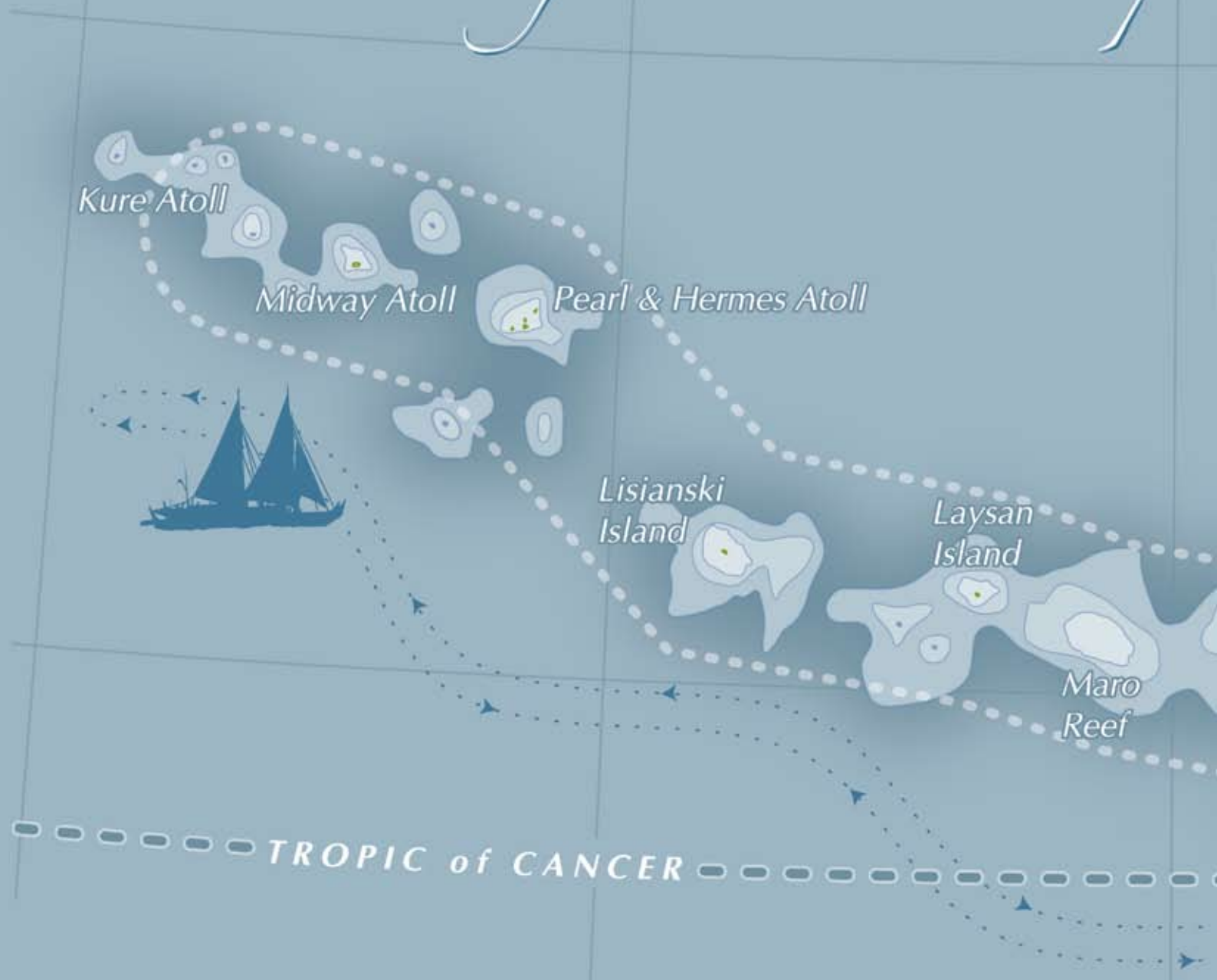
Papahānaumokuākea is a sacred area, which contains the boundary Pō, a place of darkness that is reserved for their many revered gods and ancestral spirits. The best-known genealogical and creation chant of Hawai'i, the Kumulipo, describes the Hawaiian universe as being comprised of two worlds: Pō and Ao, the realm of light where Native Hawaiians and the rest of Hawai'i's living creatures reside. Native Hawaiians believe that Mokumanamana, in southeastern Papahānaumokuākea, represents the boundary between these two worlds.

Hawaiians know the waters of the tropics as the safest for navigation, and they mark the sacredness of that multi-dimensional realm with celestial gods. The sun's path, which Hawaiians mark as the sequential points on the horizon at which it rises and sets throughout the year, is bordered by the points at which it travels furthest north (*Ke ala nui polohiwa a Kāne* – The long, black shining road of Kāne) and furthest south (*Ke ala nui polohiwa a Kanaloa* – The long, black shining road of Kanaloa). These two gods are considered major gods of Tahiti, Tuamotu, O'ahu and Kaua'i (Lilikalā Kame'eleihiwa 22 November 2008, personal communication). The boundary of Kāne crosses Mokumanamana ("island of great spiritual power").

The name *Ke ala nui polohiwa a Kāne* refers to death, or the westward road of the ancestral spirits. Native Hawaiians believe that when a person's physical body dies, their spirit travels to *leina*, or portals found on each island. If the individual had lived a *pono* (righteous) life, they would be transported from the *leina* westward to Pō (Beckwith 1970). This spirit realm is represented by the islands and surrounding waters to the northwest of the island of Mokumanamana.

Most of Mokumanamana's *heiau* (shrines) follow the crest of the island, tracking the sun, and it is believed that the solar solstice hits the carefully placed upright stones of these *heiau* at a significant angle (Pualani Kanahele 2 July 2008, personal communication). This line of massive stones may be a physical manifestation of the celestial and spiritual significance of this island as a representation of a crossing between Pō and Ao. "The stone heiau are clues left behind by our ancestors, and are so precious because we don't know everything the ancestors knew, with their superior understanding of direction and the stars" (Lilikalā Kame'eleihiwa 21 November, 2008, personal communication).

Cultural Heritage Sites Within Papa



Partly because Mokumanamana is crossed by the Tropic of Cancer, it is considered the sacred boundary between Pō and Ao.

Tropic of Cancer - Ke ala nui polohiwa a Kane - The long black shining road of Kane.

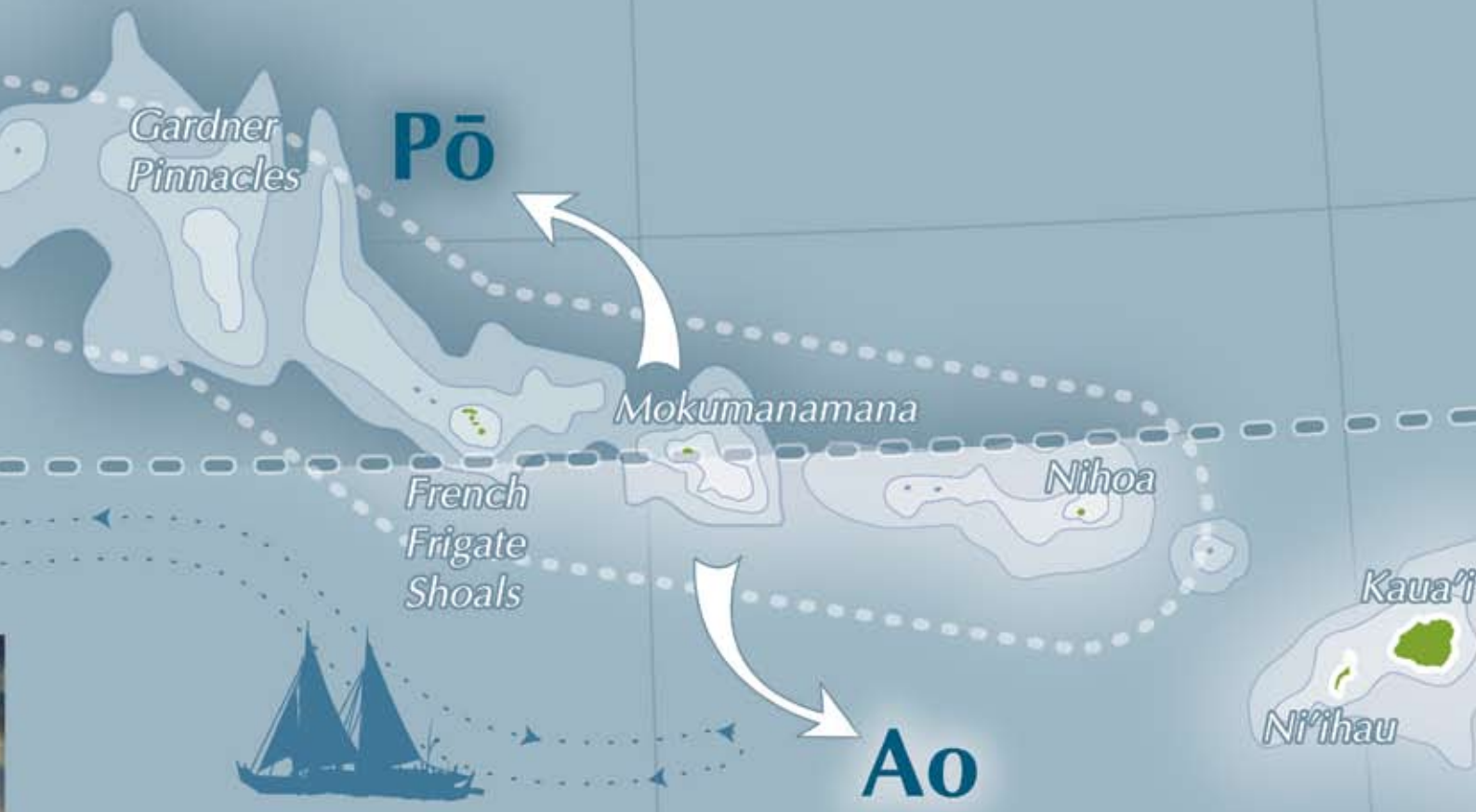
Papahānaumokuākea Marine National Monument Boundary

Voyagers from mythical, ancient, and modern times have traversed Papahānaumokuākea's seascape, as recounted in myriad oral traditions

hānaumokuākea

Upright stones are oriented to sun's angle on the summer solstice. Spanning the length of Mokumanamana's kua (spine, crest), the upright stones are part of the highest concentration of ceremonial sites in the archipelago.

Pre-contact native Hawaiian archaeological sites at Nihoa.



Mokumanamana, with its many *heiau*, is believed to play a critical role in Native Hawaiian rituals because of its position on the Tropic of Cancer. Native Hawaiians believe that a person's shadow is the physical manifestation of their spirit, and therefore, that a person has the most *mana* (spiritual power) when they have no shadow, such as at midday, because the spirit is considered to be united with the body. This is the time when rituals and prayers are conducted, as priests are at the peak of their spiritual powers. Nowhere else in Hawai'i does the sun hang overhead longer than on the summer solstice at Mokumanamana. It is believed that Mokumanamana is an important and powerful place to hold ceremonies, because on the summer solstice, a priest's shadow remains united with his or her body—and the priest's power remains concentrated—for the longest period at any time of the year, anywhere in the archipelago.

As the boundary between Pō and Ao, Mokumanamana today serves as a critical place for ongoing Native Hawaiian cultural research into celestial movements, particularly during major solar events. In 2007, renowned Native Hawaiian cultural practitioner and researcher Pualani Kanahele and a group of cultural practitioners called Ha'ae Wale Ka Hānauna Lolo visited Mokumanamana to study the relationship between the island's heiau and the path of the sun during the summer solstice.

Another famous Hawaiian *mo'olelo* (story, historical narrative) tells the story of how a family of important gods and goddesses followed the sun's path in an easterly direction, down the island chain. Pele, the fire or volcano goddess, accompanied by her sister Hi'iaka, sailed from Kahiki (Tahiti) to the Northwestern Hawaiian Islands, continuing on to Lehua and the main Hawaiian Islands, all the way down the archipelago until she found her current home in the active volcano of Kīlauea, on Hawai'i Island.

The migration *mo'olelo* of Pele and Hi'iaka, two sisters from Tahiti, tells of them first landing in the NWHI on an island named Mokupāpapa,"some point northwest of Hawai'i, along that line of islets, reefs, and shoals which tail off from Hawai'i as does the train of a comet from its nucleus" (Emerson trans. 1915). Pele left her brother Kānemiloha'i on Mokupāpapa, with instructions to build it up for habitation because it was not much more than a reef. Pele and Hi'iaka sailed southeast from Mokupāpapa, landing at Nihoa, where they briefly left another brother.

These gods are considered to be part of a volcano clan that traveled overseas and underground, creating the volcanic hotspots of Hawai'i and following the sun's path, to the east (Pualani Kanahele 2 July 2008, personal communication).

Hawaiian Voyaging and Wayfinding (Non-instrument Navigation)

Today, Papahānaumokuākea's cultural landscape, dominated by the ocean, plays a critical role in two major living traditions of Native Hawaiians: Hawaiian voyaging and wayfinding. The voyaging route between Kaua'i (in the main Hawaiian Islands) and Nihoa and Mokumanamana is used today as the best training ground for apprentices of Hawaiian wayfinding, non-instrument navigation, before undertaking a long, open-ocean voyage beyond the archipelago.

At Papahānaumokuākea, an array of attributes unique in the archipelago makes

Ka huaka'i a Pele

…'O Nihoa ka 'āina a mōkou i pae mua aku ai
Lele a'e nei mākou, kau i uka o Nihoa
'O ka hana nō a ko'u pōki'i, a Kāneapua,
'O ka ho'oili i ka ihu o ka wa'a a nou i ke kai
Waiho anei 'o Kamohoali'i iā Kāneapua i uka o Nihoa
No'iau ka hoe a Kamohoali'i
A pae i ka 'āina i kapa 'ia 'o Lehua….

Migration of Pele

…Nihoa is the island on which we first landed
We climbed upward until the top of Nihoa
The fault of my younger brother, Kāneapua,
Weighing the prow of the canoe until it beat into the waves
Kamohoali'i left Kāneapua on land at Nihoa
Skillful was the steering of Kamohoali'i
Until we landed on the island named Lehua….

the area "the ideal training platform" for novice Hawaiian wayfinders (Nainoa Thompson 4 October 2008, personal communication). Apprentice navigators are challenged to sail to Nihoa from Lehua, a small, crescent-shaped island near Kaua'i and Ni'ihau. Oral histories document that this navigational test was used in generations past; it is an ideal route for a novice navigator to prove new skills in reading the celestial and ocean environment (Maly 2003). The navigator must find an island that cannot be seen on the horizon, but is still within a relatively short sail from the safety and provisions of a larger island. Oral tradition tells that in fair weather, canoes would sail first from Kaua'i to Lehua, which is known as a navigational "pointer" to Nihoa.

On Nihoa, there is no artificial lighting to aid the apprentice navigator, and the island's small physical size (0.68 square kilometers) and low-lying nature (the highest point measures 275 meters) require astute observations of the sun, stars, swells, seabirds and the Hawaiian wayfinder's other signposts of navigation. Today, novice Hawaiian wayfinders are considered qualified to attempt to navigate a canoe on long-distance, trans-Pacific sails after they have successfully guided a voyage from Kaua'i to Nihoa. Once the voyages to Nihoa, and then Mokumanamana, have been made, the islands themselves contain archaeological sites that continue to be used to educate apprentice navigators and allow for direct communication with the elements and the gods who are personified in those elements (Pualani Kanahele 2 July 2008, personal communication).

Even apart from apprentice sails, Papahānaumokuākea is a major destination for traditional voyaging. Traditional double-hulled Hawaiian voyaging canoes have traveled throughout Papahānaumokuākea in recent years. In 2004, *Hōkūle'a* sailed from the main Hawaiian Islands to

Language and Writing

Until relatively recently, Native Hawaiian culture relied exclusively on oral traditions (*oli* (chant); *mele* (song); *mo'olelo* (story); *mo'okū'auhau* (genealogy); and *hula* (dance)) to transmit knowledge. When reading and writing were introduced to Hawai'i after Western contact, Native Hawaiians took to them quickly, and by the 1860s—less than a century later—the Native Hawaiian community was almost universally literate (Silva 2004). As a result, many oral traditions were documented and preserved in books, journals and newspapers; however, many more were either lost or continued to be transmitted only orally, to trusted recipients, in accordance with Hawaiian custom. This application relies on oral sources—first-hand accounts of widely respected Hawaiian cultural practitioners, who are considered reputable sources of information in the Hawaiian culture—as well as on academic and historic references.

Throughout this document Hawaiian words are written with appropriate diacritical marks and defined in English. As with other languages that employ diacritical marks, such as French and Spanish, the Hawaiian language uses them as part of the alphabet and the language. Words can have very different meanings when diacriticals are missing or misplaced. (For example, *kau* means "your," while *ka'u* means "mine;" *onaona* means "fragrant, sweet-smelling scent," while *'ona'ona* means "drunk.") The *kahakō* (macron) represents an emphasized or stressed vowel sound in a Hawaiian word, as exemplified by the word, *kūpuna* (revered elders, ancestors), as differentiated from *kupuna* (a singular elder or ancestor). The *'okina* (glottal stop), which indicates a consonant sound produced by closing and suddenly opening the glottis, occurs in many Pacific languages, and can be reproduced in English by saying any word that begins with a vowel, such as "open" or "above." It is represented by the symbol ', as in the word Hawai'i.

Hawaiian Wayfinding (non-instrument navigation)

The ancient and modern training grounds for Hawaiian wayfinding (non-instrument navigation)
(Photo: Polynesian Voyaging Society)

Kure Atoll, the farthest edge of the former Hawaiian Kingdom, and back. Moreover, the *ʻOhana Waʻa* (family of canoes) serve as the traditional vehicles that deliver cultural practitioners to Nihoa and Mokumanamana for religious ceremonies. In two separate voyages in 2003 and 2005, *Hōkūleʻa* and *Hōkūalakaʻi* brought the cultural group Nā Kupuʻeu Paemoku to Nihoa and Mokumanamana for ceremonial purposes.

Oral traditions reveal this seascape's place in Hawaiʻi's legendary voyaging traditions. *Kūpuna* (elders) from Niʻihau and Kauaʻi Islands (which are closest to Papahānaumokuākea and the people of which have traditionally had the most access to and relationship with the islands to the northwest) have shared knowledge passed down through generations about a voyaging "route" to Tahiti (Maly 2003). Although trans-Pacific voyaging is thought to have ceased in the 15th century (Kirch and Kahn 2007), some Niʻihau traditions state that Nihoa and/or Mokumanamana served as an embarkation and debarkation point for these voyages (Maly 2003). Traditions from Hawaiʻi Island support this,

Hawaiian wayfinding evolved from the system of non-instrument navigation used by Polynesians to routinely make long voyages across thousands of miles of open-ocean. Between 3,000 and 4,000 years ago—millennia before open-ocean sailing was undertaken elsewhere in the world—ancestors of the Native Hawaiians developed the world's first blue-water sailing technology, engineering sophisticated ocean-going vessels capable of ranging thousands of miles over open-ocean, and creating a reliable navigational system based on observations of the natural world. Navigators voyaged based on a lifetime of studying the motion, rising and setting of specific stars; the weather and times of travel; wildlife species (which congregate at particular positions); the directions of swells on the ocean; the colors of the sea and sky (clouds cluster and reflect at the locations of some islands); and the angles for approaching harbors. From the first peopling of the Hawaiian Archipelago through the 15th century, wayfinding enabled regular contact and trade between Hawaiʻi and Oceania.

All but lost for several generations, Hawaiian wayfinding has undergone a revival in recent decades, led by Nainoa Thompson, the first Hawaiian master wayfinder to navigate across the Pacific in several centuries. Thompson has developed a system of wayfinding, or non-instrument navigation, that synthesizes traditional principles of ancient Pacific navigation and modern scientific knowledge. Hawaiian wayfinding has contributed to a revival of traditional voyaging arts across Polynesia; it is now being taught in schools throughout Hawaiʻi and the Pacific. This science, art, and skill uses a plethora of environmental cues to navigate without instruments:

Master navigator Nainoa Thompson (left) instructing in the art and science of wayfinding.
(Photo: Polynesian Voyaging Society)

The following section contains brief descriptions of the individual islands within Papahānaumokuākea Marine National Monument, and their salient physical, biological, cultural and archaeological characteristics. The most commonly used name for each island is given first, with alternative names provided parenthetically. It should be noted that for the islands beyond Mokumanamana (Necker), the Hawaiian names provided are not yet in use on many modern maps. The Hawaiian placenames for Papahānaumokuākea's islands and atolls derive from diverse historic sources (for instance, from ancient chants, historic newspapers, and others). Table 2.6 summarizes the emergent and shallow reef areas on each island; further information is provided in the island-by-island descriptions.

Table 2.6: *Island-by-island comparisons of land and reef areas (hectares)*

Nihoa

23º03'N, 161º56'W

"*He pu'u kolo i Nihoa.*" ("Crawling up the cliffs of Nihoa.") This traditional Hawaiian saying is a compliment to one who perseveres in a challenging situation (Pukui 1997). Nihoa has many craggy cliffs, and the rough surf in winter makes landing there even more difficult than during the trade wind swells of summer. Hawaiian names often have multiple connotations; "Nihoa" means jagged" or "toothed," and probably refers to the island's profile, which resembles a tooth.

