Management Concerns and Responsibilities

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INTRODUCTION

Increasing pressures on the world's ocean resources in the recent decades has heightened the need for protecting marine resources. Marine Protected Areas (MPA) are an essential tool for achieving marine ecosystem-based management. MPAs in the Pacific, such as Papahanaumokuakea Marine National Monument, the Australia's Great Barrier Reef Marine Park and the Phoenix Islands Protected Area in Kiribati lead the world in protecting large-scale marine ecosystems. Each of these MPAs conserves vast contiguous areas of ecosystems ranging from shallow water coral reefs to deep water communities.

The Papahanaumokuakea Marine National Monument (Monument) is one of the largest and most unique MPAs in the world. The Monument contains relatively pristine ecosystems and cultural resources minimally affected by human activities. In seeking to preserve and protect these attributes, Monument managers identified the following mission: "Carry out seamless integrated management to ensure ecological integrity and achieve strong, long-term protection and perpetuation of the NWHI ecosystems, Native Hawaiian culture, and heritage resources for the current and future generations" (Papahanaumokuakea Marine National Monument, 2008).

Striving to achieve this far-reaching mission creates unique opportunities and challenges for Monument managers. These opportunities include the potential to manage complete ecosystems with few anthropogenic inputs and working toward restoring components of the ecosystems that have been modified. Challenges revolve around the remote and vast nature of the Monument, and include threats local to global and internal and external to the Monument. This chapter focuses on management of the Monument. This includes:

- Management structure;
- Management of protected marine species within the Monument;
- Management of greatest potential threats to the marine resources across the region; and
- Management of human activities.

BACKGROUND

Management Structure

On June 15, 2006, President George W. Bush issued Presidential Proclamation 8031 (Proclamation) establishing the NWHI Marine National Monument under the authority of the Antiquities Act of 1906 (16 U.S.C. 431). It was subsequently renamed the Papahanaumokuakea Marine National Monument. The Monument includes a number of preexisting federal conservation areas: the NWHI Coral Reef Ecosystem Reserve, managed by the Department of Commerce through the National Oceanographic and Atmospheric Administration (NOAA) Office of National Marine Sanctuaries; Midway Atoll National Wildlife Refuge, Hawaiian Islands National Wildlife Refuge, and Battle of Midway National Memorial, managed by the Department of the Interior through the United States Fish and Wildlife Service (USFWS). These areas remain in place within the Monument, subject to their applicable laws and regulations in addition to the provisions of the Proclamation.

The NWHI also include state of Hawaii lands and waters, managed by the Hawaii Department of Land and Natural Resources (DLNR) as the NWHI Marine Refuge and the State Seabird Sanctuary at Kure Atoll. These areas also remain in place and are subject to their applicable laws and regulations.

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2. Clancy Environmental Consultants, Inc.
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The organizational structure for the Monument consists of:

- Three Co-Trustees-- Department of Commerce, Department of the Interior and the State of Hawaii-- responsible for the management of the Monument. The Co-Trustee agencies have developed a joint management plan that will guide management of the Monument for the next 15 years;
- A Senior Executive Board composed of a designated senior policy official from each Co-Trustee agency that is directly responsible for providing oversight and guidance for management of the Monument;
- A Monument Management Board composed of representatives from the federal and state agency offices that carry out the day-to-day management and coordination of Monument activities; and
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- An Interagency Coordinating Committee representing other state and federal agencies as appropriate to assist in the implementation of Monument management activities.

Management Zones

Monument regulations define three types of marine zones within the Monument (Figure 10.1):

1. Special Preservation Areas: These are discrete, biologically important areas of the Monument where resource harvest and almost all forms of discharge are prohibited;
2. Ecological Reserves: These areas consist of contiguous, diverse habitats that provide natural spawning, nursery, and permanent residence areas. Resource extraction is highly restricted within Ecological Reserves; and
3. Midway Atoll Special Management Area (SMA): Recreational activities in the Monument are restricted to the Midway Atoll SMA.

Zoning not only provides protection to highly sensitive habitats, it also protects the ecological linkages between these habitats. Each zone addresses a number of factors including the protection of habitat and foraging areas of threatened and endangered species; the inclusion of a representative range of the diverse array of marine

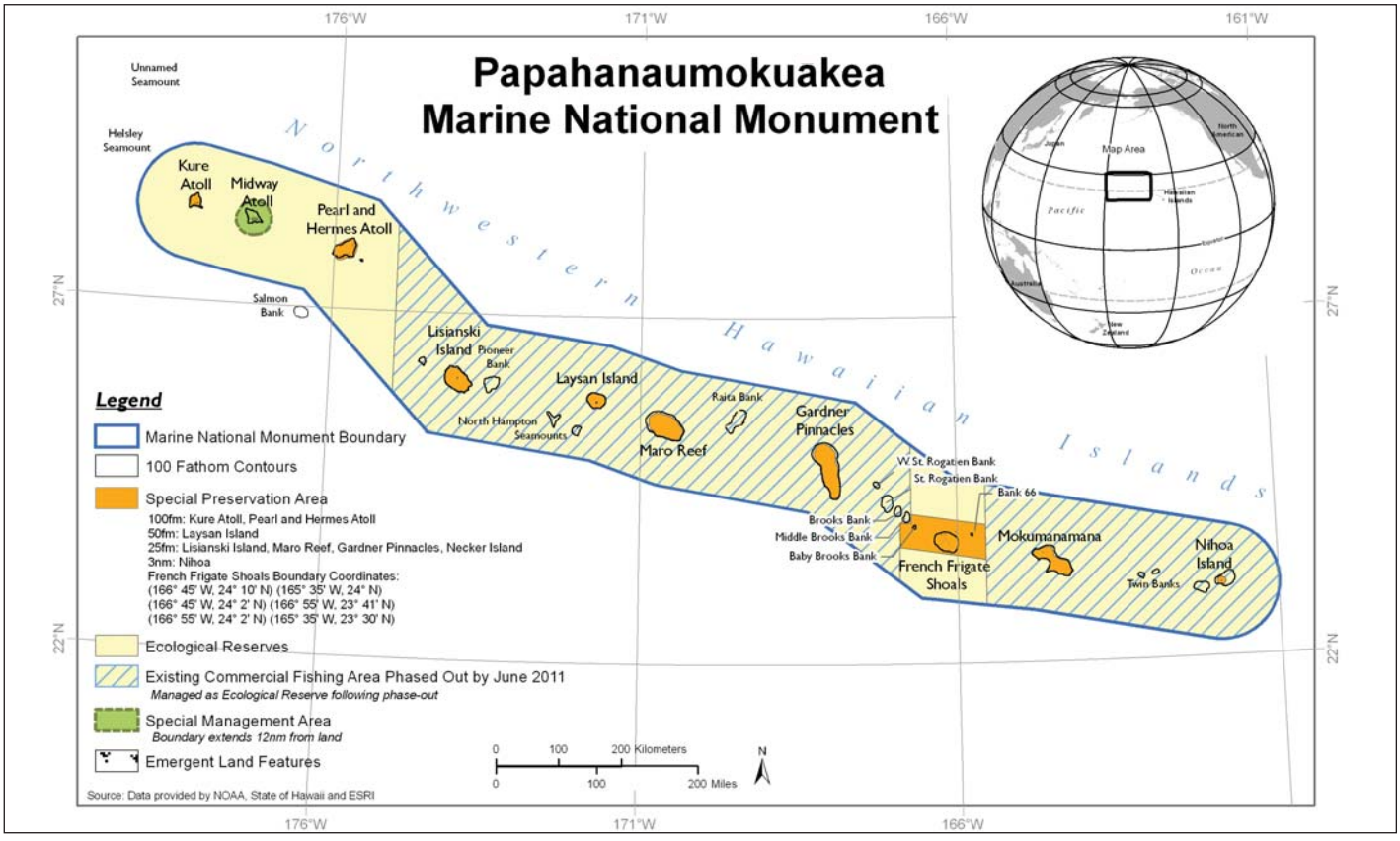

Figure 10.1. Map of the Papahanaumokuakea Marine National Monument and zones. Map: PMNM.

habitats, including shallow coral reef environments, as well as deepwater slopes, banks and seamounts; and finally, the minimization of risks associated with specific activities such as fishing and recreational activities. As of June 2011 all commercial fishing will be prohibited within the Monument.

In addition to the designation of the Monument management zones, in 2007 the Monument was designated "in principle" as a Particularly Sensitive Sea Area (PSSA) by the International Maritime Organization (IMO), a Specialized Agency of the United Nations (Figure 10.2). The designation puts into effect internationally recognized measures designed to protect marine resources of ecological or cultural significance from damage by ships while helping keep mariners safe. PSSA designation augments domestic protective measures by alerting international mariners to exercise extreme caution when navigating through the area. A U.S. proposal for PSSA designation was submitted in April 2007 for consideration at the IMO's Marine Environment Protection Committee meeting with the final designation made in April 2008. PSSA designation has been granted to only 10 marine areas globally, including the marine areas around the Florida Keys, the Great Barrier Reef and the Galapagos Islands. The PSSA area is coterminous with the Monument boundary.

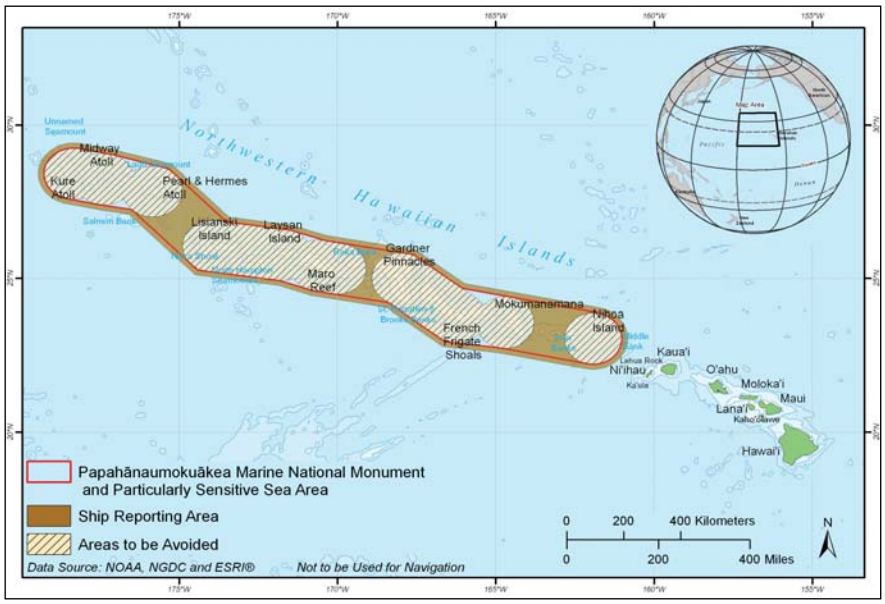

Figure 10.2. PSSA, Areas to be Avoided (ATBA) and Ship Reporting Boundaries around the Papahanaumokuakea Marine National Monument.

In addition to alerting international mariners to exercise extreme caution when in the area, as part of the PSSA designation process, the IMO's Maritime Safety Committee adopted the U.S proposals for the associated protective measures (APMs) of: (1) the expansion and amendment of the six existing recommendatory Areas to be Avoided (ATBAs) in the area, which would enlarge the class of vessels to which they apply and augment the geographic scope of these areas, as well as add new ATBAs around Kure and Midway atolls; and (2) the establishment of a ship reporting system for vessels transiting the Monument, which is mandatory for ships 300 gross tons or greater entering or departing a U.S. port or place and recommendatory for other ships. These APMs were implemented in May 2008.

WORLD HERITAGE NOMINATION

The unique habitats and ecosystems within the Monument are of great importance to local, regional and global marine biodiversity (Figure 10.3). The Monument contains some of the world's most significant marine and terrestrial ecosystems and areas of cultural significance, and is one of the world's largest protected marine areas. It also serves as an example of ongoing geological processes and biological evolution. The volcanic rocks, large atolls of sand and coral, and islets surrounded by reefs provide unique habitats for endemic and rare species of animals and plants. These features are of universal value from scientific, conservation, cultural and aesthetic perspectives. This relatively pristine region contrasts sharply with most insular and marine ecosystems, which are more severely affected by human activities and populations around the world.

In January 2008, Papahanaumokuakea was selected by the Secretary of the Interior to be included as a candidate for the U.S. Tentative List for nomination as a World Heritage mixed site due to its exceptional natural and cultural importance. World Heritage is the designation for places on earth that are of outstanding universal value to humanity and as such, have been inscribed on the World Heritage List to be protected for future generations to appreciate and enjoy. In early 2009, the U.S. put forth a full nomination package to the World Heritage Centre to have the Monument added to the World Heritage List. The Monument was recommended

for consideration as a World Heritage Mixed Site. The reasons for listing for the Monument for natural values include:

Figure 10.3. The variety of ecosystems within the Monument have been recognized for their uniqueness and importance to global marine biodiversity. Photos: J. Watt.

- The string of islands comprises a classic, important and unparalleled example of later stages of island and atoll evolution. The archipelago has provided some of the most compelling confirmation of current theories of global plate tectonic movements;
- Papahanaumokuakea is a spectacular example of evolution in isolation, which results in enhanced speciation and a phenomenally high degree of endemism in both marine and terrestrial flora and fauna. The coral reef ecosystems of Papahanaumokuakea also represent on of the worlds's last apex predator dominated ecosystems, a community structure characteristic of coral reefs prior to significant human exploitation; and
- The region is home to, and a crucial refuge for, many endangered, threatened, and endemic species, including critically endangered marine mammal, bird, and plant species for whom it is the last or only refuge anywhere on earth. Papahanaumokuakea is also the largest tropical seabird rookery in the world.

Remote, uninhabited and relatively pristine in comparison to other marine ecosystems in the world, the Monument has the potential to serve as one of the few reference sights for monitoring and deciphering short-term and long-term responses to local, regional, and global environmental and anthropogenic stressors. The Monument is one of the few regions on Earth where monitoring and research activities can be conducted in the virtual absence of local human habitation. In comparison, most reef systems in the coastal regions of the world are adjacent to human population centers, where vessel traffic, overharvesting, sedimentation, habitat destruction, and other human actions have altered the terrestrial and adjacent marine environments. Ongoing research, monitoring, habitat restoration and conservation management of the insular and marine ecosystems in the NWHI will continue to provide significant insights that will benefit management interventions not only for the NWHI, but for insular and marine ecosystems around the world.