Nihoa is located approximately 250 kilometers northwest of Ni'ihau, the closest of the main Hawaiian Islands. Measuring roughly 0.69 square kilometers, this island is the largest emergent volcanic island within Papahānaumokuākea and the tallest, reaching an elevation of 275 meters at Miller Peak. It is also Papahānaumokuākea's geologically youngest island, with an age calculated at 7.3 million years (Clague 1996), only a little older than Ni'ihau.

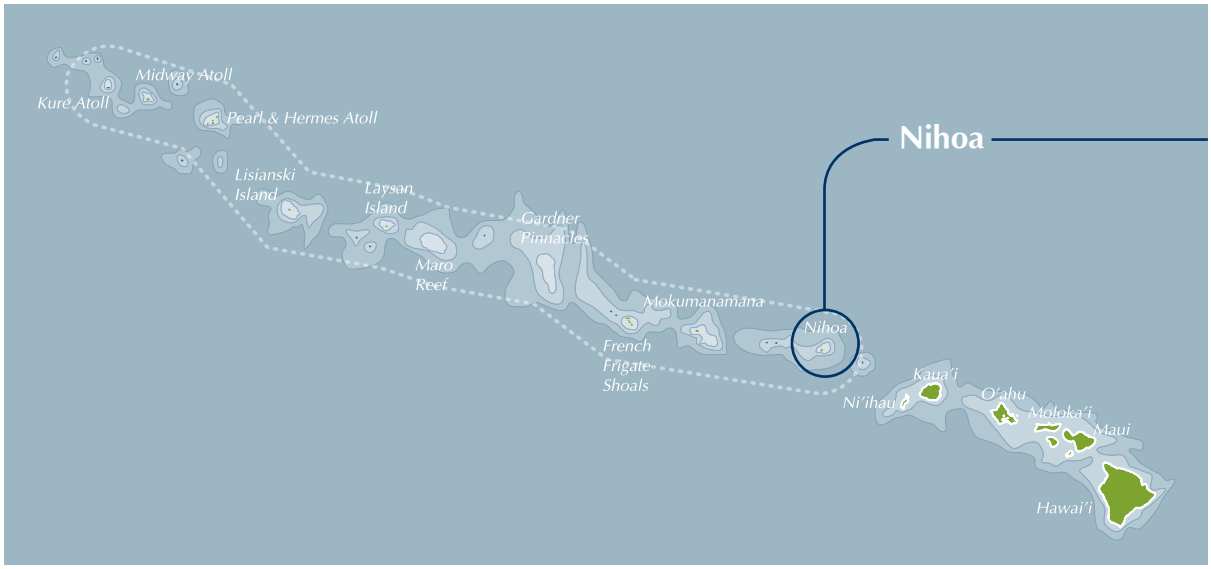
Nihoa is a deeply eroded remnant of a once-large volcano, and the large basaltic shelf of which it is a part stretches 28.9 kilometers in a northeast-southwest direction and averages between 34 and 66 meters deep (NOAA 2003). The island's two prominent peaks and steep, fortress-like sea cliffs are clearly visible from a distance. Its northern face is a sheer cliff made up of successive layers of basaltic lava, within which numerous volcanic dikes are visible. From its high northern cliffs, the island declines southward, with an average slope of 23º (Johnson 2004).

(Photos: David Boynton)

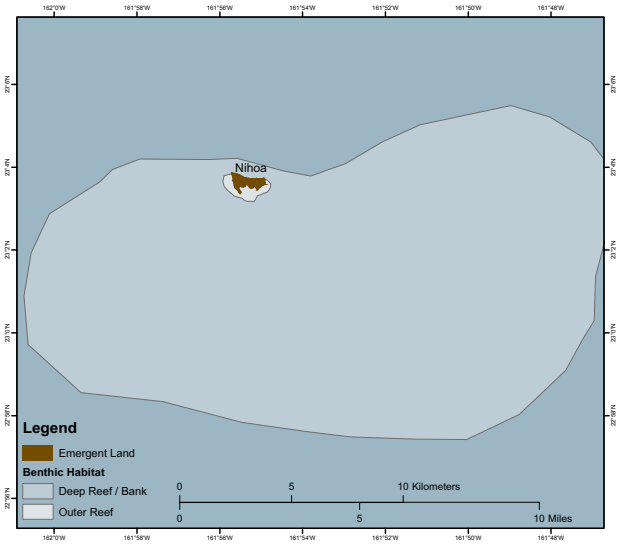
On Nihoa's stark landscape, the endemic Nihoa Finch resides among ancient heiau (temple) and 13th c. residential sites

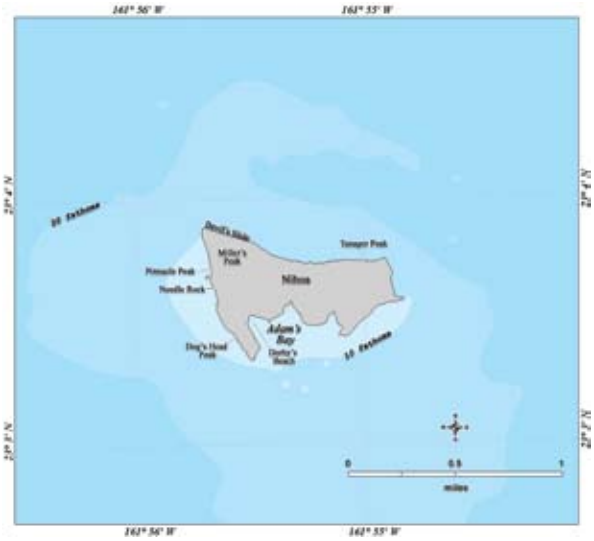
(Photo: James Watt)

The island's surrounding submerged reef habitat totals approximately 575 square kilometers and is a combination of uncolonized hard bottom, macroalgae, pavement with sand channels and live coral, and uncolonized volcanic rock (NOAA 2003), supporting at least 127 species of reef fish and 17 species of corals.

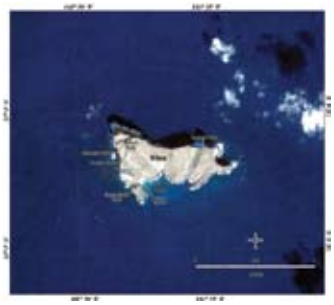


Nihoa: benthic habitat, bathymetry and satellite imagery





(Photo: James Watt)



Another historical name for Nihoa is Moku Manu, or "Bird Island." Nihoa's seabird colony boasts one of the largest populations of Tristram's Storm-Petrel, Bulwer's Petrel, and Blue-gray Noddies in the Hawaiian Islands. The avifauna of the island includes two endemic passerine birds: the Nihoa Finch (*Telespiza ultima*) and the Nihoa Millerbird (*Acrocephalus familiarus kingii*), both listed as endangered under the federal ESA.

The island is a unique example of a lowland native coastal community, resembling lowland communities that once occurred commonly on the main Hawaiian Islands but are now almost completely eliminated due to the pressures of human population (Wagner et al. 1990). The island's vegetation can be classified as part coastal mixed community (*Sida* mixed shrub and grassland) and coastal dry shrubland dominated by *'ilima* (*Sida fallax*), *'āweoweo* (*Chenopodium oahuense*), and *'ōhai* (*Sesbania tomentosa*). The island supports 21 native plant species, including three endemics: a palm or *loulu* (*Pritchardia remota*), an amaranth (*Amaranthus brownii*), and an herb (*Schiedea verticillata*) (Wagner et al. 1999). The arthropod fauna of the island includes 33 species of mites, three species of spiders, and 182 species of insects, 17 of which are endemic, including a katydid (*Banza nihoa*), a giant tree cricket (*Thaumatogryllus conantae*), two species of seed bugs (*Nysius nihoae* and *Nysius suffusus*), and a trapdoor spider (*Nihoa mahina*) (Evenhuis and Eldredge 2004).

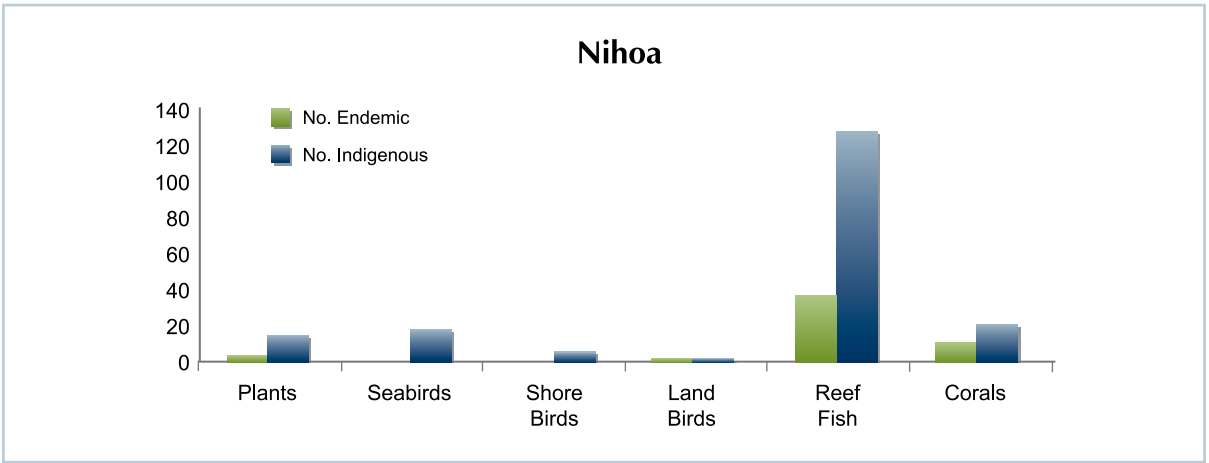


Figure 2.8: *Number of endemic and indigenous species at Nihoa*

As was noted previously, Nihoa exhibits clear evidence of habitation in prehistoric times. Sites thought to date between the 13th and15th centuries include 25 to 35 house terraces, 15 ceremonial structures, burial caves, bluff shelters, and agricultural terraces. Numerous artifacts found on Nihoa establish a close relationship with Native Hawaiian culture in the main Hawaiian Islands, and to the first settlers of Hawai'i who sailed through the Pacific on large voyaging canoes. Nihoa also has a rich cultural heritage, with at least 89 known *wahi kūpuna* (ancestral sites) constructed by the pre-contact Hawaiians who inhabited the island for approximately 700 years (until 1700 AD); the island is listed on the National Register of Historic Places. This island also has significant soil development for agriculture along with constructed terraces, which suggests investment in agricultural food production. As many as 100 people are estimated to have lived on Nihoa at one time, but the relative shortage of fresh water was likely a limiting factor (Cleghorn 1988). Because fresh water and food could be found there, Nihoa may have been a good place for voyagers to stop and resupply their canoes.

Abundant marine life beneath the waters of Nihoa
(Photo: James Watt)

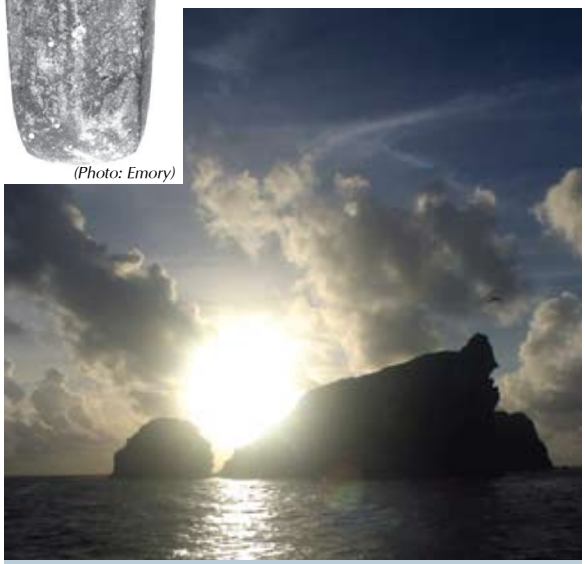
Mokumanamana
(Necker Island)
23°35′N, 164°42′W

Mokumanamana is often translated as a branching or pinnacled island, which is an apt description, but many people who have studied its high density of religious and cultural sites suggest that the repetition of the word "*mana*" (spiritual power) after the word "*moku*" (island) is likely to be even more significant, and related to the 33 shrines on the island that follow the *kua* (spine) of the island, and that the Hawaiian axes of life and death cross directly over Mokumanamana. On Mokumanamana, a total of 52 archaeological sites have been documented, including the 33 ceremonial features, the highest density of religious sites found anywhere in the Hawaiian archipelago.

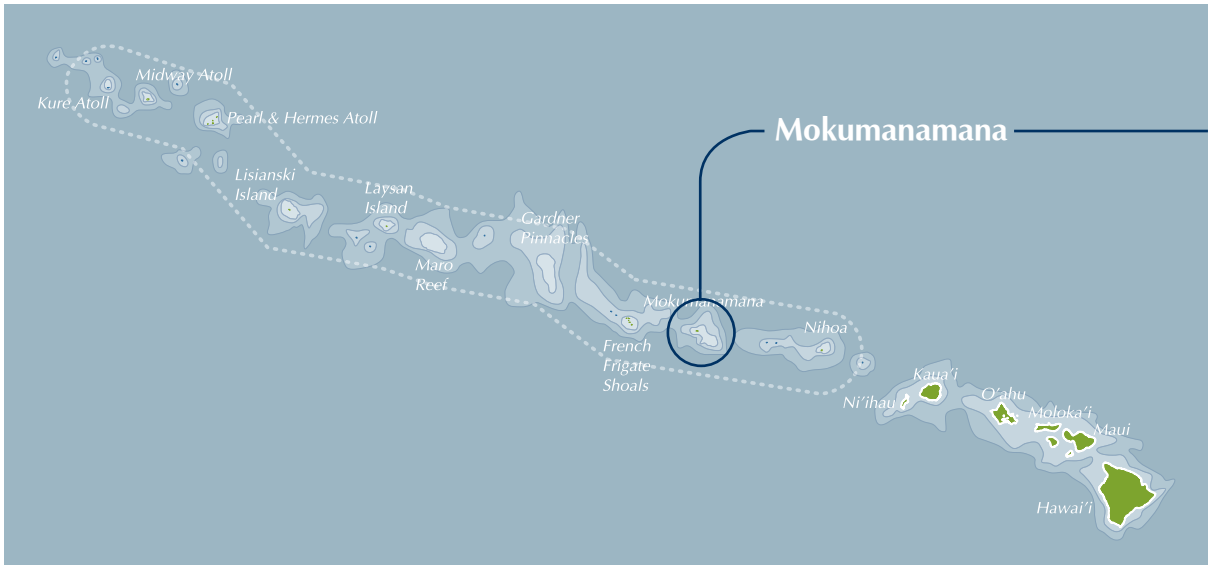
Mokumanamana is a dry volcanic island shaped like a fishhook, and includes approximately 0.19 square kilometers of land. Geologists believe the island, with an estimated age of 10.6 million years, was once the size of O'ahu in the main Hawaiian Islands, and attained a maximum elevation of 1,036 meters (Clague 1996); millennia of erosion have left its highest point, at Summit Hill, now only 84 meters above sea level. Wave action has eroded the remainder of the original island into a submerged shelf approximately 64 kilometers long and 24 kilometers wide.

(Photo: Emory)

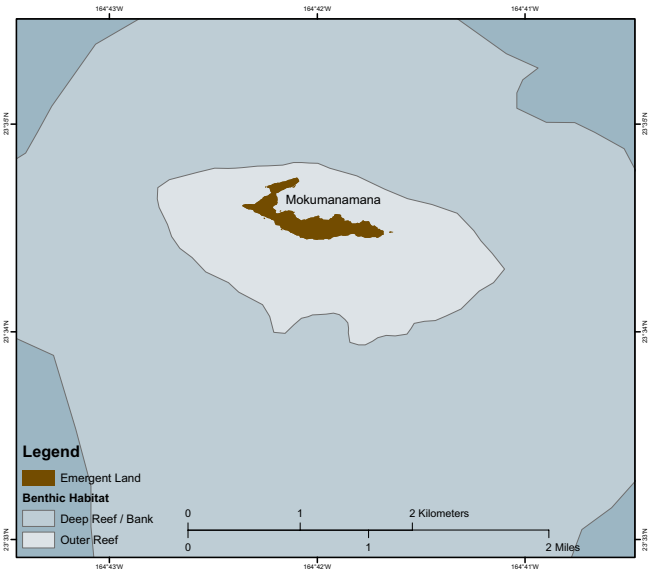
(Photo: US FWS)

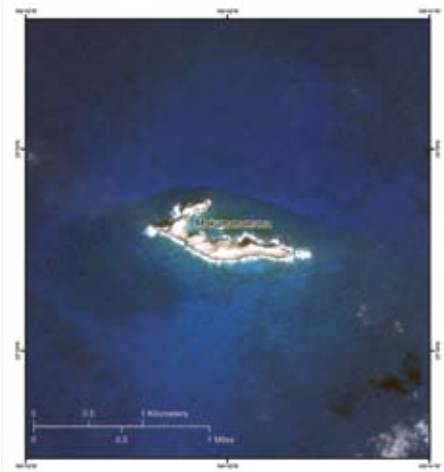

Mokumanamana sits on the axes of the Hawaiian universe and boasts the highest concentration of ceremonial sites in the archipelago (Photo: James Watt)

While this shelf supports more than 1,538 square kilometers of coral reef habitat (which, in turn, support 125 reef fish species and 18 coral species), severe wave action and currents in the exposed areas tend to inhibit coral growth. The bank provides excellent habitat for spiny lobsters (*Panulirus marginatus*) and slipper lobsters



Mokumanamana: benthic habitat, bathymetry and satellite imagery





(*Scyllarides squammosus*), especially in areas of variable intermediate relief (Parrish and Polovina 1994).

Because of its limited size, Mokumanamana supports only five indigenous plant species and no land birds, but does harbor three species of mites, two species of spiders, and 70 species of insects, of which 11 are endemic. These include a large weevil (*Rhycogonus biformis*), two species of seed bugs (*Nysius neckerensis* and *Nysius chenopodii*), and a trapdoor spider (*Nihoa hawaiiensis*) (Evenhuis and Eldredge 2004). Sixteen species of seabirds breed here, including the Black Noddy (*Anous minutus*), which historically was called the Necker Island Tern.

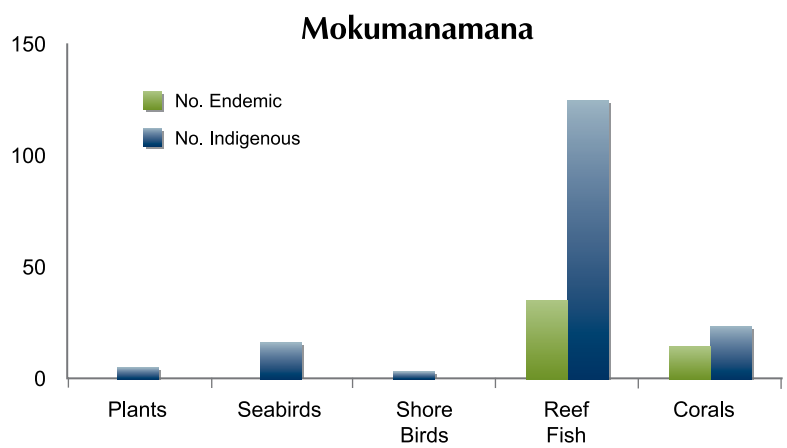


Figure 2.9: *Number of endemic and indigenous species at Mokumanamana*

Mokumanamana also occupies a special place in the Native Hawaiian world-view. It bears 33 *heiau* (ceremonial sites) with standing stones that stretch the length of the island's central spine, suggesting that it was visited by Native Hawaiians for spiritual and navigational purposes. It is believed that Mokumanamana played a central role in Hawaiian ceremonial rites and practices a thousand years ago because it is directly in line (23° 34.5′ N latitude) with the rising and setting of the equinoctial sun along the Tropic of Cancer. Mokumanamana, like Nihoa, shows clear evidence of prehistoric Hawaiian visitation. With its numerous religious sites and no evidence of long-term settlement, the island appears to have been used primarily for worship by visitors from other Hawaiian Islands. Mokumanamana's ceremonial sites, which contain upright stone features, share similarities with sites found on Mauna Loa and Mauna Kea, on Hawai'i Island, and on Haleakalā, on Maui. These ceremonial sites also closely resemble Tahitian temples, possibly establishing a link between this site and early Polynesian culture, as Emory first noted (1928). Moreover, Emory pointed out that the carved basalt human figurines found here exhibit similarities to those found in the Marquesas. Emory considered the sites of Mokumanamana to be a "pure sample of the culture prevailing in Hawai'i before the thirteenth century." Despite its dense concentration of religious sites, Mokumanamana is considered too small and dry to have supported human inhabitants for any length of time. Mokumanamana also is listed on the National Register of Historic Places as an Island Archaeological District.