MANAGEMENT OF PROTECTED SPECIES

The NWHI provides habitat for a wide variety of species including species specifically protected by federal acts and state statutes. Three federal acts, as well as multiple state statutes, provide protections for specific species in the NWHI. The federal acts are the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA) and the Migratory Bird Treaty Act (MBTA). The ESA of 1973 provides for the conservation of species at risk of extinction throughout all or a significant portion of their range, and the conservation of the ecosystems on which they depend. The state of Hawaii has adopted specific criteria for indigenous species to be listed as threatened or endangered, as codified in chapter 195D-4, Hawaii Revised Statutes (HRS), as well as chapter 183D, HRS Wildlife, and chapter 125, Wildlife Sanctuaries, Hawaii Administrative Rules Title 13. The MMPA provides protection and conservation of all marine mammals whether or not listed under the ESA. The MBTA is a domestic law that implements the United States' commitment to four international conventions (with Canada, Japan, Mexico and Russia) for the protection of shared migratory bird resources. All migratory birds and their parts (including eggs, nests and feathers) are fully protected.

The Monument provides habitat for many protected marine species including the Hawaiian monk seal, five cetacean species, five marine turtles and five bird species (Figure 10.4).

Figure 10.4. The various ecosystems within the Monument are inhabited by of protected species, including marine mammals, marine turtles and seabirds. Photos: J. Watt (right), T. Summers (center) and USFWS (left).

Hawaiian Monk Seal

The Hawaiian monk seal (*Monachus shauinslandi*) is in crisis. The population is in a decline that has lasted 20 years, and today only about 1,200 monk seals remain. Modeling predicts that the species' population will fall below 1,000 animals by the year 2012. Actions to date have not been sufficient to result in a recovering population. Most of the population of Hawaiian monk seals breed and forage inside the Monument boundaries. NOAA's National Marine Fisheries Service (NMFS) is the primary federal agency responsible for the management of the Hawaiian monk seal and has identified the recovery of this species as the number one priority, based on the high magnitude of threats, the high recovery potential, and the potential for economic conflicts while implementing recovery actions. NMFS recently updated its Hawaiian monk seal recovery plan and has detailed several key actions required to address current and potential threats to the recovery and survival of this critically endangered species (NMFS, 2007). To advance these efforts, the Monument management board is pursuing several key strategies as identified in its management plan in support of monk seal recovery efforts (PMNM, 2008).

Cetaceans

Sightings and acoustic recordings of baleen whales, as well as toothed whales and dolphins have been documented throughout the Monument. Five species of baleen whales listed as "endangered" under the ESA and as "depleted" under the MMPA have been sighted or heard in the Monument area. In addition to these five, the endangered sperm whale (*Physeter macrocephalus*) and at least 18 other non-ESA listed species are found in the Monument (see the Marine Protected Species chapter for more information). It has now been documented that humpback whales (*Megapera novaeangliae*) are calving in the eastern portion of the Monument (Johnston et al., 2007). Recovery actions for this listed species are summarized in the final recovery plan for the humpback whale (NOAA Fisheries, 1991). Draft recovery plans are available for the fin whale and sperm whale (NOAA Fisheries, 2006a, 2006b), and a final plan is available for the recovery of the blue whale (NOAA Fisheries, 1998).

Marine Turtles

The Hawaiian green turtle (*Chelonia mydas*), hawksbill (*Eretmochelys imbricate*), loggerhead (*Caretta caretta*), and leatherback (*Dermochelys coriacea*) turtles are known to occur within the Monument boundaries. While there are no records of the endangered olive ridley (*Lepidochelys olivacea*) within Monument waters, their wide distribution throughout the tropical Pacific makes it plausible that they also occur there Green and loggerhead sea turtles are listed as threatened species; the hawksbill and leatherback turtles are classified as endangered species. Recovery plans and five-year reviews jointly published in 2007 are in place for each of these species in the Pacific (NOAA Fisheries and USFWS, 1998a; 1998b; 1998c; 1998d; 1998e, 2007). Sea turtle population declines have occurred across the Pacific due to nesting habitat loss, fishery interactions and the harvest of eggs and turtles for commercial and subsistence purposes. About 90% of the green turtles

in the Hawaiian Islands nest in the NWHI, the majority on a few islets at French Frigate Shoals (Balazs and Chaloupka, 2004). Green turtle populations have steadily increased in Hawaiian waters since the species was added to the list of threatened species in 1978.

Seabirds

Five endangered bird species in the NWHI are protected under the ESA. The only seabird occurring in the NWHI listed under the ESA is the Short-tailed Albatross (*P. albatrus*). The other four ESA listed endangered bird species are the Laysan Duck, Laysan Finch, Nihoa Finch and Nihoa Millerbird.

The Short-tailed Albatross breeds primarily on Torishima, an island owned and administered by Japan. The Short-tailed Albatross was first observed at Midway Atoll between 1936 and 1941. Since then, one to three individuals have been observed every year in the NWHI, primarily on islands in the northwestern half of the Monument. Although short-tailed albatrosses do not currently nest in the NWHI, a small number of adult birds conduct breeding displays each year at Midway Atoll. The Short-tailed Albatross Draft Recovery Plan provides recommendations for ways in which Monument staff can facilitate recovery of this species (USFWS, 2005).

The Laysan Albatross (*P. immutabilis*) and the Black-footed Albatross (*P. nigripes*) are both considered endangered by International Union for Conservation of Nature (IUCN) and BirdLife International. Both species breed in the NWHI and also forage outside of the Monument. A Conservation Action Plan for both Black-footed Albatross and Laysan Albatross (Naughton et al., 2007) has been developed to provide managers with a framework for the conservation of both species. In addition to the three albatross species that occur in the Monument, another 18 species of seabirds and five species of shorebirds that regularly breed and overwinter, respectively, in the NWHI, are fully protected under the MBTA. The Monument Management Plan (MMP) includes activities to protect and enhance seabird and shorebird habitat and to minimize impacts of habitat destruction, contaminants and fisheries interactions

Management and conservation of migratory species such as cetaceans, marine turtles and seabirds will require coordination with international partners and conservations organizations outside of the Monument.

MANAGEMENT OF THREATS TO THE ECOSYSTEM

Anthropogenic activities impact oceans worldwide (Halpern et al., 2008). On a global scale, the highest ranking threats to coral reefs were identified as sedimentation, coastal development, trampling and nutrient inputs (Halpern et al., 2007). At a regional scale, these threats vary by location. The remoteness of the Monument as well as its limited emergent land results in a different suite of identified ecosystem threats.

The Monument is affected by past changes to the ecosystem as well as current on-going threats. The emergent land areas and potentially some near shore waters continue to be affected by contaminants left over from military use of the islands. During World War II, large scale modifications such as channelization were made to the environment which changed the flow of water within the atolls and continues to impact the local ecosystem. In addition, marine species that also use emergent land such as seabirds are negatively impacted by invasive terrestrial species and other terrestrial based threats such as contaminants. It is important for mangers to be able to identify the potential threats and evaluate the impact of the threat to the overall functioning of the ecosystem at a local scale as well as a regional scale.

In a recent threat analysis of the NWHI region, 24 potential threats were analyzed based on vulnerability factors and order of magnitude of the threat (Selkoe et al., 2008; Table 10.1). The analysis was focused on threats to the marine environment across the NWHI region. A systematic and quantitative method was used to collect and synthesize expert opinion on the ecological effects of these potential anthropogenic threats to the region.

The following discussion of threats to the Monument focuses on the top four threats identified across ecozones for the region by expert opinion. These threats are:

1. Climate change
2. Marine debris/ghost fishing
3. Alien species
4. Ship groundings

Table 10.1. Potential threats analyzed by Selkoe et al., 2008. Source: Selkoe et al., 2008.

THREAT	EXPLANATION
Alien species	Includes only populations that have established, not single sightings
Anchor damage	Includes large anchors in deepwater and small anchors of tender boats
Aquarium collecting	Primarily aquarium trade activities, only one example of legal event to date
Bottomfishing	An ongoing fishery for a suite of deepwater snapper and grouper using hydraulic handlines >100 fathoms depth outside three nautical miles. Boats also troll in transit, impacting pelagic fish and birds
Coastal engineering	The lingering impacts of past dredging, seawalls and pier construction, and ongoing maintenance activities, primarily at Midway and French Frigate Shoals
Diver impacts	Includes diving for any purpose (but it primarily occurs for research); may cause disturbance to animals, damage to corals, potential for inter-site transfer of micro-organisms
Ghost fishing	A subcategory of marine debris - mostly discarded monofilament and rope nets and some lost lobster traps that ensnare and drown animals and smother reefs
Increasing UV radiation	Increased ultraviolet radiation from the anthropogenic thinning of the ozone layer
Indigenous fishing	Fishing by native Hawaiians for consumption - this potential activity is likely focused on southeast end of NWHI
Chemical contamination	The leeching of chemical waste from past and ongoing military activities and habitation, primarily at Midway and French Frigate Shoals
Lobster fishing	Lobster fisheries were halted in 2000 due to population collapses. Only lingering impacts were considered -- there has been little rebound of lobster to date, potentially impacting lobster predator populations (e.g. monk seals)
Marine debris	All types of man-made materials (including plastics and derelict fishing gear) that may break corals, entangle animals, are ingested by animals and accumulate on beaches
Recreation	Any recreational activities not covered by fishing and diving, such as boating, water sports, and wildlife viewing.
Pelagic fishing	Pelagic fishing is banned in NWHI waters but biological connection to the wider Pacific where longlining and net fishing is intense may impact NWHI species which forage in the Pacific, both as bycatch and because the tuna on which some birds depend for foraging are being depleted
Research installations	Installation of equipment or otherwise modifying benthos, or disturbing animals
Research wildlife sacrifice	Any lethal sampling of organisms for research activities
Sea level rise	Increased sea level from the anthropogenic warming of the planet. May alter habitat availability and stress populations of depth-dependent species like corals
Sea temperature rise	Increased temperature from the anthropogenic warming of the atmosphere. A suspected cause of increases in coral bleaching and coral disease, among other potential effects
Sea water acidification	Decreased sea water pH due to the anthropogenic carbon loading of the atmosphere
Ship groundings	Includes the damage and disturbance from grounding, fuel spill, debris, cyanobacteria inoculation and debris removal.
Ship pollution	Includes the discharge of bilge water, sewage, spilled fuel, trash and noise and light pollution. Includes all types of vessels (fishing, research, shipping, tourist).
Sport fishing	Most relevant to southeast end of chain, the lingering impacts of the abated catch-and-release operation at Midway and Pearl and Hermes, and ongoing trolling during ship transit
Trampling damage	Walking on beaches, intertidal, emergent land and reef flats not associated with diving
Vessel strikes	When a small or large vessel hits benthic communities or large mobile animals while in transit, without grounding

Managers recognize the need to evaluate threats based upon the source and impact of the identified hazard. If a threat occurs within the management boundary, managers have more opportunity to successfully mitigate the threat. Threats generated outside of the management boundary still require a response, but they are often more difficult to prevent. Of the top four identified threats to the Monument, climate change and marine debris originate outside the boundaries of the Monument. Alien species establishment and ship groundings are considered locally-based threats that occur within the Monument boundaries.

Climate change factors are already affecting the NWHI ecosystem and will have a widespread impact. Sea-level rise is already impacting available habitat for species such as the Hawaiian monk seal, green turtle and the seabirds. The impact from sea surface temperature (SST) changes will be seen throughout the ecosystem including coral bleaching and potential impacts to prey species for seabirds and other predators. Marine debris was also identified threat from outside the Monument that will impact many different ecozones.

Alien species and ship groundings are identified as high local threats because they have a potentially large impact on ecosystem function and long recovery times. To date, the threat of alien species may not be highly significant in marine areas within the NWHI (i.e., 13 marine alien species currently known to occur within the Monument) but the potential impact from an introduction could be widespread. There is always the potential for ship groundings but emergency response plans to minimize the impacts of the groundings are under development

Selkoe et al. (2008) evaluated, eight different ecozones (Table 10.2). A finer-scale threat analysis can occur by examining the ecozones and assessing how a threat may impact each specific area. The inner and outer reef zones were identified as the most vulnerable. Emergent land was considered vulnerable because of sea level rise and the potential loss of habitat. The shallow water ecozones were more vulnerable to extra-boundary threats than local threats. Many of these top threats are difficult for local managers to control because they arise from activities outside the Monument boundaries, indicating that additional work is needed to preserve the NWHI despite its highly protected status. The analysis indicates where interagency cooperation in removing and mitigating threats should be focused (Selkoe et al., 2008)

Table 10.2. Ecozones evaluated in the threat analysis. Source: Selkoe et al., 2008.

ECOZONE	DESCRIPTION	DISTRIBUTION
Terrestrial	Interior land distinct from the littoral zone	Kure, Midway, Lisianski, Lysan, Mokumanamana and Nihoa
Rocky Intertidal	Solid substrate at intertidal depth composed of basalt rock	Gardner Pinnacles, La Perouse Pinnacle (French Frigate Shoals), Mokumanamana and Nihoa
Sandy Beach	Intertidal beach and adjacent shallows with soft benthos	Kure, Midway, Pearl and Hermes, French Frigate Shoals, Lisianski, Laysan, and Nihoa
Algal Beds	Primarily Halimeda beds in lagoons and deeper terraces, but also small stands of endemic seagrass at Midway	Kure, Midway, Pearl and Hermes,French Frigate Shoals, Lisianski, Laysan, Mokumanamana and Nihoa
Inner Reef	Refers to shallow, mostly protected reef areas (lagoonal, back, reticulated or patch reefs)	Kure, Midway, Pearl and Hermes, Lisianski, Neva Shoals, Laysan, Maro, and French Frigate Shoals
Outer Reef	Exposed seaward reefs from the crest down to the slope less than 30 m depth	Most NWHI locations where depth is <30 m
Deep Reef/ Banks	Deep reef is designated >30 m depth. Banks are sites of high relief benthos in deep waters with rich fish communities, with or without reef builders	There are approximately 30 deep banks in the NWHI. Deep reef is usually found adjacent to any shallow reef area.
Pelagic Waters	The entire water column, from surface to depth, outside of lagoon and shallow reef environments	Makes up the majority of NWHI habitat.

Climate Change

Sea level rise, changing storm intensity and frequency, sea surface temperature (SST) rise and acidification are components of climate change most likely to affect the Monument. Evidence of sea level rise has already begun to adversely affect the available terrestrial habitat and models predict that sea level will continue to rise. SST is monitored via satellite in addition to using buoys at several locations throughout the NWHI, resulting in a long-term temperature time series for Midway Atoll (Jokiel and Brown, 2004). Elevated SST has already

impacted corals as indicated by recent coral bleaching events in the Monument (see Coral Bleaching for more details). With regards to ocean acidification, the third component of climate change most likely to affect the Monument, staff members are in the process of designing experiments to characterize the carbonate chemistry and establish a baseline for the NWHI.

Sea Level Rise

Global mean sea levels have risen an estimated 3.1 ± 0.7 mm yr^{-1} from 1993-2003, an amount higher than any other 10-year period since 1950 (IPCC, 2007). However sea level rise varies regionally and in order to understand the effects on the ecosystem it must be monitored at the island and atoll scale.

One effect of rising sea level in the NWHI is the loss of habitat. Emergent land in the NWHI is estimated at a total 14 km^2 and the loss of available emergent land will greatly reduce the available habitat for many species. The effect of habitat loss on species that use emergent land features will impact many of the species that are already rare and maybe devastating to those populations that depend on these islands for survival. Marine species that will be impacted by sea level rise include the Hawaiian monk seal, green turtle and several seabird species. In addition there is the potential for further habitat degradation with the release of contaminants contained in landfills and other areas as the islands are eroded or flooded from sea level rise.

Table 10.3. Sea level rise scenarios modeled for French Frigate Shoals, Lisianski Island and Pearl and Hermes Atoll. Source: Baker et al., 2006.

SCENARIO	RISE LEVEL	BASE SEA LEVEL
Scenario 1 - Low	9 cm	Mean Low Water (MLW)
Scenario 2 - Low		Spring Tide
Scenario 3 - Median	48 cm	Mean Low Water (MLW)
Scenario 4 - Median		Spring Tide
Scenario 5 - High	88 cm	Mean Low Water (MLW)
Scenario 6 - High		Spring Tide

Evidence of sea level rise can be clearly observed with the submersion of Whaleskate Island within French Frigate Shoals in the late 1990s (Baker et al., 2006). NOAA Pacific Islands Fisheries Science Center (PIFSC) modeled the potential terrestrial habitat loss from sea level rise using estimated sea level rise values and current elevation data collected in the field. The study included islands within Pearl and Hermes Atoll, Lisianski Island and French Frigate Shoals. Pearl and Hermes Atoll and French Frigate Shoals are both composed of small low lying islets surrounded by a barrier reef, whereas Lisianski Island is a single large, low-lying island (Figure 10.5). Six different scenarios using three sea level rise values and two different tide conditions were evaluated (Table 10.3). The results of the modeling indicate that sea level rise will affect each island group differently. Lisianski Island (the largest and highest island in the analysis), could experience the least amount of impact with only a 5% decrease in area using the highest sea level rise scenario. In contrast, the highest seal level rise scenario for the islets at Pearl and Hermes Atoll and French Frigate shoals range from a 25% loss up to 90% loss (Baker et al., 2006). The estimates produced by the model were based on the assumption that the island shape remains constant and the model did not include erosion factors. Efforts to develop a monitoring system of the changes in the size of the islands are currently underway.

Sea turtles are dependent on terrestrial areas for nesting. Islets in French Frigate Shoals support the majority of the Hawaiian green turtle breeding population. The loss of habitat and the possibility for nesting areas to be flooded during nesting times could have a large impact on the species. In other regions, green turtles have demonstrated intra-specific nest destruction once habitat is lost and nest density becomes high (Bustard and Tognetti, 1969). This behavior may occur among nesting Hawaiian green sea turtles in the Monument if nesting habitat is destroyed.

Impacts to seabirds will vary depending upon the species. Over 90% of Black-footed and Laysan Albatrosses breed in the Monument and the loss of habitat in this area could affect the overall world population. The largest breeding populations of these albatross species occur at Midway Atoll and Laysan Island which were not analyzed in the sea level rise study, but habitat loss is expected to be similar to Lisianski Island because they are both large islands. The predicted decrease in area would not be large, but the species remain vulnerable as the islands represent such a critically important breeding area. Other seabird species may also be potentially impacted by the loss of nesting habitat as the result of climate change.

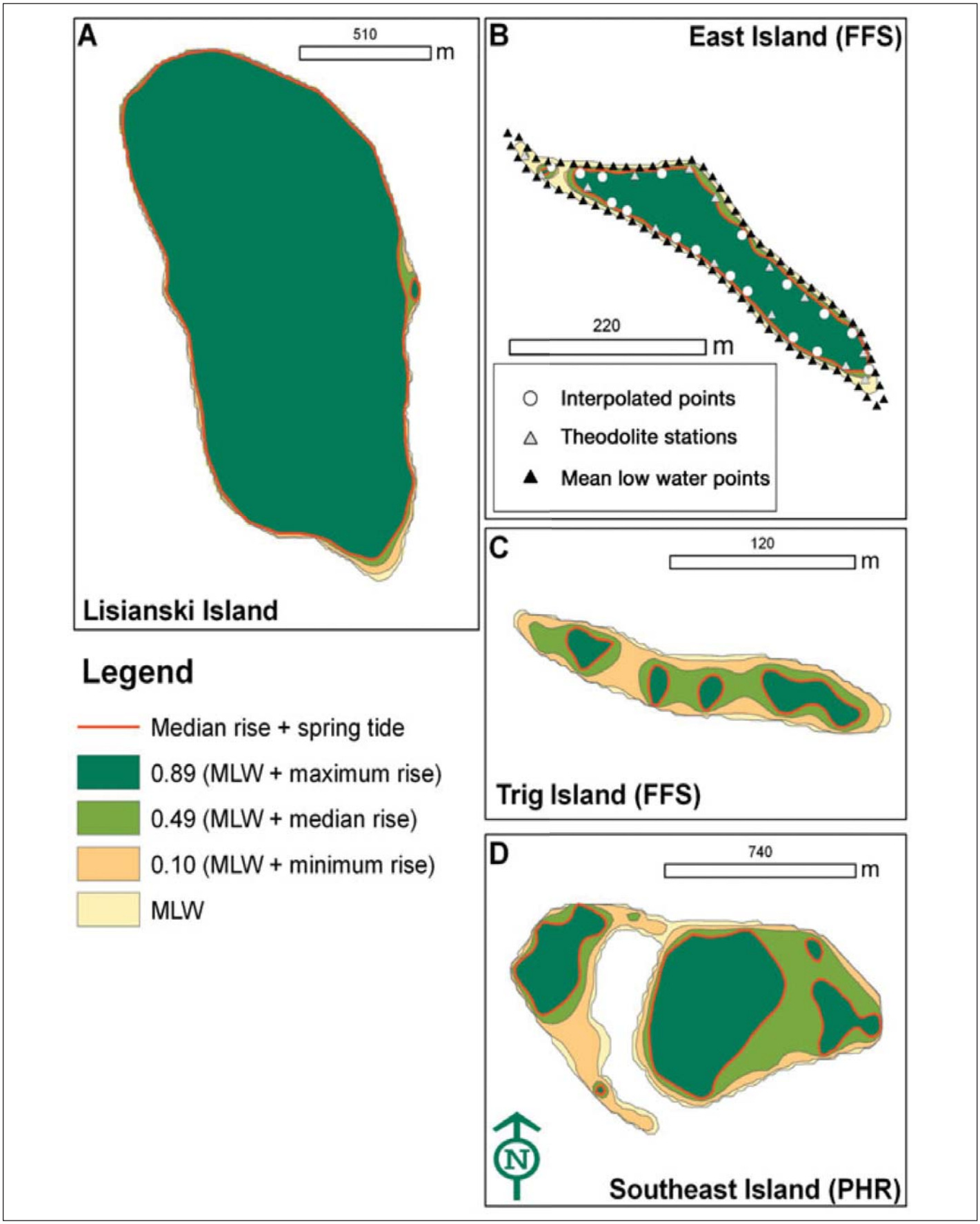

Figure 10.5. Current and projected maps of four NWHI at mean low water (MLW) with minimum (9 cm), median (48 cm) and maximum (88 cm) predicted sea level rise. The median scenario at spring tide is also shown. (A) Lisianski Island; (B) East Island, French Frigate Shoals, showing the measured and interpolated points along the waterline and berm used to create the Triangular Irregular Network (TIN); (C) Trig Island, French Frigate Shoals; (D) Southeast Island, Pearl and Hermes Reef. Source: Baker et al., 2006.

Storm Intensity and Frequency

Global weather patterns appear to be changing and climatologists suggest that the increasing intensity and frequency of storms may be related to modern, anthropogenic influences (IPCC, 2001; Nott, 2003; Nott, 2004; Nott et al., 2007). Studies into storm trends have shown that while SSTs have been rising, the intensity of the storms occurring in this time period has increased (Hoegh-Guldberg, 1999; IPCC, 2001; Hughes, 2003; Webster et al., 2005; IPCC, 2007; NOAA Satellite and Information Service, 2007). While sheer numbers of tropical storms have remained relatively constant, the destructiveness of the cyclones has increased over the past 30 years and hurricanes in the Category 4 and 5 range have nearly doubled since the 1970s (Emanuel, 2005; Webster et al., 2005). If climate patterns follow the projections, storms may continue to increase in intensity over the coming years. As storm intensity increases, the impacts felt by low-lying islands and atolls could prove detrimental to the inhabitants.

The damage from high intensity storms to low lying sand islands was demonstrated in late December 2008 at French Frigate Shoals when high levels of erosion occurred at East Island. Using remote cameras available for monitoring turtle nesting activity scientists at PIFSC were able to evaluate the damage to East Island which included several feet of erosion along the northwest side of the island (G. Balazs pers. comm; Fig 10.6). Monitoring will need to be conducted to evaluate the long-term impact of the erosion event and to determine if accretion will occur to other parts of the island. Researchers active in the NWHI over the past 30 years have observed changes to the size and shape of many of the islands (G. Balazs and J. Maragos, pers. comm.). In order to determine if these observed changes are from sea level rise or storm damage a monitoring program will need to be developed.

Figure 10.6. High levels of erosion on East Island just days after highly intense storms passed through the area in December 2008. Photo: PIFSC and G. Balazs.

Sea Surface Temperature Change

Eleven of the years spanning 1995 to 2006 are ranked among the warmest 12 years of recorded global surface temperature (IPCC, 2007). Temperature change is another component that may impact the Monument's marine ecosystems. The NWHI are monitored as part of the Coral Reef Early Warning System (CREWS). The system provides managers and researchers with telemetered meteorological and oceanographic data at precise locations. In the NWHI, NOAA's PIFSC, Coral Reef Ecosystem Division (CRED) has deployed long-term moored observing stations, satellite-tracked drifting buoys, and subsurface instrumented moorings (Table 10.4 and Figure 10.7) Changes in SSTs will result in changes to available habitat for temperature dependent species and coral bleaching.

As SSTs change species currently using habitat near the surface may move to lower depths or different latitudes to find the appropriate habitat conditions. This will end up impacting other species dependent on these species. For example, seabirds feed on fish and other marine species near the ocean surface. As SST increases, seabird prey species move to deeper, cooler water, decreasing food availability for foraging birds, or requiring birds to fly further north in the Pacific to obtain food resources.

Changes in SST poses a threat to coral reef ecosystems in the form of coral bleaching. Corals are symbiotic organisms which secrete a hard, mineral calcium carbonate structure. The symbiosis is between microscopic, photosynthetic organisms called zooxanthellae that inhabit the soft tissue of the coral polyp. Zooxanthellae provide the pigmentation of the coral and produce energy which is donated to the host and contributes sig-

Table 10.4. Distribution of long-term oceanography monitoring buoys in the Monument.

LOCATION	CREWS-ENH[1]	CREWS-STD[2]	SST-ARGOS[3]	ODP[4]	WTR[5]	STR[6]
Kure	--	X	X	--	X	X
Midway	--	--	X	X	--	X
Pearl and Hermes	--	X	--	X	X	--
Lisianski	--	--	X	--	X	X
Laysan	--	--	X	--	--	X
Maro Reef	--	X	--	--	--	X
Gardner Pinnacles	--	--	--	--	--	X
French Frigate Shoals	--	--	--	--	--	X
Mokumanamana	--	--	--	--	--	--
Nihoa	--	--	--	--	--	--

[1]Coral Reef Early Warning System Enhanced - Moored buoys which provide high resolution SST, barometric pressure, wind speed, wind direction, and additionally provide salinity, UV-B, and PAR.
[2]Coral Reef Early Warning System Standard - Moored buoys which provide high resolution SST, barometric pressure, wind speed and wind direction. Subsets of these data are transmitted daily via satellite telemetry.
[3]Moored buoys which provide high resolution SST. Subsets of these data are transmitted daily via satellite telemetry.
[4]Subsurface Ocean Data Platform - Subsurface moorings, providing high resolution current profiles, directional wave spectra, and temperature and salinity.
[5]Subsurface moorings providing high resolution wave and tide records, temperature and conductivity.
[6]Subsurface moorings providing high resolution temperature. Additionally used on towed platforms for temperature and pressure-based depth.

nificantly to the ability of a coral to grow and reproduce. When a coral is stressed by higher than normal temperatures, sometimes as little as a 2-3ºC increase in temperature above their optimal temperature, they expel their zooxanthellae into the water column resulting in a loss of color (Hoegh-Guldberg, 1999). In this bleached, energy depleted state a coral is more susceptible to disease infiltration and overgrowth by fast-growing turf algae. Anthropogenic activities resulting in increased nutrient loads, sedimentation and physical damage at the site can make bleaching events worse.

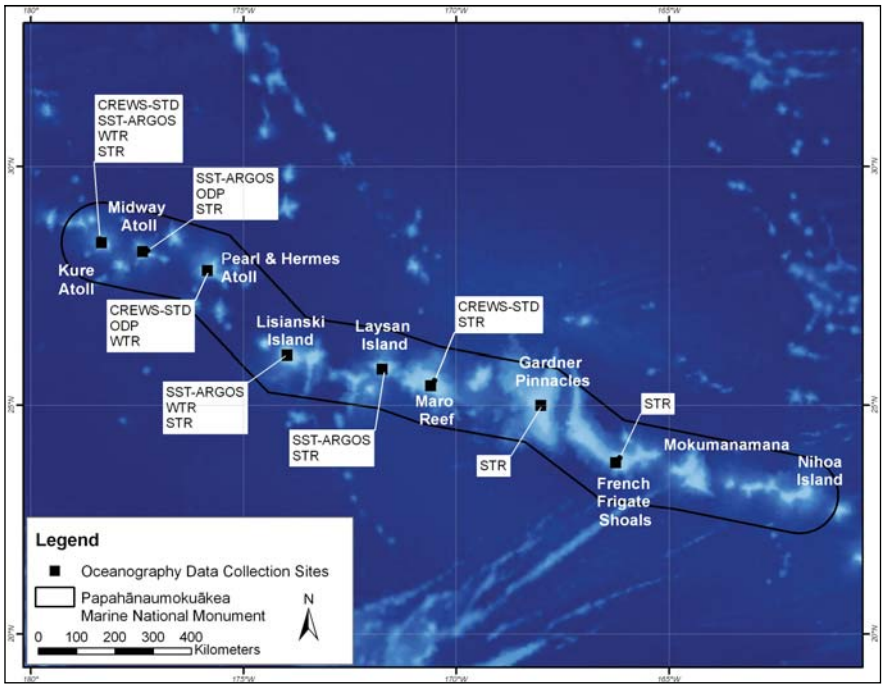

Figure 10.7. Locations of oceanography monitoring buoys in the NWHI. Map: K. Keller.