Mokumanamana's wide banks support large pelagic fauna (Photos: James Watt)

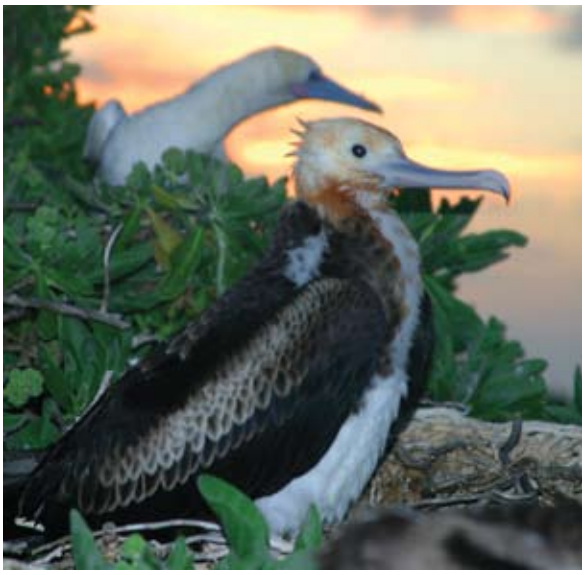
French Frigate Shoals
(Kānemilohaʻa and Mokupāpapa)

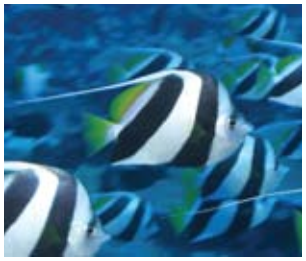
23º145'N, 166º10'W

The first atoll to the northwest of the main Hawaiian Islands, Kānemilohaʻi is also the midpoint of the archipelago and the largest coral reef area in Hawaiʻi. On this low, flat area, the volcano goddess Pele is said to have left one of her brothers, Kānemilohaʻi, as a guardian during her first journey to Hawaiʻi from Kahiki (Tahiti). Pele continued down the archipelago until finally settling in Kīlauea, Hawaiʻi Island, where she is said to reside today (Beckwith 1970).

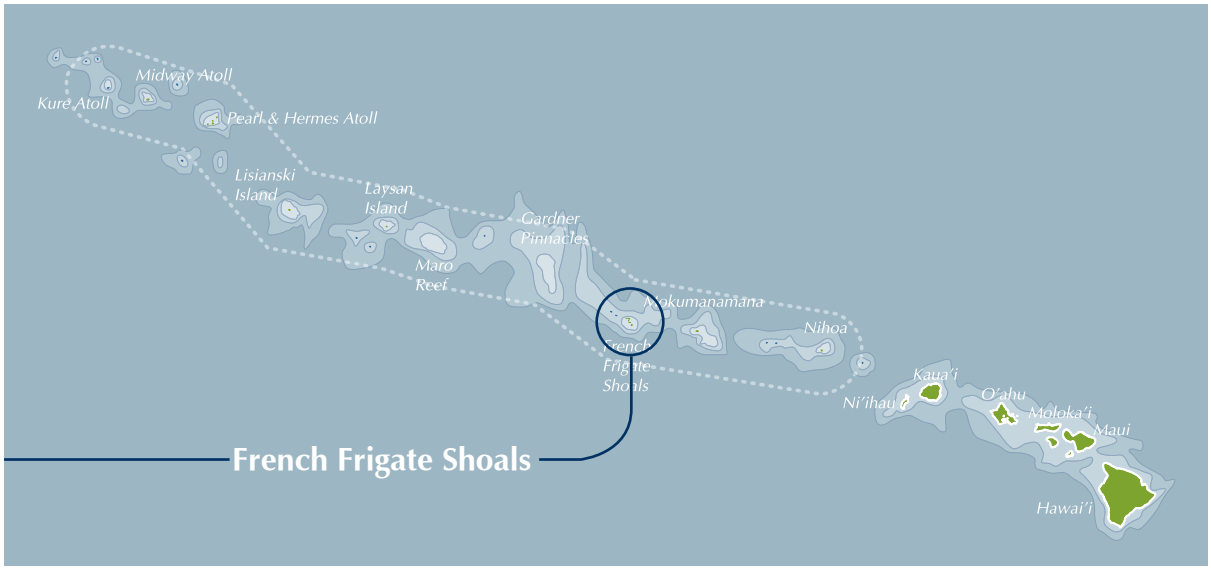
Neither French Frigate Shoals, nor any of the other islands further to the northwest, bear Native Hawaiian archaeological sites, although there is plentiful evidence in oral traditions and historical documents (see Section 2.a) that Native Hawaiians not only knew of the islands and atolls beyond Mokumanamana, but created *moʻolelo* (stories, oral histories) that wove them into their foundational creation stories.

French Frigate Shoals is the largest atoll in the chain, taking the form of an 18-mile-long (28.9 kilometers) crescent. It is estimated to be 12.3 million years old (Clague 1996). The shoals consist of 0.38 square kilometers of total emergent land, surrounded by approximately 931 square kilometers of coral reef habitat, with a combination of sand, rubble, uncolonized hard bottom, and crustose coralline algae in the windward and exposed lagoon areas, and patch and linear coral reefs in more sheltered areas (NOAA 2003b). Tern Island in the atoll is the site of a FWS field station, which occupies a former U.S. Coast Guard Long-Range Aids to Navigation (LORAN) station that closed in 1979.

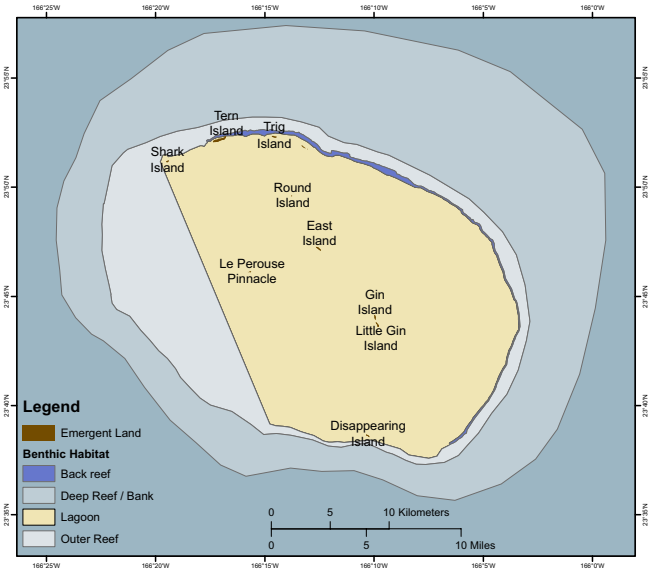


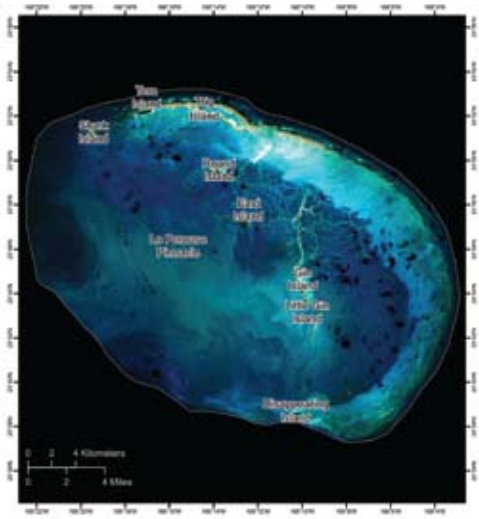


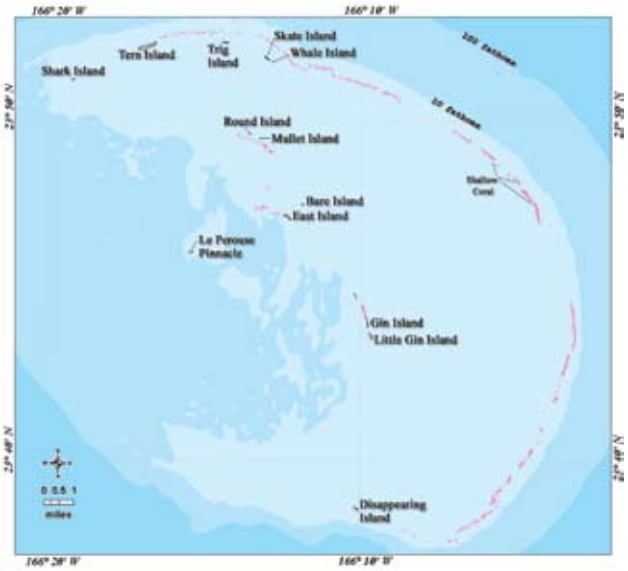
Pennant Banner Fish, Leopard Blenny, and Great Frigatebird of French Frigate Shoals (Photos: James Watt)



French Frigate Shoals: benthic habitat, bathymetry and satellite imagery







Within Papahānaumokuākea, French Frigate Shoals is the center of diversity for corals (more than 41 species, including the genus Acropora, which is all but absent elsewhere in Hawai'i) and reef fishes (178 species). A relatively deep (25 to 30 meters) coral reef at this atoll has been recently discovered to function as a spawning site for the Giant Trevally, *Caranx ignobilis* (Meyer et al. 2007), an important finding in relation to the population dynamics of top predators.

The lagoon is also unusual in that it contains two exposed volcanic pinnacles representing the last vestiges of the high

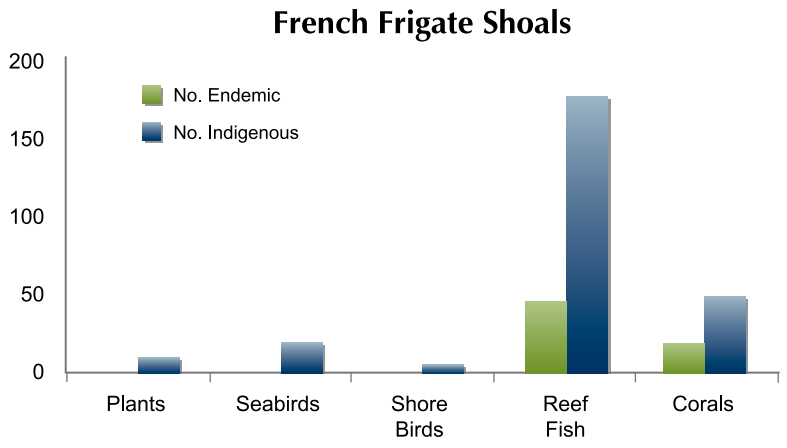


Figure 2.10: *Number of endemic and indigenous species at French Frigate Shoals*

island from which the atoll was derived, as well as nine low, sandy islets. The sand islets are small, and can shift position, disappear and reappear with seasonal changes. In 1923, the *Tanager* Expedition mapped 16 islets (Amerson 1971). In 1963, Whaleskate was a vegetated island of 0.068 square kilometers (Amerson 1971); by 1998, it had completely disappeared (Antonelis et al. 2006). These islets provide crucial habitat for the world's largest breeding colony of the imperiled Hawaiian Monk Seal, which is listed as endangered under the ESA and is also internationally recognized as critically endangered by IUCN. The atoll's sandy islets also provide nesting sites for 90% of the threatened Green Turtle population breeding in the Hawaiian Archipelago. In addition, 19 of Hawai'i's 22 breeding seabird species are found on French Frigate Shoals, giving it the highest species richness of breeding seabirds within Papahānaumokuākea. The dry coastal shrublands of the larger islets within the atoll also support an endemic seed bug (*Nysius frigatensis*), a moth (*Agrotis kerri*), and a mite (*Phauloppia bryani*) (Usinger 1942; Nishida 2002).

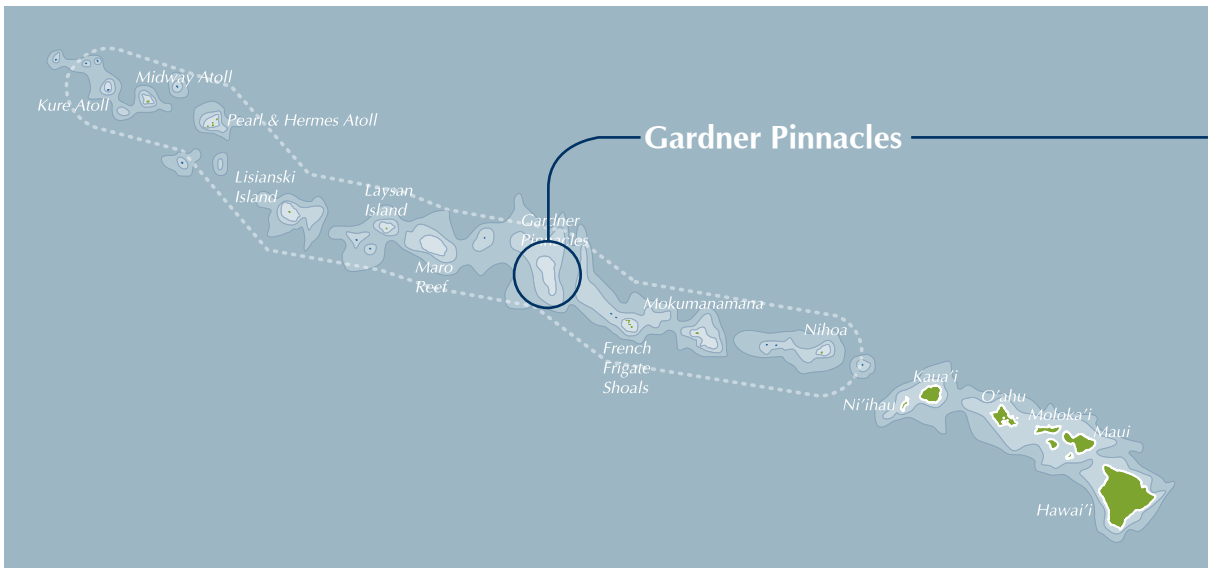
Underwater vista of French Frigate Shoals (Photo: James Watt)

Gardner Pinnacles
(Pūhāhonu)
25º02′N, 168º05′W

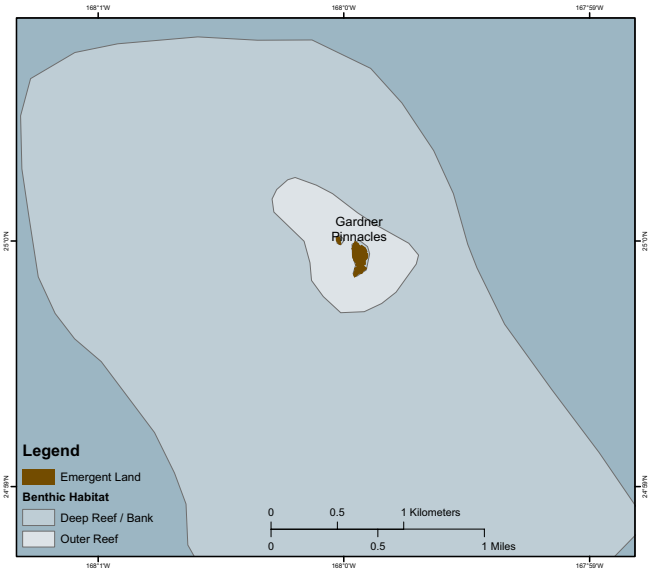
"He pūkoʻa kū no ka moana." ("A large rock standing in the sea.") This traditional Hawaiian saying describes someone who is stubborn, unchangeable, or determined. It is also a suitable description for Pūhāhonu (surfacing of a sea turtle for air/breath), which looks a bit like a turtle's beak coming up for air.

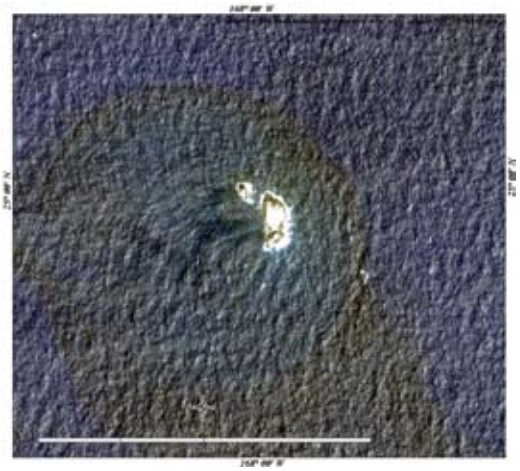
Gardner Pinnacles' two emergent volcanic peaks are estimated to be 15.8 million years in age (Clague 1996). These are the oldest high islands in the Hawaiian chain. In scale, these pinnacles are small, the largest reaching only 55 meters high, with a diameter of approximately 180 meters. Because of their limited size, they support only a single species of land plant (*Portulaca lutea*) and a few terrestrial arthropod species, but they are an excellent, rat-free habitat for seabirds, which roost and breed there (Clapp 1972). Guano from at least 12 subtropical seabird species gives the peaks a "frosted" appearance. Landings and terrestrial surveys rarely take place due to the difficulty of getting ashore under all but the calmest ocean conditions.

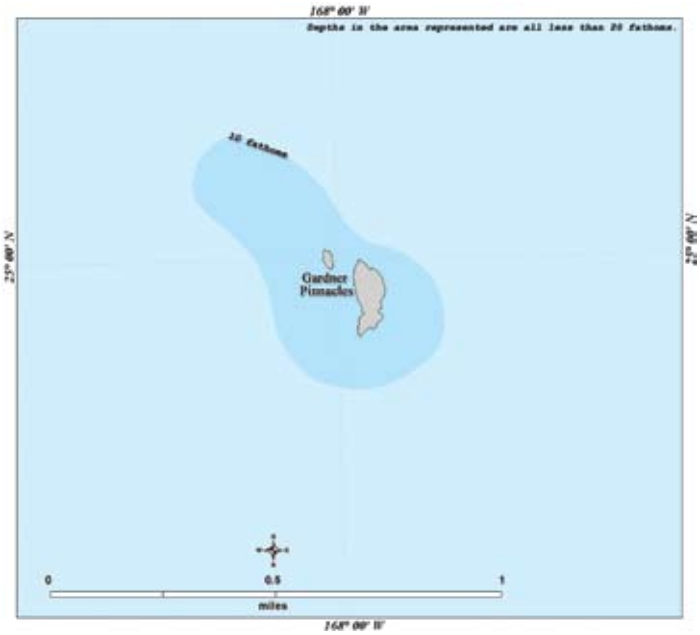
Gardner Pinnacles, the oldest high islands in the Hawaiian Archipelago
(Photos: James Watt)



Gardner Pinnacles: benthic habitat, bathymetry and satellite imagery







These remnant volcanic pinnacles are surrounded by approximately 2,425 square kilometers of coral reef habitat, most of which is in waters of greater than 20 meters in depth, harboring 124 reef fish species and 27 species of corals. The intertidal bases of the pinnacles are studded with large populations of ‘opihi, endemic Hawaiian limpets that have been seriously depleted by overharvesting elsewhere in the main Hawaiian Islands.

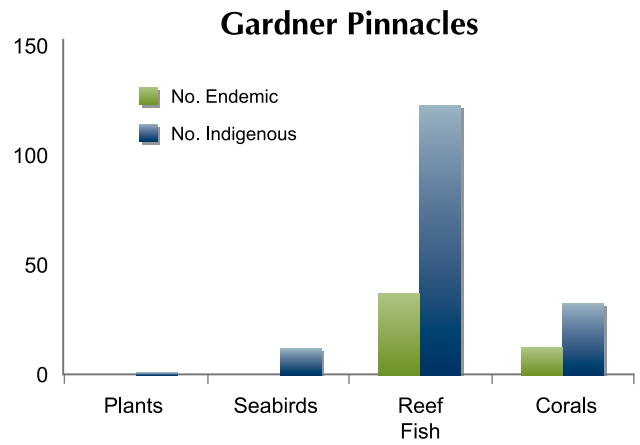
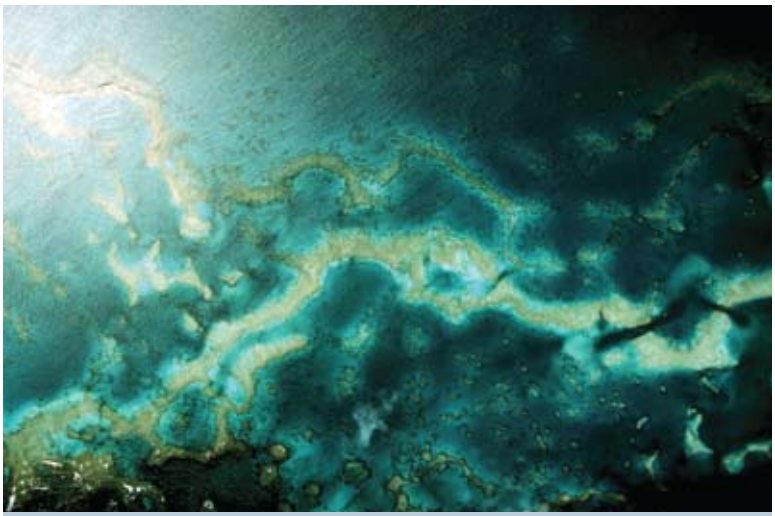


Figure 2.11: *Number of endemic and indigenous species at Gardner Pinnacles*

Maro Reef
(Koʻanakoʻa and Nalukākala)
25º22′N, 170º35′W

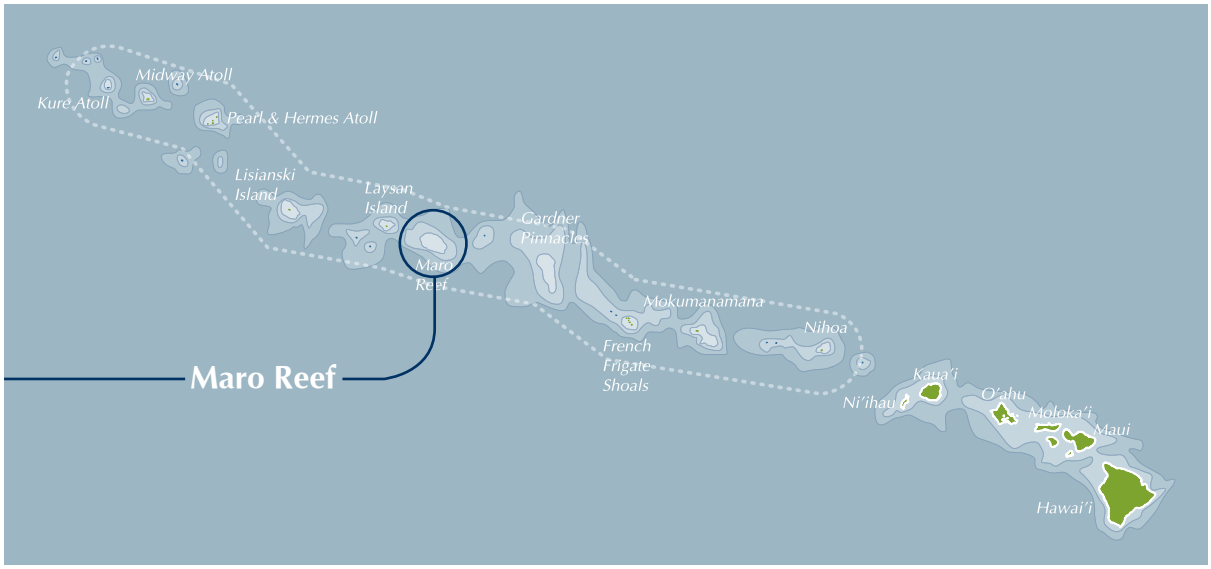
(Photo: James Watt)

The name Koʻanakoʻa literally means the settlement of coral, referring to Maro's expansive coral reefs. Another name for Maro, Nalukākala, describes surf that arrives in combers, such as the surf that froths over shallow reefs.

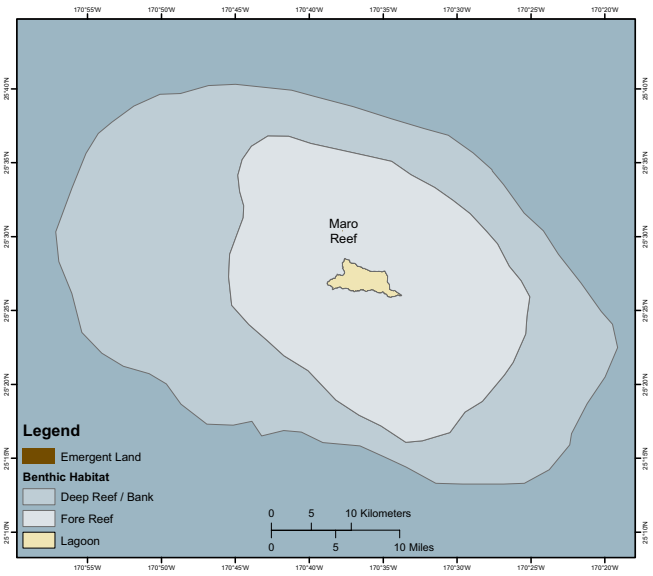

Maro Reef's sealife abounds with traditionally important fish, like the ulua (jacks) (Photo: USFWS)

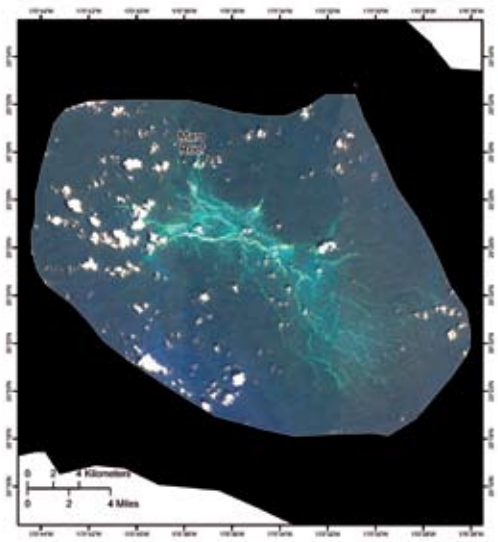
Maro Reef is a submerged open atoll, 19.7 million years old (Clague 1996). At very low tide, only a small coral rubble outcrop of a former island breaks above the surface; as a result, Maro supports no terrestrial biota. The shallow-water reef system, however, is extensive; covering nearly 2,023 square kilometers, Maro is the largest coral reef in Papahānaumokuākea. It is also one of the chain's most ecologically rich shallow-water marine ecosystems, with 64.1% coral cover over the entire area (which is among the highest coral-cover percentage observed in Papahānaumokuākea) (Maragos et al. 2004).

The documented marine biota at Maro Reef includes 37 species of corals and 142 species of reef fish, with endemic fish abundance making up half of all those recorded here. Maro's reefs are intricate and reticulated, forming a complex network of reef crests, patch reefs, and lagoons. Deepwater channels with irregular bottoms occur between these shallow reef structures, but navigation through them is difficult and hazardous. Cover types range from unconsolidated, with 10% or less macroalgae cover, to areas with greater than 10% coral or crustose coralline algae (NOAA 2003). Because the outermost reefs absorb the

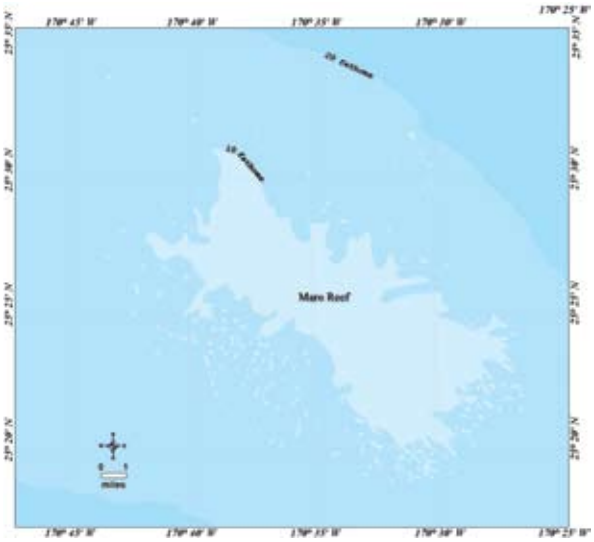


Maro Reef: benthic habitat, bathymetry and satellite imagery





majority of the energy from the open ocean swells, the innermost reticulated reefs and aggregated patch reefs are sheltered and have the characteristics of a true lagoon. This platform's structural complexity means that its shallow reefs are still poorly charted and largely unexplored.



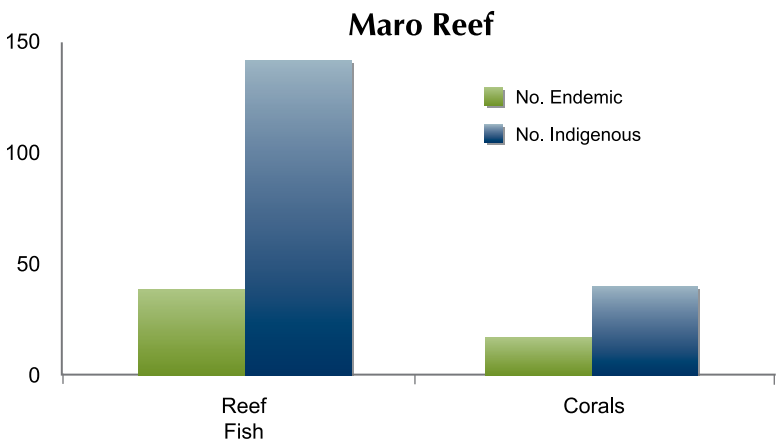


Figure 2.12: *Number of endemic and indigenous species at Maro Reef*

Laysan Island
(Kauō)

25°46′N, 171°45′W

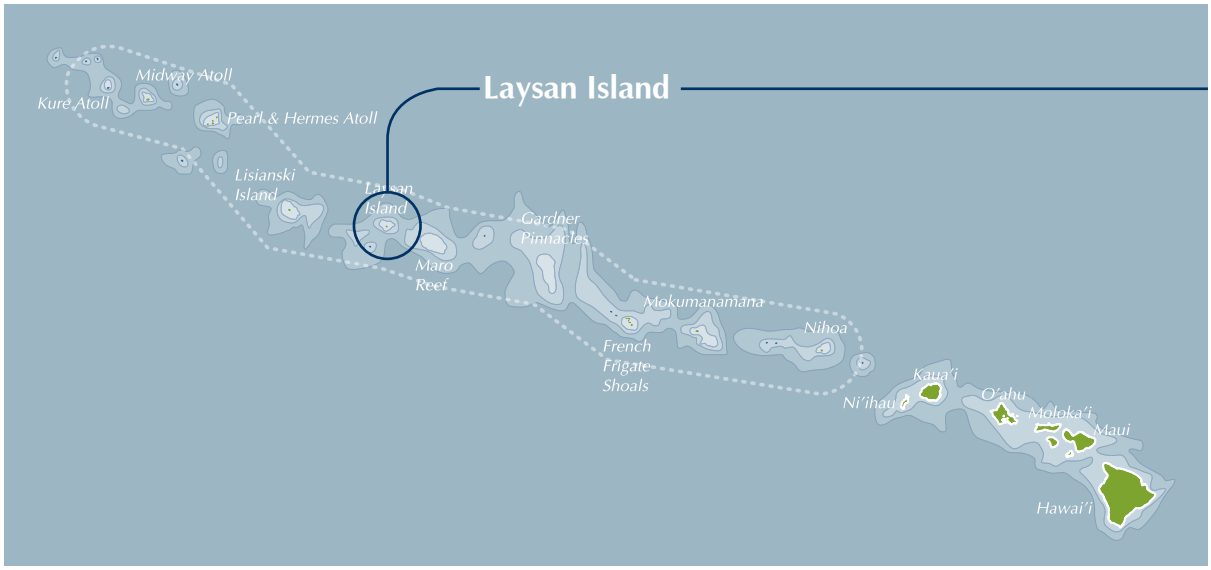
Kauō (egg) describes both the shape of this island, and perhaps also refers to the abundant seabirds that nest here.

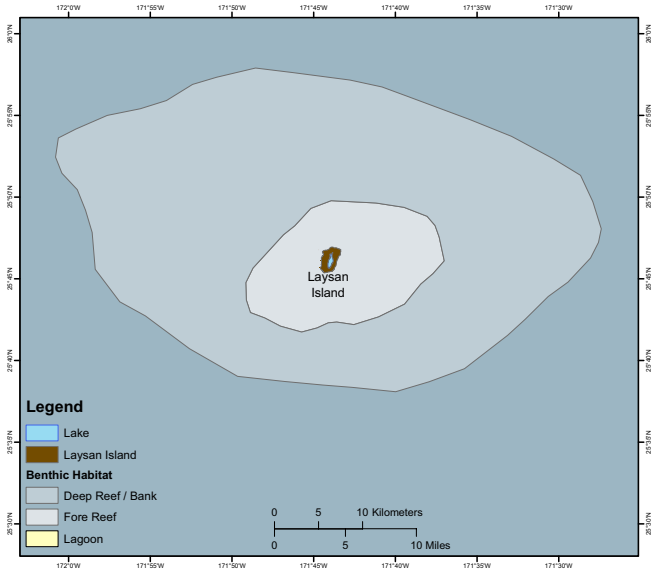
Laysan is a raised atoll, estimated to be 20.7 million years old (Clague 1996), with a maximum elevation of approximately 15 meters above sea level. It represents the second-largest island in Papahānaumokuākea, with a land area of approximately 4.1 square kilometers, surrounded by close to 405 square kilometers of coral reef.

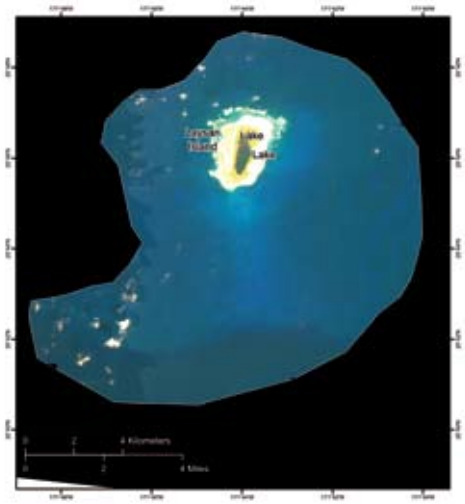
Most of the reef area at Laysan lies in deeper waters, with a small, shallow-water reef area in a bay off the southwest side of the island. The reef system as a whole supports 131 species of reef fishes and 27 species of corals.

Laysan is also home to a semi-permanent FWS field camp to support wildlife monitoring and habitat restoration. The island's ring of sandy dunes surrounds a 40-hectare hypersaline interior lake, a feature unique within the Hawaiian Archipelago and rare within the Pacific as a whole. Because of its average elevation of about 12 meters, Laysan is well vegetated, supporting at least 30 species of flowering plants. The original flora included five endemic subspecies prior to human contact (Athens et al. 2007), many of which were driven to extinction by the misguided introduction of rabbits in 1902 during the guano mining era (Ely and Clapp 1973). The plant community is divided into five different associations arrayed in concentric rings around the interior hypersaline lake: (1) coastal shrubs, (2) interior bunchgrass, (3) vines, (4) interior

Laysan's namesakes, the Laysan Duck and the Laysan Finch, grace this atoll's shores (Photos: James Watt)







Laysan Island: benthic habitat, bathymetry and satellite imagery

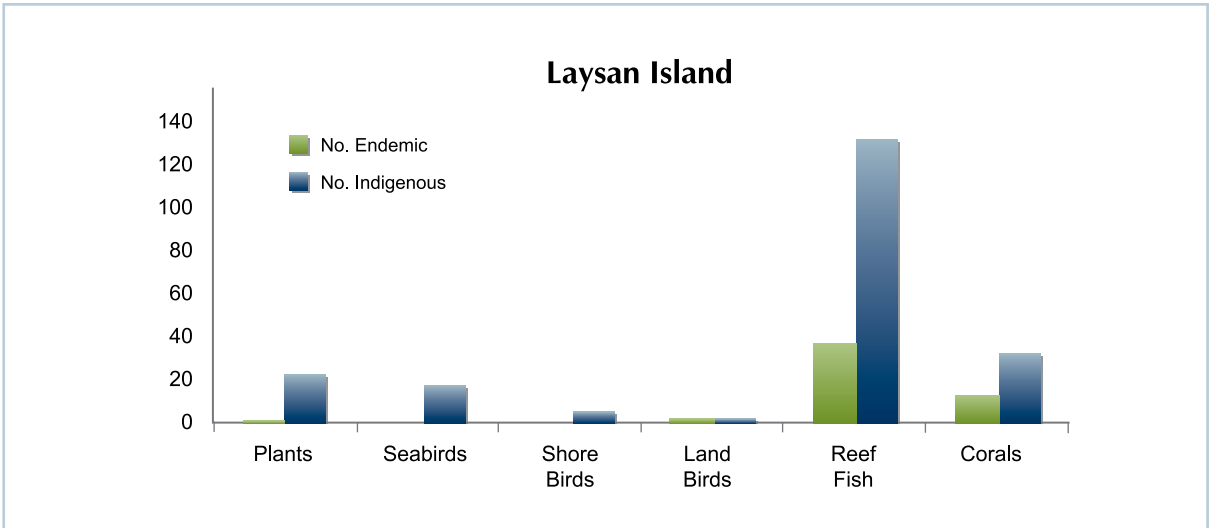


Figure 2.13: *Number of endemic and indigenous species at Laysan Island*

shrubs, and (5) wetland vegetation (Newman 1988). The island also previously harbored five endemic birds, of which two, the Laysan Finch (*Telespiza cantans*) and the Laysan Duck (*Anas laysanensis*), still survive (Pratt et al. 1987). In addition, approximately two million seabirds nest here, including boobies, frigatebirds, terns, shearwaters, noddies, and the world's second-largest Black-footed and Laysan Albatross colonies.

The island also supports a relatively rich arthropod fauna, including a large endemic weevil (*Rhyncogonus bryani*), four endemic moths, an endemic wasp, and three endemic mites. A successful 12-year eradication project to remove the invasive sandbur Cenchrus echinatus, a plant that had displaced native vegetation over 30% of the island, has been completed, and an active ecological restoration project is underway to bring back a number of other plants and animals that were lost after the introduction of rabbits (Morin and Conant 1998).

Aquamarine waters lap the shores of Laysan Island
(Photo: James Watt)

Lisianski Island
(Papa'āpoho)
26º04'N, 173º58'W

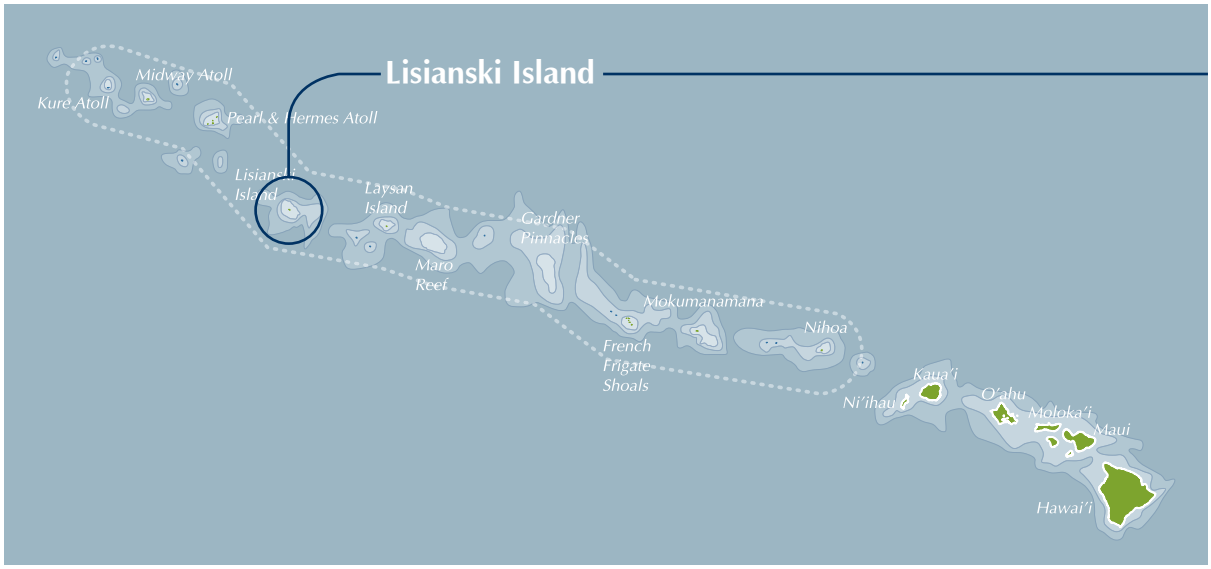
"Papa'āpoho" describes a flat area with a depression or hollow, which is exactly how the raised atoll of Papa'āpoho (or Lisianski) is shaped. This 23.4-million-year-old island (Clague 1996), about 1.9 kilometers across, consists of an elevated rim surrounding a broad central depression, although unlike Laysan it does not enclose an interior saline lake. With approximately 1.6 square kilometers of emergent land, it is the third largest island within Papahānaumokuākea.

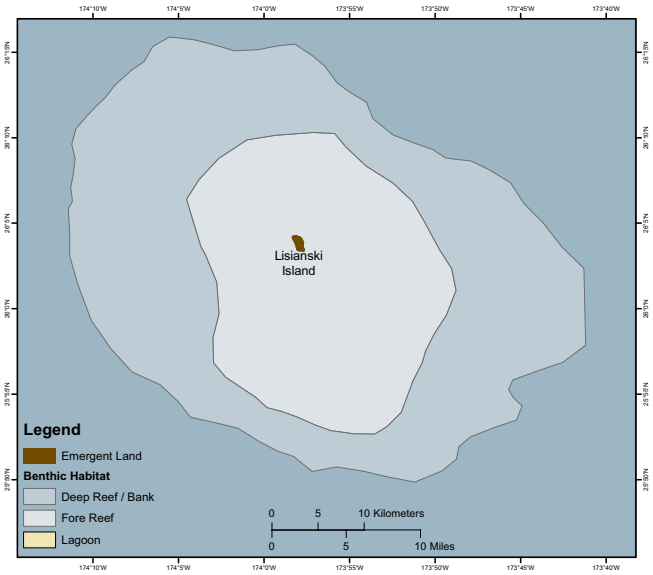
The coral cover on the platform around the island, called Neva Shoal, is extensive, totaling over 1,174 square kilometers with an average of almost 60% cover of the substrate. There are 24 coral species at Lisianski, and 124 species of reef fish, with fish species abundances endemic to the Hawaiian Archipelago making up 58% of all those recorded here.