SST anomalies resulting from regional and global-scale climatic phenomena are believed to be the cause of bleaching in the NWHI. Mass coral bleaching in the NWHI occurred during late summer 2002 (Aeby et al., 2003; Kenyon and Brainard, 2006). This was the first ever recorded bleaching event known to occur in the NWHI. Coral bleaching occurred again at high levels in 2004, and was detected again at low rates in 2006 (Kenyon and Brainard, 2006). The corals in the NWHI were believed to be less susceptible to bleaching due to the high latitude location. Bleaching was most severe, however at the three northernmost atolls (Pearl and Hermes Atoll, Midway Atoll and Kure Atoll), which experience both higher and lower SSTs than other reefs of the NWHI. During the bleaching event, greater magnitude and longer durations of temperature anomalies were recorded and attributed to the bleaching events of 2002 (Hoeke et al., 2006). Lisisanski, Laysan and Maro experienced shorter and less severe temperature anomalies, resulting in comparatively minor bleaching events. Field investigations conducted in 2004 indicate that bleaching occurrence was highest in shallow back reef and patch reef habitats (Kenyon and Brainard, 2006). Researchers from the University of California, Santa Cruz are currently modeling circulation patterns at Midway Atoll to determine if anthropogenic changes to the flow and circulation patters may exacerbate bleaching events.

In addition to using field measurements it is possible to detect potential coral bleaching events using satellite information. NOAA's Coral Reef Watch produces near-real-time alerts from 24 selected reefs around the globe. Midway Atoll is one of the sites that is monitored. Figure 10.8 contains graphs indicating when Midway Atoll SSTs reached levels that are associated with beaching events. The graphs show the 2002 and 2005 SST associated with bleaching events were detected by NOAA's Coral Reef Watch prior to being documented in the field.

The development of a bleaching response plan is critical to effective reef management. This ensures that when a bleaching event occurs, decisive action can be taken as soon as possible to mitigate the effects of the bleaching event. The NWHI will require a unique response plan given that the region is largely free from local sources of anthropogenic stressors, so bleaching is largely a result of increased SSTs. However, managers will work to identify resilient areas based upon the best available information from monitoring data, research projects, past bleaching events and modelling. A bleaching response plan would call for identification of specific groups and actions that should take place prior to a bleaching event, during the event and follow up after SSTs have returned to normal.

Ocean Acidification

Coral reef systems maintain a delicate balance between calcification and erosional forces. For the reef to grow and accrete mass, the corals' ability to calcify must outrun the pressures put upon the system, such as bioerosion, physical erosion from wave action and storms and anthropogenic damage. The NWHI are relatively shielded from most anthropogenic effects due to their remoteness, but they are still subject to natural forces. The shallow and deep water coral reefs in the NWHI will potentially be impacted by changes in the carbonate levels in the ocean. If the reef

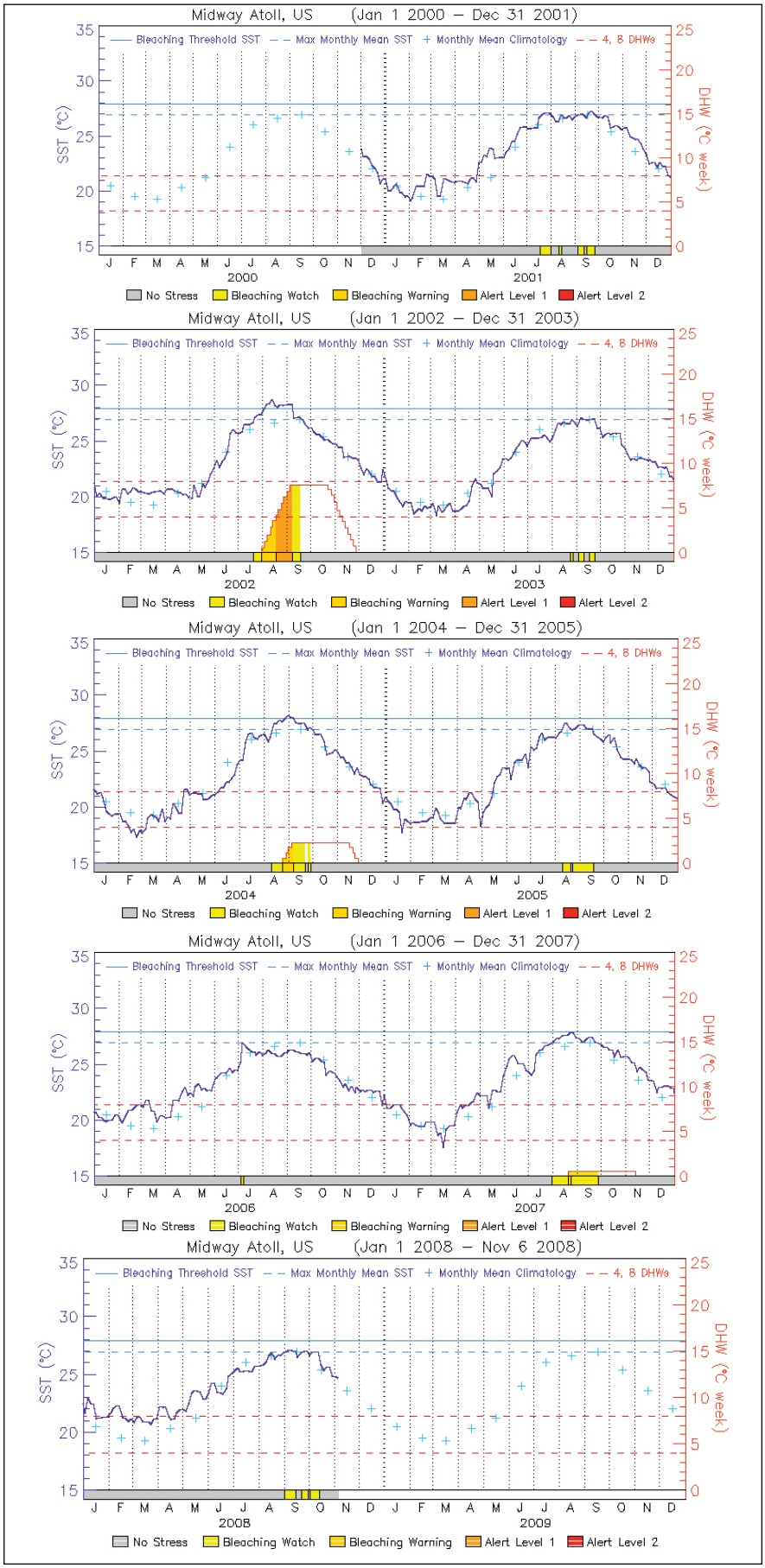

Figure 10.8. Sea surface temperature values recorded at Midway Atoll documenting potential conditions for coral bleaching events (2000 - 2008). Source: NOAA Coral Reef Watch.

structure changes there can be will be an ecosystem wide effect as habitat availability and species ranges change.

Evidence of undersaturation has been reported in the Intermediate Pacific in relatively shallow waters of between 200 m and 1,000 m (Feely et al., 2002). This is of concern to the NWHI deepwater habitat which for these purposes will be defined as depths greater than 50 m. A number of corals have identified habitat ranging from 20-3,000 m (Hourigan et al., 2008). These corals provide structure to the benthos as well as serving as habitat for other organisms living in the deep that have yet to be fully explored. Endangered Hawaiian monk seals with attached animal borne imaging systems (Crittercams) have been recorded foraging for fish that find shelter in black coral beds (Parrish and Baco, 2008). However, due to the remoteness of the NWHI follow-up deepwater surveys have yet to be conducted, as they require extensive time, planning and budgeting considerations. Deepwater corals are mainly slow-growing species, and the effects of undersaturation may not manifest for years after it has occurred. Or, conversely, if the saturation horizon rises to shallow depths, the aragonite structure of the deepwater corals may begin to dissolve away into the ocean.

The degree to which ocean acidification will affect Monument coral reefs is presently under investigation. Plans are underway to establish a baseline of the carbonate chemistry of the NWHI. This would be done by utilizing the CTD (conductivity, temperature, depth) sensor scanner onboard R/V *Hiialakai* and outfitting it with a pH sensor. Carbonate chemistry of a water sample can be characterized by taking three measurements; the dissolved inorganic carbon, alkalinity and pH. All three of these measurements are planned to be performed onboard during regular CTD casts and the seawater samples brought back for further analysis. These types of measurements, taken from deepwater habitats and lagoon waters (from small boat platforms) will help the Monument to develop an understanding of the current carbonate chemistry of the waters and allow us to monitor future changes.

Ocean Acidification

Ocean acidification is the process of seawater becoming less basic and is likely to upset the delicate balance between reef calcification and erosion (Hoegh-Guldberg, 1999). The carbonate equilibrium describes the process of calcification in marine animals and is illustrated by equation 1 (Kleypas et al., 1999; Royal Society, 2005; Kleypas and Langdon, 2006). Acidification, where atmospheric CO_2 is absorbed by the surface of the ocean where it forms carbonic acid, is illustrated by equation 2;. This acid then dissociates into free hydrogen and bicarbonate ions resulting in increasing amounts of bicarbonate, leaving less carbonate ions available to interact with the abundant calcium ions present in seawater. Calcium ions are not thought to be a limiting factor in calcification (Royal Society, 2005). Therefore, when the amount of CO_2 in the atmosphere increases, the availability of carbonate ions for calcifying organisms (corals, calcareous algae, plankton etc.) to incorporate into their skeletons decreases and the carbonate equilibrium shifts facilitating the dissolution of the calcium carbonate skeleton (Kleypas et al., 1999; Royal Society, 2005; Kleypas et al., 2006).

Equation 1: The Carbonate Equilibrium

$$\underset{\text{Skeletal dissolution}\rightarrow}{\overset{\leftarrow\ \text{Skeletal formation}}{CaCO_3 + CO_2 + H_2O \leftrightarrows Ca^{2+} + 2HCO_3^-}}$$

Equation 2: Acidification

$$CO_2 + H_2O \leftrightarrows H_2CO_3 \leftrightarrows H^+ + HCO_3^- \leftrightarrows H^+ + CO_3^{2-}$$

There are two forms of calcium carbonate found in skeletons of $CaCO_3$ secreting organisms. The first is calcite, which is the less soluble form found in crustose coraline algaes, and the other is the aragonite form of calcium carbonate, which is utilized by scleractinian corals and other pteropods. There is a critical concentration of carbonate ions in seawater below which calcium carbonate will dissolve. The solubility of calcium carbonate is a function of depth and pressure. The critical concentration occurs at a depth known as the “saturation horizon”, under which calcium carbonate structures tend to dissolve. Due to increased amounts of CO_2 in seawater and the resultant decrease in the carbonate ion concentration (equation 2) the saturation horizon will move ever shallower with increasing releases of anthropogenic CO_2 into the atmosphere. This means that the depth at which corals are able to calcify will grow shallower as more CO_2 is input into the atmosphere. Latitude also plays a role when looking at where saturation boundaries occur. Lower latitudes near the equator tend to have saturation states conducive to the solidified structure of corals, while poleward areas are already showing evidence of undersaturation at the surface waters. Currently the surface waters of the NWHI still fall within saturation parameters (Feely et al., 2002).

Marine Debris

A multiagency effort initially launched in 1996 by the University of Hawaii's Sea Grant College Program began to address the problem of marine debris, a problem that was much larger than any one agency alone can resolve. An estimated 750 to 1,000 tons of marine debris were on reefs and beaches in the NWHI (NOAA PIFSC, unpublished; Figure 10.9). NOAA, in collaboration with 14 other partners including the U.S. Coast Guard (USCG), Schnitzer Steel Hawaii Corporation (formerly Hawaii Metals Recycling Company), the Hawaii Sea Grant College Program, U.S. Navy, USFWS, the City and County of Honolulu, the state of Hawaii, The Ocean Conservancy, Hawaii Wildlife Fund, Matson Navigation Company, and others removed 66 tons of marine debris and derelict fishing gear from 1996 to 2000. In 2001, the multiagency cleanup effort was extended, resulting in a corresponding increase of marine debris removed from reefs and beaches of the NWHI (Table 10.5). The total amount of marine debris removed from 1996 to 2007 was 582 tons.

Figure 10.9. Divers cutting away nets from the reef in the NWHI. Photo: CRED.

Table 10.5. The total amount of marine debris removed from 1996 to 2007 was 582 tons. Source: NOAA/PIFSC.

YEAR	TONS REMOVED
1996 - 2000	Approximately 25 tons per year
2001	68
2002	107
2003	118
2004	126
2005	57
2006	21
2007	59

The source of much of the marine debris is fishing nets discarded or lost in the northeastern Pacific, well outside of the Monument boundaries. In order to address the source of marine debris in the Pacific, Monument managers will need to work with international partners to look at methods and develop policies for reducing marine debris. Even if all new input of debris were stopped, existing debris in the ocean would continue to accumulate in the NWHI for years to come. At a Pacific basin scale, it is suggested that the subtropic convergence zone (STCZ) that moves between 25°N and 35°N is an area of high ghostnet retention (Figure 10.10). When the STCZ moves within range of the NWHI, the nets often become entangled on reefs and continue to be an entanglement hazard for many species. Once the debris reaches the NWHI, the rate of accumulation of nets on reefs varies by island and atoll and within island and atoll

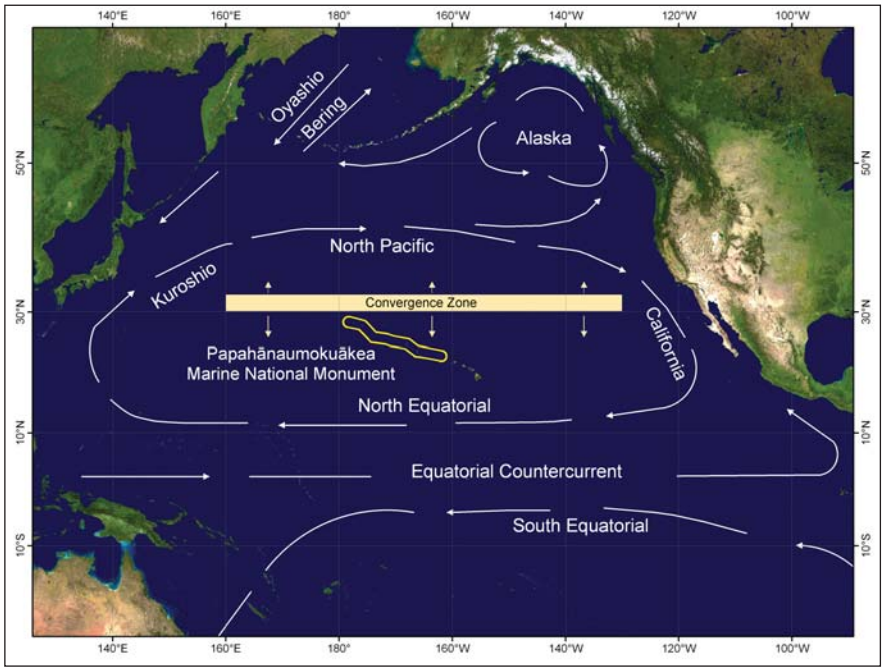

Figure 10.10. Map illustrating regional current movements and the convergence zone.