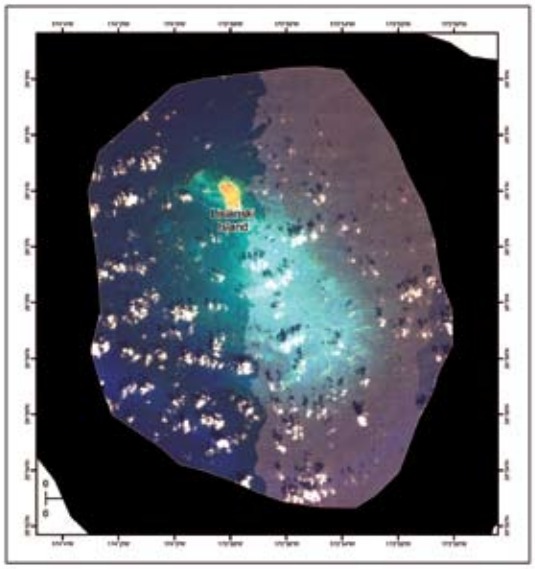
Lisianski suffered ecological perturbations similar to those on Laysan due to guano mining and the release of rabbits in 1903 (Tomich 1986). It supports no endemic land plant or bird species, although it does harbor an endemic seed bug (*Nysius fullawayi flavus*) and an endemic moth (*Helicoverpa minuta*) (Usinger 1942; Nishida 2002). The island also hosts large Bonin Petrel and Sooty Tern colonies, as well as a variety of other seabirds. Lisianski also has the only grove of

(Photo: Rob Shallenberger)

Lisianski Island is a popular breeding ground for Hawaiian Monk Seals (Photo: James Watt)







Lisianski Island: benthic habitat, bathymetry and satellite imagery

Pisonia grandis trees in the entire Hawaiian Archipelago; this tree is dispersed by seabirds and is favored as a nesting site for many tree-nesting seabird species

As part of a biological and paleontological study in the summer of 1990, an archaeologist conducted excavations and investigated the possibility of early Native Hawaiian occupation of Lisianski. Although wave action on the island had scoured any potential evidence of previous human habitation within the shoreline, the archaeologist did find "an unmodified fine-grained basalt flake as well as a polished granite pebble" that were foreign to the island (Ziegler 1990). Study continues on that material evidence, and a more thorough examination of the island has yet to occur.

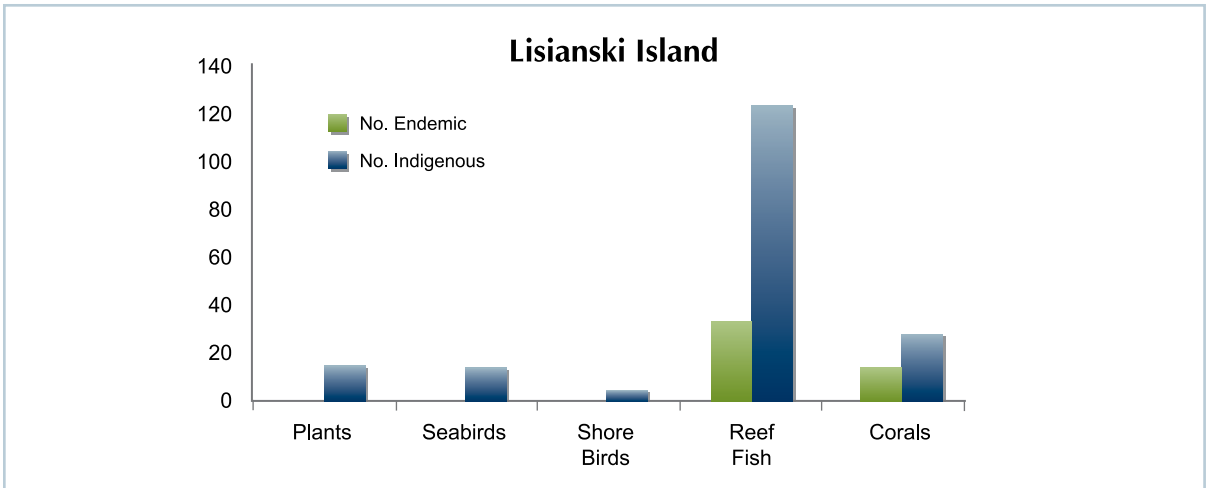


Figure 2.14: *Number of endemic and indigenous species at Lisianski Island*

Pearl & Hermes Atoll
(Holoikauaua)

27º50′N, 175º50′W

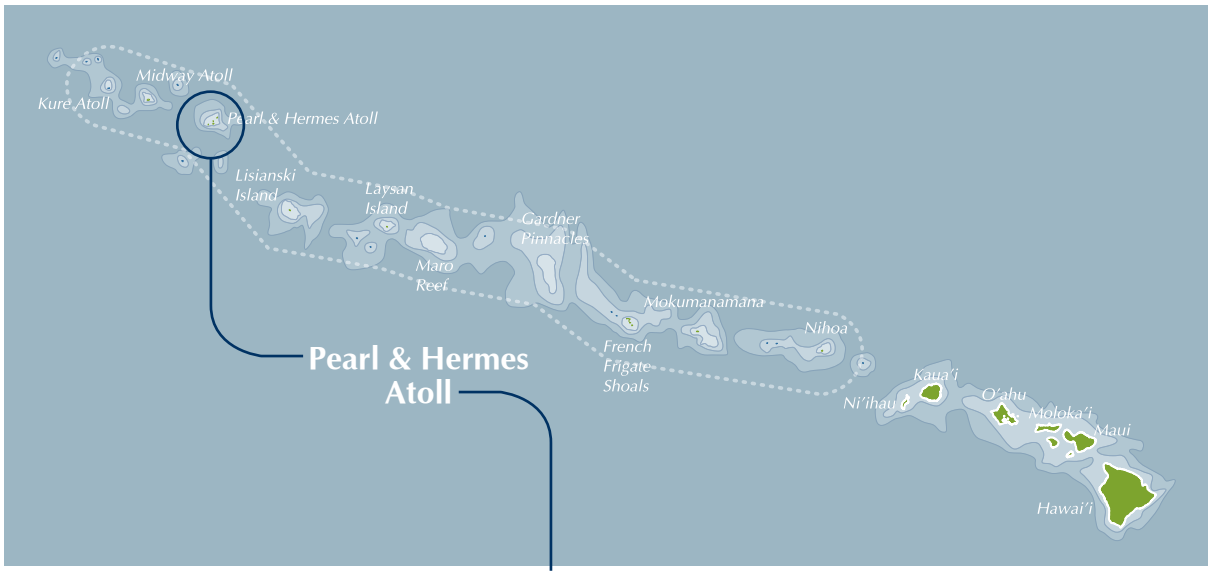
(Photo: James Watt)

Pearl and Hermes Atoll contains the highest percentage of endemic fish species in the archipelago. Shown here: a school of Hawaiian Squirrelfish (ʻalaʻihi).
(Photo: US FWS)

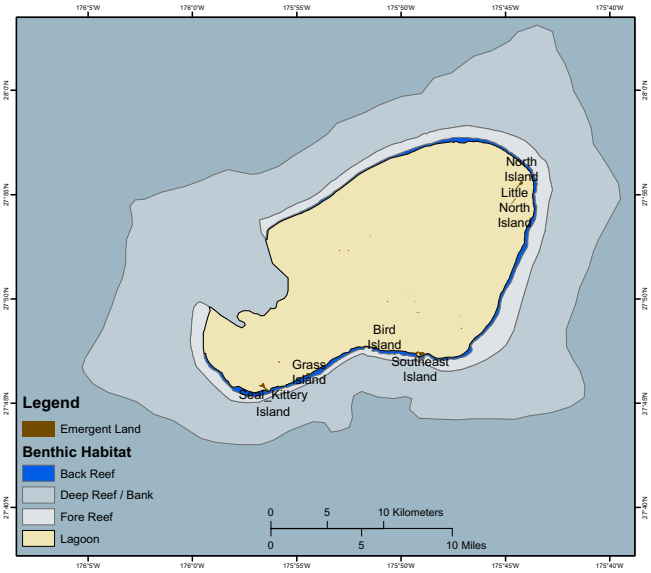
The name Holoikauaua celebrates the Hawaiian Monk Seals that haul out and rest here. Holoikauaua relates to the word ʻīlioholoikauaua, which refers to a seal and literally means "the quadruped running in the rough seas."

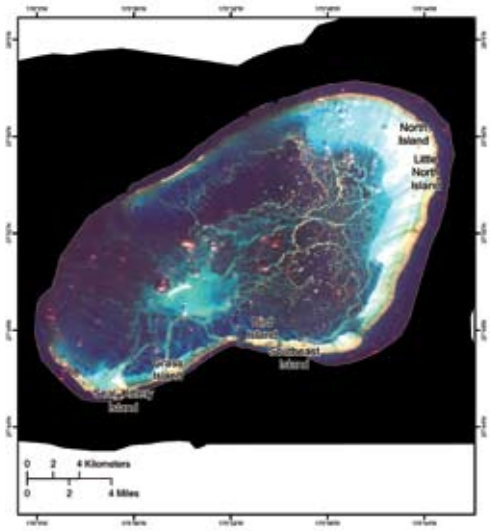
Pearl and Hermes Atoll is a large atoll with several small islets. It covers 0.39 square kilometers of land and is surrounded by over 1,214 square kilometers of coral reef habitat. The atoll has an estimated age of 26.8 million years (Clague 1996) and in its entirety is more than 32 kilometers across and 19.3 kilometers wide, with dunes rising well above sea level. Unlike Lisianski and Laysan to the southeast, Pearl and Hermes Atoll is a true atoll, fringed with shoals, permanent emergent islands, and ephemeral sandy islets. These features provide vital dry land for Monk Seals, Green Turtles, and a multitude of seabirds, with 16 species breeding here. The islets are periodically washed over when winter storms pass through the area.
The atoll boasts the highest rate of reef fish endemism in the Hawaiian Archipelago; endemic species represent 62% of the numerical density of reef fish present at Pearl and Hermes Atoll. Coral species richness is high as well, with 33 species present. The atoll also supports the second largest population of Hawaiian Monk Seals in the archipelago.

The permanent islands with higher dunes also support an endemic subspecies of native seed bug (*Nysius fullawayi* ssp. *infuscatus*) (Usinger 1942). Pearl and Hermes also hosts a small population of endangered Laysan Finches that were translocated here in the 1960s.

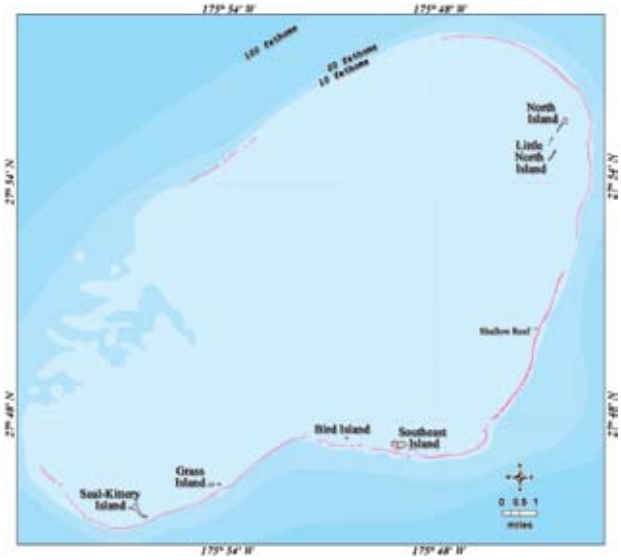


Pearl and Hermes Atoll: benthic habitat, bathymetry and satellite imagery





Reef scene from Pearl and Hermes Atoll
(Photo: James Watt)



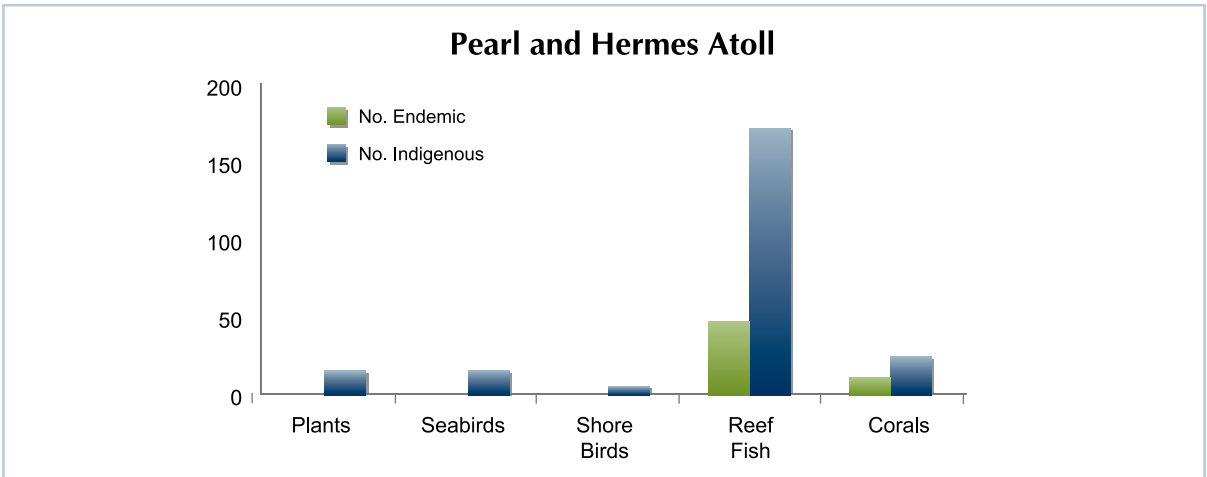
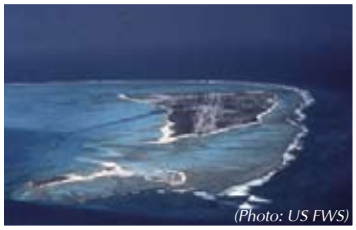


Figure 2.15: *Number of endemic and indigenous species at Pearl & Hermes Atoll*

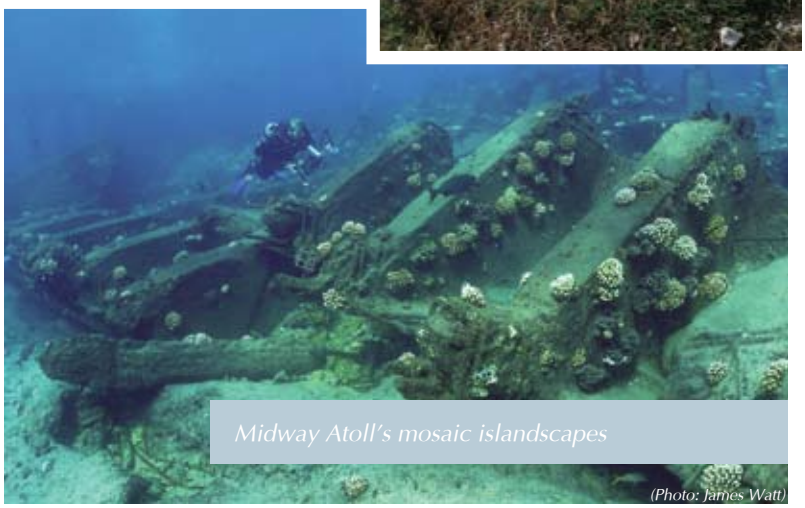
Midway Atoll
(Pihemanu, Brook Island, and Middlebrook Islands)

27º50'N, 175º50'W


(Photo: US FWS)

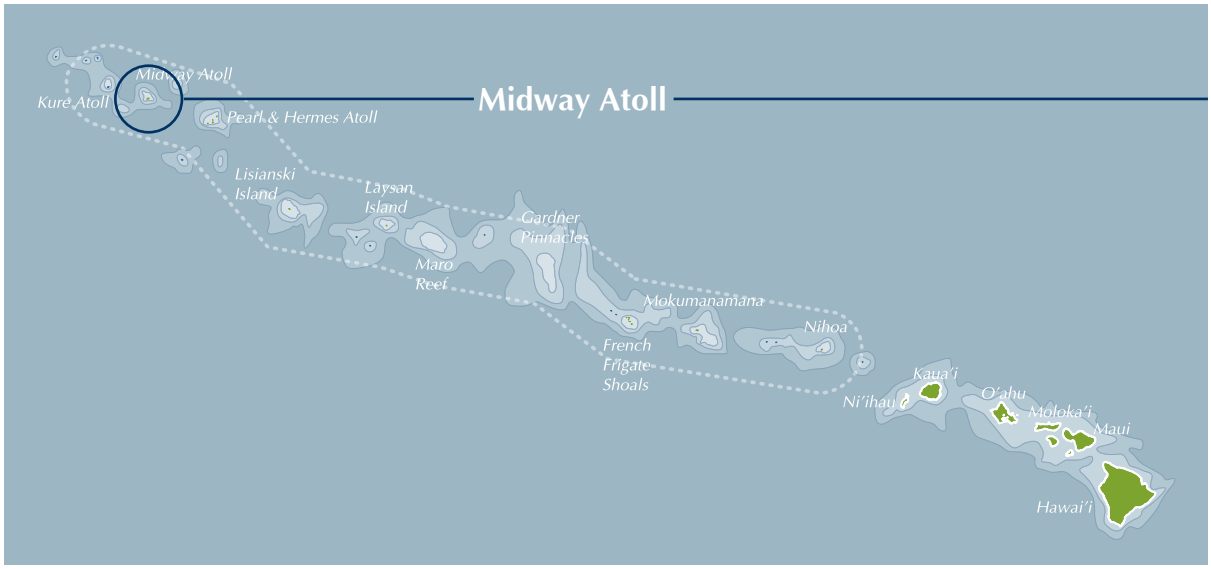
Midway Atoll's Hawaiian name, Pihemanu, evokes the loud din of birds that one hears on this atoll.

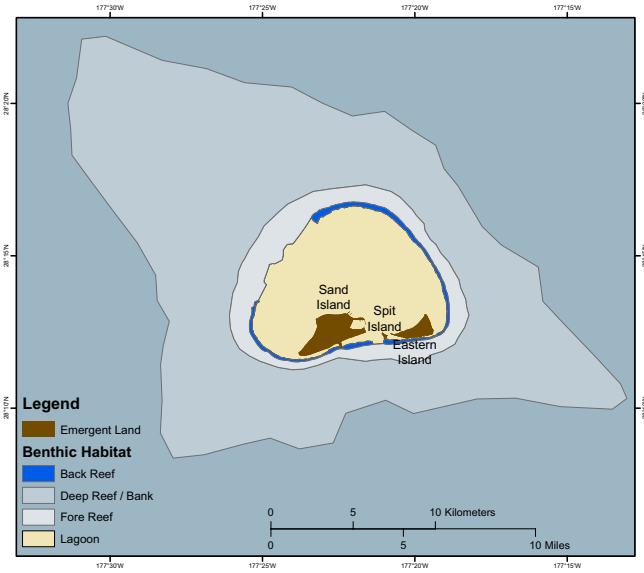
Midway Atoll consists of three sandy islets: Sand (4.56 square kilometers), Eastern (1.36 square kilometers), and Spit (0.05 square kilometers) for a total of 5.97 square kilometers in terrestrial area. These islets lie within a large, elliptical barrier reef measuring approximately 8 kilometers in diameter. The atoll, which is 28.7 million years old (Clague 1996), is surrounded by more than 356 square kilometers of coral reefs. In 1965, the U.S. Geological Survey tested Darwin's theory of atoll formation by drilling test bores at Midway, and hit solid basaltic rock 55 meters beneath Sand Island and 378 meters beneath the northern reef (Ladd et al 1967).

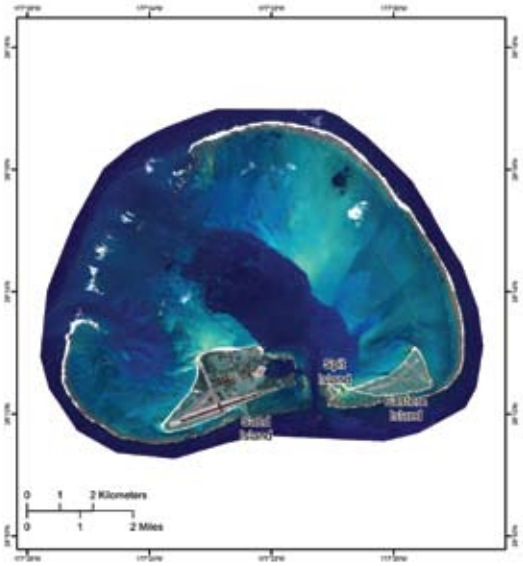

Midway Atoll's mosaic islandscapes
(Photo: James Watt)

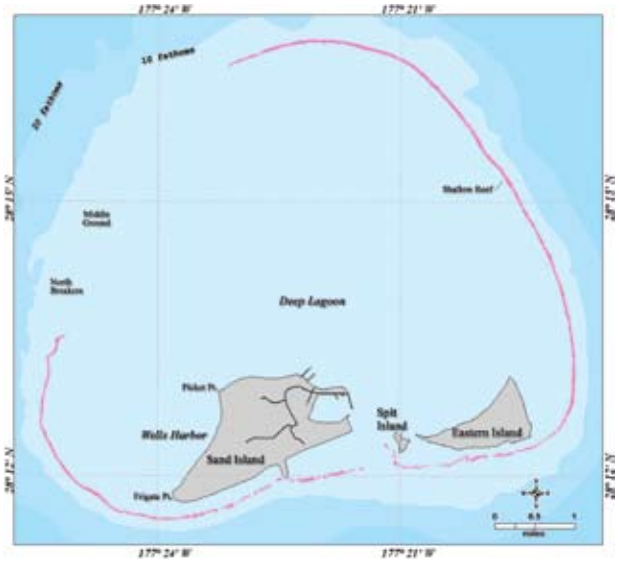
Numerous patch reefs dot the sandy-bottomed lagoon, supporting 163 species of reef fishes and 16 species of corals.