(Dameron et al., 2007). A model of potential accumulation rates was developed for the NWHI to help evaluate the distribution of marine debris and where efforts should be focused for removal. The results from the model can be used by managers to target areas for marine debris clean-up efforts.

In the 2007 field season Kure Atoll, Pearl and Hermes Atoll, Lisianski Island, Laysan Island and French Frigate Shoals were targeted for marine debris removal (Table 10.6). In addition to the marine debris removal efforts, a study of the effects of marine debris and marine debris removal on NWHI coral reef benthic communities was initiated at Midway Atoll in 2008. The study will be assessing the long-term effects of removal of nets from reefs as well as the effects of nets left in place. Initial survey and removal efforts began in August 2008 and the study will continue into 2009. The results of the study will help managers develop better guidelines for marine debris removal and decreasing overall impact to the coral reef ecosystems. In addition the results will begin to provide managers with information about recovery rates of the benthic communities following debris removal or other anthropogenic disturbance.

Table 10.6. 2007 field season marine debris removal by island and atoll. Source:

LOCATION	DEBRIS TYPE	REMOVED (kg)	REMOVED (tons)
French Frigate Shoals	Marine Debris	5,554	6
	Land Debris	1,735	2
Kure	Marine Debris	2,860	3
	Land Debris	1,431	1
Laysan	Marine Debris	0	0
	Land Debris	2,073	2
Lisianski	Marine Debris	0	0
	Land Debris	4,396	4
Pearl and Hermes	Marine Debris	39,250	39
	Land Debris	1,911	2
Total Marine Debris Weight		**47,664**	**48**
Total Land Debris Weight		**11,546**	**12**
Total Debris Weight		**59,210**	**59**

Marine Alien Species

Monument managers have identified marine invasive species including pathogens as a significant threat and are taking action to prevent any additional introductions. Because of the Monument's vast size, it is difficult to carry out surveys to detect marine invasive species. However, based on the few surveys conducted (see Nonindigenous and Invasive Species Chapter), there are currently 13 marine invasive species that have been identified and documented in the NWHI. Compared to the 343 marine invasive species that have been identified and documented in the Main Hawaiian Islands (MHI), the NWHI have a relatively low abundance of invasive species (Eldredge and Carlton, 2002; Godwin et al., 2006; Godwin, 2008). The potential of additional introductions of non-indigenous species in the NWHI could have dramatic consequences to the ecosystem. Management tools to reduce the potential introduction and spread of alien species in the Monument are the permitting process, enforcement of regulations and development of a monitoring and research program.

Mandatory hull inspections for all permitted vessels are the primary tool managers can use to reduce the potential of marine alien species introductions. Prior to receiving a Monument permit, any ship that has applied for a permit to access the Monument must complete a hull inspection. Another mechanism for potential introductions is by way of ballast water exchange. In response to national concern regarding invasive species, the National Invasive Species Act of 1996 was enacted. The Act reauthorized and amended the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990. In addition to the Monument discharge regulations, ballast water exchange in the Monument is regulated by the USCG which codified a national mandatory ballast water management program for all vessels equipped with ballast water tanks that enter or operate within U.S. waters. These regulations also require vessels to maintain a ballast water management plan that is specific for that vessel and that assigns responsibility to the master or an appropriate official to understand and execute the ballast water management strategy for that vessel.

There have been several reports written recently on the topic of marine invasive species in the NWHI (Eldredge, 2005; Godwin et al., 2006; and Godwin, 2008). They provide a number of recommendations for managers to deal with invasive species. These reports provided the foundation for the prohibitions on ballast discharge in

the Proclamation and the actions outlined in the MMP Alien Species Action Plan. The Alien Species Action Plan addresses prevention, monitoring of alien species, and education of Monument users and the public about the need to prevent alien species introductions. The following section focuses on how managers can utilize the geographic locations of known marine invasive species to shape their actions in three distinct realms: monitoring, permitting and research.

Monitoring
The locations of existing alien species populations can provide a foundation for future monitoring efforts. Monitoring of existing infestations and identification of new infestations is a key component to the Alien Species Action plan in the MMP. In the past, relatively few marine invasive surveys were conducted and usually only once and often opportunistically. The MMP calls for the need to establish a coordinated and systematic effort to survey distributions and populations of known alien species at regular intervals. Understanding where existing populations are can help guide managers in the development of monitoring protocols for the detection and potential eradication of current populations as well as future infestations. The monitoring program will provide important information on the spatial distribution, spread and population sizes of marine alien species within the Monument. Currently the existing Rapid Assessment and Monitoring Program monitoring does not specifically target alien species, but alien species would be identified during the MMP proposed alien species monitoring surveys.

Permitting
Knowing the locations of marine invasive species can assist managers in making decisions regarding the issuance of permits in the Monument. An understanding of potential invasive vectors, combined with the knowledge of where marine invasive species reside in the MHI and NWHI will allow managers to take steps to minimize those vectors. Steps to minimize the introduction of potential invasive vectors can most effectively be implemented through the permitting process.

Activities authorized under a Monument permit can be structured so that vessels visit the islands in an order that minimizes the risk of transporting invasive species. The more pristine sites should be visited first, and the most invaded locations last, to minimize the likelihood of organisms being transported from invaded sites to pristine areas. This may not always be possible but can be implemented where possible. These recommendations are currently being done on an informal basis through consultations with the applicant, but they could be formally incorporated as permit conditions in the final permit.

Managers can also restrict where vessels anchor or identify a route through the NWHI so as to minimize the risk of spreading invasive species through hull fouling or ballast water. To make effective decisions that can be justified, managers must have good geographic information on the locations of marine invasive species within the Monument.

Research
Information about where marine invasive species reside in the Monument is needed to inform managers and can serve as a guide on how best to direct management-driven research. Research about the effects of invasive species can be effectively targeted to the locations where known populations of those species do or do not exist. Accurate information about the abundance and positions of invasive species can help prioritize research based on species or sites. Research should be directed at the more abundant species, or the species in more vulnerable sites. In addition, other research that should be undertaken includes factors that cause alien species to become invasive and the interactions between native and alien species.

Vessel Hazards

With the exception of a few small boats at Midway Atoll, French Frigate Shoals, Pearl and Hermes and Kure Atoll, no vessels have home ports in the NWHI. Therefore, almost all marine traffic in the waters surrounding the NWHI is the result of transiting merchant vessels, research ships, fishing vessels, cruise ships, USCG ships and recreational vessels which visit infrequently. An estimated 50 vessels pass through the U.S. EEZ

surrounding the NWHI each day (Franklin, 2008). Vessels entering shallow waters intentionally or unintentionally have a higher risk of impacting resources.

Hazards to shipping and other forms of maritime traffic such as shallow submerged reefs and shoals are inherent in the NWHI's 1,931 km of islands and atolls. The region is exposed to open ocean weather and sea conditions year-round, punctuated by winter severe storm and wave events. Vessel groundings and the release of fuel, cargo and other items pose real threats to the NWHI. A number of factors have contributed to vessel groundings and cargo loss over the years. These factors include human error, lack of appropriate navigational practices, inaccurate nautical charts, and treacherous conditions due to low-lying islands, atolls, and shallow pinnacles and banks. Periodically, accidental loss of cargo overboard causes marine debris or hazardous materials to enter sensitive shallow-water ecosystems.

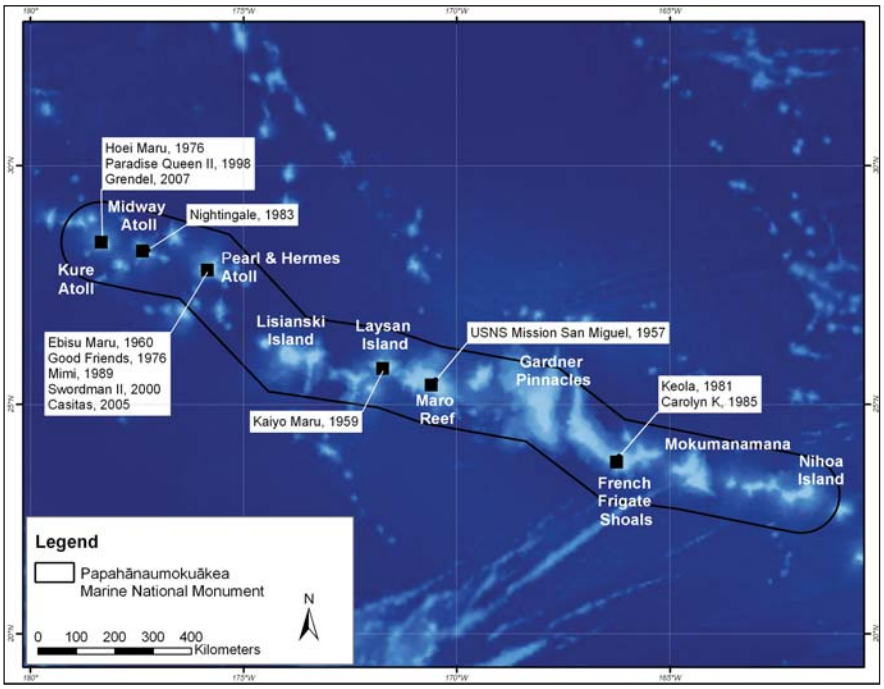

Figure 10.11. Groundings in the NWHI in the last 60 years. Map: K. Keller.

The history of shipwrecks and groundings is as old as the history of ships in the NWHI. Many islands and atolls are named for ships that went aground. In the last 50 years this history has continued, with several vessel groundings (Figure 10.11). Most recently the *Paradise Queen* and *Grendel* went aground at Kure Atoll in 1998 and 2007, respectively, and the *Swordman II* and *Casitas* went aground at Pearl and Hermes Atoll in 2000 and 2005, respectively.

Unexploded ordnance, debris and modern shipwrecks, such as the fishing vessels *Houei Maru #5*, the *Paradise Queen II* at Kure Atoll or the tanker *Mission San Miguel* lost at Maro Reef, are not protected as maritime heritage resources and represent a more immediate concern as threats to reef ecosystems. Mechanical damage from the initial grounding, subsequent redeposition of wreck material by storm surge, fishing gear damage to reef and reef-associated organisms, and release of fuel or hazardous substances are all issues to be considered in protecting the integrity of the environment. Dissolved iron serves as a limiting nutrient in many tropical marine areas and tends to fuel cyanobacteria (blue-green algae) or other iron limited species growth when the iron begins to dissolve and corrode. This is a problem particularly on atolls and low coral islands where basaltic or volcanic rock is absent in the photic zone and natural sources of dissolved iron in seawater are minimal. Therefore, any ships left in place would be an iron source that could contribute to potential cyanobacterial blooms. It has been demonstrated that not removing nonhistoric steel vessels will have long-term detrimental effects, which in most cases can be worse than any short-term damage to the environment caused by the removal action. Vessel traffic can also affect natural resources through direct damage to the reef from anchors, waste discharge, light and noise. Monument regulations which prohibit anchoring on or having a vessel anchored on any living or dead coral to prevent anchor damage to reefs. Discharge of waste in the Monument is also regulated by Proclamation and permit requirements.

The designation of the PSSA and expansion of the ATBA is intended to reduce the potential for large vessel groundings within the Monument. In near shore areas, the mandatory requirement for a vessel monitoring system will allow better tracking of permitted vessels as well as provide information for emergency response thus reducing any potential impact from vessel grounding. Reducing the response time when groundings do occur will also minimize environmental impacts.

MANAGEMENT OF HUMAN IMPACTS

There is a long history of managing impacts from human activities in the NWHI. Beginning in the early 1900s, several federal and state agencies, including the Department of Defense, Department of Agriculture, Department of the Interior, the state of Hawaii, and the Department of Commerce were assigned protective responsibilities in the NWHI. Additionally, military defense needs during and after World War II required the construction of facilities and the presence of U.S. Navy and U.S. Air Force, and USCG stations on several islands in the northwestern archipelago through the end of the 20th century. The following figures (Figures 10.12 and 10.13) indicate periods of protective responsibilities of the various federal and state agencies and the time periods in which military presence occurred in the NWHI. The following section focuses on the management of human activities since the designation of the Monument.

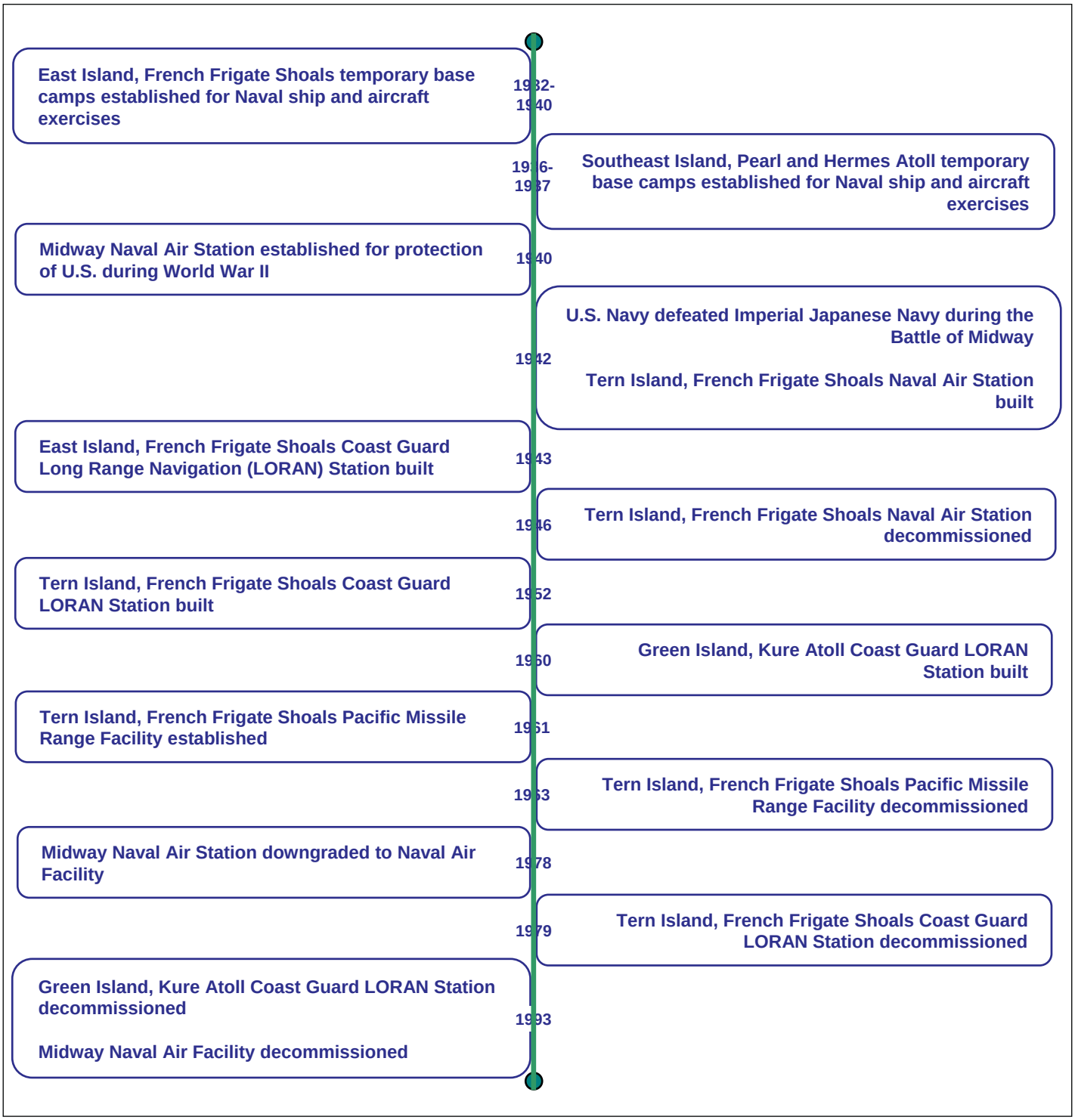

Figure 10.12. History of military presence in the NWHI.