Although Midway's native vegetation and entomofauna have been greatly altered by more than a century of human occupation, the island boasts the largest nesting colonies of Laysan and Black-footed Albatrosses in the world, forming the largest combined colony of albatrosses on the planet. The Navy, FWS, and U.S. Department of Agriculture-Wildlife Services (USDA Wildlife Services) successfully eradicated rats from Midway in the 1990s, and









Midway Atoll: benthic habitat, bathymetry and satellite imagery

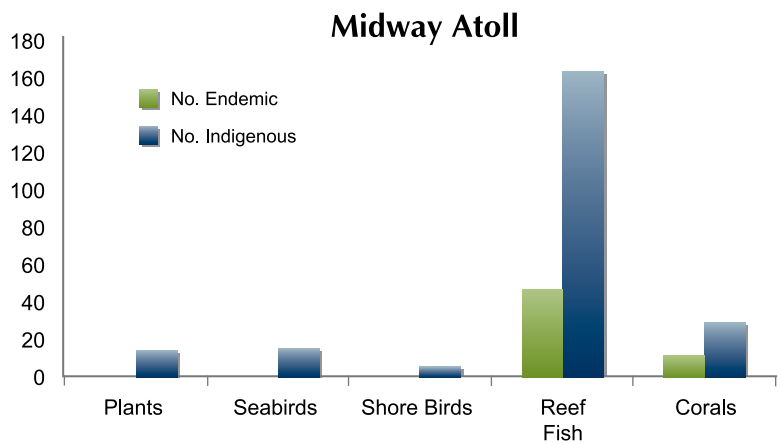
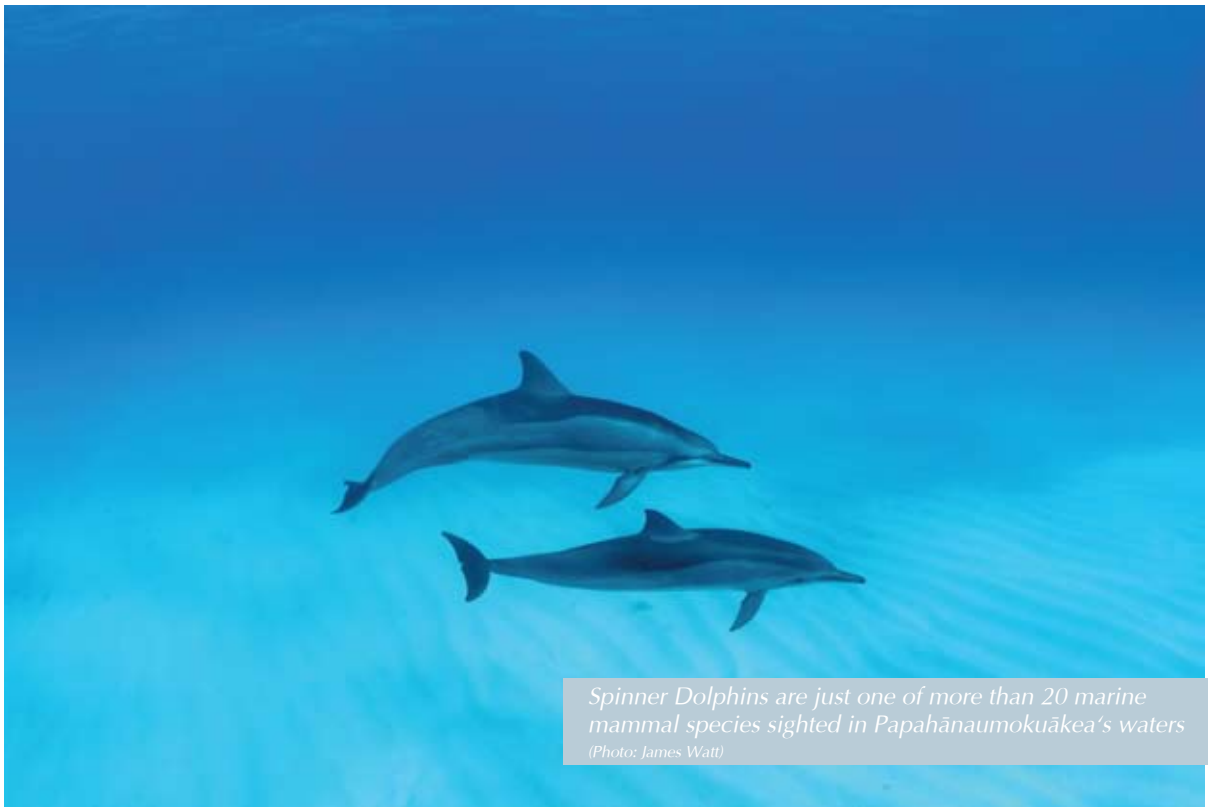


Figure 2.16: *Number of endemic and indigenous species at Midway Atoll*

invasive ironwood trees have been entirely removed from Eastern Island. Currently the cover on all of the islands at Midway is approximately 30% paved or structures, 23% grass and forbs, 18% woodland, 7% sand and bare ground, 22% shrublands, and <0.23% wetland. A translocated population of Laysan Ducks is supported by the introduced insect community at Midway, and a large program of invasive weed eradication and native plant propagation is ongoing.

Canaries introduced in 1910 still breed among the historic buildings that housed the beginning of cable communications across the Pacific in the early 20th century. The atoll and surrounding seas were also the site of a pivotal battle of World War II; Midway was also an active Navy installation during the Cold War.



Spinner Dolphins are just one of more than 20 marine mammal species sighted in Papahānaumokuākea's waters
(Photo: James Watt)

Kure Atoll
(Mokupāpapa and Kānemilohaʻi)

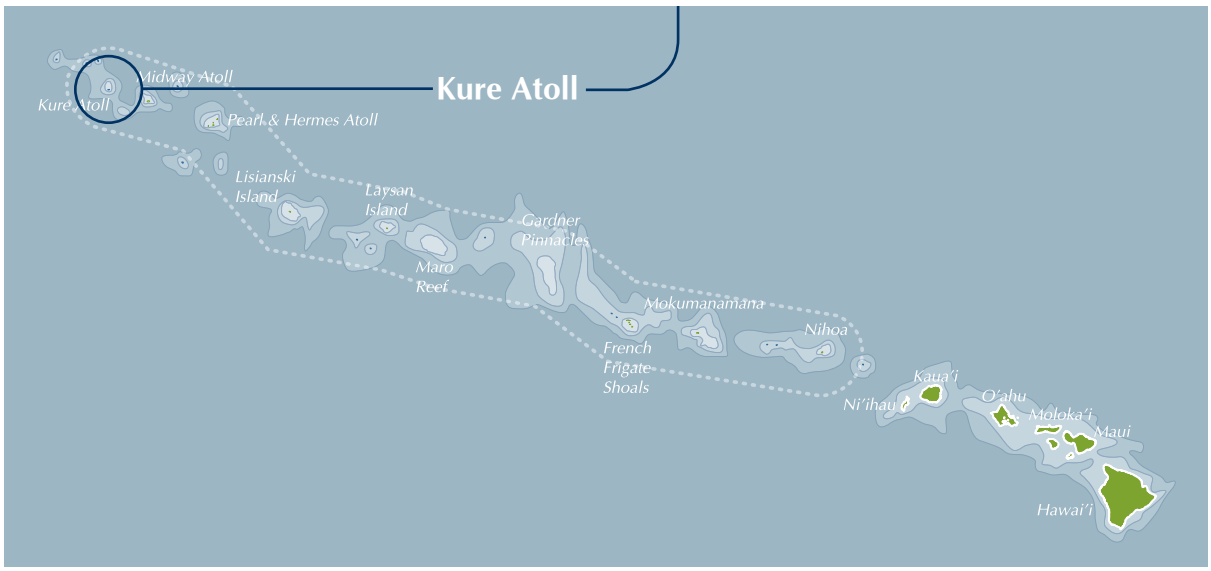
23º03'N, 161º56'W

Mokupāpapa literally means flat island, and the name was ascribed to Kure Atoll by officials of the Hawaiian Kingdom in the 19th century, when King David Kalākaua disbursed an official envoy to the atoll to take "formal possession" of it. At the time, Kure was known in the kingdom as Ocean Island, but Hawaiian Kingdom officials indicated that Kure was "known to ancient Hawaiians, named by them Moku Papapa and recognized as part of the Hawaiian Domain" (Department of Hawaiian and Pacific Studies, Bishop Museum 2002).

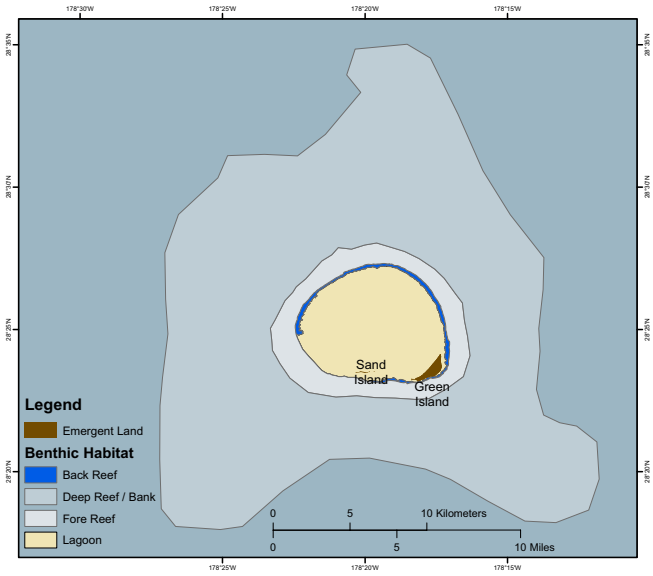
Kure Atoll is the most northwestern island in the Hawaiian chain and occupies a singular position at the "Darwin Point": the northern extent of coral reef development, beyond which coral growth cannot keep pace with the rate of geological subsidence. At present, Kure's coral is still growing slightly faster than the island is subsiding, keeping the atoll above sea level. North of Kure, however, where growth rates are even slower, the drowned Emperor Seamounts foretell the future of Kure and all of the Hawaiian Archipelago. As Kure Atoll continues its slow migration atop the Pacific Plate and moves into slightly cooler waters, it too will cease to maintain sufficient coral growth, and will eventually slip below the surface.

This 29.8 million year old atoll (Clague 1996) is nearly circular, with a reef 10 kilometers in diameter enclosing a lagoon with two islets comprising over 0.89 square kilometers of emergent land, flanked by almost 324 square kilometers of coral reef habitat. The outer reef forms a nearly complete circular barrier around the lagoon, with the exception of passages to the southwest, and the associated marine habitats support 155 species of reef fishes and 27 species of coral. Abundance of fish species endemic to the Hawaiian Archipelago compose 56% of all fish abundance recorded here.

Kure Atoll, the northernmost island in the chain, sits at the Darwin Point (Photo: James Watt)



Kure Atoll: benthic habitat, bathymetry and satellite imagery



Of the two enclosed islets, the only permanent land is found on crescent-shaped Green Island, which rises to 6 meters above sea level and is located near the fringing reef in the southeastern quadrant of the lagoon. In addition to harboring an apparently endemic mite (*Hemicheyletia granula*), the atoll is also an important albatross breeding site, and the lagoon supports a population of Spinner Dolphins (*Stenella longirostris*).

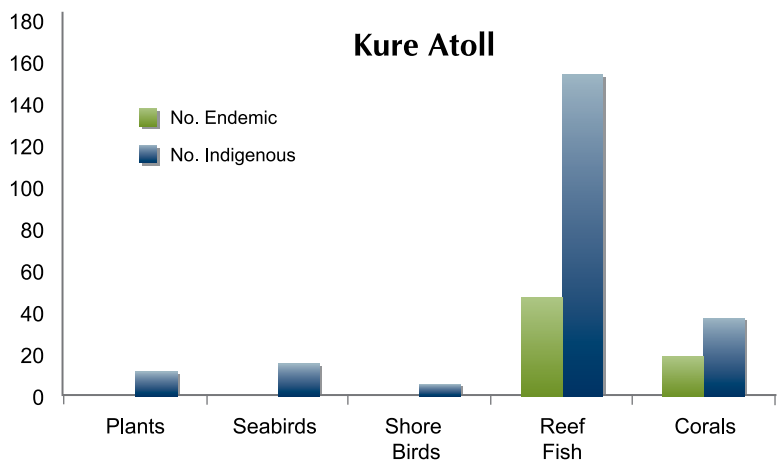
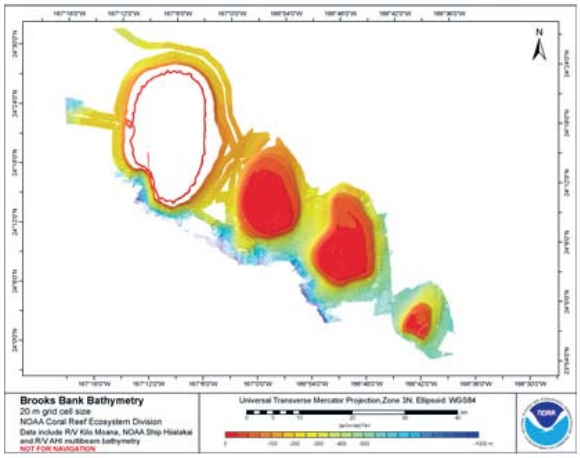


Figure 2.17: *Number of endemic and indigenous species at Kure Atoll*

Banks and Seamounts

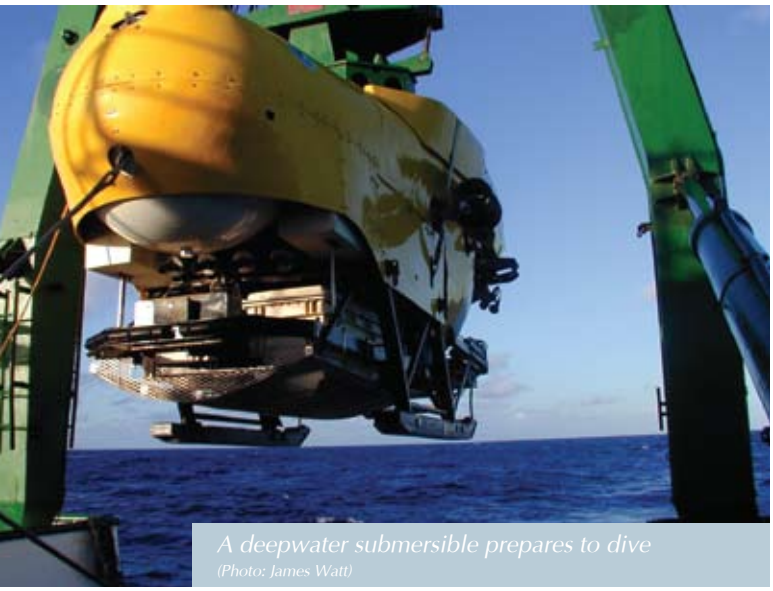
Approximately 30 submerged banks lie within Papahānaumokuākea (Miller et al. 2004). Deepwater banks and seamounts are one of Papahānaumokuākea's least-studied environments. Recent use of shipboard mapping technologies, submersibles, and remotely operated vehicles, however, has provided valuable information to characterize the physical and biological components of these ecosystems. Multibeam mapping expeditions have revealed dramatic geologic features, including knife-edge rift zones, seafloor calderas, sea-level terraces, submarine canyons, underwater landslide scars and debris fields, and previously unmapped seamounts (Smith et al. 2003; Smith et al. 2004).



Bathymetric mapping of an underwater seamount

(Photo: Amy Baco-Taylor)

Submersible surveys on South Pioneer Ridge (Pioneer Bank) and at two unnamed seamounts, one east of Laysan Island and the other east of Mokumanamana, have revealed the presence of various substrate types, deposited when these geologic features were at sea level (Smith et al. 2004). In some areas, dense communities of corals (ahermatypic) and sponges at depths approaching 1,000 fathoms (1,830 meters) obscure the underlying substratum. The deepwater marine plants of the area are a mixture of tropical species, species with cold-temperature affinities, and species with disjunctive distributions, suggesting alternative biogeographical patterns and dispersal routes from the main Hawaiian Islands (McDermid and Abbott 2006).



A deepwater submersible prepares to dive
(Photo: James Watt)

All of these banks provide prime habitats for bottomfish and other associated fish species that are important food sources for Hawaiian Monk Seals. Such banks also support populations of Spiny and Slipper Lobsters, and colonies of precious gold, pink, and black corals that have been heavily disturbed in much of the remainder of the Pacific by the use of physically damaging harvest methods, such as trawling. These deep-living corals are unique in that they reside below the depth where enough light penetrates for photosynthesis, and derive their energy from the capture of plankton and small, organic particles from the water column with their tentacles, rather than relying on the symbiotic dinoflagellate algae, known as zooxanthellae, that virtually all shallow-water reef-building corals harbor in their cells.

2.b History and Development of the Property

The human history of Papahānaumokuākea can be divided into two historical periods: Native Hawaiian history before Western contact (~300–1778 AD); and post-contact history (1778–present), including the Hawaiian Renaissance of the late 20th century to the present.

Native Hawaiian History Before Western Contact

The Polynesian settlement of the Pacific Ocean began around 300 BC, when the first seafarers set off from Sāmoa and Tonga to explore the waters around them. Over the next 1,300 years, these voyagers would employ a sophisticated, non-instrument navigational system as they journeyed across the ocean, establishing their presence across a more than 10-million-square-mile triangle of the Pacific. They founded settlements on Aotearoa (New Zealand) in the west, on Rapa Nui (Easter Island) in the east, Hawai'i in the north, and on hundreds of islands in between (Howe 2006). The epic journeys to these far-flung points were the last wave of migration in the Pacific, and represented the apex of Polynesian voyaging and navigation skills.

More than 1,500 years ago, Polynesian voyagers arrived in the Hawaiian Archipelago, the Polynesian Triangle's northernmost point, where they found islands filled with abundant natural resources. Over the next millennia, Native Hawaiians, the descendents of the first Polynesians who discovered Hawai'i, made the islands into a landscape that sustained both man and nature, creating agricultural terraces along the hillsides and extensive water paddies for their staple food, *kalo* (taro), in the valleys, constructing fishponds over the shallow reefs, and managing sustainable nearshore and pelagic fisheries.

While the majority of the populace lived in the main Hawaiian Islands (the eight volcanic islands from Hawai'i Island in the south to Ni'ihau in the north), the islands and atolls of Papahānaumokuākea were both considered deeply sacred and visited regularly for cultural and subsistence resources. On Nihoa, Native Hawaiians established permanent and semi-permanent habitation sites, agricultural terraces, and burial grounds. It is believed that Hawaiians on Nihoa fished, raised crops, and staged the construction of sacred ritual sites on Mokumanamana. *Kūpuna* (elders) on Kaua'i and Ni'ihau say that their families visited Nihoa and Mokumanamana for weeks to months at a time, throughout the period of Western Contact, although after the United States' annexation of Hawai'i, much of this happened in secret (Maly 2003).

Papahānaumokuākea as a primary training ground for apprentice navigators, and Nihoa, Mokumanamana and French Frigate Shoals served as resource gathering places, as evidenced in Native Hawaiian oral histories and the journals of Captain James Cook. One of Captain Cook's crewmembers, David Samwell, reported that while near Ni'ihau, they planned to "set sail in the morning for Mokoopapappa [sic], a small, low Island uninhabited which the Indians tell us lies to the Westward of us at a distance of a day's sail from here, where there are plenty of Turtle" (Beaglehole 1967).

Papahānaumokuākea in the Post-Contact Era

When Europeans arrived in the Hawaiian Archipelago in the late 18th century, they found a thriving society of between 250,000 and one million Native Hawaiians (Stannard 1989), with a distinct culture and complex social and religious systems. Papahānaumokuākea was very much a part of Native Hawaiian geography and life; Captain James Cook's crews encountered a Native Hawaiian canoe returning from the Northwest Hawaiian Islands with a vessel full of seabirds and turtles. Some of the highest-ranking Native Hawaiian chiefs of the 19th century, including Queen Ka'ahumanu, King Kamehameha IV, King David Kalākaua and Queen Lydia Lili'uokalani, visited Nihoa to reconnect with the island.

In 1898, five years after Queen Lili'uokalani was overthrown by the self-

proclaimed Provisional Government of Hawai'i, the archipelago (which included Papahānaumokuākea) was collectively acquired by the United States through a domestic resolution called the "Newlands Resolution."

Through *mele* (song), *mo'olelo* (story), *oli* (chant), *hula* (dance), *mo'okū'auhau* (genealogy) and archaeological resources, Hawaiians maintained continuous ties to the islands to the northwest. Using these cultural resources, Native Hawaiians recount the travels of seafaring ancestors between Papahānaumokuākea and the main Hawaiian Islands. Archival resources written in the Hawaiian language have played an important role in providing this documentation, through a large body of information published more than a hundred years ago in local newspapers (e.g., Kaunamano 1862; Manu 1899; Wise 1924). More recent ethnological studies have highlighted the continuity of Native Hawaiian traditional practices and histories in the Northwestern Hawaiian Islands. Only a fraction of these have been recorded, and many more exist only in memories and life histories.

Starting in the 1960s and 1970s, a scant lifetime after American annexation, Native Hawaiians launched a movement of resistance to Western assimilation by looking to their *kūpuna* (revered elders and ancestors) and other sources to reclaim their language, music, *hula* (traditional Hawaiian dance) and history. Part of this renaissance included the strengthening of bonds with sacred places and a return of traditional skills and knowledge to the center of cultural life; Papahānaumokuākea has played a pivotal role in both of these movements.

Native Hawaiians and Papahānaumokuākea in the Modern Era

The *ea* (sovereignty and life), as well as the *kuleana* (responsibility), for the entire Hawaiian archipelago continues to exist in the central beliefs of many present-day Native Hawaiians—a perspective formally recognized by the U.S. Apology Resolution (U.S. Public Law 103-150), a joint resolution of Congress signed by President Clinton in 1993. The Apology Resolution states, in part, that "The Congress … apologizes to Native Hawaiians on behalf of the people of the United States for the overthrow of the Kingdom of Hawaii on January 17, 1893 with the participation of agents and citizens of the United States, and the deprivation of the rights of Native Hawaiians to self-determination;…" (see Appendix D for full text of the Apology Resolution).

In 1997, an organization called Hui Mālama I Nā Kūpuna O Hawai'i Nei repatriated sets of human remains to Nihoa that had been collected by archaeologists in the 1924–1925 Bishop Museum *Tanager* Expeditions (Ayau and Tengan 2002). Hui Mālama seeks to return the *mana* (life-force, spirit, and power) of the *kūpuna* (ancestors) to existing and future Native Hawaiian life.

Aboard the Hōkūle'a, Hawaiian wayfinders navigate this seascape as their ancestors did 2,000 years ago
(Photo: Na'alehu Anthony)

The Hōkūleʻa, a modern-day replica of ancient double hulled sailing canoes, approaches Nihoa in 2005 (Photo: Naʻalehu Anthony)

This repatriation set the stage for a reawakened relationship between Native Hawaiians and the NWHI in 2000, when President Clinton signed the Executive Orders creating the NWHI Coral Reef Ecosystem Reserve. With new channels of access possible, the cultural group Nā Kupuʻeu Paemoku traveled to Nihoa on the traditional double-hulled voyaging canoe *Hōkūleʻa* in 2003 to conduct traditional ceremonies. The following year, in 2004, *Hōkūleʻa* sailed more than 1,200 miles (1,931 km) to the most distant end of the archipelago, visiting Kure Atoll as part of a statewide educational initiative called "Navigating Change." Concurrently, the *ʻOhana Waʻa* (literally, family of canoes – an organization representing the Hawaiian voyaging community and their seven canoes, inclusive of those currently sailing and those under construction) recognized that the ancient sailing route between Kauaʻi and Nihoa was still an appropriate training route for the next generation of Native Hawaiians interested in reestablishing the traditional system of navigation practiced by their ancestors.

In 2005, Nā Kupuʻeu Paemoku again sailed to Papahānaumokuākea, this time to Mokumanamana, where they conducted protocol ceremonies on the summer solstice. During the 2007 solstice, as a follow-up to the 2005 access, the Hawaiian cultural group Haʻae Wale Hānauna Lolo ventured to Nihoa and Mokumanamana to conduct its own cultural research initiatives and to better understand the relationships between the *wahi kūpuna* (ancestral places) and the northern pathway-of-the-sun.

Timeline of Events:

Official Hawaiian presence in NWHI following Western Contact

1822

Queen Kaʻahumanu travels to Nihoa and claims it under the Kamehameha Monarchy.

1856

Nihoa is reaffirmed as part of the existing territory of Hawaiʻi by authority of Alexander Liholiho, Kamehameha IV.

1857

King Kamehameha IV voyages to Nihoa. He instructs Captain Paty on the *Manuokawai* to verify the existence of other lands in the northwest. Paty travels to Nihoa, Mokumanamana, Gardner, Laysan, Lisianski, and Pearl and Hermes.

1857

The islands of Laysan and Lisianski are declared as new territory under the domain of the Kingdom.

1885

Princess Lydia Liliʻuokalani and a scientific expedition visits Nihoa on the ship *Iwalani*.

1886

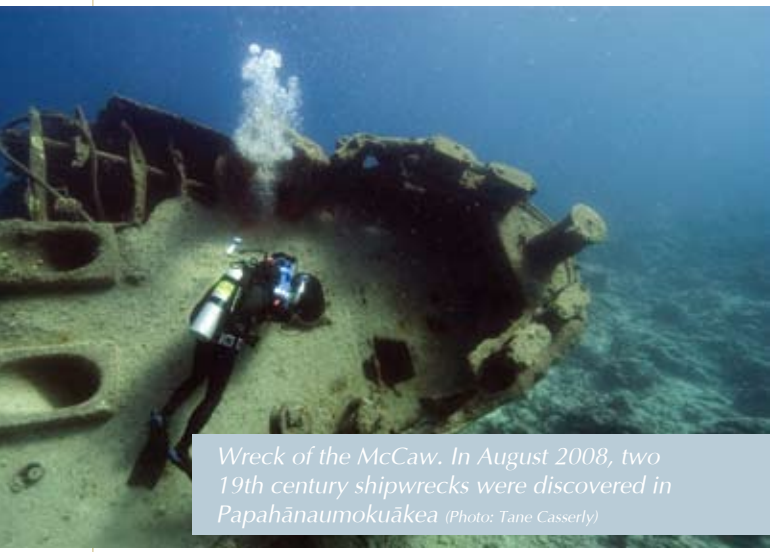
King David Kalākaua, through Special Commissioner Colonel James Harbottle-Boyd, claims possession of Kure Atoll (Ocean Island).

1893

The Hawaiian government is overthrown by the Provisional government, with the assistance of Minister John L. Stevens and the U. S. military.

1898

The archipelago, inclusive of the Northwestern Hawaiian Islands, are collectively ceded to the United States through a domestic resolution, called the "New Lands Resolution."



Wreck of the McCaw. In August 2008, two 19th century shipwrecks were discovered in Papahānaumokuākea (Photo: Tane Casserly)

Reestablishing ceremonies and practices in Papahānaumokuākea "complete[s] the cycles we have in all of our stories," says Pualani Kanakaʻole Kanahele, a *kumu* (teacher of cultural practices) and leader of Haʻae Wale Hānauna Lolo.

Maritime Heritage and Maritime Archaeology

The Hawaiian Islands have a rich maritime history; specific remnants of this are preserved in Papahānaumokuākea Marine National Monument. Following Captain James Cook's first encounter with Hawaiʻi, the presence of European and American vessels at the main Hawaiian Islands slowly began to increase, and early European voyages of discovery included several encounters with the Northwestern Hawaiian Islands. The French navigator Jean François de Galaup, Comte de La Pérouse (Cook's contemporary) made brief surveys of Mokumanamana and French Frigate Shoals in 1787. Russian navigators such as Urey Lisianski also conducted surveying expeditions in this portion of the Pacific in 1805. In the mid 19th century, American surveying efforts by N.C. Brooks (1859), Lieutenant John Brooke (1859), and Captain William Reynolds (1867) added to the growing body of knowledge on the area.

Western whalers, in their early search for productive areas, encountered the low and uncharted atolls on their passages westward from Honolulu and Lahaina, Maui to the whale-rich seas off Japan, the Japan Grounds, which extended from Japan eastward to Kure Atoll (Richards 1999). Several of the islands, therefore, received their Western names from the early landings and/or shipwrecks of these Pacific whalers. Midway was originally sighted by Captain Daggett of the New Bedford whaler *Oscar* in 1839. Laysan was reportedly discovered by the American whaling ship *Lyra* prior to 1828. Pearl and Hermes Reef is named for the twin wrecks of the British whalers *Pearl* and *Hermes* in 1822. Gardner Pinnacles was named by Captain Allen on the Nantucket whaler *Maro* in 1820, the same year the ship came across Maro Reef. Whaling, which decimated marine mammal populations worldwide, carried with it major ramifications in terms of oceanic discovery, cultural contact, economic development, and political expansion.

Seafaring activity in the Hawaiian Islands quickly became culturally mixed. Hawaiian chiefs purchased and operated numerous schooners and brigs, and Native Hawaiians found employment on a wide range of sailing vessels. Many were well aware of the evolving whaling industry, and were recruited and served on board whaling ships. It is estimated that 500 Hawaiian sailors shipped out annually onboard Western whalers during the peak of the Pacific whaling era, between 1840 and 1860 (Chappell 1997: 180).

There are ten known whaling shipwrecks in the Northwestern Hawaiian Islands (see Appendix E). Five of these shipwreck sites (*Pearl* 1822, *Hermes* 1822, *Parker* 1842, *Gledstones* 1837, and an unidentified 19th century whaler) have been documented by field survey. These are the earliest wrecks yet found in Hawaiian waters, and provide a rare archaeological glimpse into this period of whaling in the Pacific. Whaling shipwrecks are an example of the international importance of this region in the early 19th century, when whale oil fueled the cities of the Industrial Era, and drove ships halfway around the globe in search of this invaluable resource.

The U.S. Guano Act of 1856, which enabled commercial claims to many remote and

uninhabited islands in the Pacific, heralded the hunt for mineral resources. Several of the Northwestern Hawaiian Islands were leased by private companies for guano extraction. The local development of facilities supporting these activities was most significant on Laysan Island, where a small community existed from the 1890s through the early 20th century. Guano works among the atolls necessitated supply ships and passage for contract laborers, increasing local vessel traffic in the region.

The U.S. Navy's interest in Midway destined the atoll to play a distinctive role in history. Captain William Reynolds of the USS *Lackawanna* took formal possession for the U.S. in August 1867, making Midway Atoll the first islands annexed beyond the West Coast. The harbor had been erroneously described as similar to Honolulu, both roomy and safe, and the low Sand and Eastern Islands as "productive for agriculture." These were unrealistic claims at best, but early in the age of steam navigation, the U.S. sought transpacific coaling stations and the establishment of commercial links to East Asia. The effort was not without a cost, as the USS *Saginaw*, a Civil War–era gunboat, was lost at nearby Kure Atoll in 1870. The Midway Islands were the first fruits of Secretary of State William Seward's expansionist policies, and grew in political importance during the American period.

The islands were not the only focus of activity. Commercial fishing in the waters surrounding the islands of Papahānaumokuākea began with the arrival of large sailing vessels that hailed from ports around the world. These vessels left the reefs and shoals with cargoes of shark meat, fins and oil, turtle shells and oil, and sea cucumbers. Commercial harvesting of tuna, bottomfish, lobsters, and other marine animals in the region continued through the 20th century.

Throughout this period, Papahānaumokuākea presented significant hazards to shipping because of the low, inconspicuous nature of the islands, which makes their shoals and reefs difficult to detect from the water,

Cavernous cauldrons indicate this shipwreck was likely a historic whaling vessel (Photo: Tane Casserly)

and their often incorrect location on marine charts. This, combined with the increase in commercial activities over time, has made Papahānaumokuākea into a veritable graveyard of maritime disaster in the 19th century. Fortunately, the frequent proximity of sandy "desert" islands, not barren at all but rich in terms of marine mammals, seabirds, and ocean resources, granted castaways the opportunity for survival. Many tales of shipwreck in these islands present similar themes: unexpected groundings on low coral atolls, difficult survival on turtles, seals, fish and bird eggs, and construction of craft from debris for rescue voyages eastwards back to the main Hawaiian Islands. Also, not surprisingly, several commercial outfits in the main Hawaiian Islands sent local schooners on "wrecking" or salvage cruises to the northwestern atolls.

Currently, 60 known shipwreck sites are known in Papahānaumokuākea, the earliest dating back to 1822. Combined with known aircraft losses, there are a total of 127 potential maritime resource sites, giving Papahānaumokuākea a significant and basically undisturbed marine archaeological legacy. These submerged historical resource sites are international in scope and represent a cross-section of the many cultures that engaged in Pacific seafaring history. Twenty-five of these sites have been confirmed by field survey. Because maritime archaeology is such a new field of research in Papahānaumokuākea, discoveries of new shipwreck sites in this region occur frequently. Each new survey of the area yields further important information to add to the inventory and assessment of shipwreck sites in this area.

Fertile grounds for maritime archaeology (Photo: James Watt)

In fall 2002, for example, a multi-agency research expedition that included a small team of maritime archaeologists conducted the first systematic survey for maritime cultural resources in the distant portion of the archipelago. The study area encompassed the islands and atolls stretching from Nihoa in the south to Kure in the north. In 2003, maritime archaeologists conducted a survey of selected sites at Kure and Midway Atolls. The 2003 work featured the discovery of the wreck site of the USS *Saginaw*, lost at Kure Atoll in 1870. In 2005, the maritime archaeology team focused on documenting the 19th century whaling shipwreck sites at Pearl and Hermes Atoll and Kure Atoll. Non-invasive survey of three wrecks, the British whalers *Pearl* and *Hermes* (which sank in 1822), and the American whaler *Parker* (which sank in 1842), were initiated. Further follow-up surveys were conducted to the newly discovered whalers in 2006, and a yet-to-be-identified site known as the "Oshima" wreck. In 2007, the maritime archaeology team discovered the 1917 wreck of the four-masted schooner *Churchill*, lost under mysterious circumstances while in transit with copra (dried coconut meat) from Tonga to Seattle, Washington. Very little maritime archaeological work has been conducted in atoll environments, and pelagic whaling vessels in an archaeological context are a rare discovery; for global comparison, only two shipwreck sites, both located in Australia, yield similar information to the shipwreck sites in Papahānaumokuākea. In late summer 2008, two additional shipwrecks were discovered, the *Gledstones* (which was lost in 1837) and an unidentified 19th century whaler.

The American period

The Kingdom of Hawai'i was officially annexed by the U.S. in 1898. Claims to the Northwestern Hawaiian Islands, substantiated by the former Kingdom, were transferred (except Midway) to the Territory of Hawai'i. Statehood for the Territory occurred in 1959, following World War II and subsequent large-scale social, political, and economic transformations in the Pacific.

Hawai'i and the Northwestern Hawaiian Islands played a crucial role in global communications. In 1903, a transpacific submarine cable was completed via Honolulu, Midway, and Guam. Residence at Midway also meant an increasing awareness of the area by the American government. Illegal poaching in the remote archipelago prompted the first U.S. Marine presence at Midway, and in 1909 President Theodore Roosevelt declared the whole area (with the exception of Midway) the Hawaiian Islands Reservation, for the protection of seabirds.

A textured ecological, cultural, and historic islandscape (Photo: James Watt)

With the first "round-the-world" cable message sent by President Roosevelt on July 4, 1903, and the subsequent construction of the Pan American Airways facilities (see Midway Atoll overview, below), Midway became a crucial connection for the Pacific region and the world. The U.S. Navy's interest in the strategic location of Midway centered on its use as a seaplane base, and in 1940, construction of the naval air station at Midway was begun. Growing infrastructure at Midway reflected its strategic importance as a trans-Pacific communication and transportation hub.

World War II had a dramatic impact on the region. Tern Island at French Frigate Shoals was initially developed as a naval facility for staging aircraft. Besides the naval air station at Midway, the Navy also built a major submarine refit and repairs base. Together, these areas comprised a vital center for submarine, surface fleet, and aviation operations. In fact, the Hawaiian Sea Frontier forces stationed patrol vessels at most of the islands and atolls.

Midway Atoll itself was the focus of one of the most important naval battles in the war's Pacific theater. In June 1942, the Japanese Imperial Navy attempted the invasion of the atoll. Ultimately, four Japanese aircraft carriers and one American carrier were sunk, and hundreds of aircraft shot down. The Imperial Japanese Navy was forced to withdraw. This was a watershed moment in the Pacific; had the invasion succeeded, America's line of defense would have retreated to the West Coast. The majority of the sea battle took place between 160 to 300 kilometers to the north of the atoll, but an intense air fight was waged directly over and around the atoll itself (see Midway Atoll overview, below). Numerous Japanese and American planes splashed down into the waters surrounding Midway, and many of these sites are now war graves. At least 67 naval aircraft are recorded as being lost in the vicinity of the Northwestern Hawaiian Islands. These submerged aircraft reflect the important aviation legacy of Midway and the surrounding region.

Midway Atoll today is designated as a National Memorial to the Battle of Midway. Nine defensive structures related to the Battle of Midway were designated as a National Historic Landmark in 1986. Numerous other structures are eligible for placement on the National Register of Historic Places.

Overview of Each Island – History and Development of the Property

Nihoa – 23º03'N, 161º56'W
The islands of Papahānaumokuākea, particularly in its southeastern portion, were used through the time of James Cook's expeditions by Native Hawaiians as seasonal dwelling sites for fishing, turtle harvest and feather gathering. Nihoa and Mokumanamana are thought to have been utilized by Native Hawaiians periodically until well into the Western era, with voyages continuing, in

Schools of Convict Tangs or manini thrive in Papahānaumokuākea (Photo: James Watt)

secret, into the 20th century for the gathering of turtles, fish, bird feathers and eggs (Tava and Keale 1989; Maly 2003).

In 1789, Captain Douglas of the *Iphegenia* was the first Westerner to visit Nihoa. Several Hawaiian ali'i (royalty) journeyed to Nihoa in the next century. In 1822, Hawaiian Queen Ka'ahumanu visited the island with her husband, King Kaumuali'i, chief of Kaua'i. They rediscovered historic evidence of prior habitation, as the Queen had learned from *oli* (chant) and *mele* (song) passed down through the generations (Rauzon 2001). King Kamehameha IV, or Alexander Liholiho, formally annexed Nihoa for the Hawaiian Kingdom in 1857 (Paty in Emory 1928). In 1885, Queen Lili'uokalani and her 200-person entourage landed on Nihoa, to study the palms, wildlife and artifacts on the island (Bishop in Emory 1928).

Mokumanamana (Necker Island) – 23º35'N, 164º42'W
Mokumanamana was documented by La Pérouse in 1786. Captain John Paty claimed Mokumanamana for the Kingdom of Hawai'i in 1857, per the request of King Kamehameha IV, and that claim was later contested, with the island being annexed again by Hawai'i's Provisional Government in 1894. The British once sought to lease the island as a communications cable relay station, but the idea was quashed by the American Congress. More recently, the island was used by the military for bombing practice.

French Frigate Shoals (Kānemiloha'i) – 23º145'N, 166º10'W
French Frigate Shoals was first encountered by Europeans when La Pérouse, sailing with the frigates *Boussole* and *Astrolabe* nearly ran aground there in 1876. Military activities during World War II resulted in significant alterations to the atoll, with Tern Island being largely dredged up and formed into the shape of a runway to serve as a refueling stop for planes en route to Midway. The original seawall, runway, and some structures remain. The U.S. Coast Guard occupied Tern and East Islands from 1944 until the 1970s and ran a LORAN station, evidence of which still remains.

The U.S. Fish and Wildlife Service has maintained a field station at Tern Island since 1978, staffed by two permanent employees and a handful of volunteers. National Marine Fisheries Service also maintains staff on the island in support of Hawaiian Monk Seal and Hawai'i Green Turtle projects.

Gardner Pinnacles (Pūhāhonu) – 25º02'N, 168º05'W
Gardner Pinnacles was given its Western name by Captain Allen on the Nantucket whaler Maro, who encountered the island in 1820. The land area of this island is not large, and the two rocky pinnacles that project above the water are difficult to land on. As a result, there is no record or evidence of any previous human activity.

Hawaiian Morwong, common in Papahānaumokuākea
(Photo: James Watt)

Maro Reef (Ko'anako'a) – 25º22'N, 170º35'W
Captain Allen of the *Maro* first charted Maro Reef in 1820, when he recognized the danger of the area and steered clear of it. The reefs and shoals of Maro Reef are so extensive and vast, that it is thought that this area was generally avoided by mariners. There are at least six recorded shipwreck losses at Maro Reef, beginning in 1852.

Laysan Island (Kauō) – 25º46'N, 171º45'W
On May 1, 1857, Captain John Paty of the Hawaiian schooner *Manuokawai* landed on Laysan and annexed it to the Hawaiian Kingdom. During his visit, Captain Paty commented on the great number of albatross nests and guano deposits on the island. Scientific expeditions to Laysan continued in 1859, with Lieutenant J.M. Brook's visit aboard the *Fenimore Cooper* to collect soundings, positions and physiographic data to make a chart of the island for the United States Hydrographic Office.

In 1890, Laysan was leased by the Hawaiian Kingdom to the North Pacific Phosphate and Fertilizer Company for a period of 20 years. Guano mining and digging occurred on Laysan from 1892 to 1904, when the supply was exhausted. This period saw the construction of several buildings, including a lighthouse and a small railroad, which supported this trade; between 100 and 125 tons of guano could be shipped from Laysan per day (Ely and Clapp 1973). Today, the only obvious terrestrial remnants of this operation on Laysan are guano piles, pieces of rail, and human grave sites. Large 19th century anchors, which may have served as moorings for the guano landing, lie submerged near the shore.

By 1900, Japanese feather poachers began raids on Papahānaumokuākea, slaughtering thousands of albatross and other birds for their plumage. This prompted President Theodore Roosevelt to issue Executive Order No. 1019 on February 3, 1909 to set aside all the islets and reefs from Nihoa to Kure (except Midway) as the Hawaiian Islands Reservation. In April 1923, Laysan was visited by the U.S.S. *Tanager* in what became known as the *Tanager* Expedition. The objective of this mission was to make scientific observations and collections of the flora and fauna in the NWHI for the U.S. Bureau of Biological Survey (Bryan 1978). The party of explorers established a camp on shore for one month, and made detailed records and collected specimens of the various forms of life on Laysan (Macintyre 1996). The previous guano business venture had also introduced rabbits to the island to augment the food supply in 1903. The rabbits' unchecked herbivory and breeding resulted in the almost complete de-vegetation of the island. In 1923, the scientists of the *Tanager* Expedition successfully eradicated the last rabbit, but not in time to prevent the extinction of at least three native land birds and an unknown number of plants and terrestrial invertebrates.