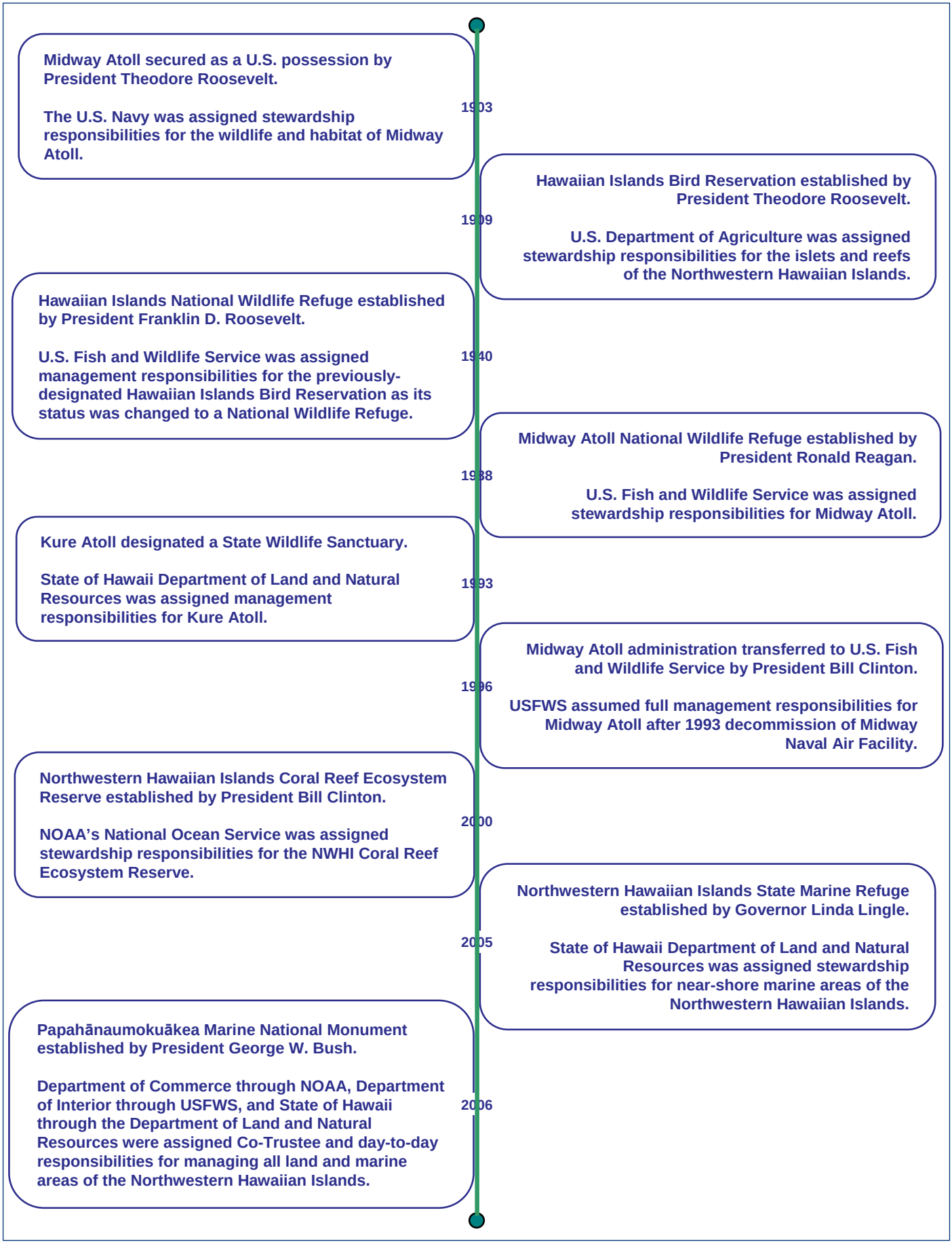

Figure 10.13. History of Management in the NWHI.

MONUMENT PERMIT APPLICATIONS AND PERMIT ISSUANCE

Since the designation of the Monument, all activities conducted within the Monument boundaries must meet the findings of the Proclamation and obtain a permit from the Monument. The Monument permitting program is one of the management tools that the Co-Trustees use to regulate the potential impacts of human activities on the Monument resources. Prior to the establishment of the Monument, the separate agencies responsible for management of the NWHI had separate permit applications, reviews and issuance processes and their own permit reporting requirements. Under Co-Trustee management, activities in the NWHI are prohibited, with limited exception, unless authorized by a Monument permit. Applications for all applicable activities are reviewed and permits issued jointly by the three Co-Trustee agencies.

A joint Monument permit application template and review process were developed and implemented in 2007. All applications are reviewed by managers, scientists, other experts within the three Monument Co-Trustee agencies and by Native Hawaiian cultural reviewers. In addition, summaries of permit applications are posted for public notification, and all applications for activities in State waters must be posted in full for public review before they are considered for approval by the State of Hawaii Board of Land and Natural Resources Land Board.

In order for a project to be permitted, it must comply with National Environmental Policy Act requirements and all other federal and state required permits and consultations. In addition, any permitted activity must meet all of the Findings of the Presidential Proclamation (Proclamation 8031) establishing the Monument. Information on Monument permit application procedures is available at http://papahanaumokuakea.gov/resource/permits.html.

In addition to meeting the findings in the Proclamation, proposed activities to be conducted in the Midway Atoll SMA and the other National Wildlife Refuge areas, proposed activities continue to be subject to findings of appropriateness (603 FW 1) and compatibility determinations (16 U.S.C. 668dd-668ee and 603 FW 2) by USFWS to ensure the activities meet the purposes for establishing the Hawaiian Islands and Midway Atoll National Wildlife Refuges and the mission of the National Wildlife Refuge System.

Findings of Presidential Proclamation 8031

- ❑ The activity can be conducted with adequate safeguards for the resources and ecological integrity of the Monument.
- ❑ The activity will be conducted in a manner compatible with the management direction of the Proclamation, considering the extent to which the conduct of the activity may diminish or enhance Monument resources, qualities, and ecological integrity; any indirect, secondary, or cumulative effects of the activity; and the duration of such effects.
- ❑ There is no practicable alternative to conducting the activity within the Monument.
- ❑ The end value of the activity outweighs its adverse impacts on Monument resources, qualities, and ecological integrity.
- ❑ The duration of the activity is no longer than necessary to achieve its stated purpose.
- ❑ The applicant is qualified to conduct and complete the activity and mitigate any potential impacts resulting from its conduct.
- ❑ The applicant has adequate financial resources available to conduct and complete the proposed activity and mitigate any potential impacts resulting from its conduct.
- ❑ The methods and procedures proposed by the applicant are appropriate to achieve the proposed activity's goals in relation to their impacts to Monument resources, qualities, and ecological integrity.
- ❑ The applicant's vessel has been outfitted with a mobile transceiver unit approved by NOAA Office of Law Enforcement and complies with the requirements of Proclamation 8031.
- ❑ There are no other factors that would make the issuance of a permit for the activity inappropriate.

Types of Permits Issued

Applicants can apply for Monument permits under the following six permit categories: Research, Conservation and Management, Education, Native Hawaiian Practices, Recreation and Special Ocean Use.

Research

Research permits are authorized for those activities that enhance the understanding of Monument resources and improve resource management decision making. Priority is given to research proposals that help to meet the management needs of the Monument Co-Trustee agencies. Examples of types of activities issued under a research permit include biological inventories, ecosystem-based research, benthic mapping, habitat characterization, restoration investigations, cultural studies, and terrestrial and marine archaeological research.

Conservation and Management

Conservation and Management permits are authorized for those activities that are required for general management of the Monument. This may include activities associated with resource management, such as field station operations, marine debris removal, development and maintenance of infrastructure, species and habitat restoration, and long-term resource monitoring programs such as monitoring of endangered species, seabird populations, and terrestrial native plant communities. Conservation and Management permits also provide a mechanism enabling rapid response and follow-up to critical events in the Monument that cannot be anticipated, such as vessel groundings, coral bleaching episodes and invasive species detection.

Education

Education permits are authorized for those activities that further the educational value of the Monument. These activities may enhance the understanding of ecosystems, improve resource management decision making, promote Native Hawaiian knowledge and values, or aid in enforcement and compliance efforts. Priority is given to those activities that have clear educational or public outreach benefits and that promote “bringing the place to the people, rather than the people to the place.” Examples of past projects issued under an education permit include teacher-at-sea programs, distance learning projects, and university classes.

Native Hawaiian Practices

Activities conducted under a Native Hawaiian Practice permit must be noncommercial, deemed appropriate and necessary by traditional standards, benefit the NWHI and Native Hawaiian community, perpetuate traditional knowledge and restrict the consumption of harvested resources from the Monument. Examples of activities permitted under a Native Hawaiian Practice permit include the entry of vessels for the purpose of applying and transferring knowledge of traditional navigation techniques and conducting ceremonies at historic cultural sites on Nihoa or Mokumanamana. Permit conditions and protocols for Native Hawaiian Practice permits will continue to be developed by the Monument Management Board, including the Office of Hawaiian Affairs through consultation with the Native Hawaiian Cultural Working Group and the Native Hawaiian community.

Recreation

Recreation permits are limited to the Midway Atoll Special Management Area in the Monument. Recreational activities may not be associated with any for-hire operation or involve any extractive use. Examples of recreational activities that may be permitted include snorkeling, SCUBA diving, wildlife viewing and kayaking.

Special Ocean Use

Special Ocean Use permits are authorized for those projects related to commercial ocean uses, such as ecotourism or documentary filmmaking, that have a demonstrated net benefit to the Monument. Special Ocean Use is defined as any activity or use of the Monument that will generate revenue or profits for one or more of the persons associated with the activity or use. Activities that could potentially qualify as another permit type but that directly generates revenue or profit for at least one of the persons involved in the activity can only be permitted as Special Ocean Use. In addition, Special Ocean Use proposals involving activities outside of the Midway Atoll Special Management Area must have demonstrated educational or research purposes that directly benefit the conservation and management of the Monument.

Emergencies, Law Enforcement Activities and Armed Forces Actions
Permits are not required for those activities conducted within the Monument that are necessary to respond to emergencies or that are necessary for law enforcement purposes. Activities and exercises of the Armed Forces (including those carried out by the USCG) do not require a permit but must be conducted consistent with applicable federal laws. All other human presence, including activities conducted by the Co-Trustee agencies, require review and approval through the Monument permitting process.

Transit Without Interruption Through the Monument
Uninterrupted passage by vessels through the Monument does not require a permit but vessel operators must provide official notice prior to entering and upon departing. Official notification ensures that managers know at any given time who is present in the Monument either conducting activities under an authorized permit or transiting without interruption

Additional Federal and State Permits and Consultations Required for Work in the Monument
In addition to the permit requirements of the Monument, several other federal and state permits and/or consultations are required for many of the activities conducted in the NWHI. For example, all personnel working with threatened or endangered species must obtain an endangered species permit. Anyone handling any bird species must obtain one or more permits from the U.S. Fish and Wildlife Service Office of Migratory Bird Management, and all scientists working with marine mammals must obtain one or more permits from the NOAA Fisheries Office of Protected Resources. Consultations may also be required as described under the U.S. ESA or Environmental Protection Agency regulations. Finally, although bottomfishing within the Monument boundaries will be phased out in 2011, all current bottomfishing operations are required to have valid federal fishing permits and state commercial marine licenses and fishing vessel registrations to operate within the Monument

2007 Permitted Activities Conducted Within the Monument

The first full year in which permits were issued by the Monument was 2007. Prior to June 2007, the State of Hawaii issued separate State permits for the Monument. Of a total of 51 permitted projects in the Monument in 2007, six were issued both Monument and state permits. The remaining 45 projects were issued a single joint Monument permit, issued by all three Co-Trustee agencies. Table 10.7 presents information on the number of permits issued, by permit type, for activities conducted in the Monument in 2007. The numbers of newly permitted projects and renewal projects (i.e., ongoing or long-term projects initiated in previous years) are shown.

Table 10.7. Numbers of Monument permits granted, by permit type, for activities conducted in 2007. Numbers of projects that were newly-initiated in 2007 and renewal projects (ongoing or long-term projects initiated in previous years) are also listed.

PERMIT TYPE	NUMBER OF MONUMENT PERMITS GRANTED	NUMBER OF NEW NWHI PROJECTS	NUMBER OF RENEWAL NWHI PROJECTS
Research	37	16	21
Conservation and Management	5	0	5
Education	2	2	0
Native Hawaiian Practices	1	1	0
Recreation	1	1	0
Special Ocean Use	5	5	0
TOTAL	**51**	**25**	**26**

Human activity in the NWHI has been greatly reduced relative to the height of military activity associated with World War II. Between 1940 -1945 more than 3,000 people were stationed at Midway Atoll and approximately 125 were stationed at Tern Island wintin French Frigate Shoals. (Amerson, 1971). The overall level of human presence in the Monument in 2007 is indicated in Table 10.8. Eighteen ship cruises and a total of 99 flights transported permitted personnel and supplies to and from the Monument. The average number of people aboard ship per day throughout the year was 32, and the average number of people on land per day throughout the Monument was 83, for a total average of 115 people in the Monument per day in 2007. The number of people on land per day was highest at Midway Atoll, with an average human population of 70. Human presence on all other islands and atolls was an order of magnitude lower, with an average of 6.3, 4.2, and 1.5 people on land per day at French Frigate Shoals, Laysan Island and Kure Atoll, respectively, and on average, less than

one person per day on all other islands and atolls in the chain.