Since 1991, FWS has operated a semi-permanent field camp on Laysan, with efforts focused on eradicating invasive plant species and restoring native habitats. Active restoration in the form of control and eradication of introduced mammals, insects, and plants is occurring at several islands in Papahānaumokuākea. The most comprehensive of these restorations is occurring at Laysan Island. The plant community present today is descended from either the surviving seed bank, adventive species that have re-colonized, or plantings in the decades following the guano business venture. Of the 27 plant species documented in early observations and three more discovered in recent pollen cores of Laysan Lake, 18 still grow at Laysan, along with 11 species of alien plants. A 12 year effort to eradicate the invasive grass *Cenchrus echinatus* has succeeded, though biologists remain vigilant should any seeds resprout. Efforts to restore the plant community to its pre-contact state are proceeding, with a year-round camp where staff are propagating and out-planting eight species (five for re-introduction and three for enhancement of existing small populations). All replanting is conducted using the original species or closest relatives from similar habitats. Replanted plants are started from carefully processed seeds to prevent accidental introductions of fungus and insects. To date, two of six previously extirpated species are reproducing independently, and another two have been out-planted and have survived at least one annual cycle.

Efforts to fill the ecological niche of the extinct Laysan Millerbird (*Acrocephalus familaris familaris*) will be carried out using birds from the only remaining Millerbird population within Papahānaumokuākea (at Nihoa; *Acrocephalus familaris kingi*) as soon as the habitat is judged ready to support the species at Laysan Island. Similar restoration efforts are also occurring at Midway and French Frigate Shoals, and are planned for other terrestrial sites in the archipelago.

Numerous researchers have worked on Laysan, including biologists from the U.S. Geological Survey. They have established an additional population of the endangered Laysan Duck at Midway Atoll.

Lisianksi Island (Papa'āpoho) - 26º04'N, 173º58'W
Lisianski gained its Western name in 1805 when the Russian exploring ship *Neva* grounded on the reef. Under the command of Captain Urey Lisianski, the *Neva* was sailing from Sitka to Macao to meet the *Nadeshda*, her sister ship, on Russia's first circumnavigation of the world (Clapp). The ship was re-floated, but was once again driven into a reef, and the crew began repairs on the battered ship during a break in the weather (Bryan 1978).

Early expeditions to Lisianski include a visit by Captain Benjamin Morrel, Jr., of the ship *Tartar*, who wrote about the inland bird rookeries, Green Turtles, sea-elephants (probably Hawaiian Monk Seals) on the beach, and the lack of any fresh water (Clapp and Wirtz 1975). Captain John Paty arrived at Lisianski in 1857 to take possession of the island for the Hawaiian Kingdom and estimate the amount of guano there (ibid.). Lisianski was later visited by the bark *Gambia*, the schooner *Ada* (which collected sharks, turtles, and sea cucumbers), and the schooner *Kaalokai*, which was hired for an ornithological survey of Lisianski (Bryan 1978). Evidence shows that little guano mining took place at Lisianski, though several Japanese feather poachers raided the island in the early 1900s (Bryan 1978). The first scientific visit to Lisianski occurred in 1928 by the *Moller*, an exploring vessel under the command of Captain Stanikowitch. The team made observations of the island and collected several species of birds, and their records comprise the first list of bird species on Lisianski (Clapp and Wirtz 1975).

Pearl and Hermes Atoll (Holoikauaua) - 27º50'N, 175º50'W
Pearl and Hermes Atoll derives its Western name from the two British whaling ships, the *Pearl* and the *Hermes*, that wrecked on the reef on April 24, 1822 while sailing in consort to the newly discovered Japan whaling grounds. One of the carpenters on board the Hermes, James Robinson, supervised the building on the beach of a small 30-ton schooner they named *Deliverance*. Though most of the crew elected to board the passing ship *Earl of Morby*, Robinson and 11 others took possession of the nearly finished *Deliverance*, sailed her back to Honolulu, and eventually sold her there for $2,000. The remains of the *Pearl* and the *Hermes*, the oldest wrecks in Hawai'i, were discovered in 2004. National Historic Register nominations are in process.

Following a few scientific expeditions to Pearl and Hermes Atoll in the early 1900s, the atoll was home to a short-lived pearl fishery after pearl oysters were discovered in the lagoon in the 1920s. Military activity occurred at the atoll in the mid 1930s and continued through the end of the Battle of Midway (Amerson et al. 1974).

Each summer for nearly two decades, personnel from the U.S. Fish and Wildlife Service and National Marine Fisheries Service have established temporary field camps at Pearl and Hermes to monitor bird and Hawaiian Monk Seal populations. Neither permanent structures nor year-round human activities occur on these islands.

This 3-inch gun on Midway's Eastern Island defended the atoll during the Battle of Midway (Photo: Pete Leary)

Midway Atoll (Pihemanu, Brook Island and Middlebrook Islands) – 28º15'N, 177º20'W
Of all of the islands within Papahānaumokuākea Marine National

Monument, Midway Atoll has been most affected by human activity.

(Photo: FWS)

In 1903, the Commercial Pacific Cable Company established Midway as a link in the first around-the-world communications cable. The employees of the Midway Cable Station built five concrete buildings, cultivated a garden with imported soil, and planted ironwood trees, which then spread around the island, as wind breaks.

In 1935, Pan American Airways constructed a base for its amphibious "flying boats" at Midway. The facility included tourist and employee amenities such as a hotel, a solar hot water system, tennis courts, baseball fields, and a golf course.

In 1941, as World War II raged in Europe, the United States commissioned the Naval Air Station Midway. The military expanded the harbor and developed a seaplane landing basin. They constructed runways on Eastern Island, several defensive batteries, and the infrastructure to support a few thousand military personnel. December 7, 1941, saw not only the famous attack on Pearl Harbor, but also one on strategically important Midway. Japanese destroyers shelled Sand Island for two hours, damaging several buildings, including the seaplane hangar and power plant.

On June 4, 1942, more than one hundred Japanese planes zoomed toward Midway as American military aircraft, PT boats, and anti-aircraft batteries tried to slow their progress. Japanese bombs blasted the seaplane hangar, torpedo and bomb-sighting building, Navy mess hall, administration offices, brig, and other buildings, and damaged several more on Sand Island. On Eastern Island, bombs hit the mess hall, power plant, gasoline lines, sick bay, command post, post exchange, engineering tents and runways. Dark smoke rose from blazing oil tanks. The 17-minute attack left the buildings of Midway Atoll in ruins.

Meanwhile, a massive sea and air battle raged 480 km north of Midway Atoll. The U.S. Navy sank four Japanese aircraft carriers and shot down 292 planes. The Japanese defeat in the Battle of Midway has been called the "turning point of World War II in the Pacific" (Allen 1950: 63 in Yoklavich 1993: 29)

After World War II, the military base at Midway continued to support American military presence in the Pacific until 1993, when the Naval Air Facility was closed. From 1983 to 1997, the Navy and FWS conducted a massive cleanup of Midway Atoll. All the buildings and structures from Eastern Island have been removed. On Sand Island, most of the Cold War–era buildings, 106 underground storage tanks, 15 large above-ground tanks, connecting pipelines, subsurface petroleum, PCB, and DDT-contaminated soil, and large amounts of metal debris were removed. Rats were eradicated.

Today, the FWS maintains a small staff and volunteer program on Midway. They work to remove invasive vegetation, plant native vegetation, collect marine debris, monitor wildlife populations, provide educational activities for visitors, restore historic structures, and clean up contaminants. Midway is not unlike a very small town in its needs for electricity, food service, sewage treatment, and communication. A FWS contractor with 60 employees provides infrastructure support on the island. An airport on Sand Island serves the needs of staff, visitors, and as an emergency diversion site for trans-Pacific commercial aircraft.

Kure Atoll (Mokupāpapa, Kānemiloha'i, Ocean Island and Cure) – 23º03'N, 161º56'W

Historical records contain references to contact with Kure Atoll in 1799 by Captain

Don J. Zipiani of the Spanish vessel *Senhora del Pilar*, who named the island Patrocinio (Woodward 1972). In 1804, the ship *Ocean* arrived at the island, and its captain named the island "Ocean Island" (Bryan 1967). In 1835, Admiral Krusenstern of the Russian Navy stated that Captain Kure, a Russian navigator, landed on the atoll and named it Kure. The exact date when Kure visited the atoll is not known.

Kure Atoll has seen a history of several shipwrecks and scientific expeditions. Following the wreck of the British collier *Dunnottar Castle* in 1886, King Kalākaua, the Hawaiian Monarch, dispatched the *Waialeale* to rescue the crew and take possession of the island. On September 20, 1886, Colonel James H. Boyd of the Waialeale took formal possession of Kure, naming the island Mokupāpapa (Bryan 1978). The U.S. Government acquired Kure as part of the Territory of Hawai'i on July 7, 1898, and in February 1909, Kure Atoll became part of the Hawaiian Islands Reservation when President Theodore Roosevelt signed Executive Order No. 1019 (Bryan 1978). Kure Atoll was under control of the U.S. Navy between 1936 and 1952, after which it was turned back over to the Territorial Government of Hawai'i (Woodward 1972).

Monitoring the extent of coral bleaching in Papahānaumokuākea (Photo: James Watt)

Unlike Midway and French Frigate Shoals, Kure Atoll was not modified during World War II. The U.S. Navy did install a radar reflector in 1955, and opened large areas for albatross in 1959, but no other alterations were made to the island until the U.S. Coast Guard established a LORAN (Long Range Aids to Navigation) station on Green Island, commissioned on March 17, 1961 (Woodward 1972). Promising to protect the flora and fauna on Kure Atoll, the Coast Guard leased Green Island from the Hawaiian Commissioner of Public Lands. Kure was chosen because its isolation enabled clear electronic transmissions for navigational purposes without interference (Gibbs 1977). The Coast Guard built a 1,220-meter runway and a 190-meter-high LORAN tower, along with several structures that included a barracks, a signal/power building, a transmitter building, a pump house, and seven fuel tanks (Woodward 1972). The Coast Guard maintained the station until 1992.

In 1993, the State of Hawai'i Department of Land and Natural Resources, Division of Forestry and Wildlife (DLNR/DOFAW) worked with the Coast Guard to demolish the majority of the buildings on the island. Only one small brick house, a storage shed, a water tank, and the runway remain on Green Island. DLNR/DOFAW manages Kure Atoll as a State Wildlife/Seabird Sanctuary. Since 1994, DOFAW has set up an annual field camp on the island to monitor seabird populations, conduct habitat restoration, monitor Hawaiian Monk Seals and remove the marine debris from the shoreline and coral reefs. National Marine Fisheries Service has an annual field camp each summer on Kure Atoll to monitor Hawaiian Monk Seals. For the past five years, researchers have also been monitoring a resident population of *nai'a* (Hawaiian spinner dolphins) in the atoll.

History of Research in Papahānaumokuākea

Assessment, monitoring and mapping of the flora and fauna in the Northwestern Hawaiian Islands began nearly a century

ago as exploratory research voyages set sail primarily to collect data and specimens for cataloging purposes. These Western scientific voyages began with the R/V *Albatross* expedition in 1902. The scientific expedition, conducted by the U.S. Fish Commission, visited what were then referred to as the "Leeward Islands," including what is now known as Nihoa, Laysan and Midway. The expedition purpose was mainly to collect samples from the deeper waters around the Hawaiian Islands, and to document newly discovered species of deep-water fishes and invertebrates. In addition to the marine studies, the crew conducted terrestrial explorations, documenting key species as well as collecting photographs of many now-extinct species such as the flightless Laysan Rail.

Shipboard analysis of coral health (Photo: James Watt)

Following the *Albatross* expedition, the next notable scientific voyage was the R/V *Tanager* expedition of 1923–1924. While technically the second phase of exploration (the first by post-contact Native Hawaiians), the *Tanager* was perhaps the first voyage driven entirely by scientific inquiry. Archaeologists and biologists documented archaeological sites and conducted numerous types of surveys all the way to the western edge of the NWHI. Perhaps of most importance was the *Tanager's* documentation of human impact to terrestrial systems. While on Laysan, scientists witnessed the extinction of the endemic Laysan *'apapane* (Hawaiian honeycreeper, with crimson body and black wings and tail (*Himatione sanguinea freethi*)) when the three remaining birds died during a storm. They also recorded the vast changes in vegetation and birdlife that had taken place over the previous 20 to 30 years. During this period, mining for guano, the introduction of rabbits, and the harvest of seals and birds took an enormous toll on the island ecosystem. Of the 27 species of plant life that were originally documented before these extraction activities, only four remained in 1923 (Grigg 2006). In addition to documenting ecological change, archaeologists at Nihoa and Mokumanamana discovered extensive artifacts and ruins, some of which are unlike any known from the main Hawaiian Islands.

Historical scientific expeditions, such as the Rothschild and Schauinsland expeditions of the late 1890s, the *Albatross* in 1902, and the *Tanager* in 1923 and 1924, briefly explored the islands in the pursuit of scientific knowledge. However, their activities were generally limited to species inventories and the collection of large numbers of specimens. For example, the 1896 Schaunsland expedition collected at least 271 skins of 25 bird species, whereas J. J. Williams' trip in 1892–1893 yielded "several barrels of stuffed birds."

From 1963 through 1969, numerous voyages were made to the NWHI as part of the Pacific Ocean Biological Survey Program (POBSP) and the Smithsonian Institution. A number of biologists took part in ten trips to French Frigate Shoals, where numerous specimens were collected and data were gathered. The main goals of this program were to

Pristine Papahānaumokuākea reef with numerous Acropora coral colonies, a species extremely rare in the main Hawaiian Islands (Photo: James Watt)

learn what plants and animals occurred on the islands, the seasonal variations in abundance and reproductive activities, and the distribution and population of the pelagic birds of that area. During this project, more than 10 million square kilometers of the central Pacific Ocean were surveyed, and numerous publications were released in the Smithsonian's *Atoll Research Bulletin*.

Following the vast POBSP studies of the 1960s, the Tripartite NWHI Fishery Investigation expeditions in the mid 1970s aimed to establish information baselines on the flora and fauna in the area. These expeditions were unique in that three major agencies (National Marine Fisheries Service, U.S. Fish and Wildlife Service, and the Hawai'i Division of Fish and Game) actively collaborated to create an integrated research program in the NWHI. This collaboration provided a unique opportunity to document the relationships between species and assess the effects of commercial fishing and other activities on the region's ecosystems. This endeavor also launched the first intensive marine-based research expedition. Although the Tripartite expeditions laid the groundwork for management plans covering a variety of resources, much of the research of these expeditions was geared toward resource assessment, with a primary focus on commercially important species.

In the late 20th century, scientific research efforts underwent a paradigm shift, becoming more focused on knowledge and conservation of the natural ecosystems. This shift stemmed from the recognition that increased technology and human populations have created significant pressures on ocean ecosystems. In 2000, the State of Hawai'i, U.S. Fish and Wildlife Service, NOAA and several research institutions launched the NWHI Reef Assessment and Monitoring Program (NOWRAMP) to characterize and monitor coral reefs and establish a baseline for comparison and to facilitate monitoring temporal changes in the ecosystem. In addition to this group, NOAA has also initiated a comprehensive mapping effort using satellite imagery, multibeam sonar, and other remote sensing techniques to provide detailed characterizations of benthic habitats.

Several NOAA vessels have been commissioned primarily to support the research and mapping activities in the area that has become known as Papahānaumokuākea, and as a result multiple scientific projects have been initiated in the region. These activities range from basic monitoring of various species and environments to technologically advanced studies incorporating the latest scientific tools such as genetic analyses, satellite tagging, and deep water submersibles. More recent scientific voyages to Papahānaumokuākea Marine National Monument are far less extractive, and are of extraordinary benefit to the preservation and protection of the area's natural resources. These cruises generally take tiny biopsies of corals, or collect feathers or scat from the beaches, and using modern laboratory techniques, have produced important information on key management issues such as population connectivity. Papahānaumokuākea is one of the world's largest marine protected areas; an enhanced understanding

Volunteers participate in the annual Midway Atoll National Wildlife Refuge albatross count. Each active nest is marked as it is counted
(Photo: Roy Lowe)

Laysan Duck

Papahānaumokuākea Marine National Monument is home to one of the world's rarest ducks, *Anas laysanensis*, commonly known as the Laysan Duck. Having the most restricted range of any duck species worldwide, the remaining Laysan Ducks have been relegated to a single naturally occurring population on one island in the Northwest Hawaiian Islands. The species was extirpated from most other islands of the Hawaiian Archipelago after the arrival of the first humans approximately 1,500 years ago. Bones of the Laysan Duck have been found on the islands of Hawai'i, Maui, Moloka'i, O'ahu, Kaua'i and Lisianski. Total estimated population sizes on Laysan Island have ranged from seven to 688 adult birds in the past century, while a recent population estimate cites 459 adults. Viability models for species with small populations and high isolation predict a high risk of extinction due to catastrophic, environmental, genetic, and/or demographic stochasticity. As a result, the Laysan Duck is the subject of intensive active management, research and restoration actions.

The recovery of the Laysan Duck focuses on the following actions: 1) management to reduce risks to the Laysan Island population; 2) protection and enhancement of suitable habitat; and 3) actions to reduce or eliminate threats sufficient to allow successful reestablishment of additional wild populations.

Activities to increase the longevity of this species in recent years have focused on translocations to establish the species on additional islands and atolls within Papahānaumokuākea. Midway Atoll, part of the National Wildlife Refuge System, was chosen as the most promising site for initial translocations. Eighteen months of extensive habitat restoration and modification were required to prepare for the arrival of the ducks. Refuge staff and volunteers excavated nine shallow freshwater seeps, removed non-native plants, planted native vegetation to provide cover, forage and nesting habitat and constructed 16 holding aviaries to provide for a "soft-release" of the translocated ducks.

Within three years, and while overcoming the challenges of working in the most remote island system in the world, these teams have successfully established breeding populations of Laysan Ducks on two different islands of Midway Atoll, and are now at work preparing for the translocation and establishment of a third population on yet another island. The creation of additional breeding populations has greatly reduced the likelihood of extinction of the Laysan Duck, and the team's continuing efforts toward further reintroducing the species, expanding its range and increasing its population size has set the species on the road to recovery.

An endangered Laysan Duck nurtures its newly hatched brood on Midway Atoll National Wildlife Refuge. The Laysan Duck, Anas laysanensis, is one of the rarest ducks in the world (Photo: Jimmy Breeden)

of this place through management-driven research continues to benefit the understanding of ecosystem management and interpretation.

Overall, the most recent scientific expeditions to the NWHI are not unlike the voyages undertaken at the turn of the century. As in initial expeditions, the primary focus of research in recent and forthcoming expeditions is of comprehensive data collection, and with the technology now available, new discoveries. To advance scientific understanding of the region, Papahānaumokuākea is working toward synthesis of all the various data and modeling programs to allow an in-depth understanding of the area and the processes on which the health of the region depends. With the wealth of new information being collected each year, this information can be utilized to combine and synthesize the vast ranges of information from various agencies and institutions, and from them, develop a new management paradigm.

Management in the Modern Era

Due to its remote location, the property has suffered relatively few major human perturbations. During the 19th and 20th centuries, the NWHI faced many extractive uses as Honolulu became an important port in the Pacific, and provided a convenient jumping-off point. Extractive activities included whaling, hunting of monk seals and birds, and fishing for shark, turtle, sea cucumbers, and pearl oysters. Terrestrially, several of the islands were leased for guano extraction, and feathers and albatross eggs were collected. The most significant activities of this nature occurred on Laysan and Lisianski Islands and Midway Atoll. All of these activities ceased by the early 20th century, when American President Theodore Roosevelt acknowledged the need to protect the region's birds, setting aside the islets and reefs of the Northwestern Hawaiian Islands (except Midway Atoll) as the Hawaiian Islands Reservation. Since then, numerous efforts have been made to eradicate alien species, and to protect, preserve, maintain and, where appropriate, restore natural communities, including habitats, populations, native species, and ecological processes as a public trust for current and future generations.

The lands and the waters of Papahānaumokuākea have always been remote, and therefore not heavily accessed. Thus, use of the natural resources of the property was historically minimal and sporadic. In recent years, human access to the property has been primarily limited to commercial fishing, conservation and management, and research activities. At times, longline, crustacean and bottomfish fisheries have operated in Papahānaumokuākea. However, even before the designation of the National Monument, only the bottomfish fishery continued to operate under a limited-entry system. This fishery continues to operate in Papahānaumokuākea, limited to no more than eight permitted vessels that are capped in terms of catch. All commercial fishing will cease in 2011, as per terms of Presidential Proclamation 8031.

Current management strategies result in careful scrutiny of activities within the property, with particular attention to cumulative impacts. This oversight ensures that any potential negative human impact to the natural resources of Papahānaumokuākea will be negligible.

Management and conservation activities that take place within Papahānaumokuākea Marine National Monument undergo the same rigorous review and permitting process as scientific activities. Examples of management and conservation activities include the continuation of a decade-long effort to remove marine debris from the coral reefs and beaches of the property, alien plant species removal projects on several islands, and restoration of native plant and animal species.