The following map (Figure 10.14) indicates locations where permitted activities occurred in the Monument in 2007. Many of the permits issued allowed for work to be conducted at multiple locations. Thus, for example, a single permit may have included work only at French Frigate Shoals, or it may have allowed for visits to all islands and atolls. In 2007 the majority of the activities occurred at Midway Atoll, Pearl and Hermes Atoll and French Frigate Shoals. Midway Atoll and French Frigate Shoals have relatively easy access and the infrastructure to support activities, including landing strips and facilities to house year-round personnel.

In order to assess cumulative impacts, it is important for managers to understand the trends and patterns of the different types of permitted activities that have occurred in the Monument. The following section spatially represents the distribution of activities that took place in the Monument by the types of permits issued in 2007

Table 10.8. Number of ship cruises and flights, and average number of people on land per day in the Monument in 2007.

TRANSPORTATION	
Number of Ship Cruises	18
Number of Flights	
French Frigate Shoals	13
Midway Atoll	86
VISITATION	
Average Number of People on Land per Day	83
Nihoa	0.02
Mokumanamana	0.06
French Frigate Shoals	6.30
Laysan	4.20
Lisianski	0.30
Pearl and Hermes Atoll	0.80
Midway Atoll	70.0
Kure Atoll	1.50
Average Number of People on Ships per Day	**32**
Average Number of People in Monument per Day	**115**

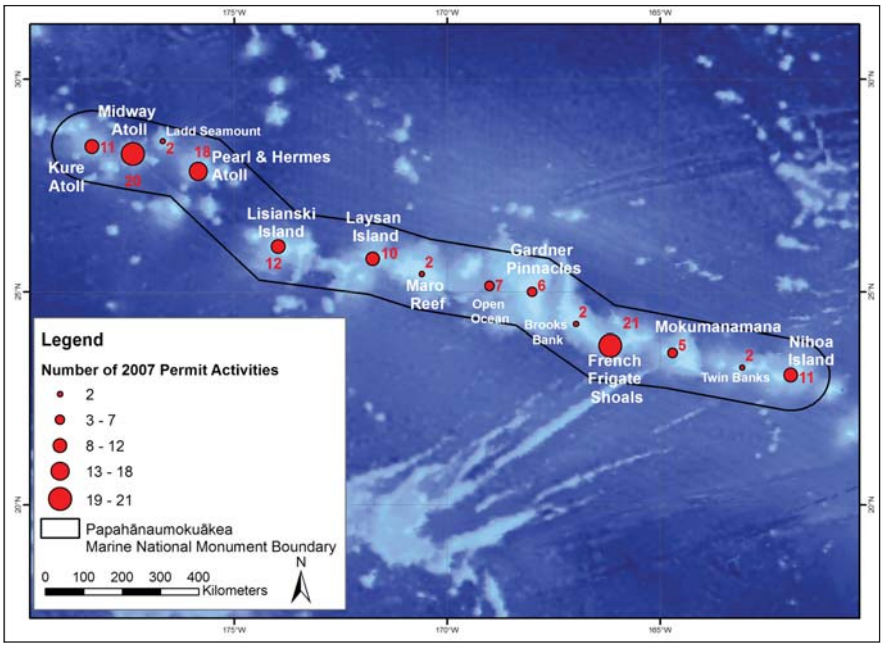

Figure 10.14. Locations of all permitted activities within the Monument in 2007. Map: K. Keller.

Research Activities by Location

Islands and atolls with the highest levels of permitted Research activities in 2007 included French Frigate Shoals, Pearl and Hermes Atoll, and Midway Atoll (Figure 10.15). Non-emergent banks and reefs, including Twin Banks, St. Rogatien and Brooks Banks, and Maro Reef, saw the lowest levels of research activities, while Mokumanamana and Gardner Pinnacles had the fewest number of Research activities conducted on emergent lands. Managers can use information on the distribution of past research activities to better plan and target future research and to ensure that data gaps are filled for those areas for which with less information is available.

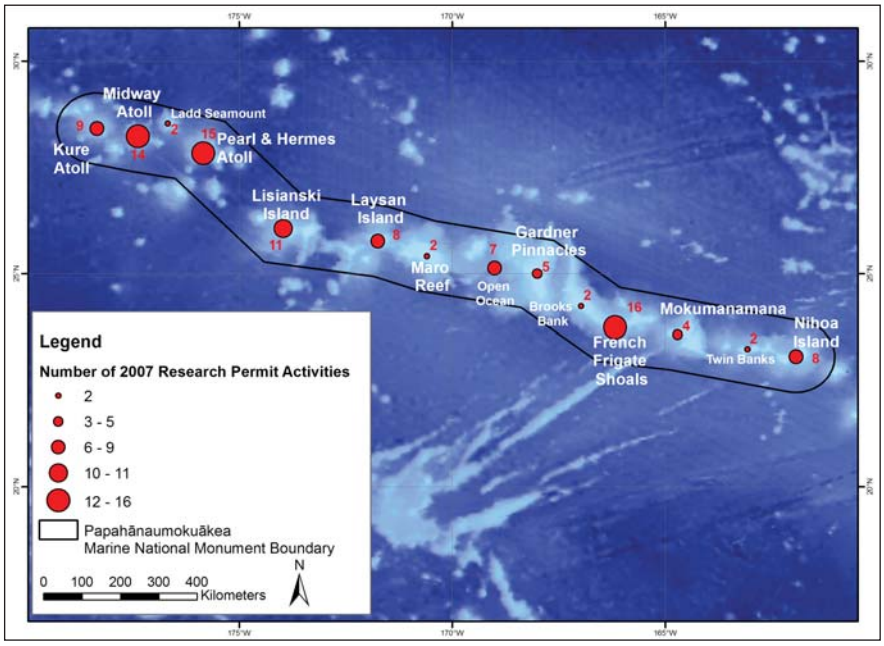

Figure 10.15. Locations of permitted Research activities in 2007. Several of the 37 Research permits authorized work at multiple locations within the Monument; thus, the total number of permits in the figure below adds to more than 37. Map: K. Keller.

Conservation and Management Activities by Location

In 2007, U.S. Fish and Wildlife Service Conservation and Management activities took place at Nihoa, French Frigate Shoals, Laysan, and Pearl and Hermes Atoll (within Hawaiian Islands National Wildlife Refuge), and at Midway Atoll (Midway Atoll National Wildlife Refuge). State of Hawaii DLNR activities took place at Kure Atoll, and NOAA PIFSC-CRED marine debris removal activities occurred at French Frigate Shoals, Laysan, Lisianski, Pearl and Hermes Atoll, and Kure Atoll (Figure 10.16).

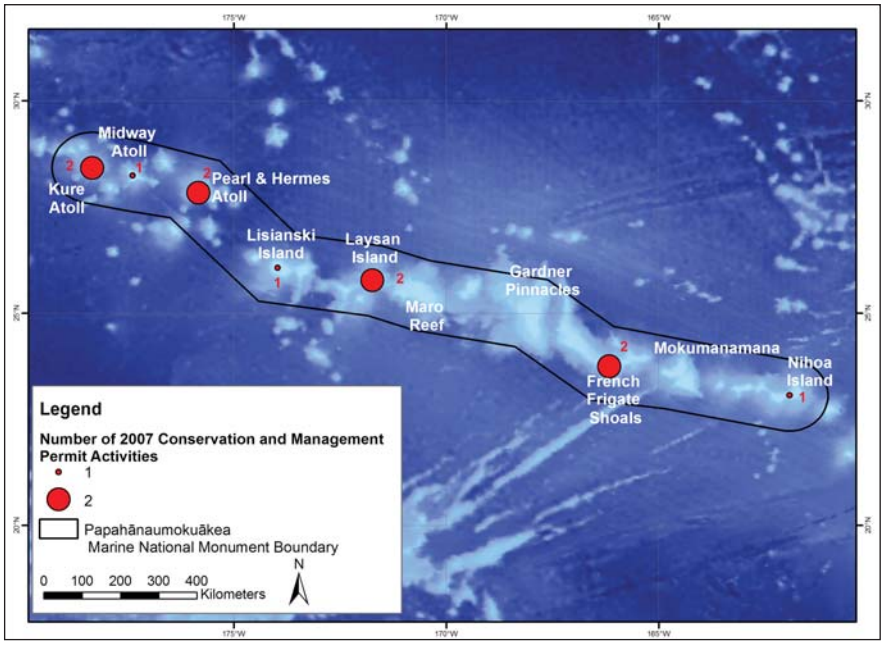

Figure 10.16. Locations of permitted Conservation and Management activities in 2007. Two of the five Conservation and Management permits authorized work at multiple locations within the Monument; thus, the total number of permits in the figure below adds to more than five. Map: K. Keller.

Education Activities by Location

NOAA Monument education activities in 2007 took place almost entirely aboard ship and during 12 shallow-water free dives, with land visits made only at Midway Atoll and Kure Atoll. Sites visited, where photos and video footage were taken, included Nihoa, Gardner Pinnacles, Laysan, Lisianski, Pearl and Hermes Atoll, Midway Atoll and Kure Atoll.

DLNR education activities took place aboard ship and during 13 shallow-water dives at French Frigate Shoals, Pearl and Hermes Atoll, and Midway Atoll (Figure 10.17). Photos and video footage were taken at each of these sites.

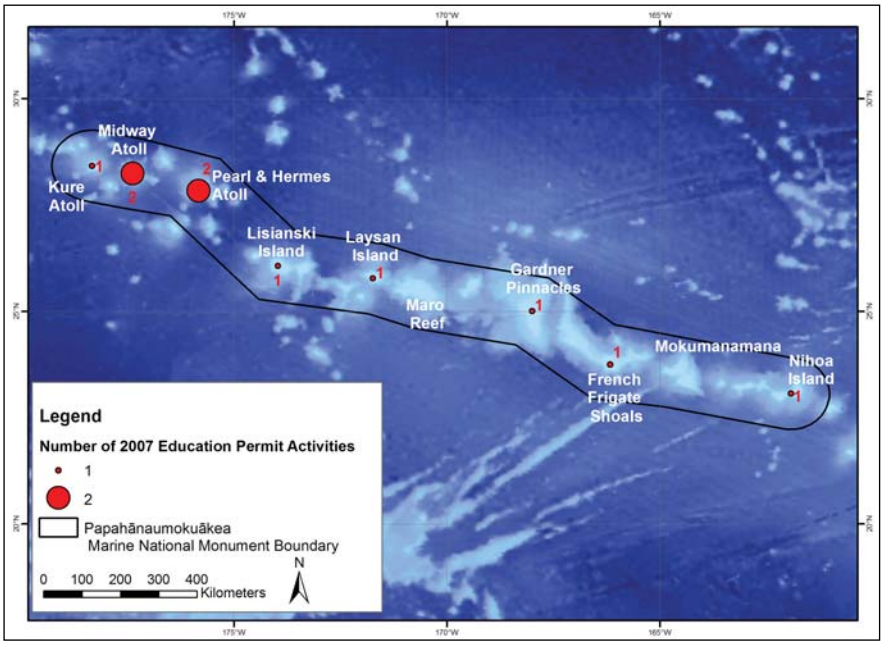

Figure 10.17. Locations of permitted Education activities in 2007. The two Education permits authorized work at multiple locations within the Monument; thus, the total number of permits in the figure below adds to more than two. Map: K. Keller.

Native Hawaiian Practices Activities by Location

A single Native Hawaiian Practices permit was issued in 2007, to the University of Hawaii. Activities conducted under this permit included an overnight stay on Mokumanamana to conduct traditional ceremonies in observance of the summer solstice, and a stop off of the island of Nihoa to conduct additional ceremonies aboard ship (Figure 10.18).

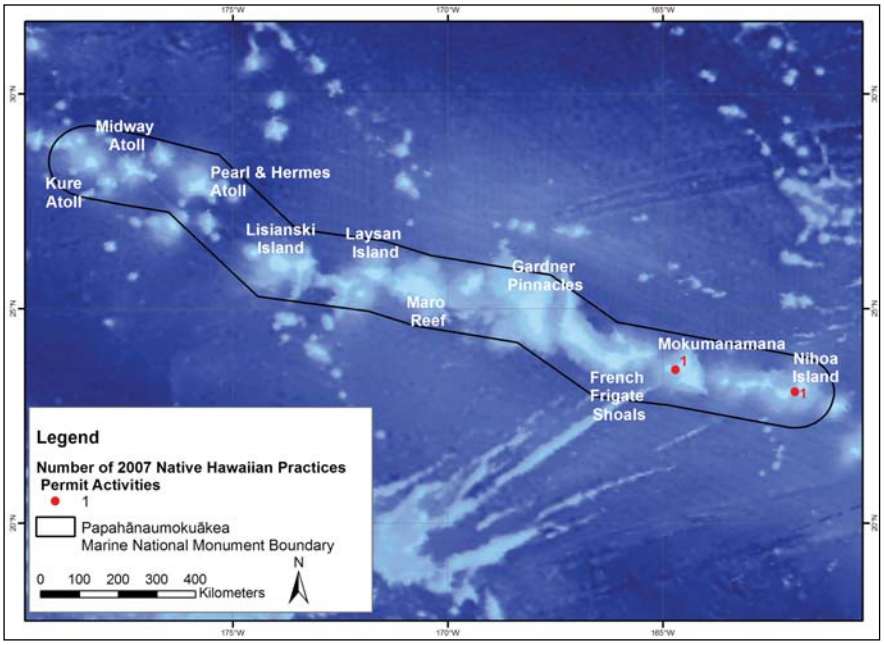

Figure 10.18. Locations of permitted native Hawaiian practices and activities in 2007. Map: K. Keller.

Special Ocean Use Activities by Location

Five Special Ocean Use permits were issued in 2007 occurring at Midway and French Frigate Shoals (Figure 10.19). Two of these permits were associated with the commemoration of the 65th Anniversary of the Battle of Midway and involved flight and ship transportation of World War II veterans and their families to Midway Atoll for the one-day celebration. A third Special Ocean Use permit was issued to the British Broadcasting Corporation for high-definition filming of tiger shark predation on albatross fledglings at French Frigate Shoals. The final two Special Ocean Use permits were issued for two individuals to conduct filming and still photography associated with NOAA Education and Research activities.

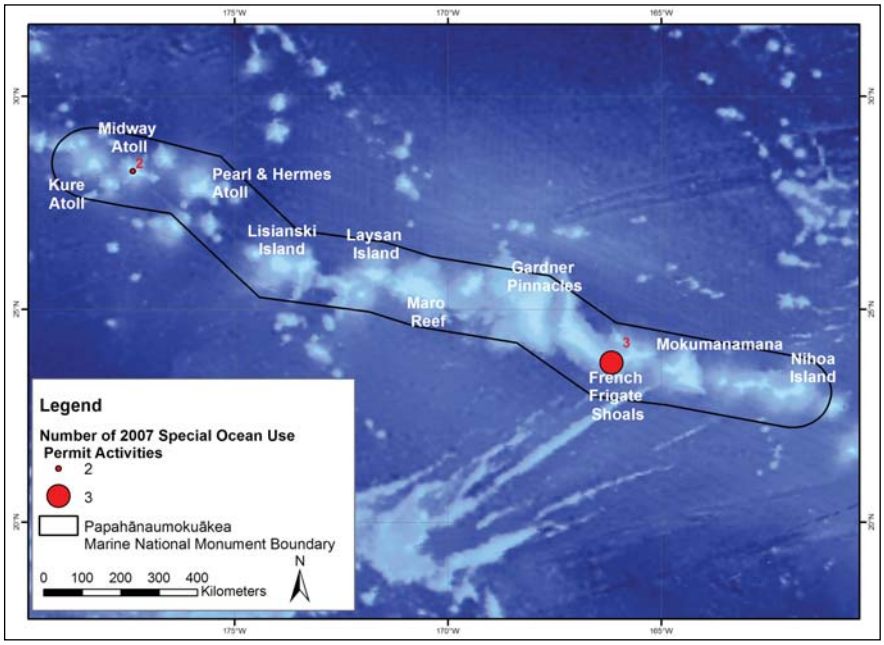

Figure 10.19. Locations of permitted Special Ocean Use activities in 2007. Map: K. Keller.

PMNM Relative Size and Visitation Rates

Papahanaumokuakea Marine National Monument is the largest protected area in the United States, and is larger than all of the U.S. National Parks combined. It is also larger than almost all other protected marine areas in the world, including Great Barrier Reef Marine Park. Because of the protections put in place by Presidential Proclamation 8031, followed by the permitting system established by the Monument Management Board in 2007, the visitation rate to the Monument was significantly lower in 2007 compared to visitation rates to Hanauma Bay Nature Preserve, Yosemite National Park, and even Great Barrier Reef Marine Park (Table 10.9). The following figure (Figure 10.20) also illustrates the scale of Papahanaumokuakea Marine National Monument relative to western states on the mainland U.S. The Monument is larger than 46 of the 50 states, and if overlain on the west coast would span an area from Arizona through Nevada, Oregon, and Washington state.

Table 10.9. Relative size and visitation rates for Hanauma Bay, Yosemite National Park, Great Barrier Reef Marine Park and Papahanaumokuakea Marine National Monument.

PROTECTED AREA PER DAY	SIZE	VISITATION RATE	PEOPLE PER ACRE
Hanauma Bay Nature Preserve	100 acres	3,000 people/day	30
Yosemite National Park	760,000 acres	9,600 people/day	0.01
Great Barrier Reef Marine Park	85,100,000 acres	5,423 people/day	0.00006
Papahanaumokuakea Marine National Monument	89,500,000 acres	115 people/day*	0.000001

*Includes 70 people per day at Midway Atoll.

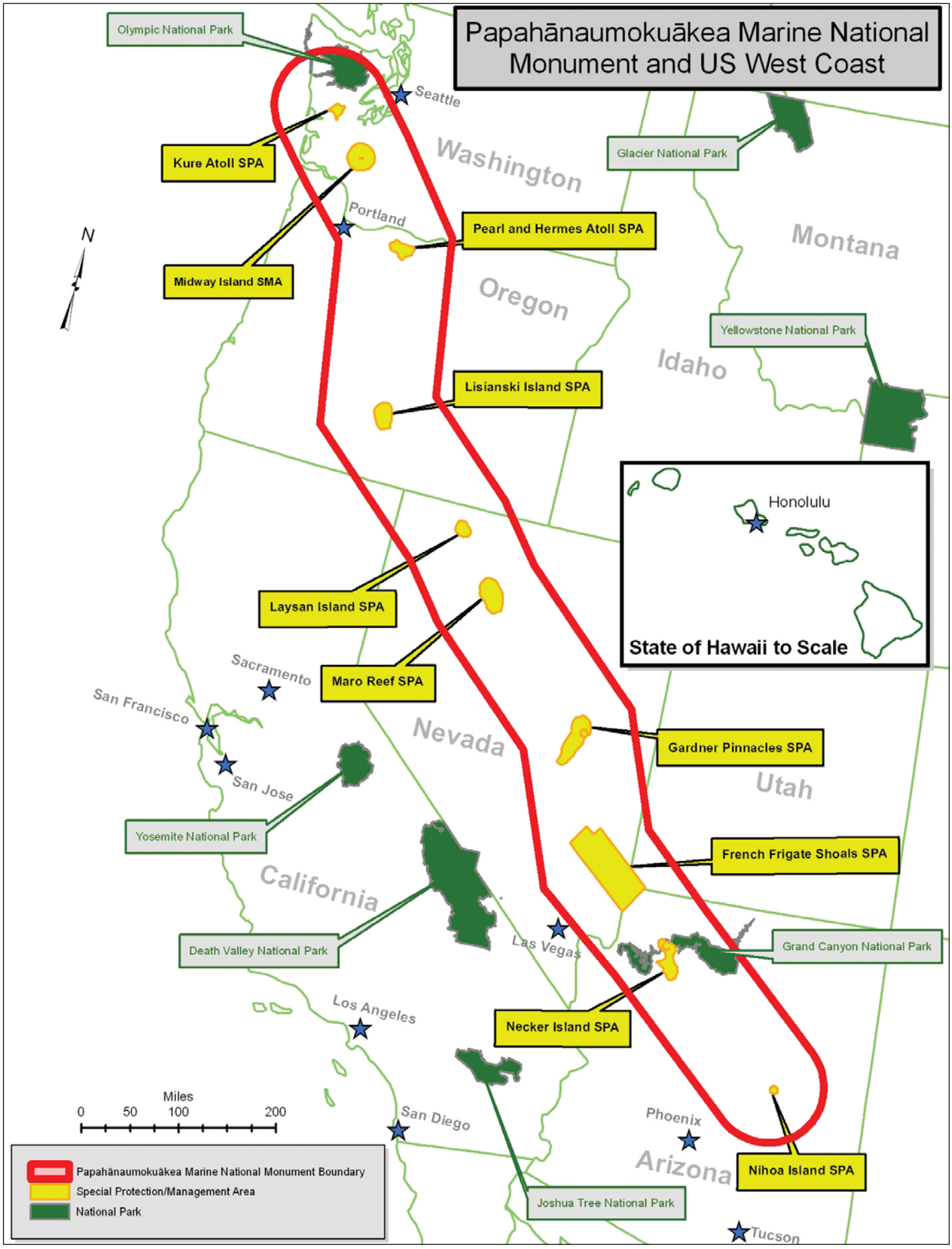

Figure 10.20. Size of the Monument relative to states on the west coast of the mainland U.S. Source: D. Turner, PMNM.

FUTURE DIRECTIONS AND IMPLICATIONS FOR A BIOGEOGRAPHIC ASSESSMENT TO SUPPORT HAWAIIAN ARCHIPELAGO SPATIAL MANAGEMENT

A primary use of implementing a marine biogeographic assessment for the NWHI was to further the understanding of the temporal and spatial coupling between the oceanographic characteristics, pelagic and benthic habitats, living marine resources and human uses that collectively comprise the NWHI ecosystem. The biogeographic assessment process is defined in this document's introduction and illustrated in Figure 10.21. Much of the data and information synthesized for this investigation addressed an area (e.g., oceanographic characteristics) much greater than the boundaries of the Monument or the individual atolls that comprise the island chain. However, the study area did not encompass the entire Hawaiian Archipelago that would place in context the biogeographic results for the NWHI when compared to the Main Hawaiian Islands (MHI). The exception is the work that has been done to characterize the shallow-water reef fish assemblages around both the heavily fished MHI and the very limited exploited reef fishes of the NWHI.

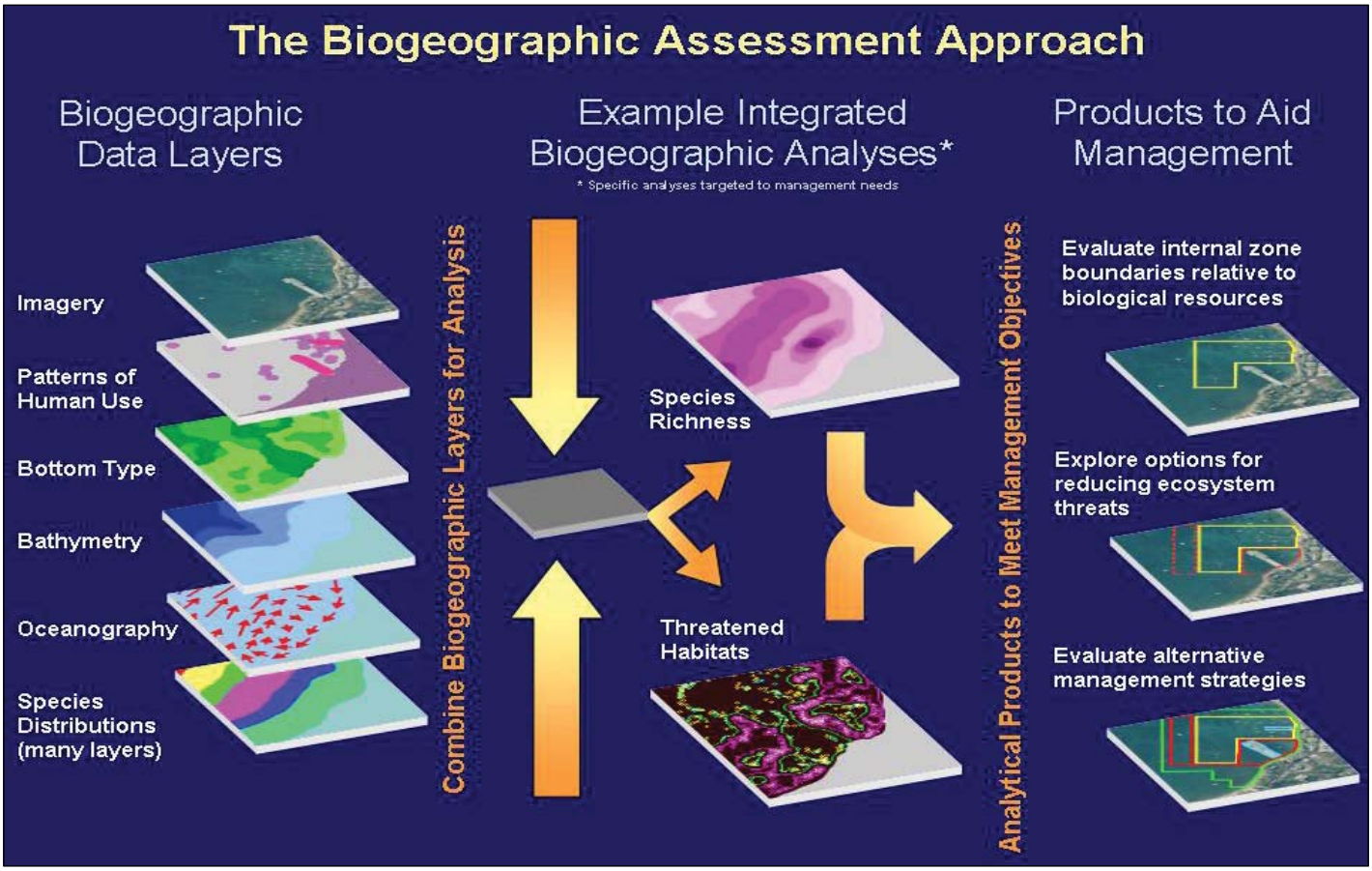

Figure 10.21. Generalized biogeographic assessment process developed by CCMA-BB. Source: Kendall and Monaco, 2003.

The 2,500 km long Hawaiian Archipelago is unified by its geologic origin and geographic isolation. This vast area is subject to great spatial gradients in oceanography, erosion and geomorphology. The Hawaiian marine ecosystem has some of the highest marine endemism on the planet, with many species unique to the archipelago. Given these broad-scale characteristics, the recently published NOAA Technical Memorandum (NOAA, 2008), "Hawaiian Archipelago Marine Ecosystem Research" plan (HAMER), noted that Hawaii could

serve as "a large scale archipelagic laboratory for the investigation of biophysical processes, comparing the protected and nearly pristine NWHI to the heavily used MHI to improve resources management in Hawaii and in comparable marine ecosystems worldwide (NOAA, 2008; Figure 10.22). HAMER identified six research themes important to the management of the Hawaiian Archipelago. They are:

- Ecosystem Indicators and Metrics;
- Native Biodiversity and Invasive Species;
- Connectivity;
- Human Interactions;
- Resilience and Recovery; and
- Modeling and Forecasting.

Consistent with HAMER, the draft Papahanaumokuakea Marine National Monument Natural Resources Science Plan (NRSP), specifically cited a need for archipelagic-wide homogeneity in research planning and execution and adopted nearly identical thematic focus areas:

- Ecological Processes and Connectivity;
- Biodiversity and Habitats;
- Human Impacts;
- Indicators of Change and Monitoring; and
- Models and Forecasting.

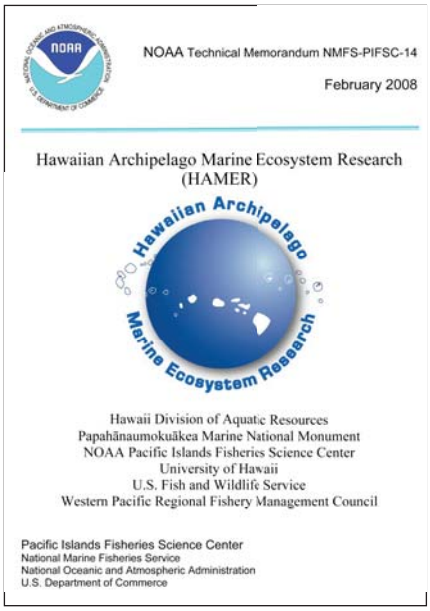

Figure 10.22. The Hawaiian Archipelago Marine Ecosystem Research.

Although HAMER is a plan for implementation over a ten year period, and the NRSP spans a shorter, five year period. Both plans provide the spatial and institutional framework to conduct research and integrate data and information in support of management of the Hawaiian Archipelago as a single, interconnected entity. With the recent increase in ecosystem monitoring data (e.g., Hawaii Coral Reef Assessment and Monitoring Program [CRAMP], MHI and NWHI Reef Assessment and Monitoring Programs [MHI/NWHI RAMP]), benthic habitat mapping (NOAA, 2007), and the assessment of habitats and associated fishes in and outside of marine protected areas (Friedlander et al., 2005, 2007), our ability to conduct archipelagic-wide research syntheses and biogeographic assessments is greatly enhanced. The biogeographic assessment process and this NWHI product directly support these multi-agency visions of HAMER and the PMNM NSRP, and provide a key starting point and many spatial data products that could be incorporated in a recommended MHI or archipelago-wide biogeographic assessment.

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